A Long-term Power Purchase Optimization Method Considering the Equal Completion Progress and Minimize Power Purchase Cost

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ABSTRACT: The current long-term purchase power optimization, mainly consider the equal completion policy requirements, and do not consider the optimization of power purchasing cost. This paper presents a long-term power purchase optimization method, which uses the electricity purchasing cost as the goal, with the equal completion as the constraint, considering the generator load rate, unit maintenance and other constraints. It is MIP model which using provincial data to analysis.

KEYWORD: Long term power purchase optimization; Minimize power purchase cost; Equal completion progress

1 BACKGROUND INTRODUCTION

1.1 Introduction

The current long-term purchase power optimization, mainly consider the equal completion policy requirements, and do not consider the optimization of power purchasing cost. At present, the annual power purchase plan is allocated to each month to ensure that in December all the plant's annual plan is completed with the consistent progress, the deviation between all plant's progress and average progress is not more than plus or minus 3%. In this process does not consider the purchase cost. How to meet the completion progress requirement, at the same time reduce the purchasing cost as much as possible, is an urgent problem to be solved.

1.2 The domestic and foreign research situation

In Europe and the United States, the methods of long-term contracts and real time transactions are used in power market.

In China, the electricity market is not mature enough. At present the government department issued the plant's annual plan, and then the annual plan is decomposed into the 12 months, according to the same completion progress requirements. How to reduce the purchasing cost as much as possible, this problem has some relevant research results in China.

Document 1 introduce the conditional value at risk of provincial electricity company purchasing portfolio risk measurement, based on the provincial electric power company portfolio theory under the

purchasing portfolio optimization model; Document 2 analyze the current situation of purchase cost and put forward optimization power plans to reduce power purchase cost of power grid model and strength analysis. Article 3 introduces the existence of free purchasing space, and put forward the power purchase optimization model. Article 4 proposes a power purchase plan model taking into account the loss. In the existing research, only Article 2 consider the equal completion progress, but the given deviation model due to determine the energy balance point calculation is complex, it is difficult to practical application, the other articles and documents don't consider the equal completion progress requirements.

This paper puts forward an optimization method which can satisfy the equal completion progress requirements, and reduce the purchasing cost as much as possible at the same time. The method uses provincial data to analysis.

2 OPTIMIZATION OF MULTIPLE OBJECTIVES

In accordance with the policies and regulations, the deviation between all plant's progress and average progress is not more than plus or minus 3%. If the electricity whole load is 40000000 MWh, we assume the half electricity load borne by the expensive units, half by the low price units, The average deviation of expensive price and low price is 100 Yuan/MWh, we will make the completion progress of the expensive unit 3%, make the completion progress of

the low price unit negative 3%, it can approximately reduce power purchase costs:

$$40000000 \times 0.03 \times 100 = 120000000 \text{ (Yuan)}$$

Thus, under the equal complete progress limitation, the optimizing space of power purchase cost is relatively large. The long-term power purchase optimization, considering the purchase cost, it is not simple to make the completion progress of the expensive unit 3%, make the completion progress of the low price unit negative 3%. It is a mixed integer programming problem, considering monthly load balance constraint, load rate constraint, unit maintenance scheduling and so on.

3 POWER PURCHASING OPTIMIZATION MODEL

In this paper, the optimization method considering the equal completion progress and power purchase cost is put forward. The optimization objective is the minimum purchase cost, the optimization constraints include the equal completion progress, monthly balance, the maximum load rate of units, the smallest load rate of units, unit maintenance and so on. It use MIP optimization model.

3.1 Optimization objective model

Power purchase cost model:

$$C = \sum_{i=1}^I \sum_{mon \geq SM}^{EM} PE(i, mon) * Pr(i) \quad (1)$$

$Pr(i)$: The energy price of unit i ;

$PE(i, mon)$: The monthly plan energy of unit i in month mon , it is a optimization variable;

SM : The start month of power purchase optimization;

EM : The end month of power purchase optimization;

Through setting the SM and EM parameter, we can get three types optimization object: the power purchase cost of current month, the power purchase cost of current season, the power purchase cost of current year

3.2 Optimization constraints model

3.2.1 The constraint of monthly load energy balance

$$LE(mon) = \sum_{i=1}^I PE(i, mon) \quad (2)$$

$PE(i, mon)$: The monthly plan energy of unit i , it is a optimization variable;

$LE(mon)$: The forecasting monthly load energy;

I : The count of all units;

3.2.2 The constraint of unit minimize energy

$$PE(i, mon) \geq R_i(i, mon) * MinEng(i, mon) \quad (3)$$

If the load rate of any unit is too low, the unit should be stopped, avoiding the unit running in not economical status;

$MinEng(i, mon)$: The minimize energy of unit i in month mon ;

$R_i(i, mon)$: The status of the unit i in month mon , 1 express running status, 0 express stopped status, it is a optimization variable.

3.2.3 The constraint of unit maximum energy

$$PE(i, mon) \leq R_i(i, mon) * MaxEng(i, mon) \quad (4)$$

$MaxEng(i, mon)$: The maximum energy of unit i in month mon , considering the max load ratio of unit i , the unit maintenance and so on. The constraint can prevent the unit from running in high load ratio situation, which can hold reserve capacity for power grid.

3.2.4 The constraint of equal completion progress

1) The standard completion progress model

$$SP(mon) = \left(\sum_i^I \sum_{pm=1}^{pm \leq PM} FE(i, pm) + \sum_{mon=PM+1}^{mon} LE(mon) \right) / \sum_i CE(i) \quad (5)$$

$FE(i, pm)$: The finished energy of unit i in month mon ;

$LE(mon)$: The forecasting load energy;

$CE(i)$: The year plan energy of unit i ;

$SP(mon)$: The standard completion progress in month mon ;

PM : The month before the start plan month.

2) The deviation constraint of completion progress

$$\left(\sum_{pm=1}^{pm \leq PM} FE(i, pm) + \sum_{mon=PM+1}^{12} PE(i, mon) \right) / CE(i) < SP(mon) + Poffset \quad (6)$$

$$\left(\sum_{pm=1}^{pm \leq PM} FE(i, pm) + \sum_{mon=PM+1}^{12} PE(i, mon) \right) / CE(i) > SP(mon) - Poffset \quad (7)$$

$Poffset$: The max deviation of completion progress, it is a parameter, it can be plus or minus 3%.

4 EXAMPLE ANALYSES

Case description: The example is based on actual provincial data. There are 64 thermal units, which has capacity of 32000000 kilowatts. We need to optimize monthly unit plan energy from April to December, the considering constraints include: April to December monthly energy balance, unit load rate within the reasonable range (0.6 to 0.85), the unit maintenance scheduling, the unit completion progress deviation does not exceed the limit (here set to plus or minus 0.03). From April to December the monthly power loads list in Table 1.

Table.1 The forecasting load energy

month	The forecasting load energy (hundred million kWh)
April	153.96
May	158.22
June	159.12
July	183.96
August	182.95
September	163.87
October	150.30
November	156.69
December	171.28

There are three optimization objectives as following:

The first objectives: the minimum power purchase cost of current month;

The second objectives: the minimum power purchase cost of current season;

The third objectives: the minimum power purchase cost of current year.

There are three optimization results as following:

Table.2 Optimization results

Three optimization objectives	The power purchase cost of current month (Billion Yuan)	The power purchase cost of current season (Billion Yuan)	The power purchase cost of current year (Billion Yuan)
The first objectives	75.65	234.81	740.87
The second objectives	76.76	234.44	740.84
The third objectives	76.82	236.86	740.66

Figure 1. The Comparison of the power purchase cost of current month

Figure 2. The Comparison of the power purchase cost of current season

Figure 3. The Comparison of the power purchase cost of current year

Analysis: in the first objectives, the power purchase cost of current month is the lowest, the power purchase cost of current season is in the middle, the power purchase cost of current year is the highest, because in the first objectives, the optimization object is current month, so the power purchase cost of other months is without control, so the power purchase costs of season and year are in the higher situation. Conversely, in the third objectives, the optimization objectives is power purchase cost of current year, so the power purchase cost of current year is the lowest, it saved 21000000 Yuan compared with the first objectives,

the power purchase costs of month and season are in the higher situation.

Three optimization schemes have their pros and cons, the decision maker can choose one as the ideal solution according to the actual situation.

5 DEADLINE

This paper presents a long-term power purchase optimization method, which minimize the power purchase cost considering the equal completion proress. This method is successfully used in a provincial gird company to meet the production demand.

ACKNOWLEDGEMENT

The work is supported by Project of Scientific and Technical Supporting Programs Funded by North China Power Grid Company, Project Name is “Multi

Days Unit Commitment Optimization Technology Research and Application in North China Power Grid”.

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