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Review of typical institutional modes of power dispatching and power exchange in different countries' electricity markets

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Abstract. In the construction of the electricity market, the relationship between grid ownership, power dispatching center and power exchange is an important issue. In the construction of some countries' electricity markets, it can be divided into several typical modes. This paper summarizes the modes of power grid ownership, institutional setup of power dispatching center and power exchange in the major countries of the world in detail. The underlying reasons behind them are summarized. Finally, the divisions of responsibilities in the medium and long term market, spot market of electricity in different modes are summarized. These can serve as a reference in the process of China's power market construction.

1. Introduction

In recent years, China is rapidly promoting the construction of the electricity market [1]. In the new round of reform, the power exchange in China's electricity market reform is further independent from the power grid. The relationship between grid ownership, power dispatching center and power exchange and their divisions of responsibilities in the medium and long term market, spot market of electricity are important issues. So it is very meaningful to refer to the actual experience of countries around the world and summarize the reasons behind them.

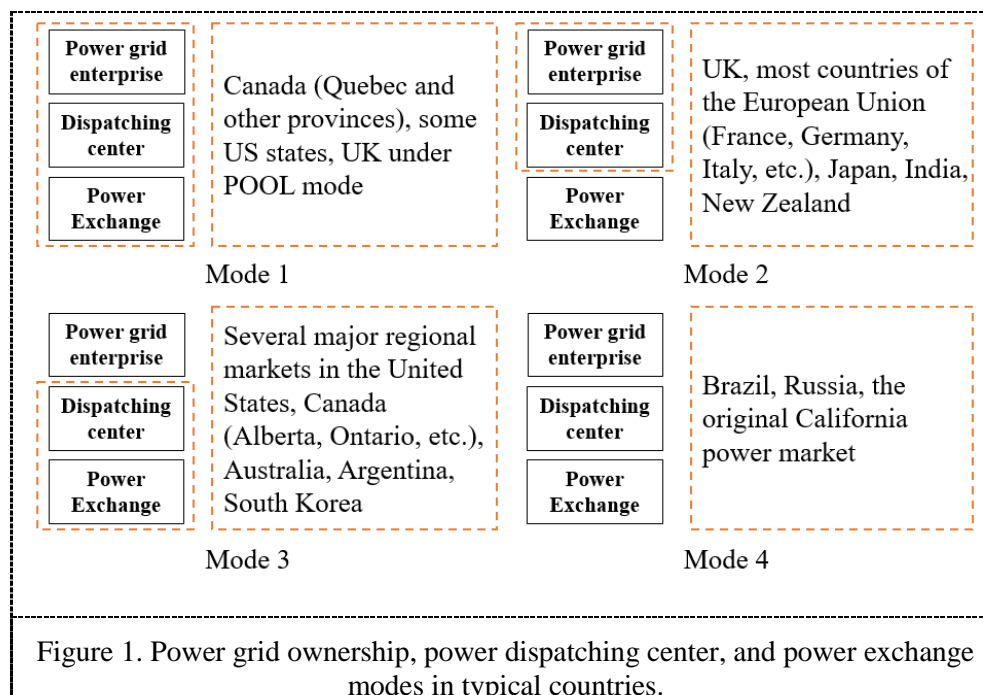
For example, the construction of the United Kingdom electricity market has mainly experienced four stages: Pool, New Electricity Trading Arrangements (NETA), British Electricity Trading and Transmission Arrangements (BETTA), and new reform in 2011 [2]. In the UK power market reform process, the power exchange is independent from the power grid, which is similar to China's current reform process. The Electricity System Operator (ESO) in Great Britain only balance electricity supply and demand in real time since 2017 [3]. While in other countries, they have the different situations.

Modes of grid network ownership, institutional setup of power dispatching center and power exchange in the major countries of the world are compared in this paper. The underlying reasons behind them are summarized. The paper also summarized the divisions of responsibilities in the medium and long term market, spot market of electricity.

2. Modes of power grid ownership, power dispatching center, and power exchange in typical countries

As shown in Fig. 1, from a global perspective, modes of power grid ownership, power dispatching center, and power exchange in typical countries can be mainly divided into the following four kinds.





2.1. Mode 1: Integration of power grid ownership, power dispatching center and power exchange

It is mainly applicable to only one transmission company in the electricity market. The market is a single power purchase mode, and the power trade is based on the centralized bidding market. This mode ensures a high degree of coordination of power trading, system scheduling, system operation and maintenance.

Countries and regions based on this mode mainly include the provinces of Quebec, Canada, some unreformed states in the United States, and the United Kingdom under the POOL mode. For example, in the United Kingdom under the POOL, the power dispatching center and the power exchange are all set up within the British National Grid Corporation (NGC). The NGC transmission, dispatching and trading functions are one.

2.2. Mode 2: Power grid ownership and power dispatching center integration, independent power exchange

Power grid ownership and power dispatching center integration is the common mode of the power grid operation, and practice has proved to be a reasonable choice for adapting productivity to production relations.

In most countries around the world, including the United Kingdom, France and other countries with advanced electricity market reforms, they have chosen the organizational mode of power dispatching center and power grid ownership integration. In the United Kingdom, for example, two independent trading institutions, APX and N2EX, and the power dispatching center System Operator for Great Britain (GBSO), which is affiliated with the British National Grid Corporation, have been established. The trading organization is mainly responsible for electricity financial contract transactions, on-site standard contract transactions and the organization of the centralized bidding market. The dispatching agency is responsible for operating the balanced market and the auxiliary service market, ensuring real-time power balance and power system security.

Some countries have also clarified the integration of power dispatch and power grid in legal form. For example: Italy, Portugal, Spain, France, Germany, Norway, Sweden, Finland, Denmark, the United Kingdom and other European countries as well as Japan, New Zealand, some US states. The repeated process of re-integration with the power grid after the establishment of an independent dispatching agency in Italy fully demonstrates that power dispatching and power grid integration are

the development trends of grid dispatching in countries around the world. Japan is similar to Europe, and its dispatching function still belongs to several major vertically integrated large-scale power companies such as Tokyo Electric Power. In Russia, which has implemented a fragmented structure split, its power system reform strategy also proposes to consolidate the system dispatching company and the federal power grid company (transmission company) in order to ensure the safe and reliable operation of the power system.

2.3. Mode 3: Power dispatching center and power exchange integration, independent power grid ownership

This mode is mainly applicable to the situation that property rights of the transmission and distribution network belong to multiple investment entities due to some historical and practical reasons, which make it difficult to integrate in the electricity market. This mode is a second-best method, which can better adapt to the needs of large-scale optimization of energy resources and ensure safe production of the grid. Due to the administrative and information barriers between the dispatching agencies and the power grid companies and between different dispatching agencies, the complexity and coordination difficulty of the planning, investment and construction of the power grid and the implementation of the safety responsibility have been significantly increased.

The United States, Canada and so on use this mode. Taking the PJM in the United States as an example, it undertakes three functions of power grid planning, electricity market operation and power dispatching operations, and is responsible for organizing the day-ahead and real-time market, capacity market and transmission rights transactions. PJM does not have a separate power trading institution. Bilateral transactions are determined by market members on their own. The power financial transactions are mainly conducted on the New York Mercantile Exchange and the US Intercontinental Exchange.

2.4. Mode 4: Independent power grid ownership, power dispatching center and power exchange

This model is mainly applicable to countries with a fragmented split reform mode and a more dispersed power grid management system. In this type of model, system dispatchers, power trading institutions, and grid owners are completely separated according to their functional division of labor.

There are fewer countries adopting this model, mainly including Russia and Brazil.

3. The relationship of the power system development behind the different institutional settings

From the international experience, in order to ensure the safe operation of power systems, power dispatching and power grid integration are the common choice and development trend of most national power grid dispatching modes. The setting of power exchange is closely related to the characteristics of the power industry in various countries, the main trading mode of the electricity market and the marketization process.

In the initial stage of power marketization, most countries in Europe and the United States did not set up separate power trading institutions (power exchange). The integrated operation of the power grid, power dispatching and power exchange has ensured the safe operation of the power grid, significantly improved market efficiency and fairness, and promoted a smooth transition in the initial stage of power marketization. On the one hand, in the initial stage of the construction of the electricity market, there are fewer market entities. As the main body of purchase, the grid companies, in accordance with market rules, organize the purchase of electricity through bidding, which can maintain a high degree of uniformity between the electricity market and the power grid, while meeting the needs of fairness and justice. There is no need to set up an independent power trading institution. On the other hand, in the initial stage of electricity market construction, the transaction types are mainly based on physical transactions. Physical transactions are subject to physical objects and delivered on time. It is necessary for trading institutions, power dispatching agencies, and grid companies to closely cooperate to keep abreast of the operation of the power system and ensure the trading efficiency.

With the increasing degree of marketization of electricity, most countries have begun to introduce a large number of power financial trading types to avoid market risks and hedges, and gradually set up independent power trading institutions. One of its important functions is to carry out futures, option-based power finance and derivatives trading. It provides a neutral platform and uses this as a means to introduce a large number of financial entities to participate in trade and expand the scale.

4. Power dispatching and trading business division mode

4.1. Business division mode of power grid ownership and power dispatching center integration, independent power exchange

For the mode of power grid ownership and power dispatching center integration, independent power exchange, e.g., United Kingdom, most countries in the European Union (France, Germany, Italy, etc.), Japan, India, New Zealand and other countries, the power exchange is mainly responsible for the medium and long term market, spot market of electricity (including the day before and during the day). For example:

4.1.1. United Kingdom.

Trading: The UK's APX and N2EX two power exchanges are mainly short-term power trading, mainly providing power trading from a few months to half an hour ago.

Dispatching: The British NGC is responsible for running the balance mechanism and using market-based means to resolve the deviation between the contracted and actual power.

4.1.2. France.

Trading: The current electricity trading institution in France is European Power Exchange Spot, a power spot exchange under the European Energy Exchange. The French electricity market mainly includes: medium and long term bilateral power trading (market members self-developed, off-exchange OTC), power financial derivatives trading (on the European Electricity Exchange), and day-to-day spot trading (on the European Power Exchange Spot).

Scheduling: The French grid RTE is responsible for the balancing mechanism.

4.1.3. Japan.

Trading: The Japanese wholesale electricity market is organized by the Japan Electric Power Exchange. Currently, Japan Electric Power Exchange has two trading markets: the spot trading market (on September 28, 2009, the power trading was carried out half an hour ago) and the futures trading market (annual trading, monthly trading and weekly trading).

Scheduling: Scheduling does not participate in power trading, only responsible for balancing.

4.2. Business division mode of power dispatching center and power exchange integration, independent power grid ownership

In several major regional markets in the United States, Canada (Alberta, Ontario, etc.), Australia, Argentina, South Korea, etc., the power trading is integrated and independent of the grid company. The dispatch and trading agency is responsible for all markets from medium to long term to spot.

4.3. Business division mode of independent power grid ownership, power dispatching center and power exchange

California initially adopted a completely separate mode of the power exchange and the independent system operator (ISO). Power exchange is responsible for the day-ahead market and the hour-ahead market. ISO is responsible for the real-time electricity market and ancillary services. This model has been pointed out by experts to complicate operations and result in increased operating costs and conservative operations. In the 2000 power crisis in California, the flaws in this model were fully exposed. In the California power crisis, electricity prices soared. Power reserve was less than 1.5% of

total usage, and had to be divided into power outages, which had a great impact on power users. In January 2001, power exchange was insolvent due to the scarcity of power trading. The function of the day-ahead market and the hour-ahead market was transferred to the California ISO, which actually realized the merger of power exchange and ISO.

5. Conclusion

Four different modes of power grid ownership, power dispatching center, and power exchange are summarized in this paper. The relationship of the power system development behind the different institutional settings is analyzed. Finally, this paper summarized the dispatching and trading business division modes.

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