Research on the business model of distributed power trading based on blockchain technology

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Abstract. With the power system reform deepening, the distributed power trading in the market is prominent. Exploring the business model of distributed power trading has become an important issue to perfect the distributed power trading market. Firstly, the paper describes the current situation and the characteristics of the distributed power trading, summarizes the same characteristics between the distributed power trading and blockchain. Secondly, the paper analyses the interested participant of distributed power trading, clarify the value target of relevant participants, and then analyses the application of blockchain technology in distributed power trading through the literature method. Finally, the paper proposes to build a public service platform for distributed power trading based on blockchain technology, improves the principle of distributed power trading, standardizes the business trading process of distributed power trading, and then forms a kind of distributed power trading business model with multiple subjects participating in the competition. Furthermore, it can maximize the interests of the main participants and promote the distributed power trading fairer and more open.

1. Introduction
In recent years, with the continuous deepening of the national electric system reform, the power system is gradually transforming to sustainable and low-carbon, the distributed power trading has attracted as an important renewable energy development model. Distributed generation has the characteristics of small capacity, large volatility, scattered distribution [1], and the production and consumption structure present a non-centralized, multi-node state, which put high demand on the high efficiency of capital carry-over and transaction information transparency in power transactions. Under the policy conditions of the gradual opening of the electricity market, the blockchain, as a distributed ledger with the characteristics of decentralization and multi-node, is integrated with the multi-agent participation and decentralization of distributed power trading. The advantages of blockchain technology such as digital signatures, consensus mechanisms, and smart contracts can provide a trust basis, which is conducive to improving the operational efficiency and reducing the transaction cost for distributed power trading. Therefore, in the period when distributed power trading is shifting from explosive to improving quality and efficiency, it is a great significance to build a distributed power trading platform, accelerate the improvement of the operating rules of distributed power trading, and explore a business model suitable for distributed power trading.
2. Overview of distributed power trading

2.1. The current status of distributed power trading policy

With the increasingly serious energy and environmental issues, the national departments have made important policy support for distributed power trading. In November 2017, National Development and Reform Commission, National Energy Administration jointly issued “The Notice on the Pilot Project of Marketization for Distributed Power Generation” [2]. In December, the “Supplementary Notice on the Pilot Project of Marketization of Distributed Power Generation”, which the pilot project of distributed power generation market-oriented trading started. In March 2018, National Energy Administration issued “Administrative Measures for Distributed Power Generation (Draft for Comment)” [3], the measure not only emphasized the definition of distributed power generation and the principle of nearby consumption, but also clarified three market transaction modes for projects, which has laid a good policy foundation for distributed power trading. In May 2019, the National Development and Reform Commission and National Energy Administration issued “Notice on Announcement of the First Batch of Wind Power and photovoltaic Power Generation Projects on the Grid in 2019”, which identified a list of 26 pilot projects in ten provinces and cities for distributed power generation market-oriented transaction. In recent years, the power market construction has achieved remarkable results in power trading organization, power trading settlement systems, and power trading technical support systems, such as the provinces of Guangdong and Jiangsu.

2.2. The definition and characteristics of distributed power trading

The distributed power generation is defined as small and medium-sized power generation facilities, which are connected to the distribution network to operate and are consumed nearby, at the same time meets energy efficiency, environmental protection, and safety[4]. From a fundamental point of view, distributed power trading has the characteristics of numerous entities, decentralized transactions, environmental protection and safety. The decentralization and decentralization of transactions will increase the complexity of transactions, expand the choice of transactions, and reduce the stability of market prices [5]. In addition, the user group has a weak judgment ability for power load forecasting, which easily leads to an increase in the risk of default and a lack of trust among the transaction subjects. Therefore, it is necessary to use credible authentication management methods to avoid unclear measurement, high management costs and transaction costs.

2.3. The common features between distributed power trading and blockchain technology

At present, the definition of blockchain in academia is generally considered to be a new application mode of computer technology, such as distributed data storage, point-to-point transmission, consensus mechanism, encryption algorithm [6]. Blockchain is time stamped to ensure that the data can be traced. it is equivalent to a distributed database, the information in the database is shared by all network nodes, and the data manager is responsible for updating the data, and the manager provides assess rights to users of all network nodes [7]. The characteristics of blockchain technology are consistent with the distributed power trading with a decentralized network structure, there are similarities in four aspects: decentralization, smart contracts, security and trustworthiness, and collective maintenance, as shown in Table 1.

| Features               | Distributed power trading                                      | Blockchain technology                              |
|------------------------|-----------------------------------------------------------------|----------------------------------------------------|
| Decentralization       | Equal and decentralized decision-making among all subjects      | All nodes have equal efforts and obligations        |
| Smart contract         | Intelligent point-to-point transaction automatic execution      | Automatically realize the pre-set smart process     |
| Safe and reliable      | Higher confidentiality mechanism                                 | Data cannot be tampered with                       |

Table 1. The common features between distributed power trading and blockchain technology
3. The participants of distributed power trading based on blockchain technology

3.1. The blockchain application in distributed power trading
Blockchain technology is mainly used in distributed energy trading, green certificate asset digitization, supply chain finance, carbon trading market, and settlement of electric vehicle chargers in the energy field. Among them, the application in distributed power trading is mainly biased towards technical methods, trading mechanisms, application research, etc., while there is less research on business models. Literature [8] proposed a method of credit risk management for distributed energy trading based on blockchain. Literature [9] proposed a distributed power transaction bidding transaction algorithm based on blockchain, which stores all transactions through the blockchain to ensure the transaction cannot be tampered with. Literature [10] combined blockchain technology to propose a framework for a weakly centralized energy trading system, and explored the energy trading system in future energy. Internet under the complex interaction of energy and information between power sources, grids, and loads. Blockchain technology, as the basis of automated energy transactions, provides guarantee for the automatic execution and information security of distributed energy trading.

3.2. The related participants of distributed power trading
The related participants of distributed power trading include government regulatory agencies, grid companies, distributed power producers and sellers, and power users, as shown in Figure 1. The government and market regulators play the leading role in the electricity market. The government departments are responsible for the formulation of policies, the market supervision departments supervise the electricity trading market, including the review of electricity prices and incentive policies set by power grid companies. The grid companies sell the electricity and manage and dispatch the electricity transaction and the government departments in charge of the grid company check and control the work content. A distributed energy trading market might be fair competition and operation stably under the guidance and incentives of government electricity policies. Distributed energy generators storage electricity taking the PV and wind power as the main part, and they can carry out local consumption of multi-channel distributed energy power after obtaining the legal nearby sales qualification, so as to achieve high energy and electricity utilization and sustainable development of electricity. Power generators and consumers can realize economic benefits and ensure the effective consumption of electric energy through making effective trading on the electricity control centre of electric power trading centre in each province and region and the platform of transaction information service management. Electricity trading centre obtains the distributed power trading data effectively, manage, and control the real-time change of the trading information reasonably and scientifically, and establish the trading service management rules according to the corresponding scenes, and then realize the behavior of distributed power trading to optimize and make full use of energy sources.
3.3. The value target of the main participants of distributed power trading

The value target of transaction participants in distributed power market transactions is realized through specific value activities in the business model [11]. The value targets of participants in distributed power trading based on blockchain technology are as follows:

3.3.1. Distributed power generation producers. The mainly distributed power generation producers include large-scale power generation companies or household power generators, and as electric energy diggers and electric energy managers, which have the dual roles of producer and consumer. In market trading, reducing the investment cost and business operation cost is one of the business operation strategies of all enterprises. The value objectives of power generators in commercial operation are as follows:

- Reduce costs and increase economic benefits.
- Improve power generation efficiency and reduce power generation costs through the integration and innovation of emerging technologies.
- Reduce pollution, increase the grid rate of renewable energy, and obtain social benefits.
- Increase the energy storage capacity of electric energy to provide clean electricity.

The value target of electricity sales companies are as follows:

- Reduce costs and expanding business scope to increase revenue;
- The business model of electricity sales companies has become more and more flexible with the development of marketization, attracting users through the integration of power system business innovation and coordinated development and increase user loyalty.

3.3.2. Grid companies. With the opening of power market policies, distributed power trading has become a new business for power grid companies, and power grid companies have been transformed into public utility service providers. The stability of power services is also highly valued by power users. The value targets of grid companies as follows:

- Improve the efficiency of “grid fees”, under the requirements of accelerating the rapid development of distributed power trading; the efficiency of fees is conducive to maximizing the company’s interests.
- Explore new business scopes, the power grid companies as managing power in the distributed power trading market, power grid companies not only charge the “net fee”, but also explore new business scenarios to increase new profitable income.
3.3.3. Electricity consumers. In the free and opening market environment of the electricity market, electricity consumers, have more choices. Therefore, there is the value target of the power user. Such as reduce transaction risks, and realize distributed power transactions judicially effective and verifiable. In addition, the stability of power quality, different users have different requirements for power, which needs to be from the perspective of power users set out to evaluate power quality.

3.3.4. Electricity load integrator. After the distributed power trading market is fully developed, a large number of users will have the willingness to interact with the Internet of Things Platform, and load integrator needs to integrate and process a large amount of user information before interacting with the Energy Internet of Things. The value target of the load integrator is as follows. Firstly, reduce user access standards and enable more users to participate in transactions on the Internet of Things Platform. Secondly, reduce the operating burden and difficulty of operation and maintenance of the Energy Internet of Platform [12].

4. The business model of distributed power trading based on blockchain technology

4.1. The public service platform of distributed power trading based on blockchain
Establish a public service platform for distributed power trading, using the functions of blockchain technology such as identity authentication, encrypted transmission, smart contracts and judicial deposits. The platform can provide services such as identity authentication and signature, certificate issuance, transaction management and data storage for distributed power suppliers and power users, realize the security and transparency of distributed power transactions, maximize the benefits of production and sales, balanced competition in power transactions, and automatic settlement of transaction contracts.
The distributed power trading platform architecture consists of four parts, including the basic blockchain platform, blockchain services, supporting applications, and management monitoring, as shown in Figure 2. The platform can enable multiple parties to participate in distributed power transactions, ensuring the safety and credibility of transactions in all aspects. For example, uploading data to the chain for certification, expanding judicial certification, multi-node management of competitive transactions, and providing effective means for distributed power transactions prevent malicious node transactions.

Smart contract, as a very important technical means, contains a series of distributed energy trading information such as transaction time, amount buyer and seller, energy type. The application of smart contract technology will build a bridge between enterprises and power users, which is conducive to the realization of intelligent management of power grid enterprises. When the State Grid enterprise
collects the network fee, the producer and seller login to the public service platform to register more complete information, the database and account book content of the platform service layer, to analyze the potential functions and derivative services of distributed power transactions.

4.2. The principles of distributed electricity trading based on blockchain

Firstly, following the principle of fair competition, each transaction participant uses the platform to bid on individual energy supply information. When it meets the requirements of maximizing the economic benefits of energy suppliers and minimizing the costs of energy users, after the energy supply and energy use entities reach an agreement, they will conduct peer-to-peer transactions. And then a smart contract is signed, and the platform records the data of the energy supply and energy-consuming subjects of the successful transaction in the transaction ledger to realize the successful transaction. Secondly, follow the principle of encouraging bidding. After multiple rounds of cycles, the unsuccessful transaction of idle energy is stored in the platform’s energy library at a fixed price. The platform company charges a certain fee to the energy supply and energy use companies, and according to the order in which the platform system receives the energy, increase or decrease transaction fees, thereby encouraging transaction participants to bid.

4.3. A business model of multi-participation in competition based on blockchain technology

The main key process of the distributed power trading platform based on blockchain technology is shown in Figure 3. Suppliers and power users the platform as a carrier to conduct distributed power trading, and each transaction subject has equal status in the blockchain system, the main process is shown in Figure 3. Firstly, perform user registration and qualification review. Distributed generation suppliers and power users need to register their identities first, and then they can trade on the public trading platform after passing the examination [14]. If the registered distributed power trading participating members want to change or withdraw from the market, the user’s registration information needs to be approved, including user name, meter ID, user address, credit value, etc., the withdrawal can only be realized after the approval is completed. Secondly, the distributed power supplier and the power user negotiate quotations. Power generation companies and power users provide the distributed power trading platform with electricity prices and electricity consumption during the trading cycle. Thirdly, matching transactions. The public service platform conducts matching double-issue transactions based on the quotations generated in the second link, and forms an electronic prepaid order. Fourth, the smart contract is signed. Before signing a smart contract, the system platform will automatically perform a security verification of the electronic contract signed by the power supplier and the power user, and sign a tripartite supply electronic contract with the grid company as the service party. The electronic contract needs to include the detailed transaction information of both parties to the transaction and the liability for breach of contract.
5. Conclusion
The distributed power trading, as a new form of power generation and consumption, has made great progress in the electricity market, while facing the market public service lag, the management system is not sound problems. This paper proposes the establishment of a distributed power trading service platform based on blockchain technology, further standardize the trading principles of participants and build a more complete distributed power trading process, break down trade barriers among distributed entities, improve the credibility of participating entities, form a visual, verifiable and credible competitive business model, realize a more diversified and intelligent distributed power trading market, and promote the absorb energy ability of distributed power, and promote the development of clean and low-carbon energy.

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