Research on Power Line Communication Technology of Energy Internet Based on Blockchain

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Abstract. Due to the gradual improvement of the energy Internet level, its requirements for the communication structure are also stricter. The key to the Energy Internet is the power structure control network. It integrates many distributed renewable energy sources, and meets the two-way intercommunication of energy and information by means of information and communication. Through the use of blockchain and smart contract technology in the Energy Internet to complete stable and automatic P2P energy transactions, it will be possible to optimize the work efficiency of the structure and optimize the cost. Power line communication technology generally covers power line carrier and industrial frequency communication technology. It is not necessary to build leased lines or collect public communication service fees, so that grid companies can make full use of their own resources. Based on the Internet and power line communication technology, this article discusses the dilemmas that need to be resolved in the construction of the energy Internet based on blockchain, so as to provide corresponding support for the optimization of heterogeneous networks in the future.

Keywords: Energy Internet, Blockchain, Power line, Communication

1. Introduction

The ecological pollution caused by the declining fossil energy has attracted increasing attention from all walks of life. In this context, technological breakthroughs in green and renewable energy will be able to solve this dilemma to a certain extent. In the past, energy transactions generally require centralized optimization of resource allocation methods, which have disadvantages such as high cost, vulnerability, and poor user privacy and security [1]. Energy Internet will achieve two-way energy output and dynamic balance, and optimize the access rate of clean energy, which is the direction of the future development of the energy industry. Energy Internet is a shared network system constructed by the effective combination of power structure network, transportation network, natural gas network and other network structures [2]. In the past, the network system has seen more and more drawbacks, such as difficulty in grid connection, high power consumption, poor equipment utilization, and poor marginal efficiency of system capacity expansion investment [3]. Therefore, exploring ways to innovate basic power grids and make full use of clean energy has become a key research direction in related industries. The State Grid Corporation of China proposed a global energy network that will achieve the best clean energy distribution on a global scale [4]. The Energy Internet uses the power
structure control network as the core, integrates many distributed renewable energy sources, and meets the needs of two-way information circulation between energy flows through advanced technologies such as high-end communication methods and power electronics technology [5].

Energy Internet is a pan-energy system. Energy trading is diversified, products are diversified, decision-making is decentralized, information is transparent, and instant transactions are carried out with new meanings according to the guidelines, such as open interconnection, user-centric and decentralized P2P sharing [6]. When the Energy Internet integrates distributed energy into the current centralized power grid, it cannot deal with the trust problem of different distributed points, and cannot ensure that the interests of all parties are not harmed in terms of measurement, interaction, decision-making, and control [7]. The implementation of the Energy Internet still has some difficulties. The Energy Internet includes many devices such as power generation, power consumption, energy storage, transmission and power conversion. Various devices form a huge structure, and automatic, reliable, accurate and balanced real-time transactions between various devices are the key issues that need to be solved [8]. To ensure the stable and efficient operation of the Energy Internet, the communication network of the Energy Internet must implement the priority division of data transmission, the stability of data transmission, and the low delay of the communication network, which can meet the needs of multi-point transmission. And then realize the stable and efficient operation of the energy internet communication network. These characteristics of the Energy Internet have led to the complexity of the energy Internet communication network, so there will be a lot of data processing in the communication network [9]. In the energy local area network of the energy Internet, various energy devices have high dynamic topology variability, which makes the energy Internet have multi-scale dynamics [10].

The power line communication system is needed to effectively overcome the frequency selective fading caused by the multiple transmission of the power line channel [11]. In the traditional centralized transaction model, energy transaction will generate unnecessary transaction costs, because it requires various third-party management systems to create and maintain a transaction credit system [12]. The technical characteristics of the block chain are naturally suitable for energy research. With the "energy block chain", people can find opportunities for comprehensive coordination of energy and power from grassroots construction to commercial systems [13]. Power line frequency communication uses weak low-frequency variability signals of voltage and current waveforms to realize information transmission on the power grid, and has the characteristics of remote transmission through distribution transformers. The decentralized, transparent and open nature of blockchain technology promotes its key significance in the energy Internet, thereby promoting the progress of energy Internet technology [14]. To promote the progress of the energy structure in the energy network, it is necessary to adjust the traditional energy trading system and complete the transformation of the distributed market structure to replace the centralized management system [15]. The purpose of this article is to study the power communication of the current power structure Internet, discuss the main dilemmas that need to be solved in the construction of the energy Internet based on the blockchain, and bring corresponding theoretical support for the future integration of heterogeneous networks.

2. Basic Concept of Power Line Communication Technology and Its Application in Energy Internet

2.1. Basic theory of power line carrier communication

Due to the decline of traditional fossil energy and the deterioration of the ecological environment, more and more production companies have become more concerned with ecological protection, actively seeking breakthroughs in various new energy technologies, and have achieved some results. Blockchain technology will realize the transformation from the Internet of Information to the Internet of Value, which can be applied in many fields such as finance, securities, trading systems, energy, and the Internet of Things, with great application potential [16]. Blockchain enables equipment to meet the needs of management and maintenance, so that the entire structure forms a decentralized and adaptive architecture. The architecture will be able to complete point-to-point value transfer and distributed
data sharing to build a comprehensive Internet of Things with strong expansion capabilities. In the Internet of Things era, all kinds of products are connected to a huge intelligent network, and the main purpose of transaction is the circulation of product use rights. The decay of the power line carrier signal is affected by many reasons, including the input impedance of the power line, the load of the power grid and the communication distance. In power line carrier communication, signal weakening generally includes line weakening and coupling weakening. Energy Internet connects different distributed power sources to the traditional power network. Decentralized power generation can play a role in the control of transmission line consumption, control fluctuations in power demand, and reduce the pressure on the centralized grid architecture.

The future energy Internet will include a self-management and self-regulating microgrid structure. When the microgrid cannot reach balance, the coordination of multiple microgrids can form a microgrid group, which can achieve greater energy distribution balance. The architecture is roughly shown in Figure 1.

![Energy Internet architecture](image)

**Figure 1.** Energy Internet architecture

The smart contract is preset in the form of program code in the smart device and completes the operation of blockchain data. Different types of energy Internet devices have contracts to realize different operational intelligence. The smart protocol structure of photovoltaic power generation equipment is roughly shown in Fig. 2.

![Smart protocol working mechanism](image)

**Figure 2.** Smart protocol working mechanism

Energy Internet has a wide range of applications, has a large number of related equipment, and faces complex and changeable operating conditions. Its true landing will face many challenges, such
as how to establish reliable, safe, and efficient two-way transactions between the supply and demand sides and achieve accurate automatic matching between the two parties. Generally, the impedance characteristics of power line communication are mainly affected by signal frequency, line topology and electrical factors connected to low-voltage power lines [17]. In an ideal state, the existence of distributed inductance and distributed capacitance makes the input impedance decrease with the increase of signal frequency. The actual situation is that the diversification of load types makes the impedance changes at different frequencies different, which makes the input impedance amplitude the value will have a large change in the resonance frequency and the frequency near it. Energy Internet should provide a fast, credible, and automatic energy transaction model between the supply and demand parties, and help the supply and demand parties to efficiently establish and complete transactions. However, most of the existing energy Internet solutions are completed by centralized management and control agencies. In the absence of effective power distribution control conditions, even if the architecture can measure power, other participating nodes cannot reach a consensus on the data measurement situation [18].

2.2. The basic principle of power line communication

After the start of encoding of the downlink data information, that is, after the synchronization detection is completed, data demodulation with a zero-crossing change in voltage is required. When the power line power frequency communication system uses the master-slave mode, there is no need to use the synchronization signal. The blockchain-based Energy Internet can dynamically increase or decrease participating nodes according to actual needs. This structure follows the decentralized and flexible nature of new energy sources in the Energy Internet, and allows new energy nodes to operate stably and effectively without changing the network architecture. The future energy Internet will cover many users of producers and consumers. In order to achieve a huge dynamic resource balance, stable, efficient and secure energy system transactions between supply and demand parties are the main requirements of the Energy Internet. Energy trading under this trading system is generally planned by the trading center responsible for the overall balance of energy structure. Moreover, various third-party organizations are needed to ensure the security and reliability of transactions. The magnitude and unit of the transaction will not be restricted and will be conducted irregularly or in batches. For over-the-counter transactions that can be institutions or individuals, market participants will not be restricted. Different participants have inclusive trade links.

The main battle equipment pre-estimates the start time of the uplink signal according to the signal transmission protocol, and configures an inspection window next to the zero-crossing point of the receiving terminal voltage. Determine the positive or negative of the accumulated difference of the current signal at the voltage zero crossing position for detection. In the data transmission of the power grid, the power line of the power coordination signal has less decay, and the transmission delay will be ignored. Under the premise of the energy Internet credit network constructed by blockchain multi-role nodes, an energy environment that can supervise each other and develop green is formed to establish a democratic mechanism based on blockchain technology. The sub-regulatory model is adjusted to a top-down chain organization and cooperation method, thereby promoting the construction of a trustworthy environment for energy Internet-related industries [19]. Energy Internet has a variety of distributed power generation equipment, energy storage equipment and electrical equipment, and has a high level of intelligence. Blockchain technology has created a low-cost communication bridge between energy Internet smart devices that are showing exponential growth. The decentralized consensus architecture improves the security and privacy of transactions in this architecture. This will contribute to the implementation of energy internet. In general, the power line power frequency communication modulates the signal at the zero-crossing point of the voltage at the transmitting end in order to reduce the modulation power. However, due to the existence of factors such as load, line impedance, transformer model, etc., the signal has a voltage phase difference at the receiving and sending end, so there will be time domain deviation.
3. Energy Internet Power Line Communication Architecture Based on Blockchain

3.1. Characteristics of blockchain Technology
Blockchain technology is first of all a decentralized collective database maintenance technology developed for Bitcoin. Blockchain can enable each participant in the architecture to complete cooperation without the trust of all parties, and create a set of tamper-proof databases with strong data security. Blockchain technology will complete the transformation from the Internet of Information to the Internet of Value, and will be used in various industries such as finance, securities, transaction architecture and the Internet of Things. The visual analysis of node reachability is a key element in the visualization of power communication. Blockchain uses a fixed consensus algorithm to ensure that each node in the overall architecture can stably and effectively complete data exchange without trust and approval [20]. The basic reason the computer can achieve the goal of interconnection is the data transmission between the host and the terminal. In some public places, the network environment is poor. In an environment where a large amount of data is delayed, the Internet is an open communication structure and an inherent attribute of network media. The monopoly period of existing media communications will no longer occur.

3.2. Credit ecosystem of regional microgrid
The improvement of energy Internet technology is based on the network information environment and smart grid, and learning from the Internet model. When evaluating the power grid, a single index cannot be used as the evaluation condition. To fully and effectively show the working conditions of the power grid, it is necessary to consider the entire power grid and comprehensively consider each reliability index. Under the micro-grid structure constructed by blockchain, the micro-grid in each region can ensure the local power consumption, and at the same time, the corresponding business can also be informatized and intelligent [21]. The regional microgrid is divided according to the region and the number of nodes. A microgrid is a chain, and microgrids in different regions are side chains. The power communication architecture has strong complexity and can be divided into transmission network, business network and support network according to its usage scenarios. In general, the data information used as a label needs to clearly analyze the target situation, and the actual label must fully understand the effect of the user in the target business. The regional microgrid architecture is shown in Figure 3.

![Figure 3. Regional microgrid system structure](image-url)
Blockchain technology can be used to create a power trading system without changing the original power trading business model. The entire platform is divided into 3 levels. The trading platform model under the energy microgrid is shown in Fig. 4.

![Figure 4. Business operation model under the energy microgrid](image)

Since the data transaction between nodes is based on a fixed algorithm, the two parties do not need to disclose their identities, but can let the other party trust themselves with the help of the procedural rules on the blockchain. Since various network data must be stored on the server together with the database, such data must be transmitted from its own network management server to a local server with a data warehouse [22]. Generally, energy points only circulate in one microgrid. When it comes to the business between regions, the outflow side of energy points acts as the main chain, creates transactions to lock energy points, and the inflow party acts as the side chain to create a transaction proved by cryptography to ensure the circulation of energy points in the whole network. Electricity is the inner core of the Energy Internet, and the creation of a stable and effective information transmission architecture needs to be based on the traditional power communication structure. Blockchain allows devices to meet the needs of self-management and maintenance, transforming the overall architecture into a decentralized and adaptive architecture. In this architecture, it can meet the needs of point-to-point value transfer and complete the task of distributed data sharing.

4. Conclusions
The stable work of the Energy Internet requires the support of a safe and effective communication network. Energy Internet is the product of multi-energy integration, cyber-physical integration and multi-market integration, and it has a key significance for future energy production, transmission, storage and consumption. Blockchain has the characteristics of decentralization, openness, autonomy and immutable information. It is the core of the future digital wave and has become a prerequisite for building the Internet of value. The emergence of blockchain technology has brought great opportunities for the progress and use of the Energy Internet. The establishment of a blockchain-based energy microgrid system and ecosystem will strengthen the trust relationship between the energy Internet and innovate traditional business models and management models in the energy and power fields. The power line channel model should be simple and can describe all situations. The power line channel can be used not only in ordinary household electricity, but also in various intelligent power generation distributed energy. After the blockchain technology is integrated into the Energy Internet, it will be able to meet the needs of safe and reliable energy transactions, thereby completing cost optimization and promoting the implementation of the Energy Internet.
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