



Market Development Analysis of the Charging Service Industry from the Perspective of New Infrastructure

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ABSTRACT

New energy vehicles are an important step in the transformation of the energy structure of today's society. The market for new energy vehicles is expanding, so whether the development status of the corresponding charging service market can meet the rising consumer demand has become a hot issue of social concern. This paper adopts PEST analysis to analyze the charging service market from four perspectives: political, economic, social, and technological. In the past three years, China has gradually incorporated the construction of the charging service industry into the scope of "new infrastructure" and introduced various policies to promote the high-quality development of the industrial economy, so the policy conditions are good, and the economic environment has also changed from the initial difficulty to the initial market-driven industrial development. The construction and technical conditions of the whole society are gradually suitable for the initial development of the charging service market in the process of continuous progress. Subsequently, this paper presents a detailed analysis of two business models of the charging service market, the charging pile model and the switching station model, with their different advantages and disadvantages. Finally, the study presents three problems found in the study: the overall profit model of the charging and switching market is still unclear, there is still some environmental pressure on charging and switching, and there is the uneven regional distribution of charging service infrastructure and corresponding suggestions. The study finds that the charging service market is developing well, and the two business models of charging pile and power exchange can complement each other under different scenarios and conditions.

Keywords: digital economy, new energy vehicles, new infrastructure, charging and switching infrastructure

1. INTRODUCTION

1.1. Research Background

As an important supporting facility for replenishing electrical energy for pure electric and plug-in hybrid models, the lagging development of charging infrastructure is one of the factors that previously affected consumer acceptance of new energy vehicles [1]. Sales of new energy vehicles have grown rapidly in recent years, with new energy passenger vehicle sales increasing 1.6 times year-on-year in 2021 [2]. And the number of consumers who purchase pure electric models is significantly higher than plug-in hybrid models in 2021. The new energy vehicle consumer market is gradually changing from policy-driven to market-driven, and the consumer market is trending significantly. With this

comes a significant growth in demand for the charging service industry. Internationally, the United States, Japan, and other countries develop new electrode materials to increase charging efficiency, financing from different companies, and new batteries are mass-produced and installed in vehicles. Domestic charging piles, charging stations, switching stations in the country's first and second-tier cities in a large number of numbers of investment, and now in Xinjiang and other areas also completed and put into operation, 2021 with the car with the charging facilities accounted for an increase. The whole charging service market shows a booming trend.

National policy is one of the vane and power sources of industry development, and China's charging and switching policy have experienced a process of increasing attention in recent years. 2019, charging and

switching and other basic service facilities have gradually been included in the key consumer goods, and have been included in the "new infrastructure" as one of the seven major industries, with high government subsidies for new energy vehicles. Various state departments strongly support it. So far, the charging service policy is almost clear, and the construction of charging and switching equipment will enter a high-speed development stage. It is believed that the national and local governments will accelerate the implementation of details and unified standards as soon as possible to encourage the development of the charging and switching services market.

1.2. Research Significance

The Central Economic Work Conference in December 2021 pointed out that the Chinese economy is currently facing triple pressure of demand contraction, supply shock, and weakening expectations, and that it is necessary to adhere to the word stability and strengthen policy development. The Political Bureau meeting of the CPC Central Committee in February 2022 set the tone of "stable growth" in 2022, adhering to the word stability, seeking progress amid stability, and enhancing economic development momentum. Against the background of increased pressure on short-term economic growth, the country's demand for stable growth is prominent.

There is still a large gap in the national charging infrastructure. Improving the construction of charging infrastructure can help alleviate consumers' mileage anxiety about new energy vehicles and support the expansion of new energy vehicle consumption. Electric vehicle charging is considered the "last mile" of electric vehicle promotion, which is crucial to the promotion and development of electric vehicles. In this paper, we summarize the relevant policies from a theoretical perspective and break down the future development direction. We aim to analyze the macro environment of the charging service market from the perspective of "new infrastructure" and explore its business and profitability models, to examine how to make the charging infrastructure better integrated with a series of national policies such as boosting the economy, improving employment, and providing convenient services to the public. The purpose of this study is to examine how the charging and switching infrastructure can be better integrated with a series of national policies, such as boosting the economy, improving employment, and providing convenient services to the public, and provide corresponding development strategies and suggestions for the development of this industry.

2. CHARGING SERVICES MARKET BACKGROUND ELEMENT ANALYSIS

2.1. Analysis of Political Factors

In October 2021, the Ministry of Industry and Information Technology (MIIT) issued the "Notice on the Launch of Pilot Application of New Energy Vehicle Electricity Exchange Mode", proposing that a total of 11 cities would be included in the scope of this pilot project, which is expected to promote 100,000+ vehicles and 1,000+ stations, break through the key technology of electricity exchange products, improve the technical standard system of electricity exchange, and form the industrial ecology of electricity exchange model [3]. In December of the same year, the National Development and Reform Commission and the Ministry of Industry and Information Technology jointly issued the Notice on the Implementation Plan of Invigorating industrial Economic Operation and Promoting High-quality Industrial Development, pointing out that the consumption potential of key areas should be released, the promotion and application of new energy vehicles should be accelerated, and the construction of supporting facilities such as charging piles and changing stations should be accelerated [4]. In January 2022, the National Development and Reform Commission issued the Implementation Opinions on Further Improving the Service Guarantee Capacity of EV Charging Infrastructure, which pointed out that by the end of the 14th Five-Year Plan, China's EV charging guarantee capacity would be further improved and a moderately advanced, balanced, intelligent and efficient charging infrastructure system would be formed [5]. It can charge more than 20 million electric vehicles.

Not only this, the State Council Government Work Report in 2020 explicitly included charging infrastructure as one of the seven industries in the "new infrastructure". It is proposed to increase the number of charging piles, power exchange stations, and other facilities. From this, we can see that the policies in the past three years have comprehensively argued the necessity and urgency of promoting the development of the charging service market from various aspects such as promoting consumption, intelligence, stabilizing growth, and convenience. It can also be foreseen that with the further deepening of the breadth of the charging infrastructure layout, new challenges are posed to the segmentation and refinement design at the policy level [6].

2.2. Analysis of Economic Factors

In China with the carbon emission reduction promotion, new energy vehicles become one of the ways to regulate the energy consumption structure, the rapid growth of the new energy vehicle market has increased the demand for charging piles. As of the first quarter of

2022, the country's new energy vehicles have been promoted to exceed 10 million, the rapid increase in the number of new energy vehicles, but also led to the rapid development of the charging pile industry. In terms of charging and switching infrastructure construction, 492,000 units of various types of charging piles have been built, up 3.6 times year-on-year, including 85,000 public piles and 407,000 private piles, up 1 time and 5 times year-on-year respectively; 154 switching stations have been built, up 1.6 times year-on-year [2]. The operators' public charging pile investment and access efforts are steadily carried out, and the charging pile market demand will further expand.

From the perspective of new energy vehicle penetration, one is the policy-driven gradually turned into market-driven, product power accumulated to produce qualitative change as the root cause. Second, consumer acceptance is gradually rising, and the change in consumer group & consumer philosophy is the apparent driver. New energy vehicles compared to fuel cars in technology (independent operating system + three-party software access + independent development) and product experience (hardware and software smooth + multimedia entertainment functions + accelerated driving control) are essential changes, as well as the national energy strategy from the policy side to drive new energy vehicles to achieve a complete replacement of traditional fuel cars, these are giving rise to the next few years of new energy vehicle penetration rate continues to rise. The increase in vehicle penetration will also increase the demand for and dependence on charging facilities at all times. From the above analysis of the economic environment, we can see that the future development of charging infrastructure has a bright future.

2.3. Analysis of Social Factors

Charging piles are charging facilities for electric vehicles, which can be fixed on the ground or wall, installed in public buildings and residential community parking lots or charging stations, and can charge different models of electric vehicles according to their voltage levels. Different charging piles are suitable for different scenarios. They mainly include private piles and public piles. New energy vehicle owners can install charging piles for private use in community parking spaces to meet daily charging needs after approval by the State Grid. Public piles can be divided into special piles for operating vehicles and public piles for social vehicles, which are more efficient in use and are the main targets of the State Grid and the operators. The classification according to ownership is as follows.

First of all, it can be divided into public piles and private piles built with vehicles. Among them, public piles can be divided into public piles and special piles, among which public piles belong to public infrastructure products, which can provide public services for charging

social vehicles within the coverage area. It covers a large area and has a wide social demand, but at the same time, it has a high probability of irregular use and wide applicability. Dedicated piles are for specific users such as professional operating vehicles, so they are unstable in terms of charging demand distribution and operating vehicle routes. However, the charging service for operating vehicles is highly utilized and profitable. Private piles are mostly installed in the community for private use and can provide exclusive and convenient charging services for private individuals, which require fixed parking spaces to access the national grid and are suitable for charging in residential communities mainly during non-working hours.

The power exchange model is a way of fast replenishment of new energy vehicles by centralized storage, centralized charging, and unified distribution of a large number of batteries through centralized charging stations, and battery replacement or integration of battery charging, logistics deployment, and power exchange functions for new energy vehicles in the station. In terms of electrical changing stations, by the end of 2021, China has 1,298 electrical changing stations, among which niO, the main operator, has 789 electrical changing stations [7]. On January 18, 2022, The CATL(Contemporary Amperex Technology Co., Limited) announced the development of a mass-produced battery "chocolate power exchange block" specifically for shared power exchange, which will improve the economics of power exchange stations and speed up the construction process. This will speed up the construction process of power exchange stations. The attractiveness of the battery swap model to vehicle owners (in the case of NIO) lies in two main areas.

First is the convenience of five minutes of replenishment: NIO II's power exchange stations can provide owners with five minutes of automatic power exchange service, an experience even stronger than refueling. At the same time, the density of the company's power exchange stations is still rapidly increasing, and the convenience of power exchange will continue to be enhanced in the future. In addition, the NIOPower charging system also includes super-charging and one-touch refueling services, minimizing users' mileage anxiety at the current technology level. In terms of energy replenishment, it can be quite convenient

Second is the convenience of battery upgrade: Based on the power exchange design, the NIO users can achieve permanent or temporary battery upgrades. This enhances the range experience on the one hand and ensures that the value of the vehicle does not decline due to the outdated battery technology in today's high-speed battery iteration.

2.4. Analysis of Technical Factors

At present, the way of supplying electric energy to

new energy vehicles is mainly divided into two ways: complete vehicle charging and battery replacement. The whole vehicle charging method is divided into conduction charging and induction charging according to the different connection forms of the charging device and vehicle receiving device [8]. Conductive charging includes AC charging and DC charging, while inductive charging is wireless charging.

AC charging, also known as "slow charging", AC charging post technology is mature, the structure is relatively simple, easy to install, and low cost, using conventional voltage, charging power is small, slow charging, mostly installed in residential areas parking lot.

DC charging is also called "fast charging", the technology and equipment of DC charging piles are more complicated than AC charging piles, and the manufacturing cost and installation cost are higher. It adopts high voltage, high charging power, and fast charging, which is more suitable for scenarios requiring high charging time, such as cabs and buses, etc. It is usually installed in centralized charging stations.

The battery replacement mode, also known as "power exchange mode", refers to the centralized storage, centralized charging, and unified distribution of a large number of batteries through centralized charging stations, and battery replacement services for electric vehicles in the battery distribution stations or the integration of battery charging, logistics deployment, and power exchange services. The battery exchange model has certain advantages in reducing the cost of purchasing a car, eliminating mileage anxiety, and improving safety levels. However, due to the variety of battery models and different ways of battery replacement, it still faces problems such as technical standards, taxation policies, and norms for the construction and management of replacement stations. At present, the model is mainly applicable to commercial vehicles and has not yet been significantly promoted. Domestic car companies that have a battery exchange model mainly include NIO, BAIC, SAIC, Chang'an, Geely, etc.

In the future, after achieving a high range, further solutions to the charging problem will become the next key consumer anxiety to be addressed by car companies. At present, there are three main types of solutions: one is the power exchange solution represented by NIO, the second is the high-current fast charging solution represented by Tesla, and the third is the high-voltage fast charging solution represented by Porsche and others. From the point of view of cost and technical achievability, high-voltage fast charging is expected to become the mainstream solution. In addition to increasing the charging power, the high-voltage architecture can significantly reduce the current in the case of unchanged motor output power, which effectively reduces heat loss and brings about an increase in range. The significantly reduced current brings about a reduction in the wire

harness diameter, which is conducive to the optimization of the interior space layout and reduces the weight of the vehicle.

3. CHARGING SERVICE MARKET BUSINESS MODEL ANALYSIS

3.1. Charging Piles

The industrial structure of the charging pile service market can be divided into three parts: upstream, midstream, and downstream. The upstream of the industry is the manufacturers of components and equipment needed to build and operate charging piles, the midstream is the charging pile operators, and the downstream is the user service clusters around EV owners, such as charging charges, testing, and maintenance, etc.

According to the operation subject, there are three major types of charging pile mainstream operation mode, which are enterprise platform-led mode, individual operation mode, and gas station mode. In terms of profit sources, there are mainly financial subsidies, electricity tariff difference, advertising, parking space operation, repair, and maintenance, supporting entertainment, etc.

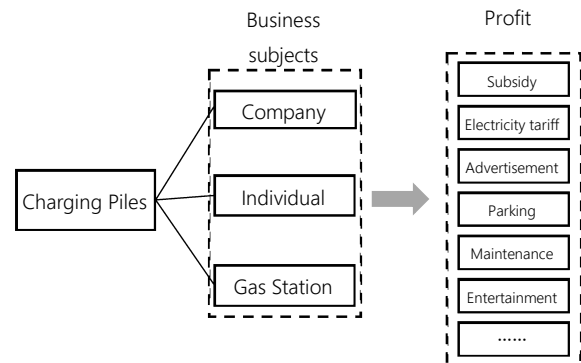


Figure 1 Different Charging Piles Profit Model

3.1.1. Business Operation

This model leaves it to the charging operator to complete the investment, construction and operation, and maintenance of the charging pile business, and to provide users with the operation and management of charging services.

Charging operators have strong capital and need to invest a lot in infrastructure such as sites and charging piles in the early stage. The model is more market-oriented in terms of service content and scene layout, and only the charging operator giants can survive. The huge investment cost is also the main reason that prevents potential entrants from joining the competition. Through high entry costs, charging operators reflect a certain degree of monopoly characteristics and provide products

and services with certain differentiation, making the whole market present a monopolistic competition pattern.

Profitability mainly depends on the utilization rate of a single pile and charging a service fee. At present, charging operators have a single model, with revenues coming from electricity service fees. Due to the fierce competition in the industry and the sensitivity of users to charging fees, it is difficult to raise charging service fees around the world. Overall, profitability of this model is not high at present, and charging operators need to continuously improve and develop their operation model, further explore other values and value-added services, and open up diversified business models [9].

3.1.2. Individual Operation

In the mode of individual pile construction, there are two main categories: the first is the family's charging pile, which is generally a community or individual-funded equipment; the second is the charging pile of individual commercial and industrial or service establishments, such as rural farmhouses, charging piles in shopping center parking lots, charging areas in street-side restaurants, etc.

The community-based charging posts are limited to the household, not for profit, and only to meet daily household needs.

Charging piles set up in service establishments such as individual businesses and catering enterprises charge rent as a means of profit, and the construction of these charging piles is usually an asset investment made by the managers of the establishments, or partly in cooperation with charging pile companies through franchising. For example, BMW has already provided more than 270,000 charging piles to car owners through a partnership with State Grid, including 80,000 DC charging piles that provide fast charging [10].

3.1.3. Gas Station

Through resource integration capability, the charging piles are connected to traditional refueling places such as gas stations and service areas on the highway network, creating an "integrated refueling and charging" transportation service facility. Through one-stop back office and online management, low-cost operation and maintenance can be realized. The cooperation between gas station operators and charging station operators has resulted in significant cost savings, including Sinopec's plan to build 5,000 switching stations by 2025 [11]. This achieves convenient charging in the middle of the city and on the side of the highway, making efficient use of the limited space resources within the city and bringing great convenience to the owners of new energy vehicles. This model is more widely distributed in coastal cities and less inland, especially in northwest China.

3.2. Power Exchange

The switching station is currently in the layout development stage, by Aoduo New Energy, NIO, BAIC new energy, and other leading enterprises to form the first echelon. According to the data of Beiqi new energy exchange station, it is estimated that the electric cabs change electricity twice on a single day, and a single exchange station can serve 135 vehicles per day, with a daily income of about 14,000 yuan, and 360 days of operation per year, with an annual income of about 5 million yuan, and two years of operation to recover the investment cost [12]. This means that there is still a lot of room for improvement in the profitability of the exchange stations. The cost of the switching station includes three major components: product cost, land construction and power supply cost, and post-operating cost. The reduction of the investment cost of the power exchange station cannot be seen in the input of each link individually but should focus on the development of the whole chain [13]. In terms of scale, the exchange station should first reach a networked distribution in the city, the level of which can be preliminary for the time being. The networked layout is determined by the matching relationship between the number of vehicles and the number of switching stations, and it is necessary to find out the optimal network for each city to maximize the efficiency of the switching.

The power exchange station also plays the role of energy storage. To maximize its level of utility and reduce costs, it should consider interacting with the national grid and jointly promote the construction of energy storage function. Currently, in the market, there is no enterprise layout of both power exchange and energy storage, but considering the backup assistance and sustainable profitability role of energy storage for power exchange stations, the strategy of power exchange and energy storage in parallel is likely to be incorporated into the strategic reserve by enterprises.

In terms of vehicle enterprises, FAW, SAIC, Dongfeng, Geely, and Chang'an Automobile have all launched power exchange versions of their models. With the continuous entry of potential entrants, the power exchange market will tend to be synergistic and standardized, the power exchange stations will inevitably improve the degree of matching with the models, and the products will develop towards the non-differentiation of the competitive market. To adapt to this development trend, save unnecessary competition costs, and improve the convenience index of users, it is likely that car companies will form alliances with each other and cooperate in the use of power exchange stations on a shared basis.

At present, there are three main types of power exchange enterprises in the market, the first is the aforementioned, including Geely, Weilai, and a series of car companies; the second is the industry that has an

upstream base or downstream advantage, trying to expand the map, to build a full range of industrial chain enterprises, around the upstream and downstream industrial pull, these enterprises are the representatives of the new energy battery leading enterprises Ningde time; the last is also the promotion of power exchange is the largest, the layout of the most fierce momentum, the largest market scale of third-party enterprises, such as Aoduo new energy.

Compared to the charging mode, saving time is its biggest advantage. At present, the development of charging piles is gradually moving towards fast charging, and it is still unknown when the charging speed of switching stations can reach the level of fast charging due to technical limitations. In addition, limited space has a huge restriction on the charging pile fast charging mode, especially in the inner city. In such a situation, the power exchange mode can play a better role as an alternative to the charging post mode. In a longer period, the power exchange model will occupy a certain position in the market by its convenience and efficiency.

4. SUGGESTIONS

4.1. Promoting Charging Infrastructure in the North West

Public charging infrastructure is being vigorously pursued in northwest China, and most of it is being built with fast charging infrastructure. The public charging infrastructure in China is concentrated by region. Guangdong, Shanghai, Jiangsu, Beijing, Zhejiang, Hubei, Shandong, Anhui, Henan, and Fujian account for 71.7% of the public charging infrastructure built in the TOP10 regions [14]. It mainly shows the problem of more distribution on the southeast coast and less distribution in northwest remote areas. It is not conducive to cross-regional travel and affects inter-regional economic and cultural exchanges. Problems such as the inaccessibility of the last 100 miles of new energy vehicles due to uneven distribution of charging and switching infrastructure have limited the development of new energy vehicles in the northwestern region as well as in the interior.

Because the current charging service market is also facing the problem of inefficiency due to too long charging time, it is recommended that most or even all of the charging infrastructure be constructed as fast charging facilities [15]. The charging demand in remote areas in the northwest is low, so the number of charging facilities needed for initial coverage can be reduced and set at fixed points to ensure complete coverage while reducing construction costs and improving the efficiency of capital use. Focusing on the current infrastructure construction in the northwest makes charging and other services available in every corner of the country, making new energy vehicle travel unrestricted, and will further promote the development of the new energy vehicle

market.

4.2. Intelligent Management of Charging and Other Service

Intelligently manage charging and other service modes, combining them with a navigation system to update in real-time the length of time users have to wait for free charging posts or other charging services near them.

At present, many charging network service management platforms exist for the new energy vehicle market to provide customers with the function of viewing charging information in an online format. However, there are some limitations in this service function, which can only be reflected in the deployment of charging piles and the sharing of information about the orientation, but other service functions have not yet been formed, and the information related to the charging service is lagging [15]. Intelligent management of charging and other services can reduce people's time of ineffective searching for charging piles and the status quo of some charging piles being idle and some charging piles waiting for a long time due to the inequality of information, which can be truly realized, efficiently and quickly. Charging high occupation fees for the occupation of piles after the charging service. Improve the utilization rate of existing charging piles to relieve the charging pressure caused by the occupation of piles.

4.3. Reasonable Sharing of Site-specific Charging Posts

Implement reasonable sharing measures for site-specific charging piles in cities with high charging demand. Implementing the opening of charging piles to the public at fixed periods. Charging piles in subdivisions, government, hospitals, etc. may have a large number of idle daytime nighttime supply and demand or a large number of idle nighttime daytime supply and demand. Combine with the prevention policy, double-door management, and charge certain charging and service fees to ensure that the shared charging activities are carried out safely and effectively. Increase the utilization rate of existing charging piles, relieve the pressure caused by charging difficulties, reduce the construction cost of new charging infrastructure, and reduce the pressure of energy replenishment in other modes. A flexible management model that makes rational use of existing resources promotes the development of the charging service market and also brings convenience to consumers, with charging facilities at various locations available for a fee, thereby stimulating demand for new energy vehicles.

4.4. Government Implementation of Preferential Taxation and Other Protection Policies

Protective policies such as tax incentives are implemented for enterprises that invest in infrastructure construction or provide raw materials for the charging service market to attract corporate capital and promote the construction of charging service infrastructure. By the end of 2021, there were 7.84 million new energy vehicles and 2.617 million charging piles in China, with a vehicle-pile ratio of 3:1 [3]. 2017-2021 vehicle-pile ratio is maintained at about 3.0, and the overall trend is slowly downward, but there is still a large gap. The increase of policy support and the opening of market space will help to strengthen the supervision and implementation of action plans related to charging infrastructure, and effectively organize and promote the development of charging infrastructure, and solidly organize to promote the development of charging infrastructure. Government subsidies are a major source of profit for charging services at this stage, and the charging service market is now in its infancy and needs policy protection. Tax incentives can reduce the price of raw materials and attract investment, the most powerful way to support infrastructure with a continuous capital chain. The perfect development of infrastructure for charging services has a greater role in promoting the new energy vehicle market. In turn, it contributes to the steady growth of the macroeconomy.

4.5. Further Technological Innovation in Environmental Energy Charging

The use of newer and cleaner energy sources for power generation, while constantly innovating processing technology to improve the efficiency of existing coal power generation. Currently, the main source of electricity is still coal power, the utilization rate of coal compared to the past greatly improved, but facing the double carbon target there is still technical pressure, new energy vehicles do not directly emit greenhouse gases, and environmental pressure is reduced but not eliminated, the pressure to improve technology and the car market, the engine market transferred to the charging service market. Further technological innovation in the charging service market is very beneficial to the future development of the power grid. At present, new energy has a problem of consumption, and the charging of electric vehicles is controlled on the supply side to increase the proportion of new energy, improve the flexibility of the grid, and thus reduce the necessary thermal power plant capacity. In Northern Europe, for example, the proportion of new energy and electric vehicles is very high, except for the randomness of hydropower, the development of wind power and electric vehicles can promote each other.

5. CONCLUSION

5.1. Key Findings

By analyzing the four elements of politics, economy, society, and technology, this paper examines the current development model of new energy vehicle charging in China, and further makes a careful division between the two markets of charging and power exchange.

Through an in-depth study of the charging post-market, this paper finds that the important factor that restricts the charging post model is the space limitation, especially the charging post service stations inside urban areas, which need both time for charging and enough space for parking vehicles. The solution is to combine the parking lot and charging post service area, create profits for the parking lot, and charge operators through site leasing or self-management.

In terms of power exchange stations, the biggest constraints are the lack of technology and the mismatch of batteries between different models. The study points out that future advances in power exchange technology will bring tremendous gains in the speed of changeover and significant potential benefits to both the operators and owners of new energy vehicles, with large savings in time and space costs. At the same time, this paper argues that the exchange stations should move toward the goal of fast charging, which can be achieved by adopting the "gas station model" of charging pile services and achieving efficient use of space through effective cooperation.

5.2. Future Studies

Firstly, in further exploration in the future, the construction of public charging infrastructure in remote areas of the northwest can be considered in a refined layout by combining it with local topography and climate.

Secondly, progress and breakthroughs in the field of technology will continue to be watched, such as whether the innovation effect caused by improved charging efficiency will bring new export opportunities.

Finally, in the intelligent management of charging and other service infrastructures, interdisciplinary exchanges and communications can be further strengthened, and the advantages of different disciplines can be integrated and complemented to design more scientific management solutions.

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