Medium- And Long-term Power Curve Division Mechanism Based on Energy Block Segmentation

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Abstract. With the development of electric power system reform, it is very important to design the medium- and long-term curve division mechanism for electric power in China. The essence of power supply is "continuous" energy block supply. The two sides of supply and demand take the power block as the interactive unit agreement to deal with electricity. The model of medium- and long-term curve division based on energy block can reflect the abundance of electric power, be beneficial to the stable and reliable supply of electric power and effectively reduce the loss of auxiliary service. Based on the development of new power systems at home and abroad, this paper designs the power curve division mechanism based on energy blocks, and takes Qinghai Province as an example to study its medium - and long-term power curve division mechanism with high proportion of renewable energy.

1. Introduction

The state has been committed to promoting the reform of electricity market and deepening the construction of this market. As an important part of the electricity market, the medium and long term electricity market has been one of the core tasks of power reform as early as 2017. The direction of medium and long term electricity market during “The Fourteenth Five-Year Plan” is determined by the Basic Rules of Medium And Long Term Electricity Trading issued by the National Development and Reform Commission and the National Energy Administration in June 2020, meanwhile, the medium and long term electricity trading mode is also guided and regulated by this document. The research on medium- and long-term electricity trading has achieved preliminary results at home and abroad, but in our country, the mode of medium- and long-term electricity trading is not mature, especially areas that are connected with electric power spot market need to be further explored. It has important practical significance to explore the practice of medium and long-term power mode in specific province combined with previous research under the background of the promulgation of the new edition of Basic rules of medium- and long-term electricity trading.

First, this paper introduces typical electricity market models at home and abroad, in the foreign electricity markets, taking the American PJM market and the UK electricity market for example, collaborative mechanism of the foreign medium and long term market and spot market in terms of electric quantity and electric power is analyzed [1, 2]. In domestic markets, medium- and long-term electricity market modes of Guangdong and Sichuan Province are taken for examples, giving a realistic
basis for providing strategy of curve trading in medium-and long-term market adapted to Qinghai province according to the characteristics of Qinghai Province. Second, the medium- and long-term electricity curve trading mechanism is introduced. Finally, taking Qinghai Province as the application object, application strategy of medium- and long-term curve trading in Qinghai Province is proposed according to the actual energy distribution and consumption in Qinghai Province.

2. Power market model at home and abroad

2.1. Typical power market in foreign countries

2.1.1. The American PJM market.
In the American PJM market, the connection between medium and long-term electricity market and spot market is mainly reflected in the level of market members and dispatching operation:

To ensure the reliability of real-time operation, PJM needs to determine the unit combination scheme in advance and make the unit start-up and shutdown plan in advance. Different from the day ahead market trading, the unit commitment scheme is the result of physical clearing and must be implemented. After the day ahead market is cleared, PJM optimizes the next day's start-up and shutdown plan according to the latest load forecasting results and the quotation of day ahead market entities (start-up and shutdown cost and fuel cost).

In addition, there are week ahead reliability unit combination and hour reliability unit combination. The week ahead reliability unit combination runs once a day, and the study interval is 7 days after the next day. This unit combination is generally used to help the units with long auxiliary start-up time and unable to complete the start-up and shutdown within 24 hours of the day ahead unit combination to make the start-up and shutdown plan. The hourly reliability unit commitment operates once an hour. According to the latest situation of the system, the day ahead reliability unit combination is adjusted to cope with the special conditions such as Reserve shortage caused by load change and power generation change. Under normal circumstances, the daily unit commitment plan will not be changed.

2.1.2. The UK electricity market.
At present, in the UK, there are two electricity exchanges trading in spot electricity market, EPEX SPOT and N2EX, varieties of transactions improved by them are very familiar. Taking EPEX SPOT exchange as an example, this paper introduces two types of spot electricity trading: auction trading and rolling trading.

The market clearing mechanism of spot electricity trading in UK is relatively simple, both the operation constraints of units and the security constraints of power grid are not considered. On the surface, it seems like that complex electricity trading has been simplified to be as simple as buying and selling ordinary commodities such as cabbage and potatoes, so there can be multiple spot electricity exchanges competing with each other; However, in fact, in the UK spot electricity market, there are many kinds of transaction and flexible quotation, closely consistent with the characteristics of power load and power production and operation and fully embodies the unique attribute of electric power commodity.

2.2. Typical power market in domestic countries

The national development and Reform Commission and the State Energy Administration issued the notice on carrying out the pilot work of electric power spot market construction in August 2017. Combined with conditions such as power supply and demand situation, network source structure and marketization degree, eight regions, including southern China (starting from Guangdong), western Inner Mongolia, Zhejiang, Shanxi, Shandong, Fujian, Sichuan and Gansu, were selected to carry out spot electric power pilot projects.

2.2.1. Guangdong.
There are two kinds of trade mode in Guangdong, one is wholesale trade, the other is retail trade. The structure of Guangdong power wholesale market is "electric energy market plus
auxiliary service market”. The electric energy market includes medium and long term electricity market based on price difference contract and spot electricity market with full capacity bidding; The auxiliary service market includes FM auxiliary service market with centralized bidding, and auxiliary service compensation mechanisms such as reserve, paid reactive power regulation, automatic voltage control and black start.

The medium and long-term electricity market is based on the price difference contract, which has financial settlement significance and does not need physical execution. The spot electricity market includes day ahead market and real-time market. Spot electricity market includes day ahead market and real-time market. The unit start-up combination, time-sharing generation output curve and time-sharing spot energy market price are obtained by means of full power declaration and centralized optimization clearing.

2.2.2. Sichuan. Sichuan electric power market transaction can be divided into inter provincial transaction and intra provincial transaction market according to the scope of market allocation resources. Inter provincial transactions are organized by Beijing Trading Center and National survey center and intra provincial transactions are organized by Sichuan electric power trading center and Sichuan survey center. Medium and long term trading is used to promote clean energy consumption and implement industrial policies in the province, to form a stable market supply and demand, and to help market players avoid price risk; The spot market is used to reduce the deviation between long-term trading and actual supply and demand. The market participants should adopt the market mode that medium and long-term trading as the main part and spot trading as the supplement.

3. The medium and long term electricity curve trading mechanism

3.1. Trading mechanism

Since the production and use of electric energy have time continuity, the goods sold or purchased are "energy blocks" with a certain duration as shown in Figure 1, no matter for power producers or power loads. Therefore, only by adding the time dimension of power commodity (power curve) and considering the time dynamic characteristics of power curve can we accurately measure the quality of power commodity (the homogeneity of electric energy in physics is not contradictory to the heterogeneity of power commodity in economics, the latter is mainly used for pricing of commercial products)[3]. The transaction process of electricity market is to fill the area under the load curve with different (horizontal or vertical) "energy blocks" to realize the balance of electric quantity and power. Prices with different connotations will also be formed during this process, as shown in Figure 2.

Pure electric quantity trading is a unique trading mode in China's power market. There is almost no such curve mechanism without power in foreign electric market. In our country, Pure electric quantity trading mostly occurs in the spot market. For this reason, this paper focuses on trading ways of the curve in the medium and long term market.

![Figure 1. Continuous time power commodity model.](image-url)
3.2. Trade mode

3.2.1. Bilateral transaction (transshipment mechanism). "Transshipment" is defined as "to use the utility company's transmission facilities to transfer electricity to other buyers and sellers". For example, when power company C purchases electricity from power company A, they are not directly interconnected, power company B owns transmission facilities between A and C. Therefore, the power that A sells to C must be transmitted through B. In other words, electricity is transferred through B. This kind of transaction is completed through the coordination among supply side, demand side and one or more intermediate transportation systems [4].

Mechanisms of transshipment pricing can be divided into participation pricing and micro incremental pricing. Ways of participation pricing are as follows: stamp method, contract path method, equipment by equipment method (also called line by line calculation method), power mileage method (including power mileage method based on distance, power mileage method based on power flow, and compact power mileage method), general protocol of parallel flow, kilometer power flow method (also called boundary power flow method). Ways of micro incremental pricing are as follows: Investment cost correlation analysis method, short-term micro incremental cost pricing, long-term micro incremental cost pricing, short-term marginal cost pricing, long-term marginal cost pricing. Power network has its own unique particularity. algorithms based on power flow analysis are as follows: Current decomposition axiom, mathematical model of network loss allocation, mathematical model of transmission equipment utilization allocation, graph theory method.

3.2.2. Centralized economy (block bidding). The essence of centralized bidding transaction is a multilateral transaction, which needs to be based on "standardized products" (otherwise it can not be bid on the unified platform), and the load curve can not be customized. A crude way is to only bid for electric quantity [5, 6]. Centralized bidding is encouraged to be done based on peak, flat and valley electric quantity(or according to standard load curve) by the Basic rules for medium and long term electricity trading (provisional) issued by the National Development and Reform Commission and the State Energy Administration on December 29, 2016. It is difficult to implement centralized bidding according to the standard load curve, because customers in different industries have different typical load curves. Block bidding (or horizontal auction) can be introduced. At first, the load is roughly divided into base charge energy, waist charge energy and peak charge energy to bid separately. Then with the development of the market, the load is divided into several load blocks (energy blocks) according to the load duration. According to different load section electric energy, centralized bidding transactions are completed.

3.2.3. Continues trading-UK model. Mechanism of medium and long-term bilateral transactions is the main trading mechanism in UK electric market. The physically delivered generation and consumption planning curve is formed and submitted to the balancing mechanism as the basis for incremental settlement. The medium and long-term trading mainly refers to the electricity trading more than one day in advance. In UK market, medium and long term transactions account for about 72% of all transactions,
all medium and long term contracts are physically executed. There are two electric exchanges named N2EX and APX. Centralized trading is carried out in electric exchange, including three sub-markets: Day-Ahead Auction, Spot Market and Prompt Market, the latter two are collectively referred to as Continuous Market.

Prompt Market is a continuous trading market, transactions can be made seven days before the transmission hours, all quotations are matched by the trading system. Prompt Market of APX mainly includes base and peak load electric quantity, weekend power consumption, combined power supply, and has seven kinds of pricing. For example, if a member chooses peak load quotation, the transmission period is from 7:00 to 19:00, a total of 12 hours, the quotation can be submitted at any time within 7 days before the start of power transmission period.

The spot market is opened 48 hours before the power transmission, and continuous trading can be carried out. At first market members submit quotations (including the competition price and the bidding), then all quotations are sorted and matched by the system according to the order (first according to the quotation price, if the prices are the same, the quotation submitted first), all successfully matched quotations are cleared automatically. If the quotation submitted by a member is not matched, the member can modify or cancel the quotation. Trading periods of N2EX can be divided into ten kinds, such as half an hour, one hour, four hours, etc. For each trading period, quotations can be submitted from zero of the day before the trading period, and the quotation cannot be submitted again about an hour before the trading period.

4. Electric curve trading strategy in Qinghai Province

4.1. Analysis on the characteristics of Qinghai electric power market

Qinghai’s new energy sources are developing rapidly, such as photovoltaic and wind power, especially photovoltaic, it has unique development advantages. Thanks to the national energy development policy and provincial government incentive mechanism, since 2011, photovoltaic has been developing rapidly with a capacity of 1 million kilowatts per year.

From January to September of 2019, the on grid photovoltaic energy is 11.916 billion kwh, the utilization hours of power generation is 1151 hours, and the discarded photovoltaic capacity is 733 million kwh; As to the wind power, the on grid power generation capacity is 5.128 billion kwh, the utilization hours of power generation is 1428 hours, and the abandoned wind power is 82 million kwh. The total amount of delivered new energy power is 6.574 billion kWh (including 449 million kwh of spot trading), accounting for 38.6% of the on grid electricity.

However, the development of power load in Qinghai Province is so slow that it is impossible to realize the local consumption of all new energy. Therefore, it is necessary to make the new energy consumed in a wider range by market-oriented means.

It is in line with the guidelines and policies of the national power system reform to do works as follows: 1, to study the medium and long-term trading mode; 2, to establish a mode with medium and long-term trading as the main and spot trading as the supplement; 3, to encourage power generation enterprises, power users, electricity sellers to carry out electricity trading through competition. These three tasks provide an important theoretical basis for building a perfect electricity market.

4.2. Electric curve trading strategy in Qinghai Province

Firstly, the annual transaction is decomposed according to the annual peak, valley, and average trading period, in different time segments, transaction contracts with different electricity prices can be signed by supply and demand sides; Secondly, the monthly transaction period is divided into multiple node periods according to the monthly "24 points", and the supply and demand sides sign trading contracts of different segment electricity price; Thirdly, the short-term trading within the week is decomposed into different periods of time and different electricity transactions, in this way, the trading period and scheme are further refined. The trading periods of electric power and electric quantity are enough, and the scheme is detailed enough and very similar to the physical electricity curve; Finally, segmented
electricity trading, such as daytime "48 points", can be further promoted and the final load deviation replenishment will be completed in the spot electricity market.

In this form, the medium and long term power contracts help both parties to avoid spot risks, restore the value curve of electricity, and at the same time, fit the curve changes of power price and power value to the maximum extent. Meanwhile, short term trading can fit the volatility and randomness of new energy generation, compared with spot trading, short term trading can reduce rigidity and tap greater regulation capacity. Medium and long-term curve trading that can be linked with spot can promote new energy consumption and reflect the space-time value of rapid regulation ability.

5. Conclusion
Based on the typical power market models at home and abroad, this paper first summarizes and analyses the operation of foreign power market and the construction of domestic power market. Then the trading mechanism and trading mode of medium and long-term electricity trading are studied after absorbing the development experience at home and abroad. Finally the strategy of curve trading is proposed for Qinghai to fit the characteristics of power supply with high proportion of renewable energy in Qinghai Power Market and to meet the load consumption demand of clean energy.

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References
[1] Zhang Xian, SHI Lianjun. Future Research Direction and Key Technologies of China's power market [J/OL]. Power System Automation :1-11 [2020-07-03].
[2] Xu zhe, huang xiaoting, Chen wei. Electricity segmentation model and electricity price scheme design based on transaction curve [J]. China southern power grid technology,2020,14(03):71-78.
[3] Song sibo, guo hongxia, Yang ping, lu zhilin, xu zhirong, he ting. Research on power market division strategy based on node marginal price [J]. Electric power construction, 2017, 38(09): 132-138.
[4] Liu Fang, Yan Cuihui, CUI Hui, Pan Yi. Research on modeling Methods of different types of Bilateral Transactions [J]. Electric Power Construction, 2008, 39(05): 130-137.
[5] Jing zhaoxia, zhu jisong. Simulation experiment analysis of monthly electricity centralized bidding market rules [J]. Power system automation,2017, 41(24): 42-48.
[6] Tian jin-yu, wang le. Research on trading strategies with load curve under medium and long term trading basic rules of power [J]. Power science and engineering,2019, 35(02): 7-13. J. van der Geer, J.A.J. Hanraads, R.A. Lupton, The art of writing a scientific article, J. Sci. Commun. 163 (2000) 51-59.