



Planning of Electric Vehicle Charging Infrastructure under the Background of Big Data

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Abstract: Today, the problems of power consumption and environmental pollution caused by road traffic are very serious. The promotion and adoption of electric vehicles can effectively alleviate these problems, but the planning of electric vehicle charging facilities needs to be resolved as soon as possible. This article aims to study the design of charging infrastructure based on the background of big data. The case analysis confirmed the importance of the billing company's design model and proposed an effective solution process. Taking M city as an example, combining the charging data obtained by simulation, the charging kits in the city center and the design area, and the effective solutions to the actual situation, the sensitivity analysis of the selection of slow charging equipment is carried out. Mode model between the two ion functions and the radio function of the charging station. The case analysis results show that a total of 10 60kW fast charging facilities need to be built in this industrial zone. The state-of-the-art mode and power model of public charging equipment proposed in this paper can solve the problem of positioning charging equipment in large-scale transmission networks.

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1. Introduction

For a century, the international community has established various forms of global energy cooperation around oil, the main energy source [1-2]. my country's oil resources are scarce, but the demand for oil is increasing year by year. As the main user of fuel, automobiles produce large amounts of carbon monoxide and nitrogen, dust and particles [3]. The use of fossil fuels and other fossil fuels undoubtedly violates the concept of energy conservation and environmental protection in future energy development, and the mass promotion and use of electric vehicles have a significant impact on reducing pressure sources and reducing greenhouse gas emissions [4].

In addition to traditional fuel vehicles, from the current development stage of battery technology, vehicle charging applications are often the main factors restricting the development of electric vehicles, such as the supporting infrastructure of electric vehicles for electric vehicles, charging pile design, etc. [5]. These applications will directly improve the comfort of electric vehicles during use, and user comfort is an important factor that affects the number of electric vehicles in the early development of electric vehicles, and directly determines the growth rate of electric vehicles [6].

Unconventional design methods will prevent the international process of replacing fuel-filled vehicles with electric vehicles [7]. Therefore, research on related charging materials and location planning and energy model design methods that are beneficial to the future development of cities can not only provide scientific support for the design of charging equipment, but also make the urban boundaries of cities more scientific [8].

Electric vehicles (EV) are advanced solutions for automakers to gradually replace traditional cars and reduce our dependence on oil. However, it takes many hours for electric vehicles to be fully charged. Reducing the charging time and energy consumption of electric vehicles is one of the main challenges in promoting such vehicles [9]. Disturbing traffic conditions such as traffic congestion and broken roads may severely affect the energy consumption of electric vehicles, which in turn affects the performance of electric vehicles. Mkahl R treats EV scheduling and proper distribution to charging stations (CS) as an optimization problem, which is expressed as a linear programming problem. The distribution of EVs should meet certain constraints related to CS status, EV conditions, and traffic conditions. Two operating modes of the system will be considered to illustrate the proposed

method. EV is assigned to CSs for the second mode under normal conditions (driving without electrical accessories, no slope and traffic jams on the road, etc.) and disturbance conditions [10]. The availability of charging infrastructure forms the basis for the mandatory market penetration of electric vehicles. Baresch M studies the distribution of future charges to various charging stations, and provides a starting point for assessing the demand for charging infrastructure, that is, the number, design, and cost-effectiveness of charging infrastructure. For the Austrian case study, a new method was applied to derive the allocation of the charging process by using demographic variables and decision rules. It was found that 88% of the expenses were paid when the user was at home [11]. The lack of public charging infrastructure is often referred to as an important obstacle to the popularization of electric vehicles. Since the construction of charging stations is a costly task, the question is how to maximize the benefits for potential users with limited resources. Therefore, Globisch J analyzes the factors that affect the attractiveness of public charging infrastructure from the perspective of potential users. Most car drivers are unwilling to pay basic fees for the possibility of using public charging infrastructure. Nevertheless, there are still some sub-groups that pay more attention to public charging infrastructure than other car drivers [12]. It is of practical significance to study the planning of electric vehicle charging infrastructure under the background of big data.

This article first introduces the basic knowledge of electric vehicle charging, how to build a charging system, and the basic knowledge of charging system charging. According to the statistical results of an electric truck, the total number of charging piles required by the city is calculated, and the total charging amount is divided into each control area according to the system status of the control area. Divide the proposal, calculate the billing requirements of each plot according to the characteristic indicators and traffic indicators, select the appropriate proposal to set up the aggregation, and determine the selected aggregation number according to the payment requirements. Finally, the convenience index confirms the validity of the design concept.

2. Electric Vehicle Charging Infrastructure Planning under the Background of Big Data

2.1 Charging methods of electric vehicles

(1) Slow charging

Slow charging is also called regular charging. The charging capacity is small and the charging time is long. Generally, it lasts for more than 5 hours, sometimes about 10 hours, and the voltage requirements are not high [13-14]. This charging method has few resources and low investment and labor maintenance costs. Most residents use this method to charge. Slow charging can help extend the battery life of electric vehicles and improve the charging performance. At the same time, because the charging time is too long, Unable to respond to emergencies during travel. Slow charging kits are generally installed in parking spaces in residential areas and factories [15].

(2) Semi-fast charging

The charging capacity is half-fast charging between slow charging and fast charging, and the charging time is balanced. Due to the use of AC charging, the charging capacity is higher than slow charging, which not only reduces the delay time of user charging, but also reduces the huge impact of DC charging on the network. At present, the charging capacity of semi-fast charging is 40kW, and BYDE6 needs 2 hours to charge 300 kilometers. This method is used for charging and using industrial electricity bills, so the final charging cost is higher than slow charging. Half-room charging kits are generally used as public charging equipment and installed in roads, shops and other places.

(3) Fast charging

The charging speed is a high-current charging method, and the charging current can reach 250A. Using direct current, the battery power can reach more than 80% in 2 hours, and the charging speed is fast, providing users with efficient and fast charging functions, covering high travel needs, and helping the popularization and application of electric vehicles. This charging method will gradually reduce the battery performance and increase the mute voltage. Therefore, when charging the charger faster, a corresponding charging device is required. In addition, the fast charging bag has a high investment cost and is only suitable for installation in charging stations. It has high requirements for construction and technical safety. The performance of the three charging methods is shown in Table 1.

Table 1. EV charging mode standard

Model	Voltage/V	Current/A	Charging time/h
Slow charging	Single phase 220	16/32	5-10
Semi-fast charging	Three phase 380	32/63	1-3
Fast charging	DC 750/1000	80/125/200/250	0.33-2

2.2 Construction mode of charging facilities

(1) Distributed charging pile

Distributed collection packages have no fixed functions, including heavy load for specific users, distributed load packages, aggregate load packages, and similar packaging models. Although the size is often small, but the connection is strong, such as shops, structures, parks and other areas are built with distributed charging piles, and the workmanship stability is high. It also has its shortcomings, some of the main components of the charging device are difficult to maintain. At present, some companies and departments are also trying to develop time-sharing leasing of special charging piles, which can be leased to foreign cars at a specific time or for free to reduce resource loss and increase charging.

(2) Centralized charging pile

Take the isolation of centralized charging and conversion stations in the charging equipment development guide provided by our country as an example. The current downtown charging stations include bus charging stations, rental charging stations, health logistics charging stations, public buildings and fast charging stations in the center.

2.3 Planning of electric vehicle charging facilities

The layout and location of charging facilities is an important part of the planning of charging facilities, and the following principles should be followed:

(1) Layout principle

The distribution of charging equipment in different regions should be consistent with the distribution of local electric vehicles, taking into account the strikes and driving routes of electric vehicles. According to the technology and use conditions of electric vehicles, and for the diversity of charging materials, different charging systems should work together to adapt to the charging

requirements of electric vehicles. The charging device should conform to the operating characteristics and network capacity of the distribution network, and should not reduce the reliability of the primary power supply.

(2) Principles of site selection

The location of the charging equipment should meet the requirements of environmental protection and fire safety, and the connected transmission, fire protection, and water supply and drainage equipment should be regularly and properly set up, and the aforementioned adjacent materials should be fully utilized. The choice of space should consider the safety of electricity and avoid dangerous sources such as flammable, explosive, and debris. The battery replacement stations and charging stations in the suburbs are as close as possible to the main roads of the city, while avoiding car traffic as much as possible to reduce road power. At the same time, it can be combined with the construction of charging facilities such as high-speed industrial zones and urban roads along the line. Billing facilities should use existing parking spaces, including public buildings, residential buildings, and industrial and institutional parking spaces.

(3) Planning steps

The programming steps of the charging application can be carried out step by step on the basis of the above content. First analyze the existing charging equipment, and then estimate the car ownership, select the appropriate charging and exchange methods, and estimate the total charging cost of electric vehicles in the area. After receiving the forecast data, formulate a plan, coordinate with the network design site, and reach an agreement. If it fails, the system must be redesigned. Finally, based on the above results, complete tasks such as default and program review.

3. Investigation and Research of Electric Vehicle Charging Infrastructure Planning under the Background of Big Data

3.1 Data background description

The experimental data used in this article comes from the national new energy vehicle monitoring and management platform, which has the ability to monitor and manage millions of new energy vehicles at the same time, and truly and reliably obtain "production, sales, purchase, and service". New energy vehicles. By applying for the National New Energy Vehicle Monitoring and Management Platform, part of the electric vehicle parking data set in City M from January 1, 2021 to January 31, 2021 is obtained. The data segment types are specifically divided into parking and charging segment parking behavior fragments (hereinafter referred to as charging fragments); vehicle types include private

passenger cars, online passenger cars, and leased passenger cars.

3.2 Data preprocessing

When the detection management platform collects electric vehicle operating data, the collected vehicle data will be affected by unstable communication signals (for example, the vehicle is in an underground parking lot), communication transceiver terminal failure, and occasional omissions in the data storage process. This unstable data will lead to a decrease in the accuracy of the next electric vehicle charging demand forecast. Therefore, before creating various models based on these data, the original data needs to be preprocessed. It should be noted that all the data analysis tasks in this article are done using the python programming language, as shown in Figure 1.

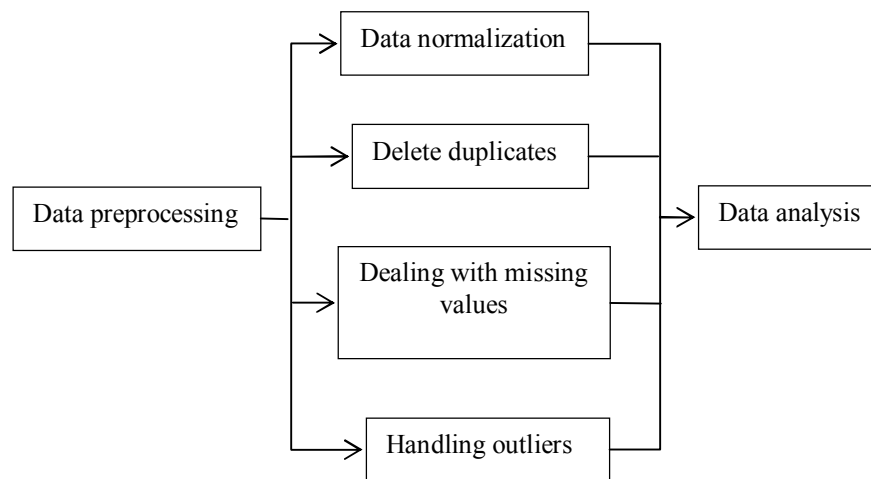


Figure 1. Data processing flowchart

3.3 Region selection

Take the location planning of electric vehicle charging facilities in a certain area of M city as an example. This area is a rectangle with an area of 5*5km², containing different types of lots, and

their land price costs are different. The number of electric vehicles distributed on a gathering point is between 30-100, and the spatial distribution of electric vehicle gathering points is shown in Figure 2.

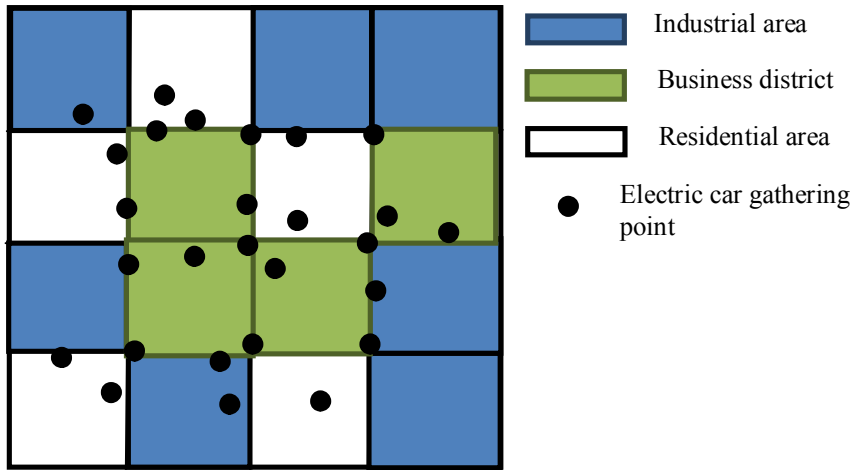


Figure 2. Distribution of gathering points

for electric vehicles

3.4 Planning and layout model of charging infrastructure

The important purpose of building charging infrastructure is to maximize revenue. The revenue of charging stations is mainly social revenue C_e and electricity sales revenue C_B . The expenditure part includes the average annual construction cost C_c , operating cost C_r , and the loss of electric vehicles to the charging station. Cost C_s , etc., taking the above factors into consideration, the income function can be expressed as:

$$\max C = C_e + C_B - C_c - C_r - C_s \tag{1}$$

Among them: the annual electricity sales revenue of the charging infrastructure is composed of the number of electric vehicles and the number of charging times from each electric vehicle to the charging station, the amount of electricity per charge and the charging price p_c , and the grid electricity price p_w :

$$C_B = \sum_{i=1}^n \sum_{j=1}^m \frac{fQM_{ij}}{\eta} (P_c - P_w) \tag{2}$$

The annual operating costs of charging stations mainly include line loss costs, equipment maintenance costs, and staff salaries. The expression is as follows:

$$C_r = \sum_{i=1}^n (\alpha C_{Bi} + \varepsilon C_{Qi} p_w) \tag{3}$$

Among them: α is the ratio coefficient of equipment maintenance costs and staff salaries to the income of the charging station; ε is the grid line loss rate of the charging station, which is related to the charging capacity of the charging station.

The benefits of electric vehicle charging infrastructure include economic benefits and social benefits, and the economic benefits can be calculated from the electricity sales. Social benefits mainly refer to low-carbon benefits. In order to maximize the benefits of charging facilities, it is necessary to reduce costs and expenses, as well as factors such as user distance.

4. Investigation and Analysis of Electric Vehicle Charging Infrastructure Planning under the Background of Big Data

4.1 Electric vehicle charging demand forecast in each functional area

Assuming that the charging power is constant and the charging efficiency is constant, the charging prediction results of each typical functional area are calculated separately. The first is a typical residential area. After data analysis, the average daily

traffic flow in this area is about 338 vehicles, and there is not much difference in traffic flow between workdays and rest days. At present, the proportion of private charging piles is about 53%. This article only considers the charging demand of electric vehicles that do not have private charging piles. The forecast results are shown in Table 2.

Table 2. Distribution of daily average charging demand in residential areas

Time/h	Working day	Off day
4	3	6
8	246	225
12	133	259
16	177	243
20	378	256
24	5	3

It can be seen from the predicted load curve that there are some differences in the distribution of peak and valley values due to different travel habits on working days and rest days. On weekdays, users need to work, the travel rules are relatively similar, and the arrival time is also close. Charging demand is most concentrated when approaching 20 o'clock in the evening; while on rest days, the arrival time of users is relatively scattered, the peak charging value is relatively reduced, and the peak-to-valley value gap is reduced.

The traffic flow in the commercial area is much larger than that in the residential area. After data analysis, the average traffic flow in the typical business area during working days is about 355 vehicles, and the average vehicle flow during rest

days is about 428 vehicles. The charging demand forecast results are shown in Table 3.

Table 3. Distribution of daily average charging demand in commercial districts

Time/h	Working day	Off day
4	3	6
8	545	325
12	128	489
16	109	343
20	348	436
24	4	23

It can be seen from the predicted load curve that there is a significant gap between the peak and valley values of working days and rest days. On working days, there is obviously a peak in charging demand around 8:00 in the morning. Most of these users are employees working in commercial areas, and their charging demand gradually declines; the proportion of users who come to consume before the rest days increases, and the peak charging demand is relatively scattered. It is distributed between 8:00 and 20:00.

The traffic flow in the industrial zone is also relatively large, but different from the commercial zone, the traffic flow in the industrial zone on working days is larger than that on rest days. After data analysis, the average traffic volume on working days in this typical industrial zone is about 365 vehicles, and the average traffic volume on rest days is about 250 vehicles. The charging demand forecast results are shown in Figure 3.

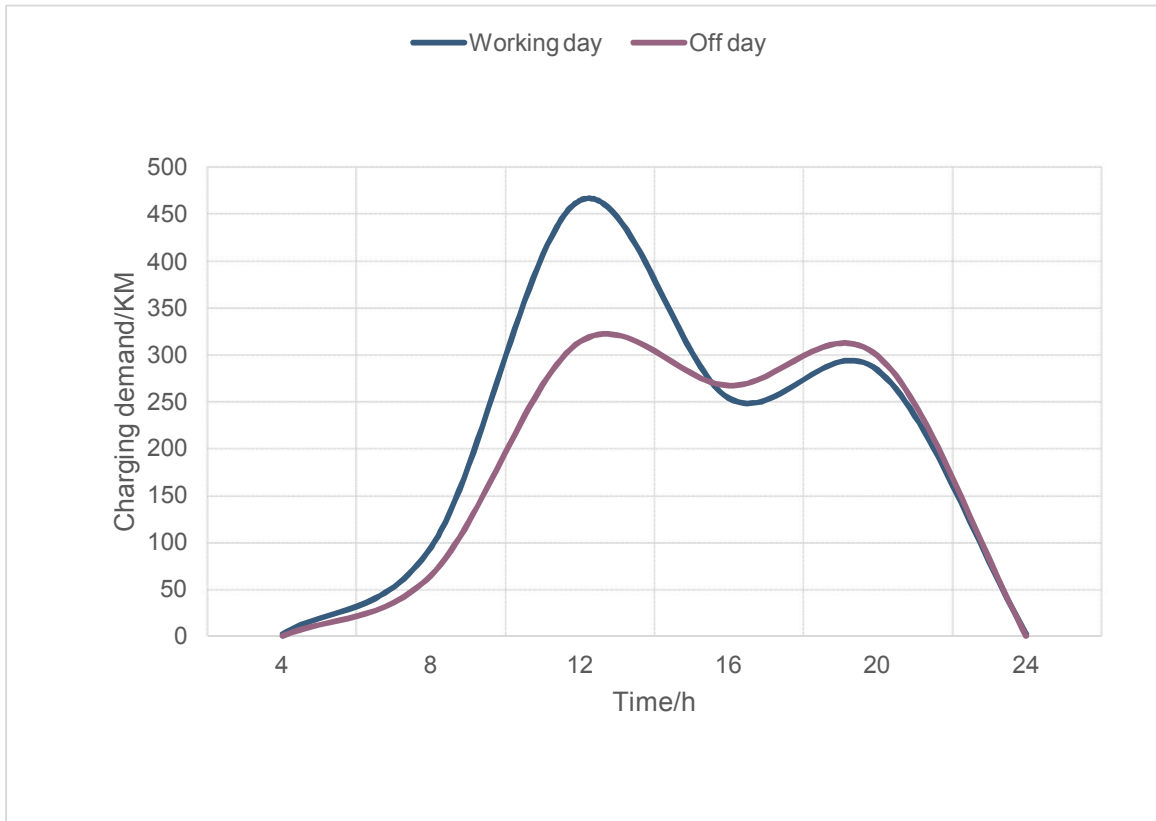


Figure 3. Average daily charging demand in industrial areas

It can be seen from the predicted load curve that the trends in industrial areas and commercial areas are similar, but the total charging demand on workdays is higher than on rest days. On working days, there is obviously a peak of charging demand around 8:30 in the morning. Most of these users are employees working in industrial areas, and there is still a small peak at around 20:00 in the evening; the charging demand on rest days has been greatly reduced as a whole. The reason is that the number of users who come to work before the rest days has decreased, and the peak demand for charging is relatively scattered between 12:00 and 20:00.

4.2 Calculation examples

The area is divided into 16 small areas according to location and nature. The unit price of land acquisition is shown in Table 4. The charging rate of different levels of charging stations is set to $S_{max}=0.03$. In order to meet the requirements of the maximum simultaneous charging of charging piles, the number of charging stations to be built it is $5 \leq n \leq 15$. Assuming that the charging station has been operating for 20 years, the annual recovery rate is

0.1, the maximum distance between charging stations $d_{max}=5Km$, $Q_{cs}=0.8*Q_c$, by reducing line loss and improving the charging efficiency factor, respectively $\eta_1=0.05$, $\eta_2=0.05$, the current year's The carbon credit transaction price of PET is 100 yuan/ton, the PCDM transaction price is 50 yuan/ton, and the carbon allocation benchmark for substations is 0.35 tons of CO2/MWh. For example, BYD E6 electric vehicle is selected, and each charge is 80% of the total capacity.

Table 4. Land acquisition prices of different types of land

Land nature	Industrial area	Residential area	Business district
Land acquisition unit price (yuan/m ²)	1500	3500	8845

Algorithm parameter selection: select the population size to be 300, the number of iterations is 400, the cross factor is 0.5, the scale factor is 0.9, and each value is calculated 20 times.

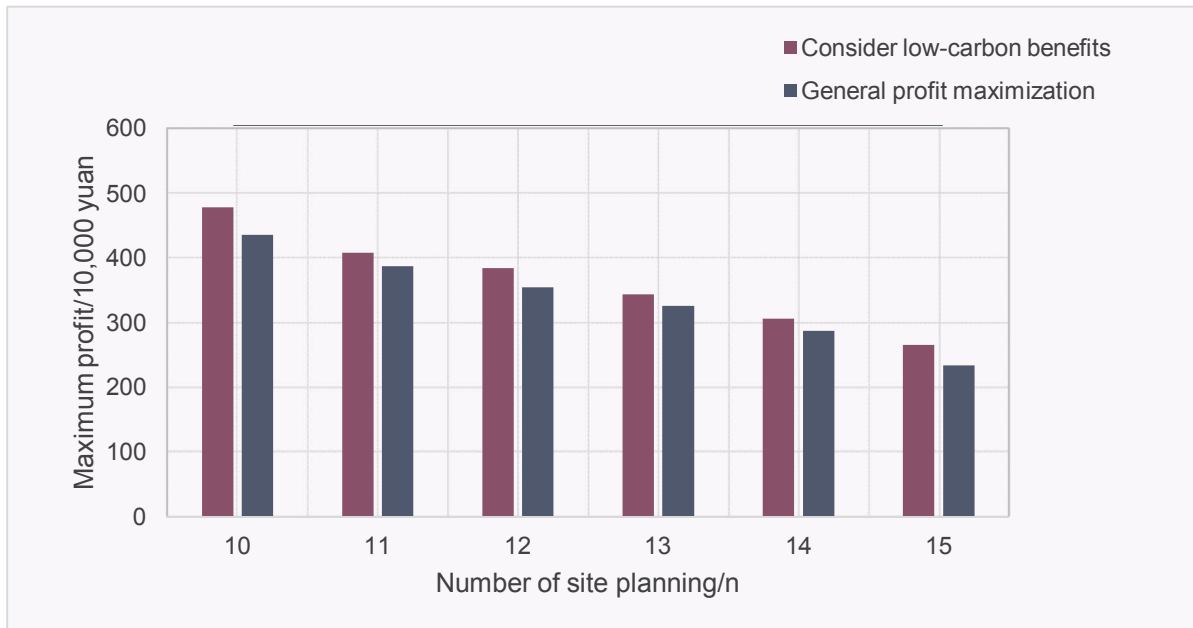


Figure 4. Benefits considering low-carbon benefits and only considering economic benefits

Figure 4 shows the comparison between the layout planning situation that comprehensively considers low-carbon benefits and only considers economic benefits. It can be seen from the figure that as the number of charging infrastructure increases, the space options for main benefits and planning economic benefits will only weaken. Site selection of charging infrastructure and comprehensive observation of low-carbon emission benefits. Since the distance is related to the frequency of use of charging station users, the charging infrastructure is built to make the charging station closer to the power source and increase the charging power. Frequency of charging station users. It not only promotes the improvement of economic efficiency, but also improves the efficiency of low-carbon emissions of power stations. Most importantly, the increase in charges for infrastructure services has made it easier for people to use electric vehicles and encouraged people to buy more electricity. In the future, electric vehicles will help save energy and reduce carbon emissions.

This example shows that considering low-carbon benefits can increase the total revenue of charging stations, which verifies the effectiveness of the model. Find the number of charging facilities when the total social cost in the charging station is the smallest. The specific results are as follows: A total of 15 60kW fast charging facilities need to be built in this residential area. With the increase in the number of charging facilities, the investment cost in the station

increases, while the total time cost of the user decreases, and the utilization rate of the device also decreases. A total of 14 60kW fast charging facilities need to be built in this commercial area. A total of 10 60kW fast charging facilities need to be built in this industrial zone. After obtaining the configuration results of each typical functional area, the device utilization rate of the charging facilities and the queuing time of electric vehicles in each charging station are obtained by simulation, as shown in Table 5, which all meet the corresponding constraints in the charging network planning process. The method is effective and feasible.

Table 5. Simulation and verification results of charging station operating indicators

Charging station type	Equipment utilization	Whether it meets the planning target
Residential charging station	0.51	Satisfy
Commercial District Charging Station	0.25	Satisfy
Industrial area charging station	0.41	Satisfy

5. Conclusions

With the urgent need of mankind to improve the local environment and the rapid development of electric vehicle technology, the whole society has an

increasing demand for charging equipment. At the same time, with the increase in car charging applications, the scale of the power grid will be larger, and the impact on the power grid will become more and more significant. This project is based on the current framework and construction process of urban vehicle charging facilities at home and abroad, combined with the current situation of urban traffic in my country and the growth of electric vehicles in the automobile market, and conducts in-depth research. The location of the built-in car charging device. The main purpose of the research is to analyze the charging requirements of electric vehicles and the functional characteristics of charging devices, investigate the relevant requirements of public vehicle charging behavior, plan site selection and control site design power. Providing technical guidance and decision support for the construction of electric vehicles and public transportation charging facilities is the future of our city.

References

- [1] Berger M, Kocar I, Farantatos E, et al. Modeling of Li-ion battery energy storage systems (BESSs) for grid fault analysis. *Electric Power Systems Research*, 2021, 196(6): 107160.
- [2] Srivastava S, Upadhyay A. India mulls law change to boost electric car charging stations. *International Environment Reporter*, 2018, 41(2): 145-146.
- [3] Starn J. Vattenfall to challenge tesla and shell in electric car charging. *International Environment Reporter: Reference File*, 2018, 41(5): 321-321.
- [4] Bhatti J. Germany clears the way for easier electric-car charging for drivers. *International Environment Reporter*, 2017, 40(10): 586-586.
- [5] Ramakrishna S, Davis K L. Supercharging your CAR. *Blood*, 2020, 135(9): 593-594.
- [6] Martinez-Lao J, Montoya F G, Montoya M G, et al. Electric vehicles in Spain: An overview of charging systems. *Renewable and Sustainable Energy Reviews*, 2017, 77: 970-983.
- [7] Globisch J, Ploetz P, Duetschke E, et al. Consumer preferences for public charging infrastructure for electric vehicles. *Transport policy*, 2019, 81: 54-63.
- [8] Du J, Mo X, Li Y, et al. Boundaries of high-power charging for long-range battery electric car from the heat generation perspective. *Energy*, 2019, 182: 211-223.
- [9] Holloway H. Charging towards the future: how to handle the EV revolution. *Autocar: Frist for New Cars*, 2017, 293(5 TN.6266): 17-17.
- [10] Frendo O, Gaertner N, Stuckenschmidt H. Real-time smart charging based on precomputed schedules. *Smart Grid, IEEE Transactions on*, 2019, 10(6): 6921-6932.
- [11] Baresch M, Moser S. Allocation of e-car charging: Assessing the utilization of charging infrastructures by location. *Transportation Research Part A: Policy and Practice*, 2019, 124: 388-395.
- [12] Mkahl R, Nait-Sidi-Moh A, Gaber J, et al. An optimal solution for charging management of electric vehicles fleets. *Electric Power Systems Research*, 2017, 146: 177-188.
- [13] Zhu L P. Research on the application of PPP Model in the Chinese construction and operation of new energy vehicle charging facilities. *AIP Conference Proceedings*, 2017, 1839(1): 1-3.
- [14] Wang H, Zhao D, Meng Q, et al. A four-step method for electric-vehicle charging facility deployment in a dense city: An empirical study in Singapore. *Transportation Research Part A: Policy and Practice*, 2019, 119: 224-237.
- [15] T D, Chen, Kockelman K M, Khan M. Locating electric vehicle charging stations: parking-based assignment method for seattle, Washington. *Transportation Research Record*, 2018, 2385(1): 28-36.

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