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A Survey on the Development Status and Trends of New Energy Vehicle Charging Piles in Beijing: A Data Mining-based Analysis

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Abstract: New energy vehicle ownership has been growing rapidly in recent years, becoming an emerging growth point for China's economic development. The construction and promotion of new energy charging piles is not only a realistic need to cope with the energy and environmental crisis but also a strategic choice to realize the high-quality development of China's economy. Based on Beijing, this study investigates the current development of new energy vehicle charging piles, reveals the problems in the development and application of new energy charging piles in the region, and ultimately provides recommendations on the layout, operation, and maintenance of new energy charging piles, the profitability of operators, and market standards. The study aims to put forward feasible suggestions for the promotion of new energy vehicle charging piles in Beijing, which will help China's automotive industry to realize the goal of "double carbon", the transformation and upgrading of the energy structure, and the high-quality development of the economy and society.

Keywords: New Energy Vehicle Charging Pile; New Energy Vehicle; "Double Carbon" Target; Consumer Preference

1. Introduction

In the context of the global response to climate change and the search for sustainable development, China is actively promoting the efficient transformation of its energy structure. Transportation emissions have become an important source of greenhouse gas emissions, so the development of new energy vehicle (NEV) has become one of the important ways for China to achieve the "double carbon" goal [1]. In recent years, the number of NEV has been growing by leaps and bounds, which has not only become an important choice for people's daily transportation but also an emerging growth point with great potential for China's economic development, especially in the scope of foreign trade [2]. At present, the global automobile industry is in a new round of technological transformation and upgrading of the key historical stage and is facing unprecedented changes and opportunities. It can be seen that the promotion of NEV in multiple dimensions and levels shows a significant and far-reaching significance, which deserves the continued in-depth investigation and attention of the academic and industrial communities.

The promotion and popularization of NEV cannot be separated from the support of charging infrastructure, in which new energy charging piles, as the core link, are of great significance to the healthy development of the NEV industry. Charging piles are not only a bridge connecting NEV to the power grid but also an important influence on user experience and market acceptance. Although China has made certain achievements in the construction of charging piles, compared with the rapidly growing market demand for NEV, there are still problems such as uneven regional distribution, insufficient charging efficiency, and a low level of intelligence. Therefore, accelerating the layout and promotion of charging piles is not only an inevitable requirement to promote the development of the NEV industry but also an important measure to

help China realize the goal of “double carbon”. The academic community has amassed a considerable body of research findings in the field of NEV, particularly in the dimensions of consumer preferences, charging pile layout, and promotion, laying a solid foundation for further research. In addressing consumer preferences for NEV, numerous scholars have employed a variety of methodologies to conduct in-depth analyses of the purchasing behavior of electric vehicle users. For instance, Wang Yuehui and Wang Qing (2013) utilized an integrated theoretical framework of TAM and TPB to explore factors influencing consumers' intentions to choose electric vehicles [3]. Researchers Li Chuang et al. selected four counties in Luoyang City, Henan Province, as their research subjects and analyzed the impact of NEV policies on potential consumers through structural equation modeling [4]. Li Wenting (2022) applied the ICLV model and Latent Class Logit model to study the purchasing behavior of electric vehicles, revealing key factors influencing user choices during the decision-making process [5]. Liu Ruoxin conducted an in-depth exploration of the factors influencing electric vehicle purchasing behavior through fuzzy-set qualitative comparative analysis [6]. Wang Ying (2020), based on the analysis results of the discrete choice model, pointed out that price is the most critical factor consumers consider when contemplating electric vehicles [7].

In the research domain concerning the charging piles of NEV, Shen Mingrui et al. (2024) analyzed the development of NEV charging facilities in the Yangtze River Delta, and proposed adaptive planning strategies [8]. Guo Lei et al. (2019) identified the shortage of charging infrastructure, high construction costs, low utilization rates, frequent malfunctions, and the difficulties electric vehicle users face in finding charging facilities as key factors limiting the development of the electric vehicle industry [9]. Researchers Yue Wei et al. highlighted the insufficiency of charging pile numbers in China [10], while Zhang Houming emphasized the issue of inefficient utilization of charging piles, noting that the utilization rates in many areas have not met expectations [11]. Huang Xueqi et al. conducted a comprehensive investment return analysis and economic benefit assessment of the entire construction and operation process of charging facilities [12].

However, the existing research still has a lot of room for improvement. On the one hand, many issues related to the operation and maintenance of charging piles have not been discussed in depth; on the other hand, there is a lack of research on consumer preferences in terms of the characteristics and functions of charging piles. In addition, based on the geographical perspective, no study has focused on Beijing and failed to analyze the status of charging piles in the region and put forward targeted and personalized promotion suggestions. In summary, the construction and promotion of new energy charging piles is not only a realistic need to cope with the energy and environmental crisis but also a strategic choice to realize the high-quality development of China's economy. This study takes Beijing as the key research area, conducts research on NEV charging piles in the region, and analyzes the current situation and problems in the development and application of new energy charging piles in the region. The study will be carried out through a literature survey, brainstorming, questionnaire survey, and field research, and the results will be processed and analyzed using SPSS, R, and other software, aiming to put forward feasible suggestions for the promotion of NEV charging piles in Beijing, which will help China's automobile industry to realize the goal of “double carbon”, the transformation and upgrading of energy structure, and the high quality of economic and social development. It aims to propose feasible suggestions for the promotion of NEV charging piles, which will help realize the goal of “double carbon” in China's automobile industry, the transformation and upgrading of energy structure.

2. Development and Problem Analysis of NEV Charging Facilities

2.1 Development Status of NEV Charging Piles

2.1.1 Development trend of NEV charging pile at the national level

China has vigorously promoted NEV charging pile construction and supportive policies, leading to a significant increase, reaching 5.209 million units by the end of 2022. At the level of annual new charging facilities, the

year-on-year growth rate of charging facilities in 2022 is as high as 142.7%, of which private charging piles have the most significant growth, which reflects the urgent demand for charging infrastructure from the public in the context of the private car purchase boom. However, private charging piles still face several problems that need to be solved during the installation process, such as the lack of fixed parking spaces, difficult property coordination, and power capacity limitations. From a technical perspective, the charging pile industry is always in a dynamic development process of continuous progress. Since 2019, the average charging power of public DC charging piles has successfully exceeded the important mark of 100kW, meeting the demand for rapid charging in high-frequency use scenarios such as highways and cab operations. In contrast, public AC charging piles, with their advantages of low cost and easy maintenance, have been stably applied in scenarios such as households and community parking lots where charging time is relatively generous, and their technological progress has focused on key aspects such as battery protection and cost optimization to improve their application value and adaptability continuously.

2.1.2 Development trend of NEV charging piles in Beijing

From 2018-2023, the number of charging piles and charging stations in Beijing shows a steady growth trend. During this period, the number of charging stations will increase by nearly 5,000, with an average of 3.28 new stations per square kilometer, taking Beijing's 16,400 square kilometers as a reference, which indicates that the penetration rate of charging facilities has increased significantly under the impetus of relevant policies. However, there is still an imbalance between charging piles and charging stations in terms of supply and demand, which needs to be addressed by exploring effective strategies. Focusing on the NEV charging pile sales industry in Beijing, the number of enterprises in the industry was in a slow-growth trend before 2021, while from 2021 to 2022, the number of enterprises showed a rapid growth trend, with the most prominent performance in Changping District, where the number of enterprises reached 711. The growth trend in the number of enterprises selling charging piles also shows the chain reaction triggered by the surge in the production of NEV.

2.2 Characteristics of NEV Charging Pile Usage and Development Dilemma

2.2.1 Characteristics of NEV charging pile use

Due to the diversity of user groups, there are significant differences in their respective needs and preferences, resulting in the diverse choices of new energy charging piles. However, in terms of general performance dimensions, charging efficiency is a factor that has attracted much attention, with up to 95.4% of users preferring fast-charging charging piles, which indicates that high-power charging piles have become the mainstream trend in the market, with the proportion of users choosing charging facilities of 120kW and above reaching 74.7%. In terms of user charging habits, most users stop charging when the SOC (remaining charge) is higher than 80%, which means that the electricity anxiety of NEV owners has been reduced, reflecting that the popularization of the public's awareness of new energy batteries has a significant effect. NEV can be divided into two categories: commercial vehicles and private cars, and the charging time of private cars is significantly longer than that of operational vehicles. From the view of charging frequency, the average monthly charging frequency of private vehicles is much lower than that of commercial vehicles. Regarding the charging period, charging of new energy private cars is mainly concentrated in the morning peak and at night, which is in line with the regular urban commuting rhythm. In terms of the location characteristics of charging piles, private cars tend to charge within 1km of their residence. If the range is narrowed down to 500m, the percentage of charging times of private cars is rather lower, which is related to the fact that there are more types of charging piles for private cars with a wider range.

2.2.2 NEV charging pile industry development dilemma

First, Beijing's NEV charging pile distribution is uneven, with urban areas and new neighborhoods having more than rural and old neighborhoods. By December 2023, China had 20.41 million NEVs, with a 40% penetration rate in first-tier cities and under 20% in rural areas. Rural areas face challenges due to population dispersion, terrain complexity, and

limited construction space for charging facilities, leading to potential resource idleness. In addition, the lack of adaptation of rural power grid systems will make subsequent operation and maintenance more difficult. Older neighborhoods, due to different construction times and standards, face high costs for installing charging piles, like line expansion, leading to fewer piles compared to newer areas and impacting the overall layout's rationality [13]. Second, in terms of charging pile operation and maintenance. As of 2023, the scale of public charging piles, charging stations, and private charging piles in Beijing is considerable. However, some areas lack production oversight, and many operators focus on building rather than maintaining charging piles, leading to issues like low. Charging spaces are often occupied by fuel vehicles, which not only reduces the charging efficiency and convenience of consumers but also hinders the NEV consumer market. Third, in the charging pile operation. Beijing's public charging pile market is dominated by a few leading companies, but high costs hinder profitability. Despite some income, the growth rate of public charging piles is suboptimal due to a low vehicle-to-pile ratio and frequent service issues, leading to losses. Even with increased revenue in 2024 for independent operators, profitability remains limited and the outlook is not promising. Fourth, in terms of charging pile market standards. Beijing's NEV charging pile market standards have not yet been standardized, and charging costs vary greatly among different operators and locations, increasing the difficulty of consumer choice and the unfairness of market competition. The non-uniformity of pile and cable jacks also greatly affects the compatibility and efficiency of charging piles. From the results of consumer satisfaction surveys, the accuracy of settlement satisfaction is low, which also highlights the negative effects of the non-uniformity of market standards.

3. Beijing NEV Charging Pile Questionnaire and Field Research

3.1 Key Factor Mining Based on Questionnaire Research

This study takes the users of NEV in Beijing as the research object, designs and optimizes the questionnaire, and conducts an in-depth analysis of the users' charging behavior and charging demand by summarizing the valid questionnaire data. The study specifically analyzes consumers' charging habits and preferences, as well as the actual use of charging piles reveals the differences in charging infrastructure between different regions (old and new neighborhoods, urban centers, and suburbs), and identifies current problems.

3.1.1 Sample distribution

A total of 115 surveys were conducted, with a 97.3% response rate. Among them, the age group of 41~50 years old accounted for the highest proportion of 37.39%, followed by 51~60 years old with 20%, and the sample as a whole was middle-aged. In terms of annual income, those with an annual salary of less than 100,000 (inclusive) accounted for the highest proportion, at 53.91%. In terms of geographic location, most respondents are often active in first-tier cities in China, accounting for 58.03%, which is in the region of high density of NEV.

3.1.2 Reliability and validity test

In this data analysis, the Alpha Reliability Coefficient method was applied to test reliability, yielding a Cronbach Alpha of 0.853, indicating good reliability and credible results. Validity was assessed with KMO and Bartlett's tests, yielding a KMO value of 0.861 and Sig=0.000, suggesting good validity and valid results.

3.1.3 Descriptive statistics

The descriptive stats (Table 1) show the smallest variance (0.101) for the question on improved facilities encouraging new energy vehicle (NEV) purchases/repurchases, indicating strong agreement on the need for better-charging infrastructure. Specifically, 65.52% want remote charging control via an app, and 55.17% prefer scheduled charging, highlighting high expectations for charging convenience and intelligence, which could boost NEV adoption.

The issue with the highest variance, reaching 1.567, pertains to the duration of charging, revealing significant differences in user requirements for charging time. 31.03% of vehicle owners indicated that a single charging session exceeds 4 hours, while 27.59% prefer to keep the charging time within 1 hour. Such discrepancies may be associated with the charging efficiency of the charging piles, the

occupational characteristics of vehicle owners, and their daily scheduling arrangements. Therefore, to meet the demands of diverse users, the construction and management of charging piles should consider providing a variety of charging options, including both fast and slow charging facilities.

In the analysis of the level of awareness regarding charging pile information, the study found that the majority of respondents lack sufficient knowledge about charging piles. Specifically, 46.09% of respondents expressed unfamiliarity with the types of charging piles, while 45.22% had some understanding, indicating substantial room for improvement in the dissemination of information about charging pile types. Regarding national policies on charging piles, over half of the respondents (47.83%) indicated unfamiliarity, and the proportion of those with some or extensive understanding was relatively low, suggesting that the promotion and outreach of policies require enhancement. In terms of the installation and usage costs of charging piles, the vast majority of respondents (61.74%) expressed unfamiliarity, demonstrating a clear deficiency in cost transparency and the dissemination of relevant information. Regarding the safety hazards of charging piles, the proportions of respondents with some understanding and those unfamiliar were comparable, with a relatively small number of respondents having a high level of understanding, indicating a need for greater investment in charging pile safety education. Over half of the respondents (59.13%) were unfamiliar with the quantity and distribution of charging piles in Beijing, with a low proportion of those who were well-informed, suggesting that there is significant room for improvement in the popularization and public disclosure of charging piles infrastructure.

Survey data shows that the most important factors for NEV charging pile purchase and use are installation price and maintenance costs (5.14), followed by safety (5.03) and charging speed (4.97). Policy subsidies (3.21) are less significant, while compatible EV brand diversity (2.46) and operational management (2.4) are relatively unimportant. Brand reputation (2.22) is the least influential. These rankings inform market positioning and policy-making for charging piles, highlighting key consumer considerations.

Table 1. Summary of Descriptive Statistics

Title	Average value	Misalignment	Variance
Type of electric piles	1.69	.765	.585
Level of policy understanding	1.67	.769	.592
Installation costs	1.57	.849	.722
Safety hazard	1.72	.767	.589
Status of distribution	1.52	.742	.550
Number of charging piles	1.54	.830	.689
Fast-slow	.67	.769	.592
Vehicle owner	.22	.414	.172
Charging time length	.63	1.252	1.567
Charging time distribution	.60	1.241	1.540
Charging locations	.37	.753	.567
Equipped with additions	.32	.656	.431
Issue prioritization	.62	1.167	1.361
Expectation of a solution	.42	.772	.596
Aspects to be improved	.49	1.173	1.375
Public-private	.80	.638	.407
Occupancy by oil tankers	.54	.501	.251
Purchasing factors	2.29	1.176	1.382
Development proposals	1.58	1.068	1.140
Comprehensive	.89	.318	.101

Survey data on NEV charging pile usage reveals that most charging occurs in the evening (18:00-24:00), with sessions often over 1 hour, peaking in residential and public parking areas. Key issues cited are high costs, overcrowding, and long charging times, impacting efficiency and user experience. Respondents recommend increasing public charging pile availability, improving technology to reduce charging times, and standardizing charging to foster development. They also highlight the need for better management and planning, as 53.91% report fuel vehicles occupying charging spots. These insights are crucial for enhancing charging pile

services and meeting user demands.

3.1.4 Extrapolation statistics

From the statistical results, it can be seen that vehicle owners who charge in residential areas and public parking lots dominate (a total of 79.49%), while 82.76% and 72.41% of respondents believe that additional charging posts should be installed in residential areas and public parking lots. The t-test (Table 2) shows that there is a significant difference between the two locations in terms of charging time. There were significantly more charging hours in the residential area than in the public parking lot. The intensive charging periods in the public parking lot were earlier than in the residential area.

Table 2. Results of T-Test for Charging Time Length, Charging Time Distribution Regarding Charging Area

	Charging area	M±SD	t	p
Charging time length	residential areas	3.05±1.050	3.878	0.001
	public parking lot	1.43±0.535	3.878	0.001
Charging time distribution	residential areas	2.65±1.461	1.085	0.288
	public parking lot	2.00±1.000	1.085	0.288

To ascertain the factors influencing charging duration, a linear regression analysis was employed to process the survey data, with the results presented in Table 3. The classification of fast and slow charging piles emerged as the primary factor affecting charging duration. The classification significantly and positively impacts the charging time, indicating that fast charging piles can substantially reduce the charging duration compared to slow charging piles, which holds significant importance for enhancing charging efficiency and meeting the rapid charging demands of vehicle owners. The number of charging piles, their public or private attributes, and the situation of fuel vehicles occupying charging spots were found to have no significant impact on charging duration.

Table 3. Results of Linear Regression Analysis

Model		Unstandardized coefficient Standard deviation B		Standardized coefficient Beta	t	Significance
1	(Constant)	0.622	0.271	-	2.299	0.023
	Quantities	-0.206	0.138	-0.136	-1.486	0.041
	Fast-slow	0.555	0.177	0.341	3.126	0.002
	Public-private	0.028	0.216	0.014	0.129	0.897
	Occupancy	-0.120	0.228	-0.048	-0.525	0.601

3.2 Analysis of Factors Constraining the Development of New Energy Charging Piles Using System Dynamics

The field research conducted for this study employed a sampling survey methodology to investigate NEV charging piles across five districts of Beijing, namely Chaoyang, Haidian, Xicheng, Shijingshan, and Fangshan. Within each selected district, five areas were randomly chosen, and a site with a high concentration of charging piles was examined. The survey focused on two primary dimensions: "Basic Information" and "Service Capability," and a field research information collection form was devised to include key details such as the type, quantity, geographical location, charging efficiency, failure rate, and issues present at the charging piles.

A system dynamics model was subsequently constructed. This model encompasses various dimensions of factors constraining the development of charging piles, including the operational mode of charging piles, pile malfunctions, operational pricing, and distribution. It aims to quantify the interplay and feedback mechanisms among these factors, thereby providing decision support for the planning and optimization of charging piles. The causal loop diagram illustrating the constraints on the development of new energy charging piles is depicted in Figure 1, and the stock and flow diagram of the same constraints is presented in Figure 2.

3.2.1 Type and layout of charging piles

Due to the limitations of electric circuits and other infrastructures, most rural areas and old residential areas are mainly installed with slow-speed charging piles, while some newly-built residential areas and mixed-use office buildings are equipped with both fast and slow-speed charging piles. Among public charging stations, most are equipped with fast charging piles, and a few are equipped with both fast and slow charging piles, but the utilization rate of slow charging piles is low.

During the study, it was found that the power of slow-speed charging piles was generally about 7 kW, while about 85% of fast-speed charging piles had a maximum power of 50 kW or more. In fast charging piles with power exceeding 50 kW, 70 kW power models accounted for a larger proportion. In addition, the number of charging piles in residential areas close to charging stations is low, and some are not even installed, while fast charging piles in charging stations are more popular among consumers. Therefore, the improvement of Beijing's charging infrastructure will probably take fast charging piles in public charging stations as the main development direction. How to optimize the layout and improve the efficiency of resource utilization has become a key issue that needs to be explored in depth.

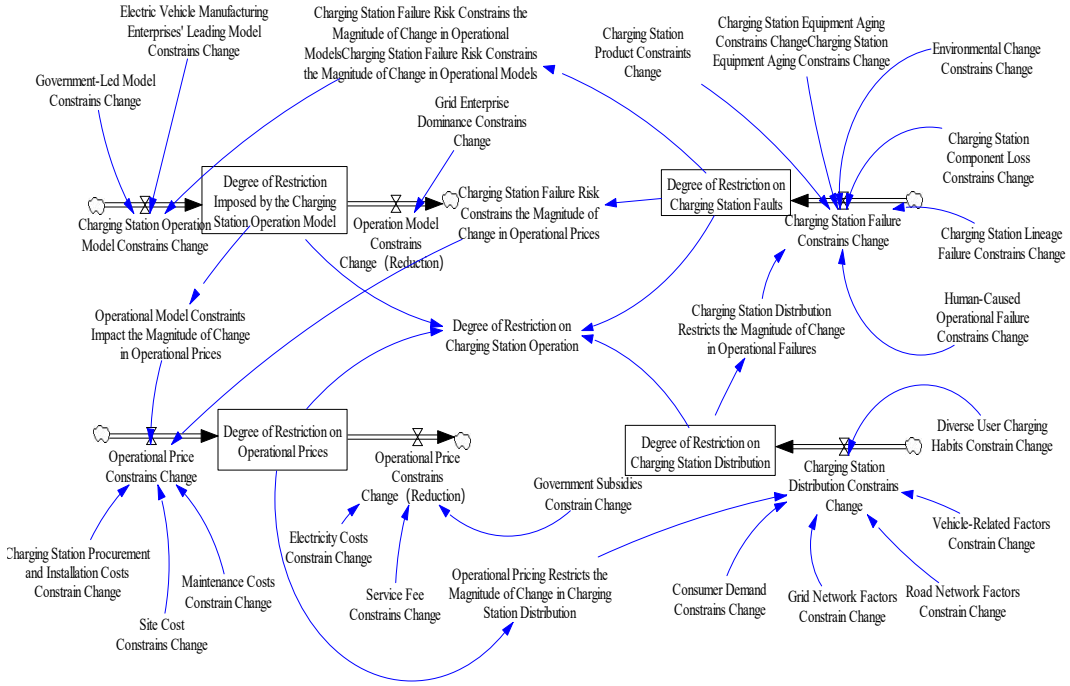

Figure 1. Causal Loop Diagram of Constraints on the Development of New Energy Charging Piles

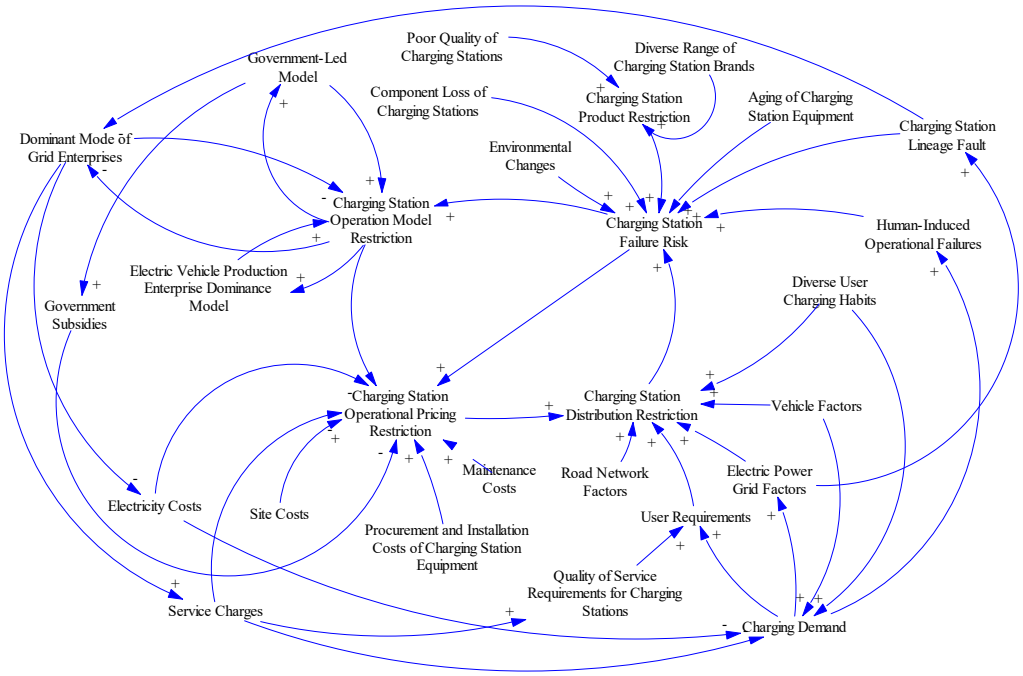

Figure 2. Stock and Flow Diagram of Constraints on the Development of New Energy Charging Piles

3.2.2 Operation and maintenance management of charging piles

In terms of operation and maintenance management of charging facilities, there is the problem of delayed updating of the status of some charging piles, resulting in some charging piles that are no longer available for use still being shown as business status in the APP, which may cause inconvenience to consumers' use. In addition, some charging piles have physical damage such as cracked rubber handles or lack the necessary fire fighting and first aid measures, posing safety risks, and this information is not clearly labeled in the APP. Regarding the daily management of charging piles, the occupancy of private charging piles in residential areas is not serious due to restricted vehicle access. However, public charging piles generally have some degree of occupancy problems, with occupancy rates generally ranging from 0% to 20%. A few public charging piles located near neighborhood entrances have been occupied by fuel vehicles for long periods of time, with occupancy rates of up to about 40%, and are plagued by problems such as neglected surveillance cameras and missing contact information for those responsible for their management. Restoring these charging piles will help ease the high demand for charging facilities in Beijing.

3.2.3 Charging pile supporting services and brands

In the field of private charging piles, brands show diversification and a need to achieve standardization and integration, and these charging piles are mainly provided with the supporting services of NEV manufacturers or produced by well-known manufacturers such as Te Laidian, National Grid, and Shell. Public charging piles, on the other hand, are mainly configured by the State Grid, demonstrating a high level of standardization and normalization. Most charging piles have realized interconnection with associated apps and provide free parking services during charging, but the existing apps are relatively single-functional and lack interaction with consumers, so the future should be devoted to the diversification of functions and the improvement of the accuracy of the positioning of charging piles. As the number of NEV users grows, the demand for charging services of different types of users in different scenarios shows differences, and the provision of differentiated charging services has become one of the challenges for the development of NEV charging piles.

4. Conclusion

This study, based on field survey data of NEV charging piles in Beijing, comprehensively employs descriptive statistical analysis, inferential statistical testing, and system dynamics modeling to delve into the influencing factors of NEV charging pile purchase and usage, user demands, and development constraints. The findings reveal key issues and factors in the development of charging piles and provide a scientific basis for their planning, construction, and management.

Firstly, the development of the NEV charging pile industry in Beijing is primarily confronted with four challenges: uneven distribution of charging piles, significant operational and maintenance difficulties, limited profit margins for charging pile operators, and lack of unified market standards.

Secondly, there is a clear room for improvement in the current charging infrastructure. Particularly, the high expectations for charging convenience and intelligence among respondents suggest that the intelligent upgrade of charging facilities could potentially have a positive impact on promoting the adoption of new energy vehicles. Additionally, the high variance in the issue of charging duration reveals significant differences in user demands regarding charging time, which may be related to the charging efficiency of the piles, the occupational characteristics of vehicle owners, and their daily schedules. This indicates that the construction and management of charging piles should offer a variety of charging options. The study also found that the majority of respondents lack knowledge about charging piles, especially regarding types of charging piles, national policies, and the costs associated with installation and use.

Thirdly, the ranking of influencing factors for the purchase and use of NEV charging piles by importance shows that installation costs and maintenance fees, safety, and charging speed are the most significant factors. Policy subsidies, compatibility with a variety of electric vehicle brands, and operational management are considered less important.

These ranking results provide data support for the market positioning and policy formulation of charging piles.

5. Suggestions on the Promotion of NEV Charging Piles in Beijing

Firstly, establish a charging station construction site selection system and improve the layout of charging piles. Within the urban area, a comprehensive public fast-charging station site selection system can be constructed by considering factors such as the distribution of old and new communities, residential density, and traffic flow. In the suburban and rural areas, the layout and construction of charging piles can be integrated into the urban-rural strategic planning according to the principle of "reasonable planning, moderate advancement, unified standards, and priority for pile stations," focusing on building a public charging network dominated by fast-charging with slow-charging as a supplement. Additionally, private file sharing and zone pricing should be utilized to alleviate layout deficiencies.

Secondly, establish and improve the operation and maintenance (O&M) system for charging piles and strengthen the management of the use of charging infrastructure. Timely maintenance or replacement of aging charging piles and adjustment of the ratio of fast to slow charging should be carried out. The promotion of smart charging technology to enhance convenience is also recommended. Smart charging technology includes not only functions such as appointment charging periods and automatic power-off but also the integration of big data and cloud computing technologies to achieve remote monitoring and intelligent scheduling of charging piles. Divide jurisdictional charging piles into zones with dedicated staff for regular inspections and maintenance, updating old equipment, fixing safety issues, and syncing pile status with operation platforms' apps. Enhance charging spots and increase law enforcement awareness.

Thirdly, the government should implement diversified subsidy policies and encourage cross-industry cooperation among enterprises. The government should increase support for the construction of charging pile networks and provide financial subsidies and tax incentives for operators. This paper suggests that the government introduce differentiated dynamic tax incentive policies, such as implementing a policy tool that grants a 5-10 years corporate income tax exemption period for infrastructure construction. In addition, considering a certain number of years of VAT exemption for the operation income of charging piles could be an option. Tax incentive policies should be dynamically adjusted according to market changes and regional differences. Encouraging cross-industry cooperation among enterprises to share user groups is also recommended. To ease operator strain, cross-industry collaboration should be aggressively pursued.

Fourthly, promote the formulation of unified standards for charging piles to promote the standardized development of the industry. Beijing should formulate and implement unified technical standards and interface specifications for charging piles to ensure compatibility and interoperability between charging piles of different brands. During field research, it was found that some community charging piles are from relatively small brands, and there have been incidents of charging pile fires, hence the establishment of a charging pile certification system is necessary. Charging piles should be included in the national 3C certification product catalog system to further enhance the quality and quality assurance of charging piles. At the same time, enhance safety testing and oversight of charging piles to ensure user safety.

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