Research on Electricity Market Transaction Model under the Background of Big Data

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Abstract. With the advancement of electricity market reform and the influence of new entities, electricity market transactions have formed a diversified development trend, which puts forward higher requirements for transaction technology support systems. In the trading market a few days ago, power producers participated in the bidding of electricity generation. The trading center gave the optimal trading plan and settlement price under the condition of satisfying the safety constraints of the power grid according to the published competitive load curve and the declared data of power generation companies. The commodities traded in the electricity market are electric energy and various services necessary for the realization of electric energy trading, so the trading in the electricity market is very different from the traditional generation plan. Only by establishing the bidding trading plan model of the trading center can the trading plan be carried out, thus forming the power purchase plan for the power generation company. This paper analyzes the basic sources and characteristics of big data in the power market, obtains the characteristic values of big data attributes of mutual benefit and win-win of both parties through the model, and realizes the visualization of transaction price.

1. Introduction
With the advancement of electricity market reform, the development trend of electricity multi-energy marketization is obvious. New entities such as communities or streets containing distributed power sources and electric vehicles gradually participate in the electricity market transactions, so there are abundant new entity data sources in the electricity market transactions [1]. In the trading market a few days ago, power producers participated in the bidding of electricity generation. The trading center gave the optimal trading plan and settlement price under the condition of satisfying the safety constraints of the power grid according to the published competitive load curve and the declared data of power generation companies [2]. The practice of the electricity market shows that the electricity market must have orderliness in addition to competitiveness. It is very important to grasp and adjust the market reasonably and timely [3]. The safe and reliable operation of the power grid also needs some auxiliary service measures to maintain, but in a monopoly environment, these auxiliary services are provided free of charge by power producers, so there is no need to study the cost and pricing of these auxiliary services, which has not attracted enough attention [4]. The commodities traded in the electricity market are electric energy and various services necessary for realizing electric energy trading, so the trading in the electricity market is very different from the traditional power generation plan [5]. In the process of building the electricity market, by establishing a set of trading mechanism evaluation index system to conduct post-evaluation of the operation of the electricity market, problems in the trading mechanism can be found and revised and adjusted in time [6].

In order to ensure the long-term safe and economic operation of the market, the trading center must collect, analyze, predict and release information on the future situation of the power market, so as to
master and regulate the market development. In the electricity market conditions, trading plans are the core of transaction management [7]. Transaction management includes bidding content such as electric energy, auxiliary services and transmission services, and the important content is electric energy bidding [8]. From the international experience, whether it is a unified market or a common market, the real-time power balance scheduling and the operation of the real-time balanced auxiliary service market must be handled by the provincial power dispatching trading center [9]. The bidding transaction plan model of the trading center is established to carry out the trading plan, thus forming a power purchase plan for the power producer. The common market refers to the establishment of a regional market operation organization and several market operation branches in an area. The energy trading and transaction prices are formed in the market operation organization [10]. The energy data involved in power trading is highly integrated on different time scales, and big data methods such as intelligent mining algorithms and machine learning algorithms are used to form a power market based on big data [11]. This paper proposes a power market trading model under the background of big data, analyzes the basic sources and characteristics of considering big data with new entity power market, and obtains the eigenvalues of big data attributes of mutual benefit and win-win between the two parties through the model to realize the transaction price. Visualization.

2. Energy Big Data Transaction Model

2.1 Big Data Sources of Energy in Electricity Market

For the big data transaction model, its essence is to trade the right to use the data. However, because the data value itself is difficult to measure and presents the complexity of the transaction, both parties to the data transaction have higher costs in data mining, price customization and efficiency evaluation. Doing a good job in the bidding transaction plan of the power system will bring great economic benefits. Under the condition of market economy, price is one of the important factors that affect commodity sales and operating profits. At the same time, it also plays a very important role in guiding the production of enterprises and adjusting the allocation of resources. Building a regional unified market and unifying the function of optimizing the allocation of power resources by the regional power market can realize a wide range of optimal allocation of resources, which is conducive to the coordinated, stable and sustainable development of the power economy. Due to factors such as weak power grid structure framework, large difference in electricity price level and unbalanced economic development in regions and provinces, the development of regional common market also has a gradual process from the reality of China's power market development [12]. From the perspective of power producers, due to capacity constraints, the electricity market and ancillary services market are interdependent.

In the electricity market, power generation is separated from the power grid, and electricity and various services necessary to realize electricity trading are traded as commodities. The traditional way of trading commodities in the market cannot meet the demand of the new generation of electricity market for multi-energy and big data. The power plant is the passive executor of the unified dispatching of the system. In the power market, the power generation company has the autonomy of production and operation and becomes the main body of market competition. It will adopt different bidding strategies and realize profit maximization by adjusting the bidding curve. Fig. 1 is a scanning speed modulation architecture of a power prediction model.
2.2 Big Data Transaction Model in Electricity Market

Buyers and sellers in the electricity market make a general analysis of the key attributes of market member data and data characteristics that need to be traded, and expound the attributes, basic types and application scope of the data. They also use structured language to describe the analysis results and construct the data trading objects in the market. Both parties in the market negotiate the transaction target data according to themselves, i.e. calculate their utility values respectively according to their utility functions, and use the calculation results as evaluation data values. The seller members of the electricity market should register the new entity data resources to be sold and form a database of data transactions, from which the buyer can query to obtain the basic information of the required transaction targets and the transaction competitors. The electricity market analysis and evaluation system should be able to predict the electricity price trend in the future market, the market share obtained by power plant competition, the balance between electricity supply and demand, and reveal the hidden dangers of power grid operation. Electric energy is a special commodity, characterized by simultaneous production and consumption. This determines that the market and the plan exist at the same time, and the transaction plan is the core of transaction management.

The objective function of trading in the electricity market has become diversified. In addition to the minimum total coal consumption or cost of power generation in the whole network, it can also be the minimum cost of purchasing electricity in the trading center, the minimum total electricity cost for users, the maximum total social profit, etc. In the process of price negotiation, the multi-objective optimization function can be used to solve the problem and form a mutually beneficial and win-win data transaction scheme for both parties. In the short-term dispatching, due to the randomness and uncontrollable nature of the power, it will cause the increase of the system's rotational reserve capacity and the change of the conventional unit start-up and stop strategy after the power is connected to the network, which may lead to the increase of the operation cost of the power system. The algorithm evolution curve is shown in Figure 2.

Figure 1 Scanning Speed Modulation Architecture of Power Prediction Model

\[
X = [x_1, x_2, \ldots, x_N]
\]

\[
K(x, x_i)
\]

N inputs

Hidden layer

\[
\sum
\]

Output neuron

Bias

Figure 2 Algorithm Evolution Curve
Large-scale power cannot be absorbed locally and needs to be transported to the load center over long distances through the transmission grid. The expression of the optimization goal is not considered in the case of electricity operating costs:

$$\theta_i = \frac{a_i p_i}{1 + \sum_i a_i p_i}$$

(1)

Power balance constraints:

$$\frac{p}{V} = \frac{1}{V_m a} + \frac{p}{V_m}$$

(2)

In the information sharing strategy, use the formula to update the speed of the particles:

$$\ln \frac{c}{c_0} = \frac{1}{RT} \cdot \frac{2\gamma M}{\rho R_i}$$

(3)

System active balance constraints:

$$RT\ln \frac{p_2}{p_1} = \frac{2\gamma M}{\rho} \left( \frac{1}{R_2} - \frac{1}{R_1} \right)$$

(4)

3. Operating Mechanism and Function

When both parties are satisfied with the price plan, the data delivery shall be started. At this stage, the data delivery shall be completed within the specified time according to the transaction contract. At the same time, the seller shall also provide additional data configuration services. The informatization stage of energy big data in the electricity market mainly focuses on the intelligent processing of big data services in the electricity market, and the research on data transaction services in electricity is limited. In order to trade various system services for electricity trading, market participants also need to quote for auxiliary services. Any enterprise has certain pursuit objectives. For example, some enterprises pursue profit maximization while others are committed to becoming industry leaders. Different management concepts will lead to different pursuit objectives. The transaction mechanism of the regional common market model is essentially a master-slave hierarchical decision-making problem [13]. This kind of decision-making problem is large in scale and complex in structure, involving many decision makers who make decisions on the problem, and these decision makers are at different levels. In terms of the nature of an enterprise, the ultimate goal of any enterprise is to obtain certain benefits to maintain and promote its own survival and development. When considering the energy service competition in the electricity market, we should not only consider the acquisition, processing, service architecture and service mode of energy big data, but also consider the trading system of energy big
data, so as to realize the reasonable pricing of multi energy big data in the market.

In order to reflect the cost structure and operation constraints of generating units, the price curve, unit start-up cost and outage cost should be declared by the power producer. The bidding transaction plan model adopted by the power producer needs to carry out the optimal unit combination. In a multi-level decision system, each level has its own objective function, and the higher the organization, the more important, authoritative and global the objective. When the generator participates in the transaction in the form of unit group, the unit start and stop costs are included in the price declared by the generator. For enterprises, any investment behavior is expected to get a certain return. When the generator participates in the transaction in the form of unit, the start and stop costs of the unit should be considered in the bidding model, while the price declared by the generator is only the price of electric energy. Because the power supply and demand must be balanced, and the power industry needs to be ready to provide enough capacity for users at any time, so in the power market, the adoption of two-part tariff is more in line with the characteristics of power industry energy storage. When enterprises determine their own return on investment, they first need to carry out the corresponding input-output analysis, that is, according to the resource input of a product and the corresponding output, define their own return level reasonably. The pursuit of maximum profit makes every enterprise have its own goal, but the pursuit of maximum profit is not equal to the highest price. Only reasonable price strategy is the guarantee for the enterprise to obtain the maximum profit.

4. Conclusion

The purpose of power system reform is to make resources allocated by the market in a wider range. An important way to achieve this is to establish regional power market. Bidding trading plan is one of the core contents of the power market. With the opening of China's power industry, it is urgent to establish a bidding trading plan model for each development stage. This paper proposes a big data transaction model for the new generation power market. In terms of the nature of an enterprise, the ultimate goal of any enterprise is to obtain certain benefits to maintain and promote its own survival and development. The transaction mechanism of the regional common market model is essentially a master-slave hierarchical decision-making problem. Due to the different operation rules of the electricity market, the models of bidding transactions are also different. Pursuing the maximum profit is the goal that every enterprise should have, but pursuing the maximum profit is not equal to the highest price. Only a reasonable price strategy is the guarantee for enterprises to obtain the maximum profit. When designing bidding modes and rules for regional power markets, the balance and coordination of interests of all parties and the fairness of resource allocation must be considered to be fair, just and open. Full consideration must be given to how to ensure the safe and stable operation of the power grid and the effective coordination between market transactions and power grid dispatching.

References

[1] Narajewski M, Ziel F. Intensity estimation of transaction arrivals on the intraday electricity market[J]. Papers, 2019.
[2] Duong T L, Gang Y J, Nguyen L A T, et al. Enhancing Total Transfer Capability via Optimal Location of TCSC in Deregulated Electricity Market[J]. Lecture Notes in Electrical Engineering, 2014, 282:47-56.
[3] Manshadi S D, Khodayar M E. A Hierarchical Electricity Market Structure for the Smart Grid Paradigm[J]. IEEE Transactions on Smart Grid, 2016, 7(4):1866-1875.
[4] Sekizaki S, Nishizaki I, Hayashida T. Electricity retail market model with flexible price settings and elastic price-based demand responses by consumers in distribution network[J]. International Journal of Electrical Power & Energy Systems, 2016, 81:371-386.
[5] Manasarani Mandala C P G P. Congestion Management under Hybrid Electricity Market using Self-organizing Hierarchical Particle Swarm Optimization[J]. International Journal of Computer Applications, 2014, 82(17):39-45.
[6] Ahmed K S, Karthikeyan S P, Sahoo S K. Comparison of Graph Theory Approach with other
Methods on Transmission Loss Allocation Problem in Deregulated Electricity Market[J]. Applied Mechanics & Materials, 2016, 839:6-13.

[7] Reddy C V B, Srivastava S C, Chakrabarti S. Fast Assessment of Available Transfer Capability Using Synchrophasor Measurements[J]. Electric Power Components and Systems, 2014, 42(7):716-726.

[8] Rai A, Arikan I, Pye J, et al. Fit and Misfit of Plural Sourcing Strategies and IT-Enabled Process Integration Capabilities: Consequences of Firm Performance in the U.S. Electric Utility Industry[J]. Mis Quarterly, 2015, 39(4):865-886.

[9] Thangalakshmi S, Ezas A M. Congestion Management in Deregulated Power Systems Using Generator Rescheduling with Particle Swarm Optimization[J]. Journal of Computational & Theoretical Nanoscience, 2017, 14(9):4416-4423.

[10] Xinyu Z, Qixin C, Rui G E, et al. Clearing Model of Electricity Spot Market Considering Flexible Block Orders[J]. Automation of Electric Power Systems, 2017, 41(24):35-41.

[11] Sekizaki S, Nishizaki I, Hayashida T. Retailers Power Procurement Considering Risk from Volatile Market Prices utilizing the Fractile Model in Chance Constraint Problem[J]. Ieej Transactions on Electronics Information & Systems, 2016, 136(5):732-745.

[12] Jiang T, Xu F, Min Y, et al. Research on Trading Mechanism of Clean Heating With Surplus Wind Power[J]. Zhongguo Dianji Gongcheng Xuebao/Proceedings of the Chinese Society of Electrical Engineering, 2017, 37(15):4286-4295.

[13] Ghofrani-Jahromi Z, Mahmoodzadeh Z, Ehsan M. Distribution Loss Allocation for Radial Systems Including DGs[J]. IEEE Transactions on Power Delivery, 2014, 29(1):72-80.