Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 4, No. 2, 2022

Analysis on Site Selection of Electric Vehicle Charging Pile in Xi'an

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Abstract: Nowadays, China practices "low-carbon life", and environmental protection is the general trend. As an emerging industry, new energy electric vehicles must solve the problem of charging pile shortage in order to maintain a good momentum of development, so as to occupy a certain market share in the automotive industry. Therefore, with limited resources, it is necessary to make the distribution of charging pile more reasonable. This paper takes Xi'an city as an example to predict the best location for charging pile construction by entropy TOPSIS method in order to improve the utilization rate of charging piles, which has reference significance for the construction of charging piles.

Keywords: New energy vehicles, Electric vehicles, Charging pile siting, Expert evaluation method, Entropy weight TOPSIS method.

1. Introduction

In recent years, a series of serious environmental problems, such as global warming, atmospheric pollution, and decreasing biodiversity, have aroused the concern of the general public. One of the major causes of these problems is the emission of greenhouse gases. To reduce greenhouse gas emission, one way is to use new energy vehicles instead of fuel vehicles. New energy vehicles refer to all other energy vehicles except gasoline and diesel engines, including hybrid electric vehicles, pure electric vehicles, fuel cell electric vehicles, etc. As new energy technology and people's awareness of protecting the environment continue to improve, new energy vehicles are beginning to be favored by more and more people. The world's new energy vehicle brands are also beginning to emerge, and more and more companies are devoting themselves to the research, development and manufacturing of new energy vehicles, constantly improving the safety, range and other aspects of the performance of electric vehicles. Figure 1 shows that the sales of new energy vehicles have grown exponentially over the past decade. According to the forecast in Figure 2, China's new energy vehicle market size will continue to grow in the next three years, which is very optimistic. It is believed that more people will accept and buy electric vehicles in the future. The literature [2] points out that the Chinese government's investment in the new energy industry will continue to increase, and the new energy vehicle industry in general will continue to rise in the future.

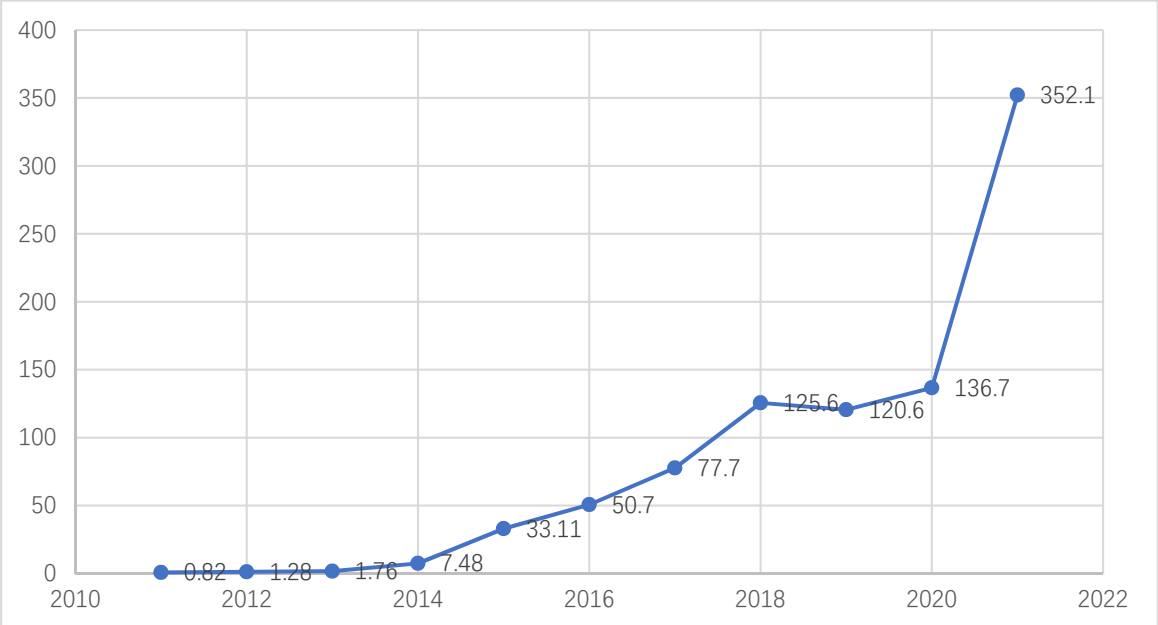

Figure 1. New energy vehicle sales in the past decade(million units)
data source: Times Business School

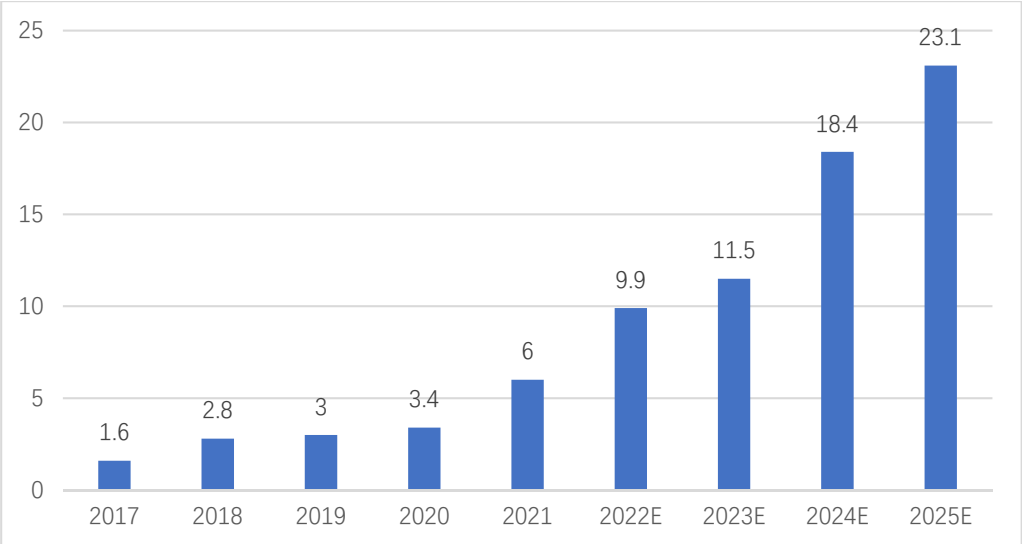

Figure 2. China new energy vehicles market size and forecast, 2017-2025 (hundreds of billions of yuan) data source: Ai Media Network

However, the increasing number of electric cars has led to a shortage of charging piles, resulting in the phenomenon of "cars without piles", which affects the sales of electric cars and creates great concern for electric cars. The literature [5] points out that the construction and operation of charging facilities face lots of difficulties, such as imperfect industry standards, difficulties in property coordination, and uneven utilization. Therefore, to build a certain number of charging piles to meet the demand in such a huge China, it requires people to plan the charging piles wisely to avoid wasting resources. This paper takes Xi'an as an example, analyzing four candidate sites by expert scoring method, entropy weighting method and other mathematical methods, which can gain the optimal site. This site selection method is also generally applicable to other medium-sized cities, so the following calculations can make full use of the limited resources and alleviate the phenomenon of "no piles for cars".

2. Analysis of Influencing Factors

2.1. Grid constraints

Some old urban areas in Xi'an cannot afford to charge many charging cars at the same time due to aging equipment and limited degree of grid load. Especially in summer, when residents use more electricity, it is easy to see how big the grid load is, resulting in local power outages, so there are still greater technical difficulties in establishing charging piles in these areas. If establishing a large number of charging pile equipment in the old city, it is inevitable that people need to upgrade or even replace the local power grid, which greatly increases the construction cost of charging piles.

2.2. Pile building cost

Building charging posts in prosperous places in Xi'an will incur larger parking space rent. Some areas may be humid, and such areas will require significant grid maintenance costs later on, as humid areas will reduce the life of the grid. Additionally, the probability of problems with the grid will increase, which will require a certain amount of maintenance staff to regularly check and ensure the safety of the charging piles.

2.3. Convenience

The establishment of charging piles in shopping malls, office buildings, and neighborhoods will greatly increase the convenience of charging for people, who can charge their electric cars while shopping and working, greatly saving time. Moreover, improving the convenience of charging electric cars will increase the sales of electric cars.

2.4. Charging cost

The cost and service fee per degree of electricity varies from region to region. In addition, as public charging posts are used, additional parking fees may be incurred during the charging process.

2.5. Charging time

In some areas, the grid meets the requirements for fast charging posts, however, in other areas, fast charging posts cannot be built. Fast charging can generally fully charge a car in one hour. By contrast, slow charging takes 6-10 hours to fully charge. Therefore, fast charging can greatly reduce charging time and facilitate people's travel.

3. Case Study

New energy vehicles in Xi'an have been developing very quickly in the past few years. With the advantages of unlimited number, environmental protection, relatively more national subsidies and lower travel costs than fuel cars, new energy vehicles are rapidly occupying a certain market share in the automobile industry. However, there are many disadvantages of new energy vehicles, which make them not as popular as fuel cars, and the sales are growing slowly after a period of surge. One of the main reasons is the charging problem of new energy vehicles. Hence, in the resource-strapped city of Xi'an, it is vital to use limited resources wisely and make the charging posts serve more people. In this paper, four candidate sites are selected for analysis. The candidate site 1 is Huimin Street, which has been under construction for a long time and has an old power grid. Therefore, a large number of fast-charging piles cannot be established, and there are large safety hazards and high costs for repairing the power grid. Candidate Site 2 is the Changan Campus of Xi'an International Studies University. The

university's demand for electric charging posts is not very high, mainly for faculty and staff. Additionally, there is no large shopping mall near the university, so the convenience level will be the biggest drawback. The candidate site 3 is Ziweilongteng New World Building, which has convenient traffic and large flow of people. Both nearby residents and office workers can use the charging piles, but charging in the area will have a larger charging cost, including parking, electricity and service fees. The candidate site 4 is Xi'an Yitian Holiday Shopping Center, which is located in a shopping mall and surrounded by a large number of office buildings with high demand for charging. It also has obvious advantages in convenience, but the parking cost will be high due to the superiority in location. We analyzed these four candidate sites by the expert evaluation method and then used a scale of 1-10 for reference scoring. The higher the value of a particular influence factor, the better the index corresponding to that candidate site.

Table 1. Scoring of factors corresponding to each site selection

Candidate site	Grid constraint	Pile building cost	Convenience	Charging cost	Charging time
1	6	7	8	7	7
2	9	9	6	9	9
3	8	8	9	8	8
4	9	8	10	7	9

These are very large indicators (efficiency indicators) and the higher the better, so no needed to matrix normalization processing.

First, standardize the data.

Table 2. Data Standardization

Candidate site	Grid constraint	Pile building cost	Convenience	Charging cost	Charging time
1	-1.4142	-1.2247	-0.1464	-0.7833	-1.3056
2	0.7071	1.2247	-1.3175	1.3056	0.7833
3	0	0	0.4392	0.2611	-0.2611
4	0.7071	0	1.0247	-0.7833	0.7833

Second, calculate the difference between each evaluation index and the optimal by the entropy weight method.

z_{ij} denotes the evaluation value of the jth indicator of the ith evaluation target.

$$D_i^+ = \sqrt{\sum_{j=1}^{m} w_j (Z_j^+ - z_{ij})^2}$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} w_j (Z_j^- - z_{ij})^2}$$

A larger D^+ value means that the farther from the optimal solution, the worse the object of study; A larger D^- value means that the farther from the worst solution, the better the object of study.

Table 3. The value of D

Candidate site	D^+	D^-
1	0.7467	0.1477
2	0.2954	0.7319
3	0.3619	0.4413
4	0.5652	0.4974

Finally, calculate the closeness of the evaluation target to the optimal solution.

Comprehensive Score Index $C_i = \frac{D_i^-}{D_i^+ + D_i^-}$

The higher the C value, the better the evaluation object.

Table 4. The value of comprehensive score index C and the ranking of candidate sites

Candidate site	D^+	D^-	Comprehensive Score Index C	Rank
1	0.7467	0.1477	0.1651	4
2	0.2954	0.7319	0.7124	1
3	0.3619	0.4413	0.5494	2
4	0.5652	0.4974	0.4680	3

Candidate 2>Candidate 3>Candidate 4>Candidate 1

From the results, the Changan Campus of Xi'an International Studies University is the most suitable for the construction of charging piles to solve the charging tension, followed by Ziweilongteng New World Building and Xi'an Yitian Holiday Shopping Center, while Huimin Street is not suitable for the construction of charging piles due to the grid constraints and other factors.

4. Conclusion

This paper analyzes the current situation, prospects and shortcomings of new energy vehicles. It focuses on the site selection analysis for the distribution of electric vehicle charging piles in Xi'an, and scores the four candidate sites in five aspects: grid constraint, pile building cost, convenience, charging cost and charging time, respectively. Matlab was used to process the data and determine the best location for the piles according to the comprehensive score index in order to reduce the investment cost.

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