Energy Blockchain Business Model Considering Physical-Information-Value

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Abstract. This paper proposes a research perspective of energy blockchain based on the three-dimensional attributes of physics-information-value: analyzes the coupling between blockchain technology and energy Internet in the dimensions of physics, information, and value under complex network systems, and proposes a physical-information-value-based research perspective. The basic framework of energy blockchain from a three-dimensional perspective of information-value, and in-depth research on the main content of energy blockchain from the perspectives of physics, information and value, and finally designed an energy blockchain from a multi-dimensional comprehensive perspective with the energy microgrid as the scene. cooperative autonomous mode and its operation process.

Keywords: component; energy internet; blockchain; complex network system; decentralization

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1 Introduction

Energy Internet is a complex multi-network flow system formed by the power system as the core, the Internet and other information technologies as the foundation, with distributed renewable energy as the main primary energy, and closely coupled with other systems such as natural gas networks and transportation networks. As a product of the interaction and integration of blockchain technology and energy Internet involving the three-dimensional attributes of physics-information-value, energy blockchain is theoretically feasible to analyze from a three-dimensional perspective of physics-information-value [1-2].

Based on this, this paper takes the complex network system with physical-information-value attributes as the basic structure, and analyzes the energy blockchain system and its operation mechanism based on the three-dimensional perspective of physics-information-value [3-4]. This paper first analyzes the compatibility of blockchain technology and energy Internet in the three dimensions of physics, information and value, and proposes the basic framework of energy Internet supported by blockchain technology, and then analyzes the physical [5-7], information, and value dimensions of energy blockchain. The specific content of the energy micro-grid is used as the scene to design an energy blockchain collaborative autonomy model that integrates physics-information-value multi-dimensional development goals and analyze its operation process, in order to provide theoretical research and practice for the currently emerging energy blockchain [9-11].

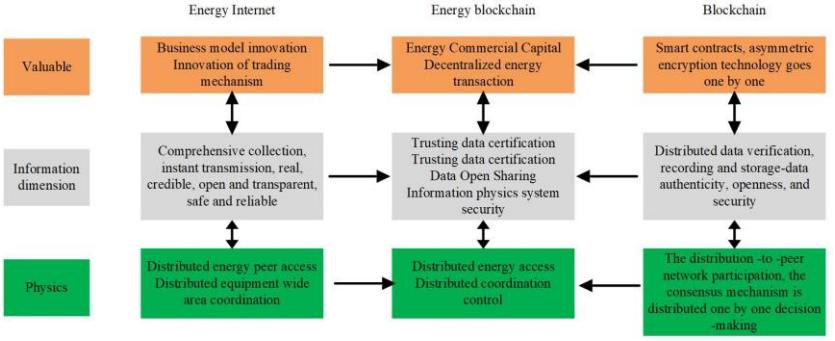

Fig. 1. Coupling relationship of energy internet and blockchain based on physical-cyber-value perspectives

2 Energy blockchain analysis based on physical dimension

Based on the coupling between the energy Internet and blockchain technology in the physical dimension, the energy blockchain can realize two functions in the physical dimension: 1) Peer-to-peer interconnection based on large-scale distributed renewable energy access, connecting a wide range of regions The scattered energy fragments aggregate to form a super energy body with a flattened structure. 2) Effective coordi-

nation of a large number of distributed physical devices to build a distributed intelligent control system.

2.1 Distributed energy access

In essence, the blockchain does not directly act on the access to the energy flow of the Energy Internet, it plays an indirect supporting role. On the one hand, the blockchain distributed peer-to-peer network, based on the connection with the distributed physical interface, realizes the peer-to-peer interconnection status of the distributed energy units of the Energy Internet, and promotes each energy unit to be open and peer-to-peer without any center. The flat topology of the special nodes is interconnected, laying the foundation for the coordination of various energy networks in the decentralized system. On the other hand, the blockchain distributed verification technology can verify the network access of energy nodes, and ensure the quality standards of green, clean, safe, efficient and sustainable development of distributed energy units from the source.

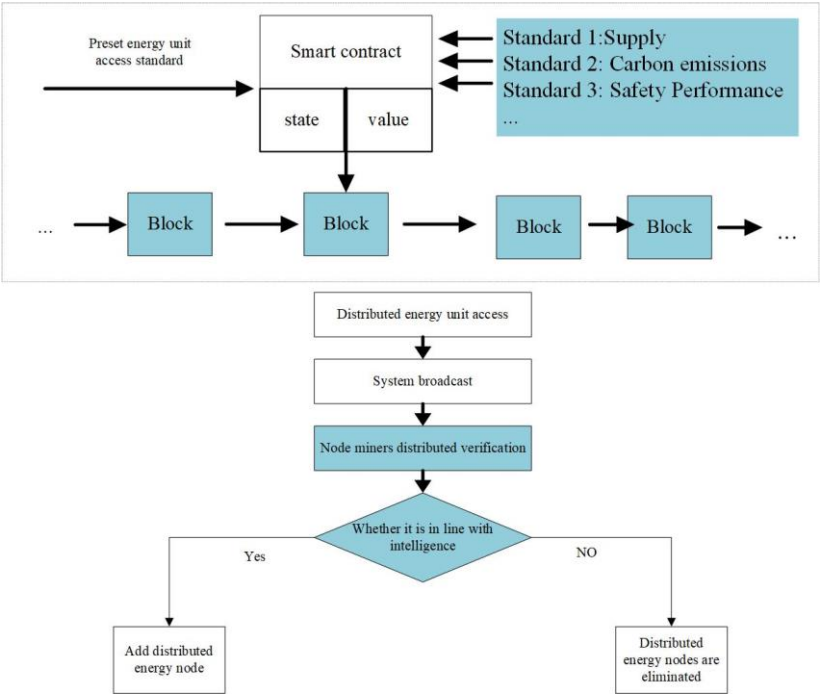

Fig. 2. Distributed verification processes of the nodes' joining into energy network

2.2 Distributed Coordinated Control

The blockchain distributed decision-making technology based on the consensus mechanism provides a solution for the distributed regulation of the energy Internet,

which can realize effective distributed coordinated control based on the optimal decision-making of the system by each distributed energy node, specifically:

1) Propose an operation plan. Each distributed participating node of the Energy Internet predicts the energy operation status of modules such as "source-grid-load-storage" according to relevant energy operation data (such as energy supply and demand/storage/price data, equipment parameters, etc.), as the next step. Guidance for phased energy system operation.

2) Shared operating scenarios. Each participating node broadcasts their respective proposed operation plans to the energy blockchain system, inquires about each other, and analyzes the feasibility and rationality of each operation plan.

3) Choose the best option. Each participating node under the blockchain proof of work (PoW) mechanism enjoys equal voting rights, and the operation plan approved by more than 51% of the nodes will be automatically upgraded to the optimal decision of the system. If the number of votes for the operation plan does not exceed 51%, each participating node proposes a new operation strategy, and repeats a new round of plan sharing and voting until the optimal decision of the system is selected.

3 Energy blockchain analysis based on information dimension

Specifically, the energy blockchain involves three aspects: trusted data authentication, data open sharing, and cyber-physical system security in the information dimension

1) Trusted Data Authentication.

Technologies such as distributed node verification mechanism and chain block structure of blockchain can ensure the authenticity of data at the information level, and play an important role in the credible measurement certification of the Energy Internet. The flow chart of trusted data authentiation of energy blockchain is shown in Figure 3. The specific process is as follows:

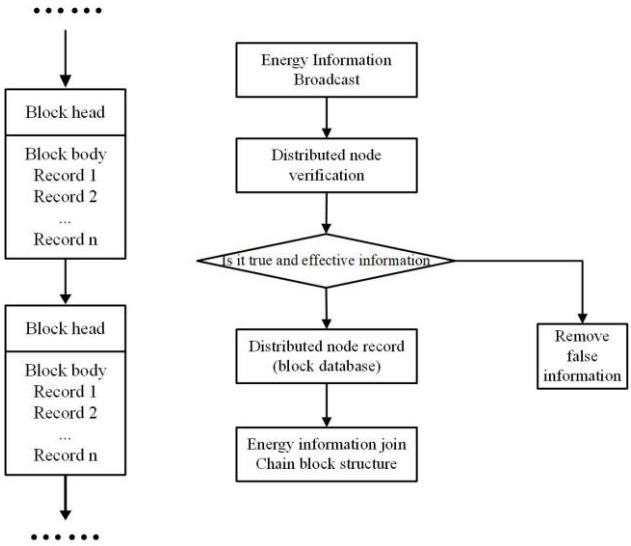

Fig. 3. Trusted data certification for the energy blockchain

2) Open data sharing.

As a collectively maintained distributed shared database, the distributed storage technology of blockchain has the characteristics of open data, real-time transparent sharing, and is an important supporting technology to break the "island" of energy information and realize the interaction of energy information.

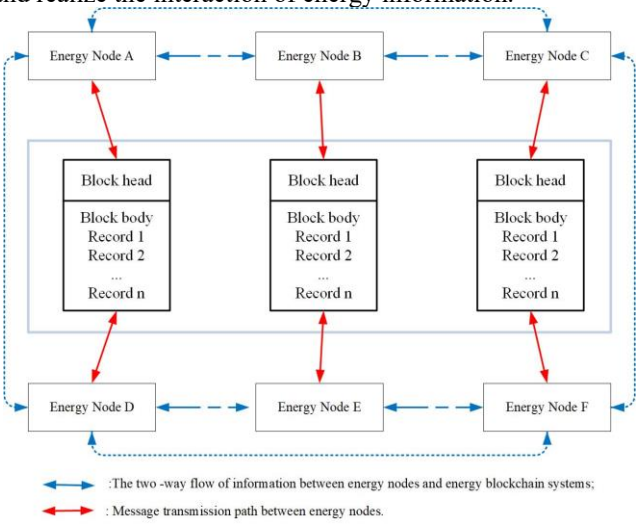

Fig. 4. Open data sharing of energy blockchain

3) Cyber Physical System Security.

The electronic data security technology based on blockchain has the characteristics of decentralization, high redundancy storage, high security and privacy protection, which can provide technical guarantee for the security of energy information physical system. On the one hand, blockchain technology can ensure the privacy and security of energy users under the premise of open sharing; On the other hand, blockchain technology can improve the system security of energy data.

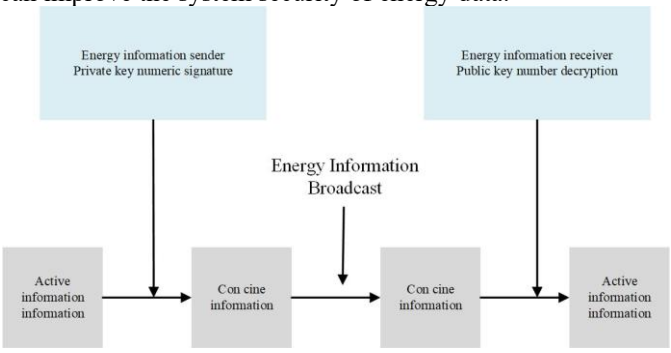

Fig. 5. Encryption processes of energy information based on digital signature

4 Energy blockchain analysis based on value dimension

The energy blockchain analysis based on the value dimension refers to the use of the decentralized value management system of the blockchain to create a diversified business model and establish a multi-faceted market mechanism to promote fair competition, extensive participation and multilateral The market-oriented autonomous behavior of docking. At present, the blockchain is effective in energy commercial crowdfunding and decentralized free trading, which is of great significance for realizing the efficient operation of the energy Internet market with decentralized management institutions..

4.1 Energy Commercial Crowdfunding

Blockchain-based smart contracts and encryption technology can effectively avoid operational risks in the crowdfunding process, and are of great significance to the effective protection of the rights and interests of investors and financiers in the energy crowdfunding model. The energy business crowdfunding process is as follows:

1) Publish energy financing project information.

2) Investors make energy investment choices

3) Terminate energy crowdfunding projects

Blockchain can provide a decentralized crowdfunding structure for energy infrastructure construction. In the case of insufficient funds for the construction of the energy Internet, a decentralized crowdfunding platform with low financing cost, convenient

supervision, safety and efficiency can be created through the multi-party participation model of the blockchain. The blockchain closely links the construction of the energy Internet with the behavior of energy system participants, which can not only improve financing efficiency, expand the source of funds for the development of the energy industry, but also ensure the profitability of energy participants while innovating energy crowdfunding methods.

4.2 Decentralized Energy Trading

The decentralized distributed value transmission protocol of blockchain has application advantages such as high efficiency, low cost, openness, and credibility, and can provide technical support for decentralized point-to-point energy transactions. On the one hand, blockchain can provide a new capital flow for energy Internet transactions. On the other hand, blockchain can enable disintermediated peer-to-peer energy trading.

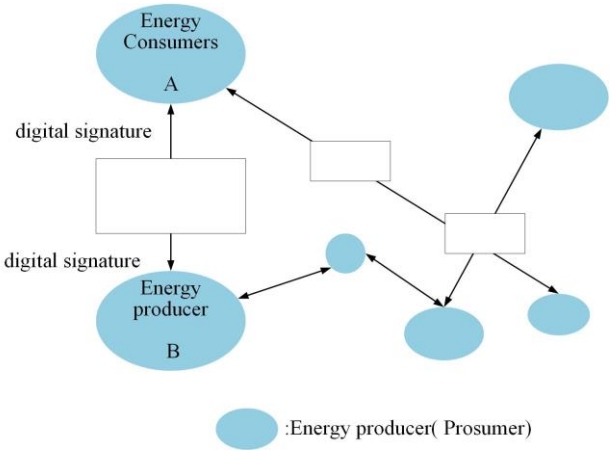

Fig. 6. Decentered energy trading based on peer-to-peer

Compared with the existing energy trading system, the blockchain energy trading system has the advantages of disintermediation and multi-network adaptability. On the one hand, compared with the existing centralized energy trading model, blockchain energy trading can minimize the intermediate links of energy trading, eliminate the centralized trading payment platform, reduce the extra costs brought by the intermediate institutions, and realize automatic Executed, safe, reliable and low-cost energy trading; on the other hand, existing energy trading platforms have trading barriers between different energy systems (for example, the trading platform built by grid companies is only suitable for power systems), while blockchain energy trading The system is suitable for various energy systems such as power grid, gas network, heat network, and transportation network in the energy Internet.

5 Analysis of Energy Blockchain Operation Scenario Based on Physics-Information-Value Fusion

Energy microgrid is an energy management problem within a local area network, mainly represented by community energy Internet (such as industrial parks, smart factories, large buildings, urban and rural concentrated residential areas, etc.). Select a qualified urban community to build an urban community energy with distributed rooftop solar photovoltaic as the core energy source, which can realize the self-production and consumption of residents in the community (autonomy) and the sale of surplus power in a point-to-point form (cooperation between users). Microgrid collaborative autonomous operation mode. Its specific operation process is as follows:

1) Distributed energy physical equipment is connected to the network. The energy physical equipment in the energy Internet system mainly refers to the physical participants of each operating module of "source-grid-load-storage", including distributed energy production, transmission, load and storage equipment. The community energy microgrid system is mainly composed of rooftop solar photovoltaic and residential users (energy producers). On the basis of the physical access of solar photovoltaics with the help of energy routers, intelligent embedded devices and other technologies, the built-in intelligent energy sensor equipment, smart contract standard rooftop solar photovoltaics and energy prosumers will be realized in the blockchain distributed peer-to-peer network. Open, peer-to-peer multi-party participants participate, and undertake functions such as energy output, node load, and power storage in the energy microgrid system.

2) Real-time collection-transmission-sharing of information. On the one hand, the output of rooftop solar photovoltaics embedded with intelligent energy sensor equipment is automatically identified and sensed by the energy blockchain data system; energy demand. The blockchain database integrates the energy output-load situation data in the community energy micro-grid, and realizes the validation and verification of energy data through distributed verification, recording, storage and update mechanisms in the distributed peer-to-peer network. Open sharing of energy data among nodes in the system.

3) Energy output – load matching. Community resident users who join the energy microgrid query the output of rooftop solar photovoltaics in the system in real time through the energy blockchain database, and match their own output with the power load demand: if "their own rooftop solar output = their own power load demand ", then achieve self-sufficiency of electric energy; if “your own rooftop solar output > (or <) own electric load demand”, broadcast surplus power (or submit additional energy load demand) to the energy blockchain system to realize the system Automatic response and balance of supply and demand for electricity between users within the “user-user”. It should be noted that if there is no excess energy output in the energy microgrid system, but the energy load demand of some users cannot be met, the energy router can be connected to the energy main grid to obtain more stable and sufficient effective energy supply; If the energy microgrid has surplus energy output for a long time, the surplus power can also be connected to the main energy grid through the energy router.

4) Decentralized trading of electricity and energy. Community resident users who cannot achieve the balance of power autonomy can realize the "mutual aid surplus and deficiency" type of supply and demand matching between users in the community microgrid system through data interaction with the energy blockchain system. Then the transaction price is negotiated based on technologies such as blockchain smart contracts, and a reliable energy market with decentralized, peer-to-peer direct transactions is built with the help of blockchain decentralized value transfer protocols and asymmetric encryption technology, in order to meet the load demand of energy users. At the same time, certain incentive rewards are given to energy suppliers.

Based on the energy microgrid with autonomous characteristics, this paper designs an energy microgrid that integrates physical-information-value multi-dimensional goals from the peer-to-peer access of energy physical equipment to the on-site balanced consumption of renewable energy and the integration of physical-information-value multi-dimensional goals with the help of blockchain technology. Network operation scene. In this energy microgrid scenario, the access of energy physical equipment is the foundation, the open sharing of energy information is a means of effective coordination and communication, and the “mutual aid surplus and deficiency” type of supply and demand matching and decentralized transactions between users are systematic Value creation method. In general, the energy microgrid system is a decentralized system that integrates physical-information-value development goals. It realizes the coordinated and autonomous operation of energy transactions between users without any centralized entity management and control, and has physical equipment in the system. The characteristics of balanced access, real-time open sharing of information, free flow of value, distributed autonomous operation, etc. are of great significance to improving users' energy experience, changing people's lifestyles, innovating energy Internet application models, and promoting smart city construction.

6 Conclusion

Under the background that blockchain technology is expected to become an important breakthrough in solving the "bottleneck" problem of energy Internet development, and the use of blockchain technology can better serve the construction of energy Internet, energy blockchain analysis has become a hot topic in the energy field. From the perspective of complex network system, this paper first analyzes the coupling between energy Internet and blockchain technology in the dimension of "physics-information-value", and initially constructs an energy blockchain framework supported by blockchain technology; here On this basis, the composition and operation process of the energy blockchain in the dimensions of physics, information and value are analyzed; finally, on the basis of considering the security of the energy main network, an integrated "physical -Information-value" energy blockchain collaborative autonomous operation mode of various development goals. It should be pointed out that the specific analysis based on the "physics-information-value" dimension is a judgment on the expected technological development of each dimension. In view of the complexity and

cohesion of complex network systems, it is impossible and unnecessary to strictly disregard the differences between attributes. Interaction.

Acknowledgment

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