A Review of Demand Forecast for Charging Facilities of Electric Vehicles

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Abstract. The demand forecasting of charging facilities is the basis of its planning and locating, which has important role in promoting the development of electric vehicles and alleviating the energy crisis. Firstly, this paper analyzes the influence of the charging mode, the electric vehicle population and the user's charging habits on the demand of charging facilities; Secondly, considering these factors, the recent analysis on charging and switching equipment demand forecast is divided into two methods——forecast based on electric vehicle population and user traveling behavior. Then, the article analyzes the two methods and puts forward the advantages and disadvantages. Finally, in view of the defects of current research, combined with the current situation of the development of the city and comprehensive consideration of economic, political, environmental and other factors, this paper proposes an improved demand forecasting method which has great practicability and pertinence and lays the foundation for the plan of city electric facilities.

1 Introduction
With the increasingly strict requirements of economic development and environmental protection, electric vehicles, with the advantage of energy conservation and emission reduction, have become the priority of the new energy resources development, as the result of which, the large-scale use of electric vehicles has become an inevitable trend. Charging facilities are the basis of electric vehicles development. The proper planning of facilities can increase the popularity of electric vehicles and alleviate its influence on the network. The demand forecast for charging facilities is the premise of its proper planning and determine the convenience and economic efficiency of the planning. Therefore, it is of great significance to forecast the demand of charging facilities and then calculate the quantity of facilities.

Based on the analysis of the factors influencing charging facilities demand, the article summarizes the recent researches and, in view of the disadvantages of the researches, proposes the forecasting method, which lays the foundation for the planning and locating of charging facilities.

2 Factors Influencing Charging Facility Demand
The charging process of electric vehicle has great randomness, which embodies the uncertainty of the charging period, the point and the state of charging when the vehicles get access to the grid. These factors make the planning of the charging facilities much more difficult. Recently, when studying the factors influencing charging facility demand, the domestic and foreign researchers mainly consider three aspects, which as follow:

A. Charging mode.

The charging period varies in different modes and the power supply function differs. Allocating different facilities for every kind of charging mode can improve the charging efficiency. Currently, there are two charging modes, switching and charging, which can also be classified into fast charge and slow charge.

Fast charge, known as emergency charge, needs the short period of charge with large charging current. It usually takes 30 minutes to charge at the 80% of the battery capacity. The factors contributing to its charge load embodies the charging power, the quality of charge at the start and the period of the charge.

Slow charge, also known as normal charge, has low charge power with a long period of charge. It takes 5-8h to be fully charged. The factors contributing to the charge load are similar to the fast charge, which includes the start point of charge, the charge power and the quality of charge.

Switching is a mode that we the professionals take down the battery and install the one with full charge, which usually takes 5-10 minutes. The factors determining the charge load are the battery capacity margin and controllable level of charge.

According to the characteristic of different charge modes, [1, 2] calculated the ratio of piles and vehicles and the quantity of the charge facilities needed. [3] considered the charge characteristic of pure electric bus in two modes, switching and dispersed charge, and calculated the electricity consumption it needed, which finally forecast the demand. [4] combined different charge modes and realized the demand forecast of charge facilities in HeiLongjiang province. [5, 6] made the demand forecast according to different types of charge facilities. [7, 8] considered different charge modes and make a demand forecast of the residents charging facilities.

B. Electric vehicle population.

With the development of the economy and promotion of electric vehicles policy, the national population of electric vehicles is going on rise. Correspondingly, the quantity of charge facility, calculated by the ratio of piles and vehicles, is rising. To forecast the electric vehicle population, the researchers usually fitted the tendency of the vehicle sales data or GDP (Gross Domestic Product) growth data, and then calculated the ratio of piles and vehicles by travel traffic distribution to make a demand forecast of the charge facilities.

[9] forecast the electric vehicle population and realize the planning and locating of the charge facilities. [10] comprehensively considered GDP, historical population of electric cars, the production of electric cars, passenger volume and other factors, through which the paper made a forecast of the population of electric cars and finally calculated the demand of charge facilities. Based on the prediction of the electric vehicle population, [11] made a forecast of the demand for charge facilities.

C. Users’ behavior habits.

Users’ behavior habits embodies the start point of charge, the period of charge, driving distance and types of electric cars. The start point of charge determines the state of charge at the start; the difference of charge period has an impact on the network load, which finally influences the charge power; driving distance has an effect on the daily demand for charging power and daily rated charging capacity of charge station, which finally determines the quantity of charge facility.

Considering the driving distance, the period of parking and the initial state of charge, [12] built a travel demand model. [13] considered the users’ average daily electric consumption and built the demand forecast model for charge facility according to the consumption. [14-17] comprehensively considered the charge power, daily driving distance and remaining battery charge, and finally made a forecast of the charge facilities. [18, 19] took the initial state of charge and the point of charge into account, estimated the period of charge and finally made a demand forecast for charge facility of the
electric taxes and buses. According to different types of users and behavior habits, [20] made a demand forecast of charge facility. [21-26] regarded the initial state of charge, charge period and daily driving distance as the main factors and made a demand forecast.

3 Demand Forecast for Charge Facilities

Based on the analysis of the factors above, the recent researches on the demand forecast for charge facility can be categorized into two types—— the forecast base on the users’ behavior habits and the one based on the population of electric vehicles.

3.1 Demand Forecast for Charge Facility Based on the Users’ Behavior Habits

Users’ behavior habits determines the period of parking, the point of starting to charge, daily driving distance and so on, which reflects the temporal and spatial distribution of the charge demand. The researchers using this method usually firstly calculates the distribution of charge demand according to the users’ behavior habits, and then through the ratio of piles and vehicles computes the number and capacity of the charge facility.

[2] firstly emphasized on the analysis of users’ travel demand and use Monte Carlo method to carry out a temporal and spatial simulation; secondly, determine the appropriate weights according to the degree of users’ acceptance to the initial state of charge so that the probability distribution of charging requirement can be solved; finally, based on the probability distribution, the ratio of piles and vehicles can be fixed and the demand of charge facility can be forecast. [7], with the help of Monte Carlo method, simulated the demand of charge power in supermarket, private charge pile, charge station and working places. [8], considering the randomness of daily driving distance, the arrived time and the remaining state of charge, simulated the demand of charging power and capacity SVM (Support Vector Machine) algorithm and historic data. [14] studied the factors influencing the demand of charge facility and, considering the charge power, the characteristic of battery, average daily driving distance and other users’ behavior habits, built a demand forecast model which took correction factor into account; to verified the model, the paper made a demand forecast with the data of Jiangsu province. [15] researched in the behavior habits of different types, which included the driving distance, the remaining capacity, the charging period, the point getting access to the network and the parking time, and realized the forecast of different types of electric vehicles. [17] described the randomness of users’ travel behavior with probability function including the driving period, the driving distance and the state of charge, and then set a model of demand charge power under various circumstances with Monte Carlo method.

At present, the forecast model based on the users’ travel behaviors has been mature, but the consideration of influencing factors isn’t sound. Most articles assumed that the users just charge once in a day and haven’t considered multi charge and intermittent charge in a day. What’s more, the recent researches mainly focus on the demand forecast of charge power, hardly considering the relation between the charge power and the quantity of charge facility.

3.2 Demand Forecast for Charge Facility Based on the Electric Vehicles Population

The method is based on the forecast of electric vehicle population and, combined with the influencing factors, calculated the charge power and capacity of charge facilities. Finally, with the fixed ratio of cars and piles, the demand can be solved.

[7] forecast the population of electric vehicles in both short term and long term respectively with elastic coefficient method and the retaining thousands of people method. [9] predicted the number of electrics for various use and integrated the statistics, which prepares for the demand forecast for charge facilities. [10] forecast the population of the electric vehicles with the BP (Back Propagation) neural network based on genetic theory and predicted the demand of charge facility with the fixed ratio of cars and vehicles calculated by the users’ travel density. [11] predicted the population in a region with multiple linear regression and did a demand forecast of various charge facilities according to their characteristics. [14], based on the forecast of electric vehicle population, quantified the
influencing factors and set up the demand model to do forecasting. [15] forecast the population of electric cars with Bass Model and, combined with different behavors of different cars, set up the forecast models for charge power and quantity of various users. [16] forecast the population with multiple linear regression method and built a demand forecast model based on queuing theory. [27] set up an improved Bass model solved by multiple linear regression and calculated the population of electric vehicles, considering politics, economy and many other factors.

Recently, the method of prediction to the population of electric vehicles has been improved, but it’s still macroscopic and how to calculate the ratio of cars and piles needs further study. Moreover, the influencing factors taken into account hasn’t been completed. For example, the environment policy hasn’t been considered.

4 A Proposed Method of Demand Forecast For Charge Facility
Considering the current research status and the factors influencing the population, such as policy, economy and users’ travel behaviors, the article, taking one city as an object, proposes a demand forecast method.

Step 1: Calculate the Ratio of Piles and Cars for Various Use.

According to the collected data about the different characteristics of charging under various modes, assume the basic parameters of the charge facility, such as charge power and the state of charge. Considering the start point of charge, users’ charge behaviors regulation and daily driving distance, simulate the daily charge load curve under the three charge modes with Monte Carlo method. Finally, calculate the ratio of piles and cars in different charge modes according to maximum number of online charging vehicles a day and the number of the batteries in charge or fully charged.

Step 2: Calculate the Population of Electric Vehicles in the City

- Search for the historic statistics of the electric vehicles population of the nation and the city, such as crude steel consumption per capita, power generation per capita, population and road mileage, automobile production, passenger traffic volume, which influences the electric vehicle population.
- According to the collected statistics of the country above, calculate the quantity of the electric vehicles of the whole country with artificial intelligence algorithm.
- According to the collected statistics of the city above, calculate the quantity of the electric vehicles of the whole city with artificial intelligence algorithm.
- According to the data of the planning in the future 20 years released by the National Development and Reform Commission, forecast the population of the electric vehicles in the future every year with HERMIT interpolation.
- According to the historical data of region’s annual technical development and the amount of cars, calculate the corresponding ratio coefficient. Considering the restriction of environmental protection policy in the area, the constraint conditions are added in the forecast, so as to estimate the quantity of the area.
- Calculate the every year population of the target region.

The process of the calculation is shown in the figure 1.
The historic statistics: the electric vehicles population of the nation and the city, crude steel consumption per capita, power generation per capita, automobile production, passenger traffic volume.

The future population of cars of the whole country and the future population of cars of the target city.

The planning data of the whole country in the coming 20 years.

The every year population of the whole country in the future.

HERMIT interpolation.

Analyze the influencing factors such as the environment policy and the development of technology.

Calculate the ratio coefficient of the factors of the target city.

Calculate the electric vehicle population of the target city.

Figure 1. The calculation of the electric vehicle population

Step 3: Calculate the Quantity of Charge Facility for Various Use
- Calculate the population of the electric vehicles for various use in the target region.
- Calculate the quantity of the charge piles, according to the probability of the charge piles being used for different types of the electric vehicles.
- Calculate the quantity of the charge station and switching station, according to the ratio of piles and cars which is calculated in the first step.

The process of the calculation of the charge facility quantity is shown in the figure 2.

Figure 2. The calculation of the charge facility

5 Summary
Demand forecast for charge facility plays an important role in its planning and is regarded as the safeguard to promote the electric vehicles. According to the factors influencing demand for charge facility, the article classified the recent researches into two types—— the forecast based on users’ behaviors and the population of electric vehicles. The former one has great randomness and usually simulates the charge power to forecast with Monte Carlo, combined with probability distribution function. But the method assumes much restriction on the users’ behaviors and lacks the analysis of multi charge and intermittent charge in a day. The one based on the electric vehicle population combined the historic data and take the artificial intelligent algorithms to forecast. Its results is more detailed, however, there is little consideration of the ratio of cars and piles and policy factors.

Based on the previous researches, this paper combines the two methods and proposes another demand forecast method with comprehensive consideration of economy, policy and many other factors. Firstly, considering the charge modes, the types of electric cars, the paramters of charge facility and the randomness of users’ behavior habits, calculate the ratio of cars and piles in various types; secondly, forecast the electric vehicle population according to the historic data and influence coefficiency of policy; finally, calculate the quantity of charge facility through the population of electric vehicles and the ratio of cars and piles. The method makes up the disadvantages of the previous researches. It takes multi algorithms to forecast in view of the economical and political environment of the target region and realizes the demand forecast for charge facilities in multi-angles, such as different charge facilities, various types of users and random users’ behaviors. The method is object and practical, which lays a solid foundation for the planning and location of the charge facilities.

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