Application Research of Blockchain Technology in Smart Energy Business Model

Ning Xu[1](✉), Bo Zhou[1], Nan Xu[1], Jing Nie[1], Yongli Wang[2], Yanan Wang[2], and Wenqiang Miao[2]

[1] State Grid Hebei Electric Power Co., Ltd., Company, Hebei, China
120202206303@ncepu.edu.cn
[2] North China Electric Power University, Company, Beijing, China

Abstract. Blockchain technology is regarded as a disruptive technology with real potential for change after steam engine, electricity and Internet, and it has huge advantages. Both blockchain and energy internet are technically decentralized, highly autonomous, market-oriented and intelligent, and thus show strong application potential. Distributed trading is the most important application of blockchain technology in the field of smart energy. Under the premise of summarizing the basic principles and application scenarios of blockchain, this paper analyzes the weakly centralized internal bidding energy business model of intelligent micro grid based on blockchain technology. This mode utilizes multi-party bidding to optimize the allocation of resources such as cold, heat and electricity, restore the commodity and financial attributes of energy, and can greatly improve the energy efficiency and economic benefits of micro grid.

Keywords: Block Chain · Integrated Energy Systems · Energy

1 Introduction

Blockchain is a disruptive technology that has emerged with the popularity of digital cryptocurrencies such as Bitcoin and Ethereum. Blockchain originates from digital currency and is the underlying technology of digital currency. However, it provides a decentralized credit building mode without trust accumulation, which has attracted great attention from all walks of life around the world, especially in the fields of finance, commerce, government, medical care and energy. If the Internet technology, mobile Internet technology is trust between the machine to solve the problems (such as via TCP/IP communication protocol), then the block chain technology is to address the issue of trust between people in the network, has provided the traditional "information" to "value" of the Internet, the Internet technology development route, also known as the "Internet+" after the next generation Internet "value" [1, 2, 4, 5, 7].

Based on the development demands of the smart energy system, this paper will study the application scenarios and technical characteristics of the blockchain, realize the value reconstruction and transfer of the smart energy system by highly integrating the energy flow, information flow and value flow of the energy system, and explore the application of the blockchain technology in the business model of the smart energy system.

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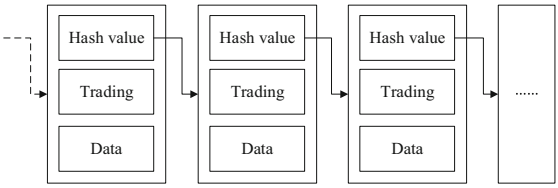

Fig. 1. Basic principle of block chain

2 The Fundamentals of Blockchain

The basic principles of blockchain include three basic concepts: trading, blockchain and chain. A transaction is each operation on the ledger that results in one change to the state of the ledger. A block records the results of all transactions and states that occur over a period of time, and is a consensus on the current state of the ledger once. A chain consists of sequential blocks and is a log of changes in the state of the entire ledger. Each transaction based on the blockchain will change the state of the entire blockchain, while each block generated by consensus will confirm the result of the transaction status change. Subsequent blocks in the blockchain record the hash value of the leading block, and new data must be added to a new block summary. The validity of the new block can be quickly verified by calculating the hash value. Each node can propose a new block, but the block must be unanimously approved by all nodes, that is, it must be selected by a certain consensus mechanism [3]. The basic principle of blockchain is shown in Fig. 1.

Blockchain has the technical characteristics of decentralization, openness, disintermediation trust, information cannot be tampered with, transaction anonymity and so on.

3 Application Scenarios

The typical characteristics of blockchain determine that it has great application potential in the field of finance and industry, and it is gradually put into practice. Using block chain to build supply chain finance platform can realize the whole chain of information link and traceability. With the accumulation of time, voucher and contract execution, transaction, pledge and other process records in the whole chain gradually become valuable credit source data. Since all data entry in the block chain is jointly confirmed and maintained by all participants, the more people involved in this type of distributed bookkeeping, the more reliable the credit will be. Moreover, the establishment of credit investigation model based on this will greatly expand the scope of acceptance and use.

Another area where blockchain is widely used is its deep integration with the Internet of Things. In the future, there will be significant changes in the elements of transactions between things. On the one hand, each device is a transaction subject and decision-making subject, and block chain can build a bridge of point-to-point direct communication between intelligent devices in the Internet of Things. On the other hand, the content of future transactions will be the use right and usufruct of equipment, data and other assets, and the carrier will be the massive data generated in various production and life processes. There will also be big changes in the frequency of trading.

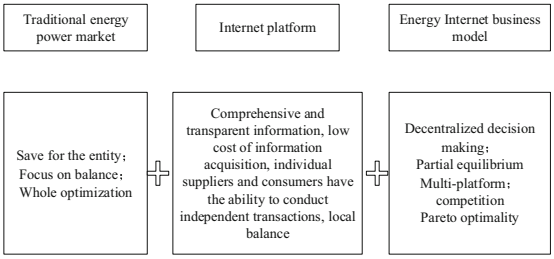

Fig. 2. Energy Internet business model characteristics

In the future Internet of Things era, transactions between devices could be hundreds of thousands a day.

4 Smart Energy Business Model Based on Block Chain

4.1 Smart Energy Business Model

The features of smart energy business model based on block chain technology are shown in Fig. 2: (1) Realize point-to-point power transaction between users and generators; Decentralized decision making; (3) Decision scheduling: The object of future power scheduling is a large number of distributed energy and intelligent power load, generating scheduling decisions through the block chain; (4) Achieve pareto optimality in market competition, with high efficiency in resource allocation [6].

4.2 Weak Centralization of Intelligent Energy Competitive Energy Business Model

Based on the block chain technology, the weakly centralized intelligent micro grid internal bidding energy business model, its physical structure includes energy layer, control layer, functional layer and other levels. The structure of the smart energy micro grid is shown in Fig. 3. It consists of several industrial enterprises, home users, commercial districts, DC power users, electric vehicles, energy storage devices and so on. Intelligent competitive trading platform, energy router, two-way intelligent metering device and other components of the control layer; The energy supply layer is composed of photovoltaic power generation, wind power generation/heat, gas turbine power plant, biomass power generation, ground/water source heat pump, etc.

All trading entities have equal status in the blockchain system and are interconnected and interactive in a flat topological structure. Trading energy includes cold, hot, electricity, gas, etc., which is allocated after bidding through energy routers and competitive trading platforms. The process of competitive energy use within the micro grid is shown in Fig. 4.

1) *Construct intelligent trading contracts between agents, including energy supply contracts, energy use contracts, storage contracts, clearing methods, payment contracts, etc.*

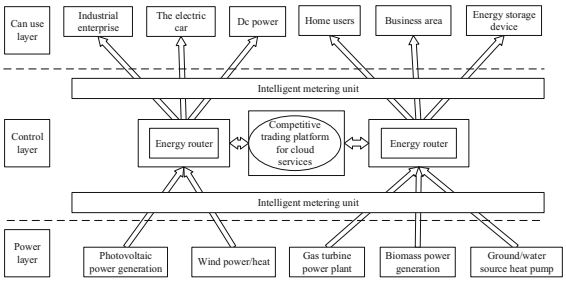

Fig. 3. The smart energy micro grid constitutes the framework

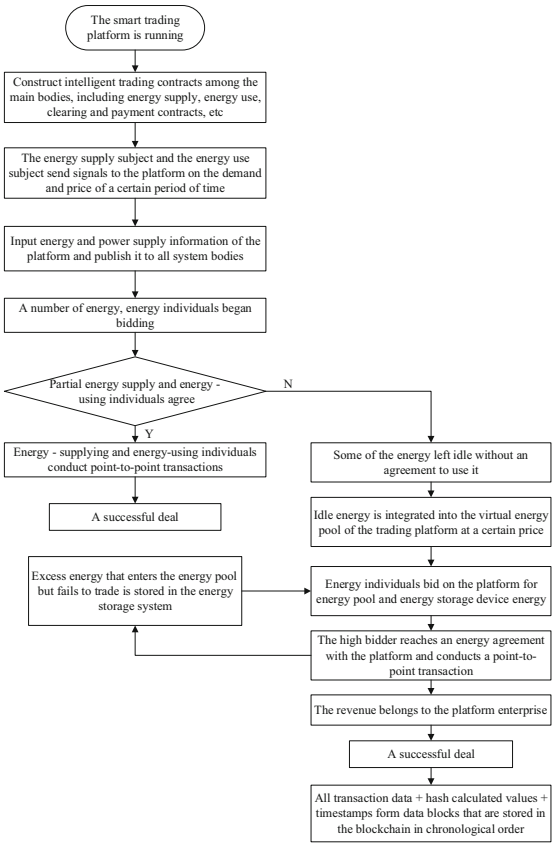

Fig. 4. Flow chart of intelligent energy Competitive energy use based on block chain

2) *Initialization of intelligent trading platform, define successful trading counters intnum1 = 0, failed trading counters intnum2 = 0, Intnum3 = 0, intnum4 = 0, array Numbers of successful trading parties sup-py_suuccess1, consumer_success1, fixed*

price of energy pool doubleFixed_price = 0.43(specific local electricity price shall prevail).

3) *The trading platform receives and publishes the energy and price data from the supplier and the supplier. The supply array consists of suP-PY_id, supply_price, and supply_output. The energy array consists of the number CONSUMER_id, consumer_price and consumer_consumption. The energy supply array and the energy Consumer array are assigned an initial value of −1.*
4) *Under the first scenario, energy supply and energy-using individuals make use of the platform to bid for individual energy, and the successful transaction needs to meet the following two conditions: maximizing the economic benefit of energy supply BSmax and minimizing the cost of energy use BCmin; and supply quantity is greater than or equal to demand (supply_output ≥ con-sumer_consumption). The bidding principle in this scenario is as follows:*

a) The energy supply quantity of $S_1, S_2, S_3 \cdots$ is $N_{S_1}, N_{S_2}, N_{S_3} \cdots$ and the price is $P_{S_1}, P_{S_2}, P_{S_3} \cdots$; The amount of energy used by individual $C_1, C_2, C_3 \cdots$ is $N_{C_1}, N_{C_2}, N_{C_3} \cdots$, and the price of energy used is $P_{C_1}, P_{C_2}, P_{C_3} \cdots$.
b) Trading principles of individual energy suppliers:

$$\begin{cases} \text{Number of power}: N_{Sx} \geq N_{Cn} + N_{Cm} + N_{Ck} + \cdots\cdots \\ \text{Economic benefits}: B_{S\max} = \max\begin{pmatrix} N_{Cn}P_{Cn} + N_{Cm}P_{Cm} + \\ N_{Ck}P_{Ck} + \cdots\cdots \end{pmatrix} \end{cases} \tag{1}$$

In the case that the energy supply meets the condition (1) and $B_{S_{\max}}$ is the largest, the system will sort the energy-using individual $C_n, C_m, C_k \cdots$ from high to low according to the sorting value = Max (the amount of energy used $N_{C_x} \times$ the price of energy used P_{C_x}). Then, the energy supply individual S_x issues the exchangeable symbol to the energy use individual in order, and trades according to the principle of prioritizing transactions.

c) Trading principles of energy-using individuals:

$$\begin{cases} \text{Can use the number}: N_{Cx} \leq N_{Sq} + N_{Sw} + N_{Se} + \cdots\cdots \\ \text{The cost}: B_{C\max} = \min\begin{pmatrix} N_{Sq}P_{Sq} + N_{Sw}P_{Sw} + \\ N_{Se}P_{Se} + \cdots\cdots \end{pmatrix} \end{cases} \tag{2}$$

In the case that the energy supply condition (2) is satisfied and $B_{C\min}$ is the minimum, the system sorts the energy supply individual $S_q, S_w, S_e \cdots$ from low to high according to the sorting value = min (energy supply quantity $N_{S_x} \times$ energy supply price P_{S_x}). Then, the exchangeable symbol of energy-using individual C_x is issued to energy-using individual in order and order, and the transaction is conducted according to the principle of prioritizing transactions.

The system writes the successful transaction to the suppy_suuccess1 and con-Sumer_success1 arrays of energy supply and consumption.

The idle energy that has not been successfully traded after several cycles will be incorporated into the energy pool pool at a fixed price. The number of the energy supply subject array will be eliminated. The number of the energy supply subject

array that has not completed the transaction will be written into the energy pool energy array Suppy_id_pool.

In this scenario, the platform enterprise will charge a certain commission to the energy-supplying and energy-using enterprises, and increase or reduce the transaction commission according to the priority of the transaction to encourage bidding.

5) *In the second scenario, energy individuals and platforms are used to bid on the platform energy pool or energy stored in the platform. The bidding principles in this scenario are as follows:*

a) The energy-using individual $C_1, C_2, C_3 \cdots$ sends competition price data to the platform, and the energy-using quantity is $N_{C_1}, N_{C_2}, N_{C_3} \cdots$, and the energy-using price is $P_{C_1}, P_{C_2}, P_{C_3} \cdots$. The energy provided by the platform energy pool or energy storage device is numbered $O_1, O_2, O_3 \cdots$, its quantity is $N_{O_1}, N_{O_2}, N_{O_3} \cdots$, and the price is $P_{O_1}, P_{O_2}, P_{O_3} \cdots$.

b) Trading principles between energy-using individuals and platforms:

$$\begin{cases} \text{Can use the number}: N_{Cx} \leq N_{Od} + N_{Of} + N_{Og} + \cdots\cdots \\ \text{The cost:} B_{C\min} = \min\begin{pmatrix} N_{Od}P_{Od} + N_{Of}P_{Of} + \\ N_{Og}P_{Og} + \cdots\cdots \end{pmatrix} \end{cases} \tag{3}$$

If the condition (3) is met and $B_{C\min}$ is the minimum, the system will sort the individual $O_d, O_f, O_g \cdots$ in the platform energy pool or energy storage device according to the ranking value = min(energy supply quantity $N_{O_x} \times$ energy supply price case P_{O_x}) from low to high, and conduct transactions in turn according to the ranking.

After the successful transaction, the remaining energy array number is the energy subject that did not complete the transaction, and the remaining energy array consumer_id_rest is written into the energy pool transaction array.

When there are more than one (or one) power supplier and user trading at the minimum cost principle. The calculation period t for statistics, feedback and judgment of the platform is temporarily set at 30s. Real-time judgment shall be performed again after each individual transaction is completed, and the revenue from the transaction between the individual energy user and the platform shall be owned by the platform enterprise.

6) *All the transaction data are packaged and stored in the data block, and the data block is formed after adding the digital fingerprint generated by hash calculation (SHA-256) and the transaction time stamp. All the data blocks are stored in the system in a chain before and after the sequence.*

Energy competitive intelligence based on block chain can use business model, and reduction of energy commodities and financial attribute, establish the competition, open and orderly power and energy market, with many bidding to cold, heat, electricity and other resources to optimize configuration, so as to achieve the competitive state of balance between supply and demand, can greatly improve the efficiency of micro network can use and benefit.

5 Conclusions

Blockchain technology, which is still in the exploratory stage, will trigger a new round of technological revolution in the energy field when combined with "Internet+" due to its significant advantages such as decentralization, distributed decision making, transparent compliance and intelligent settlement [6]. Block chain technology + energy Internet can solve the core problems that restrict the development of distributed energy, and is an important innovation for the business model of distributed trading, which will inject new vitality into the future development of China's carbon trading, micro grid, smart energy and other industries, and will also play a huge role in promoting the ecology of smart energy industry and the reconstruction of institutional mechanisms.

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