Research on Evaluation Index System for Power Market in China

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Abstract: Since the 9th document issued by the Government, China's power market construction process speeds up. It is necessary to build a quantitative electricity market analysis and evaluation tool for power market design, operation, supervision and decision-making of market participants. This paper studies the tools and methods of electric power market evaluation under the situation of electricity system reform in China, and takes the influence on power industry development and various related groups into account. The main evaluation indexes include promoting the optimal allocation of resources, promoting the sustainable development of power industry, market efficiency, and orderly operation of the market, impact on related groups.

1. Introduction

After the document No. 9 [2015]of General Office of the Communist Party of China was issued, Chinese power system reform project was start. In the process of power market construction, it is necessary to build a power market evaluation model, comprehensively considering various complex factors according to the power reform process, in order to provide a basis for power market design, power market supervision, and power reform effectiveness evaluation [1].

At present, there are two methods for evaluating the electricity market abroad: First, the cost-benefit evaluation method, which establish a cost-benefit evaluation model to estimate the costs and benefits of electricity market construction. The UK and the EU have used this approach to evaluate their market policies and mechanisms. The second is the multi-index evaluation method, which establish an indicator system in terms of efficiency, service, electricity price, environmental protection, etc., and evaluate market models and market rules [2-4].

Since 2002, domestic scholars have made an intensive study on the evaluation index system of the electricity market [5-7]. The above research results helped to shape the foundations of the China's power market evaluation. However, the power market evaluation method research, considering the new requirements and new contents for the new round of power system reform, is still insufficient.

Based on the power system reform, this paper will establish a multi-index quantitative market evaluation system, with the objectives of promoting sustainable development of the power industry and optimizing resource allocation. It can be used for market operation evaluation, market model comparison analysis, discovery of existing problems, and market trends prediction.

2. China's electricity market evaluation index system design

Compared with the foreign power market, the power market construction in China's current round of electricity reform have several features: the retail companies and customers participate in the market; the transmission and distribution price reform lay the foundation for power trading; how to promote the development of new energy during the construction of the electricity market has become a challenge;

power exchanges are relatively independent. During the process of index design, this paper focuses on the new contents and new features of this round of power reform.

2.1. Promote optimal allocation of power resources

The efficiency of power resource allocation depends largely on the degree of market competition, market openness and market organization efficiency.

2.1.1. Extent of power market competition

It can be evaluated with three indicators:

(1) Power generation enterprise market structure I_1

China's power generation group has a large market share, and the market power can be generally measured by Top-m share indicators and HHI indicators.

Top-m share refers to the market share of the largest m suppliers in the market. The larger the indicator is, the higher the market concentration is. The HHI indicator can be calculated by the sum of the squares of the market shares of each market supplier.

(2) The proportion of units participating in the market to the total number of units I_2

This indicator include the proportion of units number and the units capacity participating in the market.

(3) Market force prevention measures I_3

This indicator includes the number and duration of market price-constrained price impacts, and the amount of money affected, because of the market force prevention measures.

2.1.2. Market openness

The openness degree of the market includes the degree of openness in all aspects of power production, the degree of openness to market participants, and the interconnection between markets at various levels.

(4) The proportion of annual market electricity to electricity planned I_4

In China, direct transactions for large power consumers have been carried out for decade. The size of the market space directly reflects the openness of the market.

(5) Activity level of power retail companies I_5

The engagement of the electricity retail company in the market also reflects the openness of the market. This indicator include the proportion of the number and trading quantity of the retail company in market.

(6) The proportion of new energy trading capacity across provinces I_6

This indicator refers to the proportion of new energy such as wind power and solar energy exchanged through the inter-provincial grid to the total electricity consumption of the grid, reflecting the level of cross-province consumption of new energy across the country.

2.1.3. Market organization efficiency

(7) Power exchange operating efficiency I_7

The new round of power reform proposed "promoting the power exchanges to be relatively independent and operate normatively." Establishing an efficient market requires power exchanges with high operational efficiency and management level, and maintains open, transparent, fair and standardized market operations, and accepts government supervision. It can be evaluated from the aspects of operation level, compliance level, management level and service quality.

(8) Satisfaction of market participants I_8

The satisfaction of market participants in market organization work directly reflects the rationality and efficiency of market organization.

2.2. Promoting the sustainable development of the power industry

One of the primary goal of market construction is attracting power investment, building adequate power generation capacity, to ensure power system security and reliability.

(1) Average Markup Index J_1

The average Markup index reflects the profit of all power generation companies in the electricity market, which is expressed by the following formula. Among them, *P* the average transaction price of all bidding units in the market，*C* is the average cost of power generation. The farther the J1 index of a power generation company is away from 0, the greater the degree of price deviation from cost.

$$J_1=(P-C)/C \quad (1)$$

(2) Annual utilization rate of critical transmission lines J_2

This indicator refers to the changes in the utilization efficiency of the power grid after marketization, it can reflect whether the market price signal effectively guides the grid planning, and whether the grid investment effect is optimal.

(3) Change in power grid congestion cost J_3

The change in congestion costs can also reflect the guiding role of market price signals on grid planning.

(4) The trend of annual average line loss rate in the market range J_4

This indicator reflects the progress of the technical level of the power grid and the improvement of management level after marketization. It also reflects the production efficiency increasing of power generation companies after marketization.

(5) Transmission and distribution price level J_5

Reasonable transmission and distribution price levels are conducive to ensuring the invest ability of power grid companies.

2.3. Market efficiency

As a pillar industry of the national economy, the power industry shoulders important social responsibilities. It is necessary to evaluate the overall efficiency to reflect the influence of power market to other fields, such as energy saveing, environment protection, and economic development.

(1) Changes in market purchase cost P_1

This indicator refers to the changes in the cost of purchasing electricity before and after the power market reform, which reflecst the economic benefits of the market.

(2) Increased power consumption of enterprises P_2

The increased power consumption of enterprises means that the electricity-consuming enterprises reduce the cost of electricity consumption by participating in power market, and this part of the cost is used to increase production, and the generated electricity consumption increases. This indicator can measure the role of power market in promoting the growth of electricity consumption in the whole society.

(3) Average coal consumption of power generation and its changes P_3

This indicator reflects the impact of power marketization on energy conservation and consumption reduction in the power generation industry.

(4) Rate of change of pollutant emissions such as carbon dioxide, nitrides, and sulfides P_4

This indicator reflects the impact of power marketization on emission reduction.

(5) Rate of new energy generation ratio changes P_5

This indicator reflects the impact of power marketization on promoting new energy consumption.

2.4. Impact on related groups

For power generation companies,retail companies, and large users, power market transactions have a significant impact on their operating income.

(1) Profit and loss of power generation enterprise Q_1

It is mainly used to measure the profit and loss caused by that the generation companies participate in the market. It can be calculated by the difference between the regulated price and the market price.

(2) Generator unit utilization hours Q_2

This indicator reflects the operating hours of the average generator set capacity under full load operation conditions during a certain period of time, usually annual, mainly used to measure the utilization of the generator set.

(3) Price fluctuation risk Q3

The standard deviation of the transaction prices for each day can be used to measure the risk of price volatility in the market.

$$E = \sqrt{\frac{\sum_{i=1}^{n}(P_i - \overline{P})^2}{n}} \quad (2)$$

Among them, P_i is the average transaction price on the *ith* day of the time period in question;P is the average transaction price; n is the number of days . The larger E is, the greater the price volatility of each day during the time period in question.

3. Empirical analysis

Taking Province A as an example, an empirical analysis of this index system is carried out. At present, the electricity market in the province A is mainly based on direct transactions by large users. In view of the current limited data collection and the actual situation of the province's electricity market, this paper simplifies the index system and selects the data from 2014 to 2016 to conduct a brief analysis of the province's electricity market.

(1) Extent of power market competition

The market structure indicators of power generation enterprises are selected to simplify the calculation.

The Top-m share takes m=4. The HHI index is mainly calculated based on the market share of power generation companies and their trading electric quantity in the direct transactions of large users in A province from 2014-2016. The specific data is shown in Table 1.

Table 1 Market Structure Index of A Province 2014-2016

Year	Number of Enterprises	Top-4 Share Index	HHI Index	Market Competition
2014	7	89.71%	2267.12	Oligopoly
2015	20	42.16%	782.86	Full competition
2016	22	37.98%	689.12	Full competition

(2) Promote the sustainable development of the power industry

The trend of the annual average line loss rate in the market range is selected as the indicator to simplify the calculation. The line loss rate of province A in 2014-2016 is shown in Table 4-2.

Table 2 Line Loss Rates for Province A in 2014-2016

Year	Line loss rate (%)
2014 year	7.67
2015 year	7.42
2016 year	7.38

(3) Market efficiency

The change of the market purchase cost is used as the indicator to simplify the calculation. In 2016, province A began to implement the fixed transmission and distribution price. Therefore, the profit and loss of power generation enterprises can be regarded as equivalent to the change in market purchase cost. Compare the average price of the direct transaction with the regulated price in the same year, and multiply by the direct-trading power quantity to obtain the profit loss space of the generator set, and also the cost of electricity saved by the user, as shown in Table 3. .

Table 3 The decrease in the cost of electricity purchases in province A from 2014 to 2016

Year	Average transaction price (yuan/MWh)	transaction electric quantity(100 million kWh)	User purchase cost decreased (10,000 yuan)
2014	394.789	52.0	17371.8
2015	372.410	178.1	100439.1
2016	323.700	400.6	182674.7

(4) Impact on the related groups

The utilization hours of the generator set are used to simplify the calculation. Taking the power plant B as an example to measure the utilization hours of the generator set. This power plant has participated in direct transactions by large users since 2010. The power generation, direct transaction power and unit utilization hours in the past three years are shown in Table 4. It can be seen that after the power plant B participates in the direct transaction of large users, the power utilization hours are significantly higher than the provincial average.

Table 4 Average utilization hours of B power plants from 2014 to 2016
(unit: 100 million kWh, million kilowatts, hours)

Year	Power generation	Transaction power	Installed capacity	Generator utilization hours	Average utilization hours in the province
2014	33.8	7.8	60	5630	4702
2015	49.1	12.4	129	5994	3995
2016	56.5	13.3	129	4381	3848

Taken together, the market competition in province A is relatively full and there is no obvious market power phenomenon. With marketization, the operating efficiency of power grid enterprises has been improved to a certain extent, the cost of purchasing electricity for users has been reduced, and the reform dividends and social welfare have been fully released. For power generation companies, although participating in the market has reduced the price of electricity, it can increase the level of power generation and increase the hours of utilization of generator sets.

4. Conclusion

This paper comprehensively considers the special development characteristics in China and the requirements of new round of power market reforms. China's electricity market is comprehensive evaluated and analysed, from the aspect of promoting optimal allocation of power resources, promoting sustainable power development, improving market efficiency, impact on related groups. And the index system is provided. With the continuous deepening of the power market reform, the index system needs to be continuously developed and improved to meet the actual needs of the power market evaluation.

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Reference

[1] Zeng Ming2000. *Electricity market theory and application*(Beijing: China Electric Power Press).
[2] State Electricity Regulatory Commission Market Supervision Department2010. *Electricity market standardization design and evaluation system* (Beijing: China Electric Power Press).
[3] WAN Wei-hong, WEN Fu-shuan, WANG Lin. 2008 The inspirion from the evaluation of the world electricity market for China. *Relay*. **07**: 18-24.
[4] Federal Energy Regulatory Commission August 2016 Performance Metrics for Regional Transmission Organizations, Independent Systems Operators, and Individual Utilities for the 2010-2014 Reporting Period.
[5] GUO Lei, WEI Bin, XIA Qing, ZHUANG Yan, MA Li. 2008 Discussions on Evaluation Index Framework of Power Market in China. *Automation of Electric Power Systems*, **20 (3)**: 29-34

[6] Wang Wei, Shao Shan, Li Lei, et al. 2009 Electricity market efficiency theory and its evaluation method . *Power System Technology*, **33 (14)**: 66-71
[7] Liu Shujie, Luo Shenghua 2014 Electric Power Market Design: Deepening the Prerequisite for the Reform of Electric Power System. *Macroeconomic Management*, **12**: 37-38