The Current State and Future Prospects of Different Types of New Energy Vehicles

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Abstract. With the advent of the electrification era of passenger cars, the development and trend of new energy vehicles have attracted growing public attention. The focus of this paper is to compare the merits and demerits of different types of new energy vehicles and to look forward to their future development prospects. Based on the sales situation of NEVs in recent years, the proportion of NEVs in the current market and the existing conditions of different types of NEVs, this paper analyzes the current market structure and looks forward to the future development of new energy vehicles. The paper finds that pure electric vehicles and plug-in hybrid vehicles are the two main players in the new energy vehicle market. In the era of automobile electrification, pure electric vehicles have unique comprehensive advantages, which is the development direction of the passenger car industry. Hybrid vehicles are used as an auxiliary for their coordinated development. Hydrogen energy vehicles are currently not as selected by the public as pure electric series and hybrid series, but hydrogen energy is another new energy development direction in addition to electric energy, and there is also much room for its development with the national support. Natural gas fuel vehicles currently have a small market and can also give full play to their advantages in the transition stage of development.

1 Introduction

Currently, China has a massive demand for cars, and the industry of new energy vehicles (NEVs) is flourishing. There has been a discernible shift in consumer preferences from conventional gasoline-fueled automobiles towards NEVs , particularly in China, where there has been a consistent and escalating emphasis on the NEV industry in recent years. New energy vehicles have entered a crucial moment in their development, and related technologies are becoming increasingly mature. Driven by government subsidies and supportive policies, the sales of NEVs in China have grown year on year, maintaining the world's highest sales for seven consecutive years [1]. Amidst this large-scale environment, several types of NEVs have emerged, which can broadly be divided into pure electric vehicles, hybrid cars, hydrogen-powered vehicles, and natural gas fuel vehicles. According to Xinhua News Agency, by the end of 2022, the number of NEVs reached 13.1 million, accounting for about 13% of all vehicles. Among them, the number of pure electric vehicles was 10.45 million, accounting for 79.78% of NEVs; plug-in hybrids accounted for about 20% [2]. As such, it is evident that pure electric vehicles are currently the mainstream development, and the reasons for their success, as well as the development direction of other types of NEVs, are worth pondering. Through a comparative analysis of existing data, this article provides a look into the future of various types of NEVs. This article offers valuable insights into the present state of the new energy vehicle (NEV) market, facilitating their comprehension of the subject matter. Furthermore, it aids in the analysis and interpretation of the merits and demerits associated with various categories of NEVs.

2 Analysis of the Current State of Different Types of NEVs

Regarding pure electric vehicles, since the advent of Tesla, people's acceptance of pure electric vehicles has gradually increased, and major car companies are vying to research and develop to seize the market. At present, pure electric vehicles have transitioned from a dismissed type of car to a high-quality choice for buyers. Not only are their prices acceptable to the general public, but their operating costs are also lower than those of gasoline-powered cars. The downside is the range issue, but data shows that this problem is gradually being addressed, as shown in Table 1, and the gradual improvement of pure electric vehicle technology also predicts the future market trend.

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Table 1: Changes in the Market Structure of the Driving Range of Pure Electric Passenger Vehicles [3]

Driving Range	2013	2016	2019	2021	2022.1-6
＜300km	92.1%	81.8%	9.4%	18.4%	15.8%
300-400km	7.8%	7.9%	30.0%	17.5%	15.3%
400-500km	0.0%	5.6%	49.8%	37.0%	29.6%
500-600km	0.1%	2.1%	5.7%	20.1%	28.8%
≥600km	0.0%	2.6%	5.1%	7.0%	10.5%

Hybrid vehicles can be divided into mild hybrid, light hybrid, medium hybrid, and heavy hybrid systems based on the degree of system integration. The application scope of mild and light hybrids is relatively small because the drive provided by the motor is very limited. A light hybrid usually has a 36V, 42V, or 48V battery pack installed in the body, which works during engine start-stop, start-up, or braking to achieve a fuel-saving effect. Therefore, it is widely used in traditional gasoline vehicles. The maximum power ratio of the motor to the engine in a medium hybrid typically ranges from 15% to 40%, and the motor can assist in driving the wheels when the car is accelerating or under a heavy load. A heavy hybrid, where the maximum power ratio of the motor to the engine exceeds 40%, generally uses a mixed-link structure. Both the motor and the engine can drive the car independently. Hence, plug-in hybrids fall under the heavy hybrid category [3, 4].

Figure 1 shows the three common working principles of hybrid vehicles. The general efficacy of a conventional series hybrid is relatively modest due to the necessity of two energy conversions: from mechanical energy to electrical energy, and subsequently from electrical energy back to mechanical energy. Consequently, the inherent advantages of this system may not be readily apparent. Conversely, a typical parallel hybrid is equipped with two propulsion systems, namely an internal combustion engine and an electric motor, which can operate independently or synergistically to enable collaborative propulsion. Therefore, parallel hybrid vehicles can be used under complex conditions, and their application range is quite broad. The typical mixed-link hybrid is currently the most focused on and has the best performance. The structure diagram is shown below.

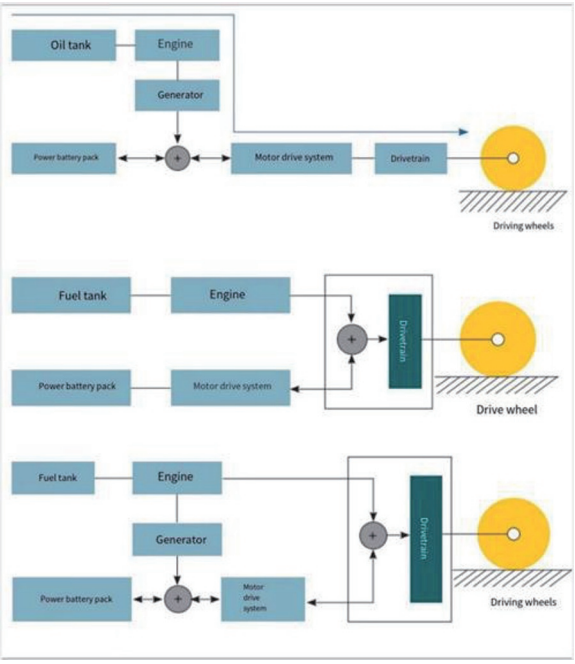

Fig. 1 From top to bottom: Typical Series Hybrid, Typical Parallel Hybrid, Typical Mixed-Link Hybrid [5]

Regarding hydrogen-powered vehicles, the Chinese hydrogen fuel cell vehicle market grew rapidly in the first half of 2022, setting a new high for the year in June with production and sales data. A total of 527 units were produced in a single month, with 455 units sold. Despite the high base in June 2021, this was an increase of 18.7% and 67.3% year-on-year, respectively, and an even more significant surge of 117% and 342% month-on-month. In total, 3,367 hydrogen fuel cell vehicles were sold in 2022, an increase of 112.8% compared to the 1,586 units sold the previous year [6]. When analyzing its technology, we generally look at its energy storage method and the working principle of the hydrogen fuel cell. The commonly used hydrogen storage methods on the market include metal hydride hydrogen storage technology, organic liquid hydrogen storage technology, low-temperature liquid hydrogen storage technology, and high-pressure gaseous hydrogen storage technology, among which the high-pressure gaseous hydrogen storage is the most mature and most used vehicle-mounted hydrogen storage technology. However, its biggest drawback is its low hydrogen storage density, which requires a large space and makes storage and transportation somewhat complicated. Figure 2 shows the most common hydrogen-oxygen fuel cell on the market. This cell's reaction materials are hydrogen and oxygen, which undergo an electrochemical reaction through the proton exchange membrane, causing hydrogen atoms to lose electrons and oxygen to gain electrons. The working principle of the hydrogen fuel cell is shown in Figure 2 [7].

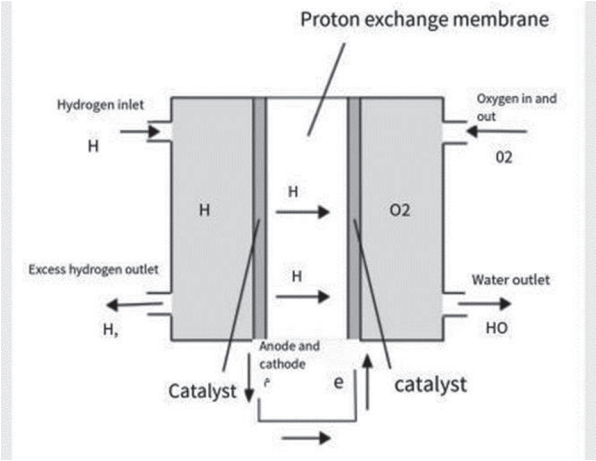

Fig. 2 Working scheme of hydrogen fuel cell

During the "Twelfth Five-Year Plan" period, the state vigorously promoted the development of natural gas fuel in the field of operational vehicles, providing financial support for the special project of energy saving and emission reduction in transportation. As a result, the proportion of natural gas operational vehicles surged to over 28%. In addition to this, the state has gradually increased subsidies for natural gas operational vehicles, including natural gas buses, trucks, and dual-fuel taxis, thereby rapidly promoting natural gas fuel vehicles and gaining a large market in the commercial field [8].

Combing with the surveys of market information, we summarize the merits and demits of the following four different types of NEVs, namely, pure electric vehicle, hybrid vehicle, hydrogen power vehicle and natural gas fuel vehicle.

1) As for pure electric vehicle, the merits lie in its rapid development of related technologies, decreasing and market-competitive costs and significant government support and subsidies. The demerits are reflected in its insufficient availability of public charging stations, concerns about vehicle fires and its safety as well as slower charging speed and unimproved battery technology. The current vehicles of this type include Tesla, Mercedes EQ series, BMW iX series, Audi e-tron series, and so on.

2) As for hybrid vehicle, the merits lie in its widely acceptation by the public and economical cost and its abundant power driven by dual engine drives. The demerits are reflected in higher operating cost after battery depletion, high overall vehicle weight and unimproved technology. This kind of vehicle has restrictions due to lack of "green license plates" and it doesn't have pure electric mode. In addition, it has safety concerns and relatively high price. The current vehicles of this type include range-extending type such as Li Xiang One, oil-electric hybrid type such as Lexus ES, as well as plug-in hybrid type such as Jeep Wrangler 4xe, Mercedes, BMW, Audi 5 series, A6, E-class PHEV version, and so on.

3) As for hydrogen power vehicle, the merits lie in its use of cleanest fuel, large reserves of hydrogen resources and promising future. The demerits are reflected in immature technology, low utilization efficiency, high price of hydrogen fuel vehicle, and lagging infrastructure development for hydrogen energy. Recently, new brands such as Seres and Polestar have focused on hydrogen fuel vehicles. Traditional brands like Toyota and BMW are leading in this field.

4) As for natural gas fuel vehicle, the merits lie in its attribute as a clean energy source, large reserves of resources, cheaper fuel costs and safety in use. The demerits are reflected in insufficient refuelling stations, low fuel endurance and policy restrictions. This kind of vehicle is mostly used in commercial fields, such as some city buses, taxis, and so on. Some car brands also have related products on the market. Our country also has some cargo vehicles with domestic brands.

3 Analysis of the Development Trends of Different Types of NEVs

Currently, pure electric vehicles account for the largest proportion of NEVs, with the highest growth rate (67.13% year-on-year) and dominate the market. Therefore, various manufacturers are striving to develop relevant technologies and capture market share. In addition, the recent decrease in the price of lithium battery materials has reduced costs, giving pure electric vehicles even greater market advantages. Currently, under the strong advocacy and support of the state, subsidies and support for this type of vehicle are substantial. However, as the development of pure electric vehicles accelerates, problems are increasingly emerging. Firstly, there is the issue of energy replenishment. The ratio of public charging piles to electric vehicles is approximately 1:3.4, indicating that the prevalence of charging infrastructure needs to be improved. This could potentially cause inconvenience when traveling. Although the speed of charging has improved, it still needs to be enhanced (a quick charge of half an hour only reaches about 80%, which cannot meet people's needs). Battery swap electric vehicles could solve this problem, but the prevalence of battery swap stations is also a challenge. The range is greatly influenced by external conditions, battery technology is still not perfect, and there are many uncertainties when traveling long distances. Furthermore, safety issues have emerged, with frequent occurrences of electric vehicles catching fire in recent years, causing some people to have concerns about their safety.

In the era of transition from oil to electricity, hybrid vehicles are a product of the times and are more easily accepted during the transition process. They not only reduce fuel consumption but are also more readily accepted by the public, hence their market recognition continues to rise. Interestingly, plug-in hybrid vehicles feature a dual-engine drive with an electric motor and a fuel engine, providing more robust power than conventional fuel vehicles. Plug-in hybrid vehicles can switch between three modes: pure electric, hybrid, and pure fuel. Furthermore, there are three types of drive modes: extended range, hybrid, and plug-in hybrid. Currently, the drawbacks of extended-range vehicles are becoming increasingly apparent. Once the battery is drained, the cost of driving increases, the total vehicle

weight is high, and the technology is not particularly advanced. Hybrid vehicles cannot receive green plates and are affected by restrictions, do not have a pure electric mode, and cannot meet consumer needs when oil prices are high. In comparison, plug-in hybrids perform best in terms of performance. However, because they are equipped with separate electric motors, there are safety concerns. Moreover, since most of these vehicles are introduced as mid to high-end models, their prices are relatively high.

Hydrogen-powered vehicles are another powerful direction for development besides pure electric vehicles. Firstly, hydrogen is the best clean energy source, and China has ample reserves of hydrogen energy. If better technology can be utilized, a promising future can be expected. Therefore, hydrogen energy is seen as the ultimate energy source. However, our understanding of hydrogen energy is still in the exploratory phase. In other words, our technology for utilizing hydrogen energy is immature, the efficiency of use is not high, and current costs are high. Compared with pure electric power, the future economy is worse, and it cannot take off in the short term. Considering the current situation, the industrial chain of hydrogen fuel cell vehicles is not perfect, and the production cost of fuel cells is high. Therefore, the price of hydrogen fuel vehicles is higher, generally above 300,000 yuan. The construction of hydrogen energy infrastructure is relatively backward, and the prevalence of hydrogen refuelling stations is low, so there may be inconveniences in daily use.

Natural gas fuel is a great clean energy source with large reserves, so the fuel is cheap, easy to use, burns completely, and easy to store. If an accident occurs, the gas is easy to disperse and is not prone to explosions, so it is safe to use. Considering the current situation in China, there are few gas stations, and the endurance is low. It had a golden period in 2014, but afterward, due to policies (prohibiting private cars from converting to gas), its use is limited and it can only be used for commercial purposes (taxis), limiting its development.

In summary, the two main forces in the new energy vehicle market are pure electric vehicles and plug-in hybrid vehicles, but due to the impact of prices and state support, the market for pure electric vehicles is greater than that of plug-in vehicles. Hydrogen-powered vehicles are in the early stage of development, limited by the lack of relevant technology and infrastructure construction, and it will take some time before they can be officially applied. The market for natural gas vehicles is smaller and not mainstream, but it also has unique advantages. For instance, geographical advantages can be observed in regions such as the western areas where the electricity infrastructure is less developed, but abundant natural gas resources are available, which can be fully utilized during the transition phase of development.

4 Outlook

In the long run, the electrification of vehicles is the mainstream of the times, and gasoline cars will eventually be replaced. "Plug-in hybrid vehicles can effectively deal with range anxiety, usage scenarios, and battery price issues. Before the era of vehicle electrification fully arrives, consumers also need a transition period to adapt. Therefore, in the foreseeable future, plug-in hybrid vehicles and pure electric vehicles will coexist [9].

For hydrogen-powered vehicles, under the context of the country's strong advocacy for low-carbon development and energy transformation, the hydrogen energy industry is undoubtedly an opportunity for the new era. China plans to have 200 hydrogen refuelling stations by 2025, with a goal of producing 50,000 hydrogen fuel cell vehicles, and even aims to have 1,000 hydrogen refuelling stations and over 5 million hydrogen fuel cell vehicles by 2050. Judging from this, the attention paid to hydrogen energy by the state is profound, and the popularization of hydrogen-powered vehicles will further progress with the gradual improvement of infrastructure [10].

In the context of vigorous development of clean energy and the imperative to save energy and reduce emissions, most charging station constructions are in central, northern, and coastal China, while the infrastructure for charging piles in north-western, south-western regions and rural areas is extremely inadequate. The slow development of local new energy infrastructure construction has reduced the desire of users in the northwest, southwest, and rural areas to buy NEVs, slowing down the development of NEVs in China [10]. Therefore, different regions should choose the development path suitable for their own energy advantages, such as some areas in the western region where oil and gas resources are abundant, but the facilities for electricity and hydrogen storage are insufficient. In the transition phase of development, vigorously developing natural gas vehicles is undoubtedly a good choice.

5 Conclusion

After comparison and in light of the current situation, we can draw the following conclusions:

In the short term, the prospects and popularity of different types of NEVs should rank as follows: pure electric vehicles > plug-in hybrids > hydrogen-powered vehicles > natural gas vehicles. As we are in the era of vehicle electrification, pure electric vehicles have unique comprehensive advantages. With the vigorous development of relevant technologies, the advantages of electric vehicles are increasingly greater than those of gasoline vehicles. The vigorous research and development by various manufacturers also provide consumers with richer choices, so the prospects of pure electric vehicles are the broadest, representing the trend of the industry. Although the market for plug-in hybrids may not surpass pure electric vehicles, the current development of NEVs is in a transitional period from gasoline to electricity. Hybrid vehicles are a product of the times. After long-term development, these types of vehicles may be completely phased out, but they are very

likely to occupy a larger market share in the short term. Natural gas vehicles can complement electric vehicles, contributing to the development of NEVs in different regions and fields. Hydrogen energy, as the ultimate energy source, is also a major direction for the development of NEVs. The state attaches great importance to the development of hydrogen fuel cell vehicles, and the subsidies provided are increasing. Therefore, the popularization of hydrogen energy vehicles will thrive after major breakthroughs in hydrogen energy technology research and more comprehensive hydrogen energy infrastructure. That could very well herald a brand-new era.

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