Optimization Model of Charge and Discharge of Electric Vehicle Based on Constraint Condition

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Abstract

With the increasing global energy and environmental issues, the development and utilization of electric vehicles has attracted more and more attention. This paper aims to realize the management of electric vehicle charging and discharging by optimizing the model, and establishes the electric vehicle charging load model and electric vehicle optimization model and algorithm. The available charging power levels are assigned to: AC 1 level 47%, AC level 2 30%, and DC 23%. This can effectively reduce equipment investment and reduce the disordered peak-to-valley difference of electric vehicle charging load. Firstly, the electric vehicles with AC 2 and DC charging are selected and sorted. Then, the proportion of electric vehicles with different charging modes is added to the charging load of the electric vehicle, and finally the charging load of 10,000 electric vehicles is calculated.

Keywords

Electric vehicle constrained optimization charging load.

1. Introduction

The energy of electric vehicles mainly comes from the power grid, and its large-scale development is inseparable from the support of the power system. The disordered charging behavior of electric vehicles has the characteristics of strong randomness and high simultaneous rate, which will bring 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.

2. Electric Vehicle Charging Load Model

By accumulating the charging load of each electric vehicle, the total charging load curve of 10,000 electric vehicles in one day can be obtained. The difficulty in calculating the charging load is to solve the specific charging time of the electric vehicle, so it is also necessary to program and calculate the specific estimated charging amount. In this paper, 24h is divided into 96 time periods, so the time interval is exactly 15 minutes. The total charging load of the i-th time period is the sum of the charging loads of all vehicles at this time. The total charging power can be expressed as:

$$L_i = \sum_{n=1}^{N} p_{n,i}, \mathrm{i} = 0,1,2,...24 ,$$

Where: Li is the total charging power of the i-th stage. N is the total number of electric vehicles; pn i, is the charging power of the nth car in the i-th stage. Take a private car as an example. In the morning or at night, you can have a longer charging time. The electric car can be fully charged. You can use AC level 1 or AC level 2. If it is at noon, the charging time may be shorter and the DC charging mode is required, which is the high-power charging mode.

Consider the load situation of electric vehicles under different charging power levels in the Monday time range. as the picture shows:

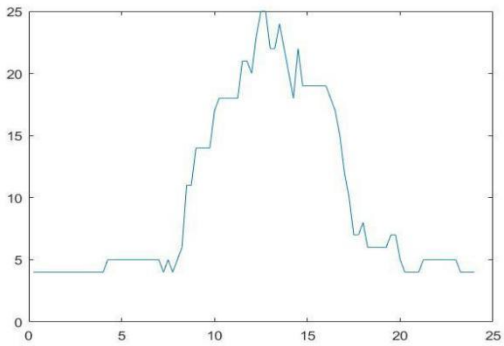

Figure. 1 Charging load curve in one day

It can be seen from the figure that the charging power is large at noon during the one-day period. It can be determined that the number of vehicles using the DC mode will be large, and the number of vehicles using the AC 1 and AC 2 charging modes at other times is relatively stable.

3. Different Charging Power Ratio Distribution

Since the above charging power is calculated as the minimum charging power, there is a certain error in the number of electric vehicles using different charging power modes. To standardize the number of electric vehicles charging in different ways, first select the upper limit power of the first class of 1.9 kW and the upper limit power of the second class of the second class of 25.6 kW. If it is greater than 1.9KW, AC 2 or DC power charging mode can be used. If it is greater than 25.6KW, DC power can only be used.

Take the one-week time as an example to calculate the number of cars using AC 2 or DC charging mode. As shown in the table:

Table. 1 Number of vehicles using AC 2 or DC charging mode

week	Number of cars greater than 1.9KW	Number of cars greater than 25.6KW
1	45	1
2	37	0
3	40	0
4	31	1
5	33	0
6	25	0
7	23	0

The power of 100 vehicles can be sorted from small to large. First, 10 electric vehicles with AC level 1 charging are used, then 40 electric vehicles with 2 levels of charging are exchanged, and 50 electric vehicles with DC charging are finally used.

4. Optimization Model

The optimization goal minimum includes the daily load peak within the charging load, because the time interval is 15 minutes, and the day is also divided into 96 stages. The optimization objective function is:

$$\min L_p$$

Where: Lp is the peak load of the grid.

The constraints are as follows:

$$L_p \geq P_0(\mathrm{t}) + \sum_{i=1}^{N} P_{iN} C_{i,R(\mathrm{t})} \quad t = 1, 2, \ldots, 96$$

$$C_{i,R}(\mathrm{t}) = \frac{P_i(\mathrm{t})}{P_{iN}}, \mathrm{i} = 1, 2, \ldots, \mathrm{N}$$

Where: P0 (t) is the basic load of the grid at time t; Ci R, (t) is the charging rate of the ith electric vehicle at time t; Pi (t) is the ith at time t The charging power of an electric car.

Based on the first stage, the optimized minimum peak load is obtained, and the optimization is used to reduce the fluctuation of the load. The minimum square of the load is used as the optimization target. Because the optimization problem belongs to the quadratic integer programming problem, and the number of decision variables is large, the calculation amount is large. To speed up the solution, we can use the method of linearization. We linearize the target, so we convert the second-stage objective function to:

$$\min \sum_{t=1}^{96} \left(\sum_{i=1}^{S} \alpha_i(t) \delta_i(t) \right)$$

5. Conclusion

In this paper, the establishment of optimization model for the interaction between electric vehicles and power grid to maximize the benefits, while taking into account the environmentally friendly development strategy, is the problem to be solved in this paper. Since the charging time is random, it is impossible to obtain a determined charging time. In this paper, the charging load curve of 10,000 electric vehicles is calculated by the fixed charging method ratio of 10%, 40% and 50%.

References

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