

Evaluation on the Effectiveness of New Energy Market-Based Trading in Promoting New Energy Consumption

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Abstract. In recent years, in order to promote the consumption of new energy, many regions in China have carried out new energy market-oriented trading exploration, including direct trading of new energy and large users, new energy and thermal power generation rights trading, new energy cross-provincial medium and long-term trading, new energy cross-regional spot trading, and the establishment of a peak shaving auxiliary service market. This research takes typical new energy-rich provinces as an example to quantitatively analyze the effectiveness of the typical trading mechanism of new energy consumption in promoting new energy consumption. It is an inevitable trend to promote the consumption of new energy through market-oriented transactions. Combined with the construction process of China's power market, the market will fully play the role of optimizing the allocation of resources, accelerate the construction of a power market-oriented trading mechanism that adapts to the consumption of new energy, and further utilize the market mechanism to promote new energy the role of energy consumption.

1 Status quo of new energy market-based trading in China

In recent years, in order to promote the consumption of new energy, many regions in China have explored the market-based trading of new energy, including new energy direct trading with major consumers, new energy and thermal power generation rights trading, new energy interprovincial medium and long-term trading, and new energy cross-regional spot trading, and establishing a peak-shaving ancillary service market. In 2020, the new energy market-based trading volume in the State Grid footprint is 157.7 TW·h, accounting for 21.7% of the new energy output, in which, the intra-provincial new energy trading, such as new energy direct trading with major consumers and power generation rights trading volume, is 65.7 TW·h, and new energy interprovincial trading volume is 92 TW·h. In addition, Northeast China, North China, and Northwest China have increased the consumption of new energy by 44.8 TW·h through the peak-shaving ancillary service market[1-3].

1.1 New energy direct trading with major consumers

New energy direct trading with major consumers (direct purchase of power by major consumers) refers to the trading organized by the provincial development and reform commission, energy bureau, and provincial power company between the new energy power generation companies and large-scale power consumers in steel and

metallurgy industry via the trading platform. The basic idea behind such trading is to attract industrial enterprises with large power consumption to use new energy at preferential prices and promote the consumption of new energy in market-based methods. New energy is involved in the direct purchase of electricity by major consumers, in which the trading price and trading volume are determined by both parties through negotiation, or through centralized matching or centralized bidding[4-5].

Since the power system reform was launched in 2002, China has carried out pilot programs and explorations in direct trading between power generation companies and major consumers. Initially, most provinces required that the power source involved in the trading must be thermal power units, and some provinces, such as Inner Mongolia, allowed centralized PV and wind power companies to participate in direct trading. Since the new round of power reform was launched, some provinces rich in new energy, such as Qinghai, Xinjiang, Inner Mongolia, Ningxia, Shanxi, and Liaoning, have all activities carried out new energy direct trading with major consumers. In 2020, the new energy direct trading volume with major consumers in the State Grid footprint reaches 53.4 TW·h, a year-on-year increase of 24.5%.

1.2 New energy and thermal power generation rights trading mechanism

New energy power generation rights trading refers primarily to the replacement of power generation rights between new energy companies and coal-fired self-provided power plants. When the power grid is forced to

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curtail wind power due to peak-shaving or grid constraints, the coal-fired self-provided power plants participating in the trading will reduce their power generation and make way for new energy. New energy companies will replace the self-provided power plants for power generation, meanwhile, the self-provided power plants will be granted a certain economic compensation, at a price negotiated by the coal-fired self-provided power plant and the new energy power generation company[6].

In 2020, the areas with a large installed capacity of self-provided power plants in Gansu and Xinjiang, have promoted the consumption of new energy by power generation rights trading between new energy and self-provided power plant. In the State Grid's footprint, the annual trading volume reaches 12.3 TW·h, a year-on-year decrease of 13.4%.

1.3 Peak-shaving ancillary service market trading mechanism

China has established a power peak-shaving ancillary service market, which is a major breakthrough in implementing "Two Rules" (Grid-connected Power Plant Ancillary Service Management Implementation Rules and Power Plant Grid-connected Operation Management Implementation Rules). A more outstanding problem of insufficient power system regulations occurred after the large-scale connection of new energy into the grid, and the compensation mode in the original supplementary service plan can no longer meet the needs of grid operation. Under the extremely limited peak-shaving space, Northeast China took the lead in exploring the power peak-shaving ancillary service market. In October 2014, Northeast China power peak-shaving ancillary service market was launched, which was the first nationwide attempt to marketize the peak-shaving ancillary service. Subsequently, various provinces and regions in China began to explore market-based power peak-shaving ancillary services[7].

As of the end of 2020, 5 regional and 13 provincial power grids in the State Grid's footprint have formulated and issued rules for the peak-shaving ancillary service market, which were all put into operation. In 2020, driven by the peak-shaving ancillary service market mechanism, the conventional power peak-shaving has consumed 44.8 TW·h of new energy more, a year-on-year increase of 261.3%.

1.4 New energy interprovincial medium and long-term trading

On December 7, 2012, in order to leverage the fundamental role of the market in the optimal allocation of resources, the State Electricity Regulatory Commission issued the Basic Rules for Interprovincial and Inter-regional Electric Energy Trading (Trial) to regulate the interprovincial and inter-regional energy trading. In August 2018, Beijing Power Exchange issued the Rules for the Implementation of Inter-regional and Interprovincial Power Medium and Long-term Trading (Interim), proposing that interprovincial trading can be

divided into interprovincial export trading, interprovincial direct power trading, and interprovincial power generation rights trading based on the transaction assets[8].

In recent years, new energy interprovincial medium and long-term trading power has steadily risen. Take the footprint of State Grid as an example, in 2010, the interprovincial medium and long-term trading volume of new energy was only 0.15 TW·h, while in 2013 it has exceeded 10 TW·h, and, in 2020, reached 88.4 TW·h, a year-on-year increase of 7%.

1.5 New energy cross-regional spot trading

At present, the cross-regional spot trading of new energy is carried out under the cross-regional and interprovincial spot trading framework of surplus renewable energy power. On August 15, 2017, the Inter-regional and Interprovincial Surplus Renewable Energy Spot Pilot Rules (Trial) was released. The National Electric Power Dispatching Control Center cooperated with Beijing Power Exchange to arrange spot trading of power through cross-regional power transmission channels between power grid companies and renewable energy power generation companies of hydropower, wind power, and PV[9-10].

2 Evaluation on the effectiveness of new energy market-based trading mechanism

2.1 Direct trading mechanism for major consumers

Under the scenario of a major consumer with fixed yearly power consumption, approximately 42% of the load power is used for new energy consumption after including new energy in the major consumer trading; in the mode of adjustable load power trading for major consumer, as the load regulation cycle increases, major-user trading reduced wind and solar energy curtailment. When the load regulation cycle increases to 8 days, the effect of reducing wind and solar energy curtailment will get basically stable. Under the current scale of wind and solar energy curtailment and the mode of major consumer trading, the proportion of direct trading with major consumers can only reach 63% of their power consumption.

2.2 Generation rights trading mechanism

Based on the two types of power generation rights trading modes for self-provided power plant, i.e., real-time active peak-shaving and shutdown backup, the new energy and self-provided power generation rights trading mechanisms are adopted to measure the power consumption increase and curtailment rate of new energy (different modes correspond to different startup methods, Mode 1 is to turn on 3 units, Mode 2 is to turn on 2 units, Mode 3 is to turn on 1 unit, and Mode 4 is to stop and stand by). The results are shown in the following graph.

With the increase in the number of shutdowns of self-provided power plants, the more new energy power can be traded, the more obvious the effect of reducing power curtailment, as shown in Table 1.

Table1. Effect of different power generation rights trading modes in promoting the new energy consumption

Statistical indicators	No substitute trading	Mode 1	Mode 2	Mode 3	Mode 4
Power generation rights trading (TWh)	0	0.84	1.34	1.83	2.29
New energy curtailment rate (%)	29.7	27.3	25.9	24.6	23.3
Wind power curtailment rate (%)	31.5	29.1	27.6	26.2	24.8
PV curtailment rate (%)	24.2	22.1	20.8	19.6	18.5

2.3 Analysis of the effect of peak-shaving ancillary service mechanism in promoting new energy consumption

In this case, the scale of flexible transformation of thermal power units on the whole grid is 4 GW, 8 GW, 12 GW, and 16 GW, respectively, and the minimum technical output of thermal power units reaches 30% and 40% of the rated capacity, respectively. A total of 8 calculation modes are generated. The calculation results show that by improving the regulating capacity of thermal power units and realizing the full utilization of flexibility of thermal power through the peak-shaving ancillary service market, the consumption of new energy can be effectively improved, as shown in Figure 1.

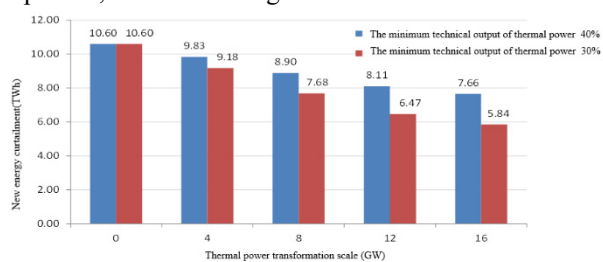


Figure 1. Analysis of the effect of thermal power peak-shaving ancillary services in promoting new energy consumption

2.4 Analysis of the effect of new energy interprovincial trading mechanism in promoting new energy consumption

According to the different interprovincial trading curves, the new energy interprovincial trading mode is set as shown in the table. The calculation results show that the proportion of new energy power generation in the power export can be increased by optimizing the interprovincial export power curve of new energy; due to the volatility of new energy output, the shorter the optimization period of

the DC power generation plan, the higher the proportion of new energy power output. At the daily level, it is most obvious to increase the actual export of new energy by optimizing the export curve based on the new energy output. Under Mode 5 (daily curve optimization), the annual export of new energy can account for 44.9% of the total planned electricity (10 TW·h), as shown in Figure 2.

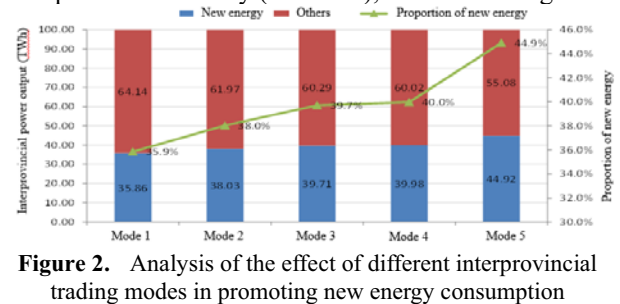


Figure 2. Analysis of the effect of different interprovincial trading modes in promoting new energy consumption

2.5 Comprehensive assessment

The evaluation results show that various new energy market-based trading mechanisms have certain effects on reducing the new energy curtailment and increasing the new energy consumption but the effectiveness of different mechanisms varies in promoting new energy consumption. For direct trading with major consumers, the reduction in the curtailment rate ranges 2.4–3.4 percentage points in the case; for power generation rights trading, the reduction in the curtailment rate ranges in 2.4–6.4 percentage points in the case. For market-based trading of peak-shaving ancillary services, the reduction in the curtailment rate ranges in 2.2–13.3 percentage points in the case. For new energy interprovincial trading, the reduction of the curtailment rate in the case ranges in 10.1–12.6 percentage points, as shown in Table 2. On the whole, the two mechanisms, i.e., peak-shaving ancillary service market and new energy interprovincial trading, have achieved more significant effects in promoting new energy consumption.

Table2. Comparison of the effects of different new energy market-based trading mechanisms

Trading mechanism		Trading effect			
		Direct trading	Generation rights trading	Peakshaving ancillary service	Interprovincial trading
Curtailment volume	Before trading	10.6			
	After trading	9.4	8.3	5.8	6.1
Curtailment rate	Before trading	29.7%			
	After trading	26.3%	23.2%	16.4%	17.1%

3 Conclusion

It is an inevitable trend to promote the consumption of new energy through market-based trading. Combined with the construction process of the power market in China, we will give full play to the role of the market in optimizing the allocation of resources, accelerate the construction of a market-based power trading mechanism that adapts to the consumption of new energy, and further utilize the role of the market mechanism in promoting new energy consumption.

First, China should build a power market system that includes medium and long-term markets and spot markets, and promote the consumption of new energy to the greatest extent possible through the connection of multiple time scales. By predetermining on the power curve or the principle of curve decomposition when medium and long-term contracts are signed, we shall establish a medium and long-term bundling trading mechanism between new energies or between new energy and conventional energy. By adjusting the balance deviations in the spot market before and during the day, we shall design a flexible resource adjustment mechanism in the power market as soon as possible to deal with the volatility and intermittency of new energy output. We shall improve the electric power ancillary service market mechanism and guide various market entities in accordance with the principle of equal rights and responsibilities to balance the costs and benefits of the system, expand the scope of ancillary service providers, and promote the market players with stronger adjustment capabilities and greater cost advantages to participate in the ancillary service.

Second, Energy authority need improve the interprovincial and intra-provincial markets, establish a unified power market trading mechanism, and promote the consumption of new energy in a wider range. We shall promote interprovincial trading in an orderly manner, improve the linkage mechanism between the intra-provincial market and the interprovincial market, clarify the timing of linkage and interactive information, and gradually realize the opening and integration of power trading in various provinces and regions. We shall establish unified rules and gradually unified power market trading mechanisms in trading varieties, trading sequence, power grid constraints, and clearing price, so as to promote the consumption of new energy on a larger scale.

Third, Chinese government should establish a capacity market mechanism in a timely manner to ensure the safe operation of the system with a high proportion of new energy. As the proportion of new energy power generation continues to increase and coal power is gradually shifting to providing peak-shaving and backup services, China's current one-part tariff system has become increasingly restrained. By exploring the establishment of a multi-part electricity price mechanism or other forms of capacity mechanisms, we can prevent the excessive low bidding price of new energy subsidized in the power market, and ensure the benefits of providing guarantee power, as well as the safety and stability of power grid.

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