Refined Resource Allocation Algorithm for Power Trading Centers Based on User Service Needs

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Abstract: In order to understand the refined resource allocation algorithm for power trading centers, a research on a refined resource allocation algorithm for power trading centers that is oriented towards user service needs has been proposed. Firstly, distinguish the nodes in the electricity market into two types of entities: energy nodes and energy block proxy routers; Subsequently, preferences in energy supply and demand are divided into three categories based on historical energy supply habits: environmentally friendly, transmission resource saving, and economically efficient; Furthermore, a class of energy information matching algorithms and comprehensive evaluation functions are proposed to meet the optimal allocation of power resources in a multi user environment. Simulation experiments show that this method can increase the proportion of clean energy consumption in market transactions, promote energy consumption nearby, and improve the resource allocation capacity of the power grid.

Keywords: Power trading; Refinement of resources;User needs

1 Introduction

The power industry is a fundamental industry that supports the development of other industries. Electricity, as a secondary energy source, has the characteristics of controllable production and free conversion with other energy sources. The use of electricity is also clean and pollution-free. In the early stages of development, the power industry has a natural monopoly characteristic, manifested as vertical integration of power generation, transmission, and distribution, mostly maintained by the government as a state-owned monopoly. This monopolistic operation can concentrate manpower and financial resources to develop the power industry in a short period of time, ensuring the safety and reliability of power operation. The electricity industry is a fundamental industry closely related to the development of the national economy. However, compared to other developed countries, China's electricity market system is still very imperfect, the degree of marketization of power trading is relatively low, the power trading mechanism is still very immature, and the electricity price formation mechanism linked to the market is not fully formed. An independent and open power trading institution is a necessary component of a competitive electricity market. Power generation enterprises, power grids, and power users can only truly utilize market signals and promote market regulation to play a role in the power market by conducting transactions through fully functional power trading platforms. This article combines the operation mode of blockchain

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and power trading market, and proposes a decentralized allocation method of power resources based on user preferences. Compared to existing research, this method can increase the proportion of clean energy consumption in market transactions, promote energy consumption nearby, and fully leverage the cost oriented role of electricity prices.

The blockchain based energy internet is different from traditional centralized energy configuration schemes. The blockchain based energy internet can construct a peer-to-peer and trustworthy network transaction environment, where all members of the network jointly verify and maintain data, mainly including two types of entities[1-2].

1) Energy nodes: There are three types of energy nodes, among which users based on small and medium-sized photovoltaic, hydropower, wind power and other power generation equipment can choose to use their own energy or use surplus energy online according to their own needs. They participate in the energy retail market as prosumers; The users of large-scale power generation equipment represented by large thermal power plants are mostly energy producers, participating in the energy wholesale market ; The pure load is the energy consumer. The network composed of prosumers, producers and consumers, participates and cooperates with each other throughout the entire process of production, transmission, transformation, distribution, and use. However, due to the complex coupling of production and consumption relationships among participating entities, their task needs and scheduling goals vary, and both have the driving force to pursue their own maximum interests, resulting in a diverse supply and marketing relationship.

2) Energy block agent router: The idea of energy router originates from the router in the Internet, which is an intelligent device for dynamic allocation of various power resources. It is a multifunctional carrier for market-oriented energy trading and systematic resource allocation, and a new method for the fusion of physical information in real power interconnection. The rapid development of energy routers provides an opportunity for the development of blockchain proxy models[3].

2 Power Resource Allocation Method Based on Node Preferences

Traditional power trading involves coordinating distribution according to scheduling plans, while unified scheduling of unidirectional power flows is constrained by conservatism and cannot maximize market enthusiasm. This article proposes a power resource allocation method based on node preferences, which achieves adaptive resource allocation from the perspective of node energy preferences.

Firstly, define an power trading network based on node electricity consumption preferences, abbreviated as N_{Er}.

Define 1 N_{er} as a six tuple, i.e. equation (1)

$$N_{er} = (G, P, R.E.T, N) \quad (1)$$

2.1 Classification of Electricity Preferences

From the perspective of consumers alone, electricity is a highly homogeneous standardized commodity, and under the unified scheduling of the large power grid, electricity itself has homogeneity. However, with the development of the energy internet, the peer-to-peer trading model between electricity supply and demand will become increasingly mature. When users have a certain power purchase option, they often consider multiple factors such as different energy types, actual energy prices, and actual network losses based on their own reality and make optimal choices. This article will conduct a quantitative analysis of electricity supply preferences, and optimize the overall energy supply environment of the energy network through preference classification and comprehensive preference evaluation.

Electricity supply preference is a subdivision of multiple behaviors such as the actual energy supply environment, daily electricity sales status, and energy output habits in a region. It can be divided into three categories: environmentally friendly, transmission resource saving, and economically efficient. The environmentally friendly type is mainly characterized by clean energy power generation, the transmission resource saving type is mainly characterized by low transmission line losses, and the economically efficient type is mainly characterized by low selling electricity prices[4-5].

2.1.1 Environmentally friendly

Definition 2 Environmentally friendly preferences.

The proportion of clean energy supply during the energy supply cycle can reflect the supplier's environmentally friendly level of power generation. The environmentally friendly preference value ξ_u^{ENV} of power generation unit u per unit time is expressed as equation (2):

$$\xi_{\mathrm{u}}^{ENV} = \frac{\sum_{\in\phi} \lambda E_a}{E_{total}} \quad (2)$$

In the formula, p, w, h, and f respectively represent the power generation types of photovoltaic, wind, hydro, and fire power; E_a and E_{total} represent the power generation of a single resource and the total power generation of various resources per unit time of u, respectively; Φ is a collection of energy generation types; λa represents the weight of environmental pollution levels for different energy types.

2.1.2 Transmission Resource Conservation

There is often a significant amount of electrical energy loss during the distribution process. The rapid development of the energy internet has made the structure of distribution networks increasingly complex, and the calculation of line losses has become more cumbersome. However, in similar network environments, transmission distance is often positively correlated with energy loss. Typically, suppliers who supply electricity in close proximity can save resources more effectively. Due to space limitations, this article only deals with the simplest form of network loss when it comes to the issue of transmission resources. The definition of transmission resource conservation preferences is as follows[6-7].

Definition 3 Transmission Resource Conservation Preferences

The preferred value $\xi_{\mathrm{D}}^{\mathrm{RES}}$ for saving transmission resources per unit time of power generation unit v is expressed as equation (3):

$$\xi_{\mathrm{D}}^{RES} = \frac{\sum_{n-1}^{N} \mu_n D_n}{N} \quad (3)$$

2.2 Power Information Matching and Preference Assessment

Definition 4: Electric Power Information Matching Algorithm (EIMA) .

Energy consumers choose one or more types of electricity supply preferences as their demand preferences based on their specific living environment, electricity requirements, economic factors, and personal preferences. Energy prosumers can be divided into two types based on their own electricity consumption: self purchasing electricity and surplus electricity grid connection, which belong to two types of buying and selling behavior. They are a composite carrier of supply and demand preferences. The energy supply information provided by energy producers is filtered and filtered through EIMA, and a matching consensus is reached with the demand side. The optimal energy trading partner queue is recommended to the power purchaser, who can freely trade according to actual demand and personal wishes, ultimately forming the energy trading set T. The steps are as follows.

1) Select units with the same preference from the power generation units based on their electricity consumption preferences.

2) Filter the power matching list SA_List from the same preference list SP_List based on the expected power consumption of the power consuming unit.

3) Based on the historical energy supply data of the power generation unit, the optimal energy trading order is selected from SA_List through a multi preference comprehensive evaluation function and recommended to the power consumption unit.

The energy supply preferences of energy suppliers reflect their energy supply habits, and the level of evaluation of energy supply preferences affects the energy consumption efficiency of suppliers, thereby directly affecting economic benefits. However, energy suppliers often do not only have a single preference for energy supply, but also pursue a process of environmental friendliness, transmission resource conservation, and economic efficiency. After conducting electricity preference matching and planned electricity quantity matching, a comprehensive evaluation of the overall energy supplier is conducted, and based on this, SA_List is ranked to determine the recommended transaction targets. A multi preference comprehensive evaluation method is proposed below[8].

Definition 5 Multiple Preference Comprehensive Evaluation Function (MPCSF) Equation (4)

$$\xi_b^{CEV} = \omega \xi_z^{EVN} + \mu \xi_z^{RES} \quad (4)$$

2.3 Decentralized Energy Matching Model

In N_{er}, G and P P provide the energy supply plan, load demand, supply and demand electricity preferences, electricity quantity, electricity price, and other information at a certain time to their respective Rrnx. R_{ERA} coordinates energy surplus and deficit within the region, collects revenue and sales information in the energy network, and broadcasts the needs of each entity. On the one hand, through EIMA, the selection and intelligent matching of multiple user trading partners are achieved through preference matching, electricity matching, and comprehensive preference sorting matching. After the user independently selects the trading partner, T is formed; On the other hand, the overall efficiency evaluation of trading partners is achieved through a multi preference comprehensive evaluation function, and the weights of various information are adjusted based on the final operation of the electricity market.

RERA connects various trading entities to provide users with services such as energy exchange, information transmission, power grid monitoring, flow optimization, and auxiliary analysis. At the same time, RERA forms a blockchain network to establish trust in the energy network, jointly record, verify, supervise, and maintain the operation of the entire electricity market, and achieve the transfer of energy entities and economic value. Smart contracts maintained on the chain can effectively regulate market trading systems and improve operational efficiency. The smart contract is jointly maintained by the electricity market, disseminated through RERA broadcasting and stored in the blockchain. When it is verified that the expected supply and demand of electricity and preferences meet the requirements and ensure accuracy, a specific event is triggered and the smart contract is executed. RERA intelligently recommends the optimal supplier for demand side proxy users by writing the EIMA of the contract, achieving decision analysis; Provide feedback on demand side electricity purchase for the supply side, promote adjustment of supply side energy supply habits, and optimize the overall production capacity structure. After the final transaction is confirmed to be correct, it enters the transaction storage pool of RERA and competes to obtain accounting rights, resulting in a new block. Once the smart contract is executed, information such as transaction preferences, electricity consumption, and comprehensive evaluation values cannot be changed or destroyed.

3 Example analysis

3.1 Analysis of electricity preference and comprehensive evaluation value calculation examples

To verify the relevant characteristics of the N_{er} model, MATLAB simulation analysis was used, and the simulation program was run in a computer environment with CPU i7-6700 and 8GB of memory. Assuming that the energy market in a certain region adopts the N_{er} model, the electricity supply and demand sides screen based on preferences and electricity quantity, and use the comprehensive evaluation value as the recommended trading sequence. Analyze and calculate the initial information of 350 energy supplier nodes. In practical applications, specific parameter settings can be adjusted according to the actual needs of the market environment. If the weight of clean energy is increased, it can promote suppliers to transform towards green energy supply types; Adjusting the comprehensive evaluation coefficients of two preferences affects the proportion of corresponding preferences in the comprehensive evaluation value. Suppliers can adjust their supply habits based on the proportion, thereby obtaining a larger comprehensive evaluation value in subsequent transactions.

Throughout the entire trading cycle, classify all energy supply nodes according to their preferences, remove nodes that do not meet preference requirements, integrate nodes with multiple different preferences, and count the number of successful energy transactions matched with different preferences. The preferred quantity and corresponding number of transactions are shown in Table 1.

Table 1. Number of suppliers and transactions

Preference type	Number of suppliers	Number of transactions
Environmentally friendly	170	325
Resource-saving transmission	145	375

To illustrate the impact of different preferences on the overall trading situation, a specific analysis is conducted on two different preferences.

1) Environmentally friendly. Compare and analyze the changes in the total trading volume of photovoltaic, wind, hydro, and fire energy types. Among them, random transaction matching (RTM) is a randomly determined trading partner without screening, while comprehensive evaluation highest matching (LCEVM) is a matching method that takes the supplier with the highest comprehensive evaluation value as the only trading partner after matching electricity and preferences; Comprehensive Evaluation Value Recommendation Matching (CEVRM) refers to recommending suppliers with higher comprehensive evaluation values to users. In this simulation, the top three of SA_List are selected. As shown in Figure 1, different energy types have different proportions in LCEVM and CEVRM, and power suppliers with a higher proportion of clean energy tend to have higher environmentally friendly preference values, thus being more inclined to have higher CEV values. Compared with RTM, the fire power energy consumption of both in the simulation is lower than the average energy consumption, and the use of other clean energy has increased. Compared with CEVRM, LCEVM has a higher average increase in the amount of clean energy traded in LECVM. However, users have almost no power options, which does not meet their personalized needs and can easily lead to excessive concentration of power supply resources. Therefore, the following analysis adopts the methods recommended by the top three. Environmentally friendly preferences have a certain filtering effect on suppliers with severe pollution. Increasing the proportion of clean energy output can increase the confirmation rate of trading partners, and this preference has a positive incentive effect on increasing clean energy generation and reducing pollution emissions[9-10].

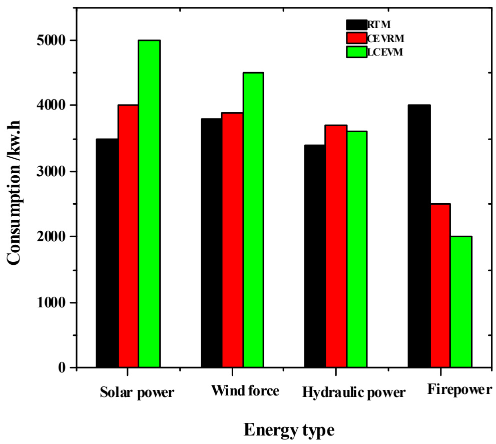


Figure1. Consumption of clean energy under different trading modes

2) Energy saving transmission resources. The distance of energy transmission between Rx indirectly reflects the magnitude of energy loss. In the simulation experiment, the impact of line loss rate on the preferred values for saving various transmission resources is approximate and small. For the convenience of calculation, it is assumed that the N between each node is 0.2 (k W - h)/km. In all transactions with transmission resource conservation as the settlement preference, the number of energy transactions in each interval is calculated based on a distance of 16 km. From Figure 2, it can be seen that the number of energy transactions decreases with the increase of transmission distance, and almost no transactions are implemented when the distance reaches 160 km (the maximum transmission distance set between all nodes). The energy requests for close range transmission are prioritized to be satisfied in N, and the transmission resource conservation preference encourages energy consumption nearby.

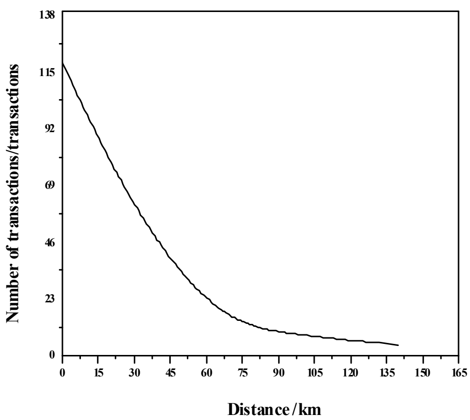
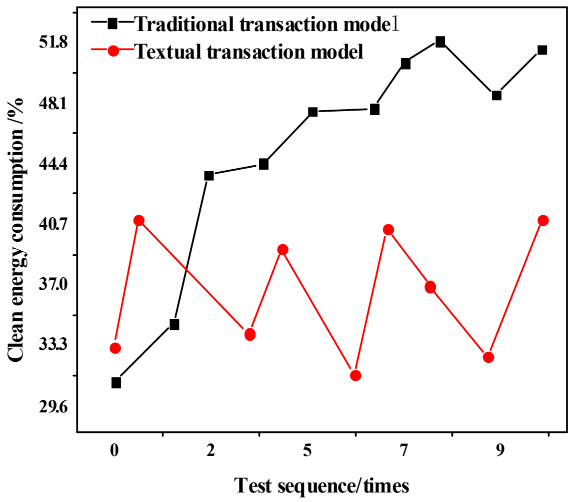


Figure2. the influence of electricity and distance on the number of transactions

3.2 Comparison and Analysis of Energy Matching Models

This article compares the overall proportion of clean energy in the market with traditional scheduling models. Assuming that the energy supply attributes of the energy supplier remain unchanged each time, that is, the proportion of generated energy, transmission distance, and quotation are the same, six cumulative transaction simulation tests are conducted on the transaction model proposed in this paper and the traditional method model. The test results are shown in Figure 3.



Figuer3. Comparison of clean energy proportion

From Figure 3, it can be seen that the trading model proposed in this paper outperforms traditional methods in the proportion of clean energy. The preference based power resource allocation method proposed in this paper can effectively incentivize suppliers with a high proportion of clean energy to prioritize transactions. While the energy supply habits remain unchanged, the proportion of clean energy shows a continuous upward trend, and after 10 simulation tests, the proportion has increased by about 20%. However, traditional methods adjust the overall cleanliness level of the market based on energy weights, but when the supplier attributes are the same, the market cannot effectively and dynamically screen and incentivize clean energy supply behavior. Resource allocation methods based on environmentally friendly preferences can make screening adaptive.

4 Conclusion

This article proposes a decentralized allocation model for power resources based on blockchain and user preferences, targeting the complex coupling relationship between multiple users in production and consumption. By providing proxy services for information communication, energy transmission, and data sharing through energy blockchain routers, the coupling between multiple users has been reduced. The market transaction rules based on preferences and comprehensive evaluation stipulated in smart contracts can increase the proportion of clean energy consumption in market transactions, promote nearby energy consumption, fully leverage the cost oriented role of electricity prices, and actively guide the energy trading market to develop in an environmentally friendly, resource saving, and economically efficient direction. Simulation experiments have proven the effectiveness of the model.

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