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A Method of Spot Price Bidding in Day-Ahead Power Market With the consideration of power shortage factor

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Abstract: Under the environment of electric power market, it is important for generation owners or dealers how to evaluate the pool marginal price so that their forward competitive bid in every division of the time period could no larger than that of the marginal price in corresponding period. This paper put forward a method to calculate spot prices which both take into consideration of the generation cost and the relation between energy supply and demand in power supply areas.

This paper takes the Shanghai Power Market as the research object, following the regulation of the Shanghai Competitive Operation Center (SCOC), the spot generating schedule and the respective spot price will unchangeable after finishing the day ahead competitive bid. Based on this rule, this paper divides day-ahead spot price into tow parts, one is calculated from variable generation cost, and another part will be evaluated from energy supply and demand curve by the power shortage factor. This paper sets up a model to calculate the power shortage factor and to describe the relation between the day-ahead load prediction curve and the electric energy supply curve. A practical example proved that use upon method, the spot bidding approach the pool purchase price in a comfortable range.

Key-words: power system, electric power market, bidding price, load prediction curve, energy supply and demand curve, power shortage factor

1 Introduction

In China, only a few electric power markets is the real time market, almost all the energy market are day-ahead markets. Such as in Shanghai, it is running as a typical day-ahead market. According to the regulation of the Shanghai electric power market manage and operation organization, the Shanghai Competitive Operation Center (SCOC), the electric energy contract is composed of the forward contract and the spot contract. The forward contract is based on the investment in the construction of each thermal power plant, and the spot contract is mainly due to the fuel cost and the energy market demand. The spot contract is realized by the competitive bid during the members of Shanghai electric market pool. Every day, SCOC will publish a day-ahead load forecast curve, publish the forward dispatch for each generator and publish a daily whole spot generating schedule curve for every pool members' bidding. The daily spot schedule curve is divided into 96 intervals, each interval stand for 15 minutes and is represented by a trade point or trade moment, so after a series of bidding it will emerge 96 spot prices as the daily marginal prices for each interval respectively. When spot prices in every trade point are defined, they will keep unchanged and the energy balance in real time market will rely on the improvement of the forward plans of each pool members. For this reason, the daily spot price curve represents the short-term load supply and demand relations of the power market. Figure.1 shows the outline of electric energy supply and demand curve in Shanghai. D_1 and D_2 are the load demand curve in valley and in peak periods respectively, MC is the marginal cost curve. Their crossing point will be the load supply-demand equilibrium point and will be used to determine spot price. In general, the MC curve will large than a minimum value, this is the average variable generating cost. The main object of this paper is to describe the components of the spot price and evaluate or calculate the variable generating cost and the short-run market opportunity cost in bidding.

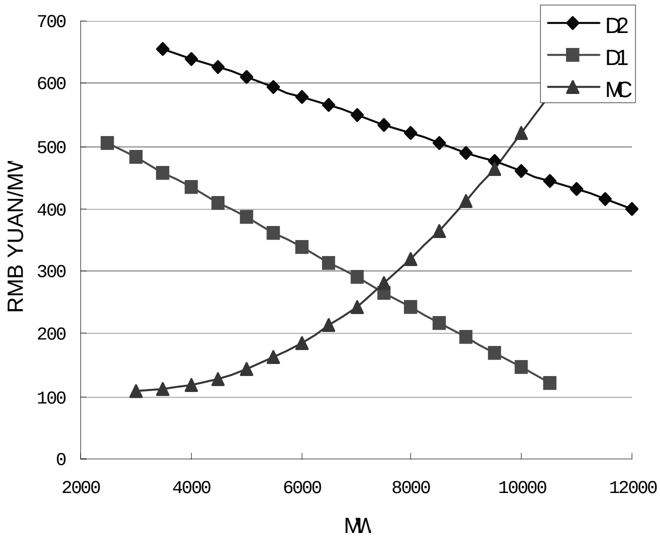

Fig.1 Energy supply-demand curve

2 The components of the spot price

The spot price is composed of two different parts. One is the short-run marginal variable cost that mainly depend on the variable generating cost of the fuel, another is rely on the opportunity of the load demand of the electric power market.

2.1 The Short-run Marginal Variable Cost

The short-run marginal variable cost function has the same form with the incremental variable generating cost function, may be different from with each synchronous machine, but the practical test proves that it is a second order concaved function show as figure.2.

The fuel incremental curve is a typical one of the 300MW unit, it product by the unit price of the fuel will be the incremental variable cost curve. The curve shows that when generator is operating in its rated capability, it has an economical cost; otherwise, as the load decreases the variable cost will rise sharply especially in valley periods. So the short-run marginal variable cost (SMVC) function can be expressed as:

$$SMVC = aP_g^2 + bP_g + c \qquad (1)$$

Where P_g is the per unit value of the generator output and the range limited in 0.4~1.05 , a, b, c are constants, in general a, c>0, and b<0.

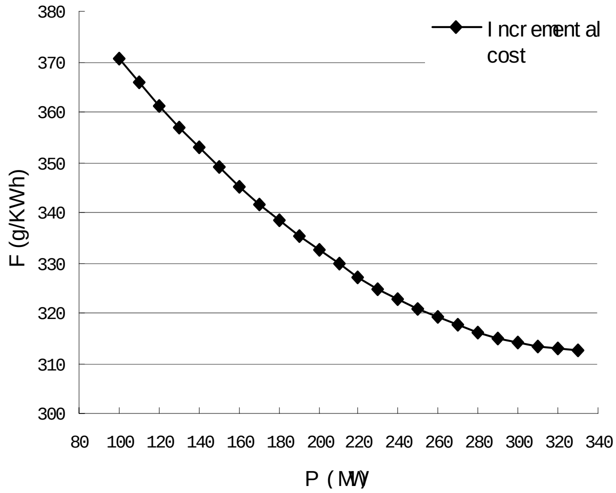

Fig.2 The fuel variable cost curve of a 300 MW

2.2 The Short-run Market Opportunity Cost

The short-run market opportunity cost is directly proportional to the total load demand of the market P_{TL}, and is inversely proportional to the total available installed capacity of the power grid P_G, further take into the consideration of the loss of reserved power capability A_2* P_g, the short-run market opportunity cost (SMOC) can be expressed as a Cobb-Douglas function:

$$SMOC = A_1\left(\frac{P_{TL}}{P_G}\right)^{\alpha} A_2 P_g^{\beta} = AK^{\alpha} P_g^{\beta} \qquad (2)$$

Where A is the proportional constant, the total available installed capacity P_G equal to total installed capacity P_{TG} minus total repairing capacity P_R:

$$P_G = P_{TG} - P_R \qquad (3)$$

In equation (2), we define $K=P_{TL}/P_G$ as the power shortage factor. If $K<0.6$, it means there are sufficient reserved power back up, the market supply great than the market demand, the spot price grade must be in a lower level, on the other hand, If $K>0.9$, it means not enough reserved power to be left, SCOC must consider to ask the help of other areas, and at this time, the spot price grade must be in a higher level. The index α describes the different sensitivity of power market in response to the power shortage, and α great than zero. The loss of reserved power capability $A_2{*}P_g$ will obviously effect the bid price when in peak load periods, the more output of the generator, the less of reserved power capability and then the less of stability margin of the generator. To consider the peak load is about two times than that of the valley in Shanghai market, the index β is nearly equal to 2.

2.3 The Short-run Bid Function and power shortage factor

To sum the analysis of above, the short-run bid function $SB(P_g)$has the follow character:

$$SB(P_g) = aP_g^2 + bP_g + c + AK^{\alpha}P_g^2 \quad (4)$$

In order to find the power shortage factor, it is necessary to consider the load prediction curve and available installed capacity curve of the power system. These data are shown in figure.3 and figure.4 respectively.

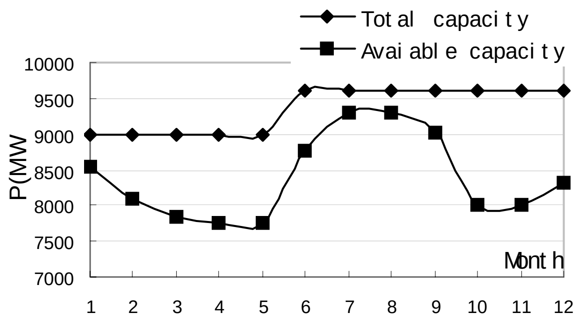

Fig.4 The total installed capacity & available Installed capacity curves

Fig.3 The annually day-ahead maximum & minimum load forecast curves

In figure.3, it is clear that there are three apparently valley, they appeared near the periods of the Spring Festival, May 1st holiday and October 1st holiday. During these periods, the power shortage factor dropped below 0.5, that means the electric power is sufficient, while in the July and August, the power shortage factors approach or exceed 1, in this case, the power market need to buy energy from the outside areas. Table 1 gives a list of the average power shortage factors of several typical months. Because the available power capacity is scarce in the December, the power shortage factor also rises to a higher grade though the load level was relatively lower in that month. As the average shortage factor in peak section of the whole year is 0.96, it is clearly that Shanghai is seriously shortage in electric power source.

Table 1. The average power shortage factor

Month	Average *K*	
	Peak	Valley
January	0.84	0.52
April	0.90	0.61
July	1.12	0.67
August	1.07	0.65
December	1.04	0.62
Whole Year	0.96	0.60

3 Case study and results

The described method was tested for half year from the October of 2004, the figure.5 shows the clearing price curve of the SCOC and the bidding price curve of a pool member in one day of the July this year. The bidding price curve is draw according to the equation (2), it proved that the bidding spot price approach the pool purchase price in a comfortable range. The daily power shortage factor curve is also dotted in the figure 5, in order to be seen clearly, it is amplified for 200 times. In recent years, the power gap between peak and valley load increased greatly, this will force many generators operating in a quite lower state at the mid-night and make the variable cost increased obviously.

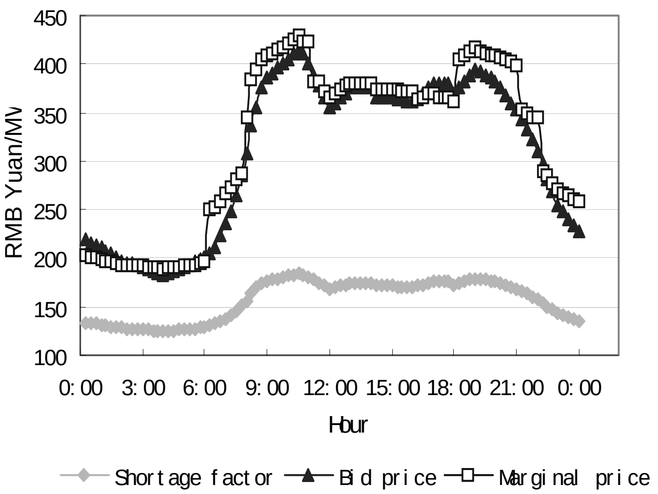

Fig.5 The marginal price and bidding price curves

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