Power Energy Supply and Demand Scheduling Method Based on Blockchain Technology

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Abstract. In order to solve the problem of a large difference between the dispatching operation power and the actual required operation power existing in the traditional power energy dispatching, which affects the dispatching efficiency and causes serious energy waste, the design of power energy supply and demand scheduling method based on blockchain technology is carried out. Based on the power energy supply and demand scheduling hierarchy, based on the supply and demand scheduling model of the blockchain technology architecture, the distributed consensus mechanism for the supply and demand scheduling of power energy is established, and a new power supply and demand scheduling method is proposed. Through the experiment, it is proved that compared with the traditional dispatching method, the dispatching power obtained by the new dispatching method can be close to the actual dispatching power on the basis of meeting the normal operation needs of each equipment, realizing the energy saving of electric power, and providing technical support for the construction of green power grid.

1. Introduction

At present, with the rapid growth of energy demand, there is a serious shortage of traditional energy. In order to further realize the sustainable development of energy, researchers in related fields have carried out research into the rational development of clean and renewable energy. After long-term research, many renewable energy and related technologies have been developed and gradually applied. With the application of these emerging technologies, the penetration rate of power grid has been continuously improved in the power industry [1]. In the power grid, with the continuous increase of the total amount of access, the overall operation stability of the power system and the negative impact of the corresponding stability maintenance measures in the later period have been greatly hit [2]. In view of this problem, some researchers say that the optimization of the whole supply and demand schedule can be realized through the implementation of multi energy complementary. But at present, most of the research is still in the theoretical stage, and no mature technology has been reasonably applied in power energy scheduling. In practical applications, it is also necessary to take into account the impact of power energy in various factors around the scheduling process, as well as the efficiency issues and accuracy issues, etc. [3]. Blockchain is a technology to connect different regions in a certain order according to the time sequence. Compared with the traditional database, blockchain can effectively ensure that all the data in the system will not be tampered and realize the security protection of data. The application of blockchain technology can use hash algorithm to realize the forward solution of transaction records and the verification of data. Therefore, in view of the problems in the current power energy scheduling process, this paper carries out the design and research of its supply and demand scheduling method based on blockchain technology.
2. Design of power energy supply and demand scheduling method

2.1. Power energy supply and demand scheduling hierarchy design

According to the requirements of power grid supply and demand, the whole power energy scheduling process is divided into two different levels, namely, power energy block agent layer and power energy node layer. Among them, the first level is an important level of distributed energy scheduling, and can provide basis for power energy scheduling in this hierarchy [4]. It can also provide a more stable and reliable communication foundation for subsequent blockchain technology. Since there is a certain credit problem in the scheduling process, it is necessary to consider whether the proxy service issues provided by third parties are required to determine whether there is unfair competition relationship and malicious behavior. The second level is the main body of power energy scheduling, mainly through the previous level to participate in the scheduling of power energy. At this level, the evaluation of the load efficiency of power energy is also needed to ensure the rationality of the whole dispatching process. The overall structure of the power supply and demand scheduling hierarchy is as Figure 1.

![Figure 1 Overall structure diagram of power energy supply and demand dispatching hierarchy](image)

In the actual power energy scheduling process, considering the distribution and operation of power energy in different regions, there will be very obvious regional concentration characteristics. Therefore, according to the current situation, according to different regional classification, the regional construction of power energy can be realized, and the effect of power energy autonomy can be achieved. In such a hierarchical structure, the coordination and optimization of power supply and demand can be realized through a higher-level scheduling mode, which is also more conducive to providing an integrated scheduling framework for subsequent supply and demand scheduling based on blockchain technology [5]. In this scheduling framework, the security of the blockchain can be better realized, and the transaction data of power energy in the power supply and demand scheduling can be distributed and stored in the alliance nodes. The data modification at a certain location will not affect the operation results of the whole power grid. The data generated in the process of power energy supply and demand scheduling can be stored permanently. Once it is written into the blockchain, it cannot be tampered with, which solves the problem of unfair competition and malicious behavior [6]. The blockchain in power energy supply and demand dispatching is interconnected in a specific time sequence. When the power energy dispatching data is verified to be correct, it can be written into the blockchain. In the case of subsequent scheduling problems, it can be traced to further reduce the loss of power enterprises.

2.2. Power supply and demand scheduling model based on blockchain Technology

After completing the hierarchical design of power energy supply and demand scheduling, this paper uses the blockchain technology to realize the construction of power energy supply and demand scheduling model. The whole model is divided into two parts according to the dispatching level, and applied to the power energy block agent layer and the power energy node layer respectively [7]. According to the above discussion in this paper, the operation characteristics of the agent layer of power energy block are obtained, and the corresponding dispatching model can be expressed as follows:

$$\min W = \sum_{i=1}^{T} \sum_{n=1}^{N} w(P(t)) + w(P_{grid}(t)) \quad (1)$$
In formula (1), $\min W$ is the operation cost of power energy block agent layer in the process of power energy supply and demand scheduling; $T$ is the period of power supply and demand scheduling; $N$ is the amount of power energy contained in the regional power grid environment during the dispatching process; $P$ is the power of power exchange in different grid environments; $P_{\text{grid}}$ is the power of each grid in different grid environments; $w$ is the total cost of power generation in the region. The calculation formula of $w$ in formula (1) is as follows:

$$w(P(t)) = aP(t)^2 + bP(t)$$  \hspace{1cm} (2)

In the formula (2), $a$, $b$ are respectively expressed as two different power generation costs in the region. In the calculation of formula (2), it is necessary to treat the total cost of the grid power generation in the region as equivalent, and treat each region as a power grid unit. The variables that need to dispatch the power supply and demand in the power energy block agent layer include all the total power generation and distribution on the whole blockchain, as well as the exchange power between blocks [8]. In practical application, the calculation model also needs to be completed under the constraints of power balance of blockchain power energy and total output always within the standard limit.

Then, the scheduling model of power energy node layer is designed, and the objective functions in different regions of the blockchain are expressed by the following formula (3):

$$\min C = \sum_{t=1}^{T} (C_{\text{wt}} + C_{\text{pv}} + C_{\text{dg}} + C_{\text{chp}})$$  \hspace{1cm} (3)

In formula (3), $\min C$ is the operation cost of power energy node layer in the process of power energy supply and demand scheduling; $C_{\text{wt}}$ is the operating cost of wind turbine equipment; $C_{\text{pv}}$ is the operating cost of photovoltaic generator equipment; $C_{\text{dg}}$ is the operating cost of energy storage equipment; $C_{\text{chp}}$ is expressed as the operating cost of the hot and heat electrical unit.

From the above formulas (1) ~ (3), it can be seen that the power energy supply and demand scheduling model based on blockchain technology has different variables, constraints and objective functions at two different levels [9]. In order to facilitate the actual power supply and demand scheduling process, it can be more quickly and efficiently realized scheduled. This paper combines the blockchain technology to construct the corresponding relationship between the above three formulas, and sets up the supply and demand dispatching target for the power energy block agent layer and the power energy node layer as a whole [10]. Firstly, in the agent layer of power energy block, combined with all kinds of power generation equipment, the lowest total power generation cost is taken as the control target, and the hash algorithm is used to calculate the total power output of different partitions on the blockchain. Then, the total generating power of each partition is distributed to different subordinate power energy node layers in a reasonable order [11]. In the power energy node layer, the internal configuration of each partition should be carried out according to the total generated power. In the process of power supply and demand scheduling, the possible long-distance and large-scale transmission constraints are discussed. In this paper, the generation power in the agent layer of power energy block is taken as a variable to build a connection among different power energy systems, and the long-distance coupling of power energy is completed by reasonable use of coordination and optimization, and then according to the transmission mode of the lowest power energy loss, the purpose of reducing the cost of power energy supply and demand scheduling is achieved.

2.3. Establishing power energy supply and demand scheduling distributed consensus mechanism

Consensus mechanism is also the key content of blockchain technology. Based on the application advantages of consensus mechanism, in the process of power energy supply and demand dispatching, by adding distributed consensus mechanism, all nodes in the whole power grid environment can reach an agreement when generating new blocks [12]. The comparison of distributed consensus mechanism and features is as Table 1.
Table 1 Comparison of distributed consensus mechanism and characteristics

| Characteristic               | Consensus mechanism I | Consensus mechanism II | Consensus mechanism III | Consensus mechanism IV |
|-----------------------------|-----------------------|------------------------|-------------------------|------------------------|
| Node control                | Non-publicise         | public                 | public                  | Non-publicise          |
| Time ductility              | High (min)            | Low (s)                | Low (s)                 | Low (ms)               |
| Data and information        | High                  | High                   | Low                     | Low                    |
| throughput capacity          |                       | < 50% stock            | < 50% verification       | <22.2% malicious node  |
| Security                    |                       | computational power    |                         |                        |
| Expansibility               | Good                  | Good                   | Poor                    | Poor                   |
| Energy efficiency           | High                  | Low                    | High                    |                        |

In practical application, combined with the different practical characteristics of different partitions in the blockchain, four different consensus mechanisms in Table 1 are selected. At the same time, when implementing the consensus mechanism, it is also necessary to discuss the whole power energy supply and demand scheduling workload. The nodes of the whole grid spend a certain amount of time together to find out the random number that meets the specific requirements, and obtain the corresponding accounting right [13]. According to the power resources spent in the whole grid environment, the data that no benefit exists in any node is given. The power resources spent are regarded as workload, and the specific numerical value shows that the workload can effectively improve the security of the whole power energy supply and demand scheduling. Then it is proved by the way that the equity value replaces the power value in the traditional scheduling method, and the equity size of each node in the blockchain is determined according to the currency age, so as to affect the difficulty of solving the random number of nodes, reduce the loss of power resources, and further shorten the consensus time [14]. Due to the process of proven, the node finds the difficulty of decreased random number, thereby causing malicious tampering data, blockchain finificial and other behavior to generate [15]. At this stage, it is also necessary to encrypt the power supply and demand dispatching data of each partition in the blockchain, so as to ensure the security of the data in the transmission process. Combined with consensus mechanism IV, when there are more than 22.2% malicious nodes, the data will be automatically checked to confirm that they have not been tampered, and the scheduling will continue. If tampered, the whole scheduling behavior will be stopped, so as to achieve more efficient power supply and demand scheduling.

3. Comparative experiment

3.1. Experimental preparation

Through the above discussion, this paper realizes the theoretical design and research of power energy supply and demand scheduling method based on blockchain technology. In order to ensure the reasonable application of the dispatching method in the actual power grid operation environment, according to the hierarchical structure of power energy, a number of different partitions are constructed. The hierarchical structure of power energy is as Figure 2.
It can be seen from the schematic diagram of power energy hierarchical structure in Figure 2 that the power energy hierarchical structure includes three different levels, among which layer I is the system layer, layer II is the area layer, and layer III is the equipment layer. The main function of layer I is to complete the coordinated configuration of power energy in different areas of layer II, so as to complete the interactive needs of upper and lower power grid operation, and realize the efficient and safe operation of power energy. In order to ensure more objective results of the comparative experiment, the maximum exchange power between each distribution network is 120kW. In the process of experiment, the algorithm of two different scheduling methods is constructed by real number coding, and it is stipulated that both methods need to obtain a population of 60, the maximum number of iterations is 150, and the electrothermal conversion coefficient is controlled in the range of 0.65 ~ 0.87. In this paper, the power supply and demand scheduling method based on blockchain technology and the traditional scheduling method are respectively used to schedule the power energy of different partitions in the hierarchical structure. By comparing the scheduling results of the two methods, the further verification of the actual application performance of the scheduling method in this paper is realized.

3.2. Experimental results and analysis
Combined with the above experimental content in this paper, in order to facilitate the comparison of the two scheduling methods, this paper takes the power Q of power supply and demand scheduling operation as the experimental comparison index, records the power of power supply and demand scheduling operation in multiple different partitions under the two scheduling methods, and obtains the comparison of the experimental results of the two scheduling methods as Table 2.

| Partition | Actual required operating power | γ value of this method | γ value of traditional method |
|-----------|---------------------------------|------------------------|------------------------------|
| A district | 328kW                           | 330 kW                 | 523 kW                       |
| B district | 463 kW                           | 464 kW                 | 593 kW                       |
| C district | 593 kW                           | 593 kW                 | ——                           |
| D district | 241 kW                           | 243 kW                 | 426 kW                       |
| E district | 353 kW                           | 356 kW                 | 495 kW                       |

It can be seen from the data in Table 2 that both the dispatching method in this paper and the traditional dispatching method can meet the actual operation power demand, but it is obvious that the dispatching operation power γ obtained by the dispatching method in this paper is closer to the actual operation power demand. However, the operation power of the traditional dispatching method in A, B, D and E districts exceeds the actual power. In this case, due to the high operating power, the power grid will always be in the full power operation state in the process of operation. In the power generation stage, a lot of heat generated by electric energy will enter into the air, resulting in more serious energy waste. Moreover, in the process of power energy supply and demand scheduling in C district, due to the irrationality of traditional methods, the power energy scheduling exceeds the load, resulting in the problem of unable to record effective data, which seriously affects the safe and stable operation of all equipment in C district. Therefore, through the comparative experiment, it can be concluded that the power energy supply and demand scheduling method designed by introducing the blockchain technology in practical application can reasonably coordinate according to the actual power energy demand of different regions, and realize the efficient use of power energy on the basis of meeting the demand of supply and demand, so as to achieve the purpose and effect of energy saving.

4. Conclusion
This paper analyzes the problems existing in the current power energy scheduling, introduces the blockchain technology, proposes a new scheduling method, and verifies the feasibility of the practical
application of this method through experiments. In the process of research, it is found that the security and stability of power supply and demand networks are guaranteed with the support of blockchain technology. In the dispatching process, by introducing the distributed consensus mechanism of power energy supply and demand dispatching, the corresponding consensus mechanism can be selected for each partition of the whole blockchain, which can not only make each partition reach an agreement, but also establish the centralized characteristics of power energy supply and demand dispatching, achieve the balance of various operation parameters, and achieve higher quality grid connection.

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