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Research on Evaluation Index System of Market Operation for Power Sale Market

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Abstract. With the deepening of the electricity market reform, electricity retail companies have sprung up across the country and the power sale market began to grow. However, the trading rules and operation mode of the power sale market in the initial stage of development are not sound, and the accumulated market experience is not sufficient. Therefore, how to make a reasonable evaluation of the market operation becomes an important and urgent problem. First, the architecture model of the competitive electricity market is studied. Then the trading mode of the competitive electricity market and the relationship and influence among the factors are analysed. Finally, the evaluation index system is constructed on the basis of market operation mode.

1. Introduction
The main purpose of China's power industry market reform is to break monopoly, improve efficiency and optimize resource allocation. With the introduction of market mechanism, the retail market of electric power becomes more competitive, which ensures the rights and interests of consumers. More importantly, through the price competition mechanism of the electric power retail market, power generation enterprises are forced to carry out production and operation according to the feedback price information, so as to achieve the goal of power market reform.

From the practice of power marketization reform in western developed countries, they all put the focus of reform on the selling side, because the reform of selling side marketization mainly needs perfect technical support system and complete regulation system. Compared with the benefit adjustment of the market reform of power generation side, the reform of power sales side is more feasible. For example, the UK changed from the power bank system to the retailer license system, and the US PJM power retail market reform; Australia introduced competition mechanism directly in the retail market. Norway, Sweden, Finland, Denmark and other northern European countries also started the competitive power retail market reform. Singapore in Asia has established a competitive electricity retail market, and from 2004 all households will be able to choose any power supplier.

In order to "break the monopoly, introduce competition, improve the efficiency, reduce the cost, improve the electricity price mechanism, optimize the allocation of resources, promote the development of power, promote the national networking, construct the electric power system reform overall goal of the government enterprise, fair competition, open order and healthy development under the supervision of the government”, China must conduct the market-oriented reform of the electricity selling side in
time, and establish the competitive power retail market, and achieve comprehensive and sufficient economic benefits through retail competition. In view of that success of the reform of the retail market, it must be guided by mature theory. Therefore, it is urgent to study the mode of China's competitive electric power retail market, and this is of guiding significance to the establishment of the electric power retail market.

Although there is a lot of literature on the operation evaluation of power market in China so far, which focuses on the power generation side, and the transaction rules and transaction modes of the power sale market in the initial stage of development are still not sound. On this basis, this paper studies the architecture model of the competitive electricity market and builds an evaluation index system on the basis of the market operation mode.

2. Competitive electricity market model

The model of China's competitive electricity market is established by establishing the sale channel of electricity commodities in which freely competitive is unlimited. The establishment of competitive electricity market is the ultimate goal of China's power market reform, and the competitiveness of the model is the key factor to the effectiveness of the model. In this model, the strength of competitiveness is mainly related to the autonomy of trading behaviors of market players, the selectivity of trading channels and the controllability of risks in trading.

The competitive electricity selling market model has different characteristics from the traditional electricity selling model:

Firstly, the service attribute of electric goods is fully reflected. On the premise of monopoly operation of power side, consumers' understanding of power commodities mostly starts from the physical characteristics of "electricity" without considering its service properties. When the competition mechanism is introduced in the power sale market and consumers have the option, the requirement of this service attribute becomes an important part of the competition in the power sale market. As a competitive commodity, power supply should include reliability, safety, timeliness and economy in addition to traditional physical indicators such as voltage and frequency. With the clarity of service attribute of electric power commodity, the product heterogeneity of electric power commodity has been paid more and more attention. This also provides a theoretical basis for power enterprises to create product differences and extend power supply services.

Secondly, users have the option to consume. Users can either buy power directly from an independent power plant or select a specific selling power company. Distribution companies can also compete as part of a retailer, but if the distribution company's retail price is not competitive, the user will choose another retailer because the user has the option. As a result, distribution companies no longer have monopoly rights over consumers, which is the biggest feature of the competitive electricity market.

Thirdly, the nature of the operation process has changed. In the model of competitive power selling, the traditional management has changed, and the power generation, distribution, transmission and distribution are all independent. Transmission is the logistics function, only responsible for the transmission of electricity and do not participate in transactions, and because the transmission network is related to national security, so government monopoly management; Distribution, like transmission, is charged for services provided to consumers.

Fourthly, the technical support system is simple and easy to operate. The realization of competitive electricity market does not need the centralized technical support system as the safeguard. In order to realize power supply to users, as a power supplier, we must have our own management software, which includes user management system, information release system, measurement system, contract management system and settlement system. Each terminal retail user can know the service items and prices of power suppliers in the market through various public media, and choose the most favorable service provider from which they can freely choose.
3. Formatting the text
In the market of selling electricity, the complicated market relationship formed by various market channels is the market model of retail competition. In the model, the specific relations among the elements are as follows.

3.1. Power generating enterprises
As a power producer, it is responsible for producing power commodities. They can either transmit power directly to the end user through the grid, or to the spot market, such as the power bank or the futures market, and then to the user through the power transaction middlemen.

3.2. Electricity retail companies
In a competitive retail sale model, the sale of the electricity dealer could be from the former power distribution company, or from a newly built company. In the market of selling electricity, the competition between selling e-commerce companies is not only in the price of the product offered, but also in the service of power supply. In the face of fierce competition, retailers will fluctuate in the service and management, through the adoption of improve the service content and service quality, reduce operating costs and other measures to keep the original users of the contract, and to explore new users of the contract. It is not possible to monopolize power supply by a single power supply or to a small number of retailers to handle retail price due to that large number of vendors. Retail electricity prices will gradually stabilize at a lower level as full competition among many power suppliers gets lower and lower.

3.3. Power users
Power users refer to all consumers who need to use electric energy, including individuals, families, enterprises and institutions. In a competitive selling electric market model, a wide range of resident users have also obtained a consumer option by selecting a seller of electricity, which is of the epoch-making significance for the competitive electricity market competition.

3.4. Electricity trading market
In the futures market of electric power, both parties trade futures through the futures exchange by means of public bidding or computer matching. In this type of trading mode, the power consumer would be able to voluntarily adjust their respective power demands, which would allow the price elasticity to be introduced, which would allow the price elasticity to be introduced to the side of the load, which would allow the power to be used on the side of the power line to accept the result of the power of the electric power, but also to weaken the power of the power grid to control the power price. Therefore, the price of power futures can better reflect the actual value of power commodities. In addition, in the competitive electricity market model, the market power of the system dispatch center will be limited.

In the existing transaction mode, as the system dispatch center is responsible for the security of the power system while participating in the formulation of the power transaction plan, the system dispatch center has the absolute right to intervene in the trading plan, while the power traders lack the means to actively adjust the trading plan. However, in the futures trading of the new model, the system dispatch center does not participate in the futures trading. Its impact on the futures trading is only to decide the delivery plan of the futures in the market where the futures and the spot cooperate, but does not affect the hedging behavior of the two parties of the futures trading. Therefore, the system dispatch center no longer has the decisive ability to intervene in the electricity trading behavior, and no longer has the status above both sides of the electricity trading. Futures trading and spot trading are the inevitable trend of the development of China's power sale market, which not only makes the market more commercial, but also makes China's power sale market more secure in risk prevention.
3.5. Trading channels
One of the primary problems of competition in the electric distribution market is to break the monopoly of power distribution companies in their exclusive distribution areas. Only when the distribution network is open can it be possible to provide electricity transfer service. In the traditional vertically integrated monopoly model, the transaction of electricity is along the "power-generation-power-distribution-power-supply" channel, finally reaching the user. Such a trading channel is the basic transaction channel that exists in the production of electricity industry, in which the user is actually in a non-standard or disadvantaged position. In a competitive selling electricity market model, due to relax banned the sale of electricity, so the commodity trading channels is also a variety of more auspicious.

There are three trading channels in the competitive electricity market:

Firstly, the traditional channel, namely "power generation - distribution - retail - user" mode. This channel evolved from the traditional "distribution, transmission, distribution and sale" channel, in which the traditional distribution function is divided into two businesses: power grid and non-power grid. The power grid business, together with the transmission of power transmission, only serves as a tool for the transmission of power commodities and no longer participates in the channel as a market subject. In this channel, the electricity generated by the power generation enterprise enters the power bank through the transmission network, while the selling e-commerce enterprise selects the appropriate power distributors through the grid or directly purchases power from the power bank and sells it to the terminal power users. Because of the large number of retailers, users have the right to select retailers.

Secondly, distribution channel, namely "power generation - retail - user" mode. In this channel, the functions of the power bank gradually deteriorate, and the e-commerce sellers can purchase the required power directly from the power generators according to the power sales plan and then sell it to the end users. Compared with the traditional channels, the transaction is more efficient because the distribution channels are omitted. In this kind of channel, the commercial function of the distribution company is weaker, has completely withdrawn from the sales competition and only assumes the responsibility of grid maintenance.

Thirdly, direct sales channel, namely "power generation - user" mode. This kind of channel, because trade link is less, accordingly more efficiency, also be helpful for reducing trade charge. In view of that development of electric power market in China at the present stage, the direct sale can only be directed to large users, while the ordinary resident users also do not have the condition to purchase electricity directly from the power plant. However, with the establishment and development of China's competitive electricity market, it is inevitable that all users can purchase electricity directly from power generators.

In summary, in a competitive sales market, a user of electricity can both obtain electricity supply from a sale of electricity and purchase directly from a power generation company. A variety of sales channels fully guarantee consumers' choice of consumption and fully reflect the competitiveness of the market.

4. Construction of evaluation index system for sales marketing operation evaluation
From the perspective of data source analysis, market structure, market performance, market prosperity degree and market welfare, and combining the overall structure and operation mode of the competitive selling electricity market, a market operation evaluation index system applicable to and competitive selling electricity market is constructed.

| Evaluation theme | Evaluation index | Function |
|------------------|------------------|----------|
| 1. Market structure | 1) HHI index  | Reflect the possibility of the abuse of monopoly power in the market |
|                   | 2) Top-m         | Reflect market concentration |
3) **Gini coefficient**

Reflect market concentration

2) Market performance

1) The ratio between the rate of change of the transaction price and the rate of change of the electricity coal price

2) Time series of total social electricity consumption

3) Market generator quantity time series

3) The number of the main bodies of electricity selling bodies time series

4) Market user number time series

5) Electricity consumption of users in the secondary industry time series

6) Electricity consumption in the tertiary industry time series

4) Welfare index

1) The difference of electricity price

2) Price differential change ratio

3) Correlation analysis

Calculate the impact of the correlation analysis on the power change

4.1. **Market structure**

Well, the HHI's is largely based on the size of the market and the size of the market, and the smaller the market, the more concentrated the market, and the bigger the HHI, the greater the probability that it would be that the market would be abused. Where $s_i$ is the market share of the i-th supplier.

The monopoly market HHI is 10,000, and the fully competitive market HHI goes to zero. Generally, HHI < 1800 markets should be considered competitive.

$$HHI = \sum_{i=1}^{n} (100 \times s_i)^2$$ (1)

Top-m share refers to the market share of the largest m suppliers in the market. It is commonly used in that general industrial field that the top-4 index is used, namely, m = 4, and the Top - 4 indicator > 65% show that the market has the property of oligopolistic monopoly. The larger the indicator, the higher the market concentration.

The horizontal axis of Lorentz curve is the cumulative percentage of the number of users starting from the minimum user, and the vertical axis is the cumulative number of users' electricity sold or electricity charges. The calculation formula of Gini coefficient is:

$$G = \frac{S_A}{S_A + S_B}$$ (2)

Where, $S_A$ is the area between lorentz curve and the equal distribution line; $S_B$ is the area of the right lower right triangle minus A.
The higher the Gini coefficient, the greater the unevenness of user scale and the higher the relative concentration of large users. The higher the market concentration indicates that a small number of large users in the market play a major role in the contribution of the total electricity sold (electricity charge).

4.2. Market performance
The trading result reflects the result of the market game, and is a comprehensive Index to evaluate the market operation status after trading. The Index that reflects the market efficiency is selected as LI (Lerner Index).

$$LI = \frac{(MP-MC)}{MP}$$  \hspace{1cm} (3)

Where, MP represents the market marginal price; MC stands for market marginal cost. LI reflects the degree of difference between the actual market price and the fully competitive market price.

4.3. Prosperity index
Synthetic climate index can reflect the fluctuation range of system variables. Usually, synthetic index calculation method based on growth rate cycle is adopted. This calculation method can be roughly divided into four steps: standard symmetry of indicators, calculation of standard average change, initial value calculation of synthetic index and systematic trend adjustment.

First, the symmetric change rate of $Y_i(t)$ is calculated:

$$C_i(t) = 200 \times \frac{Y_i(t) - Y_i(t-1)}{Y_i(t) + Y_i(t-1)}, \quad t = 2,3,4 \ldots, n$$  \hspace{1cm} (4)

$$C_i(t) = Y_i(t) - Y_i(t-1) \times 200, \quad t = 2,3,4 \ldots, n$$  \hspace{1cm} (5)

The above formula is to avoid the occurrence of zero or negative values of $Y_i(t)$ in the index vector group, and the first-order difference is taken when the ratio sequence exists:

$$A_i = \sum_{i=2}^{n} |\lambda_i(t)|$$  \hspace{1cm} (6)

$$S_i(t) = \frac{C_i(t)}{A_i}, \quad t = 2,3,4 \ldots, n$$  \hspace{1cm} (7)

The standardized rate of change $S_i(t)$ is obtained by taking the difference between the dimensions of different indicators and the fluctuation range into account. Where $A_i$ is the standardized factor, its function is to calculate the total average absolute value of each vector group equal to 1 without changing the trend of the original sequence. The essence of such standardized processing is a data processing method that can be compared by enlarging or shrinking the data of different indicators in different proportions.

Calculation formula of standard average change rate:

$$R_i(t) = \frac{\sum_{i=2}^{n} S_i(t) \times \omega_i}{\sum_{i=2}^{n} \omega_i}, \quad t = 2,3,4 \ldots, n$$  \hspace{1cm} (8)

Calculation formula of initial value of composite index:

$$I(t) = I(t-1) \times \frac{200+R_i(t)}{200-R_i(t)}, t = 2,3,4 \ldots, n, I(1) = 100$$  \hspace{1cm} (9)

4.4. Welfare index
Welfare index refers to the relative number of changes and development of electricity price in the electricity market after market transaction. Reflect the direction and degree of the electricity charge change in the electricity market analysis and measurement of the total welfare change in the electricity market affected by the change of various factors.

$$I_n = \frac{\text{calculated value}}{\text{Basic value}} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} Q_{ij} \times P_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{m} Q_{ij} \times P_{ij}}$$  \hspace{1cm} (10)

Where:
- $Q_{ij}$ refers to the market transaction quantity of category j in the month i of the power trading center during the reporting period;
- $Q_{ij}$ is the base period electricity trading center's j-class market transaction electricity quantity in the month i, which is marked by the monthly average quantity.
$P_{ij}$ is the market transaction price of category $j$ in month $i$ of the reporting period;

$n$ is the current number of monthly shares;

$m$ is the number of market types;

Note: the data unit of all electric quantity is MWh, with two significant digits after the decimal point;
All price data are in yuan/KWH, with two significant digits after the decimal point.

The changes in the benefits of market-oriented transactions may be affected by the following four major factors: GDP, coal price, total electricity consumption of the whole society, the proportion of market liberalization, and market transaction prices. The influence degree of each factor on electric charge change is analyzed by calculating the correlation.

5. Conclusion

This paper studies the architecture model of the competitive electricity market and builds an evaluation index system based on the market operation model. Based on the real data, this paper evaluates the market operation of power sales and verifies the applicability of the indicator system through the example demonstration. By analyzing the factors influencing the change of the welfare index, it is concluded that the factors of the whole society's electricity consumption, coal price, GDP, market transaction ratio and transaction price are all the key factors affecting the welfare index. Among them, the larger the total electricity, the higher the price of thermal coal, the larger the GDP, the larger the market transaction ratio, and the higher the market transaction price, the larger the welfare index will be; while the opposite is smaller. The index system constructed in this paper can scientifically and rationally evaluate the operating condition of the power sale market from many aspects.

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