

Research on Certification and Circulation Mode of Green Electricity Environmental Value Based on Blockchain

Ming Li^{1,a}, Wenyu Zhang^{2,b,*}, Meng Yang^{3,c}, Hongyong Liu^{4,d}, Jie Ren^{5,e}, Jiageng Dai⁶, Shuailiang Yao⁷

¹State Grid Hebei Zhangjiakou Scenery Storage and Transportation New Energy Co. LTD Zhangjiakou, Hebei, China

²State Grid Hebei Zhangjiakou Scenery Storage and Transportation New Energy Co. LTD Zhangjiakou, Hebei, China

³State Grid Hebei Zhangjiakou Scenery Storage and Transportation New Energy Co. LTD Zhangjiakou, Hebei, China

⁴State Grid Hebei Zhangjiakou Scenery Storage and Transportation New Energy Co. LTD Zhangjiakou, Hebei, China

⁵State Grid Hebei Zhangjiakou Scenery Storage and Transportation New Energy Co. LTD Zhangjiakou, Hebei, China

⁶State Grid Hebei Zhangjiakou Scenery Storage and Transportation New Energy Co. LTD Zhangjiakou, Hebei, China

⁷ State Grid Hebei Zhangjiakou Scenery Storage and Transportation New Energy Co. LTD Zhangjiakou, Hebei, China

Abstract—In the process of green power trading, green power reflects the value of electricity energy and green environment, and green certificates aim to reduce the pressure of new energy subsidies and guide the concept of green electricity consumption. In order to promote the integration of new energy through market-oriented mechanisms, ensure the basic income of new energy projects, reflect the environmental value of green electricity, promote the sustainable development of the new energy industry, and meet the needs of users for green electricity at the same time, this paper constructs a blockchain-based green electricity environmental value authentication and circulation method by using the characteristics of blockchain centralization, distributed ledger, consensus mechanism, and smart contract.

1. INTRODUCTION

The purpose of this paper is to further improve the national subsidy system for wind power generation and photovoltaic power generation. There is a small transaction volume in China's green certificate trading market, and the sales volume of different types of green certificates has a large gap. The purchase and sale of green certificates is mainly listed publicly on the trading platform, resulting in information asymmetry between the buyers and sellers of green certificates and the buyers of green certificates, that is, the buyer can see the information listed by the seller of green certificates, and the seller of green certificates does not know what the buyer's intended purchase price is before listing. Let the green certificate buyers only want to buy low-priced green certificates according to the listing price, and the seller wants to sell at a high price, so the transaction volume is small. Therefore, there is a need for a green power certificate trading method and system that can increase the transaction volume and improve efficiency.

2. ANALYSIS OF THE CERTIFICATION AND CIRCULATION STATUS OF GREEN POWER CERTIFICATES

Due to the transitional impact of various policies, China's green certificates lack the uniqueness of environmental rights and interests, resulting in relevant international organizations questioning their "purity", and the institutional mechanism of mutual recognition of China's green certificates and international mainstream green certificates has become a major problem at present.

2.1 China Green Certificate and I-REC

On June 15 next year, I-REC will lift restrictions on listed companies so that both state-owned and non-state-owned enterprises can participate fairly. At the same time, from January 1, 2023, all renewable energy projects will no longer issue I-REC green certificates. The domestic mainly relies on a few agents familiar with I-REC, which is basically completed by over-the-counter bilateral transactions. The derailment of domestic green certificates and I-REC international green certificates has led to some domestic multinational enterprises still choosing to purchase green certificates through the international

e-mail: ^a565742354@qq.com *Corresponding author: e-mail: ^bZhang.wyu@hotmail.com e-mail: ^c790715461@qq.com e-mail: ^dliu_hongyong123@126.com e-mail: ^e534971271@qq.com

market, which has caused certain resistance to the expansion of the allocation scope of domestic green certificates. Compared with domestic green certificates, I-REC has the advantages of high international acceptance and relatively low price, and it is in greater demand from export-oriented enterprises and internationally renowned energy-consuming enterprises. However, domestic green certificates lack the connection with the settlement business of various market entities, and lack status tracking such as the use, invalidation, and cancellation of green certificates.

2.2. Analysis of the current situation of green certificate trading in China

- Under the current green securities trading system, the purchase of green certificates cannot obtain additional income or enjoy other preferential policies, enterprises cannot sell green certificates again after purchasing them, and the liquidity of green certificates is restricted, so the enthusiasm of enterprises and individuals to buy green certificates is discouraged.

- At present, domestic green securities are still mainly based on voluntary subscription. Although the consumption obligation has a certain degree of mandatory, it has three ways, one is the main one, and the two are substitutionary, that is, when enterprises purchase green electricity, purchase excess consumption from excess consumption companies, and purchase green certificates, they can freely choose to buy green electricity, purchase excess consumption, purchase green certificates, and purchase green certificates, all three ways do not need to buy green certificates, nor do they stipulate fines, only stipulate rectification within a time limit, bad credit records, and joint punishments, which has caused the mandatory reduction of green certificate transactions.

- The upper limit of the price of the subsidized green certificate is the subsidy amount of $kWh * 1MWh$, and the specific subscription price is determined by the buyer and seller themselves or through bidding, and the average price of China's parity green certificate is 50 yuan / piece, which is significantly lower than the price of subsidized green certificate. As a result, the subsidy green certificate is "priceless and marketless". Since the benchmark electricity price of wind power is different from that of photovoltaic power generation, wind power green certificates have a price advantage over photovoltaic power generation green certificates, which affects the transaction volume of green certificates for photovoltaic power generation projects.

- China's green certificates have not established a tracking mechanism for green electricity, and trading and cancellation are not allowed. Moreover, the price of green certificates in China is higher than the price of GO certificates in Europe and the price of unbundled certificates in the United States, resulting in a lower willingness of international enterprises to purchase green certificates in China.

3. CERTIFICATION AND OPERATION SYSTEM CONSTRUCTION OF GREEN ELECTRIC POWER ENVIRONMENTAL VALUE

For power generation enterprises, the balance point of subsidized participation in green power trading lies in the accounting and trade-off between the environmental premium of green power trading and the benefits of receiving subsidies or green certificates in the next few years; The balance point between the participation of subsidized projects in green power trading lies in the accounting and trade-off of environmental premium, system cost sharing. After the promulgation of Document No. 1439, the range of fluctuations in the trading price of coal power market has expanded, and the mechanism of green power trading price formation is not clear, and it is necessary to explore how to protect the income of new energy enterprises through market transactions and promote the development of new energy industry.

The first is to strengthen green certificates as the only proof of green electricity consumption. Recognize the status and role of green certificates, green attributes cannot be repeatedly applied for internationally and domestically, and cannot be repeatedly profitable in the electricity market and carbon market, maintain the authority of green certificates, and promote the integration of China's green certificates with international green certificates.

Second, the green environmental value of the green certificate belongs to the power generation. The price of green electricity includes the price of electricity energy and the environmental premium, which respectively reflect the production and operating costs of green electricity and the value of environmental attributes. Green certificates reflect the environmental value of green electricity, and the additional income generated by environmental value should belong to the power generation enterprise.

The third is to design a coordination mechanism between voluntary and compulsory trading of green certificates to increase the trading volume of green certificates. One of the common points of the green certificate schemes in Europe and the United States is that voluntary trading and compulsory markets run in parallel, except that the two markets in the United States can be combined, interrelated or independent, and the two European markets do not cross and do not overlap with the scope of electricity prices or premium policies. Referring to the experience of Europe and the United States, we can improve the green certificate trading and management model suitable for China's development situation and needs by designing a collaborative mechanism for voluntary green certificate trading and compulsory trading.

The fourth is to incorporate more renewable energy into the green certificate system and expand the scope of green certificate issuance. In the future, with the development of the industry and technological progress, distributed photovoltaic power generation, offshore wind power, solar thermal power generation and biomass power

generation projects will be included in the issuance objects to reflect fairness.

The fifth is to design a green certificate full life cycle verification system. From the whole process of production, trading and write-off, green power needs a complete set of scientific and perfect management system to maintain the uniqueness of its green environmental value, establish a green certificate full life cycle verification system, and realize the unique traceability of the whole life cycle of green electricity, so as to participate in green power trading. The multi-party market entities provide better services, accelerate the establishment of a market system to promote green energy production and consumption, and further promote the mutual recognition mechanism of China's green certificate and international renewable energy certificate (I-REC).

The sixth is to promote the effective connection of green electricity and green certificates trading mode. On the one hand, green electricity can participate in the electricity market as a commodity attribute of electric energy and comply with the trading rules of the electricity market. On the other hand, green certificates, as the only evidence of the environmental value of green electricity, promote the value return of new energy in a more flexible way.

The seventh is to cancel the transaction of excess consumption of renewable energy. The Renewable Energy Excess Consumption Trading aims to provide a flexible way of fulfilling the weight of renewable energy consumption responsibilities. However, there is a double calculation of green electricity on the consumption side of renewable energy excess consumption trading, and it is recommended to cancel the excess consumption transaction to enhance the international credibility of domestic green certificates.

4. BLOCKCHAIN-BASED GREEN CERTIFICATE TRANSACTION METHOD AND SYSTEM DESIGN

Blockchain is currently the most basic Bitcoin technology, it has the characteristics of decentralization, distributed ledger, consensus mechanism, smart contract and so on, and has been widely used in medical, financial, communication and other fields. Combining blockchain technology with other industries is a major breakthrough in China's independent innovation. The integration of green securities trading and blockchain technology is an important innovation in energy, blockchain and other aspects.

4.1 Decentralization and Consensus Mechanisms

Distributed peer-to-peer network (P2P) is the foundation of blockchain, and its decentralized architecture enables participating nodes to store, transmit and receive files, and on this basis, maintain the peer-to-peer status of both parties, and effectively carry out peer-to-peer data transmission. On the other hand, in the case of distrust, through the negotiation mechanism of the blockchain, all

nodes in the entire network can reach an agreement, so as to ensure the safe operation of transactions. As an example, consortium members choose a management node on one chain to authenticate and confirm other user nodes. After completing the transaction, the network node stores all the transaction information in its own block to avoid losses caused by data destruction. In green certificate transactions, the information center can act as a management node on the alliance chain to supervise and confirm the transactions between buyers and sellers. At the same time, after the transaction between the buyer and the seller is completed, the transaction information will also be pushed to other participating nodes for confirmation by broadcasting to prevent the transaction from repeating. At the same time, some information no longer needs to be released after third-party statistics, which can prevent the cost waste caused by time asymmetry.

4.2 Encryption Algorithm

The encryption algorithm used in a blockchain network is called an asymmetric cryptographic digital signature, which includes the following components: encryption and decryption algorithms, encryption keys (private keys), and decryption keys (public keys). The private key is generated by a random function, while the public key is generated from an elliptic curve. In blockchain, hashing algorithms are irreversible and unique. In the blockchain, when other users receive the message, they use the public key to restore the password and compare it with the original text to determine the authenticity of the password. The encryption of the original key and the recovery of the public key pair key are based on the encryption and decryption algorithm. Through symmetric encrypted digital signatures, it can ensure that only the transaction initiator can authorize the transaction, and even the platform operator or the supervision agency cannot directly initiate the transaction without bypassing the account owner, thus ensuring the independence and freedom of transactions in the green certificate market.

4.3 Smart Contracts

Smart contracts are a fully automated process that automatically processes transaction information according to pre-set logic to finally obtain the final transaction result. After the audit node is on the chain, all power generators can be audited during the opening hours, and after the power generator completes the information, the contract will certify and issue green certificates to the power generators who have passed. The transaction of green certificates requires the smart contract to be called to verify whether the green certificate sold by the seller belongs to him and is in the validity period. Smart contracts provide transactions that are irreversible and prevent buyers and sellers from defaulting.

4.4 Blockchain-based Green Certificate Transaction and Circulation Mode

There are two types of entities participating in green certificate transactions: green power producers and green certificate consumers. Green power producers need to carry out green certificate issuance on the platform through green power generation, and can trade green certificates to green certificate buyers through the platform, and such entities only exist enterprise types, not individual types. Green certificate consumers obtain green certificates through platform transactions, and the green certificates obtained can be deducted for other businesses, and the used green certificates can be deregistered on the platform. Green power production users select the number of green certificates that need to be certified, submit the system for verification, and the system checks the account authentication information and electricity data according to the application. Before issuing green certificates through the platform, green power production users need to declare the correctness of the information and the sole use of the electricity used to issue green certificates. The system provides a declaration template, and the user directly confirms the content of the declaration online.

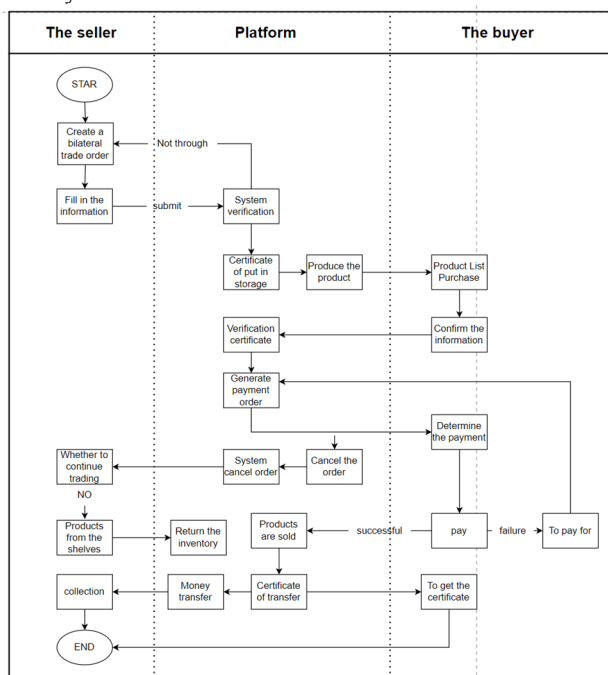


Figure1 Green Certificate transaction process

After the user registers, the information maintenance is completed, and the operation personnel need to review the maintenance and modification, and the business can be carried out only after the review is passed. Personal users mainly review: personal ID information, upload documents, financial information, invoice information and other content. Enterprise users mainly review: enterprise information, social credit code, registered address, business license, enterprise unit information, financial information, invoice information and other content.

After the two parties to the transaction reach an intention, the seller will establish a bilateral transaction form on the platform, fill in the transaction information,

including the number of transaction certificates, the transaction unit price, the system automatically calculates the transaction amount according to the unit price and quantity, the green power production time range, the type of buyer (select the enterprise, individual, the default is the enterprise), the buyer's unified social credit code, and the system and bring out the enterprise name, buyer contact person, and contact phone number according to the unified social credit code; The seller's name and unified social credit code are automatically associated according to the current account information, and the contact person and contact phone number can be filled in.

For enterprise users to purchase, the system fills in the unified social credit code, and the system automatically brings out the enterprise name; For individual users to purchase, fill in the ID number, the system will automatically bring out the name.

After the seller submits the data, the buyer enters the platform to confirm the data. Orders that have not been confirmed for more than 30 days are automatically canceled. After confirmation by both parties, the system generates an order according to the transaction information, and after the buyer pays successfully, the platform will check and reduce the seller's certificate, and the buyer will issue it.

The platform will uniformly manage the orders generated by the system, the operation personnel can view the order information of all users, and users can view their own orders in order management. You can query according to the search conditions, and the search fields include: order name, order number, order type, order status, and order time. The list displays the order retrieval result information, and the operation personnel can select one of the data to view the details, including: order name, order number, order type, payer, payee, order amount, order time, payment status, payment time, and payment method.

The above is the whole process of green certificate trading on the platform.

5. CONCLUSION

The "green certificate" is to ease the subsidy pressure on new energy and guide its green consumption. The green certificate reflects the environmental value of green energy, and the added value of environmental benefits brought by it should be attributed to the power generation enterprise. However, due to the temporary limitations of China's green certificates in the international situation, it is urgent to promote the integration of China's green certificates with international green certificates, and improve the green certificate trading and management mode suitable for China's development situation and needs. Problems such as untimely information disclosure and cumbersome information verification process.

ACKNOWLEDGMENTS

On the occasion of the completion of this article, I would like to express my heartfelt thanks and sincere respect to the leaders and colleagues of the research and application

project of green electricity environmental value internationalization certification technology (project number: SGJBXY00YXJS2250010) funded by the science and technology project of State Grid Jibei Zhangjiakou Wind and Photovoltaic Storage and Transmission New Energy Co., Ltd. Thank you for your patient guidance and for providing me with so many learning materials. The smooth completion of this article is inseparable from your help.

REFERENCES

1. Yuanji, C., Yuxuan, G., Gang, L., Xuan, Z., Qixin, C. (2020) Green certificate trading platform based on blockchain: concept and practice. *Automation of Electric Power Systems.*,44:1-9.
2. Jingli, S. (2019) Comparison and enlightenment: the advantages and disadvantages of green certificate mechanisms in Europe, the United States and China. *Energy.*,11:37-40.
3. Li, D. (2017) Voluntary subscription of green certificates condenses the consensus of green electricity consumption. *Energy Conservation and Environmental Protection.*,08:26-33.
4. Jinliang, Z., Yuzhu, W. (2022) Design of green electricity certificate trading mechanism based on blockchain technology. *Journal of North China Electric Power University(Social Science Edition).*,02:40-48.
5. Hao, W., Yin, B., Chang, D. (2021) Research on green certificate trading mechanism of electricity market based on blockchain technology. *Inner Mongolia Electric Power Technology*,39:47-50.