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Research on compensation mechanism for inter-provincial renewable energy trading based on power generation rights

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Abstract. In China, the distribution of energy supply and demand is reversed. Besides, significant differences in energy resources and economic development level among regions and rapid development of renewable energy have been observed. Thus the energy allocation must be coordinated nationwide. In recent years, the power trading among provinces has been increasing. While promoting optimal allocation of resources, inter-provincial power trading brings adjustment of the interests of different provinces and participants. Based on the current situation of power generation right trading in China, this paper analyses the interest demands of different participants of inter-provincial power trading, and designs the inter-provincial trading compensation mechanism based on power generation right. The research can realize the interest adjustment of different participants in inter-provincial power transactions and is beneficial for the full utilization of renewable energy resources through large scale power trading.

1. Power generation rights trading status

1.1 Provincial power generation rights trading status

1.1.1 Trading participants. The main participants of power generation right transaction are usually divided into the seller party and the buyer party. The seller party mainly includes two aspects. The first is unit that has been shut down by the state. According to the relevant provisions of the state, units included in the national small thermal power unit shutdown plan or shut down ahead of schedule can enjoy power generation indicators within the specified period in accordance with the relevant provisions. They can trade in paid alternatives to electricity generation. The second is small-capacity unit. According to the transaction rules, some provinces require units with a capacity of less than a certain scale to participate in the substitution transaction of power generation right as the seller party, and encourage other units to participate in the transaction. The substitution mainly includes two kinds of transaction. The first is between thermal power generators. Inefficient and high-emission thermal power generating units are substituted by efficient and environment-friendly thermal power generating units. The second is between hydro and thermal generators. Generation from thermal power units are substituted by hydropower, wind power, photovoltaic or other clean energy units.

1.1.2 Mode of transaction. Substitution power generation mainly includes two forms: internal substitution within a power generation enterprise and external substitution of different power generation enterprises. Substitution generation within a power generation enterprise refers to the



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generation of units within the same power plant or within the same power generation group. The enterprise itself optimizes and adjusts the operation mode of internal units. The external alternative power generation of power generation enterprises refers to the power plants of different power generation enterprises or power generation groups. It is usually organized by the trading center to replace the transaction of power generation rights. The modes of transaction include bilateral and centralized transaction. Among them, centralized trading is divided into centralized listing trading, centralized bidding trading.

1.1.3 Transaction cycles. Provincial power generation rights trading mainly includes annual, quarterly, monthly, weekly and above weekly medium - and short-term transactions.

1.1.4 Settlement method. From the perspective of settlement cycle, there are mainly two ways: monthly settlement monthly clearing, and monthly settlement annual clearing. From the perspective of settlement order, it is clear in some provincial rules that the generation rights trading takes precedence over the planned electricity and other trading electricity settlement. From the perspective of network loss compensation, the network loss can be borne by the seller party, by the buyer party or shared by both parties in proportion.

1.2 Inter-provincial power generation rights trading status

Inter-provincial (regional) generation right transactions are mainly organized between renewable and thermal power generation. This trade refers to renewable generators in Province A trading with thermal generators in Province B through market-oriented way across the province (regional) to purchase power generating capacity index, where thermal power in Province A has been reduced to minimum operation mode but still faces that risk of wind curtailment, and thermal power in Province B have trading willingness and space.

1.2.1 The northwest region. In 2014, Northwest Power Grid Corporation issued the "Interim measures for cross-provincial replacement of renewable and thermal power generation rights of northwest power grid". In 2014, cross-provincial generation right replacement transaction of wind power in Gansu province and thermal power in Shanxi province amounted to 50.75 million kWh. In this trading, Gansu new energy enterprises reduced wind curtailment by 50.75 million kWh, and Shanxi reduced carbon dioxide emissions by 45,000 tons and standard coal by 17,000 tons. It opens up a new way for renewable energy consumption in northwest China.

1.2.2 The eastern region. In November 2016, the Shanghai Development and Reform Commission and the Economic and Information Technology Commission approved the work plan of cross-regional and cross-provincial power generation rights trading in Shanghai and the rules of cross-regional and cross-provincial power generation rights trading in Shanghai. In December 2016, Shanghai and Ningxia completed the first cross-regional and cross-provincial power generation right centralized bidding transaction through the national unified power trading platform. Shanghai coal-fired power generation were replaced by Ningxia renewable energy power generation in this transaction, and the final transaction volume was 69,564 megawatt hours (Shanghai side landing power). It can save 20,200 tons of standard coal, 52,500 tons of carbon dioxide and 404.12 tons of sulfur dioxide.

1.2.3 The southern region. On June 20, 2017, Guangzhou power trading center carried out the first cross-provincial power generation right trading in the southern region. Guangdong has 49 power generation enterprises and Yunnan has 14 hydropower enterprises. In the transaction, 15 enterprises on the Guangdong side participated in the bidding, and 13 enterprises on the Yunnan side made biddings. The transaction volume of this transaction is only 24 million kWh, and the electricity price is 0.358 Yuan/kWh.

2. Analysis of the interests of various subjects in inter-provincial transactions

Inter-provincial transaction involves many subjects, which is essentially the interest adjustment between different market participants and different governments. Due to the relatively loose supply and demand of power in most provinces, there is a serious oversupply in some renewable-rich provinces. In this analysis, it is assumed that the sum of the on-grid price of the delivery port and the transmission price across the province is lower than the benchmark generation price of receiving province.

2.1 Analysis of the interests of market entities in the sending province

For power generation enterprises in the sending province, the main purpose of participating in inter-provincial transactions is to increase the hours of power generation utilization, avoid wind and solar curtailment, and thus improve economic benefits. Except for the power generation of state mandatory plan or supporting auxiliary power supply, the opportunity cost of the other power generation enterprises to send out electricity is low, so they usually participate in the provincial power transactions with a relatively low price.

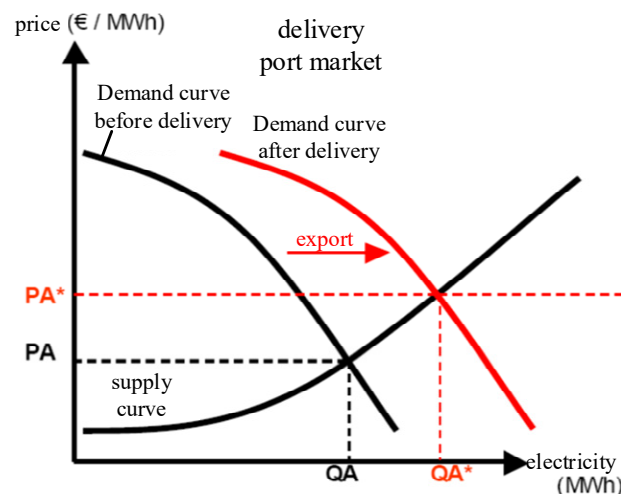


Figure 1 Changes in the sending market before and after participating in inter-provincial transactions

Since currently the power supply exceeds the demand seriously, the impact for power users and power selling enterprises in the sending province is less significant. However, with the increase in the proportion of liberalized users, under the condition of relatively balanced market supply and demand, inter-provincial power transmission will push up the purchase price of local users to some extent. Its specific principle is shown in Figure 1.

For the local governments in the sending province, they hope to promote the export of surplus local power and make full utilization of renewable energy through inter-provincial transactions. The transaction helps improving the hours of power generation of local units, alleviating the balance pressure of local electric power and the contradiction of wind and solar curtailment.

2.2 Analysis of the interests of the market entities in the receiving provinces

To some extent, power supply from outside the province occupies the generation space of the generation enterprises (especially thermal power enterprises) in the receiving provinces, which leads to the decrease of generation utilization hours and operating income of the receiving generation enterprises. In addition, with the increase in the proportion of the inter-provincial renewable sources, the generation enterprises in receiving provinces may need to provide peak-regulating ancillary services for the sending renewable energy sources.

Since the marginal cost of external power supply is generally lower than local units, power purchase cost for power users in the receiving provinces will be reduced during the inter-provincial

transaction. Thereby the production cost of the enterprises can be reduced and operation efficiency can be improved.

The receiving provincial government needs to weigh the interests of generation enterprises and power users in this province at the same time, and determine the trading quantity and price between provinces through negotiation with the sending provincial government.

3. Design of compensation mechanism for inter-provincial transaction participants based on the generation right transaction

3.1 Design idea

While promoting the optimal allocation of large-scale resources, inter-provincial transaction forms the adjustment of interests among market subjects and between provinces. Therefore, it is urgent to establish an inter-provincial transaction benefit compensation mechanism. The benefits generated by inter-provincial transactions are distributed by the sending and receiving provinces through negotiation (or according to the compulsory proportion), which compensate the losses of the receiving provinces, enhance the government's willingness to accept inter-provincial power transmission, further break down barriers between provinces, and promote the further expansion of the scale of inter-provincial transactions.

As shown in Figure 2, the inter-provincial trading price mainly consists of two parts: generation price of the sending province and the inter-provincial trans-regional transmission price. There will be a spread space between the trading price and the benchmark price of the receiving province. Based on the analysis of the interests of the market subjects in the provinces, it is necessary to establish a mechanism to compensate the interests of the receiving generation enterprises, power users, power grid enterprises and local governments.

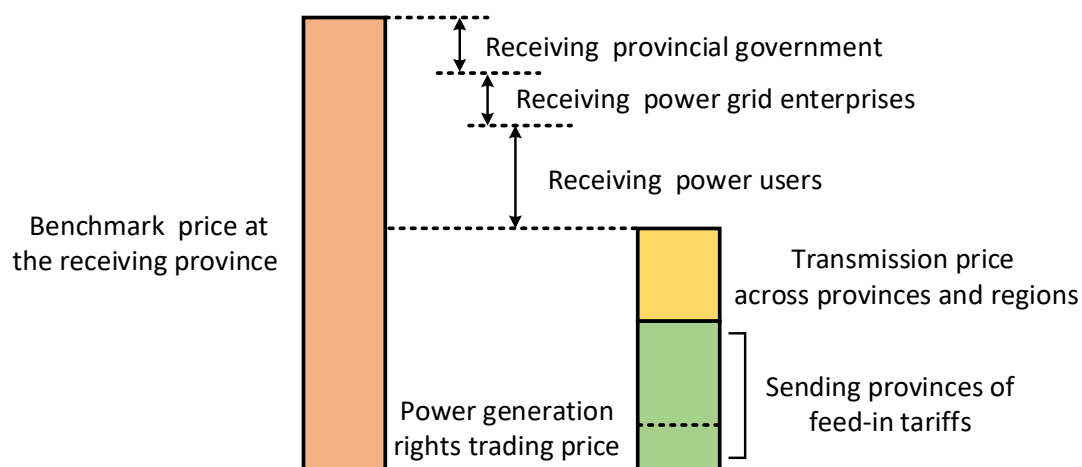


Figure 2 Allocation method for inter-provincial transaction price reduction space

Compensation to the receiving generation enterprises can be carried out by means of marketization mode to carry out inter-provincial generation rights transactions, and the receiving generation enterprises will transfer the generation indicators to the sending generation enterprises to obtain certain economic compensation. The compensation for power users, power grid enterprises and local governments mainly comes from the price reduction space formed between the benchmark price of receiving province and the inter-provincial transaction price. The distribution of the price reduction benefit to the power users is mainly to reduce the electric cost in the real economy of the receiving province. A part of the price reduction benefit is distributed to local governments, mainly to compensate the affected provinces in terms of taxation and other aspects. In addition, part of the compensation will be made to power grid enterprises, mainly to compensate for the increased costs of network losses, ancillary services and general service costs.

3.2 Recent trading mechanism

Recently, it is possible to compensate the receiving generation enterprises, power grid enterprises, local governments, etc. by means of inter-provincial generation rights transactions and fixed proportion distribution of price reduction benefit. The inter-provincial generation rights transactions is mainly carried out between the thermal power enterprises in the receiving province and the hydropower and renewable energy enterprises in the sending province. The transaction mode can adopt centralized bidding transactions or bilateral negotiation transactions, and the price mechanism can choose the high and low matching method or the unified clearing method.

The price reduction benefit distribution mechanism for inter-provincial transaction needs to consider the inter-provincial transaction mode. Under the two modes of inter-provincial power direct transaction and inter-provincial transaction with power grid company as agency, different settlement modes are adopted, and the proportion of compensation to local governments and grid enterprises can generally be a fixed proportion, which can be agreed by the sending and receiving provinces in advance. A renewable energy quota trading mechanism can be implemented in order to encourage generation enterprises to take an active part in inter-provincial transactions.

3.2.1 Distribution mechanism under the inter-provincial power direct transaction mode. Inter-provincial power direct transactions refer to the way in which the receiving power users directly participate in inter-provincial transactions. In this way, the purchase price of the power users (power sale enterprises) in the direct transaction between provinces consists of market transaction price, transmission price, transmission loss and compensation cost.

3.2.2 Distribution mechanism under the inter-provincial transaction with power grid company as agency mode. This mode refers to the inter-provincial power transactions in which the power grid enterprises act as the agency for power users in the receiving province. In this way, there will be a price difference between the purchase price of power grid enterprises and the price of end users, for which the distribution proportion can be determined by receiving provincial government, and distributed among the government, users and power grid enterprises.

3.3 Medium and long-term trading mechanism

With the liberalization of power generation plan, power generation plan of the thermal power enterprises gradually turns to the medium and long-term contracts, and the generation rights transaction will gradually evolve into the power generation contract transfer and replacement transaction, and gradually become financial transaction. At the same time, the implementation of the province-based renewable energy quota trading mechanism can further enhance the provincial government's willingness to participate in inter-provincial renewable energy trading and promote the large-scale consumption of renewable energy.

4. Conclusion

In recent years, the scale of inter-provincial transactions in China has been increasing year by year, but the problem of inter-provincial trading barriers is still prominent. In order to enhance the government's willingness to accept inter-provincial electricity transmission and further promote the further expansion of inter-provincial transaction scale, this paper designs an inter-provincial transaction benefit compensation mechanism based on generation rights. Recently, the generation enterprises, power grid enterprises and local governments in receiving provinces can be compensated by conducting inter-provincial generation rights transactions and distributing the price reduction benefits in a fixed proportion. In the future, the generation rights trading will gradually evolve into power contract transfer and replacement transactions, and gradually become financial transaction, which will be incorporated into China's power financial market system.

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