Research on Funding Differences among Regional Electricity Markets in Northern China based on Thermoelectric Decoupling

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Abstract. With the development of China's electricity spot market, planned power and market power will coexist for a long time. At the same time, by avoiding the risk of market price fluctuation through medium and long-term market, spot market guarantees electricity balance and secure operation of the grid. The electricity market mechanism has an increasingly large influence on the operation and dispatching model of power system. In spot market, decoupling operation model of market and non-market power has a large influence on both supply and demand sides and improper dredging mechanism may cause significant settlement deviation. To solve this problem, the paper, taking a city in northern China as an example, analyzes the electricity spot market, compares the sources of difference fund of market and non-market power under decoupling and non-decoupling models and compares the pros and cons of coupling and decoupling. The paper also studies the disparity of difference fund and proposes advice adapted to the electricity spot market development of northern China.

1 Research Background

In the development of China's electricity market, power generation and consumption plan has gradually been liberalized, so planned power and market power will coexist for a long time. At the same time, by avoiding the risk of market price fluctuation through medium and long-term market, spot market ensures electricity balance and secure operation of the grid.

In electricity spot market, for the power generation side, there is a deviation between the power generation curve of day-ahead transaction clearing and the financial settlement curve of the medium and long-term transaction contract and the decomposition of planned power. And a deviation also exists between the power generation curve of the real-time transaction clearing and the settlement curve of the day-ahead transaction contract. But the consumer side lacks a reasonable electricity decoupling mechanism of planned power and market power, which can balance the planned power and market power with the demand of non-market consumer and market consumer respectively. The paper will compare the decoupling of market power and non-market power of a city in northern China, compare the pros and cons of coupling and decoupling and compare the disparity in difference fund with system marginal price mechanism and nodal electricity price mechanism. The paper also proposes advice on spot market development mechanism for northern cities. The core index of evaluating market competitive efficiency and market maturity is also the

basis for the operation and decision-making of market players. Therefore, it is very important to make a statistical analysis and prediction of spot price in electricity market.

2 Source of Difference in Funds in the Decoupling Mode

Until the reform of electricity market all power generation was settled in accordance with the feed-in tariff subject to the approval of the government, while the users settled electricity in accordance with the catalogue tariff issued by the government. Since the initiation of electricity market reform planning and market in northern cities still coexisted, is coexisting and will coexist over a long period of time to guarantee the electricity consumption of households and enterprises, ensure the peak and frequency modulation and safeguard the safety operation of the grid, and make certain that the renewable energy power generation is acquired on schedule with indemnity provided. Some power generation enterprises after engaging in market still retain a part of the planned power, namely the base power. It can be concluded that power generation in northern cities consists of both planned and market-oriented electricity in the current situation where electricity market is undergoing reform. Electricity consumption covers that of market users and non-market users.

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2.1 Analysis on the Advantages and Disadvantages of the Decoupling Mode

The biggest advantage that the decoupling mechanism of planning and market enjoys is the perfect match in electricity between planned power generation and non-market consumption, and between market-oriented power generation and market-oriented consumption, which to a certain extent contributes to the mitigation of settlement risks and the smooth advancement of electricity market reform. Nevertheless, deficiencies also arise from the decoupling of planning and market: for one thing, settlement appears complicated. With the settlement of the unit's base power under the influence of non-market users, it is necessary to make ex-post adjustment to the base power distributed to power generation enterprises. Once the electricity of a non-market user is calculated inaccurately, all interconnected units might need to refund the overcharge and supplement the shortage; for another, the decoupling mode is unsustainable. This mode demands exact consistency between the liberalization of market users and the liberalization of power generation plan.

2.2 Analysis on the Particularity of a Northern City concerning Managing the Difference in Funds in the Decoupling Mode

2.2.1 Double-track Operating Cost

In the decoupling mode the difference in funds is mainly derived from imbalanced structure and imbalanced market settlement. This northern city in its primary stage adopted the system marginal electricity price mechanism. Electricity users had to pay extra transmission and distribution price apart from fees paid in accordance with the system marginal price. The price mechanism in the middle and later stage gradually transitioned to the nodal price mechanism. Non-market users still consumed electricity and make their settlement in the current method. No difference in funds exists between market-oriented power generation and consumption in the decoupling mode of planning and market, a mode in which the system marginal price mechanism is adopted. Two solutions exist to resolve this issue. One is to set a fixed purchase-sale spread by Beijing power enterprise. Fees should be charged in accordance with such spread regardless of prospective power purchase capacity. This solution is of benefit for Beijing power enterprise to ensure its stable revenue. Nevertheless, for one thing, the difference between purchase and sale expenses of non-market users generally fails to precisely correspond with the cost calculated in accordance with the

purchase-sale spread, which generates difference in funds required to be managed and adjusted. For another, transmission and distribution price should be strictly audited and subject to relevant supervision. On the premise of ensuring power company's normal revenue, market entities should be allowed to engage in market at a lower cost so that the market dynamism gets boosted. Another solution is to allow the grid company to take the risk of price fluctuation, a situation in which all the difference between non-market power generation and consumption costs, regardless of its amount, will be regarded as the cost of purchase-sale spread that is in the possession of the grid company. This solution is simple to implement without the necessity of managing the difference in funds; the grid company will show more initiative to sharpen its negotiation skills so as to reduce power purchase price, which helps the company enhance their operation. However, if the company fails to purchase external power at a lower price, the increase of overall purchase price will compromise their earnings; the fact that all the difference between power purchase and sales is possessed by the grid company is liable to provoke the market entities' suspicion of market unfairness.

2.2.2 Example Analysis on Congestion Surplus in the Decoupling Mode

Example Analysis on Congestion Surplus in the Decoupling Mode is as shown in Figure 6. In Figure 6, user group L1 is composed of entirely market-oriented users. The actual power consumed by group L1 stands at 90MW. The total power consumed by user group L2 stands at 210MW, including 200MW of planned electricity and 10MW of market-oriented. The line transmission is limited to 130MW. In accordance with the principle of "determining power generation based on power consumption", the bids won by non-market unit and market unit respectively stand at 200MW and 100 MW. Under the system marginal price mechanism, the nodal electricity price on node A and B both stands at 1; whereas under the nodal price mechanism, network congestion caused by line transmission capacity limit drives the nodal price on node B up to 1.5.

The above two solutions are beyond market users' acceptance due to the identical net expenditures, despite a slight difference of cash flow. The second solution, nevertheless, is a more sustainable one that highlights the physical significance of the nodal electricity price. Accordingly, in its primary stage where the nodal price mechanism is adopted, this company is recommended to adopt the second solution to apportion the congestion surplus while intensifying its training for market entities.

Figure 1. Analysis on congestion surplus in the decoupling mode of planning and market

3 Source of Difference in Funds in the Non-decoupling Mode

3.1 Analysis on the Advantages and Disadvantages of the Non-decoupling Mode

In the non-decoupling mode, planned power generation can not strictly match planned consumption, which similarly holds true to the market-oriented power generation and consumption. Difference in funds will arise in the process of settlement. A lack of reasonable mechanism to adjust the difference will force some market entities to take extra market risk, causing damaging to market returns. The fair distribution of interests is beyond guarantee without strict market supervision and increasingly detailed rules pertaining to particular problems during market operation.

3.2 Analysis on the Particularity of a Northern City concerning the Difference Management in Funds in the Non-decoupling Mode

3.2.1 Double-track Operating Cost

When the system marginal price mechanism is adopted, although the price gap between the two sides of power generation and consumption is bridged (without considering transmission and distribution price), difference in funds still arises due to a lack of perfect match in electricity. Meanwhile, difference in funds also correspondingly arises from imperfect match between non-market power generation and consumption.

When the nodal price mechanism is adopted, both quantity and price differ between the power generation side and the consumption side. In consequence, difference in funds appears in both market-oriented and non-market power generation and consumption. Here unnecessary details will be left out.

3.2.2 Example Analysis on Congestion Surplus in the Non-decoupling Mode

Example analysis on congestion surplus in the non-decoupling mode of planning and market is as shown in Figure 7 and Figure 8. Among them Figure 7 represents day-ahead market clearing results, whereas Figure 8 represents real-time market clearing results.

Figure 2. Day-ahead market clearing results in the non-decoupling mode of planning and

In day-ahead market, user group L1 which is formed merely by market users has declared 90MW of electricity consumption; user group L2 which is formed merely by planned users is predicted to consume 210MW of day-ahead electricity with catalogue tariff priced at

0.7yuan/kWh. The planned power output Q1 of the node 1 unit group stands at 200MW, and the feed-in tariff approved by the government is 0.45yuan/kWh; the bid won by the node 1 unit group in day-ahead market amounts to 20MW. No planned power is arranged in

the node 2 unit group Q3; the bid won by Q3 in day-ahead market amounts to 80MW. Under the system marginal price mechanism, node 1 and node 2 are both priced at 0.5yuan/kWh; under the nodal price mechanism, node 1 and 2 are priced at 0.5yuan/kWh and 0.6yuan/kWh respectively. On condition that the composite weighting factor is 0.3 on node 1 and 0.7 on node 2, then the user's composite settlement price is:

$0.5 \times 0.3 + 0.6 \times 0.7 = 0.57$ yuan/kWh. The transmission and distribution price stands at 0.25yuan/kWh. It is demonstrated that in the non-decoupling mode of planning and market the difference in funds is bound to exist that needs to be managed, regardless of what price mechanism is adopted, the system marginal one or the nodal one.

Figure 3. Real-time market clearing results in the non-decoupling mode of planning and market

(2) Their motivation is insufficient.

4 The Mode to Adjust the Difference in Funds

4.1 The Mode to Adjust the Difference in Funds in Pilot Provinces

In the spot market currently being built by experimental units, electricity settlement remains mainly in the charge of grid companies. For the time being the pool of difference funds in each pilot province is set in grid companies, which under certain rules apportion the difference in funds generated during the operation of spot market to the power generation side and consumption side by specifications.

4.1.1 Advantages of Refunding or Apportioning the Difference in Funds to the User Side

(1) It is simple to conduct and feasible to implement to apportion the difference in funds according to the actual electricity consumed by market users.

(2) The principle is highlighted, namely “those who reap the benefits bear the risks”. Market users are required to take corresponding market risks when enjoying the market dividends.

(3) Disputes among market entities in the power generation side are likely to be mitigated.

4.1.2 Disadvantages of Refunding or Apportioning the Difference in Funds to the User Side

(1) Market users are at risk which is so high that disputes might be sparked to a certain extent.

4.2 Suggestions for Selecting the Method of Managing the Difference in Funds

(1) Selection should be made based on market pattern. As bilateral market, power spot market in Northern China allows electricity users to engage in market competition by proposing a quantity rather than quoting a price. Therefore it is slightly unreasonable to refund or apportion the difference in funds merely to the power generation side;

(2) Selection should be made based on market structure. Market-oriented electricity possessed by the grid market in northern cities is less than 20% (100 billion non-market electricity, 20 billion market-oriented electricity). Therefore, the deviation of the actual electricity consumed by non-market users from the day-ahead prediction will impose tremendous influence on the difference in funds. Additionally the electricity and transmission rights from external provinces account for a high proportion in Beijing, which strengthens that influence. Consequently during designing the mechanism for refunding or apportioning the difference in funds, it is required to consider the influence imposed by non-market users on the difference in funds so as to transmit market risks to non-market users;

(3) Selection should be made based on the reality of spot market construction. Currently northern grid has introduced a mechanism that allows local bulk users to trade directly with coal electricity plants in nearby cities, yet the foundation of spot market construction is still weak and the market entities' concept remains to be cultivated. For that reason accessibility and feasibility are suggested to be the underlying principles of the method

for managing the difference in funds at the primary stage, which matters to ensure market a smooth start.

In conclusion, it is suggested that the difference in funds should be transmitted to the user side in the initial stage. Meanwhile, the catalogue tariff mechanism at a floating price should be established to prevent market users from bearing excessive risks and to resolve the market risks caused by non-market users.

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