

New Energy Vehicle Charging Facility Industry and Technology Forecast in China

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ABSTRACT

The new energy vehicles (NEV) production in China has accounts for over 65% of the global sales. However, the unbalanced development between NEV and charging facility has brought new challenge. This essay explores domestic charging facility industry, analyzes the effects of NEV industry and charging facility on carbon emission and finally predicts the technology trends by collecting and analyzing the relative data from 2011 to September 2023. The results show that the NEV and charging facility development have made obvious progress in declining carbon emission. The article also provides suggestions and guidelines for the future development of this industry.

Keywords: energy transition, new energy vehicles, charging facilities, low-carbon economy

NONMENCLATURE

Abbreviations

EV	Electric Vehicles
NEV	New Energy Vehicles

1. INTRODUCTION

As the largest carbon emitter in the world, China was culpable for approximately 30% of the global carbon emission in 2022 [1-3]. As a responsible developing country, China committed to achieving carbon peak in 2030 in the "The Paris Agreement" of the 21st United Nations Climate Change Conference (COP21) [4]. Therefore, it is particularly important to achieve carbon

emission reduction and energy transition as soon as possible.

International Energy Agency pointed out in "World Energy Outlook 2023" that "the emergence of a new clean energy economy, led by solar PV and electric vehicles (EVs), provides hope for the way forward. [5]" According to the United Nations' assessments, the transportation emission emerges as a major proponent of greenhouse gases and air pollutants, bearing responsibility for 23% of global carbon footprints, with this proportion manifesting an ascending trend [6]. Therefore, the development of NEV industry will greatly support the energy transition and the realization of low-carbon economy.

In the last decades, China's NEV industry has witnessed significant ascendancy. From more than 8,000 in 2011 to the 20 millionth NEV in 2023, the production has increased nearly by 2,500 times, taking a proportion of 65% global NEV sales, making a significant contribution to the global carbon emission reduction.

However, the rapid expansion of the NEV industry has also brought novel challenges such as the imperfection of charging infrastructures. In 2022, the global number of NEV will exceed 25 million, with the proportion of these vehicles to public charging edifices standing at 9:1. And in China, the ratio of NEV to public charging piles in China hovers around 7:1. A harmonious development between charging infrastructural and NEV s can further stimulate the whole industry [7]. In another word, any discord between these constituents could potentially restrict the industry's process.

Therefore, this article mainly carries out analysis and prediction based on the charging facilities industry data in China's NEV industry from 2011 to September 2023, and analyzes the development process of two types of charging facilities, namely, public charging piles and

private charging piles. The correlation analysis between charging facility and carbon emissions shows that the development of charging facility will further promote the NEV industry development and make an important contribution to carbon emission reduction. This provides a new analytical perspective for the future development of the charging facility industry and even for the technological development forecast of NEV.

2. METHODOLOGY AND DATA

2.1 Patent frequency analysis

In this section, we analyze and summarize the development and technology trends of the NEV industry to explore the main technical routes that restrict the development of NEV and explore the future technology development trends.

We first extract the main keywords from the Chinese patent database [8] and process and analyze the patent document data related to NEV. Then we screen the original keywords and eliminate irrelevant keywords. The conditions for selecting keywords are that the frequency of occurrence is no less than 200 times, and 23 high-frequency keywords are finally obtained, as shown in Table. 1, sorted from high to low frequency.

Table. 1 Patent frequency statistics

Key words	frequency	Key words	frequency
New energy vehicle battery	3974	Charging pile	3591
New energy electric vehicles	1171	Charging device	690
Power Battery	592	Battery pack	554
Preparation	480	Battery box	442
Cooling device	392	Lithium battery	389
Fixtures	363	Detection device	344
Battery	323	Driver Motor	289
Charging equipment	271	Controller	265
Replacement parts	248	Thermal management system	240
Protective device	238	Battery module	237
Charging system	211	Appearance design	205
Defensive equipment	202		

From the keywords extracted from the patent document data, we can see the distribution of hotspots in China's NEV technology field. NEV batteries, charging

piles, new energy EV, charging devices and power batteries are the major technological innovations of China's NEVs. The main technical fields including charging piles, charging devices and charging equipment have a total frequency of 4552 times, indicating that charging infrastructure represents a hot technology research direction in the NEVs field.

2.2 Literature research

Based on Citespace, we performed keyword cluster analysis on 497 documents data. Through visual analysis of the documents, we obtained the keyword co-occurrence map as shown in Fig. 1.

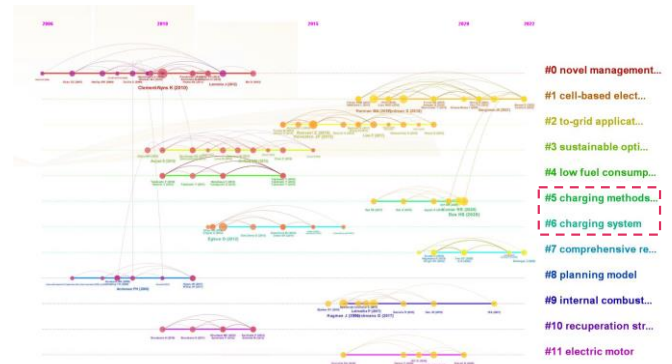


Fig. 1 Literature keyword cluster analysis

It can be found that research on charging methods and charging systems has gradually become a research hotspot in recent years, which further proves that charging infrastructure has become one of the hotspot trends of exploring NEV technology.

2.3 Google trends analysis

Furthermore, we also compared the search trends of keywords related to charging pile in Google Trends between 2011 and September 2023 in China and globally as shown in Fig.2. It can be clearly seen that the overall trend is developing rapidly, but at the time point of 2015, January 2020, July 2022 and January 2023, there are some obvious differences between the trends in China and the world.

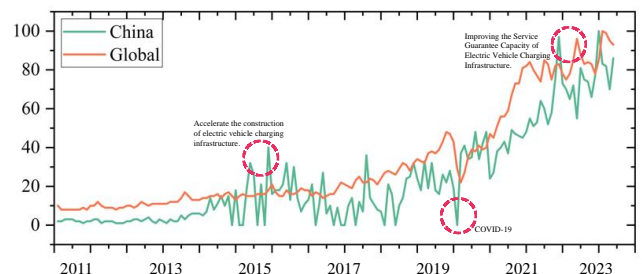


Fig. 2 Google trends analysis

2.4 Charging piles classification

To explore the main technologies of NEV charging facilities, we classified and organized the charging facilities according to their basic functions and methods [9], as shown in Table. 2.

Table. 2 Charging method classification

Classification methods	Classification	Contents
Charging methods	DC charging station	DC charging is directly connected to the power grid and can directly charge the batteries of EV. Generally, three-phase four wire or three-phase three wire power supply is used, with a wide adjustable range of output voltage and current, thus can achieve rapid charging of EV.
	AC charging station	AC charging is not equipped with charging function, but only provides power output and needs to be connected to an on-board charger. Due to the low power of electric vehicle on-board chargers, AC charging cannot achieve fast charging.
Installation locations	Public EV charging	Built in public parking lots to provide public charging services for social vehicles.
	Dedicated EV charging	Built in companies' own parking lot for to provide service for internal people.
	Private EV charging	Built in a private-owned parking space to provide service for private users.
Charging port	One to one charging	One charger for one EV only.
	One to many charging	One charger could serve more than one EVs at the same time.

2.5 Policy collection

We also have collected the major policies of NEV charging facilities in China, and the following Table. 3

shows a summary of those policies from 2011-September 2023 [10-12].

Table. 3 China Charging Pile Policies

Year	Policies
2012	1.“The 12th Five Year Special Plan for the Development of Electric Vehicle Technology” 2. “ Notice of the General Office of the State Council on Issuing the Development Plan for Energy Conservation and New Energy Vehicle Industry (2012-2020)”
2015	3.“Guiding Opinions on Accelerating the Construction of Electric Vehicle Charging Infrastructure” 4.“Guidelines for the Development of Electric Vehicle Charging Infrastructure (2015-2020)” 5. “ Action Plan for Construction and Transformation of the Distribution Network (2015-2020)”
2016	6. “ Notice on the Incentive Policy for Charging Infrastructure of New Energy Vehicles and Strengthening the Promotion and Application of New Energy Vehicles by the 13th Five Year Plan ” 7. “ Notice on Accelerating the Construction of Electric Vehicle Charging Infrastructure in Residential Areas” 8.“Guiding Opinions on Promoting Green Consumption” 9.“Guiding Opinions on the Energy Work”
2017	10. “ Notice on Coordinating and Accelerating the Integrated Construction of Parking Lot and Charging Infrastructure” 11.“Notice on Accelerating the Construction of Internal Electric Vehicle Charging Infrastructure at the Workplace”
2018	12.“Action Plan for Improving the Charging Guarantee Capability of New Energy Vehicles”
2019	13.“Notice on Further Improving the Financial Subsidy Policy for the Promotion and Application of New Energy Vehicles” 14. “Implementation of the Guiding Opinions on Promoting the Development of Energy Storage Technology and Industry, 2019-2020 Action Plan”
2020	15. “ Announcement on the Policy of Exemption from Vehicle Purchase Tax for New Energy Vehicles” 16. “ Development Plan for the New Energy Vehicle Industry (2021-2035)”
2021	17. “The 14th Five Year Plan for the Development of Comprehensive Transportation Services”

2022	18. “ Implementation Opinions on Further Improving the Service Guarantee Capacity of Electric Vehicle Charging Infrastructure”
	19. “ A Package of Policy Measures to Solidly Stabilize the Economy”
2023	20. “ Implementation Opinions on Accelerating the Construction of Charging Infrastructure and Further Supporting the Rural Revitalization of and NEV in Rural Area”
	21. “Guiding Opinions on Further Building a High-Quality Charging Infrastructure System”

2.6 Case information

According to Intergovernmental Panel on Climate Change (IPCC) guidelines [13], national carbon dioxide emissions can be calculated as follows,

$$CE = \sum_{ij} CE_{ij} = \sum_{ij} AD_{ij} \times EF_{ij}. \quad (1)$$

Among them, CE_j is the carbon dioxide emissions from the activity type i of the industry J , AD is the activity data (such as energy consumption), and EF is the emission factor, which can measure the carbon dioxide emissions released by the unit activity. Then industry emissions can be calculated according to the following method,

$$CE_{ij} = CE_{ij} \times \frac{SI_{ij}}{SI_{ij}}. \quad (2)$$

SI represents industry statistical indicators, including industry energy consumption, industry energy intensity, industry added value, industry output, etc. J refers to the industry defined by the official national statistics, while j means the matching industry in the China Carbon Accounting Database (CEADs) [14] industry list.

Thus we select and analyze the data of the total sales of automobile and sales of NEV, the number of domestic charging piles (data collected from the website of China Association of Automobile Manufacturers), and the carbon emission data (CEADs) of transportation, storage and post industry from 2011 to September 2023, and then carries out fitting prediction among the sales of NEVs, the number of domestic charging piles, and the carbon emission data (CEADs) of transportation, storage and post industry.

3. RESULTS AND DISCUSSION

3.1 The development of charging piles in the whole NEV industry method

This article selected the installation location as the analysis subject, according to which the public charging piles and private charging piles are the two major piles.

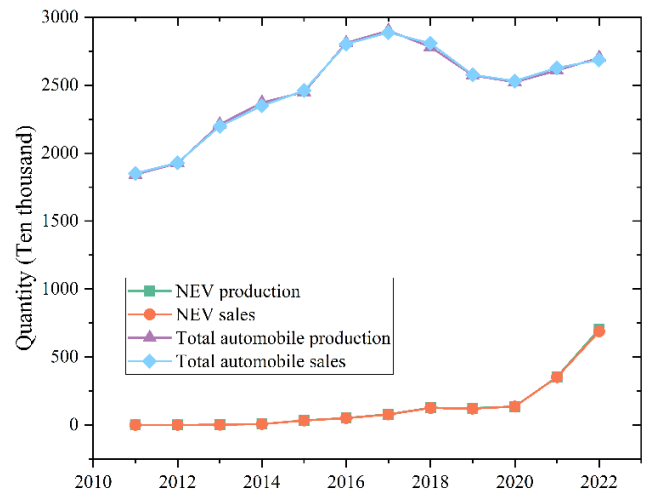


Fig. 3 Comparison of production and sales of automobiles and NEVs

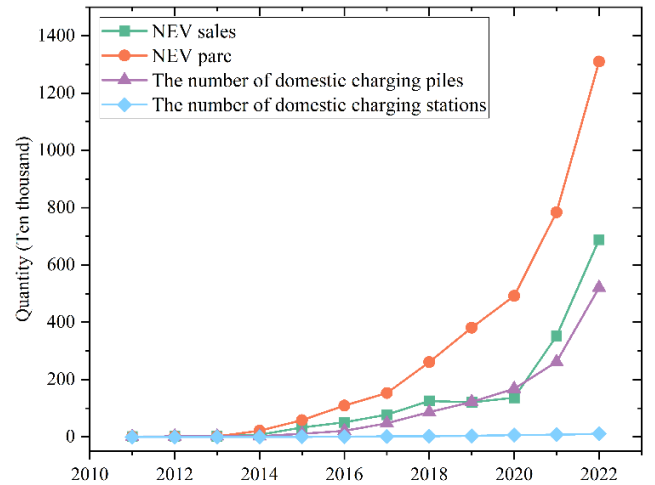


Fig. 4 Comparison of NEV sales, parc, and number of charging piles and charging stations

Fig. 3 and Fig. 4 show the proportion of NEV in total automobile sales and production from 2011 to September 2023, as well as the comparison of the sales, parc and total number of charging piles of NEV. We can find that NEVs have grown rapidly from only 0.04% of total automobile production and sales in 2011 to 30% in September 2023. The number of NEVs has also grown from less than 10,000 in 2011 to 18.21 million, making China the country with the largest NEV parc. The number of charging facility including charging piles and charging station is also increasing.

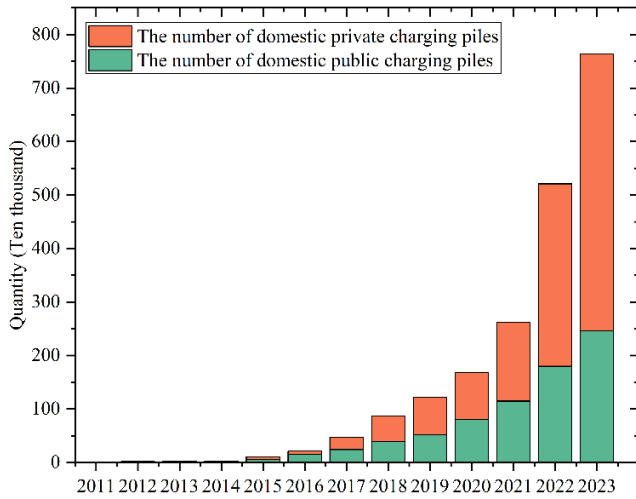


Fig. 5 Comparison of public charging piles and private charging piles

By comparing the development trends of China's public charging piles and private charging piles shown in the Fig. 5, we can find that before 2015, the number of private charging was near zero due to the impact of support policies. However, with the continuous opening up of policies, the number of private charging piles increased exponentially after 2015. Growing rapidly, the number of private charging piles will exceed that of public charging piles in 2018. In the latest data in September 2023, the proportion of private charging piles has reached 67.8 %.

industry has entered a stage of rapid expansion, and technological trends in the charging infrastructure field have developed significantly.

Although the number of charging piles has grown rapidly, the vehicle-to-pile ratio in China has basically remained around two or three in recent years as in Fig. 6. In September 2023, the vehicle-to-pile ratio was about 2.38, and the public vehicle-to-pile ratio was about 7.4, although it is far higher when compared with the global average of 105.7 and the American average of 66.6.

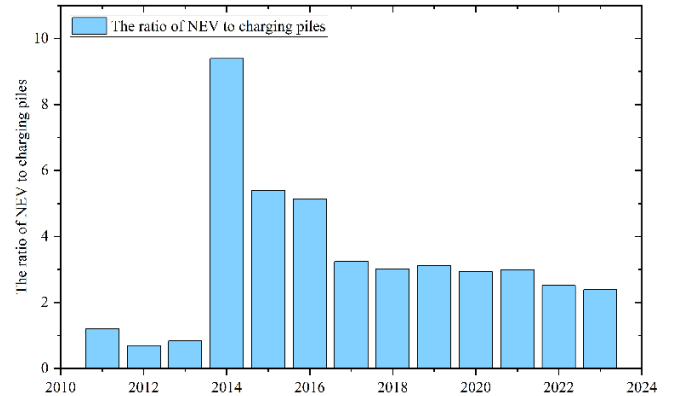


Fig. 6 The ratio of NEVs to charging piles in China

But at the same time, it also reflects the lack of further improvement and the slowdown in growth rate, which requires the further development of new energy charging technologies.

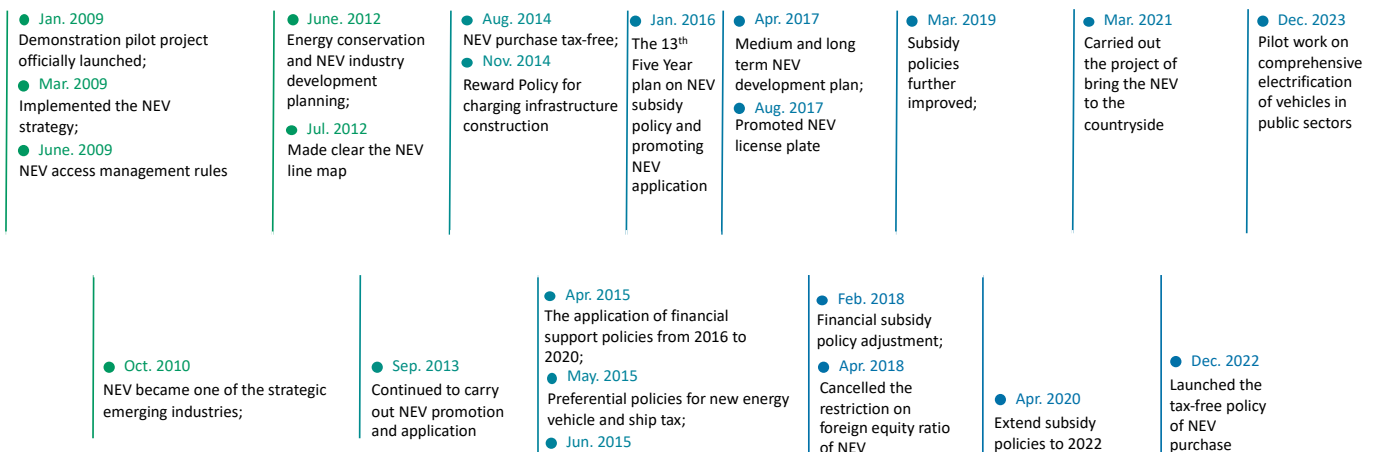


Fig. 7 China's new energy policy development

Together we conduct an analysis about the policy development of China's major new energy and charging facility from 2011 to September 2023 [15] as shown in Fig. 7.

It can be further found that the support policy focus on charging piles occurred during 2014-2015, and the whole NEV industry got affected by the COVID-19 in January 2020, and then restore to developing rapidly during 2022- September 2023. To sum up, China's NEV

3.2 The fitting prediction of the number of NEV parc, charging piles and the carbon emission

We analyze the development of NEV charging technology in view of issues such as the slowdown in the growth of charging piles, and analyze the relationship between NEV charging technology and carbon emissions.

According to the data we compared the number of NEV, the number of charging piles in China, and the

carbon emissions of the transportation, storage and post industry (CEADs) from 2011 to 2022. It can be clearly seen that the NEVs parc and the number of charging piles in China from 2019 to 2022 is growing rapidly, but according to data from CEADs, carbon emissions from the transportation, storage and post industries have fallen slightly. This shows that NEVs have a positive effect on carbon reduction, and the number of charging piles has further promoted the rapid development of NEVs.

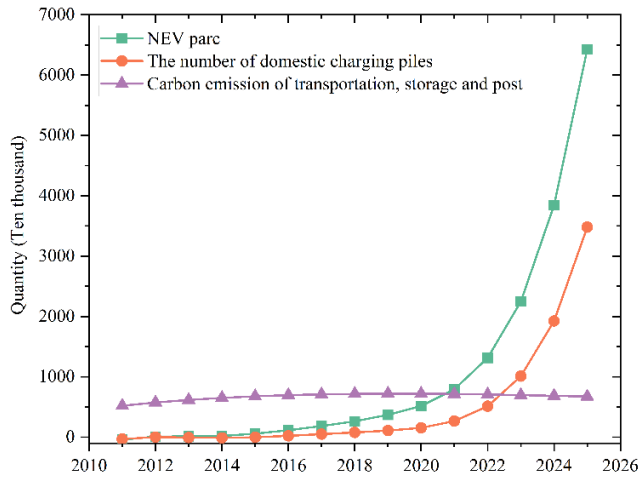


Fig. 8 Forecast of NEV parc, sales and carbon emissions

Based on MATLAB, we made a fittings prediction of the number of charging piles and the carbon emissions of the transportation industry as shown in the Fig. 8. The number of charging piles will reach 10.1 million in 2023, which is very consistent with the data of 7.6 million during the first nine months of 2023. The carbon emissions in 2023 are predicted to be 698.4 million, and it is expected that the automobile carbon emissions will peak in 2025. NEV reduced gasoline and diesel energy consumption by 50 million tons per month in 2022. The guarantee of charging infrastructure determines the limits of NEV development and the choice of NEV technology routes.

At the same time, we have also noticed that starting from 2019, some leading NEV companies began to actively build battery swap stations. In 2019, there were 306 charging stations. By September 2023, there will be a total of 3,460 charging stations. A battery swap station only takes 2-4 minutes to complete the battery swap, which is an improvement over the time of 7-12 hours at a charging pile [16]. At the same time, the State Grid etc. are also actively promoting the construction of "battery banks", hoping to supplement the problem of insufficient charging piles.

However, in the future there will still be problems such as the renovation of old community charging facilities, the standardization of battery standards, and

the inconsistent battery replacement methods. It is hoped that these problems can be solved through rapid technological evolution.

4. CONCLUSIONS

By collecting data of NEV and charging piles in China from 2011 to September 2023, we found that the rapid development of NEV has great significance to realize our ultimate goal of carbon neutrality, while it also brought us new challenges like the unbalanced development between NEV and EV charging facilities, the standardization of batteries and battery changing issues, which may stagger our previous progress in the next one or two years if the challenges not get solved. Thus, it is necessary to focus more on problems like developing all types of battery charging and changing solutions and constructing the related infrastructures, to accelerate the sharing of private EV charging and to keep the policy stable. As a country that owns half of the global NEVs, the status quo and challenges of China NEV industry also shed lights on the global NEV industry that the development of charging and swapping and other related infrastructure must be put more attention to keep the stable, balanced, coordinated and sustainable development of the whole industry, and together to contribute to our ultimate goal of the carbon neutrality.

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