Research on Planning and Layout of Electric Vehicle Public Charging Piles in Historical and Cultural Street Based on Big Data

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Abstract: Nowadays, with the development and popularization of electric vehicles, electric vehicle charging pile has become an important green infrastructure in cities. The optimization of the layout of charging piles in the urban area has drawn the attention of more and more research groups. However, only a few of them concerned the distribution of piles in the historical distinct. In this paper, we proposed to use big data tools to obtain parking and electric parking space information, such as the parking lots, on-street parking spaces and plazas. We tried to transform them with the charging function. we also proposed a “P + W” mode, which takes advantage of the present parking lots and street parking area. We wanted to optimize the current layout and offer a new layout plan for further research and application.

1. Introduction
With the development of cities, the commuting distance of citizens has been increasing year by year. More and more residents selected private cars to commute nowadays. As a result, the overall number of vehicles was increasing dramatically year by year, followed by countless related problems. The oil was drying up, and the air was being polluted as well as humans’ health. The electric vehicles and the “zero emissions” transportation had great significance in alleviating atmospheric pollutants such as PM2.5 in cities caused by fuel vehicles [1]. In order to solved these problems, the Chinese government began to promote new energy vehicles vigorously [2]. At present, the number of electric vehicles in China was about 3.44 million, and it was snowballing at a rate of 70% each year [3].

At present, the lack of public charging piles for electric vehicles was the main obstacle to the growth of the electric vehicles market. Due to the tight land resources, it was difficult to arrange public charging piles for electric vehicles in historical districts. The historical districts, the most meaningful and dynamic blocks in the city, carried the memory of the city and play an important role in the city's development. Therefore, it was particularly important to improve the layout of related facilities in the historical districts.

2. Overview of the layout of electric vehicle charging facilities
Developed countries started to construct the electric vehicle charging piles earlier. After years of construction, the charging conditions meet people’s demands now [4]. They remodelled the existing parking spaces and transformed them into a parking space with the function of charging electric vehicles [5]. However, in recent years, electric vehicles have been put on the agenda in China [6].
2.1. The layout of electric vehicle charging facilities abroad
The US started to build electric vehicles charging piles earlier. In 2012, electric vehicle facilities have basically covered the whole country, with a high-density distribution of electric piles in the west and an even better distribution in the east. The Japanese government implemented two charging programs based on the current situation: setting up fast-charging stations in big cities and highway service areas and set up slow charging stations in the countryside for tourists. Charging facilities in France covered all parts of the country. In Paris, charging facilities were spreading outward from the central commercial old city and the number of charging station are increasing [5]. Developed countries provided some good examples to learn. We can learn from their advances experience.

2.2. The layout of electric vehicle charging facilities in China
At present, there were two main charging modes in China, one was a large public charging station and the other was a parking lot charging pile mode. The large public charging station model occupied a large place, which mainly used in urban road and highway service stations. It could supply 10-40 electric vehicle charging places at the same time and will take 1 hour for those vehicles to be fully charged. The main disadvantage of large public charging station model was that it required a large place, high initial investment, and high requirements on the regional voltage system. In the other model, parking lot charging pile mode, the charging pile mainly combined the construction of public parking lots and on-street parking. It occupied a smaller place and had a lower investment. Due to the voltage limitation, slow charging is mainly used and it will take 5-8 hours for the vehicles to be fully charged. These methods were commonly used in the city and the layout of electric vehicle charging facilities in historical streets lacked attention.

3. Policy and related research on electric vehicle charging facilities
At present, most of the policies stipulated the layout scale and service radius of electric vehicle charging facilities from a macro perspective. There was no research conducted on the layout of charging piles in historical districts.

3.1. Relevant policies for charging facility layout
The "Automotive Industry Adjustment and Revitalization Plan" announced by the Chinese government in February 2009 indicates that a fast-charging network for electric vehicles needs to be established to accelerate the construction of charging facilities for public facilities such as parking lots. The "Development of Electric Vehicle Charging Infrastructure (2015-2020)" released in October 2015 has promoted the construction of electric vehicle charging infrastructure in China. More and more cities have also issued relevant regulations and recommendations for the layout of electric vehicle charging piles to respond to the government’s call [7].

In August 2017, the Beijing government stipulated that the service radius of charging facilities in central urban areas should not be less than 0.9Km and the charging radius of general areas should not be less than 5Km by 2020. In August 2018, Beijing required that the proportion of public electric vehicle charging facilities in urban areas should not be less than 10% of parking lots. Wuhan proposed that electric vehicle charging piles could be combined with parking spaces. With the increase of electric vehicles in Wuhan, the government proposed that the number of charging piles should reach 15,000 by 2020.

3.2. Relevant research on the layout of charging facilities
Electric vehicle charging pile was a new-born concern in the development of cities. With the development of society, they have gradually become a necessity in people's daily life. The rational deployment of electric vehicle charging facilities was the basis for urban development. Wang et al, have analysed the domestic and aboard regulations and implementation of electric vehicle charging piles related to the actual situation in Dalian. He believed that the construction of electric vehicle charging piles could be built in as ‘stations’, ‘groups’ and ‘pile’ [8]. Wang et al. have taken the central area of
Anyuan city as an example and arranged the charging piles according to public parking spaces such as transportation hubs, public parking lots, auxiliary parking lots, and on-street parking [9]. Du and Qi et al. have proposed the layout strategy of electric vehicle charging facilities by studying the impact of charging piles on the surrounding power supply load [10]. We studied the layout of electric vehicle charging piles in historical districts with the help of big data tools and the considering of accessibility. We hoped to optimize the layout and improve the construction situation of electric vehicle charging piles in historical districts.

4. Research on the layout of electric vehicle charging facilities in historical districts

4.1. The problems of the layout of electric vehicle charging facilities in historical districts

Historical districts needed to retain their original features while developing. As a new thing, electric vehicle charging pile was an indispensable part of residents' lives, and the charging piles needed to be arranged in the historical streets rationally. As an important public resource of the city, historical districts gathered lots of business, office and cultural resources, attracting a large number of people and cars. However, due to the out of date planning, the historical districts always had narrow streets which prevented adequate parking spaces. At present, the problems existing in the layout of electric vehicle charging facilities in historical districts were as followed.

4.1.1. Charging demand is difficult to predict. It was difficult to determine the number of vehicles in the historical districts timely under traditional research methods. Therefore, the difficulty of predicting the number of electric vehicle charging piles would contribute to the waste of resources.

4.1.2. Lack of charging space. The pattern of roads in historical districts needed to be protected. The buildings in the historical districts were age-old without reserved parking spaces. As the number of cars was increasing year by year, parking demand far exceeded parking spaces. Residents and tourists parked their cars not only on the square but also on both sides of the road. The crowded space would destroy the environment in historical district. Fewer parking spaces in the district also made it hard to find spaces for charging facilities.

4.1.3. Limiting charging load. Electric vehicles applied higher load to the electric system when charging. It was hard for the old and poor electric systems in the historical district to survive. The construction of large-scale charging stations would worsen the electricity load in historical districts, which would cause certain hidden dangers to safe electricity use in these areas and influence people's life. The upgrade of the electricity load in the historical districts would also face a large-scale power grid transformation, which will cause inconvenience to people's life and also resulted in large expenditures.

4.1.4. Large cost. Most of the charging facilities were privately invested in China. Historical districts located in the valuable area of the city. The price of land in these areas was usually higher than other regions, so the investment cost of setting up charging facilities in historical districts would be higher than in other regions. This situation also hindered the deployment of charging facilities in historical district.

4.2. Layout method of charging facilities in historical districts

4.2.1. Getting vehicle data via big data. The facilities were based on the number of electric vehicles. Unlike the traditional data analysis systems, big data tools could help us understand the number of vehicles, the coordinates of the parking lot, the nature of the parking lot and the number of parking spaces in the historical districts. By application of big data base, the location and number of electric vehicles charging piles combining these data with relevant policies could be determined. We would judge the rationality of the layout of the charging pile based on the service radius analysis of the electric
vehicle charging pile and the population distribution. We would add the charging piles in others way in the place with the poor conditions after planning.

Therefore, we would use the big data to get the number of vehicles, parking spaces and parking space coordinates in the historical districts timely. Applying these data and combining the existing national regulations and indicators, we could estimate the current number of electric vehicles in the current situation and determine the electric vehicle charging pile reasonably.

4.2.2. Improving charging facilities in combination with existing public parking spaces. We could equip the existing public parking spaces with the electric vehicles charging piles under the power load in historical distinct. In areas where public parking spaces were tight, the proportion of charging parking spaces could be increased, both parking and charging of vehicles could be considered in daily use. It could be used in some historical districts where public parking spaces are insufficient. We could also arrange the charging piles with squares in the historical districts. In the daytime, it would be used by people. The electric vehicle would be charged at night. Last but not least, we could increase the density of electric vehicle charging facilities near historical districts so that their service radius can partially cover historical districts.

4.2.3. Setting charging piles in combination with pedestrian streets. More cities began to take parking and walking model in their transportation system in to consideration recently. In this model, setting up a parking lot near the main transportation hub to encourage people to use public transportation. We could attract electric vehicle owners by increasing the number of parking spaces with charging facilities around pedestrian streets in historical districts in the similar way. We named it ‘the parking and walking’ model. The owner could have a good time during the charging time. This mode can also increase the attractiveness and vibrancy of historical districts.

5. Conclusion
In this paper, we analysed the layout of electric vehicles in developed countries and combined with the existing electric vehicle charging pile layout in China. We raised the difficulty in the layout of electric vehicle charging pile in historical district after analysing the limitation. At last we proposed three methods to improve the situation by getting vehicle data via big data, improving charging facilities in combination with existing public parking spaces and setting charging piles in combination with pedestrian streets.

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