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Will New Energy Vehicles Gradually Dominate?

-- Exploring the Evolution of New Energy Vehicles through the Lens of Carbon Emissions and Market Penetration

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ABSTRACT

In recent years, the automotive landscape has undergone a remarkable transformation, shifting from the roar of gasoline-powered engines to the serene silence of new energy vehicles. This paradigm shift is primarily driven by the substitution of gasoline with innovative energy sources, resulting in a quieter and cleaner driving experience. Given this backdrop, what constitutes new energy sources? What advantages do new energy vehicles offer? Will they eventually supersede traditional fuel-powered cars? And what lies ahead for their future development? To address these questions, the author has conducted a comprehensive research and analysis on new energy vehicles.

KEYWORDS

New Energy Vehicles; Carbon Emissions; Market Penetration

1. INTRODUCTION

1.1. Energy Types of New Energy Vehicles

According to the Rules for the Administration of Access to New Energy Vehicle Production (Announcement [2007] No. 72 of the National Development and Reform Commission), new energy vehicles refer to automobiles that utilize unconventional automotive fuels as their power source (or use conventional automotive fuels with new types of on-board power devices), integrating advanced technologies in vehicle power control and propulsion, resulting in vehicles with advanced technical principles, featuring new technologies, and innovative structures. Based on this definition and current mainstream models in the market, the types of new energy vehicles can be broadly categorized into battery electric vehicles, hybrid electric vehicles, fuel cell vehicles, hydrogen engine vehicles, gas-powered vehicles, and alcohol-ether vehicles.

The energy usage for each type of new energy vehicle is as follows:

Table 1. Energy Sources for Different Types of Vehicles: Direct and Indirect Supply

Vehicle Type	Common Direct Energy Source	Indirect Energy Source
Battery electric vehicle	Electricity	Thermal power (coal), hydropower, wind power, solar power, nuclear power, etc. China primarily relies on thermal power, accounting for approximately 66% of electricity generation in 2023.
Hybrid electric vehicle [1] (plug-in, extended range)	Electricity, fuel (gasoline, diesel, etc.)	Same as above, electricity
Fuel cell vehicle	Hydrogen	Hydrogen production from fossil fuels such as oil, coal, and natural gas; Hydrogen production through water electrolysis; Hydrogen production through biomass fermentation. Currently, coal gasification is the primary method for hydrogen production.
Hydrogen engine vehicle		
Gas-powered Vehicle	Natural gas/LPG (liquefied petroleum gas)	-
Alcohol-ether vehicle	Methanol, etc.	Natural gas, coal, Biomass, etc.

Data source: Compiled from public information

1.2. Comparative Analysis of Pollution Between New Energy Vehicles and Traditional Fuel Vehicles

New energy vehicles have obvious advantages in terms of tailpipe emissions during driving, but from a comprehensive perspective of the entire vehicle life cycle, the electricity and hydrogen used by new energy vehicles still generate carbon emissions during production, and battery production and recycling processes are also accompanied by carbon emissions. Therefore, whether new energy vehicles are more environmentally friendly compared to traditional fuel vehicles must be viewed dialectically.

The China Automotive Low-Carbon Action Plan 2020 [2] divides the entire life cycle of a vehicle into a vehicle cycle (including parts production, vehicle production, after-sales maintenance, etc.) and a fuel cycle (including the production of electricity and gasoline, as well as their consumption during vehicle operation). Taking battery electric vehicles and gasoline passenger vehicles as examples, within the entire life cycle of a vehicle, the carbon emissions per unit mileage of pure electric passenger vehicles are 153.7gCO_2, significantly lower than those of gasoline passenger vehicles. Relevant data is as follows:

Table 2. Carbon Emissions Comparison Between Battery Electric and Gasoline Vehicles Over Full Life Cycle

-	Battery Electric	Gasoline
Carbon emissions per unit mileage ①	153.7	209
Vehicle cycle contribution (%) ②	45.2%	19.4%
Fuel cycle contribution (%) ③	54.8%	80.6%

Data source: China Automotive Low-Carbon Action Plan 2020

Based on this report, we can further estimate the carbon emissions of vehicles at different times or mileage. Assuming a vehicle life cycle of 11.5 years [3] and a driving distance of 150,000 kilometers, we will next calculate the carbon emissions during the vehicle cycle and fuel cycle respectively: In terms of the vehicle cycle, the carbon emissions of battery electric vehicles and gasoline passenger vehicles are calculated as follows: unit mileage carbon emissions of passenger vehicles ① * vehicle cycle contribution ② * vehicle driving distance of 150,000 kilometers. The result shows that the carbon emissions of battery electric vehicles are 10.42 tons of CO_2, while those of gasoline passenger vehicles are 6.08 tons of CO_2. In other words, during the vehicle cycle, the carbon emissions of battery electric vehicles are significantly higher than those of gasoline passenger vehicles. In terms of the fuel cycle, the annual carbon emissions of battery electric vehicles and gasoline passenger vehicles are calculated as follows: unit mileage carbon emissions of passenger vehicles ① * fuel cycle contribution ② * vehicle driving distance of 150,000 kilometers/11.5 years. The result shows that the annual carbon emissions of battery electric vehicles are 1.1 tons of CO_2 per year, while those of gasoline passenger vehicles are 2.2 tons of CO_2 per year. In other words, during the fuel cycle, the carbon emissions of battery electric vehicles are significantly lower than those of gasoline passenger vehicles.

If the carbon emissions during the fuel cycle of vehicles are evenly distributed throughout the entire vehicle life cycle, during the first 1-4 years (or within 52,000 kilometers of driving), the cumulative carbon emissions of gasoline passenger vehicles will be less than those of pure electric passenger vehicles. However, after 4 years (or more than 52,000 kilometers of driving), pure electric passenger vehicles will have a more significant advantage in terms of carbon emissions.

The specific details are as follows (in tons):

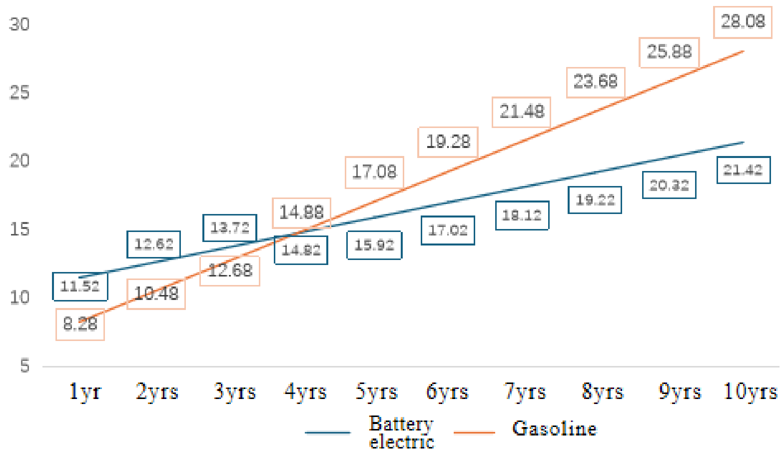


Figure 1. Carbon Emissions Comparison by Vehicle Type and Life Cycle Phase over a Specific Period

1.3. Sales of Vehicles of Different Energy Types [4]

According to publicly available statistics, since 2021, the sales of new energy vehicles worldwide have risen rapidly, and the industry has developed rapidly, with the penetration rate increasing from 3.65% at the end of 2020 to the current 17.32%. From January to July 2024, global sales of new energy vehicles reached 8.86 million, a year-on-year increase of 23%.

Global sales and penetration rate of new energy vehicles (in 10,000 units/%)

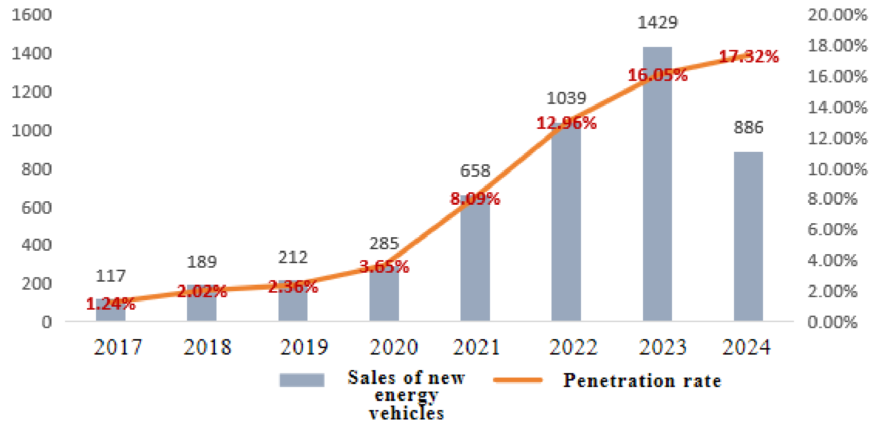


Figure 2. Global Sales and Penetration Rate of New Energy Vehicles (2017 - 2024)

Data source: Official account of Cui Dongshu, Secretary-General of China Passenger Car Association

Globally, from January to July 2024, sales of non-new energy vehicles reached 42.27 million, accounting for 83% of total sales, with a slight year-on-year decrease of 0.26%. In terms of new energy vehicles, sales of battery electric vehicles reached 5.75 million, accounting for 11% of total sales, with a year-on-year increase of 10%; sales of plug-in hybrid electric vehicles reached 3.11 million, accounting for 6% of total sales, with a year-on-year increase of 58%; while sales of other types of new energy vehicles accounted for a relatively small proportion.

The global sales of various powertrain types are as follows:

Table 3. Comparison of Vehicle Sales by Type: Jan.-Jul. 2023 vs. Jan.-Jul. 2024

Unit: 10,000 units

Type	Jan.-Jul. 2023	Jan.-Jul. 2024	Share	Year-on-Year Growth
Battery electric vehicles	525	575	11%	10%
Plug-in hybrid electric vehicles	197	311	6%	58%
Fuel cell vehicles	0.7	0.7	0%	0%
Total new energy vehicles sales	722	886	17%	23%
Non-new energy vehicles	4238	4227	83%	-0.26%
Total sales	4960	5114	100%	3%

Data source: Official account of Cui Dongshu, Secretary-General of China Passenger Car Association

From China's perspective, in the period from January to July 2024, sales of non-new energy vehicles reached 10.38 million, accounting for 64% of total sales, with a year-on-year decrease of 7%. In terms of new energy vehicles, sales of battery electric vehicles reached 3.57 million, accounting for 22% of total sales, with a year-on-year increase of 10%; sales of plug-in hybrid electric vehicles reached 2.361 million, accounting for 14% of total sales, with a year-on-year increase of 87%. The sales of various powertrain types in China are as follows:

Table 4. Vehicle Sales Performance in China by Type: Jan.-Jul. 2023 vs. Jan.-Jul. 2024

Unit: 10,000 vehicles

Type	Jan.-Jul. 2023	Jan.-Jul. 2024	Share	Year-on-Year Growth
Battery electric vehicles	326	357	22%	10%
Plug-in hybrid electric vehicles	126.3	236.1	14%	87%
Fuel cell vehicles	0.27	0.34	0%	25%
Total new energy vehicles sales	452.6	593.4	36%	31%
Non-new energy vehicles	1110	1037.6	64%	-7%
Total sales	1562.6	1631	100%	4%

Data source: Wind, China Association of Automobile Manufacturers (CAAM)

Based on the above data, it can be observed that the sales of new energy vehicles, both globally and in China, are primarily concentrated in battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), with BEVs dominating the market. However, the growth rate of PHEVs is relatively faster.

2. KEY REGIONAL MARKET SITUATION OF NEW ENERGY VEHICLES

The global sales of new energy vehicles are primarily driven by passenger cars. From January to July 2023 and 2024, the global sales of new energy passenger cars were 13.82 million and 8.48 million units respectively, accounting for over 98% of total new energy vehicle sales. Regarding the sales of new energy passenger cars by region, from January to July 2024, global sales were concentrated in China, Europe, and the United States, with these three markets accounting for over 90% of total sales. Specifically, China’s sales of new energy passenger cars reached 5.56 million units, accounting for 65% of the total and representing a year-on-year increase of 52%, making it the largest new energy vehicle market globally. Europe’s sales were 1.66 million units, accounting for 19% of the total and ranking second after China, with a year-on-year increase of 23%. The United States’ sales were 0.82 million units, accounting for 9.6% of the total and representing a year-on-year increase of 3.8%.

2.1. China: Transition From Policy-Driven to Market-Driven, With Industry Growth Returning to Stability

In March 2009, the Ministry of Industry and Information Technology (MIIT) issued the Automotive Industry Adjustment and Revitalization Plan, officially kicking off the industrialization of new energy vehicles in China. Since 2009, the development of new energy vehicles in China can be broadly divided into three stages: Firstly, from 2009 to 2015, the “from 0 to 1” stage, where subsidies, tax reductions [5], and other measures were used to encourage and promote the development of the new energy vehicle market; secondly, from 2015 to 2020, the industrial upgrading stage, where automakers were guided to increase R&D investment in new energy vehicles, and the development of the new energy vehicle industry was standardized, including the regulation of qualifications [6] for newly established battery electric vehicles enterprises, the phasing out of subsidies, and the implementation of the dual-credit policy [7]; thirdly, from 2021 to the present, the transition from policy-driven to market-driven stage, where the role of policy subsidies has diminished, market acceptance of new energy vehicles has increased, the supply of high-quality models has increased, and new energy vehicle sales have continued to rise, with the monthly sales penetration rate of new energy vehicles in China exceeding 50% in July 2024.

(1) Scale: steady growth rate with autonomous brands shining

The overall growth rate has returned to stability. From a full-scale perspective (passenger cars and commercial vehicles), China's new energy vehicle sales in the first seven months of 2024 reached 5.93 million units, representing a year-on-year increase of 31.1%. Compared to the rapid growth from 2020 to 2022, under the influence of factors such as a high base year and the withdrawal of subsidies, the transition from policy-driven to market-driven has led to a general return to stability in the growth rate of new energy vehicles since 2023, with stable sales in the first seven months of 2024.

China's new energy vehicle sales and penetration rate (in 10,000 units/%)

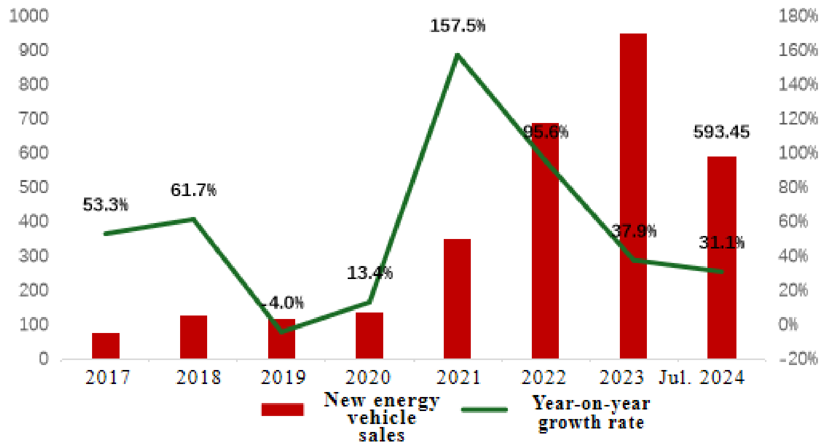


Figure 3. New Energy Vehicle Sales and Year-on-Year Growth Rates (2017 - Jul. 2024)

Data source: China Association of Automobile Manufacturers (CAAM)

From the perspective of China's new energy passenger vehicle sales and brand distribution, the penetration rate of passenger vehicle sales (retail) has been increasing year by year. In July 2024, China's new energy passenger vehicle sales reached 878,400 units in a single month, with a monthly penetration rate exceeding 51%, setting a new record high. Notably, the new energy passenger vehicle market is dominated by domestic brands, maintaining a share within the range of 70% to 90%.

China's new energy passenger vehicle sales and penetration rate (in 10,000 units/%)

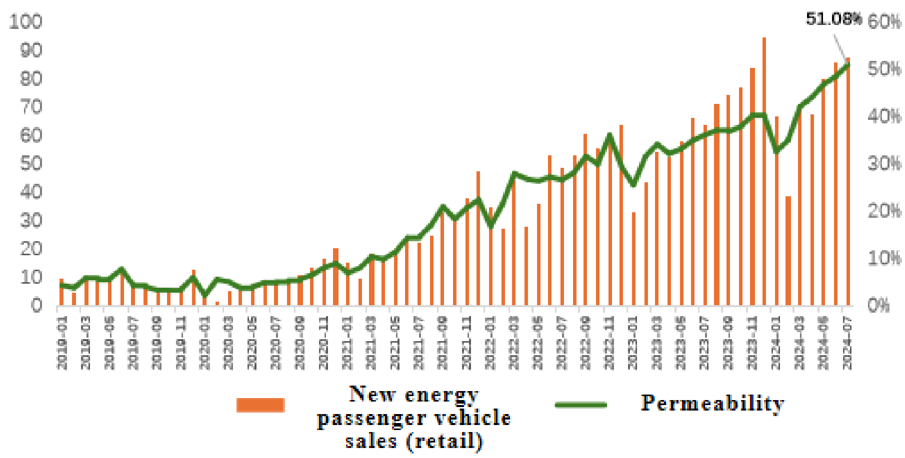


Figure 4. Trends in Retail Sales of New Energy Passenger Vehicles and Their Market Penetrability (2019 - 2024)

Data source: China Passenger Car Association (CPCA)

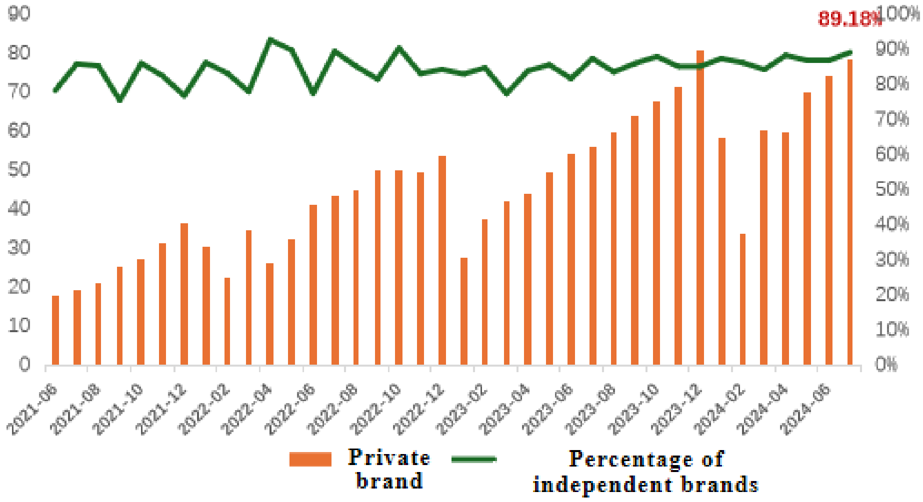


Figure 5. Trends in Private-Brand Sales and Percentage of Independent Brands (Jun.2021 – Jun.2024)

Data source: China Passenger Car Association (CPCA)

In terms of brands, BYD holds a market share of over 30%, while Tesla and GAC Aion occupy 7.3% and 6.5% respectively. From January to July 2024, the market share of the top three automakers (CR3) nearly reached 48%, and the market share of the top ten automakers (CR10) exceeded 78%. As the penetration rate of new energy vehicles increases rapidly, the gap between leading automakers and those in the middle and lower tiers of the industry widens, making it less likely for newly established brands to challenge the dominant position of leading automakers and disrupt the industry landscape.

Table 5. Comparison of Automakers' New Energy Vehicle Sales, Year-on-Year Growth, and Market Share: 2023 vs. Jan.-Jul. 2024

Ranking	Automakers	2023			Automakers	Jan-Jul 2024		
		Sales	Year-on-Year Growth	Market Share		Sales	Year-on-Year Growth	Market Share
1	BYD	270.6	50.3%	35%	BYD	170.03	22.7%	34.1%
2	Tesla	60.4	37.3%	7.8%	Geely	36.35	107.1%	7.3%
3	GAC Aion	48.4	76.7%	6.2%	Tesla	32.45	-0.3%	6.5%
4	Geely	46.9	54%	6.1%	Changan	30.81	80.3%	6.2%
5	SAIC-GM-Wuling	45.8	3.6%	5.9%	SAIC-GM-Wuling	25.40	19.8%	5.1%
6	Changan	38.7	82.5%	5%	Lixiang	24.00	38.5%	4.8%
7	Lixiang	37.6	182.2%	4.9%	SERES	22.01	631.5%	4.4%
8	Great Wall Motors	23.7	90.3%	3.1%	GAC Aion	19.42	-23.7%	3.9%
9	NIO	16	30.7%	2.1%	Chery	15.23	205.2%	3.1%
10	Leapmotor	14.4	29.7%	1.9%	Great Wall Motors	14.02	31.4%	2.8%

Data source: China Passenger Car Association (CPCA)

Despite the rapid development of China's new energy vehicle (NEV) industry as evidenced by the aforementioned data, the number of NEVs in circulation in China remains relatively low, according to the Ministry of Public Security. In 2023 and by July 2024, the number of NEVs in China stood at

20.41 million and 24.72 million respectively, accounting for 6.07% and 7.18% of the total vehicle population. Although the proportion has been continuously growing, it is still at a relatively low level.

Unit: 10,000 units/%

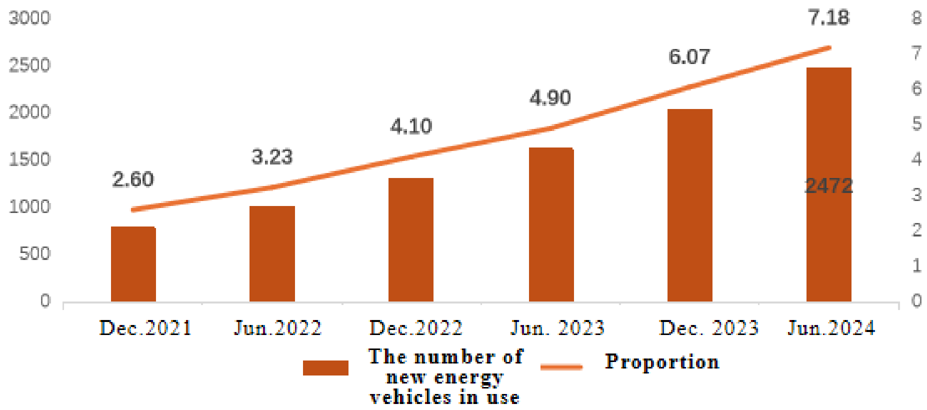


Figure 6. Growth Trends in the Number and Proportion of New Energy Vehicles in Use (Dec. 2021 - Jun. 2024)

Data source: Wind, Ministry of Public Security

(2) Exports: sustained high-speed growth in automobile exports

Automobile exports have maintained high-speed growth. In 2023, China's automobile exports reached 4.91 million units, with a year-on-year increase of 57.9%, surpassing Japan to become the world's largest automobile exporter (Japan exported 4.42 million units in 2023). Among them, exports of new energy passenger vehicles reached 1.049 million units, up 72% year-on-year. From January to July 2024, China's automobile exports totaled 3.262 million units, a year-on-year increase of 28.8%, with exports of new energy passenger vehicles reaching 677,000 units, up 17.8% year-on-year.

Table 6. China's Auto & NEV Passenger Vehicle Exports (Total/BEVs/PHEVs) with YoY Change: Dec.2022 – Jul.2024

Unit: 10,000 units

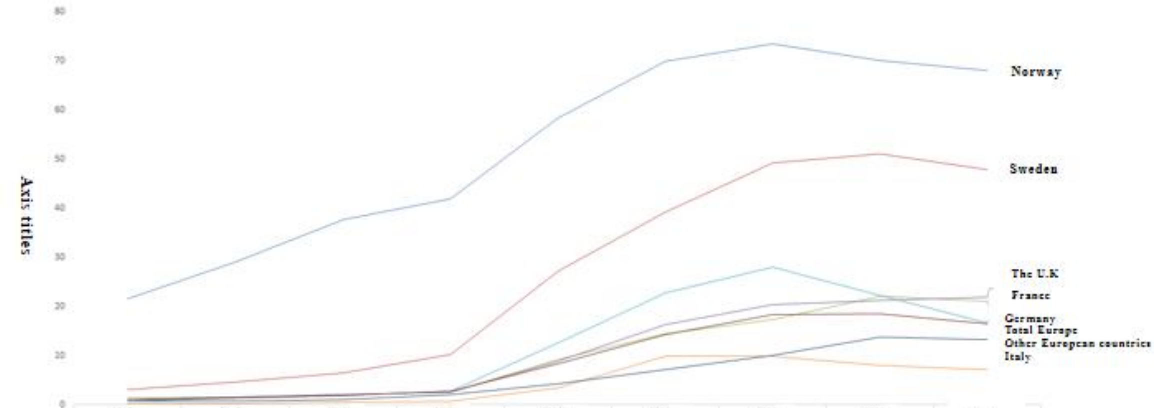
Time	China's Automobile Exports	Among Them: Passenger Vehicle Exports	New Energy Passenger Vehicle Exports	Among Them: Battery Electric Vehicles	Plug-in Hybrid Electric Vehicles
2022-12	311.06	267.18	60.97	55.60	5.37
2023-12	491.00	443.32	104.86	96.68	8.19
2024-07	326.20	299.16	67.73	53.32	14.41
Year-on-year change	72.94	67.04	10.23	-0.24	10.47

Data source: Wind, China Association of Automobile Manufacturers (CAAM), China Passenger Car Association (CPCA), General Administration of Customs (GAC)

Overseas export business has become an important source of revenue for some automakers. For example, in the first half of 2024, Chery's total sales exceeded 1.1 million units, with exports accounting for 532,000 units, nearly half of its total sales. Meanwhile, Great Wall Motors' total sales reached 554,900 units, an increase of 6.95% year-on-year, with overseas sales reaching 199,800 units, up 62.09% year-on-year.

2.2. Europe and the United States: Lower Penetration Rates and Slowed Electrification Progress

(1) Europe: As the birthplace of traditional automobiles, Europe boasts advanced technologies in reducing emissions from fuel-powered vehicles and automotive engines. After the revelation of Volkswagen's "Dieselgate" scandal in September 2015, European automakers such as Daimler and Volkswagen shifted their development focus towards electrification. Overall, from 2020 to 2023, the sales of new energy passenger vehicles in Europe were 1.27 million, 2.18 million, 2.48 million, and 2.83 million units, respectively, with penetration rates of 8.3%, 14.2%, 18.3%, and 18.5%. However, due to factors such as the phasing out of subsidies and high electricity prices, the growth of new energy vehicle sales in Europe has slowed down since 2023, with the penetration rate dropping to 16.5% from January to July 2024. From a country-specific perspective within the region, there are significant differences. For instance, in July 2024, Italy's penetration rate was only 7.2%, while Norway and Sweden, which have been the most aggressive in promoting electrification, achieved penetration rates of 68% and 47.8%, respectively.



	2016	2017	2018	2019	2020	2021	2022	2023	Jul 2024
Norway	21.6	29	37.7	41.9	58.3	69.8	73.5	70	68
Sweden	3	4.5	6.5	10.2	27.1	39.1	49.1	51.1	47.8
France	1.4	1.6	2	2.5	9.1	14.4	17.3	22	21
The U.K	1.1	1.6	2	2.6	8.9	16.3	20.3	21.2	21.9
Germany	0.7	1.3	1.8	2.7	12.6	22.7	28	22.2	16.7
Italy	0.1	0.2	0.5	0.7	3.4	9.8	9.8	8	7.2
Other European countries	0.7	0.7	1	2.1	4.3	7.2	10	13.8	13.2
Total Europe	1.1	1.4	1.9	2.7	8.3	14.2	18.3	18.5	16.5

Figure 7. Comparative Trends in Relevant Indicators (2016 - 2024) Among European Countries

Data source: Official account of Cui Dongshu, Secretary-General of China Passenger Car Association

(2) United States: As the third-largest market for new energy vehicles globally, the United States had an early start in the development of electric vehicles. However, the government's indecisive policies towards new energy vehicles have led to fluctuations in the development of this sector in the country, and the penetration rate has not surpassed double digits. From 2020 to July 2024, the sales of new energy passenger vehicles in the United States were 320,000, 660,000, 950,000, 1.41 million, and 820,000 units, respectively, with penetration rates of 2.2%, 4.2%, 6.9%, 9.1%, and 9.3%.

The recent shifts in new energy vehicle (NEV) development strategies by European and American countries and automakers have garnered significant market attention. For instance, in September 2023, UK Prime Minister Rishi Sunak announced the postponement of the ban on the sale of new petrol and diesel cars from 2030 to 2035. In December 2023, Germany completely abolished its electric vehicle subsidy policy. German automakers "BBA" (BMW, Benz, Audi) have all postponed their electric vehicle launch plans. However, these moves by European and American countries represent a slowdown in the electrification of automobiles rather than an abandonment of the NEV route. Electrification remains a long-term development goal for European and American countries and traditional automaker giants. For example, Mercedes-Benz officially responded to doubts about abandoning electric vehicles by stating, "We will continue to drive the electrification transformation in China, and the speed of transformation depends on market conditions and customer needs."

Additionally, the United States' Inflation Reduction Act provides significant subsidies for electric vehicles and clean energy sectors, while imposing strict exclusionary clauses on batteries and critical minerals produced and sold outside the United States.

3. CHARGING INFRASTRUCTURE AND BATTERY RECYCLING FOR NEW ENERGY VEHICLES

3.1. Charging Facilities

The increase in the penetration rate of new energy vehicles (NEVs) has driven the rapid development of charging piles. As of the end of July 2024, the total number of charging infrastructure nationwide reached 10.604 million (including public and private charging piles), an increase of 2.008 million or 23.4% from the beginning of the year. Among them, there were 3.209 million public charging piles and 7.394 million private charging piles. In terms of the vehicle-to-pile ratio, based on the estimated number of NEVs (24.72 million), the vehicle-to-pile ratio in China was approximately 2.33:1 in July 2024, with a public vehicle-to-pile ratio of 7.7:1. This is a certain gap from the targets set by the Ministry of Industry and Information Technology, which aims to achieve a vehicle-to-pile ratio of 2:1 by 2025 and 1:1 by 2030. Furthermore, there is a structural issue of insufficient public charging piles. In July 2024, the top ten regions, including Guangdong, Zhejiang, Shanghai, Shandong, and Beijing, accounted for 69.5% of public charging piles.

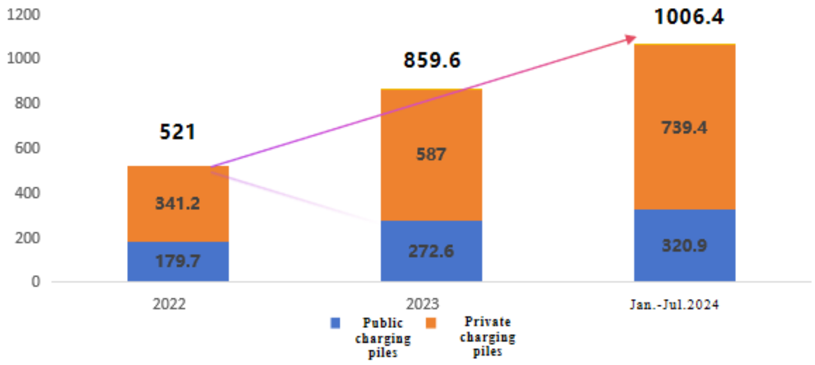


Figure 8. Growth in the Number of Public and Private Charging Piles (2022 - Jan.-Jul. 2024)

Data source: China Charging Union

In terms of public charging pile operators, the market shares of CR3, CR5, and CR10 in the industry are 53.26%, 64.81%, and 80.51%, respectively.

Table 7. Deployment and Market Share of Public Charging Infrastructure Providers (2024)

Company	Public Charging Piles (Units)	Share (%)	Cumulative Share (%)
Teld	608032	18.95%	18.95%
Star Charge	563665	17.56%	36.51%
Yun Express Charging	537714	16.75%	53.26%
State Grid	196484	6.12%	59.38%
Evking	174305	5.43%	64.81%
Xiaoju Charging	167915	5.23%	70.04%
China Southern Power Grid	90403	2.82%	72.86%
Shenzhen Carenergy Net	86034	2.68%	75.54%
Hoo Energy	82731	2.58%	78.12%
Ewe Energy	76639	2.39%	80.51%

Data source: China Charging Union

3.2. Battery Recycling

According to data from the China Automotive Battery Recycling Cooperation Alliance (CABRCA), in 2023, the number of decommissioned new energy vehicles nationwide reached 389,000, a year-on-year increase of 161.2%. This resulted in the generation of 168,000 tons of retired power batteries nationwide, marking a year-on-year growth of 78.3%. As of December 2023, China's capacity for the cascade utilization, recycling, and dismantling of lithium-ion batteries reached 3.793 million tons [8], while the actual recycling volume was approximately 623,000 tons, indicating a low capacity utilization rate and overcapacity in recycling capabilities.

Regarding the participants in the battery recycling market, the landscape is relatively fragmented. Currently, there are 156 enterprises officially included in the Ministry of Industry and Information Technology's "white list" that possess the qualification for recycling waste lithium-ion batteries. However, the number of enterprises registered in China under the category of "battery recycling" has exceeded 140,000, most of which are small enterprises with irregular management, low battery recycling efficiency, and the industry's management needs to be further strengthened. At present, the types of battery recycling enterprises include battery manufacturers, lithium battery material enterprises, and recycling enterprises.

4. FUTURE DEVELOPMENT TRENDS OF NEW ENERGY VEHICLES

4.1. Development Trends of New Energy

Currently, the global new energy vehicle market is dominated by electric vehicles. Hydrogen-powered vehicles, gas-powered vehicles, and others face issues such as high vehicle costs, safety concerns, lack of refueling/charging infrastructure, as well as challenges in the production, storage, and transportation of energy sources. These factors have led to a slower commercialization process, and their current development lags significantly behind the battery-powered vehicle route.

The advantages and disadvantages of various types of power-driven vehicles are as follows:

Each type of power-driven vehicle has its own unique advantages and disadvantages. Among them, battery-powered vehicles, when comprehensively evaluated in terms of technology, industrial maturity, as well as environmental friendliness, safety, and economics, are superior to vehicles powered by other energy sources. It is expected that battery-powered vehicles will continue to dominate the market in the short term. As for hydrogen-powered vehicles, if they fail to achieve revolutionary technological breakthroughs in infrastructure construction, hydrogen production, storage, and transportation, it is anticipated that their global promotion will face significant challenges.

From China's perspective, in terms of battery technology, solid-state batteries are potentially one of the most important development directions for current power batteries, based on the need to improve energy density and safety. In August 2024, the listed company Great Power Energy Storage released its first solid-state battery product, marking a significant breakthrough in the field of solid-state batteries. Regarding the development of hydrogen-powered vehicles, China's Government Work Report in 2024 proposed to "accelerate the development of cutting-edge and emerging industries such as hydrogen energy and new materials", with hydrogen energy being mentioned for the first time. Since 2024, provinces such as Shandong, Inner Mongolia, Guangdong, Jilin, and Shaanxi have successively introduced preferential policies such as exempting hydrogen-powered vehicles from highway tolls, providing investment subsidies for hydrogen refueling stations, and relaxing traffic restrictions, to promote the development of the hydrogen-powered vehicle industry.

Table 8. Comparative Analysis of Different Automobile Types: Energy Sources, Representative Makers, and Their Advantages & Disadvantages

Automobile Types	Energy Sources	Representative Automakers	Advantages & Disadvantages Analysis
Electric vehicles (including hybrids)	Electricity	Tesla, BYD, Geely, NIO, ZEEKR, XPeng, GAC Aion, SAIC-GM, Changan, Chery, etc.	Advantages: 1. Environmental protection. Reduced carbon emissions and low noise (zero carbon emissions during driving). 2. High energy efficiency. Traditional internal combustion engines have a thermal efficiency of about 40%, while electric motors can achieve an efficiency of up to 90%, with strong acceleration performance. 3. Low operating costs. The cost per 100 kilometers is generally lower than that of comparable gasoline-powered vehicles. Disadvantages: 1. Limited driving range, unfavorable for long-distance travel (especially for heavy-duty vehicles), and significant reduction in battery performance in low-temperature environments. 2. Low energy replenishment efficiency. Low distribution density of charging stations and long charging times, making it less efficient than hydrogen-powered or liquid fuel vehicles. 3. Environmental controversy. Currently, electricity is primarily generated from fossil fuels, and there are pollution concerns during battery production and recycling. 4. Consumption of rare metal resources.
Fuel cell vehicles	Hydrogen	Toyota, Honda, BMW, Mercedes-Benz	Advantages: 1. Environmental protection. Reduced carbon emissions and low noise (zero carbon emissions during driving). 2. High energy efficiency. Hydrogen fuel cells can achieve an energy conversion efficiency of over 50%, higher than internal combustion engines. 3. Rapid energy replenishment when infrastructure is adequately developed. 4. Longer driving range than battery electric vehicles. Disadvantages: 1. Insufficient infrastructure for energy replenishment. 2. Issues with hydrogen sources. Currently, most hydrogen is produced as an industrial by-product (gray hydrogen), with a small proportion from renewable sources (green hydrogen) or natural gas (blue hydrogen). Producing green hydrogen via electrolysis faces the same challenges as electric vehicles regarding electricity generation. 3. Special equipment or technologies are required for storage and transportation, resulting in high costs. 4. Safety concerns. In enclosed spaces, hydrogen mixed with air in certain proportions poses an explosion risk.
Hydrogen engine vehicles		Mercedes-Benz, Chevrolet, etc.	
Gas-powered vehicles	Natural gas/LPG	BYD, Hyundai, Changan, Dongfeng, Santana, Volkswagen, etc.	Advantages: 1. Compared to gasoline-powered vehicles, they emit fewer harmful emissions into the atmosphere (though there are still carbon emissions during driving). 2. Lower operating costs. Compared to gasoline-powered vehicles, the cost per mile is relatively lower. 3. Lower vehicle maintenance costs due to reduced carbon deposits, which helps extend engine lifespan. Disadvantages: 1. Natural gas is a non-renewable resource, and China's natural gas resources are limited. 2. Limited driving range, unfavorable for long-distance travel. 3. Uneven distribution of energy replenishment infrastructure.
Alcohol-ether vehicles	Methanol, etc.	Geely, Shaanxi Heavy Duty Automobile, Yutong	Advantages: 1. Relatively clean exhaust emissions (though there are still carbon emissions during driving). 2. Higher energy replenishment efficiency compared to electric vehicles. Disadvantages: 1. Primarily reliant on coal-to-methanol processes, which still utilize non-renewable resources. If traditional electricity-to-hydrogen-to-methanol routes are adopted, they face the same electricity generation challenges as electric vehicles. 2. Although methanol has a higher energy density than batteries, it is still challenging for long-distance transportation. 3. Improvements are needed in energy replenishment facilities, storage, and transportation technologies or infrastructure.
Data source: Compiled from public information			

4.2. Future Development Trends of New Energy Vehicles

Amidst the global context of “carbon peaking” and “carbon neutrality”, traditional automakers and new automotive forces continue to invest heavily in the new energy sector, signifying a continually promising future for new energy vehicles. The eventual displacement of traditional gasoline-powered vehicles from their dominant market position is merely a matter of time. Notably, the Beijing Automotive Group (BAIC) plans to cease selling gasoline-powered vehicles entirely by 2025, BMW aims to halt production by 2030, and Volkswagen intends to withdraw from the European market by 2035. Furthermore, Honda, Kia, General Motors, and others have all outlined plans to discontinue the sale of gasoline-powered vehicles.

Currently, the market landscape of the new energy vehicle industry has largely taken shape, with the future competition centering on “electrification + intelligence”. The L2+ [9] level of urban NOA (Navigate on Autopilot) autonomous driving technology is rapidly gaining popularity among automakers, enabling point-to-point intelligent driving in complex urban scenarios. This technology is gradually infiltrating from luxury models to mid-low-end models, with high-level intelligent driving features that were once concentrated in the market of vehicles priced above 300,000 yuan now gradually reaching down to models priced below 200,000 yuan. The number of cities where NOA is promoted and implemented has become a focal point of competition among brands. Xpeng plans to launch NOA in 200 cities by 2024; Huawei covered 45 cities in the fourth quarter of 2023; Lixiang plans to cover 100 cities by the end of 2023; Xiaomi’s urban NOA will be launched nationwide in August 2024; and in April 2024, Tesla was selected as one of the first data security models, accelerating the implementation of FSD (Full Self-Driving) in China.

5. CONCLUSION

Based on the development of “electrification + intelligence”, with the integration of the Internet, communications, third-party service platforms, and other elements into the automotive industry, it is not impossible for new energy vehicles to undergo a transformation similar to that of feature phones to smartphones in the future, potentially evolving into the largest intelligent terminals. All indications suggest that in the future, new energy vehicles are destined to dominate the transportation sector.

REFERENCES

[1] Excluding oil-electric hybrid vehicles

[2] This report was jointly researched and written by 16 domestic and foreign institutions including China Automobile Data Co., Ltd., the United Nations Environment Programme, the National Center for Climate Change Strategy and International Cooperation, the World Resources Institute, and Beijing University of Technology.

[3] Under the Compulsory Scrapping Standards for Motor Vehicles, the reference range for the service life of passenger vehicles is 8 to 15 years.

[4] Currently, the International Energy Agency (IEA), the Organisation Internationale des Constructeurs d’Automobiles (OICA), the Marklines Auto Information Platform, Gasgoo, the China Passenger Car Association (CPCA), and the China Association of Automobile Manufacturers (CAAM) all report global or regional vehicle sales based on their respective statistical standards. The global sales data presented here and in the following text are sourced from Cui Dongshu, Secretary-General of the China Passenger Car Association, while the sales data for China’s automotive industry are sourced from the China Association of Automobile Manufacturers and the China Passenger Car Association.

[5] Including: The Notice on the Pilot Subsidy for Private Purchase of New Energy Vehicles issued by the Ministry of Finance, the Ministry of Science and Technology, and the National Development and Reform Commission in 2010; the Development Plan for Energy-saving and New Energy Automobile Industry (2012-2020) issued by the Ministry of Industry and Information Technology in 2011; the Notice on Continuing to Promote the Application of New Energy Vehicles jointly issued by the Ministry of Finance, the Ministry of Science and Technology, the Ministry of Industry and Information Technology, and the National Development and Reform Commission in 2013; the Guiding

Opinions on Accelerating the Promotion and Application of New Energy Vehicles issued by the General Office of the State Council the in 2014;

[6] The Regulations on the Administration of Newly-established Pure Electric Passenger Vehicle Enterprises jointly issued by the National Development and Reform Commission and the Ministry of Industry and Information Technology in 2015.

[7] The Parallel Management Measures for the Average Fuel Consumption of Passenger Vehicle Enterprises and New Energy Vehicle Credits issued by the Ministry of Industry and Information Technology in 2017.

[8] Data source: The White Paper on the Development of China's Lithium-ion Battery Recycling, Dismantling, and Secondary Use Industry (2024), jointly issued by research institutions EVTank, Yivi Economic Research Institute, and China Battery Industry Research Institute.

[9] China's Ministry of Industry and Information Technology issued the Classification of Automotive Driving Automation in March 2022, dividing driving automation into 0-5 levels. Among them, L2 (Combined Driving Assistance): The automated driving system continuously executes lateral or longitudinal motion control of the vehicle within the designed operational conditions and possesses the ability to detect and respond to corresponding vehicle motion control.