The Predicting of Charging Load for Pure Electric Buses

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Abstract. The driving time, space and distance of buses are more regular. On the basis of a large number of statistics on the driving and charging rules , and on the basis of full consideration of the electricity consumption and opening time of the cold and hot air conditioning of the pure electric bus, a hybrid charging model is obtained for the combination of the night regular charging of the pure electric bus and the fast charging during the working period. After considering the above factors fully, the Monte Carlo load forecasting method is used to predict the charging load of pure electric buses. The related experimental data show that the prediction method has good prediction accuracy. The prediction method can provide reliable analysis basis for reliable access of electric vehicle charging load.

Introduction

At present, the research methods of the charging law of electric vehicles are mainly divided into three categories: Comprehensive analysis methods、Specific analysis methods 、Probability analysis method[1~8].The Monte Carlo method is widely used in this field. Based on the number of different types of electric vehicles, the literature [9] uses the Monte Carlo method to simulate space-time distribution according to different charging habits, charging duration, and charging mode; [9] Based on the temporal and spatial distribution law, an adaptive dynamic smoothing index method is proposed. The smoothing coefficient is continuously adjusted with the error result to improve the accuracy. The literature [10] analyzes four different types of electric vehicles. The charging difference, including the charging location, charging method, etc., makes each type of electric vehicle charging load more accurate.

Factors Affecting the Charging Load

Electric buses have fixed working hours and driving routes relative to family cars and taxis, so it is relatively stable in time and space. Charging sites are generally located at the bus departure station, and the initial-charging time is the arrived time.

According to statistics, the initial charge time of electric buses is approximately uniform distribution $U(a,b)$：

$$f(x)=\frac{1}{b-a} \tag{1}$$

In the above formula, a and b indicate the time when the bus first started charging and the last charging time.

During the normal working hours of buses, high-power and fast charging is used. $a=6.5$, $b=23$,After the bus has been off work, it uses conventional charging mode, at this moment, $a=23$, $b=30$（The next morning 6 o'clock）.

During the work period of the bus, there is no long time for regular charging, so it is necessary to fill or charge the battery in a short time to the amount of battery that can support the bus to go back and forth. However, after the buses have been shut down from work, there is a longer parking time. In order to reduce the impact on the power grid, regular charging is proposed.

At present, the constant current and constant voltage charging mode is generally used for charging, and the charging power is constant during most of the charging process. Therefore, the charging power during the charging process is set to be constant. According to the above interface standards, it is determined that the normal slow charging power and the fast charging power during the day will be 21 kW and 200 kW respectively.

At present, electric vehicles are in a stage of rapid development, and the daily mileage of various types of electric vehicles also lacks actual statistics. Here, it is assumed that electric vehicles and fuel vehicles have the same driving patterns[12], so the fuel vehicles can be The daily mileage law is applied to electric vehicles. According to the daily mileage calculated by NHTS [13], these data are fitted in the Matlab software and the probability density function of the daily mileage of the electric vehicle is obtained after fitting:

$$f(x,\mu,\sigma)=\frac{1}{x\sigma\sqrt{2\pi}}\exp\left[-\frac{(\ln x-\mu)^2}{2\sigma^2}\right] \quad (2)$$

Electric buses are distinguished from other types of electric vehicles by not only having great regularity in time and space, but when the charging load is counted against the energy consumption of air conditioners, the buses leave the originating station, and the air conditioners will always be in working condition.

The establishment of a charging load model

Divide the day into 144 time periods. The calculation time step is 10 minutes. The charging power in each time period is:

$$P_i=\sum_{m=1}^{M} p\ (m,i) \quad (3)$$

Wherein, P_i represents the total power of the traveling charge in the i-th time period; M represents the total number of electric buses; $p(m,i)$ represents the charging power of the m-th vehicle in the i-th time period (i=1, 2, 3...144).

The electricity consumed by a bus for a day is:

$$C_X=k_s\cdot\frac{D}{D_m}\cdot C_N \quad (4)$$

Energy consumption of air conditioners during driving:

$$C_\alpha=k_sW_h\cdot\frac{D}{v} \quad (5)$$

In formula:

$$k_s=\begin{cases}1 & \text{flat peak of vihicle flow}\\ 1.2 & \text{peak of vihicle flow}\end{cases} \quad (6)$$

According to formulas 4, 5, 6 charge time:

$$T_c=\frac{6\times(C_X+C_\alpha)}{K\times P_n} \quad (7)$$

Among them, K,representingthe charge efficiency of the charging pile, is generally 0.9; W_h is the rated charging power of the charging pile , T_c is 10 minutes.

Using the unifmd command on the Matlab software platform is to randomly extract the initial charge time of the bus and round it. Charging end time is:

$$T_e=T_s+T_c \quad (8)$$

If $T_e \geq 144$, $T_e = T_e - 144$, T_e is at the moment in the next day.

For a single bus, from the initial charging time T_s to the ending charging time T_e , the charging power is calculated every 10 minutes. The charging power of *M*the buses is as follows:

$$P = \sum_{i=T_s+1}^{T_e} P_i + K_\alpha = \sum_{i=T_s+1}^{T_e} \sum_{m=1}^{M} P(m,i) + K_\alpha \tag{9}$$

Assuming that under the premise that the power grid does not participate in the regulation of bus charging, we set the conventional charging power P_1 and high-power fast charging power P_2 , the maximum mileage of the bus on a daily basis D_m , the battery capacity of the bus C_N , the charging efficiency of the charging pile K , and the energy consumption of the air conditioning K_α .

Initializing the number of simulations N and record the number of simulations starting from n=1,and satisfying $n \leq N$;

Initializing the number of electric buses (M) in an area, m=1,which means starting from the first bus and satisfying $m \leq M$;

According to the formula 1 to extract the bus starting charging time T_s , indicating a charging time period, in $[0,144]$between, when the initial charging time plus the charging time exceeds 144, the charging end time shall be subtracted by 144, that is $T_e = T_e - 144$, time is the next day;

For the calculation of power, the calculation formula for the charging power of the bus is as follows:

$$P_m = \sum_{i=T_s}^{T_e} P(m,i) + P(m,\alpha) \tag{10}$$

Judging whether or not to converge. Calculate the accuracy of the charging load by the variance coefficient. The formula for calculating the variance coefficient is as follows:

$$\varpi = \frac{\beta}{\alpha\sqrt{N}} \tag{11}$$

Here, α represents the average of the charging load , β represents the standard deviation of the charging load , and N represents the number of simulations. When $\varpi < 0.0005$ is set, it means convergence and simulation ends; otherwise, it means there is no convergence, and go to step (2).

Conclusions and Prospects

Since the bus has a certain regularity in time and space distribution ,compared with the family car and taxi, the charging location and the charging start time can be roughly determined, so the orderly charging of the bus can be carried out smoothly. When V2G technology is used, buses can be managed centrally. When the grid is at peak load, the buses are discharged to the grid. When the grid is in a valley load, a large number of electric buses are charged and the electric energy is stored , attaining peaking load shift. At this stage, electric buses are not yet universally available. The number of electric buses is limited, and the amount of energy that can be stored is relatively small compared to the daily load of the power grid. Even if V2G technology is implemented, the effect will not be obvious.

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