Applicability evaluation of blockchain technology in distributed power transaction

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Abstract. With the proposal of peaking carbon dioxide emissions and carbon neutrality target, distributed generation, especially distributed renewable energy generation, will play a more and more important role in the future power system and become the main source of power supply. The rapid development of blockchain technology provides more imagination and development opportunities for distributed power transaction. Its security, decentralization and rapidity are very suitable for distributed power transaction. This paper analyzes the key factors affecting the level of distributed power transaction, establishes the applicability model of various transaction modes for distributed transaction, analyzes the applicability of blockchain technology for distributed transaction, and puts forward the improvement direction of blockchain technology in distributed power transaction in the future.

1. Introduction
Blockchain technology originates from bitcoin and is the underlying technology of bitcoin [1]. Bitcoin is also the earliest application object of blockchain technology [2]. In recent years, there have been many cases of application of energy blockchain technology, and many domestic and foreign energy enterprises have started to explore, mainly applied to distributed energy trading, green certificate asset digitization, supply chain finance, carbon market trading, electric vehicle charging and settlement, etc., reducing transaction costs and improving efficiency.

Distributed generation is mainly distributed photovoltaic, which has the advantages of green environmental protection, renewable energy utilization, simple operation, as well as fast construction and installation [3]. In recent years, it has been developed rapidly in China. In the early stage, the construction of photovoltaic power generation was mainly based on the centralized development mode. Most of the areas with good lighting conditions and cheap land resources were selected. In the form of photovoltaic power stations, large-scale construction was carried out, and the power supply was centralized connected to the power grid.

With the sharp decline of manufacturing cost of photovoltaic power generation, distributed photovoltaic power generation based on family, factory and community has developed rapidly. These power generation resources are usually connected to the power grid from the local distribution network or power supply network. While meeting their own power consumption, they connect the surplus power to the power grid, or send all the power generation to the power grid. From the point of view of single or single distributed generation project, the capacity of distributed photovoltaic power generation is not large compared with the main grid system, but from the overall point of view, the total capacity of distributed photovoltaic power generation will show a significant effect. Especially in
the past two years, the distributed photovoltaic capacity of some provinces has exceeded 10 million kilowatts, and the peak power generation capacity has changed the traditional power load curve.

It can be predicted that with the rapid development of energy transformation and photovoltaic power generation, distributed photovoltaic power generation has become an important market member in the power market. Blockchain technology is very suitable for the technical characteristics and requirements of distributed transaction. The application of blockchain in distributed transaction has become a hot research direction recently [4-5].

However, the applicability of blockchain in distributed transactions has not been studied in depth. How to effectively evaluate the feasibility and applicability of various transaction methods for distributed transactions, and identify the promotion role of blockchain technology for distributed transactions, are important factors to promote the better and faster development of distributed transactions. This paper analyzes the key factors affecting the efficiency and security of distributed transactions, establishes the applicability model and evaluation index system of various transaction modes for distributed transaction, compares the promotion effect of blockchain technology and other transaction technologies on the improvement of distributed transaction level, and puts forward the direction and suggestions for strengthening the application of blockchain in distributed transaction in the future.

2. Application of blockchain in power transaction

In the aspect of distributed transaction, in the traditional electricity trading market, power trading is in the hands of a few oligarchs, and in fact, only a few oligarchs can bear such high infrastructure construction costs in the past. However, with the improvement of photovoltaic panel technology, more and more families have deployed home photovoltaic power generation equipment, which has a large installation cost, but the excess power generated in the photovoltaic power generation equipment is not fully utilized, which is a kind of invisible loss for both families and communities. More and more families want to sell their own surplus electricity to other users, and clean power sources also want to reduce prices to attract more users.

Limited by region and economy, the mismatch between power demand and power supply is a long-standing problem. Smart grid can solve this problem effectively, and blockchain technology is the best choice to build smart grid. Through the digitalization, intelligence, independent operation and self-optimization of power grid, power production and consumption will be more precise and refined, resource utilization will be more intensive and efficient, and decision-making judgment will be more forward-looking.

At present, most of the blockchain energy projects are concentrated on P2P energy market platform. The energy point-to-point transaction of blockchain is the main application scenario of blockchain in the energy industry. The decentralization and distribution characteristics of blockchain enable power producers, electricity sales departments and consumers to realize "direct connection", which can greatly reduce the transaction cost of power and improve the transaction efficiency.

Distributed energy system has not only the basic characteristics of the Internet, but also the core problems to be solved by the Internet economy, such as the bidirectional flow of energy and information, data recording and management, etc. Through blockchain, payments can be secured by cryptocurrency, and contracts will be just numbers. All transactions can be verified by thousands of "witnesses", and if public links are used, potential fee free models will be introduced. The advantage of this radical approach is that each transaction will be recorded in a tamper proof manner.

Since the process of verifying transactions is conducted through a large number of data models of distributed computing systems, rather than trading in a limited central system, trading energy on the blockchain will allow "immediate" approval of transactions. There is a free possibility of direct trading between consumers and producers (even the production and marketing combination). At present, the traditional trading mode is that the transaction personnel execute the transaction, the bank confirms whether there is enough money to be paid for the account, and the central rights system supervises and monitors the transaction occurrence. The advantage of blockchain technology is that transactions can
be carried out directly, without the supervision of central authority and the access of banking institutions. This result greatly reduces the occurrence of intermediate service fees.

3. Key factors affecting distributed transaction and applicability evaluation system

The key factors affecting distributed trading can be identified from five aspects: trading efficiency, trading security, real-time trading, the diversity of transaction modes and the ability to promote the clean energy consumption level.

3.1. Trading efficiency

Trading efficiency refers to the speed or efficiency of transaction activities (associated with commercial activities) or business activities (associated with administrative activities) in a regional economy in a certain period of time. There are many main bodies in the distributed transaction market. Buyers and sellers need to reach an agreement on the electricity quantity and price of the distributed transaction in the shortest possible time with lower transaction cost and less link process.

3.2. Trading security

Transaction security is the key issue that market participants are most concerned about. Distributed transaction is in its infancy, the transaction system and market mechanism are not perfect, and the security of transaction is difficult to be effectively and reliably guaranteed. In order to ensure the security of distributed transaction, it is necessary to avoid the disclosure of the transaction information and quotation curve of the market subject, prevent the tampering of the transaction result information, and ensure the timeliness of the transaction.

3.3. Real-time transaction

Real-time transaction is the key to ensure fair and efficient transaction. Distributed generation, especially distributed photovoltaic generation, is intermittent and volatile compared with centralized generation. It is necessary to publish the volume and price information of transaction demand to the transaction platform in real time on the premise of accurate prediction, so as to make the supply and demand match quickly and accurately and improve the speed and accuracy of transaction matching.

3.4. The diversity of transaction modes

The diversity of transaction modes is the key to meet the personalized and diverse transaction needs of users. The power trading platform can provide more real-time trading information and provide more types of power (wind power, photovoltaic, etc.) for users to choose. Whether users can use more diversified, comprehensive and flexible trading methods for personalized power trading is the key problem to measure the diversity of trading modes.

3.5. The ability to promote the clean energy consumption level

The ability to promote the clean energy consumption level is an important factor to measure whether the distributed transaction can be carried out efficiently and smoothly. With the implementation of carbon peak and carbon neutral vision, distributed generation will focus on wind power and photovoltaic power generation. Good trading mode can effectively promote clean energy consumption, reduce the rate of abandoned wind and light, and increase the proportion of electric energy consumption in terminal energy.

These five aspects constitute the key factors to measure the level of distributed trading. Based on the five factors, the applicability evaluation system of distributed transaction level is established, and the relevant evaluation indexes are shown in the table below.
Table 1 Evaluation results of key drivers of different types of customer side resources

| First level indicators                          | Second level indicators                                                                 |
|------------------------------------------------|------------------------------------------------------------------------------------------|
| transaction efficiency                         | transaction cost                                                                          |
|                                                | trading speed                                                                             |
|                                                | the number of transaction link                                                           |
| transaction security                           | information reliability                                                                   |
|                                                | non tamperability of information                                                         |
|                                                | timeliness of information (credit qualification of market subject, market qualification, etc.) |
| real-time transaction                          | timeliness of information matching                                                       |
|                                                | accuracy of transaction information                                                      |
|                                                | transaction matching accuracy                                                            |
| the diversity of transaction modes             | diversity of power sources                                                               |
|                                                | diversity of matchmaking methods                                                         |
|                                                | diversity of trading targets                                                             |
| the ability to promote the clean energy        | measurement capacity of consumption level (quantifying the specific scale of clean energy consumption by users) |
| consumption level                              | limit the ability of repeat trading (prevent the excessive consumption of repeat trading and maintain the market order) |

Evaluation of key drivers of the expert scoring method is used to evaluate the applicability of various trading methods in distributed trading. On the basis of determining the above evaluation index system, the following five steps are taken for applicability diagnosis and evaluation:

1. Transaction method selection. Choose blockchain technology and traditional centralized transaction mode for comparative analysis.
2. Data acquisition. Mainly from the government website, social evaluation, industry analysis report, regulatory reports and related data.
3. Weight setting. Through questionnaire survey, expert interviews and other methods, AHP and expert weight method are used to determine the weight of indicators at all levels.
4. Scoring and evaluation. According to the principle of combining subjective and objective, the evaluation is carried out by refining the grading level, clarifying the grading standard and organizing experts to grade.
5. Diagnostic analysis. According to the evaluation results, the applicability of different transaction methods in distributed transaction is evaluated, and the promotion strategy is proposed.

According to the specific index data, the secondary dimension index is assigned according to 1-5 points, 5 points is excellent, 4 points is good, 3 points is average, 2 points is poor, 1 point is very poor.

4. Case study

From five aspects of transaction efficiency, transaction security, transaction real-time, transaction mode diversity and promotion of new energy consumption level, the applicability of blockchain transaction and traditional transaction mode in distributed transaction is evaluated through expert scoring method. The evaluation results are shown in the figure.
As shown, blockchain transactions have significant advantages over simultaneous interpreting transactions in distributed transactions. Blockchain transaction can greatly improve the transaction efficiency of distributed transaction, reduce the transaction cost, ensure the security and real-time of transaction information, provide more selection modes and contents for distributed transaction, and trace the power source of users, which promotes the improvement of clean energy consumption level. It is suggested that we should continue to strengthen the application of blockchain technology in distributed trading, enrich the relevant policy system, market mechanism and technical level, strengthen the cultivation of multiple market players, continue to innovate trading formats and modes, provide more personalized, diversified and customized distributed trading services for market players, help the construction of new power system, and promote the realization of dual carbon goals.

5. Conclusion
In recent years, the development of distributed generation has been accelerated, and the importance of distributed power transaction has been gradually enhanced. The characteristics of blockchain technology are similar to the concept of smart grid to a certain extent, which is very suitable for the distributed power transaction. This paper analyzes the five key factors affecting the distributed transaction, and puts forward the relevant evaluation index system and evaluation method. It can be seen that the blockchain technology is very suitable for the distributed power transaction, which can effectively improve the efficiency and security of the transaction, and promote the clean energy consumption. In the future, to strengthen the application of blockchain technology in distributed transaction, we should further improve the policy system and market mechanism, enhance the technical level, and continuously innovate the format and mode of blockchain transaction, which is necessary to provide more personalized, diversified and customized distributed transaction services for market participants.

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