Research on the Trading Mechanism and Trading Strategy of Electric Power Market under the Background of new Electric Power System

Xuefeng Gao[1]; Shuqin Wu[2*]; Bo Zhao[1]; Shuai Ji[3]; Yiwen Yao[1]; Gang Luo[2]; Rui Yang[2]

Xuefeng Gao:716618049@qq.com; Shuqin Wu*: tsintergy2022@163.com;
Bo Zhao: 862250997@qq.com; Shuai Ji: jishuai806@163.com; Yiwen Yao: yaoyadami@163.com;
Gang Luo: luogang@tsintergy.com; Rui Yang:yangrui@tsintergy.com

[1]Economic and Technological Research Institute of State Grid Jilin Electric Power Co., Led., Changchun, China
[2]Beijing TsIntergy Technology Co., Ltd., Power Grid Business Group, Beijing, China
[3]Jilin Power Exchange Center Co., Ltd., China

Abstract: Under the background of the current development of energy Internet, the scale and utilization efficiency of distributed power resource allocation are gradually improved. In order to solve the problem that distributed energy participates in market trading and the guarantee of resource allocation scale is not high in the current power spot market. Build strong flexibility, overall performance of the new power system, and put forward the optimized spot market trading mechanism, the use of distributed energy and thermal power unit equally participate in electric power market bidding, start distributed energy generation alternative mechanism, to abandon electricity distributed clean energy instead of offer higher thermal power unit. In order to verify the effectiveness of the optimization mechanism, through the method of node electricity price clearing to analyze the mechanism of the electricity market price design and settlement mechanism of thermal power unit of energy compensation, and through the algorithm instance verify the effectiveness of the optimization mechanism, promote the power market under the background of new power system can get better development.

Key words: new power system; distributed energy; power market; consumption mechanism; power generation compensation

1. Introduction

Under the background of the current spot consumption of new energy power market, the new power system has become an important direction of the optimization reform of spot power market. In order to ensure the effectiveness of the trading mechanism of power spot market and deal with the problems of distributed energy power consumption and the construction of power spot market, a large number of scholars at home and abroad have studied the consumption mechanism of distributed electricity and power market. At present, Cui D and some foreign scholars have made some discussions on the current foreign market trading mode of new energy, and made relevant research on the price system to promote the consumption of clean energy under the background of the current competitive electricity market., They have introduced MTDG technology based on blockchain technology, and

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constructed the corresponding trading mechanism, settlement mechanism and reward and punishment mechanism..Literature [2] to literature [4] reflects the domestic scholars on the contract for difference and optimization strategies in the provincial power market, which provides effective reference for the design of new energy consumption mode and spot market mechanism under the background of the current new power system. Based on the current research background at home and abroad, combined with the current clean energy affordable given rules and electricity spot market trading operation mechanism, puts forward the optimization of clean energy given trading mechanism, with distributed electricity build compensation mechanism, on the premise of protecting the rights and interests of the market, improper planning of clean energy electricity quotation, in order to increase the cost of market trading mechanism to regulate the electricity spot market trading mechanism.[1]

2. Electricity market operation structure

At present, the main participants in the operation of spot power market are thermal power units and distributed energy stations. The specific operation structure of spot power market is shown in Figure 1. The dotted line in the figure shows the power generation compensation mechanism constructed by the article. The node electricity price is taken as the short-term marginal cost pricing method reflecting the power value of different moments and different positions as the transaction mechanism to construct the power market under the background of the new power system.[2]

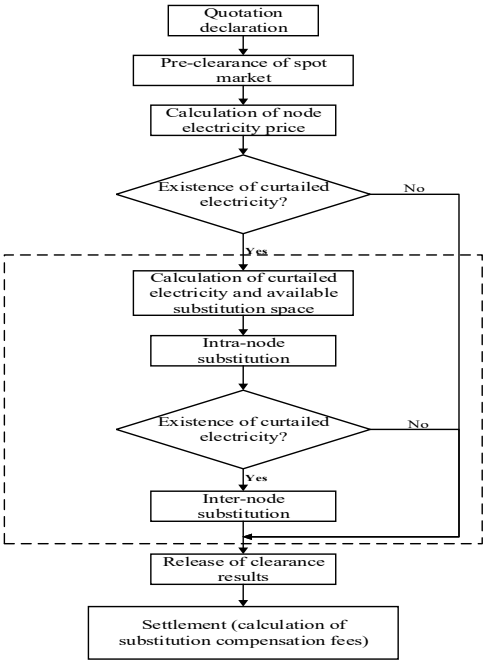

Figure 1 Operation Flow chart of electric power spot market

As can be seen from Figure 1, the transaction needs to declare its segmented quotation curves through the market participants before starting, and the market pre-clearing results should be calculated with the goal of the minimum power purchase cost. If no clean energy power is generated in the clearing result, the result is taken as the final clearing result; but if the new energy is abandoned in the result, the compensation generator system is started. According to the price difference, replace the new energy generation until the power abandonment result is reduced to the minimum output result. If there is still a starting point result, the power abandonment will not be replaced again.[3]

3. Power spot market clearing model

3.1 Market clearing model

For the total power purchase cost function of the power spot market, the units with low quotation can win the bid first. The specific mathematical model is shown in Equation (1):

$$\min \sum_{i=1}^{H} \sum_{d=1}^{D} \sum_{n=1}^{S} C_{i,s}^{dh} q_{i,s,d}^{dh} + \sum_{j=1}^{N} \sum_{t=1}^{D} \sum_{s=1}^{S} C_{j,s}^{R} q_{j,s,d}^{R} \quad (1)$$

In equation (1), H, N dB indicate the number of thermal power units and distributed energy power stations participating in the spot power market; D indicates the total time period. S represents the price of the unit.$q_{i,s,d}^{dh} q_{j,s,d}^{R}$ And represent the output of thermal power units and distributed energy plants i and j in d short time, respectively; and represents the corresponding price of distributed energy stations in a short time of d.$C_{i,s}^{dh} C_{j,s}^{R}$

3.2 Node electricity price model

According to the market clearing model, we can get the balance constraint of the power system load at the d point and the Lagrange multiplier of the section power flow constraint in each time period. The node electricity price of node p in the time period d can be calculated by Equation (2):

$$LFK_{p,d} = \mu_d - \sum_{f=1}^{F} \left(\tau_{f,d}^{max} - \tau_{f,d}^{min}\right) \cdot G_{p-f} \quad (2)$$

$LFK_{p,d} \mu_d \tau_{f,d}^{max} \tau_{f,d}^{min}$Equation (2) is the node electricity price of node p at time period d; the Lagrange multiplier of the system load in time period d; and the Lagrange multiplier of the maximum positive and maximum negative direction of section f respectively, where F is the total number of system sections.[4]

3.3 Power generation compensation mechanism

The power generation compensation passenger space provided by the thermal power unit is as shown in formula (3):

$$Qs_{i,d}^{dh} = Q_{i,d}^{dh} - Q_{min,i}^{dh} \quad (3)$$

The total amount of power abandoned in distributed energy power stations is:

$$Qs_{j,d}^{R} = Q_{max,j,d}^{R} - Q_{j,d}^{R} \quad (4)$$

3.3.1 objective function

The price of the power spot market within node d remains unchanged, and the target function of the compensated power generation model between the distributed energy power station and the thermal power unit can be directly set as:

$$\max \sum_{i=1}^{H} \sum_{d=1}^{D} C_{i,S}^{dh} Qd_{i,t}^{dh} - \sum_{j=1}^{N} \sum_{d=1}^{D} C_{j,1}^{R} Qd_{j,d}^{R} \tag{5}$$

$C_{i,S}^{dh} Qd_{i,t}^{dh}$The price corresponding to the highest price segment and the lowest price segment declared by the thermal power unit i and the distributed energy power station j, respectively.[5]

3.3.2 Constraints

When the power compensation of thermal power units and new energy stations needs to restrict the power generation space and abandoned power customer supply parts:

$$\begin{cases} \bar{Q}_{i,t}^{dh} = Q_{j,d}^{R} - Qd_{i,d}^{dh} \\ \bar{Q}_{j,t}^{R} = Q_{j,d}^{R} - Qd_{i,d}^{R} \end{cases} \tag{6}$$

3.4 Computer system

According to the constraints of Equation (5), after restricting the generating load of the distributed energy and thermal power units, the final clearing results of the thermal power unit and the distributed energy power station are calculated by Equation (6) to get the final compensation output arrangement.

$$\begin{cases} W_{i,d}^{dh\prime} = Qd_{i,d}^{dh\prime} \cdot LMP_{i,d} \cdot \beta \\ W_{i,d}^{R\prime} = Qd_{j,d}^{R\prime} \cdot LMP_{i,d} \cdot \beta \end{cases} \tag{7}$$

The final output of the alternative thermal power unit and the distributed energy station will be cleared to calculate the benefit compensation cost and penalty cost. The total revenue of thermal power units and distributed power stations is calculated by formula (7):$W_{i,d}^{dh\prime} W_{i,d}^{R\prime}$

$$\begin{cases} W_{i}^{dh} = \sum_{d=1}^{D} \left(\overline{Q}_{i,d}^{dh} \bullet LMP_{i,d} + W_{i,d}^{dh'} + W_{i,d}^{dh''} \right) \\ W_{j,t}^{R} = \sum_{d=1}^{D} \left(\overline{Q}_{j,d}^{R} \bullet LMP_{j,d} + W_{j,d}^{R'} + W_{j,d}^{R''} \right) \end{cases} \tag{8}$$

In formula (8), W_{i}^{dh} and $W_{j,t}^{R}$ represent the total benefits of thermal power units and distributed power stations respectively. Through the article to build power spot market clearing model, with node price as a model basis calculation and settlement of each node, find out the thermal power unit and distributed energy generation compensation, according to the settlement mechanism to calculate the compensation cost and punishment cost, finally realize the new power system power spot market trading mechanism can continue to run well.[6]

4. Example analysis and verification

In order to verify the effectiveness of the algorithm mechanism constructed by node electricity price, the paper uses IEEE39 node system as a tool to simulate the trading mechanism of power spot market. The new power system includes 5 thermal power units, 4 wind farms and 4 photovoltaic power stations, and its installed capacity accounts for 56.34%, 21.69% and 21.97% of the total installed capacity. To verify the effectiveness of the algorithm, the simulation system is divided into 3 different scenarios (as shown in Table 1).[7]

Table 1 Power abandonment of multiple energy sources in different scenarios

scene	Wind power abandoned electricity	Photovoltaic power abandonment	Total abandoned electricity
Scene 1	756.35	362.14	1118.49
Scene 2	903.65	482.14	1385.79
Scene 3	754.36	367.25	1121.61

It can be seen from Table 1 that in different scenarios, there will be additional power abandonment due to the high quotation. However, in scenario 2, the decibel of wind power and photovoltaic power abandonment increased by 22.36% and 32.17%.

Using the market clearing mechanism adopted in this paper in scenario 3, it can be seen that the market clearing price changes with the change of power abandonment in the morning and evening peak load. The specific market clearing price is shown in Figure 2.

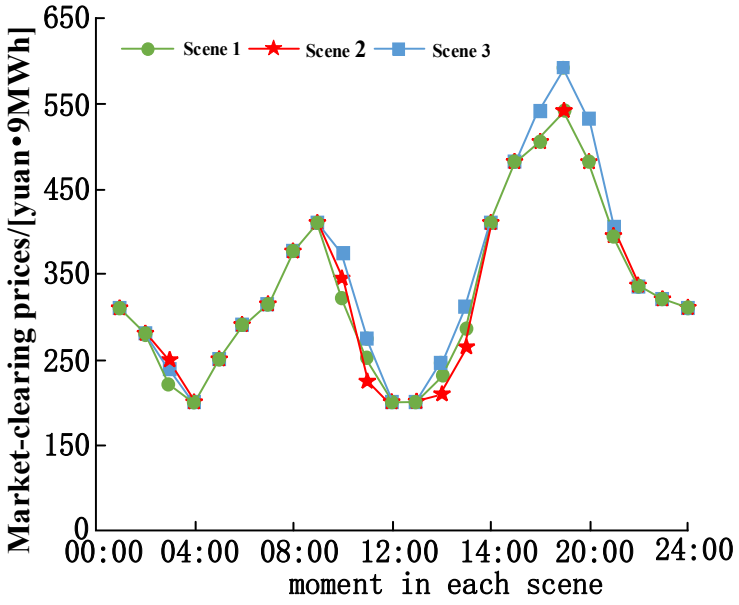

Figure 2 Distribution of market clearing prices in each scenario

Can be seen from figure 2, in part of the load time peak, the clearing price differences in different scenarios, and the article in the scene 1 generator set is more, belong to the rich area, the overall price will be low, therefore and in high load area, photovoltaic power output at night, and load demand is greater than the power output, electricity price is higher.[8]

Therefore, the cost of the final electricity spot market is calculated according to the different costs of electricity load and electricity compensation under different scenarios and different time nodes (as shown in Table 2).

Table 2 Market settlement electricity price and compensation fees

set	Average settlement electricity price / [RMB 9 MWh]$^{-1}$			Compensation fee / YUAN	
	Scene1	Scene2	Scene3	in the region	Outside the area
H1	296.54	297.25	389.45	3659.87	1125.34
H2	297.56	302.16	256.35	2546.27	-386.54
H3	235.31	254.21	278.46	-1356.27	-854.61
W1	276.25	284.56	298.24	-2865.34	-481.28
W2	284.26	293.42	236.91	-1759.68	-468.92
S1	292.36	235.67	251.34	2687.34	795.63
S2	245.34	304.21	278.59	-1986.45	-601.14

As can be seen from Table 2, the average settlement price of thermal power units is usually higher than the price of wind power and photovoltaic power, and the overall average price of thermal motors is higher when the load is too high or less processing is done. Compared with the power generation compensation costs between each unit in Table 2, due to the situation of high load blocking in different intervals, the direction of power generation compensation can be opposite to the direction of the power flow of the blocking line.[9]

5. Conclusion

To sum up, under the background of the continuous development of the new power system, the trading mechanism of China's power market should optimize the trading mechanism of the current power spot market, and solve the problem of the current power market bidding generated by the node price mechanism. According to the analysis and comparison of the calculation examples, the compensation mechanism designed in the paper enables the thermal power unit to transfer the output space to the distributed energy station while also maintaining the power market to obtain a certain income. And to a certain extent, it reduces the loss of coal resources of thermal power units, guarantees the corresponding benefits of power enterprises, and promotes the healthy and stable operation of the power spot market.[10]

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