The Research of V2G Technology Real-Time Charge and Discharge Capacity Prediction

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Abstract. The problem of spatial randomness and time randomness is very important for the characteristics of electric vehicle access network. Based on monte carlo stochastic simulation method, the daily mileage and the starting time nodes of different types of electric vehicles in the dispatch area were randomly selected and the prediction model of charging capacity of V2G system is presented. Taking the Beijing area as an example, the real-time charge and discharge capacity of V2G system is predicted in 24 hours a day, to provide data reference for power grid dispatch center.

1. Introduction

At present, Three key technologies of battery, motor and electronic control has basically meet the needs of the electric vehicle application, but its charge and the corresponding supporting infrastructure problems limited the popularization of electric vehicles. Emerging V2G (Vehicle to grid)[1-3] technology refers to two-way interaction between electric vehicle as mobile energy storage unit and power grid and its core thought is to connect idle electric cars to the grid in case of time and battery capacity. When the grid load too high, electric vehicle storage energy is dispatched to feed power grid, and when the grid too low, the excess energy in the grid is stored in electric vehicles. Through the corresponding optimization scheduling method, V2G technology can solve the problem of electric car charging and avoid the adverse effects of the charging cluster effect on the power grid. It can also respond to the frequency of the power system, curb the fluctuation of the peak valley and the network of renewable energy, maintain efficient and safe operation of power grid and reduce operating costs. At the same time, electric car[4] users can charge during low electricity prices and feed electricity to the grid during peak electricity consumption , to Lower the cost of electric vehicles.

Based on the analysis of the development status of V2G technology at home and abroad, various factors that affect the real-time charging and discharging capacity of V2G technology were considered, and taking Beijing as example, Monte carlo simulation model[5-7] was established in this paper, and the real-time charge and discharge capacity of V2G technology in the Beijing area was predicted in 2020 and 2024, to promote the development of V2G technology in China's electric vehicle industry.

2. Analysis of the influence factors of V2G technology in real-time charging and discharging capacity

2.1. Electric vehicle classification

According to the characteristics of vehicle use, electric cars can be classified into three types: electric cars, private electric cars, and electric cars that can be dispatched. Among them, utility electric

vehicles generally include: bus electric cars, rental electric cars and official electric cars. These cars are all public service and usually have fixed driving characteristics. Their average driving time is relatively long, and the peak of power grid load is still in normal use, so this kind of car is generally not used as a V2G power source. Private electric cars are different from electric cars, and their use has a strong randomness. Private electric cars idle most of the time, and can be charged at night. On the premise of establishing an agreement with the user, some private electric cars can be netted and give back electricity to the grid during peak hours to realize the fluctuation of the power grid, thus to improve the efficiency of power grid and reduce the cost of electric vehicles.

2.2. Scale analysis of electric vehicles

If it is 6 million motor vehicles in 2016 of Beijing, average annual vehicle ownership is expected to grow by 200,000 vehicles per year. The market share of electric vehicles will increase significantly in the next 10 years. At present, it accounts for 5% of motor vehicle ownership The future increases by 5 to 10 percentage points per five years. The prediction results are as table 1.

Table 1. The forecast of electric vehicle ownership in Beijing from 2020 to 2024

year	Number of motor vehicles (10 thousands of cars)	Number of electric cars (10 thousands of cars)	Market share
2020	700	70	10%
2024	800	160	20%

In the initial development phase of electric vehicles, take public transport facilities as the main operating objects, with the development of electric vehicle related technologies and facilities, private electric cars are the main force in the future electric car market. Table 2 shows the percentage forecast of the total number of electric vehicles in the market by public electric vehicles and private electric vehicles in each stage. The assumption is that the market penetration rate of the electric vehicle can be increased continuously. About 20% in 2020 and 30% in 2024.

Table 2. Estimation of the amount of electric vehicles(10 thousands of cars)

year	Number of electric cars	Number of buses	Number of private cars	Number of schedulable vehicles
2020	70	42(60%)	28(40%)	5.6(20%)
2024	160	64(40%)	96(60%)	28.8(30%)

2.3. Charge and discharge time

Different types of electric vehicles can charge and discharge at different times. The charging and discharging time and its duration influence the charging and discharging power of electric vehicle to a great extent. In order to facilitate the real-time prediction and calculation of the charging and discharging capacity of V2G technology, the characteristics and laws of different types of electric vehicles are approximated, as shown in figure 1.

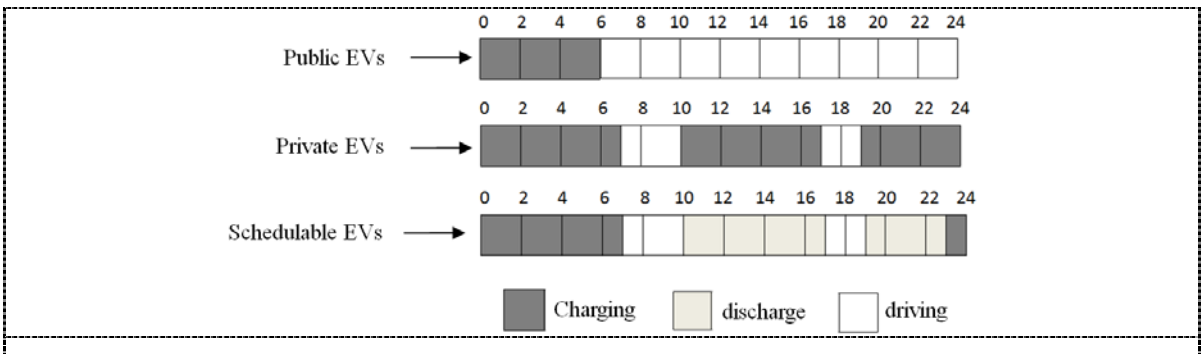

Figure 1. Charge, discharge, and travel hours for three types of EVs.

2.4. Battery system related parameters

Influenced by various factors such as the type, driving conditions and production manufacturers of electric vehicles, the relevant parameters of the battery system are significantly different, which will also affect the charging and discharging power capacity of electric vehicles. In order to simplify the calculation, the parameters of the electric vehicle battery system involved include the rated capacity, rated voltage, charging discharge efficiency, total charging time and power consumption, as shown in table 3.

Table 3. Battery parameters for electric vehicles

Rated capacity (A·h)	Rated voltage (A·h)	Charge/discharge efficiency	Total charging time (h)	Power consumption (kWH/km)
100	320	0.9	5	0.125

3. Prediction of real-time charge discharge capacity of V2G technology

Monte carlo method is also called statistical simulation method, which is used to solve the mathematical or physical problems of non-deterministic (probability or random) mathematics. The charging and discharging behaviors of electric vehicles are highly random, and the monte carlo method can simulate the random behavior well. The simulation process is very close to the actual situation, which is conducive to the accurate prediction of real-time charging and discharging capacity of V2G technology.

First, charging and discharging periods are determined according to different types of electric vehicles; second, during the time of charge and discharge, through the Monte Carlo method, according to that start charge, discharge time obey uniform distribution[8], and the average daily driving range obeys lognormal distribution[9] and normal distribution[10], the starting charge, discharge time and daily mileage of electric vehicles are randomly selected; then, calculate the initial of the corresponding vehicle; finally, the charge and discharge of all electric vehicles are randomly assigned. The total charge power and the total discharge capacity of V2G power supply can be calculated from 24 hours of the day. At the random extraction of start charging time, based on charging power and charging demand (ensure that the battery must be fully charged prior to the end of charging), calculate the required charging time. Narrow the sampling range of the starting charging time when the required length of charging is met. The specific process is shown in figure 2.

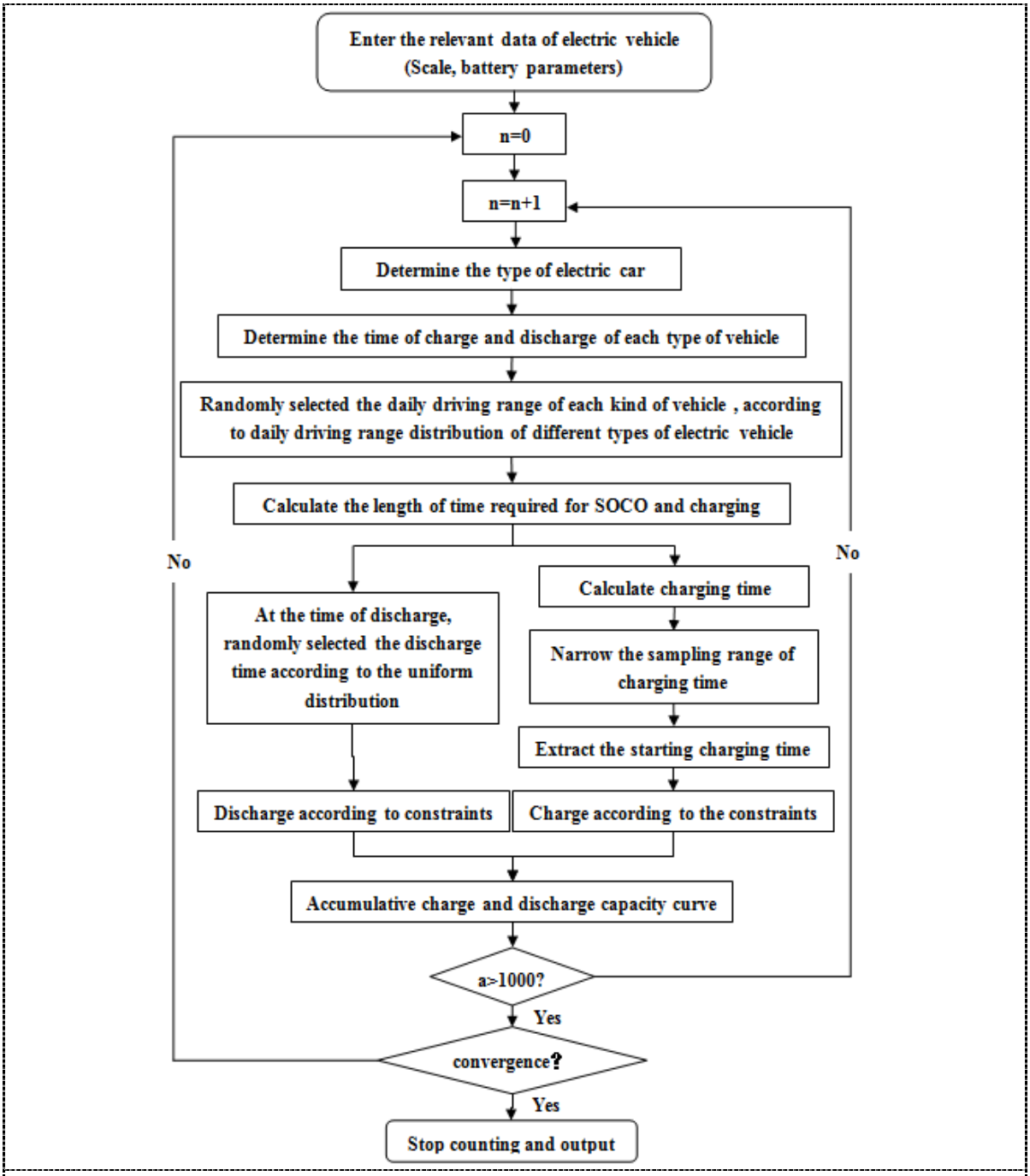

Figure 2. Flow chart of proposed algorithm based on Monte Carlo simulation.

4. Simulation results analysis

Monte carlo simulation runs at least 1000 times, and the variance coefficient is required to be less than 0.05%. The V2G discharge capacity and the charging load power curve are predicted for 24 hours a day using vehicle forecast data of the electric car in 2020 and 2024, as shown in figure 3.

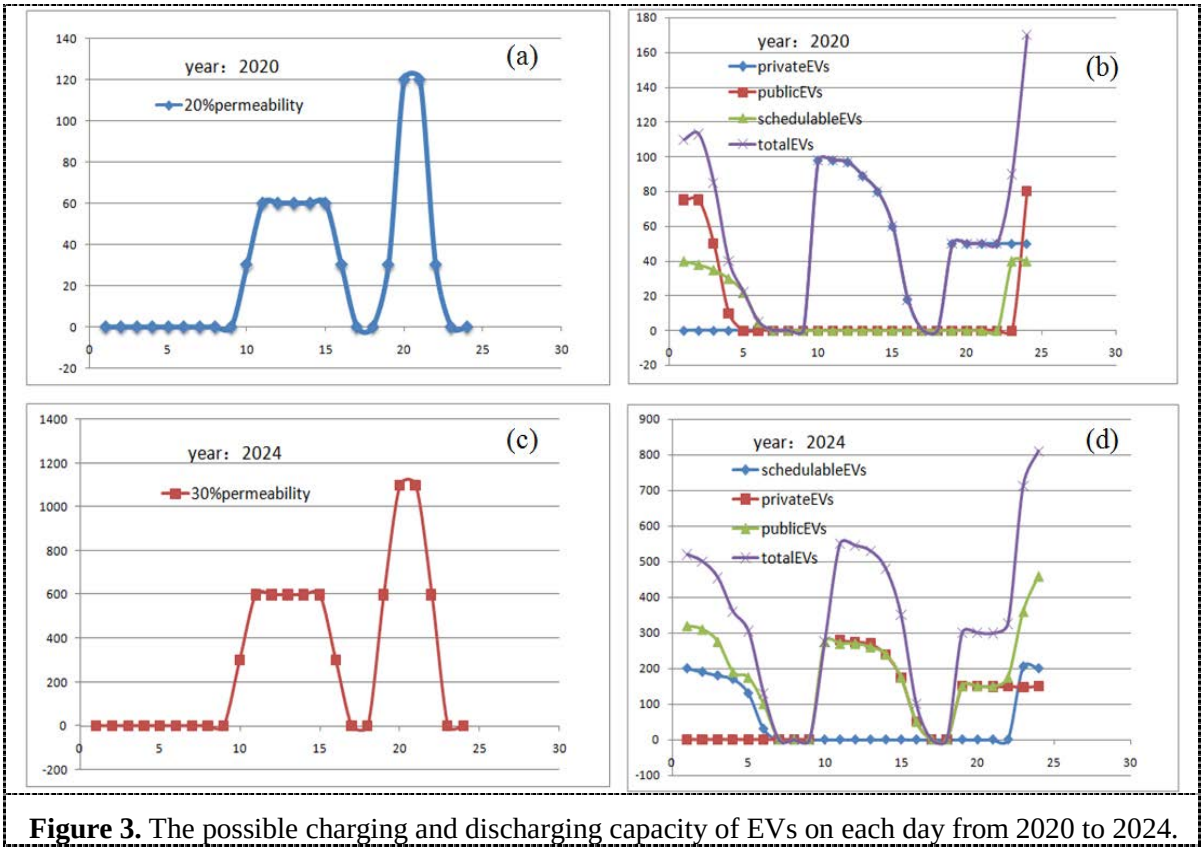

Figure 3. The possible charging and discharging capacity of EVs on each day from 2020 to 2024.

The charging load of electric cars is concentrated between 9:00 and 17:00 during the day, which is the private electric car's centralized charging time. As the number of private electric vehicles increased significantly, the charging load has risen sharply from 2020 to 2024. The evening charge is set at 19:00, which is also the time for private electric car charging. Electric car charging load obviously increases, especially in 2024, and the evening peak load is evident. This result from concentrated charging at night after the private electric cars sunrise. At the same time, as the scale of the available electric vehicles increases, it's a bit of a filling for the charging load increase resulted from evening rush hour of electric vehicles. At the same time, there is a residual capacity to meet the base load of the evening peak. It plays a role in helping the power grid to operate safely and steadily. Electric cars and electric cars that can be scheduled are charged at night time, which play a certain "fill the valley" function. From the simulation results diagram, the large-scale private charging can be a hidden danger to the stability and security of the power grid in future. To meet its charging demand, more units should be added, and thus to increase the cost of grid operation. How to guide its transfer charge more effectively is very beneficial to the safety and economical operation of the power grid. The time-sharing mechanism is used to guide charging of electric vehicles In low-power valley load times.

5. Conclusion

Based on monte carlo stochastic simulation method, monte carlo random sampling method is proposed to predict charging and discharging capacity of electric vehicles, and the simulation results are analyzed. The transformation of the modern transportation industry caused by the widespread application of electric vehicles and its impact on the development of power industry are revolutionary and far-reaching The intelligent charging and discharging management of electric vehicles is effective in dispatching and controlling charging and discharging capacity, which can obviously improve the economic and security of the entire power system operation. How to solve the optimal scheduling and control of electric vehicle charging and discharging problems fundamentally determines whether it can reduce or even avoid into the size of electric vehicles connected to the electricity grid of the negative effects on the electric power system. It also determines whether it can play its best role.

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