A Brief Analysis of New Energy Vehicle Development for Promoting Sustainability and Carbon Neutrality in China

Bojun Xiao

College of Design and Engineering, National University of Singapore, Singapore

Corresponding author: leutorcas@163.com

Abstract. With the industrialization and urbanization of China, the significance of carbon neutrality and peak carbon emissions are becoming increasingly larger in recent decades. One of the methodologies to promoting the "dual carbon targets" and sustainability by Chinese government is developing new energy vehicles (NEVs). Nowadays, NEV sales amount in China reached to 58% of the world, and the trend of NEV sales in China represents a steady and rapid augment over 5 years. This article would bring a brief introduction to current situation of NEVs in China, and analyze 4 mainstream types of NEVs, namely plug-in hybrid electric vehicles (PHEVs), extended-range hybrid electric vehicles (EREVs), batteries electric vehicles (BEVs), and fuel cell electric vehicles (FCEVs), from the parameters of travel ranges, prices, carbon emissions, and number of recharging/refueling utilities.

Keywords: New energy vehicles, carbon neutrality, sustainability development.

1 Introduction

For the last few decades, Chia's rapid economic development has been accompanied by a substantial rise in air pollution[1]. Continuous improvements in air quality are urgently necessary to meet the ecological civilization development of meeting carbon neutrality and peak carbon dioxide emissions. Air pollution generates a wide array of problems, including potential health effects and economic growth stagnation[2, 3]. In response, various methodologies and strategies have been implemented to address and mitigate these pollution-related challenges. Consequently, enhancing air quality necessitates robust government policies and heightened public environmental protection awareness, along with manufacturing technology advancements in order to reduce pollutant emissions, as emissions from manufacturing are a significant contributor to air pollution. As one of the world's largest pollutant emitters[4], China has enacted a comprehensive policy portfolio to foster technological innovation in manufacturing[5].

With the rapid proliferation of vehicles, vehicles originating from vehicles have emerged as the primary source of air pollution in numerous urban areas[6], contributing to approximately 10% - 15% of total CO_2 emissions[7, 8]. Hence, improving air quality has been a garnered significant attention in recent years. Concurrently, advancements in new energy technologies for vehicles are crucial for reducing air pollution, a

Q. Wu et al. (eds.), *Proceedings of the 2024 3rd International Conference on Public Service, Economic Management and Sustainable Development (PESD 2024)*, Advances in Economics, Business and Management Research 309,
https://doi.org/10.2991/978-94-6463-598-0_9

standpoint endorsed by international organizations such as World Health Organization (WHO) and the United Nations[9]. Thus, China has attempted to enact several important laws and policies to foster the improvement of new energy vehicles (NEVs). During the stage of market promotion, the widespread of battery electric vehicles (BEVs) greatly depends on policy assistance. Present government policies primarily encompass financial subsidies, financial subsidies, preferential tax treatments, financial subsidies, free parking and driving privileges[10]. NEVs also represent a crucial technological innovation capable of reducing the production and usage of traditional fossil fuel vehicles, thereby improving air quality[10]. In 2023, China's NEV market experienced a breakthrough., with annual sales reaching 8 million units, marking a 33.3% increase year by year, as shown in Figure 1 a)[11]. This surge indicates an explosive growth trajectory in market demand, signifying a pivotal moment in the market's evolution. China has maintained its position as the global leader in NEV sales for eight years, emerging as a critical driver in the electric automobile transition in the world[11]. The breakdown of global sales of NEVs in 2023 is shown in Figure 1 b)[11]. This article will analyze the characteristics of four different NEVs, and provide some perspective to the NEV industry in China to leave some inspiration about development in the future.

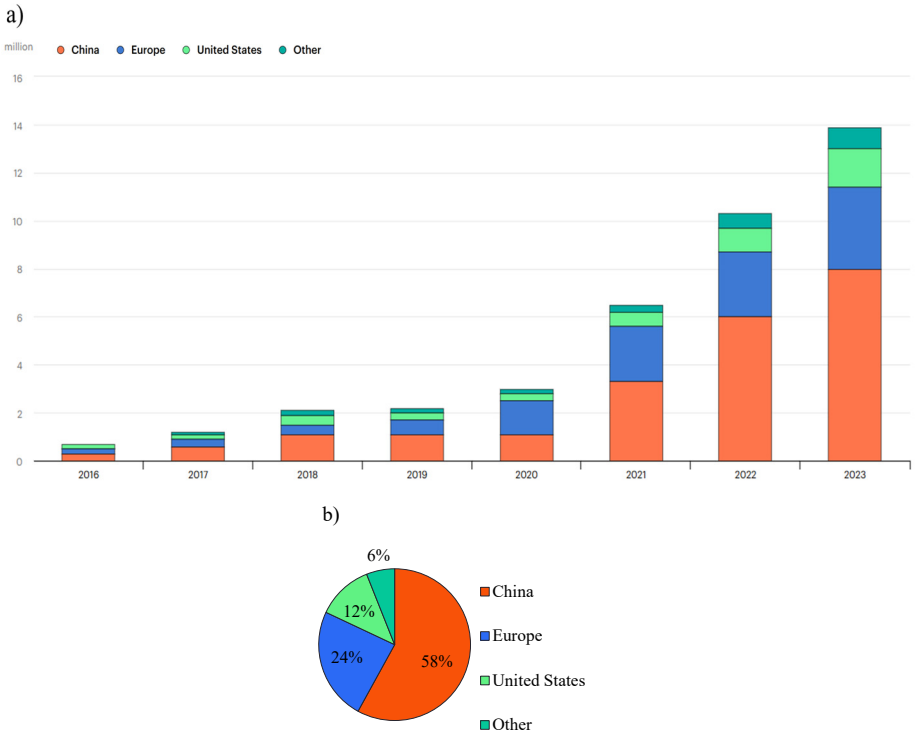

Fig. 1. a). Global sales of NEVs during 2016-2023[11]; b). NEV sales breakdown of 2023[11].

2 Description

There are four mainstream NEVs at present in the world PHEVs, EREVs, BEVs, and FCEVs, respectively. Figure 2 illustrates the market composition of distinct kinds of NEVs in China during 2011-2021[12]. BEVs was the majority, and experienced a steady increment. The percentage of BEVs for passengers was 75.9% in 2021, followed by that of PHEVs, which was 17.4%, ranked on second largest proportion. It is worth noticing that FCEVs in China was only around 0.1%, which might indicate that the development of FCEVs was still in cradle phase and had not commercialization.

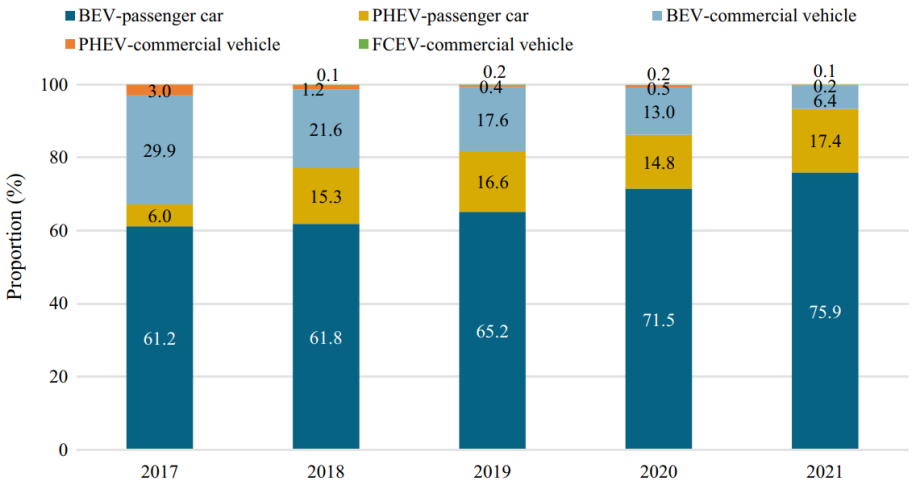

Fig. 2. Overview of the development of NEV market during 2017-2021[12].

2.1 Plug-in Hybrid Electric Vehicle (PHEV)

A PHEV is a specific hybrid electric vehicle that incorporates a rechargeable battery pack. This battery pack can be recharged directly through a charging cable connected to an external electric power source. Additionally, it has the capability to charge internally through its onboard internal combustion engine-powered generator. PHEVs have the flexibility to utilize generators of renewable energy, such as solar, wind, or hydroelectric power, enabling them to operate largely emission-free. Alternatively, they can draw power from a gas station. The present PHEVs usually have the following characteristics: fuel consumption per 100 kilometers is during 4.2-6.9L, most of which with a 1.5 L displacement internal combustion engine (either turbocharged or turbocharged direct injection). Moreover, the travel range in China Light-duty Vehicle Test Cycle (CTLC) standard by pure electric motor is 120-280 km. Overall power output by electric motor is 145-330 kW. As for the fuel displacement, most of PHEVs in China are 1.5Ti and 1.5T[13]. Ti indicates turbocharged direct injection engine, and T stands for turbocharged only. A turbocharger is an air compressor that can increase the gas inlet

of the engine, hence increase the power and torque of the engine. PHEVs is a typical example of transition from diesel fuel vehicles to electric vehicles. They undertake today's mainstream automobile market using diesel fuels and pave the way for the popularization and marketization of emission-free vehicles in China. Moreover, PHEVs do contribute to lessen the consumption of fossil energy such as petroleum replaced by the external electricity source, which enables the development of a less greenhouse gas (GHG) emission society. This expected consequence is also the main objective of NEVs. However, compared to conventional fossil fuel vehicles, PHEVs have higher prices, from 80k-440k CNY[13]. PHEVs have to pay extra attention to the battery aging problems, which might be considered as a consumable. This will bring to another issue that whether the aged battery is sustainable enough to be recycled or discarded.

2.2 Extended-Range Electric Vehicle (EREV)

According to Terminology of Electric Vehicles (GB/T19596-2017), EREVs are vehicles capable of attaining their power performance solely through pure electric mode operation. In instances where the onboard rechargeable energy storage system falls short of meeting cruising range demands, the onboard auxiliary power supply device is activated, which provides electric energy to the power system and extending the electric vehicle's travel range. Moreover, the vehicle-mounted auxiliary power supply device installed in the vehicle operates independently and lacks any transmission connections, such as a drive shaft or blet, to the driving system[14]. In other words, fossil fuel does not directly provide energy to the power system, but to the battery first, then the battery connects to electric motor and makes the vehicles moving. When the battery runs out, the fossil fuel will start to work to extend the travel range. EREVs' pure electric single travel distance interval in CTLC standard is in about 100-255km, and the overall driven distance in World Light Vehicle Test Cycle (WLTC) is approximately 1140-1440km. The power output of electric motor is around 175-365kW. For the internal combustion engine, most of EREVs use 1.5L displacement engine, and fuel consumption is around 4.3-6.5L per 100km. In contrast to PHEVs, EREV can utilize a smaller battery capacity and power output, as the fuel engine is able to convert its energy into electricity to charge the battery. Consequently, EREVs can effectively function even with a low battery capacity of less than 20kWh[15], whenever the power is low, there will be a fuel engine-generator to charge the battery. This increases the cruising range of the vehicles. Furthermore, EREVs is able to have a more flexible charging place, since the charging is not necessarily finished by the charging point, but also the electric generator from combustion engine. This characteristic also results in a higher recovery of fossil fuel energy to electricity. Nevertheless, similar to PHEVs, the basic prices for EREVs are also higher than conventional fossil fuel vehicles, usually in 140-300k CNY[15].

2.3 Battery Electric Vehicle (BEV)

BEVs are vehicles that totally powered by electric motor and batteries. The most significant characteristic is that BEVs do not require any fossil fuels, which means there is totally zero emissions. BEVs' cruising distance in CLTC standard is from 554km to

830km. Power output range by electric motor is around 194-495kW. The battery capacity of BEVs is usually larger than PHEVs and EREVs, which is about 73.6-101kWh[16]. BEVs now are still in development stage, "since charging is a hassle, if you are in highway service areas or second and third-tier cities, it may take a long time to approach the charging stations", mentioned by users of NEVs[17]. These observations suggests that concerns regarding driving range are rooted in issues like unstable battery life, lengthy charging time, and insufficient charging infrastructure in China[17]. One of the most important reasons why BEVs are promoted in the world and China is they are independent to fossil fuel utilization and environmental protection. Unlike other hybrid electric vehicles, BEVs can totally achieve zero emissions of air pollutants and greenhouse gases. Furthermore, consumers' experience would build a positive attitude towards BEVs, which in turn promotes the purchase of BEVs. Through firsthand interaction with BEVs, consumers develop a more positive perception, particularly regarding speed, acceleration, and minimal noise. Additionally, practical engagement underscores the feasibility and functionality of BEVs, reinforcing their status as a practical and viable transportation alternative[18]. On the other hand, driving range of BEVs is a major drawback, which is the reason why consumers don't choose BEVs instead of fossil fuel vehicles[19]. In addition, as previous mentioned, charging sites for BEVs are not widely spread on many cities in China. This would cause inconvenience for charging the vehicles. Lastly, BEVs have high purchase prices compared to fossil fuel vehicles, which is around 216k – 300k CNY[16].

2.4 Fuel Cell Electric Vehicle (FCEV)

FCEVs utilize fuel cells to produce electricity, propelling an electric motor. Given the power of generation properties of fuel cells, many FCEVs integrate supercapacitors or batteries into their power systems, albeit with lesser capacity compared to pure electric vehicles. Typically, fuel cells in vehicles generate electricity by harnessing high-pressure hydrogen and oxygen from the air. Regarded as zero-pollution vehicles, FCEVs solely emit water and heat while generating electricity. A typical FCEV in China is Hyundai NEXO. It has three 35MPa hydrogen cylindrical tanks, which can contain totally 168L or 3.99kg of compressed hydrogen. The fuel cell battery has 40kW of power, and 1.56kWh of capacity. The travel range in CLTC standard is 550km[20]. The advantages and disadvantages of FCEVs are both significant. The most reason FCEVs are developing is that there is no pollutant emission but H2O. FCEVs also reduced the risk of environmental contamination from fossil fuels. Lastly, the time of refilling hydrogen is fast, only takes about 5 minutes to fill up all three tanks[20]. Nevertheless, the number of hydrogen refueling stations (HRSs) is of extreme meager, which directly limit the spreading of FCEVs. In addition, even with these low travel range power output, the price is high as 800k CNY[20]. Ultimately, the hydrogen storage technology still requires developments, since carrying highly compressed tanks of hydrogen is considered a potential life risk.

3 Conclusion & Recommendation

NEVs in China is experiencing a rapid and revolutionary development. It is with the solid support of policies that NEV market had such a steep increment even China has been through Covid-19 period. NEV sales market of China is the majority among the world, the proportion is 58%. PHEVs and EREVs have similar working pattern, so they share similar benefits and drawbacks. They both have long travel range, since gasoline are utilized while working and a nice solution of transition from fossil vehicles towards BEVs. BEVs have zero emissions of greenhouse gasses and pollutants, and the according to consumers' feedback, the overall performance of BEVs is satisfactory or even better. The design of FCEVs is a perfect solution to using hydrogen energy to achieve net zero carbon emissions, and FCEVs have higher energy usage efficiency compared to other vehicles. However, they share a problem that the expensive price builds a high barrier against consumers to purchase, which somewhat halts the prompt of NEVs. In addition, the distribution of charging sites and hydrogen refueling stations are very limited and uneven, especially for BEVs and FCEVs. Lastly, FCEVs still require a more advanced hydrogen storage system to bring FCEVs a higher safety level. Based on the situation of NEVs mentioned above, the government needs to keep the policy endorsement for promoting NEVs and keep up the amount charging and hydrogen refueling stations to satisfy the needs of NEV usage. Ultimately, technological breakthrough will be definitely helpful to lower the cost of batteries and fuel cells.

References

1. Li Y et al. Construction and countermeasure discussion on government performance evaluation model of air pollution control: A case study from Beijing-Tianjin-Hebei region. J Clean Prod, 2020, 254, 120072.
2. Wang R et al. The relationship between air pollution and depression in China: Is neighbourhood social capital protective? Int Environ Res Public Health, 2018, 15, 1160.
3. Anamika P et al. Health and economic impact of air pollution in the states of India: The Global Burden of Disease Study 2019. Lancet Planet Health, 2021, 5, 25-38.
4. Zheng H et al. Leveraging opportunity of low carbon transition by super-emitter cities in China. Science Bulletin, 2023, 68, 2456-2466.
5. Jiang Z, Xu C. Policy incentives, government subsidies, and technological innovation in new energy vehicle enterprises: Evidence from China. Energy Policy, 2023, 177, 113627.
6. He X, Jiang S. Effects of vehicle purchase restrictions on urban air quality: Empirical study on cities in China. Energy Policy, 2021, 148B, 112001.
7. Murena F et al. CO_2 abatement and CH_4 recovery at vehicle exhausts: Comparison and characterization of Ru powder and pellet catalysts. Int J Hydrogen Energy, 2020, 45, 8640-8648.
8. International Energy Agency, CO_2 Emissions in 2023. IEA, 2024.
9. David P. International innovation and diffusion of air pollution control technologies: The effects of NO_x and SO_2 regulation in the US, Japan, and Germany. J Environ Econ Manag, 2006, 51, 46-71.
10. Li P, Zhang Z. The effects of new energy vehicles subsidies on air quality: Evidence from China. Energy Economics, 2023, 120, 1006624.
11. International Energy Agency. Electric car sales 2016-2023. IEA, 2023.

12. Zhang Z. Annual Report on the Big Data of New Energy Vehicles in China. China Machine Press, 2022.
13. BYD. BYD Han DMI configuration table. Copyright © BYD Co., Ltd., 2024 [in Chinese].
14. National Technical Committee of Auto Standardization. Terminology of Electric Vehicles (GB/T 19596-2017). NTCAS, 2018 [in Chinese].
15. Copyright © 2024 Shenlan Automotive Technology Co., Ltd. Shenlan S7 configuration table. Copyright © 2024 Shenlan Automotive Technology Co., Ltd, 2024 [in Chinese].
16. ©Xiaomi Automotive Technology Co., Ltd. Xiaomi SU7 configuration table. ©Xiaomi Automotive Technology Co., Ltd, 2024 [in Chinese].
17. Wu Z. et al. Public attitudes and sentiments towards new energy vehicles in China: A texting mining approach. Renewable and Sustainable Energy Reviews, 2023, 178, 113242.
18. Burgess M et al. Electric vehicle drivers' reported interactions with the public: driving stereotype change? Transp Res Part F: Traffic Psychol Behav, 2013, 17, 33-44.
19. Hackbarth A, Madlener R. Willingness-to-pay for alternative fuel vehicle characteristics: a stated choice study for Germany. Transp Res Part A: Policy Pract, 2016, 85, 89-111.
20. Copyright ©2024 Hyundai Motor (China) Investment Co., Ltd. Hyundai NEXO configuration table. Copyright ©2024 Hyundai Motor (China) Investment Co., Ltd, 2024 [in Chinese].