



Based on the Advanced Technology of the Southern Region "Point-to-Net" Power Plant Standby Market Trading Mechanism

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Abstract. With the continuous progress of new energy systems and the comprehensive and in-depth reform of China's electricity market, the introduction of the electricity reserve market trading mechanism is extremely important. In this context, computer technology, big data analysis, automation, and mechanical innovation play significant roles. For instance, mechanical automation technology like intelligent grid technology can achieve efficient power dispatching and optimization configuration in the electricity reserve market. Unmanned aerial vehicle inspection systems can enhance the operation and maintenance efficiency of transmission lines, and fault prediction and health management technology can reduce the risk of system failures. Based on this, a status analysis of the "point-to-network" power plant trading entities in southern provinces is conducted, and compared with traditional reserve market trading mechanisms. By utilizing big data analysis and artificial intelligence technology for electricity market forecasting, stable supply and development of electricity energy can be achieved.

Keywords: Power Plant Standby, Market Trading, Mechanism

1. INTRODUCTION

In the context of China's pursuit of the "dual carbon" development goal and with the application of computer technology, big data analysis, automation, and mechanical innovation in the power sector, the role of thermal power units in the power system is gradually shifting from primarily power generation to providing various backup and regulation services, which is a future trend. The China Electricity Council (first half of 2023) reported that China's new energy installed capacity exceeded 1.3 billion kilowatts, accounting for 48.8% of the total installed capacity. New energy sources, mainly wind power and photovoltaic, have

strong randomness and anti-peak regulation characteristics. Problems such as systematic peak regulation difficulties and insufficient backup are becoming increasingly prominent, posing great challenges to the safe and stable operation of the power grid. At the same time, the situation of tight power supply and tight standby resources in southern provinces like Hainan requires China to put forward a corresponding regional standby market trading mechanism. Therefore, the design of a "point-to-network" power plant to participate in the standby market trading mechanism is a crucial breakthrough and holds significant practical importance.

Many scholars have conducted in-depth research on the alternative market trading mechanism. Literature [5] analyzed the basic situation of PJM backup market and the full cost compensation mechanism of supporting units in detail, and put forward some suggestions for China's market construction. Literature [6] analyzed the agent structure of producers and consumers participating in the power-reserve market, and established the decision-making model of distributed producers and consumers participating in the power-reserve joint market on the basis of building a multi-type distributed resource regulation model. Literature [7] proposes an optimal demand assessment model for day-ahead backup market of wind power systems, adopts dynamic scenario generation and scenario reduction techniques to model the uncertainty of wind power and load, reflects the bidding strategy of standby units based on equilibrium analysis, and iteratively solve the optimal backup demand with the goal of minimizing the comprehensive cost of the system. Based on the bilateral participation rules of source and load, literature [8] constructs a joint optimal scheduling model of day-ahead energy and standby energy taking into account the bilateral participation of source and load, so as to promote the consumption of new energy and reduce the electricity cost of industrial users. Literature [9] analyzed the coupling effect of EV cluster's participation in both the electricity energy market and the backup market. Through the mechanism design of aggregator's participation in the backup auxiliary service market, the decoupling of normal EV charging and participation in the backup service was realized. Literature [10] analyzed and sorted out the mechanism of existing domestic demand-side flexible resources participating in the market transaction of electricity auxiliary services, and summarized several problems existing in the operation of the current market mechanism. However, the above research results failed to carry out in-depth discussion on the "point-to-network" power plant's participation in the standby market trading mechanism.

Based on this, this paper puts forward the mechanism of "point-to-network" power plants participating in the standby market in the southern region. Firstly, the paper analyzes the current situation of "point-to-network" power plant trading entities in southern provinces, and puts forward the mechanism of "point-to-network" power plant participating in standby market trading. Secondly, based on the calculation of channel margin, the "point-to-network" power plant in the southern region is adjusted and optimized to participate in the standby market delivery channel, which effectively improves the efficiency of power resource surplus and shortage in the southern region, and ensures the safe and stable operation of regional power supply.

2. THE TRADING MECHANISM OF "POINT-TO-NETWORK" POWER PLANT PARTICIPATING IN REGIONAL STANDBY MARKET IS DESIGNED

Analysis of the current situation of the "point-to-network" power plant participating in the transaction

In 2023, the Southern Supervision Bureau of the National Energy Administration proposed to step up the introduction of the inter-provincial standby market trading mechanism, which can effectively coordinate the standby capacity resources, and obtain significant results, that is, to continuously improve the efficiency of inter-provincial power resource surplus and shortage; The second is to use the southern regional power market dynamic monitoring system to carry out real-time monitoring to provide basic support for regulatory decision-making; The third is to continue to strengthen the supervision of unplanned outage and output obstruction of coal power units, urge and standardize the operation and management of pumped storage and promote the establishment of a market-oriented invoking mechanism. At the same time, the west-east power transmission in the southern region includes 11 "point-to-network" power plant trading entities, as shown in Table 1.

Table 1 "point-to-network" power plant transaction main situation

Main body of power network	Independent point-to-network power plant body	Main body of point-to-network power plant
Guangdong Power Grid	Tianshengqiao first-level power plant	Xiluodu right bank
Guangxi Power Grid	Tianshengqiao secondary power plant	The upper reaches of Lancang River
Yunan Power Grid	Longtan power plant	Wudonde power plant
Guizhou Power Grid	Bridge station	
Hainan Power Grid	Lei Yue River power station	
	Xingyi Power Plant #2	
	Three Gorges (State Grid)	

"Point-to-network" power plants participate in the standby market implementation plan

Under the main body of "point-to-network" power plant transaction, the overall implementation plan of "point-to-network" power plant participation in the standby market transaction in the southern region is proposed as follows:

(1) Arrange each DC power plan and each power plant generation plan.

(2) Calculate the available standby capacity of the "point-to-network" power plant, and calculate the standby capacity of the power plant belonging to the provinces according to the proportion of the electricity sent by the monthly transaction plan, and reserve the corresponding DC channel margin for the standby capacity belonging to the provinces. Set the actual vested reserve capacity (ARC), vested reserve capacity (ORC), reserved DC channel quantity (RDC), and the specific calculation expression is:

$$ARC = \min(ORC, RDC) \quad (1)$$

(3) Report the standby capacity of each central "point-to-network" power plant belonging to the provinces, and evaluate the sale of provincial standby after safety check with the central power plant, as well as the standby tradable capacity of the power plant belonging to the provinces.

(4) For example, the spare part belonging to Guangdong in Xiluodu Power Plant is preferentially reserved for DC channel, which can be regarded as Guangdong Province power plant participating in clearing. The remaining portion of the above reserve is deducted from the total DC margin and incorporated into the margin of all outgoing DC large channels in Yunnan.

3. ANALYSIS ON TRANSACTION ORDER ADJUSTMENT OF REGIONAL STANDBY CAPACITY MARKET OF "POINT-TO-NETWORK" POWER PLANT

The initial trading situation of the regional standby market of the "point-to-network" power plant

According to the implementation plan of the "point-to-network" power plant in the southern region to participate in the standby market transaction, the specific inter-provincial channels are shown in Figure 1.

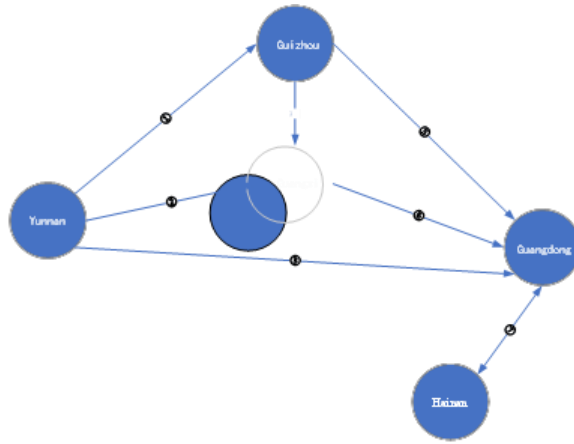


Figure. 1 Schematic diagram of interprovincial passage

It can be seen that (1) the naming rules follow the schematic diagram of inter-provincial channels, that is, 1. Yunnan-Guizhou, 2. Yunnan - Guangxi, 3. Yunnan - Guangdong, 4. Guizhou - Guangxi, 5. Guizhou - Guangdong, 6. Guangxi - Guangdong, 7. Hainan-Guangdong, reverse power flow name corresponding reverse, multiple channels are connected sequentially, such as 3, -6, -4. Yunnan - Guangdong - Guangxi - Guizhou; (2) Forward power flow 1-7 and reverse power flow 1-7 of the clearing channel are calculated according to the formula; (3) When two or more clearing channels are involved, the channel margin is min. The initial delivery channels of "point-to-network" power plants participating in standby market transactions are shown in Table.2.

Table. 2 Priority sequence and physical correspondence of buyer and seller channels

Seller	Buyer	Lv. 1	Lv. 2	Lv. 3	Lv. 4	Corresponding physical channel	Margin value
Yunnan	Guangdong	3	1,5	2,6	1,4,6	Chusui, Puqiao, Niucong, Xindong, Kunlong	(Chusui+Puqiao + Niucong + Xindong +Kunlong) limit - (Chusui+Puqiao+ Niucong + Xindong + Kunlong)

	Guanxi	2	1,4	3,-6	/	Yongfu, Jinxing, Luxi, Kunliu	(Yongfu + Jinxing + Luxi + Kunliu) limit - (Yongfu + Jinxing + Luxi + Kunliu) Planned value
	Guizhou	1	2,-4	3,-6,-4	/	Lugao	Lugao limit - Lugao Planned value
	Hainan	3,7	1,5,7	2,6,7	1,4,6,7	/	/
	Guangdong	5	4,6	/	/	Xingning, Gaozhao	(Xingning + Gaozhao) limit - (Xingning + Gaozhao) Planned value
Guizhou	Guanxi	4	5,-6	/	/	Guizhou exchange export	Guizhou exchange export limit - Guizhou exchange export Planned value
	Yunnan	-1	4,-2	4,6,-3	/	Lugao	Lugao Planned value - 300
	Hainan	5,7	4,6,7	/	/	/	/
	Guangdong	6	-4,5	/	/	Guangdong exchange entrance	Guangdong exchange entrance limit - Guangdong exchange entrance Planned value
Guangxi	Yunnan	-2	6,-3	-4,-1	/	Yongfu, Luxi	(Luxi + Yongfu) Planned value - 500
	Guizhou	-4	6,-5	/	/	Guizhou exchange export	Guizhou exchange export Planned value - 300

	Hainan	6,7	4,5,7	/	/	/	/
	Guangxi	-6	-5,4	/	/	Guangdong exchange entrance	Guangdong exchange entrance Planned value - 500
Guangdong	Yunnan	-3	-5,-1	-6,-2	-6,-4,-1	Chusui,Puqiao,Niucong,Xindong	(Chusui + Puqiao + Niucong + Xindong) Planned value - 2140
	Guizhou	-5	-6,-4	/	/	Xingan,Gaozhao	(Xingan + Gaozhao) Planned value - 600
	Hainan	7	/	/	/	Hainan Internet	Hainan Internet limit - Hainan Internet Planned value
Hainan	Guangdong	-7	/	/	/	Hainan Internet	Hainan Internet Planned value + 500
	Guangxi	-7,-	-7,-	/	/	/	/
	Yunnan	-7,-	-7,-	-7,-	-7,-6,-	/	/
	Guizhou	-7,-5	-7,-6,-4	/	/	/	/

Optimize the overall scheme of "point-to-network" power plants participating in the standby market trading mechanism

According to the overall scheme of "point-to-network" power plant participating in standby market trading, formula (1) is used to calculate the value of buyer and seller margin and adjust the buyer and seller delivery channel, as shown in Table. 3-7.

Table. 3 "Point-to-network" power plant in Yunnan sent to other provinces

Seller	Buyer	Lv. 1	Lv. 2	Lv. 3	Lv. 4	Margin value
Yunnan	Guangdong	3	1,5	2,6	2,- 4,5	(Chusui+Puqiao+Niucong+Xindong+Kunlong) limit - (Chusui+Puqiao+Niucong+Xindong+Kunlong) Planned value
	Guangxi	2	1,4	3,-6	/	(Yongfu+Jinzhong+Luxi+Kunliu) limit - (Yongfu+Jinzhong+Luxi+Kunliu) Planned value
	Guizhou	1	2,-4	3,-5	3,-6,- 4	Lugao limit - Lugao Planned value
	Hainan	3,7	1,5, 7	2,6, 7	1,4,6 7	/

As can be seen from Tab. 3, the priority order of spare capacity channels in some areas has been adjusted according to the margin measurement results, that is, in the corresponding physical channels from Yunnan to Guangdong, the fourth level has been modified, and 1 is often not in operation; In the corresponding physical channel of Yunnan to Guizhou, three levels of delivery channels are added.

Table. 4 "Point-to-network" power plant in Guizhou sent to other provinces

Seller	Buyer	Lv. 1	Lv. 2	Lv. 3	Lv. 4	Margin value
Guizhou	Guangdong	5	4,6	-1,3	-1,2,6	(Xingan+Gaozhao) limit - (Xingan+Gaozhao) Planned value
	Guangxi	4	5,-6	-1,2	-1,3,-6	Guizhou exchange entrance limit - Guizhou exchange entrance Planned value
	Yunnan	-1	4,-2	5,-3	4,6,-3	Lugao Planned value - 300
	Hainan	5,7	4,6,7	-1,3,7	/	/

As can be seen from Tab. 4, the priority order of spare capacity channels in some regions has been adjusted according to the margin measurement results, that is, three and four delivery channels have been added to the corresponding physical channels from Guizhou to Guangdong. In the corresponding physical channels of Guizhou to Guangxi, three and four delivery channels should be added; Guizhou to Yunnan corresponding physical channel, add three delivery channels.

Table. 5 "Point-to-network" power plant in Guangxi sent to other provinces

Seller	Buyer	Lv. 1	Lv. 2	Lv. 3	Lv. 4	Margin value
Guangxi	Guangdong	6	-4,5	-2,3	/	Guangdong exchange entrance limit -Guangdong exchange entrance Planned value
	Yunnan	-2	6,-3	-4,-1	/	(Luxi+Yongfu) Planned value - 500
	Guizhou	-4	6,-5	-2,1	6,-3,1	Guizhou exchange export Planned value - 300
	Hainan	6,7	4,5,7	-2,3,7	/	/

As can be seen from Tab. 5, the priority order of spare capacity channels in some regions is adjusted according to the margin measurement results, that is, three delivery channels are added to the corresponding physical channels from Guangxi to Guangdong. In the corresponding physical channels from Guangxi to Guizhou, three and four delivery channels should be added; In the corresponding physical channel of Guangxi to Hainan, three levels of delivery channels are added.

Table. 6 "Point-to-network" power plant in Guangdong sent to other provinces

Seller	Buyer	Lv. 1	Lv. 2	Lv. 3	Lv. 4	Margin value
Guangdong	Guangxi	-6	-5,4	-3,2	/	Guangdong exchange entrance Planned value - 500
	Yunnan	-3	-5,-1	-6,-2	-5,4,-2	(Chuisui+Puqiao+Niucong+Xindong) Planned value - 2140
	Guizhou	-5	-6,-4	-3,1	-6,-2,1	(Xingan+Gaozhao) Planned value - 600
	Hainan	7	/	/	/	Hainan internet limit - Hainan internet Planned

As can be seen from Tab. 6, the priority order of spare capacity channels in some regions is adjusted according to the margin measurement results, that is, three delivery channels are added to the corresponding physical channels from Guangdong to Guangxi. Guangdong to Yunnan corresponding physical channel, modify the four-level delivery channel, 1 often do not run; In the corresponding physical channel of Guangdong to Guizhou, three and four delivery channels will be added.

Table. 7 "Point-to-network" power plant in Hainan sent to other provinces

Seller	Buy	Lv. 1	Lv. 2	Lv. 3	Lv. 4	Margin
	Gua	-7	/	/	/	Hainan in-
Hai-nan	Gua	-7,-6	-7,-5,4	-7,-3,-2	/	/
	Yun	-7,-3	-7,-5,-1	-7,-6,-2	-7,-6,-	/
	Gui-	-7,-5	-7,-6,-4	-7,-3,1	/	/

As can be seen from Tab. 7, the priority order of spare capacity channels in some regions is adjusted according to the margin measurement results, that is, three delivery channels are added to the corresponding physical channels from Hainan to Guangxi. Hainan to Guizhou corresponding physical channel, add three delivery channels.

CONCLUSION

In an era where computer technology, big data analysis, automation, and mechanical innovation are widely applied, the article presents a comprehensive implementation plan for "point-to-network" power plants to participate in the reserve market trading mechanism under the Southern Regional Reserve Market Implementation Plan. By calculating the marginal values of both buyers and sellers, the delivery channels are optimized. Incorporating automated machinery content, the specific conclusions are as follows:

(1) Under the monthly trading plan, considering the power supply ratio, calculate the reserve capacity of "point-to-network" power plants belonging to provinces outside. Reserve corresponding DC channel surplus for the reserve capacity outside the province. At the same time, utilize automated machinery technology to monitor and maintain transmission lines, ensuring the stability and security of power transmission.

(2) By calculating the surplus value of the outgoing channel, increase and modify some outgoing channels to optimize resources among provinces and avoid power shortages. Based on this, employ automated machinery equipment for the installation, debugging, and maintenance of power equipment to improve the operational efficiency and reliability of the power system.

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