Design and Implementation of Power Generation Bidding System in Powerhouse

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Abstract. The electricity market is the main buyer, seller of electricity and related services. The buyer is the electricity user and the middleman, and the seller is the power producer and auxiliary service provider. Based on the comparative analysis of the bidding mode of the existing power generation electricity market and the characteristics of power grid economic dispatching by the actual situation of China's national economic development, this paper puts forward two practical bidding modes for power generation electricity market. In a province of electricity market, the proposed model is feasible. This model is conducive to the operation of the power side of the electricity market and a smooth transition, it is also conducive to the optimal allocation of resources to reduce the total cost of electricity generation, reduce user electricity prices, it can also promote the rapid development of industrial and agricultural production.

1. Introduction
In this era, the level of a modern enterprise information technology will become an important symbol of the enterprises competitiveness. Only we quickly grasp the Internet information technology, according to modern management methods to manage the logistics of enterprises, and information flow, we can achieve enterprise management information [1]. The only way to fully enhance the level of enterprise resource allocation helps to improve the operational efficiency of enterprises. The 21st century is the era of scientific and technological information, the old management model is not to adapt to the requirements of the new era, it exists management efficiency which is low, easy to record a series of shortcomings. For the above shortcomings, they will have a great impact on the economic benefits of enterprises, an increase of operating costs, reduce the productivity of enterprises [2-4]. Electric power equipment is the power material production enterprises to carry out production activities of the important material and technical basis. Equipment management level and the use of efficiency will be on the operation, the management of power production enterprises has a direct impact [5, 6]. This paper points out the necessity and urgency of establishing the electric power equipment management system by introducing the existing problems of the power company management method by introducing the background and significance of the subject and the research status at home and abroad.

According to the spirit of national documents, the actual deployment of China's power industry will gradually realize the power generation, transmission, distribution and sale of four links separated to achieve national networking [7]. At present, China's power system reform has entered the "plant network separation" of the substantive operation stage to accelerate the pace, the urgent need to develop a market economy in line with the power generation side of the electricity market bidding transaction Patterns and specific programs.
2. Analysis on Bidding Transaction Mode of Existing Power Generation Electricity Market

2.1. Two-part electricity price and bid model

Based on the objective function of the unit consumption characteristic curve, which is usually a polynomial function, the most commonly used is the quadratic function of the unit output as the independent variable.

\[
\min f(x) = \sum_{i=1}^{N_G} (f_{p_i}(P_{gi}))
\]  

(1)

Taking into account the objective function of the unit's active and reactive production costs, it is similar to active production costs, reactive production costs are described by quadratic curves.

\[
\min f(x) = \sum_{i=1}^{N_G} (f_{p_i}(P_{gi}) + f_{q_i}(Q_{gi}))
\]  

(2)

The transaction network includes router, firewall, switch, intrusion detection system, database server; application server and web tamper system [8, 9]. In order to ensure the real-time response to the transaction process, the Internet network needs to use the operator IP line access, access bandwidth requirements \( \geq 10 \) M. In the electricity market, the optimal power flow problem is a constrained nonlinear programming problem. Its objective function is summarized as follows.

Recently bid model structure

Two-part electricity price is also known as Hopkins gold price, which was first proposed by John, Dr. Hopkins. The two-part electricity price is divided into two parts: the capacity price and the electricity price. The electricity price is determined according to the fixed cost of the equipment capacity [10]. The electricity price is determined according to the change cost.

Capacity of electricity ensures that the cost of power generation enterprises to recover capacity, and the provisions of the Internet agreement ensure that the annual power generation, and the actual power generation has nothing to do, and multiple prices are paid to the same power capacity of power generation enterprises [11]. The electricity charge only by the electricity rate to pay, and the amount of electricity is still paid to the capacity of electricity.

2.2. Power generation super base bid

A complete electricity market, is generally divided into long-term contract trading market, futures and options trading market, a few days ago trading market, real-time trading market and auxiliary services by trading market.

(1) Medium and long term contracts: medium and long term contracts are medium and long term delivery contracts, it can be generated through the auction, and you can also bilateral signed.

(2) Futures and options trading market: futures trading are a futures contract transactions, options trading is a right of the sale.
3. A few days ago the market include the implementation of long-term contract power and the organization recently bid through the competition to find the market price and economic units to stop the plan.

4. Real-time balance of the market: the organization real-time imbalance in the market found real-time market prices through the competition.

5. Auxiliary services market: the competition has to find the quality of the goods to ensure the quality of the market value.

![Power Market Operation Chart](image)

**Figure 2. Power Market Operation Chart**

3. **Bidding online and model building**

3.1. **Bidding online**

In the electricity market, power producers chase the biggest economic benefits, and the market transaction management center in the user side needs to meet the need. The safe and stable operation of the power system under the conditions of the minimum purchase price determines the principle of power purchase plan [12, 13]. As the daily load changes, the market bid is usually for a number of periods, the basic process of market bidding is as follows.

a. According to the demand forecast to the power Generation Company the market issued the next day of the purchase plan, the power producers were submitted in advance by the bidding power generation curve.

b. The market transaction management center uses the market equilibrium theory to calculate the market price of MCP; a system develops to meet the system of economic and security requirements of the distribution program.

c. According to market demand and MCP Operation management arranged the generating units of each period of output and the corresponding market settlement.

3.2. **Model building**

In this paper, we analyze the following models. Assuming that there are \( n \) independent power producers in the market, each manufacturer is virtualized as a unit; only one quotation curve is declared. First, we can assume that the quotation curve of the generator is straight,

\[
B_i = \alpha_i + \beta_i P_i
\]

(3)

Its power generation cost \( C_i(x_i) \) is a quadratic curve, and the power is used to calculate the cost.

\[
C_i(P_i) = a_i P_i^2 + b_i P_i
\]

(4)

Where \( a_i \) is the curvature of the power generation cost curve \( C_i(P_i) \), the acceleration of the power generation cost has the increase of the power generation power; \( b_i \) is the slope of the power generation cost curve \( C_i(P_i) \). The power generation rate increases with the power, \( P_i \) is the power producer \( i \) active power [15].
Based on the algorithm and process of power transaction decision-making in the transaction center, the quotation strategy of the generator manufacturer $i$ can be transformed into the following optimization problem, that is the problem of maximizing revenue.

The Objective function is as follows.

$$\max U_i = R P_i - C_i(P_i)$$

Restrictions:

$$B^i(K^i, P^i) = R$$

$$\sum_{i=1}^{n} \alpha_i = 1, 2, \ldots, n$$

Where $U_i$ is the profit function of the generator $i$, $R$ is the market price, $K_i$ is the quotation curve parameter of the manufacturer, $Q$ is the market demand; the first equation represents the system marginal price; the second equation represents the system supply and demand balance.

The analysis of the problem is based on the standpoint of the generator manufacturer $A$. All $n-1$ game opponents of the generator manufacturer $A$ are virtualized into an equivalent power producer $B$, thus it is necessary to predict the bid curve and the profit function of all the game opponents. The work is greatly simplified and translated into a quotation curve and a revenue function for predicting this virtual rival [16]. This will reduce the accumulation of errors in the multiplayer game process, thereby improving the accuracy of the calculation.

With the virtual equivalent competitor, the bid strategy is transformed into a double game problem. Assume that the strategy space $S = [S_1, S_2]$ where $S_1$ is the one's own strategy and $S_2$ is the virtual rival strategy. The bidding process is as follows.

For convenience, the quotation curve is a proportional function of the cost curve, introducing the scale factor $k_i$.

$$B_i = B_i(K_i, P_i) = \alpha_i + \beta_i P_i = k_i(a_i P_i + b_i)$$

And then select the multiplier $k_i$ for the game side of the strategy, the pricing curve is too fixed ($-b_i/a_i$, 0) a set of variable slope of the straight line.

According to the historical information and the daily data released by the trading center, the probability distribution of the opponent's strategy is estimated, and the probability density function $p_2(k_2)$ of the opponent is obtained. For the sake of simplicity, this paper assumes that the virtual agent's strategy probability density function is uniform distribution. The function $p_2(k_2) = 1/k''-k'$, $k''<k_2<k$.

For each bid strategy of the opponent, we can solve the simultaneous equation (4), the market price of MCP is one's own share of the market share $P_1$, into the formula (6), the solution of one's own income function $U_1$.

$$U = \frac{b_1(b_2 k_1 - b_2 k_2 - a_2 k_2 Q)}{a_1 k_1 + a_2 k_2} - \frac{a_1(b_1 k_1 - b_2 k_2 - a_2 k_2 Q)^2}{(a_1 k_1 + a_2 k_2)^2} - \frac{k_1 k_2 (b_1 k_1 - b_2 k_2 - a_2 k_2 Q)(a_2 b_1 + a_2 b_1 + a_1 a_2 Q)}{(a_1 k_1 + a_2 k_2)^2}$$

Using the Lagrangian method to derive the function, we can calculate the extreme value, and the best strategy function is here.
\[
\frac{\partial U_1}{\partial k_1} = 0; \\
k = \frac{(2a_1b_2 + a_2b_1 + 2a_1a_2Q)k_2 + (a_2b_2 + a_1^2Q)k_2^2}{a_1b_1 + (a_2b_2 + 2a_1b_1 + a_1^2Q)k_2}
\]

By the opponent's strategy distribution \( p_1 \) needs to get one's own best strategy expectations.

\[
k_1^* = E(k_1) = g_1(k_2) \frac{1}{k'' - k'} dk_2
\]

So as to get the best bid curve.

4. Example analysis
With exactly the same units to bid, the cost characteristic is the same. The unit A is numbered 1, its opponent is unit B ~ E, and the virtual equivalent number is 2. The parameters of the cost function of the generator are shown in Table 1.

| NO. | \( b_i \) /Yuan | \( a_i \) /\( \text{Yuan} \cdot (\text{MW} \cdot \text{h}^{-1}) \) |
|-----|-----------------|----------------------------------|
| 1   | 2               | 0.020                            |
| 2   | 2               | 0.005                            |

Given system requirements \( Q = 50 \text{MW} \cdot \text{h} \). Assuming that the strategy of the known virtual counterpart is 1.5 by increasing the cost curve by 50% as the quotation curve, the corresponding result is calculated as the "ideal result" line in Table 2. The homogeneous distribution parameter is \( k' = 1 \), \( k'' = 2 \), the decision-making method proposed earlier, the results of Table 2 are the calculation method line.

| Type  | \( k_1 \) | \( P_1 \) | \( P_2 \) | \( U_1 \) | \( U_2 \) | \( R \) |
|-------|-----------|-----------|-----------|-----------|-----------|-------|
| Theory| 1.275     | 25.00     | 25.00     | 17.19     | 26.56     | 3.188 |
| Calculation | 1.267 | 25.61 | 24.39 | 17.18 | 25.88 | 3.183 |

It can be seen that in the case of accurate estimation of the virtual counterparty strategy, the self-income \( U \) calculated by this method is close to the best income.

5. Comparative analysis

5.1. Comparison of the two models proposed
Costs contract trading model in the auction principle is the grid companies and power companies were signed capacity contracts based on the development of market conditions for appropriate time to bid. The difference is the model determined in the capacity of the contract Electricity. On the basis of the contract power efficiency and replacement of the remaining real-time transactions, the power generation company contract power and contract price difference reflects its Fixed-cost difference. All the electricity supply are used to the full charge bid, the power company capacity and price requirements of the difference between the requirements of reflection its fixed cost difference.

These two models are practical in the actual operation of the grid, the national guidance on the reform of the electricity market can promote the power generation companies to reduce energy consumption, reduce production costs, save energy, optimize the allocation of resources, and gradually shut down
High energy consumption. The "efficiency first" principle of organizing the Internet can make the unit with low cost of change in full, the power generation company's income is relatively fixed, which can avoid monopoly of the power company's "speculative quotes" behavior, but the model of the market rules and operating procedures are more complex. The market rules are easy to operate the reliability of the electricity market operations, but the model as the whole network clearing power tariffs is prone to "bad competition" and distort the offer behavior, so the State Electricity Regulatory Commission should be sufficient use the market price to be supervised.

5.2. Comparison of the two models presented with the existing model

Grid companies and power companies signed a purchase /sale contracts, Ming do the same amount of electricity and contract price, and the unit of the contract power points to solve the day. Contract power is only used as a basis for settlement. Trading Center on the unit's offer needs to implement with the lowest price.

According to the unit charge of the Internet, the daily calculation has the amount of electricity on the part of the contract in accordance with the contract price count, the amount of electricity outside the contract by the average price of competing prices. Power consumption is less than the contract power, the difference between the amounts of electricity together with the price minus the cost of unit which changes to be compensated.

In essence, the capacity contract model is the "two-part electricity price" model of the specific implementation model, the "two-part electricity price" model of all the features has a model. The implementation of low cost are adapt to the transition, it is also used to maximize the optimal allocation of resources and achieve the unique advantages.

Capacity Contract Market model uses "timely market" to increase the proportion of bid volume and total market volume. Capacity contract market mode is full charge bid, so these two models can enhance the competitiveness of the electricity market to varying degrees, and the problem of the "power generation super base bid" model for the market competition.

For the difference between the contract prices, if the market clearing price below the CFD tariff will increase the power grid company's purchase risk. The two models proposed in this paper are based on capacity contracts, which make the grid companies avoid this risk.
From the above analysis, it can be seen that the two models proposed in this paper are more suitable for the early and middle stages of the power generation market in China, which is more favorable to the smooth transition from the planned economy to the market economy.

6. Conclusion
In this paper, we use the incomplete information game theory and probability theory to study the bidding behavior of power producers, and establish the power supplier bidding model based on probability theory and game theory. The example analysis shows that this method is feasible in the bidding of electric power market. The power producers to participate in the electricity market bid. But its shortcomings are obvious, because this method depends on the accurate distribution of the opponent's strategy, and these information are their own trade secrets, each other's quotation is not easy. So the practicality of the game method is still very limited, how to deal with this incomplete information game has yet to be further explored.

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