The Chilean electricity market and its implications

Hechun Wang¹, Zhonghua Xie¹, Qin Le¹, Kai Wang²,⁎, Hua Li³, Jing Tao², Dunnan Liu³

¹Jiangxi Power Trading Center Co., Nanchang, China
²School of Information Engineering, Nanchang University, Nanchang, China
³School of economic and management, North China Electric Power University, Beijing, China

⁎wk1994@email.ncu.edu.cn
792316208@qq.com

Abstract. Chile was one of the first countries in the world to successfully reform its electricity market. Limited by the dilemma of energy dependence on imports, Chile's electricity price fluctuates greatly. Therefore, in recent years, Chile has been committed to the transformation of the new energy structure and introduced a series of policies to promote its energy development. This paper analyzes the current situation, the reform process, and the operation mechanism of the electricity market in Chile, Focused on the characteristic mechanisms and policies in Chile's energy transition. Finally, combined with the current situation of China's electricity market, draw lessons from Chile's electricity market construction highlights and put forward relevant thinking and suggestions.

1. Introduction

The Electricity industry is the primary industry of the national economy and an important safeguard for economic development and social progress. Due to the large capital investment related to traditional generation technology and power-supply facilities, the power supply has been considered as a public natural monopoly industry. But this concept is gradually changing, Chile is a regional forerunner in privatizing and deregulating the power department. Today, the electricity market in Chile has entered the ranks of the most open, efficient, and competitive electricity market in the world, and the reform experience can be used as a reference for other countries that are developing the privatization of the electricity market.

In 2015, China's "Several Opinions of the CPC Central Committee and the State Council on Further Deepening Electricity System Reform" (Zhongfa [2015] No. 9) kicked off a new round of electricity system reform, with provinces beginning to explore medium- and long-term trading of electricity. China's electricity market is still in the settlement phase in the spot market. As we think about privatizing the electricity market, we should also consider the impact of a high percentage of renewable energy access on the electricity market. Chile's experience in privatizing the electricity market and energy structure transition has been very successful, which is of reference for building the electricity market in China.

This paper first presents the current development and the evolutionary process of the electricity market in Chile. Screening the corresponding institutions in the energy market and the innovative energy structure transition mechanism, focusing on the block bidding system, multiple measures to improve
energy efficiency, and capacity compensation mechanisms. By exploring the advantages of the market-building process in Chile and the actual situation in China, this paper puts forward enlightenment and suggestions to build the electricity market in China.

2. Chile electricity market reform process

2.1. Chile electricity market status

Chile is a relatively rich country in South America resources, has a very rich mining, forestry, and aquatic resources, the north is extremely rich in solar energy resources, has a vast Atacama desert; Central has wind power, solar energy, and a small amount of hydropower resources; The south has rich hydropower resources and a small amount of wind power resources[3].

As of 2020, Chile has a total installed capacity of 24745 MW[4][5], and the generation mix can be seen in fig1.

![Power generation mix in Chile](image1)

Fig.1 power generation mix in Chile

Compared with Chile's abundant new energy varieties, its traditional energy reserves are not much, and it is a typical energy importing country, especially its fossil fuel reserves. Energy sources such as oil, natural gas, and coal mainly rely on imports. Due to the lack of traditional energy sources, changes in oil prices in the international market, difficulties in importing fuels from neighboring countries, and environmental pressure from burning fossil fuels have a great impact on Chile[6]. Taking 2008 as an example, the marginal cost price of electricity rose from US$60 per MW in early 2006 to US$340 per MW in 2008 due to the reduction of imported energy. Therefore, the Chilean government has been working to resolve the diversification of the country's energy supply structure.

Since 2000, Chile's electricity demand has grown significantly with economic growth. Between 2000 and 2018, electricity consumption grew at an average rate of 4.1% per year[7].

![Chile Electricity Consumption](image2)

Fig.2 Electricity consumption in Chile 2000-2018
2.2. The history of Chile's electricity market reform
Chile has started the privatization reform of the power industry since the second half of the 1970s. It is the first country in the world to carry out extensive electricity reform[8][9] and achieve success.

In 1982, Chile promulgated the Electricity Act, which laid an important foundation for power operation activities and laid down conditions for its development. The separation of power production, transportation and distribution allows each sub-sector to participate in reasonable competition, which has resulted in a significant improvement in the electric power industry and operational efficiency in Chile, coordinated development of investment and demand and improved power transmission and distribution losses. In 2003, the reform of the power industry had basically matured in many aspects.

Chile revised the Electricity Act twice in 2004 and 2005. Among these amendments, especially some incentive measures to build new power stations, multiple ways to increase the transportation system, more transparent charging and other issues that played a good role in filling some of the shortcomings of the Electric Act.

In 2008, the development of new energy sources such as solar energy in Chile entered a new stage. In the context of narrow electricity supplies and rising electricity prices, Chile passed the Non-Conventional Renewable Energy Law. The purpose of the law was to authorize the development of renewable energy portfolio standards, which have also become the main mechanism for encouraging the development and investment of renewable energy.

In 2010, Chile passed the Energy Ministry law. The framework combining energy and mining activities has expired. The energy policy issued by the government in 2015 focused on increasing the share of renewable energy and modifying the auction system in the electricity market. The purpose of the energy policy is to increase the diversity of energy supplies while reducing costs and improving safety factors.

Chile passed the Transmission Law in 2016. The problem of grid congestion caused by the rapid expansion of renewable energy generation has been solved, making power generation planning more complete and grid administration more centralized. Adjusting the payment of transportation fees to promote the development of renewable energy. The energy roadmap released in 2018 takes low-emission energy as one of seven strategic areas to foster the development and enhancement of various renewable energy sources.

As an emerging country in renewable energy development, Chile has been developed for less than 10 years, but its renewable energy resources are plentiful and the achievements of the electricity market reform have attracted international attention.

3. Highlights of Chile's power market energy transition

3.1. Block bidding system
To encourage the adoption of renewable energy and increase competition, a new resolution was approved by the Chilean National Energy Commission in 2014[10]. It introduced a time block (hourly and quarterly) system where generators bid for specific time blocks of the day, rather than 24 hours a day. For non-traditional renewable energy sources, mainly wind and solar, where each supplier bids for different quantities and prices of energy supply for any time block defined in the bidding process, the new block bidding system can meet the disadvantages of intermittency and uncertainty of non-traditional energy sources, promoting technological change among suppliers and facilitating the development of the electricity generation market.

The hourly blocks (Supply Block #1), it consists of three unequal blocks, covering 24 hours. The quarterly block (supply block #2) consists of four equally divided blocks, each of which lasts for three months and covers one year.
The goal for the first block is to find the lowest possible price per 24-hour period. Zone B will be favored by most solar bidders because it represents sunlight (10 hours from 8 am to 6 pm). Bidders can make various combinations of quotations in these three blocks, or bid in only one block. Of course, the goal is to fill the three zones with a duration of 24 hours. If in the first round, the total price does not exceed the ceiling price, they will enter the second round.

The goal of the second block is to reduce the annual price, including four identical calendar quarters (January to March, April to June, etc.). In this case, seasonal renewable energy may have an advantage. For example, a small hydropower project may only bid within one or two quarters when it has the most certain abundant resources, allowing it to bid very aggressively; similarly, the wind power in Patagonia is in the summer (first and fourth Quarter) peak.

Chile's time-scaled energy block trading has achieved the expected results. With the intensified competition, it has promoted the consumption of renewable energy, and the price of electricity has fallen, which has been praised by all parties.

3.2. Multiple measures to improve energy efficiency

Considering that Chile's energy depends on external input, improving energy efficiency has become an important measure of the national strategy to respond to the growing energy demand. Chile has adopted a series of measures to restrain energy efficiency[11][12].

Chile has formulated a national energy efficiency strategy to save energy for large consumers. The Energy Efficiency stipulates that major manufacturers such as mining companies, shopping malls, and pulp mills must be included in any national energy efficiency strategy. For example, for the industrial and mining sectors, encourage the development and implementation of energy management systems, the promotion of cogeneration and the incorporation of effective technology and technical assistance into projects, and the adoption of energy efficiency measures.

Formulate the Energy Efficiency Seal. The issuance and category of the seal depend on the implementation of the company’s energy management system, the number and type of development projects, and the reduction rate of energy consumption. For those companies that are developing energy efficiency and efficiency, give Rewards to enhance the competitiveness of enterprises, and further reduce emissions.
On the demand side, establish minimum energy performance standards (MEPS) and labels. Under the premise of not affecting user satisfaction and product performance, limit the energy consumption of products and incorporate product energy efficiency labels into consumer decision-making; through efficient residential and street lighting schemes, encourage energy-saving electrical appliances to replace, and guide residents to more effective Technology and electrical transition. For example, in terms of residential energy use, distributed power generation has great potential for improving efficiency and deploying renewable energy, especially rooftop solar power, which has been widely used in the United States and Europe. About half of the energy consumption of Chilean households comes from water for heating. By establishing energy efficiency standards and labels for household appliances, using lower-cost, efficiency, and stored solar energy, combined with some incentive measures, promotes the development of distributed power on the user side.

3.3. Capacity compensation mechanism
Chile's capacity compensation mechanism[13] is designed to provide capacity compensation to power producers through capacity prices set by the regulator to help them recover their fixed costs. This capacity compensation mechanism is implemented by setting a capacity tariff and calculating compensable capacity.

Unlike markets in Europe and the United States, all generators do not quote prices, but simply report their available capacity and their operating costs, which are reviewed by the generation-side spot market operation center. The spot market aims at minimizing the total generation cost and makes safe and economic dispatch based on the system load and unit marginal cost of generation at a certain point of time, and the marginal discharge forms the market price of electric energy. When the market price is set by the higher variable cost, the generators with lower variable cost can recover not only their variable cost but also part of their fixed cost in the spot market; while the units with the highest variable cost in the market can only recover their variable cost from the spot market.

Thus, to help generators recover their fixed costs, Chile complements the spot market on the competitive generation side by providing capacity compensation to generators through capacity prices set by the regulator.

4. Implications for China's power market

4.1. Improve the reasonable consumption system of new energy
Over the past decade, the trading of long-term electricity supply contracts has become an important energy policy tool. This is particularly true for developing countries, where electricity markets are often highly volatile and the risks of supporting the construction of new power plants, new energy sources and financing are high. The Chilean experience is useful for developing countries in a similar situation, as well as for developed economies that can use the bidding mechanism as a powerful tool to replace traditional forms of generating unit bidding sustainably, promoting the consumption of new energy sources and incentivizing market consumers to explore energy-efficient new energy generation markets. Drawing on the Chilean block bidding system, combined with distributed power characteristics, explore the bidding method with time standard, can more reasonably suppress the fluctuating characteristics of new energy output, encourage new energy consumers to participate in the electricity market, promote new energy consumption, and promote the development of renewable energy.

4.2. Cultivate the awareness of market entities
On February 24, 2020, the National Energy Administration of China issued the "Implementation Opinions on Promoting the Independent and Standardized Operation of Electricity Trading Institutions"[14], which pointed out that the establishment of a market-based electricity price formation mechanism will be accelerated to gradually realize the power generation and consumption of commercial electricity consumers. The plan creates conditions for full liberalization. China is one of the
largest potential markets for a demand-side response, but the role of demand-side response in the balance of power grid supply and demand interaction has not yet received full attention.

5. Conclusion

Drawing lessons from Chile’s experience, China can explore the market construction that Consumers gradually open up. In the process of market construction, it is necessary for China to pay full attention to the driving role of demand-side consumers in the market, also we have to explore the refined processing of user-side market entity data, guide market entities to transform electricity consumption habits, and gradually shift to economical, efficient and energy-based electricity consumption models.

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