

Research on Application of Block Chain in Distributed Energy Transaction

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Abstract—With the promotion of electric power reform in China, distributed energy participating in power market transaction becomes possible. However, due to the characteristics of transaction decentralization, multiple energy synergies, information symmetry and the large quantity, the transaction cost and the risk of information leak increase significantly, which inhibits the enthusiasm of distributed energy to participate in electric power transaction. The block chain has been widely used in finance, logistics and other industries because of its decentralized data processing. In this paper, the characteristics and infrastructure of the block chain is analyzed and the distributed energy trading framework based on the block chain is built. The result shows that block chain has significant effect on the information security of the energy transaction.

Keywords—*block chain; energy Internet; distributed energy; electricity transaction*

I. INTRODUCTION

Distributed generation can make use of the nearest clean energy resources and energy production and consumption complete in the neighborhood. So distributed generation has obvious advantages of high energy efficiency and low pollution emissions, which represents the new direction and new form of energy development.

In 2017, Notification of Market-Oriented Trading Pilots of Distributed Power is carried out by the National Energy Commission. The distributed power generation is encouraged to participate in market transactions with the distribution network users[1]. However, due to the decentralization of distributed energy transactions, multi-functional coordination, information symmetry, multi-objective and large number of transactions, it greatly increases the transaction cost and information leakage risk and inhibits the enthusiasm of distributed energy to participate in electric power transaction. Because of its centralization, transparency, contract execution automation, traceability and so on[2-3], the block chain can promote the multi-faceted energy, the coordination of the participants, and promote the cooperation of the main body in order to protect the trust as the core to promote the transaction and authentication. It also can promote the further integration of information and physical systems and achieve the diversification of transactions and low cost[4]. At present, the application of block chain technology in energy internet has become research hotspots. The infrastructure of energy block chain is analyzed in literature [5]. The block chain can be used in information security, power transaction, multi energy cooperation and so on[6-8].

Based on the analysis of the characteristics and infrastructure of the block chain, this paper analyzes the distributed energy trading framework based on the block chain technology, and has significant effect on the information security ability of the energy transaction.

II. INTRODUCTION OF BLOCK CHAIN

A. The meaning and characteristics of block chain

Block chain technology is used to verify and store data, which can generate and update data by distributed code consensus algorithm, guarantee the data transmission and access by cryptology, program and operate data by intelligent contract composed of automated script code. It is a new distributed infrastructure and computing paradigm.

Due to the special structure of data structure, the block chain has the characteristics of distributed centralization, transparency, contract execution automation, traceability, openness and so on.

B. The infrastructure of block chain

Block chain system consists of data layer, network layer, consensus layer, incentive layer, contract layer and application layer. The data layer block the received data; the network layer checks and accounts the data; the consensus layer consists of consensus mechanisms and algorithms; the incentive layer consists of rational crowd sourcing mechanism; the contract layer is the basis of programmable characteristics; and the application layer consists of various application scenarios. The infrastructure is shown in figure 1.

C. The block chain evolution path

So far, block chain technology has gone through four stages of development, including technological origin, block chain 1.0, block chain 2.0 and block chain 3.0, which is shown in figure 2.

D. The Coupling foundation of energy block chain

There is a certain similarity relation between the energy Internet and block chain technology (as shown in Figure 3), such as decentralization of resources, multi energy cooperation autonomy, marketization and contract intellectual, which makes it possible that block chain can be used for energy Internet.

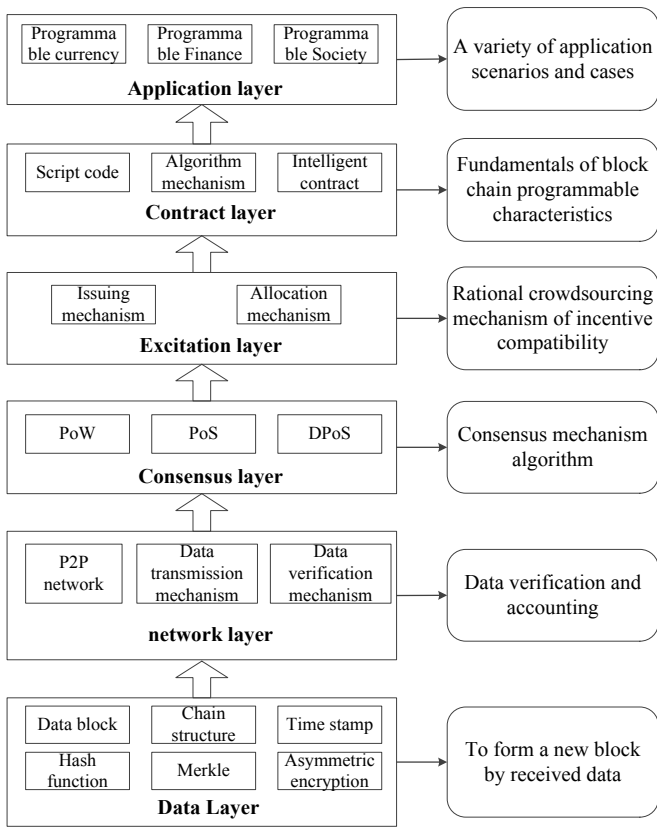


Fig. 1. The infrastructure of block chain.

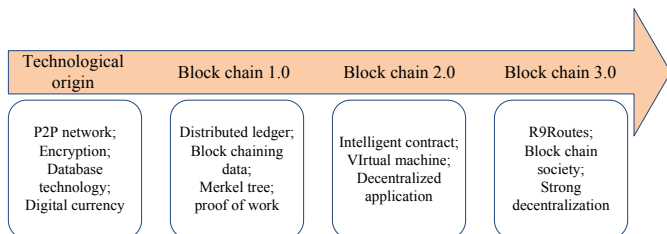


Fig. 2. The evolution path of block chain technology.

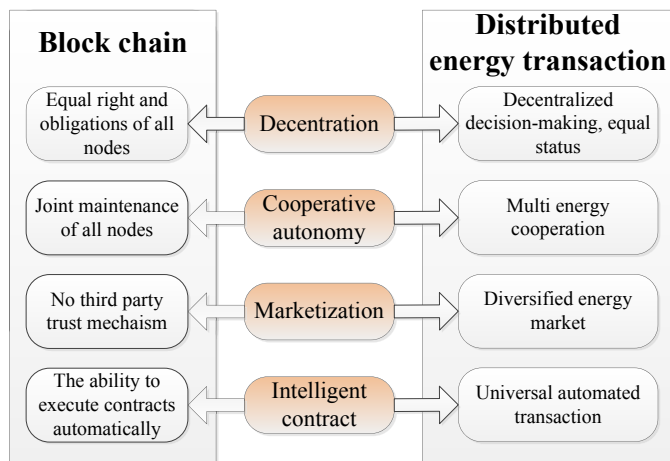


Fig. 3. The Coupling foundation of energy block chain.

III. THE APPLICATION OF BLOCK CHAIN IN DISTRIBUTED ENERGY TRADING

With the development of the Internet, the distributed energy sources, such as distributed PV, CCHP, are developing rapidly, and gradually participate in the electricity market. However, the characteristics, such as large number of distributed energy, small capacity, and high transaction costs, hinder the development of its market. Block chain technology can provide a low-cost, open and transparent platform for distributed energy trading. It can ensure that the main trading entities participate in electricity trading under the circumstance of information symmetry. It can also improve market efficiency.

A. Transaction structure

The structure of block chain is "block + Chain", which is equivalent to providing a complete history of the database. From the beginning of the first block to the newly generated block, the block chain stores all the historical data of the system. In addition, the block chain also provides the search function of each data. Each transaction data in the block chain can trace to source by the structure of block chain and verify carefully. In the case of the hypothetical micro-grid energy trading, the specific transaction process of the block chain is shown in figure 4.

Based on the distributed energy trading platform of block chain technology, various types of distributed energy, users, electricity sales company, Power Grid Corp can be two-way choice. When the distributed energy determined to participate in electricity trading, block chain system will automatically generate intelligent contract for both parties. The transaction process and results are open and transparent. It can be a reasonable measurement and certification, and encourage more users and distributed energy to participate in the power trade. In the block chain market trading platform, distributed energy and users can not only form a long term power purchase agreement by intelligent contract, but also can be traded in real time.

B. Transaction process

Assuming Through the analysis of Figure 4, we can conclude that the specific process of renewable energy trading is as follows:

(1) Power grid and electricity sales company, electricity sales company and distributed power, distributed power and users. They build a intelligent contract each other, and the intelligent contract will be stored to block chain and feedback to all parties.

(2) Users and distributed power will participate in the electricity market transactions, they will make a transaction by private key.

(3) The transaction will be issued to the whole network. The user can pay by bank. All blocks will receive transaction information, and the information will be stored.

(4) Block calculates electricity price quantity in accordance with the intelligent contract, the bank split account in accordance with the results of the calculation of the contract.

(5) Process is recorded to block chain based on the intelligent contract, and it will check the correctness and form a complete block chain.

Similarly, the demand side response resources and power grid can build on intelligent contract and participate in the

grid ancillary services transactions. The user stores the ancillary service capability and price into the block chain, and the bank settles the contract according to the results of the contract. The entire transaction process does not need people to participate through the analysis of the transaction process, and the data is credible. It can be traded at any time and completed instantly.

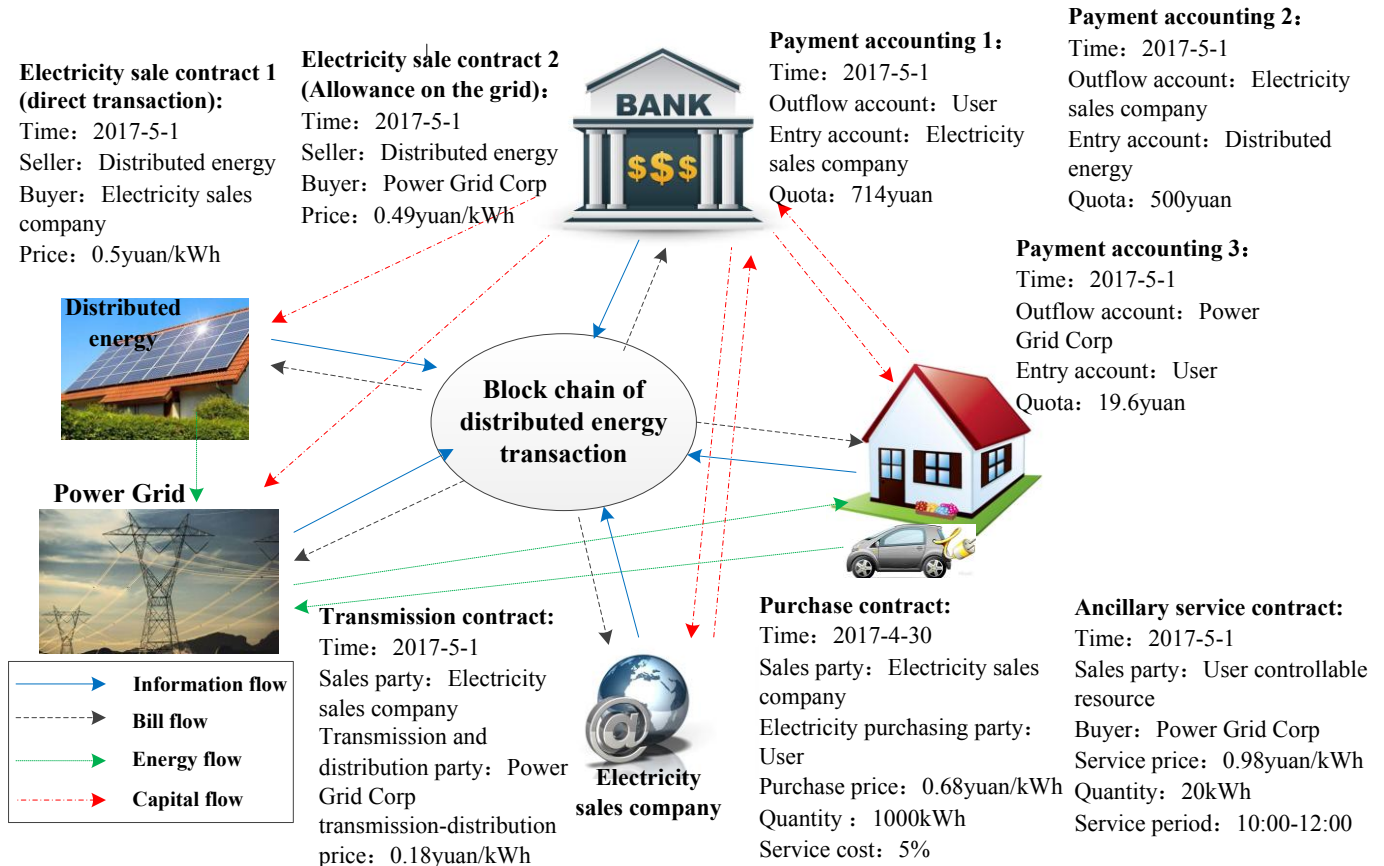


Fig. 4. Sketch of distributed energy transaction based on block chain

C. Key technologies of block chain in distributed energy transaction

(1) The coupling of block chain technology and regional energy system should be based on the physical model of energy system. The physical model of distributed energy system is weak in current power system. We should not blindly exaggerated the application of block chain technology in the distributed energy transaction, while ignore the construction of physical model of distributed energy system.

(2) The block chain technology needs to constantly improve and upgrade. The full application of block chain technology in regional energy systems requires a long time. At present, the computing efficiency of block chain couldn't meet the real-time requirements of energy production system. In addition, there are some defects in the fault tolerance analysis of block chain technology.

(3) The block chain technology must be merged with big data, cloud computing technology and so on. The current energy information system, automation and data processing ability couldn't meet the real-time requirements, which requires the block chain, big data, cloud computing technology, information communication and other advanced technology to integrate and coordinate deeply.

(4) Research on energy block chain based on intelligent contract. Power balance and physical model of energy production and consumption all depend on intelligent contract, such as balanced market, micro grid, virtual power plant, energy storage equipment etc. So the basic architecture and application model of energy block chain based on intelligent contract should be studied.

IV. CONCLUSIONS

The block chain technology is more and more widely used in the construction of energy Internet because of its

characteristics of decentration, openness and transparency. In this paper, the basic concept, typical characteristics and evolution path of block chain technology are analyzed firstly. Then, based on the characteristics of distributed energy, a distributed energy block chain transaction structure have been proposed, and the key technologies are summed up. At the present stage, the research of energy block chain is growing vigorously, and we hope that the theoretical analysis results in this paper will play a role in promoting the application of block chain in distributed energy trading.

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