Research on Power Planning Based on Multi-Objective Linear Programming

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Abstract: First of all, give full consideration to various uncertain factors, reasonably determine the peak load value in 2030, by judging near the critical value of models and number of samples, minimizing the probability of wrongful convictions, to get the best solution: add outfit type one unit 3, type 2 units 3, type 3 unit 2 sets, type four units 1. Secondly, using linear programming, this paper puts forward according to various possible situations in practice. The improved inspection method makes the benefit higher. According to the subsection method and weight comparison method, 3 sets of unit type 1, 0 sets of unit type 2, 3 sets of unit type 3 and 1 set of unit type 4 are obtained. Finally, according to enumeration methods and statistical concepts, when the average value is taken, LOLP is 0.000384 and EENS is. When the median value is taken, LOLP is 0.001249 and EENS is. The second question USES the linear programming, obtains adds the type 3 sets, other types 0 sets.

1. Introduction

Reasonable planning is the premise and foundation of safe, reliable and economical operation of electric power [1][2]. Power system planning is used to determine the time, place and type of power equipment to be installed to meet the power demand within the life span, and to minimize the total cost of the planned power system on the premise of meeting the technical indicators of the power system. On this basis, the pursuit of cost minimization

The power supply planning model usually aims to minimize the total cost of unit investment, system operation cost and power failure loss during the planning period, and optimizes the additional installation plan of the unit under the conditions of meeting the constraints of power plant construction, system safety, unit operation and system reliability.

Therefore, how to set up a power generation system, reasonably plan the power supply, minimize the total cost and reduce the cost is a practical problem.

2. The Establishment and Solution of the Model

2.1. The establishment and solution of model 1

Take 2019 as the base year, and plan to determine the increased type and number of units in 2030. Establish a multi-objective linear programming model[3][4][5][6]

$$MinG = 220x_1' + 90x_2' + 60x_3' + 50x_4' \tag{1}$$

$$s.t.\begin{cases} x_1' \le 3 \\ x_2' \le 3 \\ x_3' \le 10 \\ x_4' \le 10 \\ 250 \ge p_1' \ge 100 \\ 100 \ge p_2' \ge 40 \\ 65 \ge p_3' \ge 25 \\ 50 \ge p_4' \ge 15 \\ \sum_{i=1}^{4} x_i' p_i' \ge 700 \\ \sum_{i=1}^{4} x_i' p_i' + 3405 \ge 4631.25 \end{cases} \tag{2}$$

Lingo program is used to calculate the number of newly installed units and their actual loads. The minimum cost of newly installed units can be calculated from the number of newly installed units of each type and their respective actual loads, and the cost is $1100\times10^6\$$. Specific data are shown in table 1.

Table 1 Actual load value number of units

p_1'	p_2'	p_3'	p_4'
250	100	65	50

x_1'	x_2'	x_3'	x_4'
3	3	2	1

2.2. The establishment and solution of model 2

Based on the given information, the optimal load distribution plan for each unit of the existing system on the 12th and 24th hours of a typical day is calculated, and the type and number of additional units are planned for the year 2030.

Set $x_1, x_2, \dots, x_9$ as the number of existing units, $p_1, p_2, \cdots, p_9$ is the actual load of the existing unit. Build the following linear programming model

(1)The objective function by the twelfth hour

$$\begin{aligned} Min\ B = &(0.064p_1^{\ 2}+48p_1+401)x_1+(0.014p_2^{\ 2}+43p_2+212)x_2+\\ &(0.053p_3^{\ 2}+42p_3+781)x_3+(0.007p_4^{\ 2}+40p_4+832)x_4+\\ &(0.328p_5^{\ 2}+37p_5+86)x_5+(0.008p_6^{\ 2}+44p_6+382)x_6+\\ &(0.001p_7^{\ 2}+35p_7+595)x_7+(0.023p_8^{\ 2}+41p_8+284)x_8+\\ &(0.005p_9^{\ 2}+36p_9+665)x_9 \end{aligned} \tag{3}$$

(2)The objective function by the 24th hour

$$\begin{aligned} Min\ C = &(0.064p_1^{\ 2}+48p_1+401)x_1+(0.014p_2^{\ 2}+43p_2+212)x_2+\\ &(0.053p_3^{\ 2}+42p_3+781)x_3+(0.007p_4^{\ 2}+40p_4+832)x_4+\\ &(0.328p_5^{\ 2}+37p_5+86)x_5+(0.008p_6^{\ 2}+44p_6+382)x_6+\\ &(0.001p_7^{\ 2}+35p_7+595)x_7+(0.023p_8^{\ 2}+41p_8+284)x_8+\\ &(0.005p_9^{\ 2}+36p_9+665)x_9 \end{aligned} \tag{4}$$

(3) Electricity cost

$x_i'(i=1,2,3,4)$, $p_i'(i=1,2,3,4)$ are the quantity and actual load of additional units respectively.

$$\begin{aligned} MinE = &220x_1'+90x_2'+60x_3'+50x_4'+(0.008p_1^{\ 2}+34p_1+600)x_1'+\\ &(0.042p_2^{\ 2}+43p_2+350)x_2'+(0.054p_3^{\ 2}+38p_3+250)x_3'+\\ &(0.217p_4^{\ 2}+33p_4+200)x_4' \end{aligned} \tag{5}$$

$$s.t.\begin{cases} x_1' \le 3 \\ x_2' \le 6 \\ x_3' \le 10 \\ x_4' \le 10 \\ 100 \le p_1' \le 250 \\ 40 \le p_2' \le 100 \\ 25 \le p_3' \le 65 \\ 15 \le p_4' \le 50 \end{cases} \tag{6}$$

(4) Solution of model 2

It can be seen from the above analysis that this problem is a multivariable linear programming problem. According to the constraint conditions and objective functions given in the problem, the Lingo program is applied for programming calculation, and the number of existing units and their actual load in the 12th and 24th hours are obtained. The optimal operating cost of the power plant is calculated according to the obtained scheme.

The twelfth hour

p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9
40	227.0471	224.6204	591.0000	20.00000	334.8325	800.0000	120.0000	350.0000

The 24th hour

p_1	p_2	p_3	p_4	p_5	p_6	p_7	p_8	p_9
10	76	49.00840	197	12	155	400	50	350

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
0	4	0	3	0	1.286290	2	0	1

Through Lingo calculation results, the optimal load distribution of existing system units on the 12th and 24th hour of a typical day is solved.

The number of additional units when the load is low

x_1'	x_2'	x_3'	x_4'
0	0	0	0

The actual load value range of the additional unit

p_1'	p_2'	p_3'	p_4'
100	40	25	15

The number of additional units at peak load

x_1'	x_2'	x_3'	x_4'
3	0	3	1

The actual load value range of the additional unit

p_1'	p_2'	p_3'	p_4'
250	43	60	28

According to the weight analysis, under the constraint condition of this question, the loading and work should be increased according to the peak period to meet the minimum cost.

2.3. The establishment and solution of model 3

For typical daily loads, LOLP, EENS and power failure losses are considered.

$$\min D = \sum_{t=1}^{T} C_{It}(X_t) + CRF \cdots \sum_{t=1}^{T} [C_{Ot}(X_1, X_2 \cdots, X_t, Y)] + C_{Lt}(X_1, X_2, \cdots, X_t, Y) \tag{7}$$

Existing units are controlled by the total number of installed units and unit capacity

$$s.t.\begin{cases} 0 \le x_1 \le 4 \\ 0 \le x_2 \le 4 \\ 0 \le x_3 \le 3 \\ 0 \le x_4 \le 3 \\ 0 \le x_5 \le 5 \\ 0 \le x_6 \le 4 \\ 0 \le x_7 \le 2 \\ 0 \le x_8 \le 6 \\ 0 \le x_9 \le 1 \\ 10 \le p_1 \le 20 \\ 15.2 \le p_2 \le 76 \\ 40 \le p_3 \le 100 \\ 69 \le p_4 \le 197 \\ 4 \le p_5 \le 12 \\ 54.3 \le p_6 \le 155 \\ 150 \le p_7 \le 400 \\ 20 \le p_8 \le 50 \\ 140 \le p_9 \le 350 \end{cases} \tag{8}$$

$$LOLP = \sum_{s \in S} P_S \tag{9}$$

$$EENS = T \times \sum_{s \in S} \left(C_S \times P_S \right) \tag{10}$$

$$\begin{aligned}
&Min\ \ J = 220 \times x_1 + 90x_2 + 60x_3 + 50x_4 + \left(x_1 - y_1\right) \times \left(0.008 \times p_1{}^2 + 34 \times p_1 + 600\right) + \left(x_2 - y_2\right) \times \\
&\left(0.042 \times p_2{}^2 + 43 \times p_2 + 350\right) + \left(x_3 - y_3\right) \times \left(0.054 \times p_3{}^2 + 38 \times p_3 + 250\right) + \left(x_4 - y_4\right) \times \left(0.217 \times p_4{}^2 + 33 \times p_4 + 200\right) + \\
&[\left(0.91193004\right)^{x_1 - y_1} \times \left(0.08806996\right)^{y_1} \times \left(0.96688742\right)^{x_2 - y_2} \times \left(0.03311258\right)^{y_2} \times \left(0.97855228\right)^{x_3 - y_3} \times \\
&\left(0.0214477\right)^{y_3} \times \left(0.96774194\right)^{x_4 - y_4} \times \left(0.03225806\right)^{y_4}] \times \\
&\{[3405 + 250 \times \left(x_1 - y_1\right) + 100 \times \left(x_2 - y_2\right) + 65 \times \left(x_3 - y_3\right) + 50 \times \left(x_4 - y_4\right)] \times 0.8 - 3278.925\} \times 10
\end{aligned} \tag{11}$$

The solution of model 3

$x_1^{'}$	$x_2^{'}$	$x_3^{'}$	$x_4^{'}$
3	0	0	0

New unit actual load

$p_1^{'}$	$p_2^{'}$	$p_3^{'}$	$p_4^{'}$
250	100	25	15

The number of new unit failures

y_2	y_3	y_4
0	0	0

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