Development Mode of Regional Electricity Market in South China

Qian Sun¹,², Xiaolei Li²,³, Lin Tian¹,², Pengfei Fan²,³, Junwei Yang¹,⁴, En Lu¹,⁵, Zhisheng Huang¹,⁶, Jie Qin¹,⁷

¹Guangdong Power Exchange Center Co., LTD, Guangzhou, China
²China Electric Power Planning & Engineering Institute, Beijing, China
³Corresponding author e-mail: xiaoleili@eppei.com, sqdly@hotmail.com,
⁴33516863@qq.com, pffan@eppei.com, ⁵yangjunwei@gd.csg.cn, ⁶hbluen@163.com,
⁷haungzhisheng@gdyd.com, ⁸164970581@qq.com

Abstract. In recent years, China's electricity market reform has continued to deepen, and the construction of the electricity market has been accelerating. According to the national power pilot reform policy, the southern regional electricity market will start with the Guangdong spot market, and then gradually develop to the southern spot market. In this paper, the realization method of power market integration is analysed, and several paths for provincial market to develop into regional spot market are put forward according to the characteristics of Southern regional power system.

1. Introduction

The Third Plenary Session of the 18th CPC Central Committee proposed to make the market play a decisive role in resource allocation and better play the role of the government, actively and steadily promote market reforms from breadth and depth. It is proposed to allocate resources according to market rules and market prices, and maximize efficiency and optimize efficiency through market competition. Since the release of Document No. 9 in 2015, a new round of power market reform has been launched, and the reform of power market continues to deepen. The contents of the NO.9 file includes: deregulating dispatch schedule and the competition in wholesale and retail market; forming a relative independent trading institution and standardizing its operation; strengthening government supervision, power generation planning, efficient operation and reliable supply. By the end of 2018, most provinces of China had conducted medium and long-term transactions. In August 2017, the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) identified seven provincial spot market pilot projects and one regional spot market pilot project starting from provincial market [1].

At the end of August 2018, Guangdong electric spot market pilot announced its first trial operation [2]. In the southern region, Guangxi, Yunnan, Guizhou, Hainan provinces mainly carry out medium and long-term transactions, and have not yet formulated a spot market construction program. Southern regional electricity market can give full play to the role of market mechanism in the optimal allocation of resources in a wider range, promote the overall absorption of Southwest hydropower in the southern grid, and realize the security and stability of power system and orderly operation of market mechanism.
How to develop the spot market in the southern region on the basis of the spot market in Guangdong Province is the focus of this paper.

2. The method of power market integration

In recent years, renewable energy has developed rapidly. The intermittent nature of renewable energy leads to its need to be absorbed on a larger scale. At the same time, the enlargement of market area will also bring about the improvement of economy and security. Market integration is a trend of power market development in recent years. Many literatures have carried out in-depth research on power market merger.

References [3] studied the process of European electricity market integration, analyzed the role of some identified obstacles to delay the process of liberalization and integration of European electricity markets and to impede the achievement of its full benefits, to pass on this efficiency gains to final consumers by lowering prices of electricity. References [4] analyzed the benefits of further market integration of European wholesale electricity markets. It is pointed out that major gains from trade are still left unrealized due to uncomplete market coupling of national wholesale markets, isolated national regulation of capacity and reserve mechanisms and a lack of harmonization of national support schemes for renewable energies. References [5] studied on the Association of South East Asian Nations (ASEAN) Energy Market Integration. This paper argues that global experience in regional energy market integration provides a wide range of integration elements, including binding agreements, physical infrastructure, standardized or coordinated operational rules, and regulatory or coordinating bodies. The pathway to ASEAN Energy Market Integration should involve creating these elements.

Based on the development process of electricity markets in Europe and the United States, it can be seen that there are mainly two ways of electricity market integration [6]: consolidation and coordination.

The first way is consolidation of markets and system operators. Consolidation doesn’t change the ownership of the grid, but operations have to be unified under the responsibility of a single entity, so to achieve the merging of system operations. Consolidating has proven a very powerful approach to optimize use of scarce transmission infrastructure, particularly under a nodal pricing system, such as PJM Interconnection power market. It gradually expanded its footprint to become one of the largest interconnections in the world. These integrations increased the benefits of PJM’s wholesale electricity market.
The second way is co-ordination of system operators. European Network of Transmission System Operators for electricity is a demonstration of the application of this merger method. Compared with consolidation, co-ordination usually leads to lower utilization of cross-border capacity, complicating new network investments. The degree of market development and market structure among European countries are different, and the economic development situation, interest demands and resource endowment of each country are also different. It is more complicated to coordinate the interests. Therefore, Europe has adopted a unified model from simplicity to rarity. Starting from the long-term bilateral electricity market transactions, it has gradually developed to include day-ahead, intraday, ancillary services and balance services.

![Figure 2. The Coupling Process of European Electricity Day-ahead Market](image)

3. Characteristics of regional power system in South China

The South China Power Grid covers five provinces, including Guangdong, Guangxi, Yunnan, Guizhou and Hainan. It is connected with the power grids of Hong Kong, Macao and Southeast Asian countries. Its East-West span is nearly 2,000 kilometers, and its power supply area is 1 million square kilometers. By the end of 2017, the power supply in five southern provinces was installed at 307 million kilowatts. The electricity consumption of the whole society reached 1073.3 billion kWh. In 2015, a total of 189.13 billion kilowatt-hours were sent from west to east.

The regional power system in southern China has the following characteristics. First, the system is large in scale and complex in structure. Second, the inter-provincial electricity exchange scale is large, accounting for a high proportion. The proportion of foreign electricity in Guangdong Province is about 30%. Thirdly, the types of power supply in the region are diversified. In 2017, hydropower accounted for 37%, coal 40%, gas 5.5%, nuclear 4.5%, wind 5.5%, photovoltaic 2.7% and other types 3.5%. Fourthly, the characteristics of provincial power grid zoning are obvious. Fifthly, the grid congestion is serious in some areas. The local section of Guangdong power grid is perennially limited.

![Figure 3. Coverage of China Southern Power Grid Corporation](image)
These characteristics have an impact on the construction of the southern regional electricity market. From the point of view of power system scale, the installed capacity and maximum load of Southern Power System are equivalent to that of PJM, and it is suitable to develop into a regional power market. The scale and proportion of inter-provincial power exchange are relatively large, and the electric connection is closely related, so it is suitable to develop into an integrated regional power market. From the point of view of power supply type, hydropower and coal-fired power account for the main share, and their installed proportion is basically the same. Such power supply system structure is conducive to giving full play to the characteristics of different types of power supply and making full use of the complementary advantages of water and fire, but at the same time, attention should be paid to the impact of peak and low season conversion of hydropower on electricity market price. The characteristics of provincial power grid zoning make the Southern Regional Power Grid naturally have more accurate and reasonable pricing zoning, which provides a variety of possibilities for the development of regional power market. Finally, congestion is also a factor that must be considered in the construction of the southern regional market.

4. Development model of Guangdong market to Southern regional electricity market

In the process of the construction of the southern regional power market, we should adhere to the principle of steady start and gradual progress, carry out market-oriented construction in stages, and form a unified, open, competitive and orderly Southern regional power market under the supervision of the government.

4.1. Short-term development model

In the initial stage of the southern regional market, considering the traditional management system of the dispatching of the provinces in the southern region, the experience gained by the provinces in the new round of power market reform and the development of the technical support system, the first step is to carry out the joint optimization of the medium and long-term transactions within the southern region based on the capacity constraints of the inter-provincial tie-lines. The provinces still adopt independent days-ahead and real-time scheduling mode. Such a way of starting is conducive to ensuring the balance of power consumption and the security of power system in each province. It is operable and easy to realize. At the same time, it has a long-term foothold and lays a foundation for the development of regional market in the next stage.

The market structure of the recent stage is described as "unified medium and long-term transaction optimization + day-ahead intra-provincial scheduling + intra-provincial real-time balance". On the basis of the decomposition of power transmission contract from west to east, and based on the residual capacity of inter-provincial lines, medium and long-term transactions are carried out in many ways, including off-site bilateral negotiation, on-site listing and centralized competition, so as to optimize the medium and long-term transactions at the regional level in the south. Considering that the inter-provincial power exchange affects the power balance of each province, all inter-provincial power transactions are physical transactions.

![Figure 4. Market structure in short term](image-url)
4.2. Long-term development model
In the long run, the Southern Regional Market will enter the regional spot market. At present, as a pilot spot market in the southern region, Guangdong Province has issued a series of rules of spot market and carried out trial operation. Other provinces and regions are still in the middle and long-term trading stage. Under this situation, there are many ways to implement the regional spot market.

4.2.1. Unified Development Mode. Unified development path refers to the realization of unified joint optimization within the area of Southern China Power Grid in the day-ahead, the realization of resource optimization in a larger scope, and the completion of market integration in a shorter time scale under the condition of accumulated experience and qualified conditions. However, this path will pose certain challenges to the technical and relevant support system.

After realizing the unified operation of the market of the Southern Power Grid, the real-time market will be brought into the regional market, and extended from the energy market to the auxiliary service market, the capacity market, the transmission right market and other fields according to the development of the market, eventually forming a unified power market in the southern region.

Figure 5. Market structure of Unified Development Mode

4.2.2. Gradual evolution Mode. The gradual evolution path refers to the integration of Guangxi into the spot market framework and the formation of the "Two Guang" receiving area spot market based on the development experience of Guangdong electric power spot market. The spot markets of Yunnan, Guizhou, Hainan and "Two Guang" regions adopt the method of unified clearing of medium and long-term transactions to realize market coupling. With the development and perfection of the spot market in the "Two Guang" region, Yunnan, Guizhou and Hainan will be further integrated into the spot market, eventually forming a unified spot market in the southern region.

Figure 6. Market structure of Gradual Evolution Mode
4.2.3. **Parallel development Mode.** Parallel development path refers to the construction of spot market independently in Guangxi, Yunnan, Guizhou and Hainan provinces on the basis of the development of Guangdong’s spot market, and the realization of market coupling between provincial markets through unified clearing of inter-provincial markets. The provinces adopt the same model as Guangdong's spot market. After the development of provincial markets is improved to a certain extent, the provincial markets will be integrated. Unified integration into the Southern Regional Market.

![Figure 7. Market structure of Parallel Development Mode](image)

5. **Conclusion**
From a worldwide perspective, there is no same development model in the electricity market of different countries or regions. In recent years, China has carried out electricity market reform. Based on China's national conditions, how to develop provincial and regional electricity markets in China is an urgent problem to be solved. This paper describes the progress of China's electricity market reform since 2015, summarizes the path and method of integration of European and American electricity markets, analyses the characteristics of Southern Power System, and gives the path of transition from Guangdong Power Market to Southern Regional Power Market from short-term and long-term stages.

**Acknowledgments**
This work was financially supported by the Science and Technology Project of Guangdong Power Exchange Center Co. Ltd. (GDKJXM20173071).

**References**
[1] General Office of the National Development and Reform Commission and the National Energy Administration, Notice on Pilot Work of Electricity Spot Market Construction. http://www.ndrc.gov.cn/gzdt/201709/20170905_860117.html
[2] The first spot electricity market in China has been put into trial operation, http://www.csg.cn/xwzx/2018/mtgz/201809/t20180901_170635.html.
[3] Marta Ferreira Dias, Integration of european electricity markets, A Thesis for the Degree of PhD at the University of Warwick.
[4] Böckers, Veit, Haucap, Justus, Heimeshoff, Ulrich, “Benefits of an Integrated European Energy Market”, University of Düsseldorf (DICE).
[5] Navarro, Adoracion M, Sambodo, Maxensius Tri. The Pathway to ASEAN Energy Market Integration.
[6] Manuel Baritaud and Dennis Volk. Seamless Power Markets - Regional Integration of Electricity Markets in IEA Member Countries. International Energy Agency, 2014.