Application Research of Blockchain Technology in Energy Internet

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Abstract. At present, the application of blockchain in the energy field has begun to take shape. The decentralization, cooperative autonomy, marketization and intelligence of blockchain technology coincide with the concept of energy Internet. Some high-tech companies in Europe and the United States have begun to apply blockchain technology to the energy sector. Based on the basic research of blockchain technology and energy Internet coupling, this paper deeply analyzes the application of blockchain technology in energy internet, and analyzes the business model of energy blockchain. The aim is to lay the foundation for the transformation and upgrading of energy companies and the early deployment of relevant fields.

1. Introduction
In the past two years, blockchain technology has achieved considerable development and applied to financial, logistics, communications, digital asset trading and other fields, significantly improving the confidentiality of data analysis and storage[1-2]. On October 18th, 2016, the China Blockchain Technology and Application Development White Paper prepared by China Information Technology and Industry Development Forum under the guidance of the Information and Software Service Department of the Ministry of Industry and Information Technology and the National Standards Committee[3], “The official debut, blockchain technology finally ushered in the first official guidance document. In December of the same year, the "Thirteenth Five-Year" National Informatization Plan issued by the State Council also focused on the disruptive technology of blockchain technology as a national layout[4]. In April 2018, the “International Blockchain Development Innovation Conference” held in Beijing actively explored the application model of blockchain in various industries[5].

In the foreseeable future, blockchain will be used more and more in all walks of life and have a subversive impact on current business models. In the context of power market reform and energy internet, energy companies face challenges in all aspects of energy production, transportation and consumption. How to use big data technology to analyze the energy consumption habits of users and master the bidding strategy of competitors is of great significance to enhance their competitiveness. In the process of data analysis and mining, information security is very important. Due to the decentralization, traceability and openness of distributed data processing, the importance of blockchain technology is self-evident.

2. The basis of blockchain and energy internet coupling
The certain similar relationship between energy Internet and blockchain technology makes the application of blockchain to energy Internet, as shown in Figure 1.
2.1 Decentralization of energy Internet
Distributed energy and microgrid are important components in the energy Internet. The boundaries between consumers and producers become blurred, and energy production, trading, and use among individuals are under equal conditions, ongoing.

2.2 Energy Internet collaborative autonomy
Active distribution network, intelligent power generation, power system automation, self-healing, etc., enabling energy Internet self-scheduling and ecological operation.

2.3 Marketization of energy Internet
Emphasis on establishing a market-based trading platform and financial platform to promote energy derivatives trading, such as power trading, carbon trading, and green certificate trading.

2.4 Energy Internet intelligence and contraction
There are a large number of smart devices in the “source-network-load-storage” of the energy Internet, and it is necessary to ensure the automatic execution of scheduling and transactions of the energy system through a series of smart contracts.

Therefore, the blockchain technology is applied to the energy Internet to ensure that the data cannot be falsified, and the asymmetric encryption combined with the public and private keys is used to protect the privacy. Based on the trusted measurement, the low cost between the energy Internet interaction entities is constructed through the blockchain. Trust delivery chain; local consensus and partition-to-partition consensus among energy Internet devices based on blockchain deployment, while achieving distributed decision-making while taking into account efficiency; using low-cost trust transfer of blockchain as a means to different subjects and different systems Converged into an energy Internet super-subject, forming cluster intelligence in a wide area.

3. Application dimension of blockchain technology in energy internet
The application of blockchain technology in energy internet can be summarized and analyzed from three aspects: functional dimension, object dimension and attribute dimension, as shown in Figure 2.

The functional dimension mainly includes four aspects: measurement authentication, market transaction, organization coordination and energy finance; the object dimension can be divided into multiple energy production, transmission, storage and consumption links such as source, network, Dutch and storage; the attribute dimension mainly includes Energy flow, information flow, and value flow in the energy Internet.
3.1 Functional dimension
The blockchain decentralized data storage model and technology, which naturally includes transparency and traceability, is therefore ideal for occasions where authentication and exchanges are required to organize and guarantee third parties. The blockchain can achieve trustworthiness and self-organization in the mechanism, so there is no need for the existence of third-party institutions, which is of great significance to the future energy system under "Internet thinking". Specifically, it will play a huge role in the measurement of energy and emissions, the market transactions of energy and its derivatives, the organization of multi-energy multi-agents, and energy financing.

Measurement certification is an important basis for the realization of openness and fairness in the energy Internet. The Energy Internet involves a wide variety of market transactions. In addition to existing energy transactions, it may also involve ancillary services, emissions, and even financial transactions, and therefore requires trusted measurement and authoritative certification.

Market transactions are the main means of energy Internet ecology. Establishing a multi-faceted market mechanism and creating a diversified business model to promote the broad participation and fair competition of various energy entities is an important manifestation of the energy Internet ecology.

Organizational collaboration is an important guarantee for the energy Internet to improve operational efficiency and promote new energy consumption. The energy form of the energy Internet is no longer limited to electric energy but contains a variety of energy sources such as electricity, heat and gas. The participating entities are no longer limited to “transmission and distribution” but include energy storage operators, electricity sellers and energy agents. Waiting for many participants. Under a reasonable mechanism, it can promote multi-energy forms and participate in distributed organizational coordination of the main body.

Energy finance is an important extension of energy Internet construction. Attracting the injection of capital from all parties will further accelerate the construction of energy Internet, and innovative business models such as crowdfunding have become a new channel for energy Internet financing, realizing the efficient and rapid construction of energy Internet.

3.2 Object dimension
The traditional energy system presents a clear structure with source, network and load boundaries. In the future, the energy Internet will introduce a large number of energy storage technologies, while the boundaries of source, network and load are gradually blurred, and the coupling in different energy systems is gradually enhanced. The Internet of source, network, Dutch, and storage has created great challenges to traditional operations and trading mechanisms. The characteristics of blockchain
equivalence and decentralization can provide key technical support for the development of Internet of source, network, Dutch and storage.

At the source end, energy production will access more distributed new energy based on the original centralized conventional units and large-scale new energy generation, and the system dispatching operation will gradually move from centralized to distributed. The blockchain technology has the characteristics of decentralization. The blockchain-based dispatching system can share the power supply and demand information and real-time price of each node of the power system in real time. Each unit independently determines the power generation output according to the shared information of the blockchain, which can realize Ecological scheduling operation.

On the grid side, there is a large amount of energy flow and information flow. In terms of energy flow, it is necessary to accurately measure the energy transmitted through the network, and to ensure the reasonable distribution of energy flow to ensure the safety and stability of the energy system; in terms of information flow, it is necessary to ensure the reliability of the system state information and to be integrated. Various information is used to evaluate the global energy system.

At the load end, on the one hand, the load forms are diversified, and new types of loads such as distributed new energy, user demand response, and electric vehicles are involved, while different types of loads have different power usage and regulation capabilities; Gradually established, the user changed from accepting the monopoly price of the power grid to the power supply of the independent sales company. In addition, the user can adjust his own power consumption behavior and participate in different energy markets.

On the energy storage side, distributed energy storage systems and centralized large-scale energy storage systems will play an important role in peaking and frequency modulation of power systems in the future. The information transparency mechanism of the blockchain can promote the rational and transparent measurement and certification of the contribution of energy storage to the entire energy system, fully mobilize the decentralized and centralized energy storage to participate in the market enthusiasm, and provide auxiliary services for the efficient and clean operation of the energy system. And get the corresponding return.

3.3 Object attribute dimension
The blockchain is essentially a distributed database technology. The objects stored in the database can be not only "value" such as bitcoin, but also other quantities that need to be registered, authenticated, traced, traded or shared, such as ownership, production, Process, control signals, copyright and even health files. Energy Internet is a network that integrates energy, information and value. The information flow and physical flow are deeply integrated and flowed in both directions. The open and flat energy system will breed free and diversified energy and its derivatives market, which will bring complex and diversified “value”. Streaming, blockchain can support the operation of the energy Internet in terms of energy, information and value.

For the energy flow, in addition to the power flow in the traditional power system, it also combines various forms of energy such as heat and gas to open up barriers of various energy forms, and the integration and coordination of various forms of energy needs decentralized scheduling. Coordination platform, and reliable data system and authentication mechanism of blockchain can standardize the measurement of energy in different energy systems and standardize transactions, and provide support for breaking multi-energy measurement barriers and achieving multi-energy coordination.

4. Business model of energy blockchain
Blockchain is an application level technology. The application scenarios and business models of the energy blockchain can be designed from the power generation to the use.

4.1 Energy crowdfunding
In the context of the energy Internet, based on the Internet + crowdfunding financing model, private capital participates in energy construction and production processes. Blockchain-based energy
crowdfunding services have unique pan-fund and non-financial features that differ from traditional financial bonds or equity financing. Based on blockchain characteristics and virtual market rules, private capital can participate in the entire process of energy planning, design, construction, production, transmission, and consumption without relying on the credit endorsement of third-party crowdfunding platforms.

In addition, the use of blockchain technology, the addition of trust confirmation nodes, the related rights of transactions and equity distribution and other functions, can solve the problem of transaction opacity, content is not open. Non-public financing can also establish a trust relationship between people through the blockchain.

4.2 Energy production
Line loss notarization: the loss of conversion between different energy sources, the long-distance transmission of energy and the line loss caused by other operations are currently determined unilaterally by the grid company, but in the future, these can be carried out through the blockchain. Notarization.

Scheduling decision: There are many distributed energy sources in the object of future power dispatching, and many smart power loads, such as smart electric vehicles, smart homes, etc., the entire grid can generate local commands and signals through the blockchain and execute scheduling.

4.3 Energy trading
Energy microgrid: The distributed voltage generation has a relatively low voltage level and cannot be transmitted over long distances. Through the blockchain, power transactions between point-to-point users and generators can be realized.

Off-site registration: With the continuous opening of the power market, there will be many off-market purchase and sale transactions in the future, which requires the blockchain to realize the power trading contract between the seller and the purchaser. Registration outside.

Financial transmission rights: The trading of transmission rights is just like the trading of power generation rights. It can form resources for trading and listing transactions in exchanges, as well as over-the-counter transactions.

Intelligent electricity sales: In the future energy Internet era, it should be a scalable scenario of plug-and-play, plug-and-play, plug-and-play response. In such a scenario, how the load in the non-responsive plan participates in time, and dynamic participation in line with the demand side response will be a very big challenge. How to determine the plan, allocate income, and how to assess is difficult, and these are precisely what the blockchain can do.

Power storage sharing authorization: The future energy storage is based on the energy storage of the sharing economy. The utilization rate of a single enterprise to purchase energy storage is very low, so the application of blockchain technology, the storage of energy as a taxi and Uber taxi, the surrounding users can share the right to use, call under a user name The energy storage facility then pays for the energy-based revenue and pays the usage fee to the owner of the energy storage.

4.4 Clean energy certification
Based on decentralized, non-tamperable, full-cycle traceable blockchain technology, it can establish accurate and reliable identity information for energy products, thereby reducing the cost of credit for products and enterprises in transactions, and it is expected to solve the endless stream of electric vehicle companies. Renewable energy projects are tricky.

In the process of clean energy certification, the material information involved is supported by the blockchain, and data that cannot be tampered with is formed at each node, resulting in a highly transparent and reliable “identity card”. Since the data such as PV subsidy issuance, electric vehicle subsidy issuance, and distributed electricity sales transactions can be traced and cannot be tampered with, such fraudulent problems can be solved by the blockchain.
5. Conclusion
Based on the basic research of blockchain technology and energy Internet coupling, this paper deeply analyzes the multi-dimensional application of blockchain technology in energy Internet, and puts forward four business models of energy blockchain. On the one hand, through the coupling research of blockchain technology on energy Internet, it can provide assistance for the transformation and upgrading of energy enterprises; on the other hand, through the research on the business model of Energy Express, it can provide direction for energy enterprise business decision-making.

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