Research on Optimal Management of Charge and Discharge of Electric Vehicle Based on Optimization Algorithm

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Abstract: This paper analyzes the proportion of different charging power levels by traversing optimization algorithm, which can meet the needs of users, reduce equipment investment and reduce the peak-to-valley difference of electric vehicle charging load. First, the minimum charging power P_{min} of the electric vehicle is obtained by using the charging power in the known data than the charging time, and the overall data is sorted according to P_{min}, and the charging power levels of the sorted electric vehicles are ranked by 10%, 40%, and 50%. Divided into three levels, the actual charging time of the electric vehicle is obtained according to the charging power of the electric vehicle. This value is added to the starting charging time to obtain the stopping moment of the electric energy flow, and the total sum of the powers of all the vehicles in each time period is accumulated to obtain the sum. Charging load curve. For solving the optimal charging power level ratio, first set the ratio of the three levels to X, Y, Z, and then use the same method as the 24-hour charging load to establish the constraint condition that meets the user's demand with the unknown number, and then the device. Investment Y_{min} and peak-to-valley difference ΔP respectively give a weight of 1:1 to establish an A_{min} objective function, traverse all possible proportions, and find that when the ratio of three levels is 48:51:1, the minimum equipment investment is 1409 million yuan, the smallest peak valley The difference is 18810kW.

1. Introduction

The transportation sector consumes about half of China's oil resources and produces huge amounts of greenhouse gases. In response to increasingly serious resource and environmental problems, governments around the world are actively promoting electric vehicles (EVs). In addition to adopting a series of economic subsidy policies for its production and sales, the formulation of the timetable for the ban on the sale of fuel vehicles has also been put on the agenda by many countries including China.

The energy of electric vehicles mainly comes from the power grid, which brings challenges such as increased peak-to-valley difference, voltage drop and loss increase to the distribution network. At the same time, as a mobile energy storage, electric vehicles have broad application prospects in cutting peaks and valleys, providing power system auxiliary services, and cooperating to absorb new energy.

In the process of Vehicle to Grid (V2G), there are three stakeholders: the grid, the operator (charging station) and the EV user. The EV user can exchange energy directly with the grid or select the charger of the operator. Discharge agent service.

2. Related work

2.1 Issues that need resolving

Calculate the charging load curve of 10,000 electric vehicles in 24 hours, and analyze the proportion of different charging power levels to meet the needs of users, reduce equipment investment, and reduce the peak-to-valley difference of electric vehicle charging load;

2.2 Problem analysis

The proportions of electric vehicles that adopt AC level 1 (1.4-1.9kW), AC level 2 (7.7-25.6kW), and DC charging (40-100kW) are 10%, 40%, and 50%, respectively. The title and the attachment do not directly indicate the charging level data of the different grades of electric vehicles. Therefore, the electric vehicle charging data in Annex 1 is processed first. Using the function processing function of Excel, the minimum charging power of the electric vehicle is obtained and sorted, and the charging level of the electric vehicle is divided according to the ratio of 10%, 40% and 50%, and then the actual charging time of the electric vehicle is obtained. And divide the charging time period, and then draw the charging load curve of 10,000 electric vehicles in 24 hours. For the problem of finding the optimal ratio, first set the ratio of the three levels to x, y, z, and then use the same method as above to establish the constraint condition that meets the user's demand, and assign 1:1 to the equipment investment Y and the peak-to-valley difference. The weight of the objective function A is established, so that the minimum value is solved.

2.3 Model hypothesis

1) The sample selected by the topic is universal and can represent the whole.
2) AC 1, AC 2, DC ratio distribution is arranged in ascending order.
3) Does not consider the power consumption of the electric vehicle when it is physically connected to the charging pole but not when it is charging.
4) The power grid and the charging station attach great importance to the owner of the vehicle, and there is no artificial charging power loss due to lack of electricity.
5) Power loss only occurs on the power grid, and there is no loss in the power conversion of the car.

3. The Model

3.1 Model establishment and solution

Classification model of electric vehicle charging power level
First, the electric vehicle charging data in Annex 1 is processed. Calculate the minimum charging power of an electric car in one day by using the function processing function in Excel.

$$P_{\min} = \frac{W}{t_{\max}} \tag{1}$$

And use the automatic sorting function in Excel to sort the minimum charging power in ascending order, the first 10 electric cars are classified as AC level 1 (1.4-1.9kW), and 11-50 electric cars are classified as AC level 2 (7.7-25.6kW).), 51-100 electric vehicles are classified as DC charging (40-100kW), and are obtained in Table 1

3.2 Draw a 24-hour charging load curve

In order to more accurately determine the actual charging time of the electric vehicle (ie, the length of the electric energy flow), according to the data given in the charging power registration table in Table 1, the average value of the power interval is obtained.

$$p_i = \frac{p_{i1} + p_{i2}}{2} \tag{2}$$

Substituting the data given in the charging power registration table to obtain AC level 1 power

$$p_1 = \frac{1.4 + 1.9}{2} = 1.65 \, \text{kW},$$

AC level 2 power

$$p_2 = \frac{7.7 + 25.6}{2} = 33.3 \, \text{kW},$$

DC charging power

$$p_3 = \frac{40+100}{2} = 70\,\text{kW},$$

According to the energy formula, the actual charging time of each electric vehicle of each charging power level (ie, the duration of electric energy flow) is obtained, that is, the actual charging time of the AC electric vehicle of the first class

$$t_r = \frac{W}{p_1} \tag{3}$$

AC 2 electric vehicle actual charging time

$$t_r = \frac{W}{p_2} \tag{4}$$

DC electric vehicle actual charging time

$$t_r = \frac{W}{p_3} \tag{5}$$

Calculate the end of actual charging (power flow stop) time

$$t_e = t_s + t_r \tag{6}$$

In this way, the actual charging start and end time of the electric vehicle is obtained.

According to the time segmentation method, 24 hours a day is divided into 96 time periods in 15 minutes, and the cycle charge algorithm is used to allocate the start and stop charging time data of 10,000 electric vehicles to 96 interval segments, corresponding to each interval segment. AC level electric vehicle charging power sum, get the charging power of 10,000 cars for 24 hours.

Use MATLAB drawing function (code see attachment) to draw the charging load curve of 10,000 electric vehicles for 24 hours, and get the result shown in Figure 1.
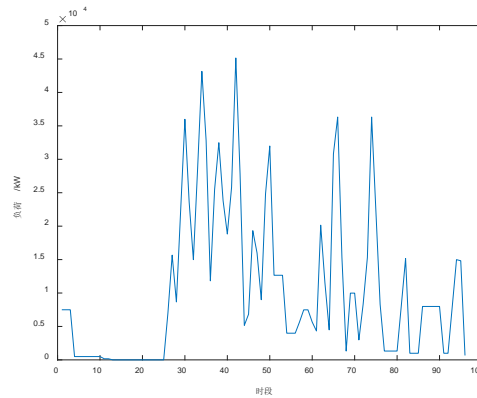

Figure 1 Charging load curve of 10,000 electric vehicles in 24 hours

Then, according to the difference between the highest point and the lowest point of the power in the figure, we calculated the 10,000 electric vehicles in 24 hours when the proportion of electric vehicles adopting AC level 1, AC level 2, and DC charging is 10%, 40%, and 50% respectively. The charge load peak-to-valley difference is 42000 kW.

TABLE I. List of minimum charging power ascending order for 100 electric vehicles on Monday

	Monday			Grade classification
	Charging connection length / h	Charging capacity / kWh	Minimum charging power P_min/kW	
E- car79	39.76	1.25	0.031438632	Exchange level 110%
E- car72	24.66	11.04	0.447688564	
⋮	⋮	⋮	⋮	
E- car8	1.29	0.94	0.728682171	
E- car39	10.09	7.64	0.757185332	
E- car76	28.27	21.80	0.771135479	
E- car42	0.83	0.68	0.819277108	Exchange level 2 40%
E- car98	15.50	13.44	0.867096774	
E- car44	9.17	8.07	0.880043621	
⋮	⋮	⋮	⋮	
E- car36	1.47	2.45	1.666666667	
E- car88	16.36	27.60	1.687041565	
E- car63	10.18	17.31	1.700392927	
E- car66	9.24	15.95	1.726190476	
E- car91	13.62	24.36	1.788546256	DC charging50%
E- car12	9.83	17.72	1.802644964	
E- car23	6.88	12.50	1.816860465	
E- car37	3.15	5.83	1.850793651	
E- car51	7.90	14.83	1.87721519	
⋮	⋮	⋮	⋮	
E- car9	4.61	22.78	4.94143167	
E- car16	3.08	15.95	5.178571429	
E- car53	2.91	16.26	5.587628866	
E- car11	1.61	9.96	6.186335404	
E- car34	0.37	12.72	34.37837838	

3.3 Optimization of charging power level ratio

The proportions of "AC Level 1", "AC Level 2", and "DC Charging" electric vehicles are optimized to be x, y, and z. For 10,000 electric vehicles, they are reassigned their charging power levels. Their actual charging time makes them optimized. For the constraint of "meeting the user's needs", we use the same algorithm as 5.2.2.1 to represent the actual charging time of the electric vehicle and use the round-robin algorithm to allocate time and power to reduce equipment investment and reduce peak-to-valley difference. The function gives the equipment investment and the weight difference between the peak and the valley 1:1, and obtains the objective function.

$$A_{\min} = Y_{\min} + \Delta P \tag{7}$$

In turn, the proportion of different levels of charging vehicles is optimized (see the attached file for the code). When we get the result of "AC Level 1", "AC Level 2" and "DC Charging" electric vehicle ratio of 46:53:1, the objective function gets the minimum value.

And then obtain the minimum investment in equipment

$$Y_{\min} = (3000x + 15000y + 500000z) \times 10000 = 140900000 \text{ yuan}$$

Minimum peak-to-valley difference

$$\Delta P = W_{\max} - W_{\min} = 18810 \text{ kW}$$

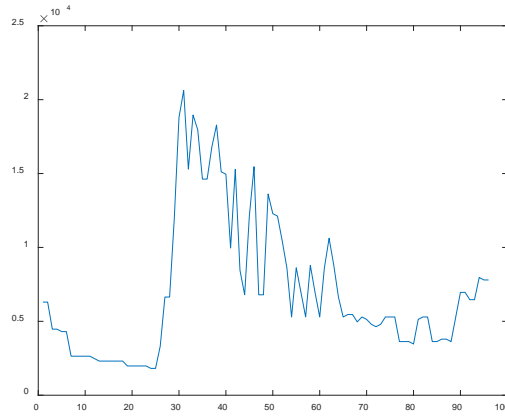The optimized charging load curve of 10,000 electric vehicles in 24 hours is shown in Figure 2.

Figure 2 Charging load curve of 10,000 electric vehicles 24 hours after optimization

Compared with Figure 1, it can be clearly seen that the optimized peak has reached an order of magnitude reduction, and the peak-to-valley difference is significantly reduced.

References

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