Research on the Linkage Mechanism of Multi-Time Scale Electricity Market in Northern Hebei

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Abstract. With the rapid marketization of the electric sector, transferring to market-oriented system from managed-based system is of utmost importance. As spot market constructing recognized as a necessity for electric reformation, Northern Hebei is treating the linkage mechanism seriously. Focusing on the spatial and temporal linkage mechanism for energy trading, this paper aims to discuss reasonable options for Northern Hebei when it’s introducing the spot market. The relationship between energy market and ancillary market, particularly in the spot market, is also discussed to better shape a comprehensive framework for the entire electric market. Some discussions on the specific electric commodity categories are demonstrated as well to help Northern Hebei look into the future and take strategies accordingly as the market develop and the government giving more guidance on the market construction.

1. Introduction

Several Opinions of the CPC Central Committee and the State Council on Further Deepening the Reform of the Electric Power System, or Policy No.9, is worthy of remark as a monument for the reformation of the electric power system. Published on March 15th 2015, Policy No.9, together with six supporting documents, requires eight provinces to serve as the pioneers and develop spot market for electricity trading, which aims to establish a more modernized trading framework for energy supply.

The goal is to build a system that contains mid-term and long-term markets as well as the spot market. While mid-term and long-term markets are for yearly, quarterly, monthly and weekly trading that deals with energy and ancillary services such as interruptible load and voltage regulation, the spot market aims for coping with energy and ancillary services such as reserve and frequency regulation for day-ahead, daily, and real-time trading. More explorations on other trading commodities (e.g., capacity market, electric power futures, and derivatives) could be made when the market is mature enough.

Centralized and decentralized markets are the two options for the market mode. Centralized marketplaces are usually carried with bilateral contracts that are delivered physically. Both supply-side and demand-side should have their daily curve for electricity production and consumption one day ahead of the real-time dispatch, and the energy differences between the planned results and the load should be balanced at the spot market. Meanwhile, Contract for difference is implemented for centralized marketplaces. While the price signal from the spot market depicts the demand-supply relationship of the market, mid-term and long-term bilateral contracts serve as hedging methods to manage the risk. Each province should build their market based on their financial situations while considering features like regional electric resources, load features, grid structure, etc.
For electric market system, trading should be done in either regional or provincial electric power markets. Unlike provincial markets merely dealing within the province, regional markets deal with a scale larger than a province and possibly contains several provinces that have bilateral transmission lines. Beijing trading center and Guangzhou trading center are the most important agencies for the national plan implementations and the regional agreements for large scale cross-provincial trading. Mid-term and long-term contracts, as well as spot market trading, should interact with each other to optimize the resources for both regional and provincial markets. It is to mention that one area should not have more than one spot market.

Under these circumstances, Northern Hebei should know their strengths and weaknesses before they start building a spot market. Considering the connection with its neighboring provinces, Hebei should pay much attention on how to integrate the spot market with the mid-term and long-term markets, as well as how to integrate the regional with inter-province market together while considering other features such as its high renewable penetration patterns and local policies.

2. Current Situation of Northern Hebei

2.1. Power Structure
Hebei Province has two power grid companies that provide the customers with electric services. Here in this article, we are only going to focus on the northern part that is taken over by Northern Hebei Power Grid company. Northern Hebei Power Grid is located at the east end of Northern China Power Grid. Neighboring to Beijing, Northern Hebei Power Grid is playing a crucial role as the electric defender of the capital in Northern China area. Northern Hebei Power Grid serve for 43 counties (including districts and cities) in Langfang, Chengde, Tangshan and Qinhuangdao. The inter-province network is of ‘three horizontal and three vertical’ framework. There are also important transmission lines between Northern Hebei and Beijing, Tianjin, Southern Hebei and West Inner Mongolia.

Northern Hebei has rich wind and solar energy. At late 2018, Northern Hebei has 1.36% of Hydro capacity, 41.96% of coal capacity, 40.15% of wind capacity, 16.42% of solar capacity and 0.10% of storage capacity. The total capacity for renewable energies has exceeded 17,283 MW. In 2018, wind provided 27.35% of total energy over 2057 hours, and solar provided 6.07% of total energy over 1310 hours. The discarded renewable energies are about 1.4 billion kwh. Zhangjiakou, rich in both wind and solar energy, has especially difficulty on market consumption of the renewable energies.

2.2. Trading characteristics within Northern Hebei
Currently, Northern Hebei only has mid-and-long-term trading and real-time dispatch. Local trading center is in charge of trading within the region, including direct trading whose suppliers and users both registered locally, Alibaba cloud computing project, and Green Electricity that only takes place in Zhangjiakou. Local trading center organizes Alibaba cloud computing project independently, and cooperates with Beijing Electricity Trading Center on other categories within Beijing-Tianjin-Tangshan area and with other provinces. At the moment, settlements for all categories are carried monthly, with a user-oriented penalty method. Details on organization of different categories will be discussed later.

3. Northern Hebei’s participation in cross-provincial trading

3.1. Electric Trading within Beijing-Tianjin-Tangshan Area
Northern Hebei is part of the Beijing-Tianjin-Tangshan economic zone area, and is playing a crucial rule in the electricity serving in this area. Up to now, Northern Hebei has to do all its trading within the Beijing-Tianjin-Tangshan Area framework, which is affiliated to Northern Area Framework. For Northern Hebei, trading takes place under direct trading (between supply side and demand side), Alibaba Cloud Computing project, and Green Electricity Trading (which is for renewable consumption).

Direct trading is mainly based on negotiation, and supplemented by central bidding. Trading categories include yearly negotiation, monthly negotiation and monthly auction. The corresponding
administrative department is responsible for the publicity of the tradable energy amount of the next year before November 1st. Relevant trading centers at all levels are in charge of decomposing the yearly tradable electricity amount into each month while following the principle of dynamic equilibrium. For yearly negotiation, an agreed monthly electricity amount between two entities should be confirmed between November 10th and November 23rd. For monthly negotiation, the negotiation processes take place between the 10th and the 20th in a certain month that is one month ahead of the dispatch, an agreed monthly amount for the next month should be confirmed then. Monthly auction is the last stage of the mid- and long-term electric market, the supply side could upload uptrend ‘load-price’ curves while the demand side provides downtrend ones. The aggregated curves from both sides then come across at a specific point and then the price at the equilibrium becomes the market clearing price. Then the winners of the bid become clear. This process should be done in two days before the 27th day of a certain month, with a notice of the open date at least three days ahead of the auction. The calculation follows the chronological sequence: monthly auction, monthly negotiation; agreed amount decomposed from yearly negotiation, and amount outside of the market. Within the scope of Direct Trading, Alibaba project operates synchronously and is in the form of unilateral listing.

Green Electricity Trading contains yearly and monthly trading in listing and bilateral negotiation. Certain users and renewable plants trade to have the electricity generated from renewable sources consumed outside the government-guaranteed hours. Green Electricity Trading now operates outside the Direct Trading framework, however will be part of the framework as it becomes mature. Green Electricity Trading only works for Wind powers in Zhangjiakou at the moment, and it is organized by Northern Hebei Power Grid Company. Decomposition of yearly tradable amount to monthly tradable amount will be decided during November and December.

3.2. Ancillary service trading within Beijing-Tianjin-Tangshan Area
Northern Area has started a spot market for peak-load regulation since 2019. This market includes day-ahead market and intraday market. It is a two-level market that contains Northern Area and the provincial levels. Beijing, Tianjin, and Hebei work as a whole at provincial level. For the first four months of market operating, the bidding electricity amount ranges from 0.50 GWh to 0.34 GWh, with the conventional plants taking up 51.59% to 46.06% and renewable plants taking up 53.91%.

3.3. Trading with other provinces
Having all trading outside Hebei done under Beijing-Tianjin-Hebei Framework, Northern Hebei does not independently take part in trading with other provinces in Northern Area. For Beijing-Tianjin-Tangshan area, there exists transmission plans with Southern Hebei, Inner Mongolia and Shanxi. Though not taking part in trading with other provinces administratively, Northern Hebei does get involved in operation for cross-provincial trading such as Ximeng-Shandong Extra High Voltage Transmission Project, Northern Area-Jiangsu trading, and Xinjiang-Hebei trading.

Cross-provincial trading follows the rule set by Beijing Electricity Trading Center. Several opinions have now been under review for cross-provincial trading, with focuses on contract repurchase, bundle for renewable energy and conventional energy, bundle for alternatives, generation rights transfer for clean energy, alternatives with clean energy and pumped storage, and trading for renewable quotas. As the construction for electric market grows rapidly, it is to mention that there is now spot market for cross-provincial renewable energy trading where the demand province does not have spot market yet, and the supply province with renewable curtailment still has capacity after the implementation of the original trading.

4. The linkage mechanism for trading in multi-scale electric power market in Hebei

4.1. The linkage mechanism within Beijing-Tianjin-Tangshan Area
As the calling for spot market construction is urgent, it is unavoidable to have spot market in the Beijing-Tianjin-Tangshan area. However, as this area has more than one province, the final form of spot market
is uncertain. Whether the region will have a centralized market or a decentralized market, could be a problem when Northern Hebei is going to participate in a spot market.

Northern Hebei, with both renewable and conventional power plants, could build a spot market itself, however, Beijing, as the capital city with more air quality requirements for certain periods, and a situation with less renewable resources, might not have the ability to build a spot market whose price can reflects the supply and demand relationship. Meanwhile, Tianjin, one of its neighboring provinces, with various types of energies including both conventional and renewable, also has the ability to build an individual spot market.

4.1.1. Beijing-Tianjin-Tangshan as one centralized market. In the situation where Beijing-Tianjin-Tangshan adopted centralized market and work as a whole, Northern Hebei could still be participating in the market spatially as it is now, and with challenges mainly focused on time-scale linkage. Then the focus will be the interaction between trading center and dispatching center. Requirements on computing system dealing with real-time monitoring, settlement, and penalty would then become vital. In this situation, Northern Hebei will have the least flexibility for organizing the market, and could possibly act like a participant with the focus mainly on logistical and technical issues.

4.1.2. Beijing-Tianjin-Tangshan as one decentralized market. In the situation where Beijing-Tianjin-Tangshan work as a decentralized market, Beijing, Tianjin and Northern Hebei will have to participate wisely in the market. As physical delivery is required in a decentralized market, precise day-ahead predictions are needed to avoid penalty. The challenge then becomes the decomposition of mid-and-long-term contracts and the prediction of generations. Like Nord Pool, most trading might have been done within the spot market, with subtle adjustments by a balance mechanism or ancillary service market. In this scenario, the flexibility and Northern Hebei will have more autonomy, and it could be more flexible if the decentralized market only contains spot market.

4.1.3. Northern Hebei as one centralized market. In the situation where Northern Hebei constructs its individual centralized market, Beijing and Tianjin will possibly have the same kind of centralized market. With the Beijing-Tianjin-Tangshan union breaks apart, Northern Hebei will have the highest flexibility and build an excellent independent spot market. The challenge would be the adjustment of working procedures as cooperation within Beijing-Tianjin-Tangshan area will have few differences with cooperation with other provinces. In this scenario, Northern Hebei will have to overcome all the challenges mentioned above for the other two scenarios, but with less urgency.

4.2. The spatial and temporal linkage for Northern Hebei under different scenarios

The following graph depicts the regional relationship between Northern Hebei (Jibeji) and other provinces in Northern Area. Corresponding linkage mechanisms are listed according to the scenarios.

![Figure 1. Northern Hebei’s linkage mechanisms in different scenarios.](image-url)
5. Conclusion
With high uncertainty of the future market framework, Northern Hebei should get prepared and build linkage mechanism for the transferring path between a manage-based system and a market-oriented system. The key is to understand the adversities and consequences of transferring to a new working mode, and therefore build reasonable strategies to overcome the possible corresponding difficulties. For Northern Hebei, its cooperating method with Beijing and Tianjin, should be the essence when coming up with a linkage mechanism and choosing strategies.

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