Intelligent Energy Services Based on Energy Blockchain

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Abstract. With the acceleration of Internet information technology, renewable energy technology and electricity reform, the development of integrated energy services has become an important development direction to improve energy efficiency, reduce energy costs, and promote competition and cooperation. Blockchain, as the core technology of industrial innovation and development, has a natural match with the integrated energy service model. The comprehensive energy service mode is analyzed, and the comprehensive energy service model based on blockchain master-slave multi-chain structure is constructed. Finally, the operation mode of comprehensive energy service supported by blockchain is explored, which provides reference for the application of blockchain technology in the comprehensive energy service.

1. The Introduction

With the acceleration of energy structure transformation and power system reform, comprehensive energy service has a broad prospect. At the same time, with the rapid development of information technology, blockchain has a natural match with the demand for comprehensive energy services in terms of smart contracts, distributed decisions and so on.

Literature [1] established a service utility model based on the matching relationship between the service capability of comprehensive energy services and the energy utilization of users in the time dimension and category dimension. Literature [2] analyzes the integrated energy service model and puts forward a new marketing model supported by integrated energy service. Literature [3] builds a comprehensive energy intelligent management system and platform based on source-network-charge-storage-modulation-to realize the comprehensive integration of energy flow, information flow and value stream in the comprehensive energy system. The above literatures established the architecture of the integrated energy service system, but did not explore the complete operation mode suitable for the integrated energy service system. Therefore, this paper constructs a comprehensive energy service model based on blockchain, establishes a comprehensive energy service system network architecture with master-slave multi-chain structure, and explores the operation mode of the comprehensive energy service system supported by energy blockchain.

2. Comprehensive energy service model analysis

Based on the characteristics, functions and role positioning of the two main task subjects of integrated energy service, this paper constructs an integrated energy service mode, which is mainly divided into three layers: the integrated energy layer, the integrated service network layer and the integrated service business layer, as shown in Figure 1.
1) Comprehensive energy layer: a comprehensive energy system composed of cold, heat, electricity, natural gas and oil promotes one-way conversion and storage between other energy sources and electric energy, as well as single (or double) conversion and storage between other multiple energy sources, based on the clean and efficient characteristics of electric energy.

2) Comprehensive service network layer: according to the transaction subject of comprehensive service, the nodes in the network can be specifically divided into energy, power grid, electricity sale company, micro grid, energy storage and users, etc., and a comprehensive energy service system can be built around the interaction of information and energy among source, network, sale, charge and storage.

3) Integrated service business layer: integrated energy service business includes power supply business, equipment maintenance, energy efficiency testing and energy saving design, data trading and distributed energy services (such as electric vehicle charging service, photovoltaic new energy service, energy storage), etc.

The comprehensive energy layer

heat energy electricity Natural gas

cold energy oil

The comprehensive energy

Integrated service network layer

energy The grid Sell electricity company

The user Energy storage

Micro network

Comprehensive service

Integrated service business layer

Integrated Energy Services Inc Integrated energy service providers (power grid and electricity sale companies)

Power supply operations equipment maintenance

energy efficiency testing energy efficiency design

data trading distributed energy services

Figure 1. Integrated energy service model

3. Formatting the text Integrated energy service model based on blockchain

3.1. Captions/numbering Integrated energy service chain transaction model

The integration of blockchain technology and sustainable development is the trend of future technology and financial development, and the development of energy and power system is one of the most important indicators of sustainable development. Therefore, in consideration of the different requirements for decentralization degree of source, network, sales and charge in the application scenario of comprehensive energy service, this paper designs the comprehensive energy service blockchain network architecture supported by multi-chain technology, as shown in Figure 2. The multi-chain form is adopted to realize the internal credibility and collaborative autonomy of the main bodies of source-netting-sales-Netherlands, ensure the information openness and credible interconnection between the main bodies of source-netting-sales-Netherlands, further guarantee the traceability and security efficiency of the application of comprehensive energy service, and further study the matching between the comprehensive energy service scene and the blockchain technology.
Blockchain network supports the safe and efficient operation of the integrated energy service system, which is divided into two parts according to the two tasks of integrated energy and integrated service. 1) Integrated energy: since the integrated energy service mode takes electric power as the central hub, electric energy is taken as the main object of analysis. Various energy sources are coordinated and integrated together, and the dispatching nodes of the power grid undertake the dispatching and distribution task of electric energy transmission in the integrated energy. 2) Comprehensive service: the comprehensive energy service companies of power grid and other private electricity sale companies provide users with various services from the nodes. In addition, each transaction subject packages its own electricity consumption and other relevant data into each selfish chain and transacts data through the master node.

3.2. Integrated energy service chain transaction model
Section 3.1 analyzes the requirements of decentralized degree of integrated energy services and constructs an on-chain transaction model of integrated energy services in order to better represent the inter-chain relationship of integrated energy services blockchain network architecture, as shown in Fig. 3, where T1, T2, T3 and T4 are the specific times of block formation in each main chain.

The main transaction process is as follows: the power grid (and private electricity sale companies) broadcast service information to the blockchain network, including the types, requirements and prices of available services, and each master (slave) node receives synchronous service information to each autonomous (slave) chain; User I calculates the required service requirements from the chain and uploads them to the main chain of its comprehensive user service. The service requests within a period of integration (usually 15min) of the main chain are divided into three categories: direct power purchase business, ordinary power supply business (electricity purchase from the grid or electricity sale company) and auxiliary service business, and broadcast to the whole network. Source side and sell electricity and power grid company to receive the business classes of trading information, by its main chain judging whether receive a service request and feedback, if you receive the service request, integration of trade information services, distributed to perform from the chain, by calculating and analyzing the corresponding from chain will broadcast the to block trading results through its main chain chain network, and the main chain and services subject to trade and docking; After the transaction is recorded and packaged on the chain.
The source side collaborates with the main chain

The main chain of electricity sale company

The main chain of the grid

User integrated service main chain

Sending total electricity demand reply

Scheduling a business request reply

Sending a service request reply

Figure 3. Integrated energy service transaction model in the chain

4. Operation mode of integrated energy services supported by blockchain

4.1. Access of new nodes

(1) When a new node expects to join a certain business alliance chain, it sends the intention information to any node of the chain, and the node returns the address of the main chain node in the current business alliance chain to it.

(2) The new node sends the application for joining, public key address and identity authentication information to the main chain node.

(3) After the main chain node verifies its identity, it writes its public key address into the registry of the head of the main chain block, encrypts the public key of the new node with its private key, and broadcasts it in the business alliance chain.

(4) Each node on the chain decrypts with the public key of the main chain node to get the public key of the new node.

(5) The new node encrypts the application information with its own private key and broadcasts it to all nodes on the chain.

(6) The slave node on the chain decrypts with the obtained public key. If the decryption succeeds, the receipt message will be returned.

(7) When the new node receives the receipt information of all the slave nodes, the access is successful.

4.2. Emergency data transmission between nodes (taking direct power purchase between charge end and source end as an example)

(1) When the supply of the slave chain node A at the source end exceeds the demand, it packs the specific information of the power supply into the slave chain block and uploads it to the main chain node at the source end.

(2) After receiving the information, the main chain node of the source end packages the information into the main chain block and sends it immediately.

(3) After receiving the information, the main chain node of the Netherlands terminal broadcasts on the union chain of the Netherlands terminal.

(4) The slave chain node B of the charge end is willing to make a transaction, and the information is replied between the main chain nodes to the node A of the source end.

(5) The node A of the source end sends the transaction information to the main chain node of the power grid company through the main chain node. The main chain node of the power grid company
broadcasts the transaction information within the business alliance chain of the power grid company, and the power grid company conducts internal consultation from the chain node.

(6) After an agreement is reached within the alliance chain of the power grid company, the receipt information shall be sent to the slave node A at the source end and the slave node B at the charge end.

(7) All the nodes participating in this transaction broadcast the transaction information through the whole network through the main chain node, and the direct electricity purchase is completed.

4.3. Non-urgent data transmission between 3 nodes (taking data transaction as an example)

(1) The node D of the charge terminal expects to sell the electricity consumption data of this quarter. It hashes the data to get a summary and appends a brief introduction of the data to pack it into a slave block and upload it to the main block.

(2) The main chain node packs the data in the block into the main chain block, and waits for the window number to be full or for emergency data to arrive.

(3) The main chain node sends the main chain block to the integrated energy service alliance chain.

(4) After the master chain node of the integrated energy service company receives the master chain block, it receives the relevant information of the data transaction in it and broadcasts it on the slave chain.

(5) The integrated energy service company is willing to enter into a transaction at the slave chain node E, and replies the information through the main chain node to the node D of the charge terminal.

(6) After the transaction is concluded at two nodes, the transaction information is broadcast through the whole network through the main chain node, and the data transaction is completed.

5. Conclusion

The continuous development of Internet technology has accelerated the digital transformation of various industries. Blockchain, as an important breakthrough of independent innovation of core technology, has promoted the rapid development of comprehensive energy service mode. Based on the analysis of the integrated application of blockchain and energy services, this paper establishes a more comprehensive master-slave chain structure of energy service network structure and the selection method of main chain nodes, and designs the corresponding comprehensive energy service energy block chain. This paper discusses the operation mode of integrated energy service supported by energy blockchain, hoping to provide reference for the application of blockchain technology in integrated energy service.

Acknowledgments

The authors would like to thank the support of the project “Hebei Provincial Innovation Capability Enhancement Program Project (20546101D)”.

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