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Research on Building a Power Market Regulation System in Gansu Province and Some Possible Monitoring Methods

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Abstract. With the deepening marketization of the electric sector, building power market regulation systems is worthy of concern. As the shaping of the spot market continually goes on in Gansu, market monitoring institutions should be built, market monitoring mechanism should be established, and market monitoring methods should be implemented. This article discusses the situation in Gansu, including the power structure and trading patterns. Then discussed the necessity and path to build a market regulation system. With possible monitoring methods illustrated, this article implemented the methods on past market data, analysed market forces situation, and proposed possible future investigations.

1. Introduction

The launch of *Several Opinions of the CPC Central Committee and the State Council on Further Deepening the Reform of the Electric Power System* and the six supporting documents, reveals the reformation of the electricity system of China. Eight provinces are required to develop spot markets for electricity trading. As the piloting provinces continually working on building their spot markets, the establishment of the corresponding market regulation system becomes a keen urge to help keep the operation of the spot market in order.

As an important part of market regulation, market monitoring can protect fair competition in the market with strategies such as real-time monitoring, investigations into pricing actions that violate the rules or regulations, punishments on activities that exploit the vulnerabilities of the rules or regulations, and suggestions on amending the existing rules according to the operational results.

Subordinating the regulatory authority or not, a key feature of the market monitoring institution is its independency from market participants. One initial part of market monitoring is market implementation monitoring, which focuses on the monitoring of market forces and reliability standards. Market forces, also known as market manipulation force, refers to the ability of power enterprises to change the market price and make it deviate from the price level under full market competition. Another aspect is market behavioural monitoring. This includes the screening and correction of market manipulation behaviour such as exploiting of the rules, or the seams between products and markets, as well as undefined circumstances. And therefore make suggestions on improving the efficiency of market price signals, improving the rules, and the dispatching procedures.

As one of the piloting provinces, Gansu has built its spot market in a centralized model where the plan and dispatch of energy are carried by the system operator rather than the power plants themselves. The test run in September 2019 reveals that there are no severe market forces issue in Gansu electricity spot market, however, the launch of *Scheme on Regional Integration of National Coal Enterprises* changed the ownership of the asset and could potentially result in market force manipulations. Followed discussions on designing a market regulation system, as well as implementing possible monitoring methods to prevent market forces, are of utmost importance for Gansu. The design of the market monitoring institution, the market monitoring mechanism towards market participants, and the implementation of possible methods and corresponding results will be discussed in this article.

2. Current Situation of Gansu

2.1. Power Structure
Currently, Gansu has 40.6% of coal capacity, 25.2% of wind capacity, 15.9% of solar capacity, and 18.3% of hydro capacity. In 2018, wind and solar provided 32.1 TWh of energy, which takes up 23.7% of the annual total energy production.

With abundant wind and solar energy, Gansu exports a huge amount of its energy to neighboring provinces. Gansu has a total of 24500MW of transmission lines and exported approximately 27% of its energy to neighboring provinces by long-term and short-term energy trading in 2018.

2.2. Trading characteristics within Gansu
Gansu has a blended trading pattern that contains a variety of different mid-and-long-term trading types and is now testing its spot market step by step. Currently, there are over 1400 companies participated in the Gansu Electricity trading market, among which over 900 companies are energy wholesale suppliers, over 400 companies are consumers, and other over 300 companies are energy retailers. In the first phase, only suppliers can participate in the spot market.

The first testing run of the spot market has 335 participants, among which 297 of the participants participated in the day-ahead market.

Table 1. Market Participation for September Test Run.

Type	Participation Proportion	Capacity Proportion	Notes
Coal	6.8%	36.9%	46 plants in total
Wind	28.6%	31.7%	-
Solar	64.6%	18.1%	-
Hydro	0%	13.3%	Price-taker

The market-clearing price of the spot market shows that transmission congestion and some certain node has obvious impacts to the price, and resulted in lower price in zone West Yellow River and higher price in zone East Yellow River. Before moving on to phase II, where consumers participate in the market as well, a market regulation institution should be built and market monitoring methods should be implemented at nodes where there are congestions to avoid market forces caused by the suppliers located there.

The integration of coal enterprises changed the asset ownership in Gansu, Huaneng, one of the Five Biggest Coal Enterprise in China, now owns all the coal assets in Gansu province. Before the integration, Huaneng owns 18 power plants with 4112 MW of capacity, and the number grows to 31 power plants with 11348 MW of capacity. Among that, coal plants grow from 2505MW to 9741MW. The proportion of its total asset capacity grows from 8.2%-22.7%, and 15.5%-60.3% for coal assets.

3. Market Regulation System and Market Monitoring methods

3.1. Market Monitoring Institution Under Current Framework

With a centralized market mode, Gansu optimizes its energy resources and dispatches its energy productions to proper customers. The market monitoring mechanism should cover the Monitoring of market force before, during, and after the dispatching process. Therefore, a monitoring institution within the organizing institution (which currently is the dispatching department of the grid) that can easily get access to all the bidding information could be suitable for Gansu to monitor the market, especially at the first stage. Another consideration to build the monitoring institution within the organizing institution is that there is no independent third party that has both market monitoring experience and power market organizing experience. As for the following phases, the monitoring institution could go for different directions according to the needs.

3.2. Market Regulation Mechanism towards Market Forces

To prevent market forces from worsening, the market regulation mechanism should be implemented during the entire life cycle of the spot market.

Market forces prevention strategy before the spot market typically includes the design of the market structure, static market forces recognition, setting a basic power plan for big companies, and disclosure of market information.

Market forces prevention strategy during the spot market is usually implemented by the trading system, with a monitoring module automatically checking for outliers. Classic monitoring methods include three pivotal suppliers (TPS) test, behavioural test, and price test.

Market forces monitoring after the spot market usually use simulation methods to analyse if there's market forces manipulation caused by the market participants. The investigation procedure begins with simulating the market, then goes for quantifying the impacts on market forces from the participants' behaviors, and ends up with keeping the records for the participants. After the investigation, participants manipulated the market will be punished according to their behaviors. Disqualifying, fining, cancelling their benefits for certain periods, setting sell limit, or sending warning letters could serve as punishments for participants that successfully manipulated the market or those ever attempted to.

Comprehensive methods could be used to keep the market away from high market forces, and each lesson learned from practice could iterate and improve the market regulation mechanism.

3.3. Market Monitoring Methods and Corresponding Implementation in Gansu

Three Market Monitoring parameters are introduced to evaluate the degree of market forces and therefore prevent the market from disorders. We use market data derived from test runs of the market to evaluate how severe the market forces are, and how the integration of the companies in Gansu has has cast impacts on them. It is to mention that in our investigation we analyze market forces in a static method, which does not consider varied bidding strategies implemented by the market participants.

HHI. The Hirschman-Herfindahl Index (HHI) is a formula for analyzing market concentration. It is calculated as follow:

$$HHI = \sum_{i=1}^{N}(100 * S_i)^2 \tag{1}$$

In this formula, S_i is the market share of the ith market participant, and N is the number of market participants. Usually in an electricity market context, S_i is the ratio that a market participant's capacity takes up of total capacity in the market. Under a monopoly context, $HHI > 10000$, on the contrary, under a complete competitive context, HHI is approximately 0. Usually, it is considered a healthy market when $HHI<1000$, when $1000 \leq HHI<1800$, the market concentration is tolerable, however, when $HHI>1800$, the market tends to be less effective. The higher the HHI gets, the more powerful the market forces become, which suggests the higher chances the market gets manipulated.

RSI. The Residual Supply Index (RSI) is a formula for analysing the impact of a certain supplier. It is calculated as follow:

$$I_{RSI_i} = \frac{\sum_{j=1}^{n} q_j - q_i}{D} \tag{2}$$

In this formula, q_j is the bidding capacity/energy of the ith market participant, and D is the total demand. When $I_{RSI_i} < 1$, the market cannot run without the ith participant, and therefore this participant has market forces. The smaller I_{RSI_i} gets, the more powerful the participant becomes when manipulating the market. Calculating the RSI for the suppliers respectively, or by combo, the manipulation possibility could be easily evaluated.

Top-m. The Top-m/CRn (Concentration Ratio) indicates the size of firms in their industry as a whole. It is calculated as follow:

$$TOP - m/CRn = \sum_{i=1}^{M} RS_i \tag{3}$$

In this formula, Top-m/CRn represents the total share of top m/n suppliers, RS_i is the market share of the ith ranked supplier whose market share is ranked from large too small. The higher this value becomes, the higher the market concentration would be. Usually, m=4 is used in industries, and when Top-4/CRn >65, the market has a trend of monopoly.

Comparison before and after the integration of coal enterprises in Gansu. We implemented these three parameters to compare the impact of the integration of coal enterprise. A static method is used here to measure the market forces of the participants without considering their bidding strategies. The entire integration consists of three steps. First are the integration of coal enterprises in 2020, second is the operation of new coal plants in 2021, and third is the retirement of certain coal plants in 2022. These changes have been taken into consideration gradually and the monitoring of each step is represented by the year that the changes will have taken place.

Table 2. Market Trend Comparing.

Year	Coal Capacity (MW)	HHI	TOP-4
2019	44981.2	562	45.9
2020	44981.3	830	46.3
2021	46981.3	874	48.5
2022	45221.3	763	46.5

Before the integration of the coal enterprises, HHI equals 562. After the integration, HHI becomes 830, 874, and 763 at each step. (Here we view small power plants as a whole.) These results show that under each circumstance, HHI is under 1000, which means the integration is healthy to market concentration in Gansu.

Top-4/CR4 changed from 46.5 in 2019 to 47.3 in 2020, 49.3 in 2021, and 45.5 in 2022, which means the market does not have a monopoly/oligopoly trend.
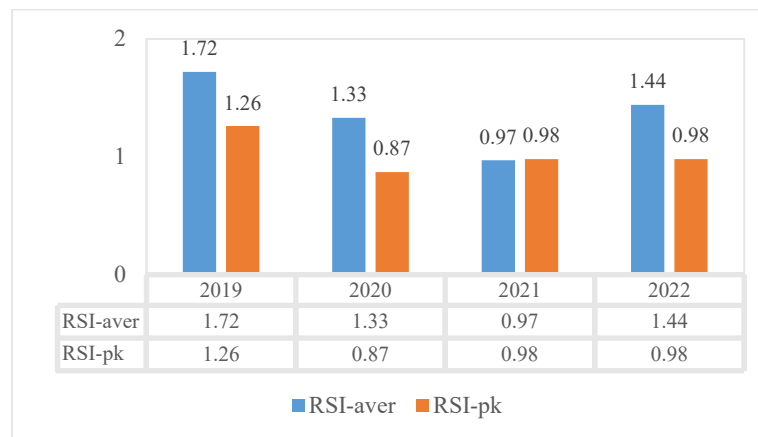
Figure 1. Huaneng RSI Comparison

RSI is examined to evaluate the manipulation potential of the market participants. Results show that under the 2019 reference scenario, the RSI is 1.26, 1.22, 1.15, 1.34, and 1.24 respectively. As none of the RSI for participating enterprises is less than 1, the market can run smoothly without any single enterprise. Closer attention is then paid to Huaneng under all four scenarios as it gains the highest market share of coal plants after the 2020 integration.

We investigated the RSI at the average hour and under peak hour, and find out that after the integration, Huaneng has its RSI below 1 at peak hours. This suggests that at peak hours, the energy supply would not be enough without Huaneng, and Huaneng has the potential to manipulate the market if the plants collude. This trend will extend to 2021 and 2022 scenario as well. Therefore, the market monitoring institute should always keep an eye on Huaneng after the integration in case it manipulates the market.

4. Conclusion and Future Investigation

A market regulation system with quantitative methods monitoring the market forces should be built as the spot market construction goes on in Gansu. Key elements should include a market monitoring institution within the current operating department, market monitoring mechanism during the entire market running cycle, and market monitoring methods that could quantitatively evaluate the market forces under different situations. Future investigations could focus on the implementation of market monitoring methods under different scenarios, such as wet seasons and dry seasons, and collusion for participants that ranks top in market forces.

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