Application of Blockchain in Energy and Power Business

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Abstract. As a decentralized, open, transparent, fair and peer-to-peer distributed database technology, blockchain has the technical characteristics of anti-counterfeiting, anti-tampering, traceability and efficiency improvement, which had attracted the attention of many industries including energy and power industry. This paper first analyzed the pain points such as data security sharing, power transaction security and power transaction mode and so on, in current energy and power business, expounded the role of blockchain in solving the above business pain points. Then designed an application framework of blockchain in power business, and illustrated power transaction and supply chain finance to describe the application of blockchain. Finally, prospected the application prospect of blockchain in power industry.

Keywords: Blockchain; Electricity trading; Energy finance.

1. Instruction

In today's society, the digital economy is booming, and a new round of energy revolution and industrial transformation is in the ascendant. The new generation of information technology represented by big data, artificial intelligence, and blockchain has promoted changes in production and lifestyle, and has become an important force of industry innovation and industrial change. The traditional energy business model and profit model are difficult to adapt to the needs of the new economic structure, and it is urgent to inject new development momentum through technical means. As a decentralized, open, transparent, and equitable distributed database technology, blockchain has extremely high strategic value and broad application prospects. Different countries and industries are actively exploring application scenarios.

In terms of domestic policies, in 2016, the State Council included blockchain technology in the "Thirteenth Five-Year Plan" National Informatization Plan; the "China Blockchain Technology and Application Development White Paper" clearly defined the use of blockchain for the new generation of information technology promotion of development. In 2019, the Political Bureau of the CPC Central Committee conducted collective learning on the blockchain, emphasizing the use of blockchain as an important breakthrough in independent innovation of core technologies, and accelerated the development of blockchain technology and industrial innovation. In terms of foreign policies, the European Union established the European Blockchain Observation Station and Forum in February 2018 to carry out policy formulation, industry-university-research linkage, cross-border BaaS service construction, and standard open source development; the Middle East led the blockchain trend with Dubai, the government leads and enterprises cooperate to explore the application of blockchain technology; Japan's blockchain development is dominated by NTT, and the government provides support behind it; South Korea uses finance as an entry point to explore blockchain applications.
In terms of application cases, reference[4] conducted study on the application of blockchain technology in the smart energy system, and proposed an energy blockchain solution; reference[5] discussed the distributed micro-energy trading on the distribution side based on blockchain technology; American energy company LO3 Energy and blockchain technology company Consensus Systems had designed a micro grid blockchain electricity sales platform TransActive Grid, which could realize the resale function of surplus electricity[6]; Austrian company Grid Singularity used blockchain technology and smart contracts to create a decentralized energy trading platform and provided data services such as data analysis, smart grid management, and investment transaction decision-making recommendations[7]. Sinochem Energy Technology used the Internet, blockchain, and online energy optimization technologies to create the world's first real-time, open, and efficient bulk petrochemical commodity industry chain transaction and service platform. Through the deep integration of blockchain technology and carbon market application scenarios, the energy blockchain laboratory team built a blockchain platform for Carbon Asset Development and management, and provided convenient Carbon Asset Development Based on blockchain[8]. The German Blockchain company Slock.it's product Share & Charge used blockchain technology to complete the automated management of authentication, charging, and payment[9]. In the financial industry, China Merchants Bank applied blockchain technology to cross-border direct settlement scenarios in the global cash management field. China Postal Savings Bank had released a blockchain-based asset custody system for use in real business environments.

The energy and power industry is rich in scenarios, huge in number of users, and has a long industrial chain. It has the inherent advantages of blockchain technology and industrial innovation and development. Judging from the current development of the power business, the following pain points still exist:

① Data security sharing issues: With the development of the Internet, massive data is collected in various business systems of power companies, and information cannot be exchanged or traded directly between the data. Data information has the characteristics of heterogeneity of multiple sources, huge scale, low correlation, and high redundancy. Data cannot be shared and it is not realizable, forming a large number of data islands. There is no effective guarantee for the integrity and immutability of data during data exchange, transmission and processing.

② Power transaction security issues: Power transaction data involves the privacy of many power users, and the development of power business requires forcing binding with identity information. During data collection, transmission, and processing, privacy leaks may occur. There are many security challenges in online power trading. The most typical ones are the authentication of the parties to the transaction, repeated reimbursement of electronic invoices, forgery of bills, transaction denial, fraud and other issues.

③ Energy trading model: Traditional energy trading is mainly a resource allocation method for centralized optimization and decision-making. It has the disadvantages of high cost, vulnerability to attack, and difficult to protect user privacy. Energy trading requires a large number of third-party management institutions to build and maintain transaction credit, which generates unnecessary high costs by the existing centralized trading model. Different energy systems are also mostly planned and operated in isolation, resulting in a difficult situation in which energy efficiency is not high and the degree of renewable energy consumption is difficult to improve.

④ Energy finance development issues: The lack of credit foundation and insufficient big data risk control still restrict the development of energy finance business. There is an urgent need to build a more secure and reliable digital credit and intelligent risk control system. At the same time, the integration of the upstream and downstream industry chains in the energy and power industry is low, and financial services mining is less intense.

Based on the characteristics of "anti-counterfeiting, anti-tampering, traceability, and efficiency improvement" of blockchain technology, this paper proposed ideas and frameworks to solve the pain points of the energy and power business, and explored the application prospect of blockchain in energy and power business.
2. Introduction of Blockchain Technology

2.1. Blockchain Concepts and Features
Blockchain technology originates from a paper "Bitcon: a peer-to-peer electronic cash system" published by Satoshi Nakamoto[10], which uses a blockchain-type data structure to verify and store data, and uses distributed node consensus algorithms to generate and update data, uses cryptographic methods to ensure the security of data transmission and access, and uses smart contracts of automated script code to program and manipulate data in a new distributed infrastructure and computing paradigm. Since its development, it has gone through three stages: one was the era of blockchain 1.0, a programmable currency represented by bitcoin, which was an innovation in the field of digital currency; the other was the era of blockchain 2.0, represented by Ethereum, and introduced programmable smart contracts; the third was the era of blockchain 3.0, which was the core of the value Internet, extending blockchain applications to all walks of life and creating great value for global development.

Blockchain has the characteristics of decentralization, transparency, openness, and information is difficult to tamper with. The blockchain data verification, storage, maintenance, and transmission processes all adopt a distributed system structure. Pure mathematical methods are used to establish trust relationships between nodes to form a decentralized and trusted distributed system[11]. The blockchain is open and transparent except for the private information being encrypted, other data is open to participants. The encryption algorithm used by the blockchain encrypts the data and uses a consensus algorithm to defend against external attacks. Only when 51% or more of the nodes are destroyed can the information be tampered with, and the probability of such tampering is extremely low. It is safe and difficult to tamper with.

2.2. Key Technologies of Blockchain
2.2.1. Distributed Ledger. Distributed ledger refers to the fact that transaction accounting is performed by multiple nodes distributed in different places, and each node records a complete account, so they can participate in monitoring the legality of the transaction and can also jointly testify for it[12]. Each node of the blockchain stores complete data in accordance with a block chain structure. Each node is independent and has the same status, relying on a consensus mechanism to ensure the consistency of storage. No single node can record ledger data separately, thereby avoiding the possibility of a single bookkeeper being controlled or bribed to keep false accounts. Every node in the system has a complete ledger. Tamperers need to modify more than half of the system node data at the same time in order to truly tamper with the data. Such tampering is extremely expensive and almost impossible.

2.2.2. Consensus Mechanism. The consensus mechanism is a way to reach a consensus on the validity of a record between all bookkeeping nodes. It is both a means of identification and a means of preventing tampering[13]. Under the coordination of the consensus mechanism, the nodes’ ledger is updated synchronously, so as to realize the functions of node election, data consistency verification and data synchronization control. Data synchronization and consistency coordination make the blockchain system have the characteristics of information transparency and information sharing. Common consensus mechanisms currently include Proof-of-Work (PoW), Proof-of-Stake (PoS), Delegated-Proof-of-Stake (DPoS), Pool verification pool, etc.

2.2.3. Smart Contract. Smart contracts are computer programs which are event-driven, stateful, running on a replicable shared blockchain data ledger. It can actively or passively process data, receive, store and send value, and control and manage the chain smart assets[14]. Smart contracts are based on credible and non-tamperable data, can automatically execute some predefined rules and terms, and allow trusted transactions without third parties. Transactions can be traced irreversibly.

2.2.4. Asymmetric Encryption Algorithm. The transaction information stored on the blockchain is public, but the account identity information is highly encrypted and can only be accessed with the authorization of the data owner, thereby ensuring data security and personal privacy[15]. In the blockchain system, the basis of the ownership verification mechanism is an asymmetric encryption algorithm. Asymmetric encryption algorithms require two keys: a public key and a private key. The
public key and the private key are a pair. If the public key is used to encrypt the data, only the corresponding private key can be used to decrypt it. If the private key is used to encrypt the data, then only the corresponding public key can be used decrypt. The basic process for the asymmetric encryption algorithm to exchange confidential information is: Party A generates a pair of keys and discloses one of them as a public key to the other party; Party B who obtained the public key uses the key to perform confidential information after encryption, it is sent to Party A; Party A then decrypts the encrypted information with another private key kept by itself.

3. The Role of Blockchain in Energy and Power Business
Blockchain plays an active role in solving the above-mentioned pain points of the energy and power business. It can promote mutual trust between upstream and downstream industries, realize efficient data sharing, and improve risk prevention capabilities.

3.1. Strengthen the Integration and Sharing of Trusted Data
Use the blockchain to achieve data autonomy and transaction transparency, ensuring the authenticity and accuracy of on-chain data. At the same time, by guaranteeing the uniqueness of data application between different blockchains, it solves the problem of mutual trust of cross-chain data. It establishes a secure access mechanism to technically solve the data security and privacy issues of the transaction subject, thereby ensuring the authenticity, reliability, availability, and privacy protection of objective data, and promoting data integration and data resource integration in the power industry.

3.2. Ensuring the Safety of Electricity Transactions
Innovative security authentication technology is to build a new type of distributed, secure, and highly automated trust system through blockchain technology, so that all institutions that become nodes can maintain real-time data uniformity among each other, break data and trust barriers, and achieve cross chain trust transmission. This provides a foundation of trust for the confirmation and transmission of energy and power business data resources, improves the security of all subjects and links in power transactions, and improves business collaboration efficiency.

3.3. Create a New Energy Trading Model
It changes the current energy trading model, and realizes the change of the distributed market model instead of the centralized management model. In the distributed energy trading model, participants in the energy trading market are peer-to-peer and decentralized. In this model, a variety of energy sources cooperate autonomously without the need for a third-party trust institution to form a distributed, new blockchain energy business model. Transform the transaction assets into "smart contracts", complete point-to-point real-time transactions, clearing and settlement, reduce the cost of value transfer, reduce the cost of capital retention and trust costs in settlement, and then reduce transaction costs.

3.4. Promote Innovation in Energy Finance
It opens up multi-party collaboration through blockchain technology, establishes a trusted intelligent risk control system, and promotes trust transmission among financial institutions, industrial units, and suppliers. Based on blockchain technology, it has established an alliance platform for all parties to share information, record and trace key information and data, and serve all aspects of the financial industry chain. Improve the stickiness of upstream and downstream enterprises to core enterprises, thereby enhancing the competitiveness of core enterprises in their peers, and improving business performance.

4. Application of Blockchain in Energy and Power Business

4.1. Architecture Design
Based on the architecture shown in Figure 1, it provides safe and reliable blockchain public services for energy and power businesses without affecting the original business processes. The functions of each part are as follows:
① Platform layer: Provide the operating environment and hardware facilities required for the normal operation of the blockchain system, and realize the recording, verification and dissemination of information in the blockchain system.

② Core layer: Distributed accounting implements information storage (including collecting transaction data and generating data blocks) to verify the local data, and adds the blocks that pass the verification to the chain, and composes them in order by time stamp. A complete block-type data structure guarantees the integrity and authenticity of the data; smart contracts are responsible for implementing the power business logic in the form of code, completing the conditions of the established rules and automatically executing them to minimize human intervention; the consensus mechanism is responsible for coordinating and ensuring consistency of data records at all nodes on the entire network.

③ Application layer: completes the encapsulation of functional modules, provides simplified calling methods for upper-layer applications, and connects to different energy and power business scenarios.

**Figure 1.** Application Architecture of Blockchain in Power Business.

4.2. Application Scenario Analysis

4.2.1. Electricity Trading Scenarios. With the advancement of the reform of the power market, the development of independent negotiation transactions by market entities has become more frequent. Data such as electricity information, user identity information, and enterprise information during the power transaction process are uploaded to the chain, and distributed transactions are stored in the distributed network through distributed shared ledgers to ensure that each transaction is authentic, reliable, and traceable. Perform quality tracing and operation monitoring to achieve accurate management of participants, equipment and settlement. Transaction smart contracts are set up between transaction entities on the blockchain. Trusted identity authentication technology is used to determine the identities of both parties to the transaction, and the corresponding smart contracts are matched to achieve efficient electricity bill settlement and settlement. In the process, the use of blockchain technology to achieve the identity verification of the parties to the transaction; the application of blockchain technology in electronic invoices to solve problems such as repeated reimbursement, bill falsification; the entire process is transparent and traceable, and resolves transaction repudiation, denial, fraud, etc.

4.2.2. Supply Chain Finance. Supply chain finance is a flexible financial product and service model provided by financial institutions linking core enterprises with upstream and downstream enterprises.
Based on the blockchain technology, all stakeholders involved in the entire process of supply chain finance become nodes, so that data is stored and shared among all nodes, so that data can be trusted to flow on the chain, and information islands problem in supply chain financial services are resolved. The accounts payable of the core enterprises registered on the trusted blockchain can be converted into digital assets, which can confirm rights, transfer, split, and finance. The core enterprise credit can be passed along a trusted trade link, and the problem that the core enterprise credit cannot be transmitted to multi-tier suppliers is solved. In the process of separation and circulation, the endorsement effect of the core enterprises remains unchanged. The whole process of the split and circulation of vouchers can be traced back, which solves the problems of difficult and expensive financing for small and medium-sized enterprises. Through blockchain smart contracts, the settlement dates and rules stipulated in supply chain financial contracts can be implemented fairly, transparently and automatically, which greatly improves the trust and transaction efficiency of the entire industry chain, and effectively manages compliance risks.

5. Conclusion and Prospect
The innovative application of blockchain technology provides a highly available solution for the high-quality development of the energy and power industry. In the energy and power business, by constructing a trusted blockchain public platform, the blockchain technology is applied in the original business process, this can further strengthen data integration and sharing, and improve business collaboration efficiency. It had played an active role in adapting to energy changes, improving the quality service level of the power grid, and optimizing the business environment. With the continuous advancement of the reform of the power market, blockchain technology will surely shine. It can create a space of mutual trust, make the value transmission more transparent, promote data sharing in all directions, optimize business processes, reduce operating costs, and cultivate new types of energy trading model and new growth points of benefits. At present, the power industry provides a wide range of application scenarios for the application of blockchain technology, but the application of blockchain technology in the energy and power business is still in the stage of innovation and exploration. It is necessary to strengthen the top-level design and planning, expand application scenarios, and explore deeper applications of blockchain technology in quality services, safe production, data sharing, electricity trading, energy finance, etc. It is also necessary to design targeted application and implementation further combining actual business needs and pain points, which aims at accelerating the innovation development of blockchain technology and industrial.

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