Research on Matching Mechanism Between CCER and Green Certificate Authentication Based on Blockchain

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Abstract. With the proposal and promotion of the "double carbon" goal, the green certificate quota system and the carbon emission trading system have attracted wide attention. However, China has not yet formed a mature and effective green certificate market and carbon emission market, and the current system has not performed well in encouraging the consumption of renewable energy and promoting the emission reduction effect. In order to improve the market activity, this paper proposes a product mutual recognition system of green certificate and CCER. Meanwhile, based on blockchain technology, the joint market business process of green certificate and carbon emission right is designed, and the consensus mechanism of blockchain is utilized and improved. On the basis of ensuring the security and privacy of the trading data of green certificate and carbon emission market, By encouraging market trading to incentivize renewable energy generation and limit the carbon emissions of conventional fossil fuel units, we will facilitate the energy transition and advance the "two-carbon" goal.

Keywords: green certificate · CCER · blockchain · consensus

1 Introduction

With the development of renewable energy, it is an important issue to enhance the absorption capacity of the power grid for intermittent renewable energy power generation represented by wind power generation and photovoltaic power generation [1, 2]. In order to alleviate the current problems of low utilization efficiency and poor market competitiveness faced by renewable energy power generation and encourage environmentally friendly renewable energy power generation, the concepts of tradable green electricity certificates (hereinafter referred to as "green certificates") and carbon emission credits have been proposed internationally, and have been applied in some countries.

At present, the academic community has carried out extensive research on the green certificate market and the carbon market in the power industry, and there have been many

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studies on the application of blockchain in the two markets of green certificate and CCER, In terms of the green certificate market, the literature [3] studies the dynamic equilibrium process of renewable energy prices fluctuating under the sum of conventional energy prices and green certificate prices with supply and demand; The literature [4] discusses the role of green certificates in balancing the grid-connected price of photovoltaic power generation; Literature [5] builds a complementary, multi-regional integrated green certificate and electricity market model, analyzes the economic impact of green certificate on promoting renewable energy power generation, and proves that green certificate can promote the market competitiveness of renewable energy power generation enterprises; Literature [6] The green power tracking mechanism model is studied, and an electric carbon coupling and certification collaborative technical support system is constructed according to the characteristics of electric carbon coupling of green power trading network; Literature [7] proposes a blockchain-based joint incentive mechanism for green certificate and carbon trading market, which uses the decentralization, openness and transparency characteristics of blockchain to combine with the renewable energy trading market to make the renewable energy market more transparent, convenient and safe; Literature [8] proposes a mechanism for the generation, transaction and traceability of user-side green power consumption vouchers. The overall architecture system based on blockchain is designed, and a green power trading system with core capabilities such as efficient consensus, on-chain transaction, and identity authentication is built.

In terms of CCER market, the literature [9] analyzes the participation of Xishan Coal Power CCER project in the carbon market, tries to make positive explorations, and puts forward some suggestions for Xishan Coal Power to carry out carbon market work in the context of low-carbon economy; The literature [10] summarizes the development status of China's voluntary greenhouse gas emission reduction trading market from the aspects of policy and regulation system construction, technical support system construction, registration management, trading platform construction and CCER and its financial derivatives trading, and analyzes the possible problems of CCER trading; Literature [11] Based on the economic essence of carbon emission rights, the CCER that enterprises choose to develop themselves in order to meet the carbon emission reduction required by the state or the needs of their own trading is recognized as carbon emission rights for non-statutory quotas, and the corresponding accounting is discussed; The literature [12] analyzes the business mechanism and main stakeholders of the blockchain-based national carbon trading system, analyzes the typical information and smart contracts of the blockchain, and focuses on designing the six-layer blockchain core technical framework and the five-step implementation process of the carbon trading model; Literature [13] It is proposed to use blockchain technology to empower the construction of carbon market, design the blockchain system architecture of carbon market for the carbon market in the future big data environment, and propose a model of individual carbon asset price driving mechanism in the blockchain carbon market; The literature [14] introduces the basic principles of blockchain technology and summarizes the four main characteristics of blockchain technology: decentralization, immutability, scalability and distribution. Two sets of blockchain architectures: intelligent scheduling system based on fog computing and sidechain structure, and carbon emission allowance and green certificate trading system based on notary mechanism are proposed.

In summary, most of the current scholars have started from the separate application of blockchain technology in the green certificate market or CCER market, and there are still few relevant studies on the joint market of blockchain technology in the carbon market and green certificate trading. The purpose of the carbon market and the green certificate trading market is to save energy and reduce emissions and sustainable development of the ecological environment, so it is necessary to consider the joint market design of the two. In addition, the green certificate and carbon emission allowance markets have high requirements for the accuracy and security of transaction information, and transaction entities need to update data asynchronously. This is a big challenge for traditional trading markets, and blockchain technology provides a viable idea for this.

In order to tap the potential of the traditional green certificate market and carbon market, we will jointly promote the sustainable development of green energy from the perspectives of energy conservation and emission reduction. Based on the common green and low-carbon goals, this paper proposes a design of green certificate and CEER exchange matching mechanism, which can promote energy transformation through the joint operation of green certificate market and CCER market to stimulate renewable energy generation and limit the carbon emissions of traditional fossil energy units. At the same time, in order to ensure the safety and effectiveness of the green certificate and CCER joint market transactions, and the information is open and transparent, the proposed market trading mechanism is trusted and endorsed by improving the consensus mechanism.

2 CCER Matches Green Certificate Certification

2.1 CCER and Green Certificate

2.1.1 CCER and Green Certificate

Green certificate is an electronic certificate with a unique identification code issued by the national energy authority for each MWh of non-hydro renewable energy on-grid electricity of power generation enterprises, which is the confirmation and attribute certificate of non-hydro renewable energy power generation and the only certificate for consumption of green electricity, and is also a tradable and currency-convertible certificate, which can be used as a trading tool to transfer the ownership of the external characteristics of renewable energy environmental benefits.

CCER stands for Chinese Certified Emission Reduction. It refers to the quantitative verification of the greenhouse gas emission reduction effects of renewable energy, forestry carbon sinks, methane utilization and other projects in China. After the emission reductions of voluntary emission reduction projects are recorded, they are registered in the national register and traded in the recorded trading institutions, that is, the emission control enterprises purchase the certified amount that can be used to offset their own carbon emissions from the enterprises implementing the “carbon offset” activities.

2.1.2 The Connection and Difference Between the Two

Both policy instruments are linked to carbon markets. In the context of “dual carbon”, renewable energy project power generation as the basis for applying policy tools, can (or potentially) can be used as a policy channel to help enterprises strengthen carbon emission management in the electricity consumption link, so its market transaction entities involve power generation enterprises and electricity consumption enterprises, and green certificates and CCER transactions are also open to social individuals. For affordable renewable energy projects, the market prices of the two policy instruments are closely related when they rely on the green attributes of electricity to participate in carbon market transactions. In addition, the stages of development of the two policies are basically the same. The two policies were introduced earlier, and although the transaction quality was not satisfactory, it accumulated more practical experience and understanding, such as technical rules, trading mechanisms, risk identification, etc. At present, domestic subsidy green certificates and parity green certificates coexist, and while continuing to issue parity green certificates for trading, early subsidy green certificates can still be traded separately.

The two policy instruments have different certification channels and belong to different trading systems. The green certificate is mainly approved and issued by the National Renewable Energy Information Management Center relying on the information management platform of renewable energy generation projects of the National Energy Administration, and relies on the transaction subscription platform to carry out transactions: CCER is completed by the certification center officially approved by the National Development and Reform Commission, and then after the registration of the national voluntary emission reduction transaction registration system, it is mainly carried out by participating in local or national carbon emission trading, and a small amount can also be negotiated by buyers and sellers themselves. In addition, the trading prices of the two policy instruments are affected by supply and demand. The trading price of the green certificate and CCER is based on the implied carbon emission reduction value of green electricity. For power generation enterprises, it is to obtain additional income, which is the basis for the existence of a certain relationship between the two policies, under the current policy, the demand space for parity green certificates is limited, especially if it is not mandatory, market transactions are not active, so its market transaction price is lower than CCER (subsidized green certificate price is another matter).

2.1.3 Current Issues

Both green certificates and CCER need to be verified and certified by certain institutions, among which, CCER needs to collect electricity data through grid metering equipment for measurement and statistical verification, green certificates need to be reviewed and verified through the process of application, application, issuance, etc., and carbon emission rights need to be verified by third-party verification agencies for enterprise carbon emission data. So as to ensure that the green certificate, CCER and carbon emission allowance data owned by the enterprise are correct, so as to ensure fair competition among various market entities and create a good development environment. However, at present, the relevant verification process is cumbersome and there are many links, and it is difficult to ensure the accuracy of the data. At the same time, due to the long cycle of the data chain and the lack of a feasible data asset defense system, there is a risk that data will be copied, retained, tampered with, and resold, and the rights and interests of data assets cannot be effectively protected. When considering the exchange of green certificates and CCER, power plants may also face double counting problems because they may register green certificates with CCER's corresponding carbon emission reductions.

2.2 Green Certificate and CCER Product Mutual Recognition System

CCER and green certificates can both promote carbon emission reduction through electric energy substitution, etc., and the two are equivalent, and can constitute a mutual recognition relationship according to the similarities and differences and trend analysis of policies. Therefore, the following technical route can be initially formed to achieve mutual recognition of CCER and green certificates: according to the "First Edition of Integration Baseline Methodology for Renewable Energy Power Generation Grid-connected Projects" (CM-001-V01) issued by the National Development and Reform Commission in 2013, The emission reduction contribution per MWh of green electricity of renewable energy generation projects can be determined by the "Emission Reduction Project China Regional Grid Baseline Emission Factor", and the dual values of electricity in different regions are different. In 2019, the Department of Climate Change of the Ministry of Ecology and Environment updated the above factors to calculate the carbon reduction effect corresponding to the green electricity certificate transaction, namely:

$$E = EF_{CM} \times P \tag{1}$$

Among them, E is the equivalent emission reduction when the green certificate is exchanged for CCER, P is the green electricity (MWh) corresponding to the green certificate, and EFCM is the combined marginal carbon dioxide emission factor (tCO2/MWh), and the calculation method is as follows:

$$EF_{CM} = \alpha EF_{OM} + \eta EF_{BM} \tag{2}$$

Among them, EFOM is the marginal emission factor of electricity, $\propto$ is the weight of marginal emission factor of electricity, EFBM is the marginal emission factor of capacity, and the weight of η volume marginal emission factor.

For wind power and solar power projects, the $\propto$ of the first and subsequent crediting periods is 0.75 and 0.25 for the η; for other types of projects, the $\propto$ and η of the first crediting period are 0.5, and the $\propto$ and η of the second and third crediting periods are the same, taking 0.25 and 0.75 respectively.

Based on the above analysis, also from the perspective of carbon emission reduction, green certificates and carbon emission allowances constitute a deduction relationship. That is, after the mutual recognition of green certificates and CCER is completed, considering that CCER and carbon emission allowances can be transferred almost completely one-to-one equivalently, the mutual recognition mechanism of green certificates and carbon allowances can be naturally completed.

3 Blockchain Technology Helps CCER Match with Green Certificate Certification

3.1 Blockchain and Consensus Mechanism

3.1.1 Applicability of Blockchain Technology

Blockchain is an innovative application mode of distributed data storage, peer-to-peer transmission, consensus mechanism, encryption algorithm and other computer technologies in the Internet era, with decentralization, information sharing, irreversibility of records, participant anonymity and information traceability and other technical characteristics, its core advantage is to ensure mutual trust between different subjects, thereby greatly reducing the cost of maintaining or retrusting trust. Every node in the blockchain network has the same authority, and the failure of any node will not affect the normal operation of the entire data system. The information recorded on the chain is redundantly backed up by multiple nodes, and multiple nodes are required to jointly authenticate when updating data information. The information recorded on the chain is permanently stored, and the complete transmission path of the information is recorded on the chain for traceability. Based on the above technical characteristics of blockchain, it also has good adaptability with the transaction or exchange of green certificates and CCER:

- Blockchain has a decentralized trusted trading platform, so each user node can conduct peer-to-peer transactions without a trust institution or trust relationship in advance. At the same time, its smart contract technology can be used to automate the registration and accounting of green certificates and CCER, which can effectively reduce the cost of the central management agency.
- Blockchains are stored through a chain structure of blocks. The block body stores the transaction record information and reflects it to the Merkle Root at the block header to ensure that the information is not tampered with. All information recorded on the chain, such as renewable energy on-grid electricity recorded by smart meters, will be asymmetrically encrypted to provide security for on-chain data.
- Based on the consensus mechanism of blockchain, each transaction or exchange of green certificate and CCER will be confirmed by nodes multiple times, which can effectively avoid the problem of double calculation and ensure the fairness, justice and openness of the transaction; At the same time, its data traceability also makes all transaction or exchange data available, providing data support for the verification of renewable energy consumption.

3.1.2 Consensus Mechanism

From a data perspective, blockchain is essentially a distributed shared ledger. The blockchain infrastructure model can be divided into data layer, network layer, consensus layer, incentive layer, contract layer and application layer. The consensus layer is used to encapsulate different types of consensus algorithms and determine the mechanism by which the blockchain forms new blocks. The fundamental purpose of the consensus mechanism is to solve the problem of node trust in blockchain networks. The blockchain design believes that each node has the possibility of data being tampered with, and a set of judgment mechanisms that all nodes can recognize for block data applications submitted by each node must be established to determine whether the data is reliable. The current blockchain consensus mechanism design generally follows the principles of "minority obeys the majority" and "everyone is equal". "Minority obeys majority" does not exactly refer to the number of nodes, but can also be computing power, number of shares, or other features that computers can compare. "Everyone is equal" means that when nodes meet the conditions, all nodes have the right to propose consensus results first, which are directly recognized by other nodes and may eventually become the final consensus results. At present, typical consensus mechanism algorithms include Proof of Work (PoW), Proof of Stake (PoS), and Byzantine Fault Tolerance (BFT).

3.2 Blockchain-Based Green Certificate and CCER Joint Market Mechanism

The operation mechanism of the blockchain-based green certificate and CCER joint trading market is shown in Fig. 1. The green certificate and carbon joint market shown in Fig. 1 includes the green certificate blockchain and the carbon emission rights blockchain, as well as the interaction of the two chains.

3.2.1 Green Certificate Trading Blockchain

Smart meters accurately record the amount of electricity charged by renewable energy sources and automatically issue green certificates based on on-chain rules. Enterprises with green certificate quotas can enter the green certificate trading market for trading, renewable energy power plants obtain economic benefits through the sale of green certificates to obtain green power subsidies, fossil energy power generators obtain corresponding green certificates by purchasing green certificates to complete quota indicators, and complete subsidies to green power enterprises through market means. All green

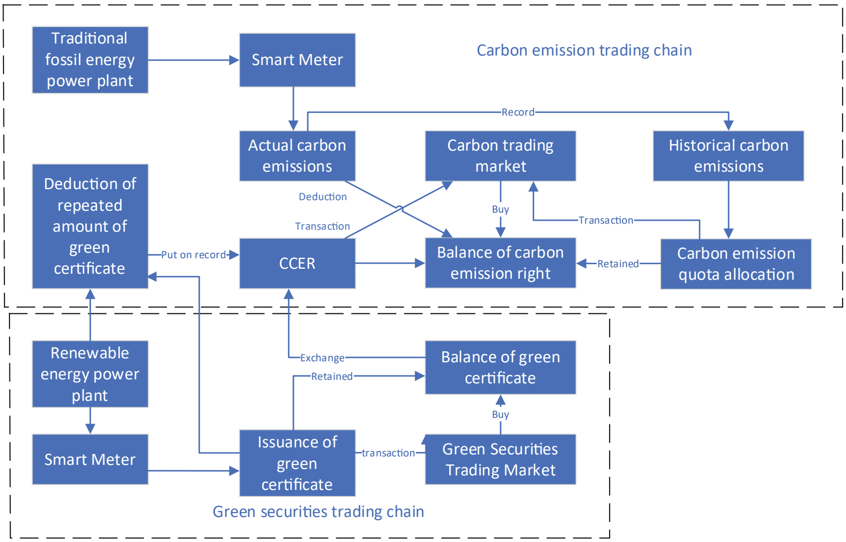

Fig. 1. Green Certificate and CCER Joint Market

certificate transactions are completed on-chain, guaranteeing transaction reliability and simplifying the regulatory process.

3.2.2 Carbon Emissions Trading Blockchain

CCER electro-certified renewable energy and agricultural and forestry carbon sink and other emission reduction projects are composed on the chain. Carbon quotas are generated according to built-in rules based on historical carbon emissions recorded on the chain, which is open and transparent. Smart meters record the actual carbon emissions of traditional fossil energy power plants in the current cycle, and if the actual carbon emissions in the current round of market are less than the balance of carbon emission allowances owned by the enterprise, the enterprise can hold the excess carbon emission allowances and enter the market as a seller of carbon emission rights trading; If the actual carbon emissions in the current round of the market are greater than the balance of carbon emission allowances held by the enterprise, the enterprise enters the market as a buyer of carbon emission allowance trading. Carbon quotas are generated according to built-in rules based on historical carbon emissions recorded on the chain, which is open and transparent.

3.2.3 Dual-Chain Interaction

The arrows between the two transaction chains in Fig. 1 indicate the interaction of the two transaction chains, because some renewable energy sources meet the CCER standards in both green certificate issuance and carbon emission rights, so it is necessary to synchronize the green certificate issuance information in the green certificate blockchain to the carbon emission rights blockchain before joint trading, and deduct duplicate amounts. When the green certificate and carbon emission allowance are cleared separately, the enterprise holding the balance of the green certificate can convert it into a CCER balance according to the rules and enter the market again for trading. The whole process is automatically completed based on smart contract technology, and the exchange or transaction between each green certificate and CCER will generate a new block through the consensus mechanism, and the data in the block cannot be tampered with, open and transparent.

4 Green Certificate and CCER Asset Authentication Mechanism Based on Consensus Mechanism

4.1 Improved PoS Consensus Algorithm Process Considering Emission Reduction Contribution

This paper improves on this. First, the concept of emission reduction contribution certificate and green age is given. The contribution value of emission reduction is a new digital token created through the energy trading process of the blockchain platform based on the preparation of smart contracts. The design purpose of the digital token is to use a "measurement or counting" carrier to distinguish the contribution and role positioning of each market participant, provide a calculation reference for the carbon reduction generated or converted by the transaction of CCER that does not participate in the green token exchange in the joint market, and represent the contribution of the main body to emission reduction. In this paper, it is believed that the buyers and sellers of green certificates and CCER and the sellers of carbon emission rights have made contributions to emission reduction. Therefore, enterprises that sell CCER and carbon emission rights and both parties that buy and sell green certificates obtain certain emission reduction contribution certificates. The emission reduction contribution certificate is generated when the block is generated from the block node, and the quantity generated is determined by the emission reduction amount corresponding to the green energy products in the transaction. Green age refers to the concept of coin age in the PoS consensus. As the equity value in the improved algorithm, the more green age the node is, the easier it is to obtain the block weight.

First, assume that there are $N = m + n$ nodes, m is the total number of renewable energy generation companies in the region, and n is the total number of non-renewable energy generation companies in the region. The proportion of block producers to all nodes is $k = \mu N$. All nodes sort the green age size of nodes in the world state, and select the top k node in the green age ranking as the block producing node. The k block producers are then sorted according to their own stake size and produce blocks in order. The process of electing a block node and producing a block is called an epoch. If after sorting, it is found that the green age of multiple nodes is the same as the kth node, resulting in the number of block nodes being greater than k, the hash value of the ID of the node with the same green age as the kth node is compared, and the sorting is performed again until the number of block producers nodes of the current epoch reaches k. Without considering hash collisions, the hash value is unique, so the comparison result is also unique. Therefore, when electing a block node, all nodes can reach a consensus, and the same k nodes can be elected to form a queue of block nodes. Improving the selection of k block producers nodes per epoch in PoS instead of selecting one block generation node is mainly to provide rewards for more nodes and motivate them to participate in emission reduction tasks, and also to avoid the situation that one node may go offline and do not perform block generation tasks, resulting in waste of system resources.

The following describes the process of generating blocks by k block producing nodes. Each node produces a block, and the order in which blocks are generated is also determined by the size of the node's green age. Each block producer waits for the previous block producer to send the temporary blockchain to itself, and verifies that the order in which this temporary block was generated matches the ordering and that the transactions or exchanges in the block are legal. If an illegal transaction is found, the block is not accepted, and the node that generated the illegal transaction is penalized and removed from the block node queue. If there is an offline node, when the node packs the block, the node does not pack the block, the node is skipped, and the next node packs the block. After all nodes complete the block generation task, the last block producer node sends the temporary blockchain to other nodes that do not participate in the consensus.

The process of an epoch is mainly divided into block node election, pre-prepare, PrepareCommit and View-change, and Replay. Among them, Pre-Prepare and Prepare

are the same as PBFT, and also have the same fault tolerance, which can accommodate f Byzantine nodes, and the total number of block nodes k in an epoch should meet $k \geq 3f + 1$, so each epoch is also allowed to have no more than 1/3 of Byzantine nodes, the specific process is as follows:

Step 1: Select the block node according to the election algorithm. In order to avoid the occurrence of no response when the node produces blocks, the maximum waiting delay of the node is set To. If the block is not received beyond To, the election algorithm is executed again by skipping the block to elect the next block producer.

Step 2: Pre-Prepare stage, after the block node generates a block, generate a pre-prepare message to broadcast to other backup nodes, and at the same time store the pre-prepare message in this log, pre-prepare message format: [(pre-prepare, v, s, d), m], where v is the current view number, d is the summary of message m, s is the signature.

Step 3: Prepare stage, after the replica node receives the pre-prepare message, check whether the message is legitimate, if the verification is passed, send prepare messages (prepare, v, s, d, i) to other nodes, bring their own id information, and receive prepare information from other nodes, the node that receives the prepare message also checks the legitimacy of the message, and after the verification is passed, the prepare message is written to the message log. At least 2/3 of the nodes have been verified before entering the ready state.

Step 4: Commit and View-change phase, when a node enters ready to load, it will broadcast a commit message to tell other nodes that the current block is ready in the view. If at least 2/3 of the node verification pass commit messages are collected, it means that the block passed and consensus is reached on the block generated by the current master node. At the same time, it enters the view switching stage to execute the node election algorithm, and the next block node generates blocks. If no block is generated after the To time, the block node is re-elected.

Step 5: Repeat the above three stages until the kth node completes the block generation task, forming a temporary blockchain, which is broadcast by the first block producer node to all follower nodes, and finally completes an epoch If other nodes exceed To and do not receive the message of the first node, the second node will broadcast the temporary blockchain to other nodes.

Step 6: In the Broadeast Blockchain phase, the masternode sends the temporary blockchain to other full nodes that are not participating in this epoch.

Step 7: In the Reply stage, the full node that does not participate in the consensus receives the temporary blockchain and executes the Reply process, verifies that the information of the blockchain is correct and sends Reply messages to other nodes, and all nodes receive more than 2/3 of the reply messages of the nodes that do not participate in block generation and reach a consensus on this temporary blockchain and add it to the local blockchain.

Block propagation time is determined by the transmission delay on each link and the transaction validation time per node. For chunks of size s, the transmission delay is:

$$\sigma_{\mathrm{p}}(\mathrm{s}) = \frac{\mathrm{s}}{\gamma^{\mathrm{c}}} \tag{3}$$

Formula: γ is a parameter related to the size of the network; c is the average effective channel capacity of each link. Since validating a transaction requires a certain amount of computation, block validation time can be modeled as a linear function:

$$\sigma_{\mathrm{v}}(\mathrm{s}) = \beta \mathrm{s} \tag{4}$$

Formula: β is a parameter determined by the size of the network and the average verification speed of each node. Then, the average time for a block of size s to propagate across the network is:

$$\sigma(\mathrm{s}) = \sigma_{\mathrm{p}}(\mathrm{s}) + \sigma_{\mathrm{v}}(\mathrm{s}) = \frac{\mathrm{s}}{\gamma^{\mathrm{c}}} + \beta \mathrm{s} \tag{5}$$

The incidence of block production due to propagation delay or node offline follows a Poisson process with an average rate of 1/T. Therefore, the probability that a node does not produce a valid block of size s is:

$$P_{\mathrm{o}}(\mathrm{s}) = 1 - \mathrm{e}^{-\sigma(\mathrm{s})/T} = 1 - \mathrm{e}^{-\left(\frac{\mathrm{s}}{\gamma^{\mathrm{c}}} + \beta \mathrm{s}\right)/T} \tag{6}$$

The number of blocks expected to be generated at one epoch is:

$$N = [\mathrm{k}(1 - P_{\mathrm{o}})] \bigsqcup = \left[\mathrm{k}\mathrm{e}^{-\left(\frac{\mathrm{s}}{\gamma^{\mathrm{c}}} + \beta \mathrm{s}\right)/T}\right]_{\sqcup} \tag{7}$$

Then the time to complete an epoch in the improved PoS algorithm is:

$$\begin{aligned} T_{\mathrm{e}} &= [1 - P_{\mathrm{o}}(\mathrm{s})]\eta \mathrm{k}\sigma(\mathrm{s}) + P_{\mathrm{o}}(\mathrm{s})\mathrm{k}T_{\mathrm{o}} + \mathrm{T}_1 \\ &= \mathrm{e}^{-\left(\frac{\mathrm{s}}{\gamma^{\mathrm{c}}} + \beta \mathrm{s}\right)/T} \eta \mathrm{k}\left(\frac{\mathrm{s}}{\gamma^{\mathrm{c}}} + \beta \mathrm{s}\right) + \left(1 - \mathrm{e}^{-\left(\frac{\mathrm{s}}{\gamma^{\mathrm{c}}} + \beta \mathrm{s}\right)/T}\right)\mathrm{k}T_{\mathrm{o}} + T_1 \end{aligned} \tag{8}$$

Formula: η is the communication complexity parameter; To is the maximum waiting time of the node; T1 is the election time of the block producer. Each epoch post-node calculates the green age of each node, sorts it and records it in the world state. The world state stores the current state of the nodes and the list of the top k nodes in the green age ranking, and the world state is updated every time epoch. If a node does not participate in this consensus because it is offline, the green age of the node will also be cleared to zero, and no block reward will be received, so the node will prefer to remain online for a long time.

4.2 Stake Calculation

The green age in this paper corresponds to the rights and interests in the traditional PoS algorithm, which is calculated by the green certificates purchased or sold by the node, as well as the emission reduction contribution certificates obtained by the CCER and carbon emission allowances sold. Since trading renewable energy products promotes emission reduction, it can be considered that it contributed to this system. In traditional PoS, there is a phenomenon of accumulation of rights, such as many nodes accumulating large stakes, and then mining at the same time causes malicious forks. In order to prevent the accumulation of equity, this paper adds an attenuation factor ξ to the green age calculation and sets an internal counter cal, when the node has not obtained the block right in z blocks, the node green age is cleared to zero and recalculated.

This is also one of the reasons why each epoch elects k nodes, which to a certain extent avoids the situation that some nodes are cleared before they have obtained the green age of the block right, and do not receive rewards.

For the absorption subject, the green age calculation method is as follows:

$$G_{\mathrm{age}_{i,t}} = \xi\left(\rho \mathrm{n}_{TGC_{i,t}} + \lambda \mathrm{n}_{CCER_{i,t}} + \tau \mathrm{n}_{CE_{i,t}}\right)\mathrm{b}_{\mathrm{cal}} \tag{9}$$

Formula: ρ, λ, τ are the calculation coefficients of green certificate, CCER and carbon emission allowance in green age, respectively; $\mathrm{n}_{TGC_{i,t}}$ is the total number of green certificates purchased or sold by the consuming entity i before the t hour; $\mathrm{n}_{CCER_{i,t}}$ is the total number of CCERS sold by user i before the t moment; $\mathrm{n}_{CE_{i,t}}$ is the carbon allowance sold by user i at the time; BCAL is a Boolean value associated with the counter, when the counter is displayed as z, bcal = 0, otherwise bcal = 1.

The probability of a user being selected as a block node is proportional to the proportion of his green age to the total green age, and the proportion of user i green age is:

$$P_{\mathrm{i}} = \frac{G_{\mathrm{age}_{i,t}}}{\sum_{j=1}^{N} G_{\mathrm{age}_{i,t}}} \tag{10}$$

The node with the top K in the proportion will be selected as the block producer, participate in the block production behavior, and receive rewards.

5 Conclusion

In order to respond to the national "dual carbon" strategic goal, effectively promote the consumption of renewable energy in the distribution network and limit the carbon emissions of high-energy-consuming power generation companies, this paper proposes a mutual recognition mechanism for green certificates and CCER products. At the same time, the PoS algorithm in the blockchain is improved and utilized, so that the product exchange and transaction records are traceable, and the rights and interests of each participating node in the consensus mechanism are related to its emission reduction in the smart grid, as long as it contributes to the emission reduction, it has the opportunity to obtain the right to block and get rewarded to encourage it to continue to reduce emissions.

This article is a phased study of blockchain technology in the field of power finance. The application of blockchain technology in the energy field is still in the preliminary exploration stage. Follow-up research can be devoted to the application and deployment of blockchain technology, effectively upgrade science and technology in the field of power finance, and promote the realization of the "dual carbon" goal.

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