Situation Analysis on the Price Formation Mechanism of New Energy in China

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Abstract. With the rapid development of China's economy, the energy shortage is becoming more and more serious. In order to realize the sustainable development of society, Chinese government has strengthened its support for the development of new energy industry. At present, the total installed capacity of new energy in China has reached 37.2%. Compared with the initial period, the scale of new energy industry has been greatly increased. However, the problem of pricing mechanism of new energy benchmarking in China is increasingly prominent, which not only increases the gap of financial subsidies, but also fails to realize the reasonable optimal allocation of resources. For this purpose, according to the current domestic electricity market environment, this article proposes a new energy price formation mechanism which is more conformed to China's national conditions. Firstly, the article summarizes the existing international new energy pricing mechanisms and analyses the countries in which they are applied. Secondly, through the analysis of the problems and challenges of new energy price in China, the formation mechanism of new energy price in this environment is proposed according to the current situation and future development trend of power market construction in China. Finally, the article summarizes the whole text and proposes relevant policy recommendations as a useful reference for the government to promote the construction of electricity market.

1. Introduction

With the rapid development of China’s economy, the pressure of various environmental protection and energy supply is increasing significantly. These problems not only restrict the sustainable development of society, but also make our energy security face severe challenges. With the pressure of conventional energy shortage, global warming and environmental protection all over the world, the era of rapid development of new energy is ushered in. Countries all over the world pay more and more attention to new energy power generation, and China's new energy industry develops rapidly. As of June 2019, the total installed capacity of hydropower, nuclear power, wind power, solar power and other clean energy has reached 680 million kilowatts, accounting for 37.2% of the total installed capacity.

From the perspective of electric power system reform, the evolution of China's electric power pricing mechanism can be divided into four stages, as listed below:

- The first stage (1986-1995): debt service pricing—interest repayment cost + reasonable profit.
- The second stage (1996-2004): operating period pricing—operating period cost + reasonable profit.
- The third stage (after 2004): benchmark electricity price—operating period cost + reasonable profit, coal electricity linkage.
The fourth stage (after 2015): benchmarking price + market bidding under the new electricity reform, direct transaction price, starting spot electricity market

In the evolution of electricity pricing mechanism, the third and fourth stages are related to new energy. The third stage began in 2004, when China began to implement the generation side benchmarking mechanism. This system has played an important role in promoting the early development of new energy in China, which makes the scale of new energy expand rapidly. After 2015, China has entered the stage of diversified benchmarking. It is not only the single policy that the government formulates the benchmark price, but also involves the market bidding, direct transaction price and gradually deepening power market under the new power reform. The establishment of these systems and mechanisms constitutes the future generation side price system in China.[1]

2. Types of New Energy Electricity Price Formation Mechanism

Due to the influence of technology and other factors, the new energy industry does not have much market competitiveness in the early stage of development. Therefore, it is necessary for governments to support policies and improve the market competitiveness of new energy power generation through reasonable price mechanism. At present, the formation mechanism of new energy electricity price mainly includes feed-in tariff system, bidding system, green certificate system (quota system) and green electricity price system. This article mainly carries on the elaboration to the first three.

2.1. Feed-in Tariff System

The feed-in tariff system refers to the government establishing a unified tariff mechanism for certain types of power generation and supporting new energy power generation enterprises to generate electricity through subsidies. Feed-in tariff system includes two pricing methods: fixed tariff system and premium tariff system.

Feed-in tariffs for new energy in the fixed electricity price system is formulated by the government uniformly, and all power grid enterprises are required to purchase all the electricity generated by new energy generation. It is the earliest proposed and the most widely used. It has been successfully implemented in many countries, among which the fixed electricity price mechanism in Germany is relatively mature. At present, China’s new energy price is mostly still implemented this system. In addition to China, France, Russia and other 40 countries also adopt this system.

Premium price system is a kind of electricity price mechanism which combines market pricing with government policy subsidies. New energy and other conventional energy participate in bidding to form market price, and then the government will give some subsidies on this basis, which is "premium". Therefore, the on-grid price of new energy is "market price + government subsidy". At present, the countries that implement the premium price system include Spain, the Netherlands, Denmark and so on.

2.2. Competitive Bidding System

Competitive bidding system refers to that the government selects new energy power generation enterprises by means of bidding, determines the on-grid price through the quotation of bidders, and selects the bid winner. After the successful bidder is determined, the power company shall sign a power purchase agreement with it for a certain period of time. The agreement shall specify the electricity price, electricity quantity and validity period of the agreement. At present, 60 countries such as Britain and France have adopted this method.

2.3. Green Certificate Trading System Based on Quota System

Under this system, the government needs to set new energy quota targets for grid enterprises that are obliged to undertake the task of new energy interconnection, and issue "green certificates" to new energy power generation enterprises at the same time. Power grid enterprises need to purchase "green certificate" to complete the quota task required by the government. In this way, the new energy power generation enterprises can not only obtain the income from the market price, but also the income from the green certificate transaction. The final composition of the on-grid price is "market price + green certificate income". At present, the United States is implementing this system. New energy pricing mechanism in electricity market environment.
3. New Energy Pricing Mechanism in Electricity Market Environment

3.1. Problems and Challenges in the Electricity Price of New Energy

At present, the scale of China's new energy industry is expanding rapidly, and the electricity market reform is gradually deepening. The current electricity price mechanism has the following problems.

3.1.1. The subsidy fund gap is huge. The current photovoltaic power generation adopts the model of “benchmark price + quota subsidy + bidding price”, while wind power adopts the model of benchmark price + competitive allocation price. Since the beginning of the "13th Five-Year plan", some relatively mature wind power and photovoltaic power generation costs have been falling rapidly. In recent years, the mechanism of price subsidy level regression has been implemented for wind power and photovoltaic power generation. But the funding gap for new energy subsidies is still growing. Since 2006, the National Development and Reform Commission has raised the standard of additional tariff of renewable energy from 0.1 fen /kWh to 1.9 fen /kWh. However, the current standard of additional tariff is still difficult to meet the development speed of new energy, which makes the gap of government financial subsidy fund increasingly larger in recent years. By the end of 2019, the subsidy fund gap has exceeded 120 billion yuan. [2]

3.1.2. Pricing of fiscal subsidies is becoming increasingly difficult. Affected by the development of different types of new energy industries, the uneven quality of technologies, and the different resource conditions in different regions, the pricing of fiscal subsidies is difficult to adjust in time. Moreover, abandonment of wind and light is more serious in recent years, which makes pricing more difficult. In addition to the above two problems, due to the significant thermal power ratio in China's power supply structure and the poor flexibility of the power grid, the new energy consumption problem is still facing more challenges. China's electric power market is in the primary stage, and the market competition is not enough, which brings challenges to the implementation of bidding system and green certificate system.

3.2. Electric Power Market Construction Practice Situation in China

With the continuous deepening and expansion of China's electric power system reform and the joint efforts of the government and relevant departments, China's electric power market construction has been steadily promoted and achieved remarkable results. The following focuses on the basic results of the construction of the national electricity market.

3.2.1. The electric power market construction progress. Beijing and Guangzhou power trading centre was founded on March 1 in 2016. Guizhou established the first provincial power market Management Committee in April 2016 in China. By the end of 2017, two regional power trading centres and 32 provincial power trading centres had been set up in Beijing and Guangzhou. Electricity spot market has entered a substantive stage in 2019. On March 7, the National Energy Administration launched “the pilot work on further promoting the construction of electric power spot market opinion ”, pointed out the direction for the construction of the spot market. Zhejiang, Sichuan, Shandong, Fujian and Mengxi have successively carried out simulated trial operation. The success of Mengxi's trial operation on June 26 marks the first batch of eight power spot market pilots in China have all entered the simulated trial operation stage. At present, trial operation settlement has been carried out and certain achievements have been made in market construction.

3.2.2. The overall framework of national unified power market construction. The overall framework of "unified market and two-level operation" has been basically completed. The functional positioning of inter provincial and intra provincial transactions has become increasingly clear. The market model with medium and long-term trading as the main and spot trading as the supplement has basically formed a consensus from all walks of life. At present, the medium and long-term electricity trading mechanisms between provinces and within provinces have all been established, and the inter provincial spot trading
mainly to absorb clean energy has also been carried out. Unified framework design, unified core rules, unified operation platform and unified service specification have played a good role in practice.[3]

3.2.3. Power market entities. To form a competitive market, there must be enough buyers and sellers. By the end of 2019, the total number of market entities registered in the power trading platform of SGCC has exceeded 143700, including 28600 power generation enterprises, 111400 power users and 3600 power sales companies. China is constantly cultivating diversified market players and gradually forming a market competition pattern of buying more and selling more. Through the introduction of market subjects, the establishment of trading institutions, the determination of trading rules and the scientific supervision of the government, the power market is gradually established to realize the decisive role of the market in the allocation of resources.[4]

3.3. Formation Mechanism of New Energy Price under the Market Environment
China's electric power market is gradually mature and developing. In different degrees of power market environment, we should adopt different price formation mechanisms and gradually transition, instead of relying on market competition directly. This will make investors face great risks, eliminate their enthusiasm, and cannot realize the steady expansion of new energy power generation scale. This article divides the stages of China's electricity market into three stages: the initial stage, the middle stage and the mature stage.[5]

3.3.1. Initial stage of electricity market. In the early stage of the electricity market, due to the simplification of the main body of the electricity market, the market operation mechanism has not been comprehensive, the new energy industry related technologies are still developing, and the electricity operation cost is large. Compared with conventional energy sources, the market competitiveness is very small, so the government still needs a reasonable price subsidy policy, but it also needs to reflect the role of the electricity market. Therefore, the market price plus premium subsidy system is the most reasonable. There are many types of premium subsidy mechanism design, including fixed premium mode, percentage premium mode, difference premium mode and double price premium mode. Here, we assume $P_1$ is the on-grid price of new energy and $M$ is the premium subsidy.

3.3.1.1. Fixed premium mode. Premium subsidy $M$ is a fixed value, and the new energy power market price $P_2$ changes constantly with the generation cost and supply and demand relationship. Therefore, the on-grid price $P_1$ obtained by new energy power generation enterprises is determined by equation (1).

$$P_1 = P_2 + M$$

Although the fixed premium mode is relatively easy to implement, but if the market price is high and the government subsidies are fixed, investors will get extra income and the pressure of government financial subsidies will not be reduced. If the market price is very low, the government subsidy is not enough to cover the investment cost, which will bring investment risk to investors.

3.3.1.2. Percentage premium mode. Premium subsidy $M$ is determined according to the percentage of new energy electricity market price $P_2$. We set the ratio constant as $a$, and the value of $a$ is mainly determined by the installed capacity and technical type of the project. Therefore, the on-grid price $P_1$ obtained by new energy power generation enterprises is determined by equation (2).

$$P_1 = P_2 + M = P_2 + a \cdot P_2 = (1 + a)P_2$$

The return of investors who adopt the mode of percentage premium still largely determined by the market price of electricity. If the market price is high, the investors will get a lot of subsidies. In this case, a large number of investors will invest in new energy, but the government subsidy pressure will increase sharply. If the market price is very low, investors will receive very low subsidies, which will
lead to investors unable to recover the cost of electricity generation, the purpose of expanding the scale of new energy may not be realized.

3.3.1.3. Difference premium mode. Firstly, the government sets a price level of on-grid, which is called $P_f$. This price is a guaranteed price, which can benefit most new energy power generation enterprises. The on-grid price $P_1$ obtained by new energy power generation enterprises is determined by equation (3), as shown in figure 1.

$$
\text{If } P_2 < P_f, P_1 = P_f, M = P_f - P_2 \\
\text{else } P_1 = P_2, M = 0
$$

3.3.1.4. Double price premium mode. In order to avoid the investment inconvenience and investment risk caused by the continuous fluctuation of electricity market price and the capital pressure caused by excessive government subsidies, a ceiling price $\alpha$ and a minimum price $\beta$ can be set. When the market price $P_2$ is less than a certain proportion of the minimum price $\beta$, the premium subsidy $M$ is the difference between $\beta$ and $P_2$. With the increase of market price $P_2$, the subsidy value $M$ gradually decreases, and the new energy on-grid price $P_1$ is equal to $\beta$. At this time, the on-grid price is similar to the difference premium mode. When the market price $P_2$ is greater than or equal to a certain proportion of the minimum price $\beta$ but less than $\beta$, the premium subsidy $M$ is fixed, and the new energy on-grid price $P_1$ is equal to the sum of $\beta$ and $M$. At this time, the on-grid price increases with the market price, similar to the fixed premium mode. When the market price $P_2$ is greater than or equal to the minimum price $\beta$ but less than the ceiling price $\alpha$, the premium subsidy $M$ is the difference between $\alpha$ and $P_2$. With the increase of market price, the subsidy value gradually decreases, and the new energy on-grid price $P_1$ equals $\alpha$. At this time, the on-grid price is similar to the difference premium mode. When the market price $P_2$ is greater than or equal to the ceiling price $\alpha$, the premium subsidy $M$ is 0, and the new energy on-grid price $P_1$ is equal to $P_2$. At this time, the on-grid price is completely determined by the market, as shown in figure 2. The key of this kind of electricity price mechanism lies in the reasonable determination of the ceiling price and the minimum price, so as to make the premium subsidy within a reasonable level.

![Figure 1. Difference premium mode](image1)

![Figure 2. Double price premium mode](image2)

3.3.2. Middle stage of electricity market. In the middle of the electric power market, the main body of the electric power market tends to be diversified, the market operation mechanism is gradually comprehensive, the development of new energy industry technology is becoming more mature, and the power operation cost is much lower than before. Many new energy power generation enterprises understand and are familiar with the electricity market environment in the operation of the market price plus premium subsidy mechanism. The fixed price mechanism can be used to launch the stage of electricity price mechanism, but it is still unable to fully compete with conventional energy in the market.
at this time. Therefore, it is necessary for the government to make certain subsidies to expand the scale of the new energy industry.

3.3.3. Mature stage of electricity market. In the mature stage of the electric power market, the market operation mechanism is very sound and the main body of the electric power market is diversified. Market competition strategies and risk avoidance systems of various parties have been improved, the development of new energy industry technology has been mature, and the scale of new energy industry has accounted for a very large proportion compared with conventional energy. At the same time, the operation cost of electricity can enable new energy to be connected to the electricity grid at a fair price. In order to further promote the technological progress of new energy, realize the rational allocation of resources and reduce the government's unnecessary financial subsidies, we should cancel the premium subsidies at this stage, and completely rely on the mature electricity market environment to realize bidding. While implementing the market price system, new energy quota system and green certificate trading mechanism can be set up to ensure the consumption of new energy.

4. Conclusion
In the introduction part, this article summarizes the development status of domestic new energy, and puts forward the evolution process of electricity pricing mechanism. The main body firstly introduces feed-in tariff system, bidding price system and green certificate trading system based on quota. Among them, premium price system, bidding price system and green certificate trading system based on quota belong to the electricity price mechanism under the electricity market environment. Then, we introduce the current situation of China's electric power market construction and summarizes the basic achievements of three national electric power market construction. They are the accelerating progress of power market construction, the basic construction of the national unified power market, and the obvious trend of diversification of market entities. According to the current domestic electricity market environment, we also put forward a new energy price formation mechanism which is more in line with China's national conditions.6

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