Analysis on the trading mode suitable for nuclear power in power market

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Abstract. The energy crisis in the 21st century has become the most imperative problem to be solved by human beings. Nuclear energy is a vital base-charge power supply, which has high security, clean function and high efficiency. With the gradual development of nuclear power, the power is participating in the direct trading of the electricity market step by step. However, the rules of direct trading in China is not relatively complete, which leads to the unreasonable decline of the economy of nuclear power units. And there are drawbacks in the adjustment of energy structure, which also has a negative impact on energy conservation and emission reduction. So the author analyzes the current national nuclear power policies and electricity price costs, and proposes the current problems faced by nuclear power in direct electricity market and provides the basic directions and ideas for solving measures to help nuclear power better participate in direct electricity trading.

1. Introduction
In 1993, first commercialized power grid in China began to operate, but the resource allocation and the economic development was unbalanced. [1] Specifically, hydropower, coal and electricity of China are relatively distributed in the western region, while the eastern region shows a shortage of resources. The eastern region is relatively more developed, while the western region is underdeveloped. [2] Up to now, the demand for the whole load is relatively uneven, which will directly affect the electricity price level of power grid region in China, but on the other hand, it provides a probability for better national resource allocation. [3] As a new type of energy, nuclear energy can relieve the energy crisis in China if the problems related to direct electricity trading can be solved.

2. Current policy and electricity price costs involved in national nuclear power
In order to further ensure the security of national energy, the entire energy structure will be adjusted to better carry out energy conservation and emission reduction, and the concept of “Lucid waters and lush mountains are invaluable assets.” will be realized, and the development of nuclear power will gradually mature. [4] The growth of the national economic development is gradually slowing down. The electricity prices of thermal power and coal power have been downgraded. The policy of the electricity market has been greatly affected by multiple factors, and the feed-in tariff and quantity of nuclear power are greatly affected. As a new type of clean energy, nuclear power itself has more advantages, and it has a pivotal position in the national security and energy strategy. It also has an excellent advantage in realizing energy conservation and emission reduction on electricity. Relevant departments in China have attached great importance to nuclear power. From the analysis of the documents, in the draft of "Energy Conservation and Low Carbon Electric Power Dispatching
Measures” issued by the state in 2016, the first power generation sequence is non-fossil energy generator sets, of which wind, solar and water energy and nuclear energy rank in the top four. [5]-[6] The basic principles of this draft are: safe and reliable, energy-saving and low-carbon, market allocation, and scientific supervision. In September of the same year, the National Development and Reform Commission and the Energy Bureau drafted a draft for nuclear power management. [7] This document directly clarified the strategic position of nuclear power development, coordinated the legal relationship and responsibility of nuclear power development, rights and obligations, and promoted the development of nuclear power in policy. In the following three years, although the Energy Bureau has always maintained a high degree of concern for the entire nuclear power, it does not make relevant policy guidance on the market-based feed-in tariff. [8] At present, the transaction price of nuclear power plants has caused great conflicts on the economic benefits of the entire nuclear power.

3. Analysis of power generation cost and pricing mechanism of feed-in tariff of nuclear power

The power generation cost of nuclear power is analyzed in details: investment and construction cost accounts for about 64%, including construction loan interest; fuel cost accounts for 21%; operation and maintenance cost accounts for 15%. [9] This generation cost of nuclear power is shown in Figure 1.

![Figure 1: The power generation cost of nuclear power](image)

Nuclear power technology itself is still in the stage of renewal and development, and the costs of different technology routes are quite different. With the particularity of costs of nuclear power, the cost of fuel disposal and decommissioning is mandatory, and the development of nuclear energy still needs to invest more energy. Among the fuel costs, nuclear fuel is about 1/3 of coal and 1/5 of natural gas, which is also one of the main factors for investors to invest in nuclear energy. [10] Another factor for investors to invest in nuclear energy is the relatively low cost of operation and maintenance. The cost of operation and maintenance, exclude the fuel costs, accounts for about 1% of the cost of power generation, which is easily neglected. Operation and maintenance costs are mostly fixed costs, and will not change significantly with the increase of power generation. But investment in nuclear energy is relatively high in spent fuel disposal and decommissioning. The decommissioning cost of nuclear power is generally included in the investment and construction cost, which means that after the operation period of nuclear power expires, the capital is needed to ensure the safety and reliability of nuclear reactor. This proportion is between 10% and 15% of the initial investment in nuclear power plants, which is currently 10% in China. [11] Spent fuel disposal costs are generally included in fuel
costs, including the storage and management costs of radioactive waste during the nuclear fuel reaction stage, and the storage and management costs of spent nuclear fuel after use. At present, the levy standard is about 0.027 RMB/kWh in China.

Pricing mechanism of feed-in tariff for nuclear power units is analyzed. At first, the domestic policy was based on the operating period electricity price policy, but with the gradual development of nuclear energy technology and the rising cost of controlling nuclear energy investment, the pricing of feed-in tariff for nuclear power in China is gradually shifting to benchmark electricity price policy. There are tens of thousand electricity prices in operation period. The price is defined according to the mode of “one-case-one-discussion, one-plant-one-price”, that is, according to the construction cost of electricity prices.

Later, nuclear energy gradually developed. In order to better control the investment cost of nuclear energy, the relevant documents, issued by Development and Reform Commission, clarifies the implementation of benchmarking tariff policy for nuclear energy. It requires that the national electricity tariff for benchmarking is 0.43 RMB/kWh, and the cost of fuel lower than the benchmarking in nuclear power implements the electricity tariff for benchmarking in nuclear power; that higher than the region, or been undertaken the introduction of nuclear energy technology, independent innovation and the first demonstration project of localization of major special equipment can be suitable improved on the basis of the electricity tariff for benchmarking in nuclear power. The promulgation of this policy is of great help to stimulate the domestic nuclear power industry to reduce costs and actively introduce new types of equipment. After the reform of electricity market, it is expected that the pricing mechanism of domestic market will be relatively perfect in 2020, and the price regulation mechanism will be basically sound. [12] At present, the on-grid tariff of nuclear power plants for local power transactions is based on the protection of internal electricity, and the two parts of the protection of external electricity are realized.

4. Main problems and solutions of nuclear power in direct electricity transaction

4.1. Electricity scale should be combined with planning of energy development and requirements of supply-side reform.

The direct completion of transactions by large users is still in its infancy, limited by many factors such as resources and system, and the transactions can not be fully opened. Therefore, it is still necessary to reform the access mechanism of the main transaction entities, push nuclear power to power users and power generation enterprises to ensure the smooth completion of direct transactions. The scale of power construction and economic development of each city are different, and the access conditions for power generation enterprises and power enterprises are also different. Power generation enterprises and power users need not only to meet the national requirements of energy-saving and emission reduction, but also to comply with the relevant measures of local industrial policies. In The electric power development planning "in 13th Five-Year" (2016-2020), it is clearly pointed out that non-fossil energy consumption needs to be increased to 15% in 2020, and the installed power generation should be controlled around 770 million KW, accounting for 39%. At the end of 2017, the total installed thermal power units in China still accounted for about 60% of the total, so the current domestic energy structure adjustment is imperative and has a long way to go. Under such circumstances, the profit margin of high-emission power generation enterprises can be compressed by means of electricity market, which can reduce the enthusiasm of power generation, realize the adjustment of energy structure and better control the emission of carbon dioxide. Low-emission power generation enterprises, represented by nuclear power and water potential, can appropriately reduce the intensity of nuclear energy in direct electricity trading, realize electricity sales in the form of auxiliary services, and encourage the enthusiasm of power generation, so that the whole energy structure will be cleaner and lower carbon.

4.2. There is a lack of rationality in the unified pricing of nuclear power and thermal power.

The pricing mechanism mainly considers the management of transaction price, transmission and distribution price and auxiliary expenses, taxation, and the pricing mechanism of transaction price has
a direct impact on the success or failure of direct electricity trading. The power generation costs of different power sources vary widely, and nuclear power and thermal power are particularly obvious. The fixed cost of the former is about 80% and the variable cost is about 20%. But the fixed cost of the latter is about 30%, and the remaining 70% can be recorded as variable cost. Therefore, if the nuclear power grid on-grid price and the coal-fired benchmark on-grid price are linked in a one-size-fits-all manner, there is a lack of rationality in direct power trading.

4.3. External cost factors and calculation basis of nuclear power unit

The external cost factor is mainly the incidental cost incurred during the production or consumption phase, but it has not paid the price for this. Environmental pollution cost is a typical representative. In the development of nuclear energy, waste treatment, spent fuel treatment, and nuclear equipment decommissioning are all calculated as power generation costs. With reference to the experience of Europe and the United States, the external cost of nuclear power is the lowest, and the external cost of coal-fired power is about 10 times than that of nuclear power.\[13\]-\[14\] When the EPA is currently managing coal, it is relatively inadequate in terms of environmental costs. The environmental value of clean energy is not fully incorporated into the price mechanism, which can easily distort the price mechanism and price distortion. There are drawbacks to the concept of energy conservation and emission reduction and the development of clean energy. External cost factors are not considered in the existing pricing mechanism.

The participation of direct electricity trading in nuclear energy is based on the unified pricing of local authorities, and there is no standardized calculation. However, in fact, taking a province with the highest proportion of nuclear power generation as an example, its theoretical value of nuclear power supportive absorption in 2016 is 7221 h, and its participation in direct electricity trading after landing is 1.847 billion kWh, which is far above policy that the actual power required by Provincial Party Committee is 7.3 billion kWh.\[15\] If the calculation of quantity of nuclear energy has better basis, and can better realize the overall transaction. In fact, the National Energy Administration has issued the document "Interim Method for Ensuring Nuclear Power Safety", which requires the priority generation rights plan to be determined by the multiple of the average hours of the previous year of the power generation equipment located at more than 6000 kW.\[16\] The multiple is planned based on the average utilization hours of the country in the previous three years. Such a model also has some drawbacks. It can integrate the average utilization hours of the whole country, and then make more flexible electricity consumption according to the actual needs of the enterprises and the background of the large market based on the local planning in the current year.

5. Conclusion

Nuclear power can be used in national defense and scientific research. It is also a vital power supply in China, and is a Chinese card in the construction of the whole area, and it is also a sign of the degree of industrialization and modernization in China. Based on the differences of R&D cost, input cost and pricing mode of nuclear energy and traditional power, local governments should fully integrate the cost and actual operation mode of quantity and feed-in tariff in direct trade about nuclear power, and formulate more reasonable and different principles from traditional fossil fuels under national policies.

6. References

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