



Trading method of electricity spot market under high penetration ratio of new energy

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Abstract. In this paper, the spot trading of electric power with high penetration ratio of new energy is taken as the research object, and all parties involved in the spot trading of electric power are investigated to form an electric energy trading chain. The decentralized blockchain technology is adopted to establish a trading model of the spot market of electric power, store the trading information of all parties involved, solve the model by using the strategy learning method, and analyze the market electric energy trading volume and the benefits of all parties. The research results show that the spot market transactions of electricity include energy suppliers, energy sellers and buyers, energy reserves and load aggregators. The spot trading chain of electric energy is built by using the platform of Ethereum blockchain, and the spot market of electric energy is simulated by strategy learning method. It is concluded that the installed capacity and clearing capacity of wind power suppliers are the largest, the maintenance cost is lower, the market income is the highest, but the maintenance cost far exceeds that of all energy suppliers; Using the spot trading method of electric energy trading chain to improve the income of each trading subject, the quotation of market subjects is more flexible and more in line with the relationship between supply and demand, and the clearing price of the market is basically positively correlated with the relationship between supply and demand; The credit value of each power trading entity is quantified as the default coefficient. When the default coefficient of each trading entity is larger, its income will gradually decrease, and the default of energy suppliers has the greatest impact on its income.

Keywords: new energy, spot market of electricity, trading mode, technical method

1 Introduction

With the rapid development of new energy in China, the trading mode of spot market of electricity is also changing. The traditional power market is dominated by thermal power, with a relatively stable market structure and mature market trading methods and technical means. However, in the power market with high penetration ratio of new energy, the instability and fluctuation of new energy generation lead to the imbalance

between supply and demand. Therefore, under the high penetration ratio of new energy, promoting the stable operation of electricity spot market transactions is the main research topic.^[1]

Some researchers put forward a quantitative analysis method to analyze the influence of new energy on the spot market of electricity. By establishing a clearing model of spot trading of new energy electricity, a cross-regional and inter-provincial electricity trading model is constructed to simulate the influence of new energy on the market clearing in a high proportion of grid connection^[2]. Some researchers put forward a virtual electricity market transaction model. Through the analysis of electricity spot market transactions, the electricity market is commercialized by means of peak regulation and frequency modulation and optimization of energy storage configuration. the new power system operation mechanism with high permeability of new energy is solved^[3]. Some researchers have studied the flexibility, efficiency and transparency of electricity spot market transactions. Through the combination of FIT and market transactions, the government has introduced policies to encourage the development of new energy, realizing the flexible scheduling of new energy through market-oriented methods. At the same time, power market dispatching institutions have been introduced to supervise the matching and scheduling of market transactions, ensure the balance between supply and demand of electricity, adopt the matching method of trading centers, and introduce bidding transactions and auxiliary service markets to improve market efficiency and transparency. ^[4-6]

2 Research method

2.1 Spot trading method of new energy and high permeability electric power

The new energy and high penetration power market refers to the market where new energy power generation technology is applied and the market penetration rate is high in the field of new energy power. Figure 1 gives the statistics of power generation of different energy sources in China in different years. It can be seen that the overall power generation of new energy sources shows a linear increase trend. In 2022, the power generation of new energy sources in China will reach 43 trillion kilowatts, exceeding the power generation of thermal energy^[7].

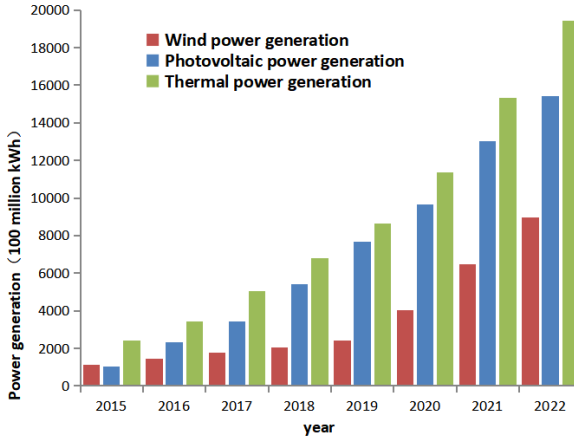


Fig. 1. Statistics of China's new energy generation in different years

In the spot trading of electric power, it is necessary to ensure the stability of the electricity trading market, and at the same time, it is necessary to improve energy conservation and emission reduction. In the spot trading of electricity, it is mainly composed of energy suppliers, energy sellers and buyers, energy reserves and load aggregators. [8]. In this paper, the power transaction chain of each power transaction subject is established, and the decentralized blockchain technology is adopted to store the power transaction information of each node, and the power transaction and settlement are completed according to the intelligent contract. The trading process of the spot market of electricity is as follows:

(1) each power trading entity generates a unique identity public key and private key through an encryption chain code, and completes registration and authorization on the spot power trading chain;

(2) After the intelligent contract is established for spot trading of electric energy, each trading entity is connected with the private chain to realize information synchronization and mutual trust of the spot trading chain of electric energy;

(3) At the same time node, each subject of spot trading of electric power conducts quotation, decryption, transaction matching and settlement according to the intelligent contract, so as to complete spot trading of electric energy in the electric energy block;

(4) Store the completed transaction data through the private key, get their own credit points for bookkeeping, and complete the clearing of electric energy in a block.

2.2 Transaction model of electricity spot market

According to the spot trading chain of electric energy, the trading model of spot market of electric energy is established (Figure 2), and the model is solved by strategy learning method, and the trading volume and income of electric energy in the market are obtained.

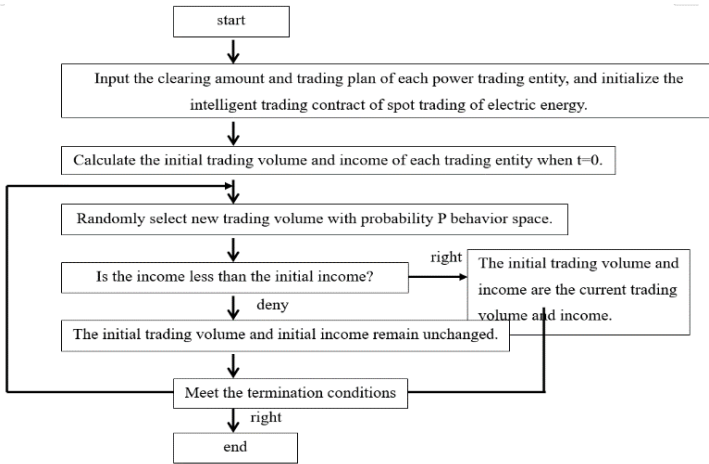


Fig. 2. Transaction model of electricity spot market

3 Research results

The intelligent contract for spot trading of electric energy established in this paper runs on the platform of Ethereum blockchain, and sets up the spot trading chain of electric energy to simulate the decision-making process of clearing the spot market of electric energy^[9]. The model is initially set as 9 energy suppliers (4 photovoltaic, 2 wind power and 2 thermal power), 2 energy reserve suppliers, 3 load aggregators and 2 energy buyers, and the maximum daily load of the system is set as 500MW. As can be seen from Table 1, wind power suppliers have the largest installed capacity, and have become the main body of power supply. At the same time, wind power efficiency is higher than photovoltaic and thermal power, and the maintenance cost is only a little higher than photovoltaic, so the overall benefit of wind power market is the highest; Energy reserves are the most efficient, but their maintenance costs far exceed those of various energy suppliers, which is 10 times that of wind power. Therefore, energy reserves can be used as a supplement when energy is insufficient.

Table 1. Equipment parameters

| category | installed capacity (MW) | maintenance expense (ten thousand yuan /MW) | efficiency (%) |
|------------------------|-------------------------|---|----------------|
| Wind power supplier | 320 | 0.5 | 52 |
| Photovoltaic supplier | 226 | 0.4 | 21 |
| Thermal power supplier | 168 | 0.9 | 44 |
| Energy reserve company | 65 | 4 | 84 |

Using the electricity spot market transaction model, energy suppliers, energy sellers and buyers, energy reserves and load aggregators complete spot transactions in the blockchain and get real-time electricity clearing results. Figure 3 shows the results of real-time power clearing. As can be seen from Figure 3, the clearing capacity of wind power suppliers is the largest, much higher than that of thermal power and photovoltaic, and the clearing capacity of wind power, thermal power and photovoltaic suppliers can basically meet the market demand, while the clearing capacity of energy reserves and load aggregators is very low.

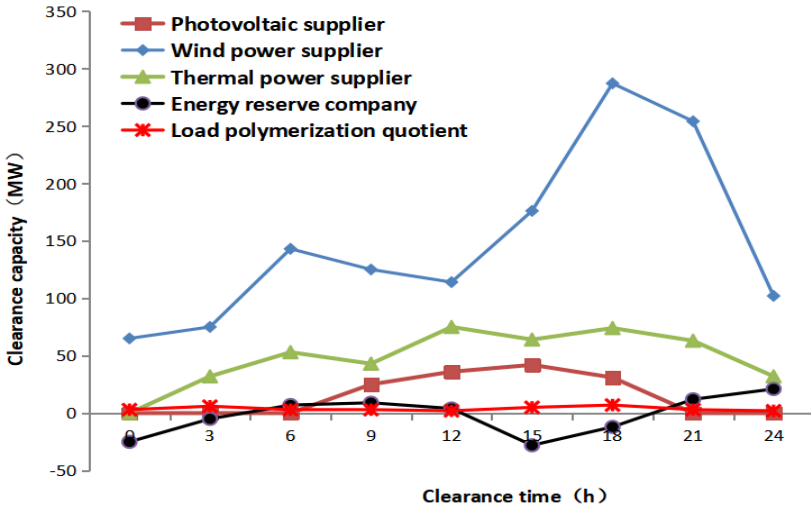


Fig. 3. Real-time power clearing result

Using the spot trading method of electric energy trading chain and giving full play to the advantages of blockchain can effectively improve the income of each trading subject and give full play to the role of each supplier^[10]. In order to maximize the interests of all parties, with the continuous improvement of the electricity trading market, the quotation of market participants is more flexible and more in line with the relationship between supply and demand. The clearing price of the market is basically positively correlated with the relationship between supply and demand, and the fluctuation of clearing price remains at a low level. As can be seen from Figure 4, the fluctuation of the clearing price in the market is relatively low, basically maintaining at 9% ~ 21%; The volatility of market quotation changes greatly. With the increase of market power demand, the volatility of market quotation decreases gradually, and the volatility of market quotation is the lowest in 18 ~ 21 hours.

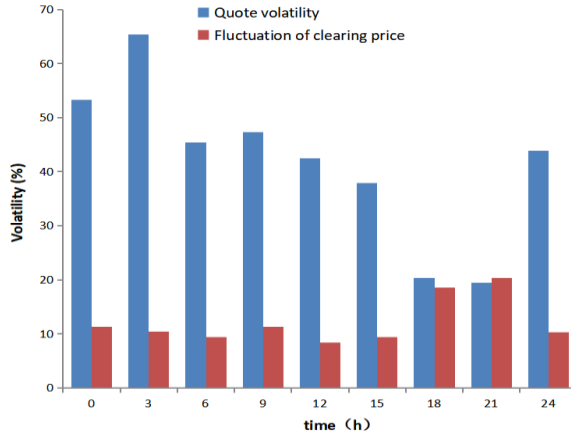


Fig. 4. Volatility of market quotation and clearing price

With the formation of electricity spot market with high penetration ratio of new energy, after a variety of renewable energy sources are connected to the grid, through decentralized blockchain technology, the credit value of each power transaction subject is quantified as default coefficient, and the default cost is calculated, so that the trading income of electricity spot market can be obtained, and multiple default behaviors in electricity spot trading can be avoided. It can be seen from Figure 5 that the more times each trading entity defaults, the greater the default coefficient value, which leads to the gradual decrease of its income, among which the default of energy suppliers has the greatest impact on its income.

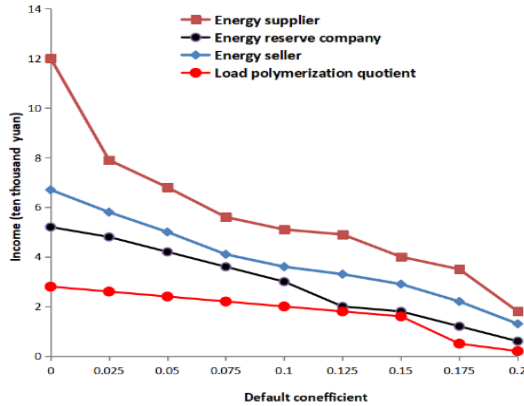


Fig. 5. Relationship between default coefficient and income of each transaction subject

4 Conclusion

In this paper, the spot trading of electric power with high penetration rate of new energy is taken as the research object, and all parties involved in the spot trading of electric

power are investigated to form an electric energy trading chain. The decentralized blockchain technology is adopted to establish a trading model of the spot market of electric power, solve the model by using the strategy learning method, and analyze the market electric energy trading volume and benefits of all parties, thus providing theoretical data support for the trading method of the spot market of electric power with high penetration rate of new energy. The main research results are as follows:

(1) Electricity spot market transactions include energy suppliers, energy sellers and buyers, energy reserves and load aggregators. The decentralized blockchain technology is adopted to establish the energy trading chain of each power trading entity, store the energy trading information of each node, and connect each trading entity with the private chain through smart contracts, and complete the energy spot trading of the energy block and the energy clearing in one block.

(2) Using the platform of Ethereum blockchain, the spot trading chain of electric energy is built, and the decision-making process of clearing the spot market of electric energy is simulated; Using the spot trading method of electric energy, giving full play to the role of each supplier can ensure the maximization of interests of all parties, the quotation of market participants is more flexible, the clearing price in the market is basically positively correlated with the relationship between supply and demand, and the fluctuation of clearing price remains low; The credit value of each power trading entity is quantified as the default coefficient. When the default coefficient of each trading entity is larger, its income will gradually decrease, and the default of energy suppliers has the greatest impact on its income.

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