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Strategic Emerging Industry: Analysis of Development of New Energy Vehicles

Supervisor:
Prof. Anna D'ambrosio

Candidate:
Jingjie Xu

Abstract

In an environment that promotes environmental protection and energy conservation, new energy vehicles (NEVs) have developed rapidly, becoming a research hotspot in the current international automotive industry, as well as a point of political and economic competition between countries. The first part of this article introduces the current condition and challenges of NEVs in major economies, including competition within the automotive industry and business games between countries.

The emergence of an emerging product requires the support of national policies and consumers, as well as healthy competition and appropriate business cooperation among peers. In the second part of the article, we will analyse the strategic choices and responses made by each country to the emergence of NEVs. Besides, based on relevant theories of consumer attitudes, we will analyse the relevant factors influencing consumer attitudes towards NEVs. Meanwhile, we will use two major NEVs brands, Tesla from United States and BYD from China, as examples to analyse the relationship between the cooperation and competition of NEVs under globalisation and geopolitics.

Last but not least, the environmental problems caused by fuel combustion are becoming more and more prominent: global warming, destruction of the ozone layer, air pollution, etc. The emergence of NEVs can not only improve the energy structure, but also save energy and reduce emissions, contribute to low-carbon consumption and promote the sustainable development of energy resources. The third part of the article will analyse the sustainable development of NEVs from three aspects: economy, environment and society.

Index

List of figures

1. Current condition

1.1. Introduction

The history of electric vehicles predates that of the most common internal combustion vehicles. In 1828, Hungarian inventor and engineer Jedlik Ányos, the father of the DC motor, first tested an electromagnetic rotating mobile device in a laboratory. In 1834, the American Thomas Davenport built the first electric car powered by a DC motor. The development of Texas oil and the improvement of internal combustion engine technology in the United States led to a gradual loss of advantages for electric vehicles after 1920. The vehicle market was gradually replaced by cars powered by internal combustion engines. In addition to attempts by traditional vehicle companies, there were also attempts by newly established companies. For example, Tesla was newly established in the United States in 2003 and BYD Automobile was newly established in mainland China. Since the 2020s, some countries and regions have initially planned to prohibit the sale of fuel vehicles in the next decade (the majority of planned bans are scheduled for 2030-2040) and transition towards the development of electric vehicles. On 14 February 2023, the European Parliament of the European Union passed a bill to prohibit the sale of fuel cars from 2035[1].

The automotive industry is becoming an intensification of competition. In the US market, Tesla has gained a significant market share due to its price advantage and excellent car performance. Additionally, several traditional foreign brands, including Toyota from Japan, Hyundai from South Korea and Nio Motors from China, they also have a greet market share in the U.S. market. In Europe, in addition to foreign car brands such as Tesla and BYD, traditional car manufacturers have gradually joined the competition. However, because of the manufacturing costs and the customer preferences towards traditional fuel vehicles, the new energy vehicles (NEVs) have not yet mass-produced. In China, as the world's largest market for NEVs, the competition in China is intense. In contrast to the situation in Europe and the United States, in the low-end market, local brands offer relatively low prices and more modern designs that align with the aesthetic preferences of younger consumers. At the same time, the high-end market has attracted significant investment and production from major foreign automakers. For instance, the Shanghai Gigafactory, operated by Tesla, is the company's largest

and most productive factory; Additionally, Volkswagen has established three pure electric vehicle factories in China: the SAIC-Volkswagen Anting MEB (Modular Electrification Tools) factory, the FAW-Volkswagen Foshan MEB factory, and the Anhui MEB factory in Hefei[2].

Therefore, this chapter will introduce today's three major economies, the United States, China, and the European Union, as well as some countries that are also at the forefront of the NEVs industry, analyse their current condition of the NEVs industry, and the reason of developing of NEVs.

1.2. China

China is not an energy-rich country, and it is currently a net importer of oil and natural gas. The recent decades China has been seeking to diversify its energy consumption structure by exploring alternative energy sources, in order to support the sustainable development of the country's economy. As the world's second-largest oil consumer after the United States, but as of 2023, China's proven oil reserves accounted for only 1.79% of the world's total proven reserves. While crude oil production is relatively stable, consumption is rising every day. According to the National Bureau of Statistics (NBS), China's crude oil production has been approximately 25.6 billion barrels since 2023. In contrast, China's crude oil consumption is 14.79 million barrels per day in 2023, and China's crude oil imports have sharply increased to 40.31 billion barrels, with an external dependence of more than 70%. The Chinese government has noticed that converting fossil fuel energy consumption into electricity consumption is an important means to reduce the country's dependence on energy imports.

The Chinese automobile industry started relatively late in comparison to other global markets. In the beginning of the establishment of the People's Republic of China, the scale of automobile production in China was relatively limited, with most of the production relying on foreign assistance and the introduction of technology. The vehicles were primarily used by government agencies, the military and a select few units, with the proportion of the ordinary people owning cars being extremely low. With the advent of China's reform and opening up in 1978, numerous foreign companies were attracted to invest in China. In 1984, Volkswagen and the Shanghai Automotive Group established the Shanghai Volkswagen Automotive Company

Limited, marking the inaugural automotive joint venture in China. During the early 2000s, the Chinese government has started to prioritize environmental protection and energy security, which was leading to the exploration and encouragement of NEVs development. Some domestic companies started to pay attention to develop electric and hybrid models, yet the production and sales remained relatively low. In the early 2010s, the Chinese government implemented a series of policies to support the development of NEVs, such as subsidies for vehicle purchases and free licences. These policies boosted the rapid growth of the NEVs market. Concurrently, domestic and foreign automakers began to increase their investment and R&D efforts in the field of NEVs. From the year 2015, the Chinese market for NEVs entered a phase of exponential growth. The government implemented further subsidies for NEVs and introduced a policy requiring automakers to achieve a certain percentage of NEVs sales. These policies continued to encourage the rapid growth of the NEVs market, in both sections of production and sales. Besides, the continuous advancement of technology and improvement of the industrial chain have led to a significant improvement in the quality and performance of Chinese NEVs. Concurrently, the domestic NEVs industry chain has been gradually enhanced, including the development of supporting industries such as batteries, motors and charging facilities. From the 2020s, Chinese NEVs industry is starting to develop and integrate the intelligence and autonomous driving into NEVs. Concurrently, domestic companies are increasing their efforts to expand their international market share and compete with other global automotive industry.

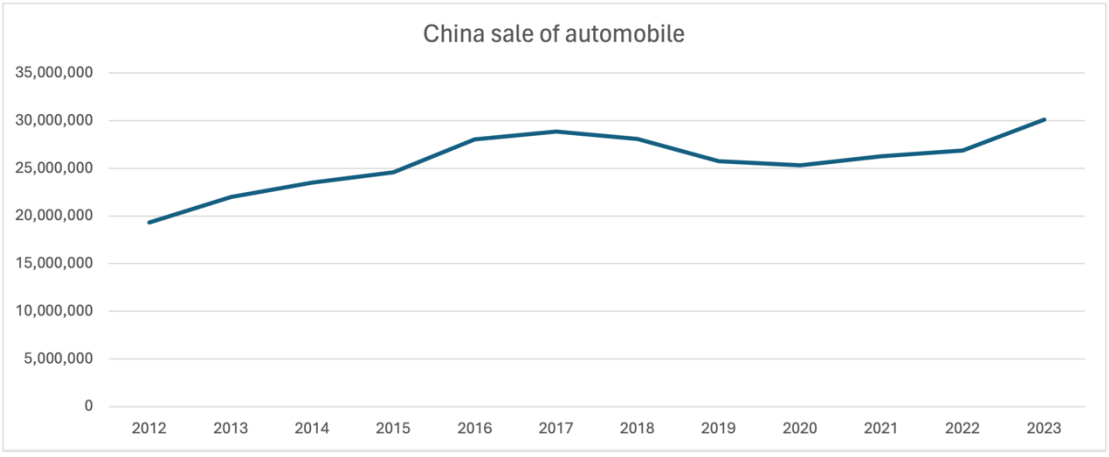


Figure 1: China sales of automobile from 2012 to 2023. (source: China Association of Automobile Manufacturers (CAAM))

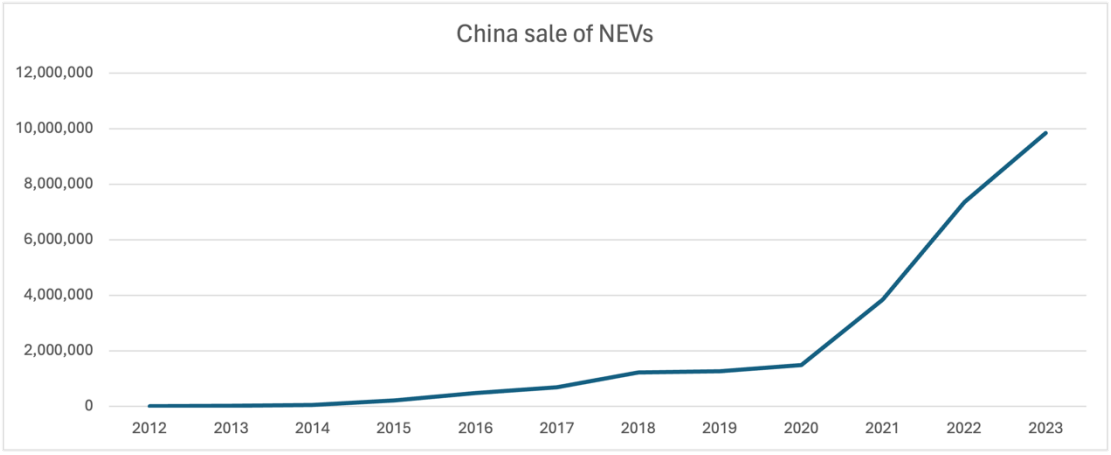


Figure 2: China sales of NEVs from 2012 to 2023. (source: China Association of Automobile Manufacturers (CAAM)

These two charts illustrate the evolution of China's automotive industry over the past decade. Overall, the industry is experiencing a period of rapid growth, particularly after 2015. This is particularly evident in the sales of NEVs. Even during the 2017-2019 period, when the Chinese automotive industry experienced a downturn, NEVs demonstrated a relative boom. This is largely due to the full blossoming of China's domestic and overseas-invested car companies.

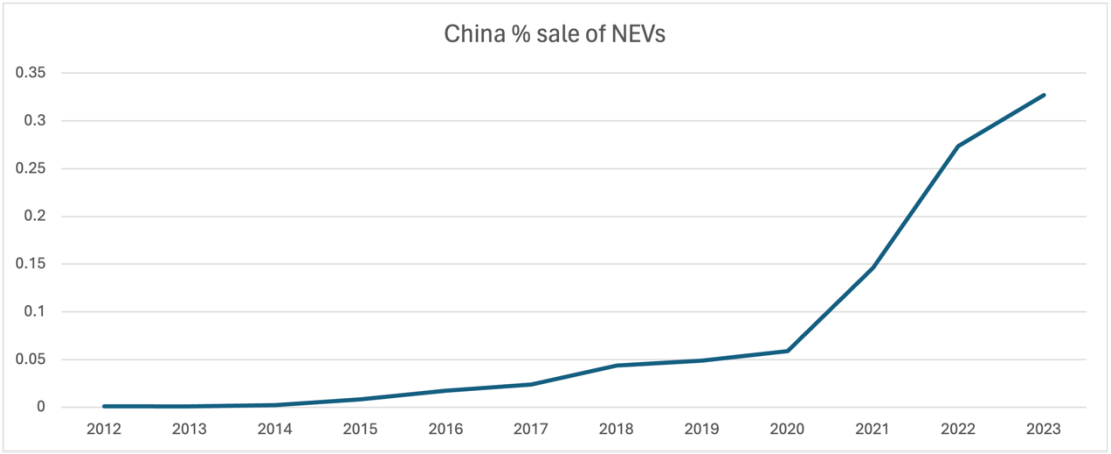


Figure 3: China sales of NEVs percentage from 2012 to 2023.

This figure illustrates that while the overall NEVs sales share is still relatively small, the growth rate is evident. The latest data from MSCI[1] Index indicates that by the end of 2022,

[1] The MSCI Thematic Index Series has been designed to reflect the performance of a range of companies associated with each key theme. Four key themes have been identified that are widely recognised as shaping the future and changing global economic trends: Environment & Resources, Transformative Technologies, Health & Healthcare and Society & Lifestyle.

sales of NEVs reached 6.87 million units, with their sales share in the country's total new car sales climbing sharply to 25.6% in 2022. China accounts for 64% of global NEVs sales, up from 40.7% in 2020. Approximately 78% of China's total NEVs production and sales are pure electric vehicles, with passenger cars being the type of NEVs with the highest production and sales volume, accounting for approximately 95% of the national production and sales volume in 2022. It is anticipated that sales of NEVs will continue to grow in the future. It is projected that electric passenger car sales in China will reach approximately 12.27 million units by 2026, which represents a near doubling of the 2022 figure[3].

Figure 4: China sales of NEVs market share in 2023. (source: China Association of Automobile Manufacturers (CAAM)

The Chinese NEVs market has a high competition, as showed by this figure of the market share of NEVs by brand in China in 2023. On the one hand, in the part of domestic automakers, for example Nio Motors as a representative of the new build Chinese companies, have officially listed on the New York Stock Exchange since September 2018. Additionally, WM Motor and Xpeng Motors have both started the delivery of their products. In March 2024, the renowned mobile phone manufacturer Xiaomi released its inaugural NEVs, the SU7. This vehicle shows the company's commerce style, which is the cost-effective design, and its quality has attracted the attention of younger people. On the other hand, in the part of foreign automakers, for example Tesla established its branch in Shanghai on May 2018, which is China’s first wholly foreign-owned automobile company. Then not long after, at the Tesla shareholders meeting in early June, Tesla disclosed its plan to build its first factory outside the United States in Shanghai, China.

1.3. United States

The United States started to pay attention to NEVs in the early 21st century, and after the global financial crisis in 2008, the government became more active in promoting this development. Prior to that, there already had been some sporadic NEVs projects and research, but they had not received much attention. What really led the government to start paying attention to the development of NEVs was the global financial crisis in 2008, which triggered a comprehensive reflection on the economy, society and environment. According to the U.S. Energy Information Administration (EIA), the U.S. energy self-sufficiency rate has gradually increased, primarily thanking to the development of shale oil and natural gas. The United States as one of the world's largest crude oil producers, the shale oil revolution has led to a rapid increase in U.S. oil production. By 2019, the U.S. energy self-sufficiency rate has reached 91%, a new high in the past 70 years. According to the EIA, the average daily crude oil production in the United States in 2019 will be approximately 12.2 million barrels per day. Therefore, even though the United States is one of the world's largest oil consumers, its dependence on imported oil is very low.

The United States as the world's largest economy and one of the world's largest consumer markets, its large population and high level of spending power has attracted the attention of companies around the world. The NEVs are one of the popular industries, and its emergence has also received great attention from the U.S. government. Although the United States has increased energy self-sufficiency rate in recent years, it is still actively promoting the development of NEVs. It is aimed to reduce its dependence on traditional petroleum energy and diversifying its energy consumption structure. With the people's awareness of energy crisis and environmental protection has increased after global financial crisis, the search for alternative energy sources has become a common goal of the government and industry. Furthermore, the scientists and environmental organisations keep warning about climate change, and this has driven the process to reduce greenhouse gas emissions. An important part of reducing urban greenhouse gases is the promotion of NEVs, which is regarded as one of the most effective ways to reduce carbon emissions in the transportation field. The most famous company is Tesla, which is the leading of domestic companies in the field of electric vehicles. Its battery

technology has been at the forefront of the industry. Tesla has launched a number of electric vehicles equipped with advanced battery technology, and it always keeps carrying out deeper research and development (R&D) and innovation to improve the energy efficiency, such as charging speed and cycle life of its batteries. All these optimizations and improvements are thanking to the large number of high-tech and innovative companies in the United States, as well as the strong support of the U.S. government for technology and innovation. Furthermore, the advancement and improvement of battery technology has reduced the cost of battery, which it is the most expensive part, thereby enhancing the competitiveness of electric cars. Subsequently, this engaged more consumers to purchase NEVs and manufacturers to invest in the electric vehicles. In addition, with the government continues to implement a series of policy measures, it will also help the development of NEVs. These policies include but are not limited to tax incentives, researching and development funding, and the establishment of charging infrastructure, etc., which can well encourage consumers to purchase NEVs and increase manufacturers' production of NEVs.

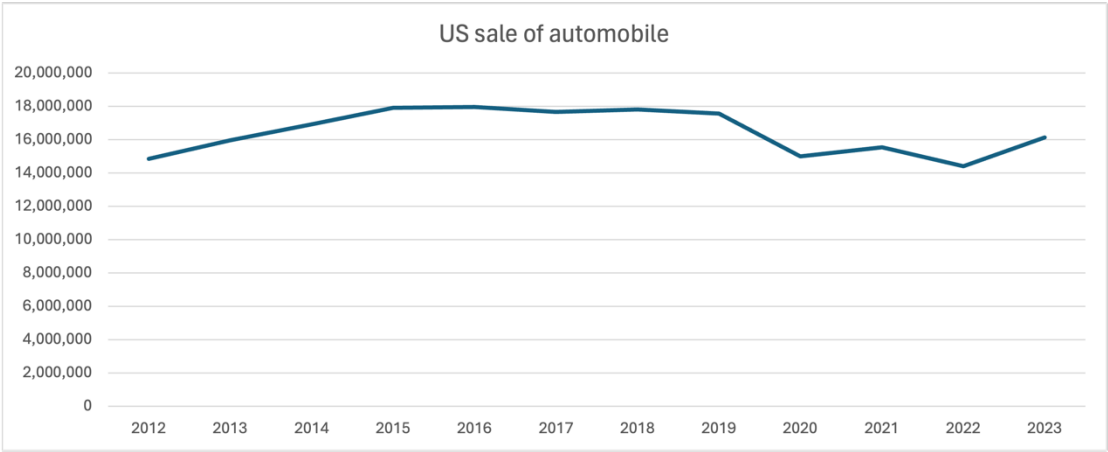


Figure 5: US sales of automobile from 2012 to 2023. (source: marklines)

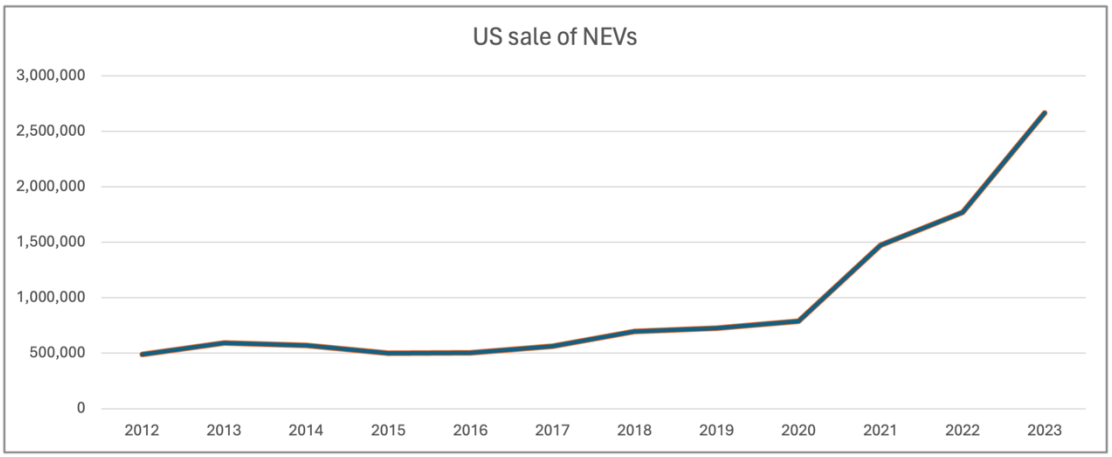


Figure 6: US sales of NEVs from 2012 to 2023. (source: marklines)

The two charts show that the U.S. vehicle sale market keeps relatively stable in recent years, with only a slight decline in 2020 because of the COVID-19. This presents a positive trend, since the United States as the world's second largest country of car owner and the seventh largest country of car owner per capita. Furthermore, the sales of NEVs in the United States are significantly increased after 2020. Even though the rate of NEVs is still relatively low, this shows the popularity keeps growing.

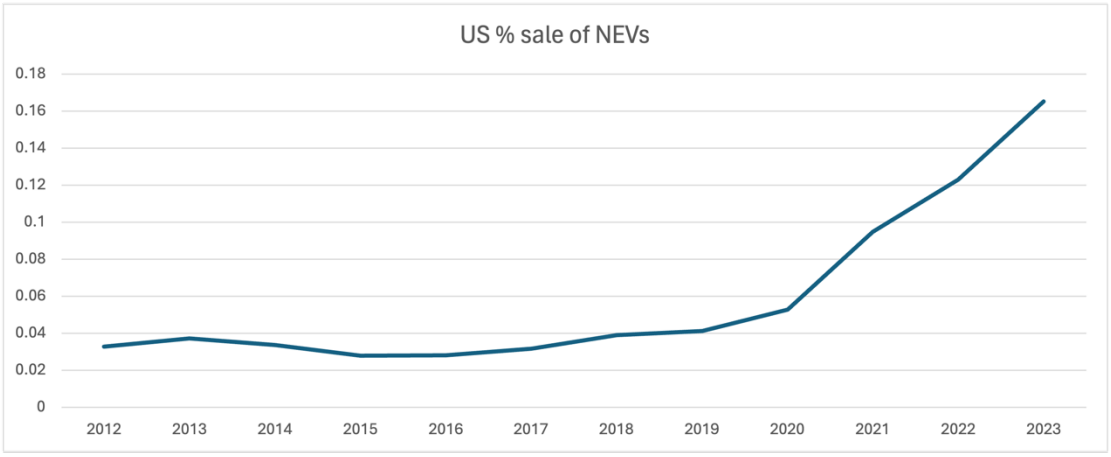


Figure 7: US sales of NEVs percentage from 2012 to 2023

After the onset of the global pandemic in 2020, the U.S. government didn't stop introducing a series of measures, to bolster support and incentives for the adoption of NEVs. During the pandemic, people's concepts of life have changed dramatically, and they started to pay more attention on the healthy and environmental problems. This change has led to a surge in demand for eco-friendly transportation, which is also reflected in the sales of NEVs, which have increased significantly. Moreover, the conflict between the Russian and Ukrainian has made energy prices instable. With oil and natural gas prices keeping fluctuating, this makes

purchasing NEVs become a better choice.

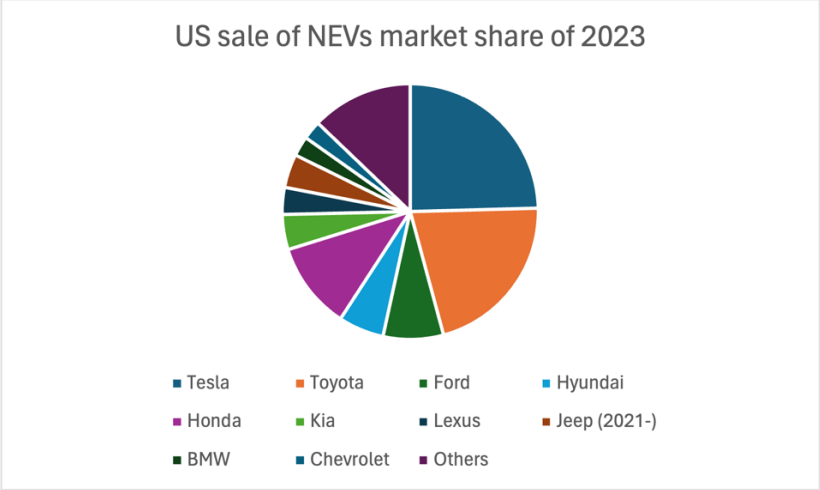


Figure 8: US sales of NEVs market share in 2023. (source: marklines)

The above chart shows that the most famous U.S. manufacturer of NEVs is the domestic company Tesla, which is one of the leading companies in the field of electric vehicles. With the forefront of the industry in terms of battery technology, Tesla has launched a number of electric vehicles equipped with advanced battery technology. Tesla keeps continue to conduct R&D and innovation with the aim to improve the energy efficiency, charging speed, and cycle life of the battery. In recent years, Tesla has earned a significant market share in the US. In the market of pure electric vehicle, Tesla has occupied typically above 50%. Moreover, in the market of plug-in hybrid, Tesla's market share is also quite significant, usually above 30%. While there are other competitors in the market, Tesla models are typically more recognisable and attractive, making other competing brands relatively less visible. For example, the Tesla Model 3 became the world's best-selling electric car of all time since 2020, and in June 2021, it became the first electric car to surpass 1 million units sold worldwide. Then in 2023, the Tesla Model Y became the world's best-selling car.

1.4. Europe

The energy issue is consistently a significant concern within the Europe. In recent years, the EU has taken a proactive stance in the sections of climate change and transitioning to a more sustainable energy system. EU members are keeping state that they have generally demonstrated to reduce their dependence on fossil fuels. Meanwhile, they are keeping increase

the share of renewable energy sources and improve energy efficiency. While the energy situation is different among countries within the EU, the overall trend is to reduce carbon emissions and increasing energy security. As known as the EU has low energy self-sufficiency, therefore all EU countries are net importers of energy. According to the latest news from Eurostat[2] on March 25, 2024, the EU's import dependency for the entire family of crude oil and petroleum products surged to a new record high of 97.7% in 2022. According to IEA[3] data, in 2022, as the three giant countries in the EU, the crude oil import rates of Germany, France, and Italy were as high as 96.9%, 98.6%, and 93.5% respectively. It is worth to notice that more than 90% of EU countries have crude oil imports with a dependency rate more than 90%. Russia used to be the EU's largest energy supplier, but after the Russian-Ukrainian conflict, due to a series of sanctions against Russia, the EU's energy imports from Russia dropped sharply by about 90%. On the one hand, it has indeed effectively sanctioned Russia, but on the other hand it has also resulted a huge impact on the EU itself. For example, the increment of energy prices has led to price increases for many daily necessities, as well as inflation. Therefore, the EU had to search for alternative energy supply chains. For instance, by December 2022, the United States has been the largest supplier of crude oil to the EU[4].

In Europe, the automotive industry reached maturity in the first half of the 20th century. Many countries have more than one famous car brand, with a range of products from low-end to high-end luxury. These include Bentley, Rolls-Royce, Ferrari, Porsche, and other luxury cars that are household names. In contrast, there are also middle-range and low-end products, such as Volkswagen, Fiat, and BMW, which are found everywhere in the world. In the beginning, the EU automotive market was dominated by traditional fuel vehicles. However, as awareness of environmental protection grew, the EU countries began to address environmental protection and energy security issues. Indeed, as early as during the oil crisis of the 1970s and 1980s, EU countries have begun to focus on alternative energy sources and energy-saving technologies. Some countries initiated research and promotion of electric vehicles and hybrid models, although the technical level and market demand were limited at that time. Following the 1990s,

[2] Eurostat is the administrative agency responsible for statistics in the European Union.

[3] IEA: The International Energy Agency is a Paris-based autonomous intergovernmental organisation, established in 1974, that provides policy recommendations, analysis and data on the global energy sector.

with increased awareness of environmental protection and technological advances, some companies began to produce electric vehicles and hybrid models and to promote their use in selected cities. Subsequently, in the period following 2000, European governments began to implement a more active policy agenda with the objective of promoting the development of NEVs. This included the introduction of tax incentives, subsidy policies, and the construction of charging infrastructure. In parallel, some automakers commenced the launch of NEVs products and increased their investment in R&D. In the period following 2010, on the one hand, governments have implemented a range of supportive policies with the objective of promoting the sale and popularisation of NEVs. These include subsidies for car purchases, free parking and free passes. On the other hand, the European Union has set stricter emission standards with the intention of encouraging automakers to accelerate the introduction of more environmentally friendly products. The European NEVs market is experiencing a period of rapid growth. By the 2020s, the European NEVs market continued to expand, particularly in the context of rising sales of electric vehicles. A growing number of automakers are investing in NEVs, launching an increasing variety of electric vehicles. Concurrently, European countries are also reinforcing their charging infrastructure with the objective of supporting the development and dissemination of NEVs.

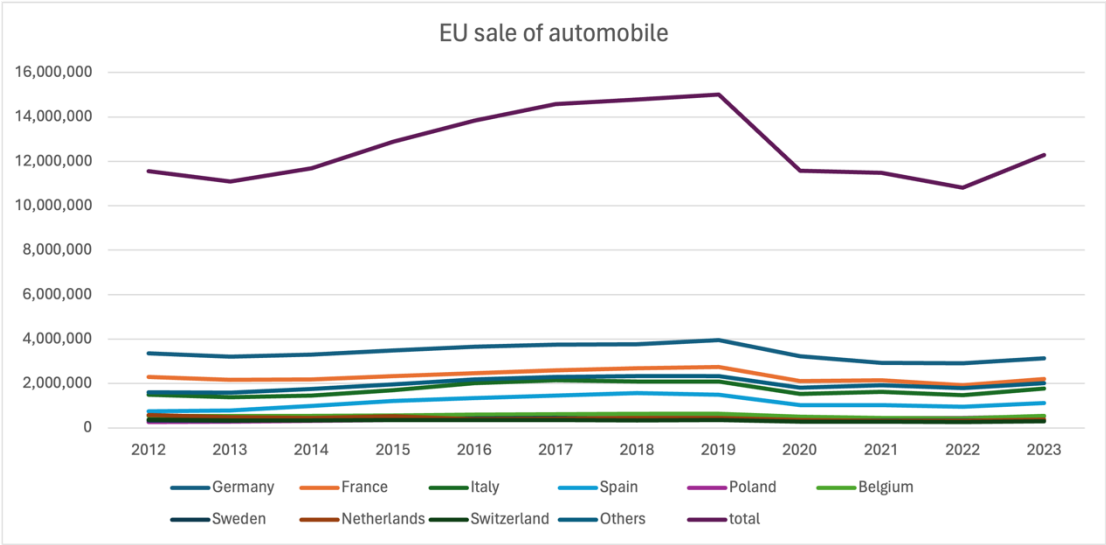


Figure 9: EU sales of automobile from 2012 to 2023. (source: marklines)

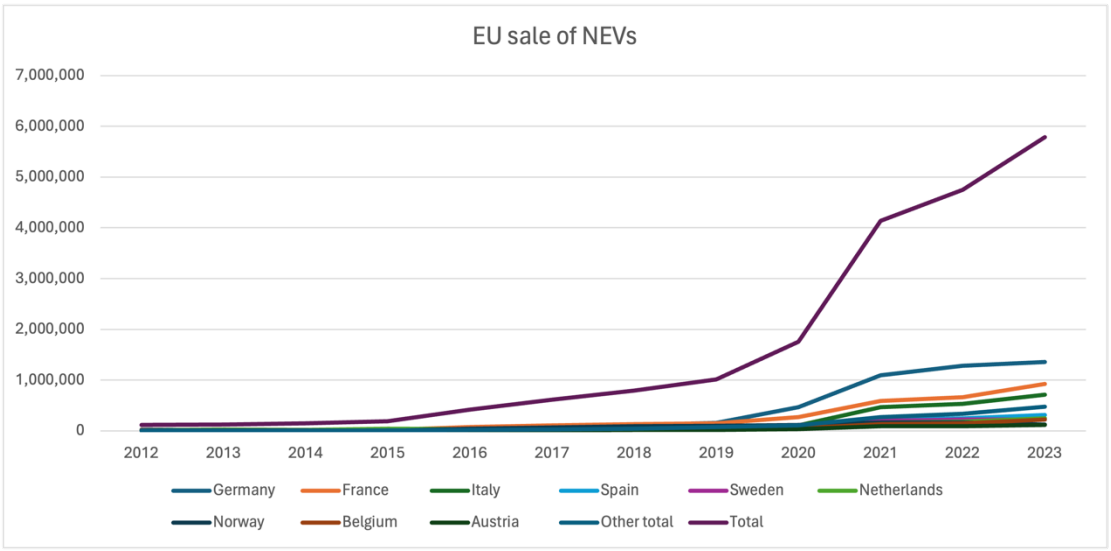


Figure 10: EU sales of NEVs from 2012 to 2023. (source: marklines)

The two charts above demonstrate that the overall automotive market in each country of the EU is relatively stable. However, it is evident that the market experienced a decline in sales due to the supply chain shortage caused by the global pandemic of 2020. Nevertheless, the market has shown signs of recovery, with an upward trend evident in 2023. Furthermore, particularly following the year 2020, the NEVs market has also demonstrated a surge in growth.

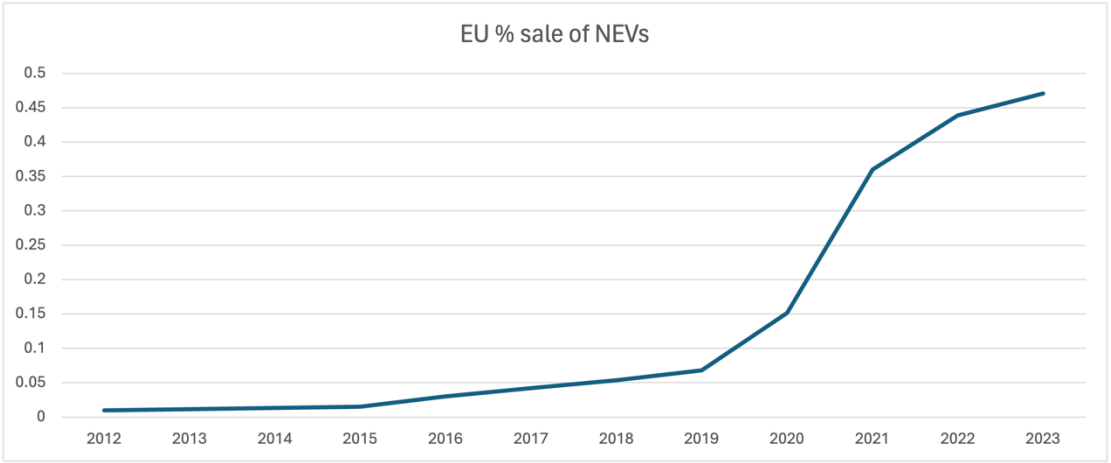


Figure 11: EU sales of NEVs percentage from 2012 to 2023

The proportion of NEVs sales in the EU has increased significantly in recent years. This is a direct consequence of the EU's substantial increase in support for NEVs. It is evident that the constraints, penalties and incentives are further strengthened. The EU has set a significant increase in carbon emission standards for cars from 130g/km between 2015-2019 to 95g/km between 2020-2025. Failure to meet these standards will result in a fine being imposed on the

relevant companies. In June 2022, the EU advanced the timeline for zero vehicle emissions from 2050 to 2035 (i.e., 0g/km of CO2 emissions from vehicles in 2035)[5]. Consequently, the companies that fail to comply with the new standards will be required to pay a fine. At the same time, the EU proposed a plan to halt the sale of all fuel vehicles by 2030, thereby accelerating the transition of traditional car companies to electrification. Secondly, the purchase and use of NEVs will be subject to the EU and national double subsidy policy, with the highest car subsidies reaching 7,000 to 10,000 euros. At the same time, there will also be tax exemptions or credits. Furthermore, the EU has stipulated that from 2026 onwards, carbon emissions from road transport will be included in the carbon emissions trading market. This pricing of pollution will create a level playing field for NEVs, and the measures will change the situation of long-term slow growth in sales of NEVs in Europe.

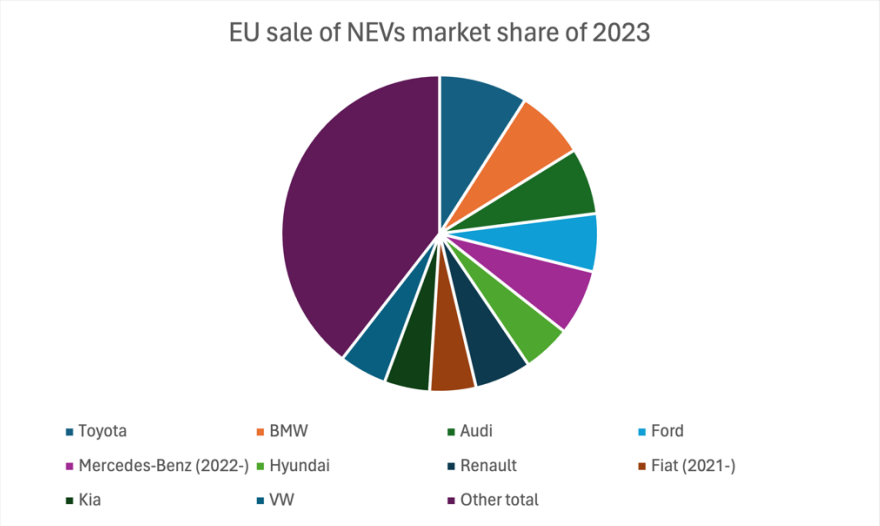


Figure 12: EU sales of NEVs market share in 2023. (source: marklines)

The situation of EU NEVs is totally different from that in China and the US. It doesn't look like neither China's intense competition among local companies nor Tesla's almost dominated power in the United States market. In Europe, the proportion of internal and external companies is more balanced, reflecting a more balanceable development. On the one hand, this is due to the long history of European local car brands, which have fostered high customer loyalty. This makes it more challenging for external companies to enter the EU market. On the other hand, the European is currently lacking a substantial industrial chain to mass produce the NEVs. But there are always exceptions, a more successful external brand is Tesla, which also has a significant influence in the EU market. Furthermore, BYD, one of China's largest NEVs

manufacturers, has also launched electric vehicle products in the European market, including the BYD Tang and BYD Qin. At the same time, BYD also has some cooperation with local government agencies. For example, in Turin, Italy, bus operator GTT has entered into a collaboration with BYD to introduce pure electric buses.

1.5. Others

Japan

Japan is one of the world's largest net importers of oil, as it has very limited oil resources of its own. This is because of the Japan's geographical location and size constraints. Japan imports its oil from other countries mainly by sea. One of its main sources of oil supply is the Middle East, others including countries such as Saudi Arabia, Iran, and the United Arab Emirates. Besides, Japan also imports oil from other regions, including Southeast Asia, Africa, and Latin America in order to ensure the stability of its supply. Japan often concludes long-term oil supply contracts with several countries and participates actively in the international oil market.

As early from the 1970s, with environmental awareness of people was rising, the Japanese government began to implement a series of environmental regulations. After the period of the oil crisis, Japan began to recognise the importance of energy security and they started to R&D of NEVs technologies. In the 1980s, the Japanese government introduced a series of policies and regulations to encourage environmental protection and energy conservation, such as the tax incentives for fuel-efficient models. In the 21st century, with global concern about climate change intensifying, the Japanese government increased support for the development and promotion of NEVs technologies. In the last decade, with electric vehicle technology continuing to improve and growing the market demand, Japanese automakers launched a variety of electric vehicle models. They keep improving the technology in order to increase performance and range. At the same time, the Japanese government introduced more policies and incentives to promote the sales of NEVs, such as subsidies, tax incentives and charging infrastructure construction.

Japan is a country with a strong sense of national identity, as a consequence, the domestic

brands have dominated in the Japan's NEVs market. Toyota as one of Japan's largest automakers, it has a wide range of product lines in the NEVs sector, such as the world's first mass-produced hybrid vehicle Prius series and the pure electric model Mirai[6]. Additionally, Nissan another Japanese major automakers, Nissan, its electric model Leaf is one of the highest selling pure electric vehicles in the world. Besides, other notable players in the Japan such as Honda, its hybrid models Insight and Clarity have achieved a certain market share, and as well as Mitsubishi Motors, which has made some attempts at NEVs, such as its plug-in hybrid electric vehicles model Outlander.

South Korea

South Korea has the similar situation comparable to Japan, because of its limited land area, results this country in a deep dependence on imported oil. South Korea is also one of the world's largest net importers of oil, and it relies almost entirely on imported oil to meet its domestic energy needs. South Korea imports oil from a number of countries, with major suppliers such as Saudi Arabia, Iraq, Kuwait, the UAE, and as well as some countries from Middle Eastern and African.

In the 1990s, the South Korean government began to support and encourage automakers to develop hybrid electric vehicle technology. South Korean automakers such as Hyundai Motor and Kia Motors started to introduce their hybrid models. In 2009, the Korean government released the "Strategy for development and commercialisation of clean energy vehicle technologies and Promotion", which set out the strategic direction for the development of NEVs in the next 10 years. In December 2010, the government set a target to commercialise semi-medium sized electric vehicles by 2015, with the name “Green Car Roadmap”[4]. This was accompanied by an investment of 70 billion Korean won, approximately 60 million US dollars. Gradually, electric vehicles and fuel cell vehicles became the focus of attention. Over the past decade, South Korea's NEVs market has experienced rapid growth. In order to promote the popularity of electric vehicles and fuel cell vehicles, the government has introduced a series of

[4] In 2020, South Korea initiated a new phase of its eco-friendly transformation with the announcement of the "New Green Deal". This initiative forecasts the introduction of 1.13 million electric vehicles and 200,000 hydrogen vehicles on the roads by 2025. By the end of the decade, the number of eco-friendly vehicles is projected to reach 4.5 million.

incentives, such as subsidies, tax incentives and infrastructure development. South Korean automakers such as Hyundai Motor and Kia Motors have also increased their investment in NEVs and launched a number of electric models. Furthermore, the South Korean NEVs market has emerged some new companies for the development of innovative electric vehicle and fuel cell technologies.

In the South Korean NEVs market, domestic and foreign brands both hold a certain market share. However, in the point of view of entire market, domestic brands account for a relatively larger share in South Korean. Since the South Korean automakers such as Hyundai Motor and Kia Motors have a long history of development and technology accumulation, they have more advantages in the field of NEVs. Therefore, their electric and hybrid model's vehicles are highly favoured by domestic consumers. Furthermore, the supports form South Korean government for domestic automakers have also helped to enhance the competitiveness of domestic brands. Nevertheless, with the global NEVs market becomes increasingly competitive, a number of automotive manufacturers from other countries have also launched some NEVs models in the South Korean. These include Tesla from the United States, Volkswagen from Europe, Nissan and Toyota from Japan, and Xpeng Motors and BYD from China.

Norway

Another country that is worthy of mention is Norway, even though it is one member of the EU. Indeed, Norway has become a leader in the development of NEVs. This leadership is not based on technology or production scale, but rather on the comprehensive implementation of NEVs policy and popularity. At the end of 1990s, Norway has started to implement measures to encourage the use of zero-emission vehicles. Besides, the government has also implemented a series of incentives to promote the sale of electric vehicles, such as free parking, tax exemptions, and motorway toll reductions. In 2008, the Norwegian government launched the first national electric vehicle purchase incentive scheme in the world. In 2011, Norway became the first country in the world with electric vehicle penetration rate exceeding 1%. This was achieved thank to the joint efforts of government incentives and people's environmental awareness. This data has exceeded 20% in 2015 with the widespread acceptance of NEVs in the Norwegian market. In 2020, the Norwegian government set an ambitious target for all new

cars sold in the country to be zero-emission vehicles by 2025[7]. This has brought a huge development of NEVs not only in Norway, but also the whole world. The successful experience of Norway provides a reference for other countries. The future outlook shows that Norway will continue to pursue the reduction of carbon emissions, as well as the strengthening of its electric vehicle charging infrastructure and the further increase of the proportion of electric vehicles in the national transport system.

1.6. Conclusion

In general, whether it is a country that is energy self-sufficient or an energy shortage country, whether it is a large or small economic country, they are all faced with the problem of increasing energy consumption and the deterioration of the global environment. At this time, vigorously developing NEVs is undoubtedly beneficial solution. And this is indeed the case, more and more countries realized, and they are beginning to invest in the development of the NEVs industry. Even though the current proportion of NEVs is generally low, according to data in recent years, their growth rate is very fast. Whether it is the investment in technology and policies from major countries such as China and the United States, or the investment in promotion and popularization of EU countries such as Norway and Sweden, they have greatly promoted the development of NEVs.

2. Challenges

2.1. Introduction

In recent years, there has been a significant increase in the promotion of NEVs in several different sectors, including family cars, official vehicles, buses, taxis, and logistics vehicles. This has led to a growing recognition of the strategic importance of promoting the NEVs industry. The development of the NEVs industry is an urgent requirement for environmental protection. Currently, urban air pollution is a serious concern, which has a significant impact on public health, and exhaust emissions from traditional fuel vehicles are the main source of urban air pollution. The development of NEVs can significantly reduce the dependence of transportation on petroleum energy.

However, difficulties are always inevitable, and an emerging industry will always encounter various challenges. This chapter will introduce the difficulties encountered by the NEVs industry in the entire automotive industry, including issues such as industrial chain and industrial structure. Meanwhile, it will analyse the challenges of NEVs in global layout and global development in today's contradictory environment of globalization and geopolitics. Finally, it will analyse possible solutions of these issues.

2.2. Industrial competition

With the rising of people's environmental awareness and more and more countries being seeking for the improvement of energy structure, the NEVs industry has ushered in unprecedented development opportunities. The continuous evolution of NEVs technology has driven the rapid development of this industry, with hybrid vehicles, pure electric vehicles and hydrogen fuel cell vehicles all playing an important role. However, with the market competition keeping intensifying and the market environment being instable, NEVs companies are facing more challenges. This section will introduce the competitive landscape between NEVs and traditional fuel vehicles, considering five key aspects.

i. Market supply and demand and competitive structure

Firstly, the competitive structure of the NEVs industry is reflected in the relationship between market supply and demand. With the raising of environmental awareness and the support from government policies, the market demand for NEVs is growing. At the same time, the supply capacity of automaker has also promoted thanking to the technological innovation and industrial upgrading. Consequently, this change in supply and demand has bought more intense competition in the NEVs market. For instance, the Chinese NEVs market keeps expanding in recent years and will be expected to maintain high growth in the coming years. The changing attitude of people towards NEVs and the increasing demand have driven the development of the entire industry chain from battery manufacturing, motor R&D to vehicle production. Each section in the chain shows a booming trend. Nevertheless, the supply of NEVs is constrained by a variety of factors. For example, the main issue is the bottleneck of battery technology. Even though there are some significant improvements in battery energy density and charging speed in recent years, it is still difficult to meet market demand for range and charging convenience. Consequently, this has led some consumers to adopt a wait-and-see attitude towards NEVs, which has prevented the further expansion of the market.

In the NEVs industry, the competitive structure covers several sections, including vehicle manufacturing, core components manufacturing, and charging facilities construction and other links. In order to better reduce vehicle manufacturing costs, it is necessary for further cooperation and integration. Indeed, there are both cooperation and competition among these segments. On the one hand, the traditional automobile manufacturers are experiencing transformation and keeping investing in the field of NEVs, in order to better gain market share through technological innovation and brand value. On the other hand, the NEVs companies have also emerged. Due to their flexible operational mode and innovative business model, they have rapidly gained a foothold in the market. The most obvious example is Tesla. As a leading company in the NEVs industry, it has successfully established a high-end and luxury brand image in the global market and occupied a large market share thanking to its advanced battery technology, self-driving technology and innovative sales model.

In addition, the NEVs industry also involves competition and cooperation in related industries, such as charging facilities and smart grids. The improvement of these related

industries will help reduce the cost of using NEVs and make it more convenient for people to travel with low emissions. Therefore, it has a great significance to develop a healthy NEVs industry. For example, more popular charging facilities will greatly improve the convenience of NEVs, while the construction of smart grids helps to improve the charging efficiency and safety of NEVs.

ii. Cost benefit analysis and competitive advantage

From the perspective of cost benefit analysis in economics, the key element of competition in the NEVs industry is cost reduction and efficiency improvement. The production costs of NEVs are primarily constructed of raw material costs, R&D costs, manufacturing costs and marketing costs. In order to have a competitive advantage, companies need to keep improving production costs and enhancing product quality, to make sure that the performance can meet consumer needs.

Firstly, is the crucial part for NEVs companies, which is the section of battery technology. As a core component of NEVs, its cost occupies a large portion of the overall vehicle cost. For example, Tesla has achieved a great control of its core battery technology by developing and producing key components independently. This advancement significantly lowered its reliance on external suppliers and prevents technological chokeholds, thus reduced costs. Furthermore, Tesla is dedicated to increase production automation, optimise supply chain management and implement a direct sales model, in order to improve cost efficiency. These measures have made Tesla's products maintain high performance and at the same time have a high price-performance ratio, thus gaining wide recognition in the global market. Another example is BYD, a leading company in Chinese NEVs industry. BYD attaches great importance to vehicle costs. Since Chinese automobiles are relatively unknown, cost-effective vehicles can help it enter foreign markets faster. Therefore, BYD is keeping optimizing product design, improving production processes, strictly controlling raw material procurement, and enhancing product quality stability. Besides, BYD has also expanded its business model to upstream raw material suppliers through a vertical integration model, which can reduce manufacture costs and enhance the industry chain's synergy effect. These measures have made BYD not only guarantee product quality, but also offer a competitive price, thus opening up the market and winning the favour of consumers.

Furthermore, the NEVs industry must focus on scale effects and economies of scope. Since the initial fixed cost investment is large, by expanding the production scale, the company can reduce the fixed cost per unit product, thereby increasing profits. For example, as the world's first mass-produced hybrid car, the Toyota hybrid model Prius was launched in Japan in 1997. As a company with a long history and reputation, Toyota is well aware of the advantages of economies of scale. As a traditional vehicle manufactory, faced with the emergence of NEVs, it has to invest in corporate transformation and production equipment upgrading. Toyota mass-produced this new model, which reduced effectively marginal costs and helped Toyota become a pioneer in the field of NEVs. What's more, Toyota's second-generation Prius was launched in 2003 and became the world's best-selling hybrid model.

Last but not least, the competitive advantage can also be increased by expanding its product lines and service scope. Due to the high degree of mechanisation and integration of the automobile manufacturing industry, many production lines can be shared, so companies can achieve resource sharing and cost sharing, thereby reducing production costs and improving competitive advantages.

iii. Policy environment and competitive landscape

The policy environment has a significant effect on the competitive landscape of the NEVs industry. At present, governments in various countries have actively implemented a series of policy measures to promote the development of NEVs, such as purchase subsidies, tax incentives, free licensing, etc. These measures can reduce customers' purchase costs and usage costs and can also increase customer groups. For example, consumers with a wait-and-see attitude may increase their purchase intention. It enhanced their market competitiveness in competing with traditional fuel vehicles. Nevertheless, in order to sustainably stabilize the market, NEVs need to strengthen corporate strength and product quality. Because with the NEVs market maturing and technology advancing, the importance of government subsidies gradually weakens.

The competitive landscape of NEVs is diverse and intense. There are three major competitors including traditional automakers, emerging technology companies, and government-supported state-owned enterprises. Firstly, traditional automakers possess strong

technology accumulation and market experience, but they are also facing the challenge of transformation. Therefore, in order to remain competitive in the market with increasing challenges, traditional automakers need to keep investing in innovation in electric vehicle technology. Furthermore, they also need to deal with the changing policy environment and the unpredictability of market demand, which makes them need to find better strategic planning and product positioning. Secondly, emerging NEVs companies possess a great capacity for technology innovation and business model flexibility. However, they also face challenges, such as the immaturity of their economies of scope and a lack of capital. They need to invest more in technology R&D, marketing, and brand building in order to enhance their competitiveness. In contrast to traditional carmakers, emerging companies prioritize user experience and service innovation. For example, they opened the car experience store similar to a mobile phone store, which can improve consumers' experience and after-sales service. Compared with ordinary automobile sales service shops, these experience stores can pay more attention to user experience and optimized services. There measures attract more consumers through smart connectivity and shared mobility and let them gain a certain market share. Finally, State-owned companies also enjoy some advantages in the field of NEVs, such as policy and resource advantages. However, they also face challenges. For example, state-owned manufacturing plants generally suffer from low efficiency and insufficient innovation capabilities. They want to enhance their competitiveness, only if they can carry out market-oriented reforms and technological innovation. At the same time, they must also strengthen cooperation and communication with other competitors to jointly promote the development of the NEVs industry.

iv. Technology innovation and industrial upgrading

Technological innovation is an important driving force for the sustainable development of the NEVs industry. Firstly, the various core technologies of NEVs, such as battery technology, motor technology, electronic control technology, etc. Only continuous innovation and improvement of these technologies can help NEVs optimise performance and reduce costs. Secondly, the application of intelligent technology in NEVs is becoming more prevalent. It won't take too long before smart technology will become a significant competitive advantage

of NEVs, and it will drive the rapid development of upstream and downstream companies in the supply chain. Among these, autonomous driving technology represents an attracted innovation point. There are many companies such as Tesla, Google have made notable progress in automatic driving technology. Thanks to the integration of modern high-precision maps, sensor fusion, artificial intelligence and other technical means, vehicles can achieve autonomous navigation, automatic obstacle avoidance, automatic parking and other functions, thereby enhancing the safety and convenience of driving. Especially when driving long distances, people will inevitably become tired and distracted. Autonomous driving can effectively share the driving task, reduce driver fatigue, and increase driving safety. Furthermore, the growth in popularity of NEVs also led to the emergence of the energy internet[5], which is likely to become an important component of the NEVs industry chain. Through expanding the application of energy internet technology, NEVs can establish interconnectivity with the smart grid, in order to optimise energy utilisation and facilitate the transition to clean energy. Consequently, companies need to keep investment of reinforcing their training employees and recruitment of talent, then facilitate breakthroughs and innovation in core technologies as soon as possible.

In section of industrial upgrading, on the one hand, companies need to proactively expand their collaboration with upstream and downstream to jointly promote innovation and achieve win-win results. On the other hand, companies need to continue to carry out technological innovation and industrial upgrading to enhance their own strength and market competitiveness. For example, in order to adapt to market changes, traditional automotive manufacturers such as BMW and Mercedes-Benz in Germany they not only increased the R&D investment in the field of NEVs but also improved their production efficiency and product quality by building smart factories and consistently optimizing them.

[5] Energy Internet represents a comprehensive utilisation of advanced power electronics technology, information technology and intelligent management technology. It comprises a multitude of distributed energy collection devices, distributed energy storage devices and various types of loads, which are interconnected to form a novel electric power network, oil network and natural gas network, among other energy nodes. This network facilitates the two-way flow of energy, energy peer-to-peer exchange and sharing.

v. Challenges

First of all, the first challenge NEVs faced is imperfect charging infrastructure. This is also an important reason why many consumers are reluctant to buy electric vehicles. Unlike traditional gas cars, there are gas stations everywhere. Currently, problems such as insufficient number of charging piles, uneven distribution, and slow charging speed are common, which can cause a lot of inconvenience to users. This not only hinders the promotion and popularization of new energy vehicles, but also restricts the further development of the industry.

Secondly, the second challenge for NEVs is cost. In comparison to traditional fuel vehicles, the manufacturing cost of NEVs is higher, primarily due to the higher cost of core components such as batteries. Before there is a fundamental breakthrough in battery technology, the cost problem will be difficult to find a solution. Without the current government support, it would be difficult for NEVs to have a price advantage in competing with traditional fuel vehicles. But long-term and sustained subsidies are not possible, fundamentally, NEVs company still need to find a technological breakthrough as soon as possible.

Moreover, the third challenge for NEVs is range limitations. Currently, the range of NEVs is generally shorter than that of traditional fuel vehicles, which is a significant drawback for consumers who require vehicles for long-distance travel. Even though there are indeed some improvement and advancement for battery technology, the range of NEVs has not yet reached the levels required to meet the needs of these consumers.

Last but not least, the fourth challenge for NEVs is intensifying market competition. With market expanding and numerous companies entering, there is no doubt the competition will intensify. This will make NEVs manufacturers harder gain a foothold in the market. The NEVs industry is basically characterised by rapid technological change, therefore keep innovating technology and upgrading product to meet the requirement of consumers is the key point. Meanwhile, companies need to adopt differentiated competitive strategies to expand their market share, in order to maintain and enhance their competitiveness.

2.3. Geopolitics and business game

The development of the NEVs industry is now a matter of great international concern. It

is not isolated, but is closely connected with geopolitical patterns, international economic and trade relations, and the policy orientation of various countries. In this context, the commercial game of NEVs is not only a technical and market competition, but also a complex game involving geopolitics.

As an emerging industry, the technological progress and market expansion of NEVs will bring significant economic effects, including improving energy efficiency, reducing environmental pollution, and promoting employment and economic growth. Therefore, governments will hope to achieve economic transformation and upgrading and sustainable development by supporting the development of NEVs industry. This section will analyse the commercial competition of NEVs under geopolitics through three aspects.

i. Energy supply

The development of NEVs is closely related to energy supply. While traditional fuel vehicles rely on fossil fuels such as oil, NEVs rely mainly on clean energy such as electricity. In a situation of geopolitical tension, the instability of energy supply will significantly affect one country and its people's life. Therefore, the sustainability of energy supply is a key factor. There are some political unrest or geopolitical conflicts in some major oil-exporting countries, which may lead to large fluctuations in energy prices, and furtherment may affect the cost and competitiveness of the NEVs industry. For example recently happened, the Russian-Ukrainian conflict and a series of sanctions for Russia have led to a significant increase in the international crude oil benchmarks of Brent[6] crude oil and WTI[7] crude oil prices, which have exceeded 100 US dollars in a relatively short period of time[8]. This has resulted in a seven-year high and a high level of operation, which has in turn led to a rise in the cost of using fuel vehicles. Conversely, the cost advantage of NEVs is becoming increasingly obvious. With market growth and consumer acceptance also rising significantly, this has led the market-driven forces become

[6] Brent crude oil is a type of international crude oil evaluation observation system. It is a sweet oil (low-sulphur crude oil) and is used to measure the oil price at both high and low levels. It is currently the world's most significant and widely used reference for oil price figures.

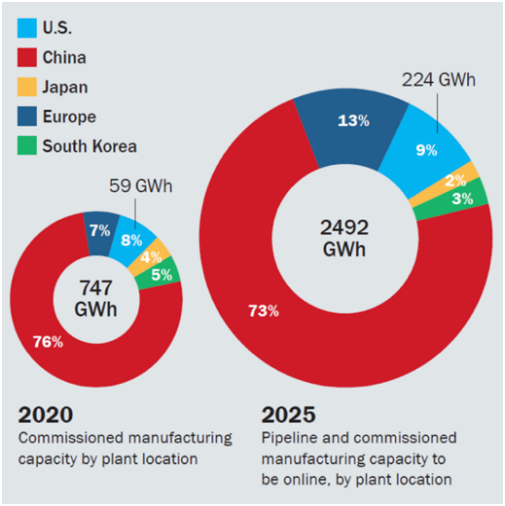
[7] West Texas Intermediate crude oil is a benchmark price in the international oil market and is the underlying factor of the New York Mercantile Exchange oil futures contract.

the primary support for the consumption of NEVs, which represent the sustainable development of the industry.

Moreover, the NEVs industry can reduce its dependence on traditional oil and mitigate the impact of geopolitical risks on by diversifying energy sources and consuming renewable energy. For example, there are certain countries and regions being proactively developing renewable energy sources, such as solar and wind energy. Besides, through policy support and technological innovation, it can affectively help to provide a clean energy supply for NEVs.

ii. Technology control and industry chain competition

As mentioned before, the NEVs industry chain covers a range of sectors, such as raw materials, components, vehicle manufacturing, and charging facilities, etc. Each of these sectors has possibility to be involved in geopolitical considerations. The battery industry, for example, since the battery is characterised by a lack of balance in the distribution of key raw materials, such as lithium and cobalt. These materials are concentrated in South America, Australia and China.



This uneven distribution of resources leads to the significant impact of geopolitical factors in the supply of battery raw materials. Since the battery technology is a key core technology, this will significantly affect the NEVs industry. Therefore the political stability and economical trade policies of these regions paly an important role on the supply chain security of the global battery industry.

Figure 13: Global lithium capacity distribution and expected. (source: FCAB)

Mastering advanced battery technology confers an important voice and competitive advantage in the industry chain. Through government support, industrial policies and R&D investment, some countries and regions are attempting to achieve technological leadership in the field of NEVs batteries.

China and the United States are engaged in a fierce competition in the field of NEVs, and the demand for lithium resources is also very strong. In order to ensure a stable supply of lithium

resources, companies in both countries have sought to strengthen cooperation in the field of lithium resources mining and processing through cross-border cooperation, the establishment of joint ventures, and other means. In parallel, governments have also strengthened cooperation with lithium-rich countries through diplomatic means with the aim of ensuring the stable development of their own NEVs industries.

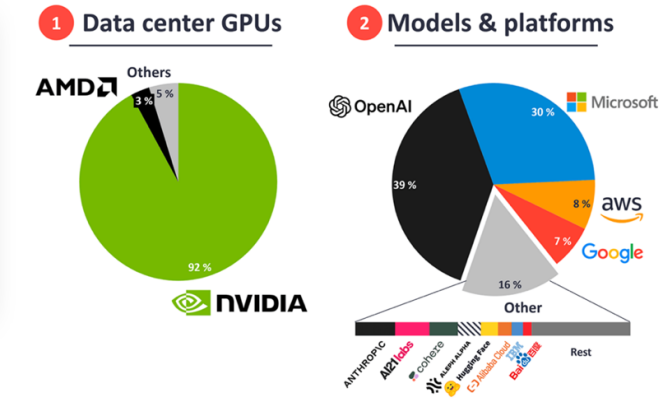


Figure 14: Generative AI: Market share of leading vendors 2023. (source: Generative AI Market Report 2023-2030)

The following examples can prove this point. On Oct. 17, 2023, the United States announced that it had expanded the scope of its chip ban to significantly restrict the export of AI chips to China[9]. As the chip is a key component that determines the core competitiveness of automobiles, especially NEVs, due to the higher requirements for vehicle integration and control, the number of chips needed by a NEVs is far greater than that of a traditional fuel vehicle. Furthermore, the chip accounts for a larger proportion of the cost of materials for the entire vehicle. China has consistently faced challenges in the production of domestic chips, which have been identified as a significant technical hurdle. The Chinese domestic chips lack the requisite competitiveness and manufactory capacity; therefore, it is difficult to produce chips with high-performance, large-scale calculation power, and the kind of vehicle-grade chips required for NEVs. In response to the aforementioned U.S. sanctions, the Chinese Ministry of Commerce and General Administration of Customs announced countermeasures on Oct. 20, 2023, that, from December 1, the highly sensitive graphite products previously under temporary control were formally included in the export control list. The aforementioned stipulation pertains to the export of high-purity, high-strength, high-density man-made graphite materials and their products, as well as natural scaled graphite and its products, including spheroidal

graphite and expanded graphite, without the requisite permission[10]. As known as approximately two-thirds of the world's lithium and cobalt, which are essential raw materials for the production of electric vehicles, are processed in China. Furthermore, nearly 60% of aluminium and 80% of polysilicon around the world originate in China. Aluminium is also used in electric car batteries, while polysilicon is a material that can be used to produce solar panels.

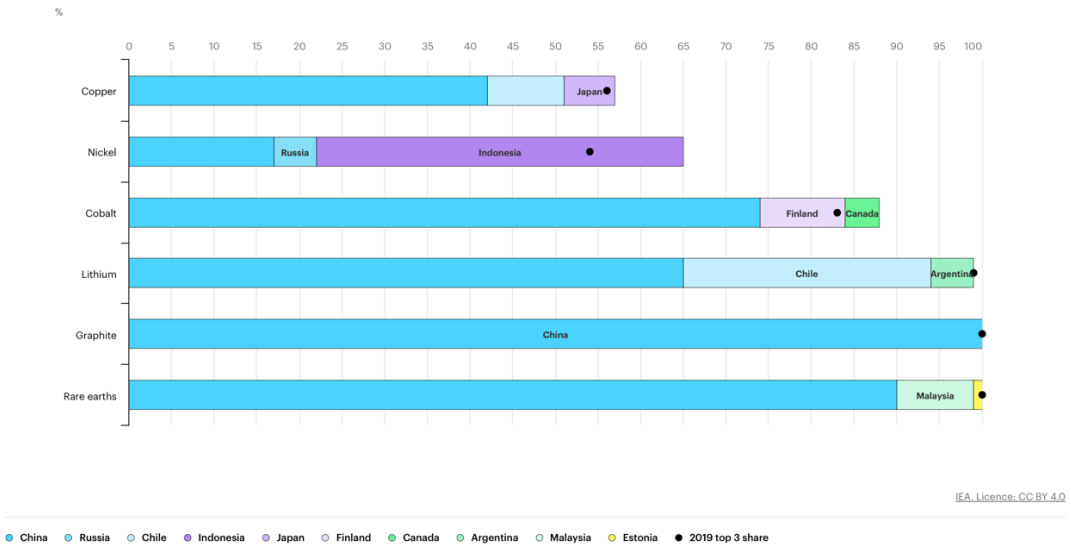


Figure 15: Share of top three producing countries in processing of selected minerals in 2022. (source: IEA)

What's more, China has greater control over rare earth minerals that are used in some key technologies, such as creating smartphone touchscreens. According to the International Energy Agency (IEA), China's rare-earth refining accounted for around 90% of the world's total refining. If China were to restrict exports of lithium or cobalt or rare earths, it would have a significant impact on non-Chinese automakers and could potentially disrupt the production of electric car batteries. While China is unlikely to take such extreme measures in the short term, especially given that domestic firms could also be affected. Nevertheless, the U.S. NEVs companies have begun to seek for diversified supply channels for rare earth elements just in case of facing this supply chain risk. Besides, they have not only established not only trade relationships with other countries, but also strengthened domestic mining and processing capabilities. At the same time, some companies are also reducing their reliance on rare earth elements through technological innovation to reduce supply chain risks.

iii. Market competition and international trade

The development of the NEVs industry is also affected by international trade policies and global market competition. Under the circumstance of geopolitical tensions, some countries may adopt trade protectionist measures, such as tariff increases and trade restrictions, in order to protect domestic automotive industries from external company.

For example, the economic and trade relations and political friction between China and the United States, as the two world's largest economies and markets for NEVs, had a profound impact on the development of the NEVs industry. In the context of the US-China trade war, NEVs, as a key strategic emerging industry, have received special attention from both sides. Currently, the United States applies a 2.5% tariff on imported passenger cars, but Chinese car exports to the United States are subject to a 25% punitive tariff on passenger cars originating from mainland China. Consequently, the total tariff rate on imported passenger cars is 27.5%[11]. With regard to the pricing of NEVs from China which it has a greater competitiveness, the United States government and federal Congress are taking countermeasures to stop the flow of Chinese pure electric vehicles into the United States domestic market. One of the potential options for Congress is to impose a tariff rate of more than 100%, including if the Chinese manufacturer carries out production in Mexico.

Another example in Europe, at the biennial German Motor Show, which ends on 10 September 2023, the strength of the German automotive industry was not evident; instead, Chinese electric vehicles attracted attention. As sales of Chinese pure battery cars in Europe have tripled in the last two years, on 13 September 2023, the European Commission announced an "anti-subsidy investigation" against Chinese NEVs companies and suspected foul play. The European Commission's investigation could result in tariffs being imposed on Chinese automotive imports, with the potential for these tariffs to exceed the 10% currently levied on Chinese car imports.

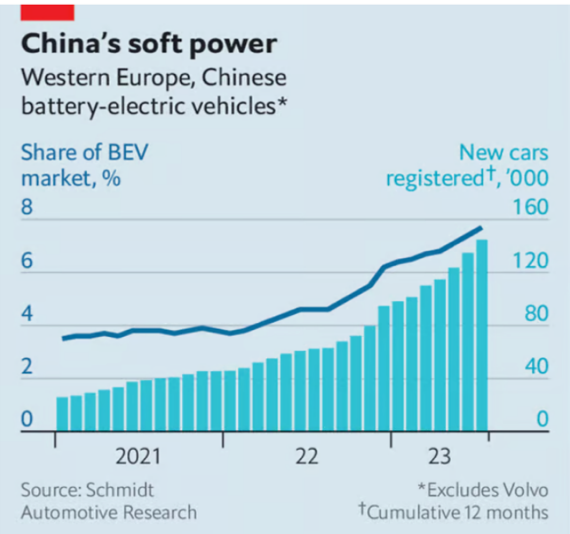


Figure 16: China's soft power. (source: Economics)

2.4. Conclusion

In conclusion, on the one hand, NEVs not only face technical bottlenecks in the industry, insufficient consumer motivation to purchase, and insufficient related facilities, but also face the dilemma of an immature market. There is a high competition in this industry, and everyone wants to seize the opportunity. However, due to insufficient technology in the industry, such as the quality and battery life, the performance of NEVs on the market are uneven. More and more new companies entered in this market, but due to the huge initial investment and the wait-and-see attitude of consumers that are not suitable for mass production, the return period of these companies will be long. Nevertheless, the appropriate competition is also helpful to the development of the industry and creating a fair market environment for consumers. Also due to the emergence of NEVs, some traditional car manufacturers had to upgrade the industry, giving consumers a better experience and more choices.

On the other hand, NEVs involve many parts related to high-end technology and high-end equipment. In this increasingly geopolitical environment, the integrity and security of supply chains is also a challenge. Due to the material monopoly of some countries and the technical monopoly of some countries, it is difficult to achieve a win-win situation on some issues. As the saying goes, there are no eternal enemies, only eternal interests. Conflicts between countries are fundamentally caused by the imbalance of interests between countries. For example, the trade war between China and the United States, the EU's oil supply problems after the conflict between Russia and Ukraine, etc. But all in all, all countries should increase cooperation to work together on the development of NEVs and overcome difficulties. After all, behind the development of NEVs is the problem of the entire global environment.

3. Government policy and its effects

3.1. Introduction

There are many national, provincial, and local governments across the world have implemented policies with the aim to foster the mass market adoption of plug-in electric vehicles. These policies cover a range of measures, including financial support for consumers and manufacturers, non-monetary incentives, subsidies for the deployment of charging infrastructure, the installation of electric vehicle charging stations in buildings, and long-term regulations with specific targets. The financial incentives for consumers are designed to make the purchase price of NEVs more competitive, since the electric vehicles have a higher upfront cost than that of traditional vehicles. The one-off purchase incentives such as grants and tax credits, exemption from import duties, exemption from road tolls and congestion charges, and exemption from registration and annual fees, with varying levels of benefit depending on the battery size. The non-monetary incentives include benefits such as allowing plug-in vehicles to use bus lanes and high-occupancy vehicle lanes, free parking and free charging. Some countries or cities have implemented regulations limiting private car ownership (e.g. quota systems for new car purchases) or imposing permanent driving restrictions (e.g. no-driving days), with greatly encouraging the use of NEVs. Furthermore, some governments have implemented long-term regulatory signals with specific targets, such as Zero Emission Vehicle (ZEV) directives, national or regional CO2 emission regulations, strict fuel economy standards, and the phasing out of internal combustion engine vehicles.

Therefore, this chapter will analyse what policies and subsidy measures the governments of the three major economies have taken in response to the emergence and development of NEVs. Then compare these measures of different economy and analyse the similarities and differences among them. Finally, analyse the impact of these policies on local NEVs development and global industry development.

3.2. China

China is not a pioneer in the NEVs industry, but it can be considered as a latecomer

prevailing. The Chinese government has developed the NEVs industry as a new key industry in order to actively resolve global climate change and energy security issues. Therefore, the Chinese government has introduced a series policies and subsidies to support NEVs companies. With these policies, Chinese NEVs industry has achieved rapid development and China has become one of the largest markets in the world.

Firstly, in order to increase the attractiveness of NEVs and encourage consumers to purchase NEVs, the Chinese government introduced a series of policy subsidies. For example, NEVs purchase subsidies began in 2009. Multiple departments of the Chinese government jointly launched the “Ten Cities and Thousands of NEVs Demonstration, Promotion and Application Project”, with the central government arranging funds to support NEVs in the public service field of pilot cities and providing subsidies for automobile consumption. In 2012, the State Council of China issued the "Energy-Saving and New Energy Automobile Industry Development Plan (2012-2020)", which further clarified the purchase subsidy policy. This policy played an important role in promoting the initial development of the NEVs industry. On the one hand, from 2009 to 2022, China's NEVs sales increased from 5,294 units to 6.887 million units, with production and sales ranking first in the world for the past eight years. On the other hand, it stimulated the vitality of market and thrived on independent brands. From 2013 to 2022, the annual registration number of companies which is related to NEVs in China increased from approximately 5, 100 to 239,400. As of the beginning of 2023, this number has reached 605,800[12]. In addition, the Chinese government has also established relevant funds and projects to support the promotion and application of the NEVs industry. For example, as we all know, China has a large population and the largest number of cars in the world. Faced with a huge number of vehicles, the traffic in some Chinese cities is overwhelmed, which leads to high prices for license plates or the introduction of license restriction policies. In the biggest city of China, Shanghai, an ordinary car license plate currently costs about 13,000 US dollars. In order to vigorously promote NEVs, the Shanghai government has issued the regulation "Shanghai Interim Measures for Encouraging the Purchase and Use of New Energy Vehicles" as early as 2014. This regulation is to encourage consumers to purchase NEVs, and the government will issue free license plates for personal use NEVs[13].

Secondly, there were always shortcomings in China’s high-end technology in the early

days. With the influence of geopolitics gradually increasing and the trade war between China and United States in recent years, the Chinese government vigorously supported technological innovation and development of related industries in order to prevent being strangled. Therefore, the Chinese government has invested a lot of money to support the R&D and innovation of key technologies for NEVs, such as battery technology, electric drive systems, intelligent network technology, etc. During the "Tenth Five-Year Plan[8]" period, Chinese government implemented the "Major Science and Technology Project for Electric Vehicles", known as the "863 Plan", which formed the overall technical route for new energy in China. The plan includes three types of vehicles: fuel cell vehicles, hybrid vehicles, and pure electric vehicles, as well as three technologies: multi-energy powertrain systems, drive motors, and power batteries. Then during the subsequent "Eleventh Five-Year Plan" period, through the "863 Plan", the bottleneck technology of key components of energy saving and NEVs was broken through and has initially established the industrial system of Chinese NEVs. In addition, the Chinese government has also built 15 national key laboratories and engineering technology research centres and formed 48 electric vehicle R&D platforms[14].

Thirdly, the Chinese government has also actively carried out industrial planning to standardize the development direction of the NEVs industry. For example, in Oct. 2020 the Chinese government has released the "New energy vehicle industry development plan (2021-2035)", which proposes strategic goals and development priorities for the development of the NEVs industry by 2035, including technological upgrading, improvement of the industrial chain, and market promotion. In addition, the "Guiding Opinions on Further Building a High-Quality Charging Infrastructure System" issued by the General Office of the State Council in May 2023 made specific arrangements for the construction of charging infrastructure. By 2030, There will be a high-quality charging infrastructure system with extensive coverage, moderate scale, reasonable structure, and complete functions being established to strongly support the development of the NEVs industry. Moreover, it is necessary to build charging infrastructure and strengthen the service management in rural areas. At the same time, the Chinese

[8] The Five-Year Plans are a series of social and economic development initiatives issued by the Chinese Communist Party. The “Tenth Five-Year Plan” is 2001-2005, The “Eleventh Five-Year Plan” is 2006-2010.

government encourages companies to strengthen independent innovation, establish R&D centres and laboratories, and cooperate with internationally renowned companies and research institutions to jointly overcome technical problems in the field of NEVs.

Finally, the Chinese government also actively participates in international cooperation, sharing experience, conducting technical exchanges, and cooperative research and development with other countries to promote the international development of the NEVs. For example, the Chinese government keeps promoting the “Belt and Road Initiative”, strengthens cooperation and exchanges with countries along the route, and helps NEVs become China’s “new business card” on the international stage. In 2015, China became the world's largest NEVs market. In 2022, China has surpassed Germany and became the second largest automobile exporter in the world. As of mid-2023, China has surpassed Japan and become the largest exporter. Every milestone in China's automobile industry in recent years is inseparable from the joint construction of the "Belt and Road Initiative".

In conclusion, the Chinese government has issued a series of policies and development plans for NEVs not only to promote the healthy development and the increment of international competitiveness, but also make greater contributions to environmental protection and sustainable economic development.

3.3. United states

United States is the country with the richest technology industry in the world, it has been at the forefront of the development of NEVs. The U.S. government keeps promoting the development of NEVs to address increasingly severe energy crisis and environmental challenges. Therefore, they adopted a series of policies and measures to encourage the R&D and production of NEVs.

Firstly, in order to promote the development of NEVs, the U.S. government uses legislation and financial support to help not only companies to reduce initial investment costs but also consumers to reduce purchase costs. The most famous one is the "American Recovery and Reinvestment Act of 2009", which they invested 19.9 billion US dollars in renewable energy and energy conservation projects, of which 13.1 billion US dollars was used for tax

credits for renewable energy production. This includes as well as the new energy vehicle industry. Another example is that this legislation allocates 300 million US dollars to state and local governments to purchase energy-efficient vehicles and 300 million US dollars to purchase electric vehicles for the Federal vehicle fleet[15]. Besides, this legislation provides tens of billions of dollars in investment and tax incentives for NEVs industry, including purchase subsidies for electric vehicles and financial support for the construction of charging facilities. In addition, the U.S. government has also established a series of R&D funding projects, such as the U.S. Department of Energy's Advanced Vehicle Technology Program, to support innovation and breakthroughs in NEVs technology.

Secondly, in order to make NEVs more standardized to comply with the national conditions of the United States, the U.S. government implemented a series of regulations and policies about environment. For example, the U.S. Environmental Protection Agency and the National Highway Traffic Safety Administration jointly developed the regulation "Corporate Average Fuel Economy" and "Tier 3 Vehicle Emission and Fuel Standards", which aims to encourage automakers to produce more environmentally friendly and energy-efficient vehicles, at the same time increasing demand for electric vehicles. In addition, the "Clean Power Plan" proposed by the Obama administration to combat global warming, although the plan didn't take effect, has still promoted NEVs in some ways such as providing more infrastructure of wind power and solar power.

Thirdly, in order to encourage the upgrading and innovation of companies, the U.S. government encourages the NEVs companies to cooperate with laboratory or research institutions. The U.S. Department of Energy has cooperated with industry leading companies and well-known research institutions to jointly carry out a series of technology R&D projects. For example, General Motors collaborated with Argonne National Laboratory. This laboratory is an important research institution of the U.S. Department of Energy, dedicated to the R&D and application of energy technologies. It cooperates with General Motors to mainly research battery technology, electric vehicle performance testing and some other aspects[16]. It indeed helped General Motors to improve the performance of electric vehicles and reduce manufacturing costs. Another example is that Tesla collaborated with Oak Ridge National Laboratory. This laboratory is the part of the U.S. Department of Energy, and focuses on

research in materials science, advanced manufacturing technology. This collaboration helped Tesla to study issues such as battery materials and electric vehicle design[17]. Tesla thus received advanced technical support to help it lay the foundation for occupying the global market. In addition, the United States has established some new research centres and laboratories, such as the "U.S. Electric Vehicle Challenge" and the "U.S. Electric Vehicle Pilot Program" to promote the new technology research results that can be applied on NEVs.

Last but not least, the U.S. government has also introduced a series of trade policies in order to protect the domestic companies. One of the most important trade tools is tariffs and quotas on imported vehicles and their parts. By imposing high tariffs on imported NEVs and key components, the United States can improve its competitiveness in the domestic market and protect the interests of its domestic NEVs companies. In addition, the United States has also made some trade agreements and negotiations with other countries to obtain a more stable supply chain and avoid the risk of material shortages. For example, the United States has comprehensive U.S. free trade agreements with 20 countries and a limited critical minerals free trade agreement with Japan[18]. The Biden administration is also seeking for other similar deals in other parts of the world, particularly Indonesia, the main nickel producer or Argentina, the world's fourth-largest lithium producer.

In conclusion, the U.S. government has adopted a series of positive policies and initiatives to promote the development of NEVs. In the future, with the continuous advancement of technology and further reduction of costs, the US NEVs market will usher in broader development prospects and make greater contributions to the realization of energy security, environmental protection and sustainable economic development.

3.4. Europe

The EU has always been a pioneer in promoting environmental protection and is therefore also an important player in the global development of the NEVs industry. The EU keeps encouraging to implement the NEVs to cope with intensifying environmental changes. In 2020, Europe became the world's largest NEVs market, with 1.4 million newly registered NEVs, accounting for nearly half of the global total, and a market share of 10.2%[19]. The EU is also

the most diverse NEV market in the world, with various models and prices for consumers. These achievements are inseparable from the policies and cooperation by the EU and its efforts to promote the innovation and popularization of NEVs.

Firstly, the EU encourages the purchase and use of NEVs through financial support and subsidy policies. Due to different national conditions, EU members have provided various forms of car purchase subsidies, tax incentives, parking incentives and other measures. On the one hand, it reduces the purchase and use costs of NEVs and increases consumers' enthusiasm for purchasing. On the other hand, it also promotes the promotion of NEVs. In France, there are up to 100% the tax free on various NEVs. If customers purchase a pure electric vehicle or a fuel cell vehicle, and if the vehicle price does not exceed 47,000 euros, individual users will receive a household subsidy of 5,000 euros[20]. In Germany, if customers purchase pure electric vehicles and hydrogen fuel cell vehicles and register it before December 31, 2025, they will receive a 10-year tax exemption until December 31, 2030[21]. In Italy, the customers purchasing pure electric vehicles or electric hybrid vehicles can receive subsidies of 2,000 to 3,000 euros depending on the selling price[22]. In addition, the EU has also actively promoted the construction of charging infrastructure and the layout of smart charging networks, in order to improve the charging convenience and user experience of NEVs. Most European countries have subsidies for the installation of charging piles in private residences and public areas, with subsidy ratios ranging from 50% to 75%. There are also some local policies, which mainly provide discounts in parking, use of exclusive roads, toll road tolls, etc.

Secondly, in order to promote new energy vehicles, the European Union has established strict emission standards and CO2 emission limits for automobile manufacturers, which requires new models need to meet relevant environmental standards when sold on the market. Since September 2014, the EU has implemented "Euro 6" emission standards, aiming to reduce air pollution and measure the impact of vehicle source pollutants on the air based on relevant environmental research. On the one hand, it stipulates the emission standards for gasoline and diesel vehicles, on the other hand, its prompt automakers to increase their R&D to produce more clean energy vehicles. Besides, in the "CO2 emission standards for new cars and vans" released by the EU in 2023, the goal is to reduce carbon dioxide emissions per kilometre of new cars by 50% by 2030, and to have at least 30 million zero-emission vehicles in Europe. By 2050,

all vehicles will be zero-emission[5].

Thirdly, the EU has also promoted the improvement of fuel efficiency of NEVs technology, prompting automakers to increase the R&D and innovation. For example, the zero-emission road transport program implemented by the European Union in the "European Research and Innovation Framework Program", which as known as “Horizon 2020”, announced in 2021, with budgets of 94 million euros and 105 million euros in 2021 and 2022 respectively, provides important support for the development and innovation of the NEVs industry[23].

Finally, the EU has also continued to increase international cooperation and technical exchanges to promote the international development of the NEVs industry. As all known, there is a large number of traditional well-known automobile manufacturers in EU, and their brands have already gained a reputation around the world. In order to cope with the problem of industrial transformation to new energy and strengthen the global layout, the EU has not only carried out serval cooperation projects among its member states, but also actively participated in the international organizations and platforms. For example, the joint venture established by France's Renault Group and China's Minshi Group invested in a battery box production line in France's Lutz Industrial Zone. This factory can provide France and the EU with timelier and sufficiently batteries, helping the EU to improve the local industrial chain, furtherment to reduce the production cost of NEVs. For another example, the Volkswagen Group has several cooperation with different NEVs companies, such as cooperated with QuantumScape to develop solid-state battery technology and cooperated with Ford Group to jointly develop electric vehicle platforms and increase the popularity of electric vehicles.

In conclusion, the EU actively promotes the development and application of NEVs and promotes sustainable energy transition and the development of green economy. And through regulations and standards, financial support, technological innovation and international cooperation, it has provided important support for the development of the NEVs global industry.

3.5. Conclusion

In conclusion, various countries have formulated various policies and strategies in the process of responding to the challenges of NEVs industry and promoting its development. There are

many aspects being covered, such as technological innovation, market promotion, infrastructure construction, international cooperation, etc., reflecting the exploration and actions made in the field of NEVs by the governments of various countries. Indeed, to promote an emerging industry, what is most needed in the initial stage is government support so that this industry can have the opportunity to develop. Whether it is helpful for manufacturers to reduce production costs, and improve industrial transformation, or to help consumers reduce purchasing burdens, improve infrastructure to optimize user experience, it is inseparable from government policies and the active cooperation of relevant departments. In addition, necessary international cooperation and technical exchanges can also help countries share experiences with each other, in order to reduce possible erroneous attempts in exploring the NEVs industry, and furthermore to accelerate industrial upgrading. These policies and measures not only promote the technological progress and market popularization of NEVs, but also make important contributions to building a clean, green, and intelligent transportation system.

4. Globalisation and cooperation

4.1. Introduction

Through the introduction above, whether it is the challenges encountered by NEVs industry or the preferential policies and financial subsidies implemented by various governments, they are all aimed at better developing the NEVs industry. No matter in terms of industry transformation and upgrading or ecological environment protection, no country should be isolated. Necessary cooperation can better achieve goals. This chapter will start from the examples of two relatively successful NEVs companies in the field of industrial globalization, analyse how they promote their products to the world, and why the globalization of their industrial chains can lead the industry.

4.2. TESLA

Tesla is an American electric car and energy company that produces and sells electric cars, solar panels, and energy storage equipment. The company headquartered in Palo Alto, Silicon Valley, California, and was first co-founded by Martin Eberhard and Marc Tarpenning in 2003. In 2004, Elon Musk joined the company and led the A round of financing. The founders named the company "Tesla" in honour of physicist Nikola Tesla. The initial entrepreneurial team of Tesla mainly came from Silicon Valley and used "IT concepts" to build cars, rather than the traditional car manufacturers represented by Detroit. Therefore, Tesla's electric car manufacturing is often seen as a story of a Silicon Valley kid fighting a Detroit giant.

i. Initial layout - United States

As the first step in its business, Tesla built its first major production plant in Fremont, California, which is Tesla's earliest automobile manufacturing base. Tesla originally planned to build it in New Mexico, but due to the high cost of this project, the company had to look for alternatives. Later, by chance, Tesla took over Toyota's NUMMI factory in Fremont, which was being sold, and began internal construction on October 27, 2010. The factory has a production capacity of up to 500,000 vehicles, laying the foundation for Tesla's large-scale mass production.

However, due to California's very strict environmental regulations, Tesla must meet a series of strict environmental standards, such as air quality control, wastewater treatment and waste management. These regulations also increased Tesla's initial investment in the early days of its establishment. Fortunately, after the 2008 financial crisis, in order to promote economic development, the United States Congress introduced a series of policies to help all walks of life, including the “Advanced Technology Automobile Manufacturing Loan Program” of U.S. Department of Energy[24], which supports 25 billion dollars to local advanced automobile technology and parts R&D through subsidies and low-interest loans. In June 2009, Tesla successfully obtained a loan of 465 million dollars. Additionally, under the background of California's zero emission policy, Tesla owners can also receive up to 7,500 dollars in federal tax credits (reduced to 3,750 in 2019)[25]. Later, in June 2010, Tesla successfully listed on the Nasdaq, raising a total of 226 million dollars[26]. This was also the first successful listing of an American auto company since Ford Motor in 1956.

The second step of Tesla's business is to increase its production capacity and stabilize its position in the United States. In particular, in order to meet the huge demand for Tesla's electric vehicles and energy storage systems, Tesla established its first factory "Gigafactory 1" in Reno, Nevada, which mainly produces batteries and battery packs, and this factory successfully doubled the battery production capacity. Meanwhile, Tesla cooperated with other battery manufacturers such as LG Chem and Panasonic Battery to provide diversified and stable core components for Tesla's electric vehicles. In Nevada, the environmental standards are not as strict as those in California. On the contrary, Tesla has received a lot of preferential policies. For example, the Nevada government has provided huge tax benefits and incentives to attract Tesla to invest in the construction of a super factory in the local area. In 2014, the Nevada state legislature approved a 1.3 billion dollars tax incentive plan, including sales tax exemptions, property tax exemptions, and payroll tax exemptions[27]. These incentives greatly reduced Tesla's operational costs and helped it gain a better foothold in the United States. Besides, the Nevada government cooperated with Tesla to carry out multiple job training programs. These programs not only helped local residents acquire professional skills and increased local employment rates, but also helped Tesla obtain the necessary talent.

The third step of Tesla's business is to continue to consolidate its position and lay the

foundation for overseas layout. Therefore, Tesla built its second factory "Gigafactory 2" in New York, which was built on an old factory left over from a former steel mill. The super factory began construction in 2014 and was completed in 2016-17. It mainly produces photovoltaic cells, panels, and Tesla superchargers. During this period, the New York State government provided several financial supports through the "Buffalo Billion" plan, therefore Tesla received an investment of 750 million dollars to help its construction and equipment purchases[28]. Meanwhile, Tesla reached an agreement with the State University of New York (SUNY) to help Tesla lease a factory at a very favourable leasing costs and it enabled Tesla to have more flexible finance to operate and expand.

ii. Overseas layout – China

After having a stable industrial chain in US, Tesla decided to start expanding its business overseas. First of all, Elon Musk noticed China's huge NEVs market, and took into account that China's automobile industry chain is very developed, especially the automobile industry chain without considering the gearbox and engine. Therefore, on January 7, 2019, Tesla's first overseas factory "Gigafactory 3" officially started construction in Shanghai, and Elon Musk attended the groundbreaking ceremony. Gigafactory Shanghai spent period significantly shorter than expected. Compared with the same capacity factory, Shanghai saves 60% of the cost of the US factory. Less than a year later, on the morning of December 30, 2019, Tesla delivered the first batch of Tesla Model 3 from the Gigafactory Shanghai to 15 employee owners, marking the official commissioning of the factory. At the same time, Tesla's stock price soared from 176.99 dollars in 2019 to 2,318.4 dollars in 2020, and Musk also boarded the cover of Time Weekly.

Tesla can have ability to build a factory so quickly is not only due to China's strong infrastructure capabilities, but also has a lot to do with the green light given by the Shanghai Municipal Government. Tesla obtained a loan of 18.5 billion yuan (2.6 billion dollars) with an interest rate of only 3.9%, which is much lower than general commercial loans[29]. Meanwhile, Tesla signed a bet agreement with the Shanghai Municipal Government. The agreement stipulates that the price of the land bid by Tesla is only one-tenth of the market price. However, Tesla's annual tax payment must reach 2.23 billion yuan (319 million dollars) starting from the

end of 2023, otherwise the land will be reclaimed[30]. From the perspective of economic benefits, according to the price of Tesla Model 3 at the time, which was about 300,000 yuan (43,000 dollars), and the price of later models such as Model Y, this goal should not be difficult to achieve. After all, as the country with the most radical electric vehicle policy and the largest market in the world, localized production can directly bring huge benefits. Even though Tesla is a foreign company, it has received a lot of preferential treatment. From 2019 to 2020, the Shanghai Municipal Government provided specific incentives of 540 million yuan (77 million dollars), 850 million yuan (121 million dollars), and 38.15 million yuan (5.4 million dollars) to Gigafactory Shanghai respectively[31]. In addition, starting from 2019, the corporate income tax rate of Tesla Shanghai Branch is 15%, which is about 10% lower than other companies.

In addition to policies, another major reason why Tesla chose China as the first station to expand its business is the low cost of making cars here. Thanks to Shanghai's advantages in the Yangtze River Delta region of China, Gigafactory Shanghai has achieved a localization rate of more than 90% of its parts. Many parts of Tesla can be delivered to this factory in 4 hours and form a large-scale industrial cluster., which is called by Tesla's "4-hour friends circle". Therefore, Tesla has significantly reduced manufacturing costs, thereby reducing sales prices and helping to better promote NEVs. For example, in December 2019, Tesla announced that it would reduce the price of Model 3 produced in China by 20% or more in 2020[32]. For Tesla, it not only helped to better enter the Chinese market, but also helped Tesla to gain cost advantages to export from China.

In addition to policy preferences and cost advantages, Shanghai, as the first city in China, has rich talent resources to help Tesla develop rapidly. Besides, there are transportation advantages brought by the world's first foreign trade port with the highest throughput for many years. As a consequence, there is a new progress of the energy storage business projects in China, which performed well in Tesla's 2023 annual report. According to the "Shanghai Lingang Approved Tesla's River-Related Construction Plan for Its Energy Storage Super Factory Project" issued by the Shanghai Lingang New Area Management Committee, the project is located in Nanhui New Town, Pudong New Area, covering an area of more than 200,000 square meters, with a total investment of approximately 1.45 billion yuan (725 million dollars)[33]. Meanwhile, the Shanghai Lingang Area Management Committee issued a document stating that

the products of this project will be supplied to the global market. The factory is scheduled to start construction in the first quarter of 2024 and go into production in the fourth quarter. The initial plan is to produce 10,000 commercial energy storage batteries annually, with an energy storage scale of nearly 40GWh. The construction and operation of Tesla's energy storage super factory is not only an important optimization of its global production layout, but also a far-reaching investment in the future of sustainable energy.

iii. Overseas layout – EU

In order to better serve the European market, Tesla has made a number of arrangements in Europe. On August 22, 2013, the first complete vehicle of the Tilburg plant in the Netherlands officially rolled off the assembly line, which also marked the official start of production of the factory established by Tesla in Europe. The plant undertook the assembly of Tesla S-type sedans and the sales tasks in the European market. In addition, it became Tesla's after-sales service and parts centre in Europe. Most importantly, Tesla built the European Super Factory "Gigafactory 4" near Berlin, Germany, which is Tesla's second overseas Gigafactory and the first complete production base in Europe. The factory not only produces electric vehicles, but also manufactures batteries and battery packs to meet the growing demand of the European market.

Actually, the preliminary discussions on the Gigafactory began as early as 2015, and Tesla was expected to announce the construction of the factory in 2017. However, during the period encountered various difficulties, which continuously led to the postponement of the construction of the factory, and the name was changed from Gigafactory 2 to Gigafactory 4. On the one hand, various EU countries hope that Tesla can be established in their own countries because it is expected to make a significant contribution to the economy. This huge factory is expected to be one of the largest production lines in Europe. Despite there are many highly automated processes, it still requires a large number of employees, so it can greatly increase the local employment rate. Meanwhile, Tesla's growing demand for electric vehicles and home energy storage systems can help Europe reduce its dependence on fuel and protect the environment. On the other hand, because the EU has extremely strict environmental standards, the project has received a lot of attention, especially from local environmental organizations, including potential impacts on water supply and local wildlife, as well as wastewater treatment.

For example, at a public hearing held at Stadthalle Erkner, protesters worried that the chemicals in the factory violated AwSV §49, which meant that plans for the factory had to be stopped. Besides, various animals that rely on living in the forest must be resettled before felling. Fortunately, the factory officially opened on March 22, 2022.

In fact, in the European market, Tesla does not seem to have a brilliant performance in the United States and China. On the one hand, it is because traditional European car manufacturers are starting to focus on the NEVs market after experiencing a "struggle of ideas". In fact, they have more technical advantages in automobile manufacturing, but they still have shortcomings in new electronic applications. To a large extent, it is not that they cannot, but that they are unwilling to break the original concept of automobile fuel system and do not accept the stubborn ideas and vested interests brought by the concept of NEVs. However, when a development trend is inevitable, acceptance is the best response. On the other hand, it is because of the preferences of European consumers. For example, Tesla's advantages are concentrated in smart driving and other aspects, but this is not a selling point to European people, which makes Tesla lack sufficient appeal in optional configuration. European consumers prefer to trust brands that have been settled for a long time, and these brands can better understand the needs of European consumers. The same example can be referred to in the 1960s and 1970s, when Japanese car companies also wanted to replicate the experience of occupying the North American market in Europe, but they failed. However, nothing is absolute, and some Nordic countries are very fond of new energy vehicles. For example, in Norway, Tesla ranked first in Norway's car sales for the third consecutive year in 2023, and expanded its lead over competitors, winning up to 20% of the market share. In Iceland, Tesla broke the record of fuel vehicles for 33 years and became the brand with the highest sales in the overall car market. In the first half of 2023, Model Y has surpassed many fuel vehicles and become the best-selling car in Iceland, breaking the annual sales record of a single model in the local area for 35 years. After the official opening of the Berlin Super Factory, Tesla's promotion in Europe has been accelerated. From 2023, Tesla's sales in Europe were 365,000, an increase of 56% from 234,000 in 2022[34]. Additionally, Tesla is also committed to increasing charging infrastructure in Europe. So far, Tesla has built dense super charging stations in Northern Europe, more than 1,500 super charging piles in Norway, and will be available to non-Tesla owners. The 500 super charging piles built in Denmark will

also be open to all brands of electric vehicles.

iv. Overseas layout and future expansion

In addition to these three major economies, Tesla is also actively deploying in the Asia-Pacific region and other markets. Tesla has sales and service centres in Japan, South Korea, Australia and Singapore, providing localized sales, maintenance and charging services. However, due to the policies and consumer preferences of some countries, Tesla's sales are not ideal. For example, Tesla Model 3 sold a total of 1.3 million vehicles in the global market in 2022, but in Japan, Tesla's sales can only be described as disaster, with less than 6,000 vehicles sold in 2022. In actually, Tesla is not very suitable for Japan's national conditions. Japan's high-speed speed limit is 90, and Tesla's performance cannot be brought into play. Besides, the densely populated urban area also cannot bring Tesla's performance into play. The Japanese favourable model is still K-CAR, which is small and fuel-efficient, cheap, and convenient and flexible for urban transportation. Additionally, in cities such as Tokyo, the streets are too crowded, and it is difficult to mark out independent parking spaces or install home charging piles. If use commercial charging piles, the electricity bill is more expensive than the oil bill, so people are more willing to choose to drive fuel vehicles.

Another example is South Korea. In 2022, Tesla's sales in South Korea were only 14,571 vehicles, a year-on-year decrease of nearly 20%. Since entering the Korean market in 2017, a wave of Tesla has swept through South Korea. In 2020, Tesla reached a peak market share of 86% in imported electric vehicles, and then declined year by year, leaving only 21% in 2023. In 2024, there is only one car being sold in January, setting a new low[35]. The main reason is that the Korean government has raised the threshold for subsidies since the beginning of 2023. If costumers want to get a subsidy of up to 6.8 million won (5,000 dollars), automakers also need to meet four standards, including the maximum range of a single charge, whether the government-specified environmentally friendly car sales target is achieved, the construction of electric vehicle charging infrastructure, and the application of innovative technologies[36]. In addition, only electric vehicles priced below 57 million won (41,600 dollars) will be subsidized by the Korean Ministry of Environment. Since Tesla does not meet all the conditions, it can no longer receive high subsidies, which means that Tesla's overall price is no longer as favourable

as usual.

Tesla is also exploring market opportunities in India and other emerging markets to seek further global expansion. For example, Tesla has previously announced that it will build a factory in Mexico that is scheduled to be put into production in 2026. Besides, Tesla is expected to invest up to 3 billion dollars to build a factory in India, with an annual production capacity of 500,000 vehicles. The company may follow the Gigafactory model in California, Shanghai, and Berlin, considering build a local battery factory in India, and arrange for suppliers to build an industrial chain nearby.

Tesla's success is not only the need of the times, but also the result of its efforts. As the backbone of the NEVs industry, Tesla has successfully promoted the development of this industry through its global layout and extensive partnerships. It has also effectively utilized the local advantages of various countries, met the needs of different markets, and promoted technological innovation, market popularization and infrastructure construction.

4.3. BYD

BYD, was founded in 1995 by Wang Chuanfu in Shenzhen, Guangdong, China. The company initially focused on the R&D and production of rechargeable batteries, especially nickel-cadmium batteries and nickel-metal hydride batteries. At that time, China's battery market was in a rapid development stage, and BYD quickly occupied the market with its cost-effective products. By 2000, BYD had become the world's second largest rechargeable battery manufacturer, with major customers including Motorola, Nokia and other internationally renowned companies. It was not until 2003 that BYD acquired Qinchuan Automobile Company and officially entered the automobile manufacturing industry.

i. Domestic layout

The company started out developing and producing traditional fuel vehicles, but as founder Wang Chuanfu realized that battery technology would play an important role in the future automotive industry, the company soon turned its attention to the NEVs market, especially the

electric vehicle. This forward-looking decision became the key to BYD's future success. In fact, he made an unexpected decision to join the automotive industry, when he was doing well in the battery industry. At that time, this decision attracted many people's doubts, and BYD's stock price was almost halved overnight on the day the news was released. Finally, in 2008, BYD launched its first mass-produced electric vehicle, the F3DM, which was the world's first mass-produced plug-in hybrid vehicle. This car is equipped with BYD's self-developed iron battery technology, marking an important step for BYD in the field of NEVs. BYD has also attracted some foreign investors. In September 2008, Buffett purchased 225 million shares of BYD at 8 HK dollars (1 US dollar) per share, which gradually solved BYD's funding problems[37]. In order to better adapt to China's huge and complex market, BYD has adopted a series of market strategies. Firstly, BYD diversified its product lines, providing a variety of models from economy cars to high-end SUVs to meet the different needs. Besides, through independent R&D and large-scale production, BYD has effectively reduced production costs, so that it can be launched on the market at a more competitive price. In addition, BYD is also actively promoting its energy storage solutions, such as household energy storage systems and large-scale grid energy storage systems, to promote the application of renewable energy and the intelligent upgrading of power systems.

Considering that the automotive industry in China has stricter technical standards and regulations than other industries, BYD needs to meet these standards, which is a huge challenge for a cross-industry company. Fortunately, BYD started out as a battery manufacturer, and as the core of electric vehicles, it has a leading advantage. Meanwhile, the Chinese government has also started to pay attention to the NEVs industry and gradually introduced policies to help. Under the strategic direction of energy conservation and emission reduction in China, BYD has indeed leveraged the government and expanded unprecedentedly. In the name of developing new energy and automobile industries, BYD has successively established industrial parks and production bases such as solar energy, iron batteries, and automobile production in Shaanxi, Guangdong, Hunan, etc. In these investments, local governments provide land and some industrial subsidies. According to the annual "Notice on the Liquidation and Application of Subsidy Funds" of the Ministry of Industry and Information Technology of China, the cumulative subsidies given by the Shenzhen Development and Reform Commission are as high

as 1 billion yuan (140 million dollars). Until 2018, during these 8 years, BYD received a total of 6.968 billion yuan (1 billion dollars) of government subsidies[38]. Considering the large number of cars in developed cities such as Beijing and Shanghai, and the conservative attitude of people towards new things, these subsidies effectively helped BYD overcome difficulties in the early stages of its development. In recent years, with the vigorous promotion of NEVs and technological upgrades, the trend of subsidies has slowed down. As a leader in China's NEVs industry, BYD's ambition is not limited to the field of family cars. On September 30, 2010, BYD's K-series bus K9 rolled off the production line for the first time at its factory in Changsha, Hunan, China, marking BYD's entry into the commercial vehicle field. Considering the high cost of buses, an electric bus can get a national subsidy of 500,000 yuan (71,000 dollars)[39], which is nearly 10 times that of a normal car, which naturally greatly increased BYD's total subsidy amount.

Although more and more domestic and foreign companies are entering the NEVs market, competition is becoming increasingly fierce, and there are some technical deficiencies, such as autonomous driving and intelligent networking, BYD has also occupied a large market share. According to data from BYD's official website, BYD has a 36% market share in NEVs market of China and a 22% share in the world.

ii. Overseas layout

BYD auto was late in going overseas, but BYD Group was not late in going overseas. As early as 1998, BYD established its first overseas branch and European headquarters in Rotterdam, the Netherlands, focusing on battery and electronics businesses. In 1999, BYD established a North American branch and began to enter the US market. The establishment of branches formed the basis of BYD's overseas experience, which not only established an overseas talent pool for BYD, but also made BYD's brand famous overseas. The second stage was the overseas expansion of commercial vehicles with such as new energy buses and coaches. In 2010, BYD proposed the "electrification of urban public transportation" strategy and began to promote new energy buses and taxis worldwide.

Firstly, the first place BYD considered was the US market, because of its huge economy and purchase capacity. However, it is not easy to open up the US market. On the one hand, US

politicians do not want Chinese electric vehicles to enter the US market, and they suspect that they are “spies”. On the other hand, the American people do not seem to buy into an unfamiliar brand. Therefore, BYD decided to change its thinking and focus on the field of electric buses and electric trucks. Therefore, BYD decided to choose Lancaster, California, which is more open to Chinese company, as its first production base in North America. In March 2013, less than two years after the establishment of its North American headquarters, BYD received an order for 10 electric buses from the Long Beach Transportation Authority in the United States. Although it encountered some political pressure, BYD still stubbornly obtained a license to sell buses in the US and completed this bill. Unexpectedly, BYD received extra order for 50 pure electric buses. And as of now, BYD has occupied more than 80% of the market share in the pure electric bus market in the US. Considering the ongoing trade war between the United States and China, and the Trump administration then introduced tariffs on Chinese imported cars to 27.5% (in May 2024, the Biden administration raised to 100%), BYD has been unable to expand its U.S. market in a bigger step.

Secondly, Europe is also an important market for BYD. Even though Europe does not have many political conflicts with China like the US, it is difficult for a foreign brand to enter the market because the traditional European automobile industry is very developed. BYD decided to start with the strategy of "first big and then small", using new energy buses to drive new energy passenger cars. In 2013, BYD's pure electric bus K9 passed the EU's WVTA certification[9] which means that BYD can sell their cars to the EU markets. On April 4, 2017, the first electric vehicle factory invested and built by BYD in Europe was officially completed and put into production, and an opening ceremony was held in Komárom, a northern Hungarian city. In early stage the factory produces mainly pure electric buses, and electric forklifts. However, in the future other light commercial vehicles will be produced. In March of the same year, BYD announced that it would invest 10 million euros to build the Allonne plant in Beauvais, Hauts-de-France, France. On December 3, 2018, the first two 12-meter pure electric buses rolled off the assembly line, marking the official start of production at the plant. With the

[9] The EU WVTA (Whole Vehicle Type Approval) certification is a type certification for automobiles authorized by the European Commission to be conducted by member state agencies. It includes 25 vehicle review projects and dozens of single product certifications.

completion of these two plants, BYD gradually opened up the European market, and therefore received a lot of orders. For example, on November 21, 2022, BYD received a large order for electric buses from Norwegian public transport operator Nobina. There are totally 64 BYD electric buses which will be delivered to Norway in the second quarter of 2023. Another example, as one of Sweden's largest public transport operators, Transdev is committed to investing in new travel solutions, especially in the field of electric buses. On February 10, 2023, BYD received an important order from Transdev, which ordered 52 electric buses. These buses will be used for operation on Transdev's routes in Gästrikland Province on the east coast of Sweden, in aim to protect the environment and sustainability of this famous scenic spot. Meanwhile, there are more than 700 BYD electric buses in service or on order in the Nordic region, and more than 3,000 electric buses in Europe. BYD electric buses have travelled more than 59 million kilometres in Northern Europe, reducing carbon dioxide emissions by more than 63,000 tons[40]. As the market for large buses gradually stabilizes, BYD has begun its overseas exploration of small NEVs. On June 7, 2021, BYD's first batch of 100 EVs "Tang" set sail from Shanghai Port to Norway, marking the official export of BYD passenger cars to Europe. In July 2023, BYD announced plans to invest more than 10 billion HUF (28.6 million dollars) to build a battery assembly plant in Hungary[41]. Moreover, in November of the same year, BYD announced the construction of a production base in Szeged, Hungary, which is also BYD's first European passenger car production base. So far, this factory has started construction and is expected to be completed and put into production in 2025. BYD has also established multiple sales and service centres in Europe to provide professional after-sales service and technical support to ensure the smooth operation of products in the European market.

Thirdly, compared with direct exports to the US and Europe, BYD's NEVs entered the Asia-Pacific market relatively late. On the one hand, as traditional automobile manufacturing powers in the Asia-Pacific region, Japan and South Korea have a set of strict entry standards, and foreign automobile brands have few footholds. BYD still uses the strategy of "first big and then small" and relying on its own high-standard products and the achievements made in the European and US markets in the past few years, and gradually broke through the high-standard Japanese and South Korean vehicle market. According to BYD's official website data, BYD also successfully entered the Japanese market in January 2023, with annual sales of 1446

vehicles. It seems that this data is not ideal but considering that the Japanese market has always been one of the most closed markets in the world for 20 years and the Japanese market has maintained a high degree of dependence on domestic brands. In Japan, the market share of domestic brand has always accounted for 92%, while imported brands have only a meagre 8% share, forming an extremely difficult competitive environment. In contrast, Hyundai of South Korea, which is much more well-known than BYD, will only sell more than 300 units in the Japanese market in 2023. In addition, BYD plans to build an electric vehicle factory in North Chungcheong Province, South Korea. After the contract is signed, BYD will use South Korea as a strategic production base to fully launch electric car production and global sales. These products produced in South Korea can not only meet domestic demand, but also be exported to North America and Europe, where have signed free trade agreements (FTAs).

Last but not least, BYD also has a large layout in South America. In August 2019, BYD delivered 183 buses to Chile, and soon after, in November, BYD announced that it had signed an order for 470 pure electric buses with Bogota, the capital of Colombia, setting a record for the largest electric bus order in the Americas. On July 4, 2023, BYD and the government of Bahia State, Brazil, jointly announced that the two parties will establish a large production base complex in Camacari, with a total investment of 3 billion reais (574 million dollars)[42]. This base is expected to be officially put into production in 2025, with an annual production capacity of 150,000 units and the ability to produce a variety of models. This factory is also the first time that BYD has built a factory outside of Asia, promoting BYD's layout in South America and accelerating its pace of globalization.

BYD has successfully promoted the development of the NEVs industry through its global layout and extensive partnerships. The establishment of production bases and sales service networks around the world not only meets the needs of different markets, but also promotes local market penetration and infrastructure construction. BYD's success is not only due to its leading technology and products, but also benefits from its active overseas strategic layout. According to public data shows that BYD's cumulative sales of NEVs reached 3.024 million units in 2023, a year-on-year increase of 61.9%. Among them, BYD exports totalled 243,000 units in 2023, a year-on-year increase of 334.2%[43]. In the future, as the global demand for NEVs continues to increase, BYD will continue to promote the sustainable development and

technological progress and contribute to the realization of global green transportation and sustainable development goals.

4.4. Conclusion

In conclusion, Tesla and BYD are two leading companies in the global NEVs industry. They have demonstrated their unique advantages and successful experiences in terms of technological innovation, market promotion and other aspects. First of all, both Tesla and BYD have invested a lot of resources in technological innovation. Whether it is Tesla's battery technology and vehicle performance, especially the Autopilot and FSD (full self-driving) systems, or BYD's deep battery technology and cost-cutting preferential to customers, they all provide customers with a better experience. Secondly, both Tesla and BYD have made extensive layouts in the global market. Whether it is Tesla's establishment of production bases in the United States, China and Europe to meet the needs of different markets, or BYD's alternative approach, using the strategy of "first large and then small", they have both gradually accelerated the company's pace of globalization. Thirdly, both Tesla and BYD have actively cooperated with local governments and companies. For example, Tesla's Gigafactory Shanghai has received strong support from the Shanghai Municipal Government and has obtained a series of preferential policy and financial support, which has enabled Tesla to expand rapidly in the Chinese market. Another example, BYD has cooperated with public transportation departments in many cities around the world to promote electric buses and electric logistics vehicles to help cities achieve green transportation goals. These also prove that the government's preferential policies and the active cooperation with companies have greatly help in the promotion of NEVs. Last but not least, as competition in the global market becomes increasingly fierce, Tesla and BYD need to continue to innovate technology, increase their competitiveness and brand awareness in the global market, and make greater contributions to global environmental protection.

5. Consumer attitude analysis

5.1. Introduction

In the NEVs industry, establishing a consumer behaviour model is of great significance for analysing market demand, in order to formulate marketing strategies and promote the popularization of products. Since consumers' purchasing decisions are affected by many factors, by building and analysing consumer behaviour models, we can deeply understand the impact of these factors, thereby helping companies and governments to establish more reasonable countermeasures.

This chapter will analyse consumer purchasing behaviour from several different factors. The first is economic factors. Such as purchase costs, fuel costs, maintenance costs, etc. will directly affect consumers' decisions. Consumers will weigh the relationship between short-term costs and long-term costs. The second is psychological preference factors, it also plays an important role in consumer decision-making. For example, the consumers' attitudes towards NEVs, including environmental awareness and trust in technology. The third is social environment factors, such as family structure, social class, cultural background, etc. will have an impact on purchase decisions.

5.2. Data research and analysis

The data source for this model is a report generated by Deloitte, which surveyed more than 26,000 consumers in 24 countries between September and October 2022 to explore different views on a number of core issues affecting the automotive industry.

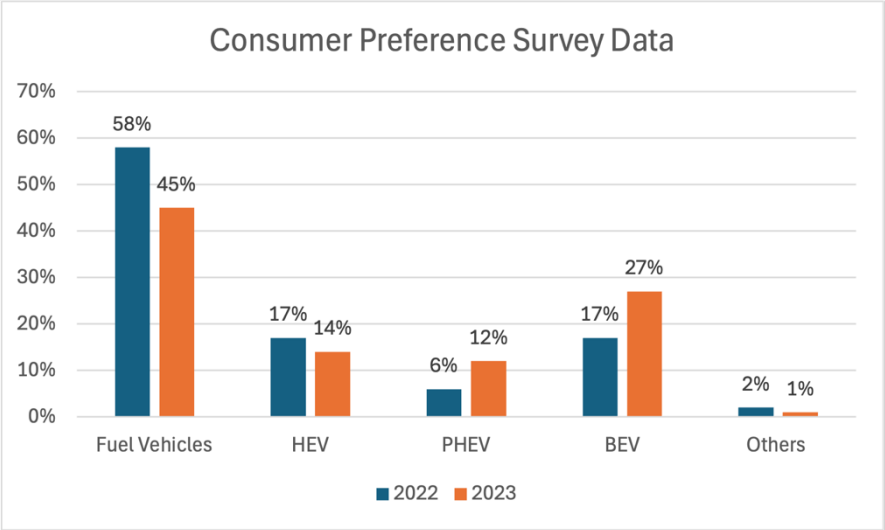


Figure 17: Survey on consumers' willingness to purchase different types of cars (source: Deloitte)

The above chart is based on the survey report, it shows that consumers' recognition of new energy is increasing year by year, and they are more willing to choose pure electric cars that are more environmentally friendly and emission-free. According to consumer feedback, the following reasons are given for the most attractive new energy vehicles. First, there is a better driving experience. Second, the cost of use is lower. Third, the car can be used as a power source. Fourth, it is good for personal health. Fifth, additional taxes on traditional cars. The following text will analyse in several aspects.

i. Consumer variables – age

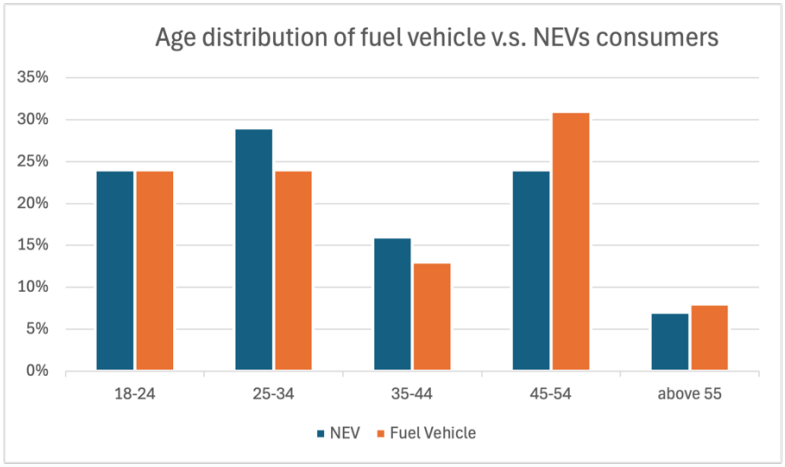


Figure 18: Age distribution of fuel vehicle vs. NEVs consumers (source: Deloitte)

According to the figure above, the trend of younger NEVs owners pursuing cutting-edge technology products is prominent. Overall, the average age of NEVs consumers is under 35

years old, and the proportion of people in each age range under 45 years old is higher than that of fuel vehicle consumers. This is mainly attributed to the curiosity about high technology and new experiences, so that the consumers are willing to pay a certain premium. NEVs are highly integrated with intelligence, focusing on high technology and electrification concepts, which makes their driving experience completely different from that of fuel vehicles. These characteristics just cater to the curiosity of young customers. Besides, the design of NEVs is fashionable and trendy, for example, the smoother body lines, simple detail design, futuristic interior atmosphere, and more consumer electronics-oriented functional loads are very consistent with the aesthetic preferences of the current young generation. In addition, the young generation generally lacks brand education in the era of fuel vehicles and is more receptive to NEVs brands. This type of customer group usually has no obsession with traditional fuel vehicle products, no inherent brand preferences, and is not restricted by the ideological transformation from "fuel vehicles to NEVs", therefore they are more receptive to emerging brands.

ii. Consumer variables – gender

The surgery report shows proportion of female consumers has increased, accounting for nearly 1/3. The female consumers tend to prefer a refined and beautiful life, therefore NEVs have huge advantages over the fuel vehicles. The female consumers are very different from male consumers. They generally have no obsession with the mechanical feel and driving pleasure of fuel vehicles, but have more expectations for the beautiful design, rich colour matching, simple purchase process, and driving convenience. Therefore, they are more likely to be impressed by new energy products. The parameters of NEVs are simple and the purchase threshold is lower. For example, as one of the most prominent differentiated selling points of NEVs, the car networking function is more easily accepted by female consumers. Besides, the operation of NEVs is simple and the driving threshold is lower. More importantly, the usage habits of many functions of NEVs are closer to the usage logic and habits of normal electronics such as mobile phones. This convenience can reduce the discomfort caused by the excessive emphasis on mechanical sense of traditional fuel vehicles, thereby improving the driving experience and attracting more female consumers to purchase.

iii. Consumer variable - education or work background

The high net worth population is expanding, people with bachelor's degrees or above or people in knowledge-intensive occupations are about 10% more likely to choose NEVs than fuel vehicles. Besides, the proportion of people with strong consumption power in corporate white-collars, finance, scientific research, etc., accounting for more than 30% of all NEVs owners. Meanwhile, this group of people has a higher acceptance and willingness to try new things, and also has a stronger sense of responsibility and agreements of the environmental protection concept of NEVs. In addition, in terms of consumption power, the purchase intention of the above-mentioned consumer group is also stronger to buy NEVs rather than fuel vehicle, and they are more open in consumption habits. They are willing to pay an extra premium for products and services that meet their needs and reduce communication and attention costs.

iv. Environmental variables - basic infrastructure

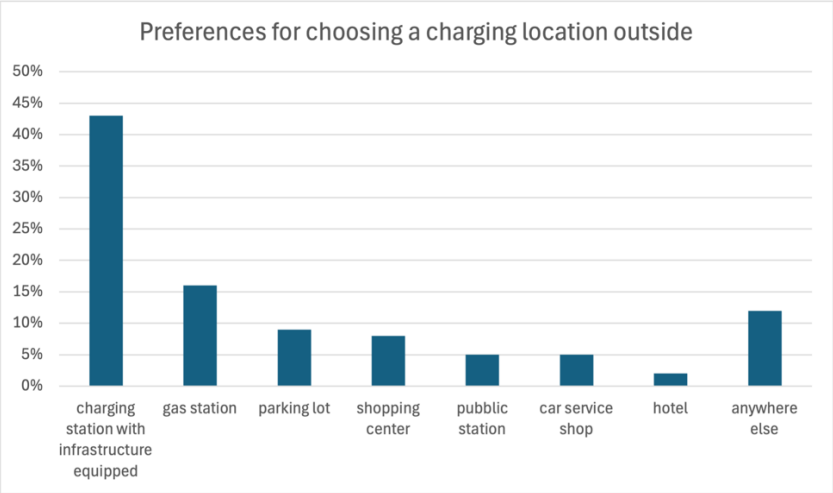


Figure 19: Preferences for choose a charging location outside (source: Deloitte)

According to the survey report, better infrastructure will increase the possibility of choosing electric vehicles. As shown in the figure above, when going out, 43% of consumers are willing to choose to charge at electric vehicle service stations equipped with convenient facilities. The convenient facilities they want to use are mainly concentrated in the lounge and hope to be equipped with WIFI connection. Besides, some food services and toilets are also facilities that many people want. At present, such service stations do exist, but the number is rare. They are all located in some places far away from the city centre, because the construction of such a service station requires a large piece of land, and the construction in the city where

every inch of land is valuable will greatly increase the investment cost. Therefore, in areas with a relatively high level of infrastructure convenience, more consumers will tend to buy NEVs.

v. Environmental variables - policies

As previously demonstrated in Chapter 3, government policy measures are significantly associated with consumers' willingness to buy NEVs. Government support for NEVs increases the likelihood that people willingness. In particular, economic incentives can encourage young consumers with lower savings rates. Additionally, some non-monetary policies, such as dedicated lanes or free parking when charging, also have a positive impact. In order to overcome some other barriers, it is necessary to increase the availability and dissemination of information about low-emission vehicles. In generally, consumers often resist new technologies because of their novelty, unfamiliarity, and uncertainty, therefore the most important point is distrust and misunderstanding of the technology.

vi. Car variables - price

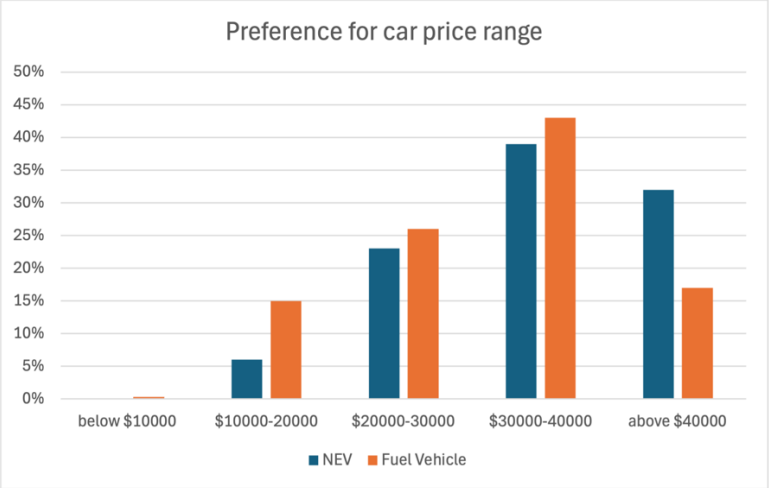


Figure 20: Price range that consumers are willing to spend: Fuel vehicles vs. NEVs (source: Deloitte)

As shown in the above figure, the price that consumers are willing to pay for traditional fuel vehicles is concentrated between 10,000 and 40,000 US dollars, while the price that consumers are willing to pay for NEVs is concentrated more than 30,000 US dollars. Additionally, nearly one-third of consumers are willing to spend more than 40,000 US dollars to buy NEVs, which is twice the proportion of that of traditional fuel vehicles. It is widely believed that high purchase price is one of the main reasons why consumers hesitate to adopt

NEVs. The initial purchase price of NEVs is usually higher than that of traditional fuel vehicles. If there is no appropriate way to reduce the purchase price, the market share and penetration rate may not increase further. Not all consumers are willing or able to pay extra costs for so-called green travel, therefore the reduction of purchase cost is the strongest driving force to promote the adoption of NEVs.

vii. Car variables - performance

It is worth mentioning that lower consumption and lower maintenance costs compensate for the higher purchase price of NEVs and lead to an increased likelihood for consumers to choose NEVs. In terms of vehicle performance, it obviously shown that higher driving range increases the acceptance of NEVs, while limited driving range leads to driver range anxiety, which refers to the fear of running out of power before reaching a charging station, which negatively affects the adoption, distribution, acceptance.

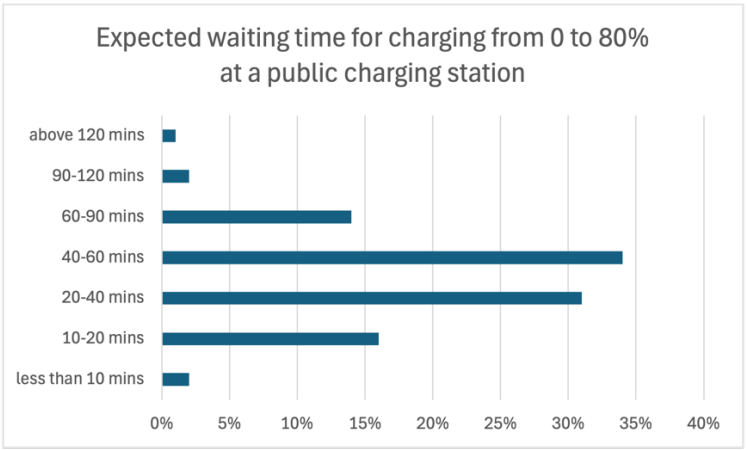


Figure 21: Estimated waiting time to charge from 0 to 80% at a public charging station (source: Deloitte)

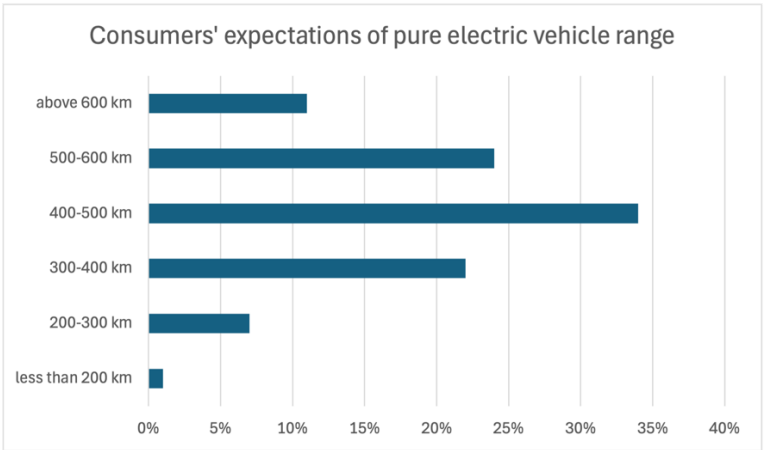


Figure 22: Expected range (source: Deloitte)

The above two figures show some of the consumer preferences for pure electric vehicles. According to the usage patterns of some electronic products and some characteristics of the battery, charging to 80% is a relatively reasonable number. On the one hand, the charging speed of the first 80% power is the fastest, and after exceeding 80%, the charging speed will slow down significantly. On the other hand, charging to 80% can better protect the battery and extend its service life. Therefore, many electronic products will set 80% as the charging dividing line. The first figure shows that the vast majority of consumers still hope that this process can be completed within one hour. In terms of range, the current industry standard is an average of 400km, which meets certain expectations of consumers. However, with the advancement of technology and higher consumer expectations, it is necessary that manufacturers improve the quality of NEVs batteries to increase driving range in order to achieve greater popularity. The longer the range, the higher the likelihood that people will choose it.

In conclusion, the effect of several different factors on consumer purchasing behaviour can be summarized in this table below.

Category	Variables	Description
Consumer	Age	The younger consumer, the more likelihood to purchase NEVs
	Gender	The female consumers are more likely purchasing NEVs
	Education or work background	The consumers with higher educated or better jobs are more likelihood to purchase NEVs
Environment	Infrastructure	The better infrastructure, the more likelihood to purchase NEVs
	Policies	The government's support will increase the consumers' willingness to purchase NEVs
Car	Purchase price	The too low and too high purchase price will both decrease the consumers' willingness to purchase NEVs
	Charging speed	The faster charging speed, the more likelihood to

	purchase NEVs
Range	The bigger range, the more likelihood to purchase NEVs

6. Sustainability

6.1. Introduction

As an emerging industry, sustainable development is also an inevitable topic in the current trend of pursuing environmental protection. This chapter will explore the sustainable development of the NEVs industry from three aspects: economy, environment and society.

Firstly, from the point view of economy, the rapid development of the NEVs industry is inseparable from a large amount of R&D investment, which not only promotes the rapid iteration of technology, but also injects new vitality into economic growth. The birth of an industry will inevitably drive a series of related new and old industries, which it will create a large number of employment opportunities. Especially in production and manufacturing, it has a significant role in driving the economy. This not only helps the development of some companies, but also drives local economic development. In addition, other factors such as market promotion and infrastructure construction can also help the upgrading and transformation of related industries and drive the growth of the green economy. In addition, the international trade and cooperation have also helped the globalization of the economy and provided a larger platform for the sustainable development of the NEVs industry.

Secondly, from the point view of environment, as an important role in urban greenhouse gas emissions, the transformation of fuel vehicles to NEVs has significant benefits in reducing greenhouse gas emissions and improving urban air quality. Considering the global impact of greenhouse gases, the sustainable development of NEVs has greatly promoted the improvement of the global ecological environment. Thanks to there are almost no direct emissions during driving NEVs, especially pure electric vehicles, which use electricity to drive and do not directly produce tail gas emissions. As the proportion of renewable energy in the power structure continues to increase, the indirect carbon emissions of NEVs will also be further reduced.

Finally, from the point view of society, the popularity of NEVs has changed people's travel methods, and inadvertently allowed people to participate in protecting the environment, in order to reduce footprint. As mentioned above, the development of the NEVs industry has promoted technological progress and industrial upgrading, created a large number of employment

opportunities, and improved the overall environmental awareness and sustainable development concept of the people, so that more consumers can enjoy the convenience and environmental benefits brought by NEVs.

However, there are always two sides to things, and there are many challenges. First economically, supply chain risks, cost pressures and policy uncertainties. Second environmentally, battery production and recycling issues, charging energy usage structure, etc. are also important links in the end-of-life of products and need to be further optimized. Third socially, challenges in consumer cognition, traffic management, etc. also need to be paid attention to.

6.2. Economic

The sustainable development of economy is an important cornerstone for the long-term development of one industry, covering all links of the industrial chain, including R&D, production, marketing, infrastructure construction, etc.

Firstly, the economic sustainable development of the NEVs industry is inseparable from a large amount of R&D investment and technological innovation. Major economies around the world, especially China, the United States and Europe, have made large-scale R&D investments. For example, the Chinese government has strongly supported the R&D of NEVs technology and industrial upgrading by setting up special funds and providing financial subsidies. In addition, the US has made significant breakthroughs in battery technology, intelligent driving systems, etc. by relying on its strong scientific and technological strength, and some related companies such as Tesla corporates with government. Some European countries have also indirectly promoted the continuous advancement of NEVs technology through strict emission standards and environmental protection regulations. Therefore, R&D investment not only promotes the rapid iteration of technology, but also injects new vitality into economic growth.

Secondly, the economic driving effect of NEVs on production and manufacturing cannot be ignored. Every excellent product is inseparable from the support of a complete industrial chain, especially the production of automobiles, from raw material procurement, parts

manufacturing to vehicle assembly, and subsequent supporting such as after-sale services, maintenance, etc. For example, as the core component of NEVs, batteries require a large amount of key raw materials such as lithium, cobalt, and nickel for their production and manufacturing, which has driven the development of the mining and material processing industries. Meanwhile, the manufacturing of parts such as motors and electronic control systems has also spawned a large number of high-tech companies and jobs. In addition, due to the transformation and upgrading of the traditional automobile manufacturing industry, the application of intelligent manufacturing and Industry 4.0 technologies have been promoted to produce more efficiently and higher product quality.

Thirdly, market promotion and penetration rate are also important roles. With the strong support of governments, market demand has shown explosive growth, and the proportion is still keeping raising. For example, China is the world's largest NEVs market, accounting for more than 60% of the global market share, followed by Europe and the United States. The growth of market demand has not only directly promoted the sales and profit growth of NEVs companies, but also further promoted the prosperity of related industrial chains. For example, infrastructure construction is the key support for the economical sustainable development of the NEVs. The extensive construction of infrastructure such as charging piles requires a lot of investment, which not only brings business opportunities to related companies, but also drives the development of related equipment manufacturing and construction industries. The improvement of infrastructure not only improves the convenience of using NEVs and promotes the growth of market demand, but also provides a virtuous circle for economic development.

Fourthly, international trade and cooperation of the NEVs industry have also accelerated the globalization of the economy. The international trade volume of NEVs and their key components has increased year by year, forming a global industrial layout. On the one hand, through trade and investment, they have promoted global economic integration and optimal resource allocation. On the other hand, cooperation and competition between multinational companies related have also accelerated technological progress and market expansion. Taking Tesla as an example, its establishment of factories in China and Europe has not only reduced production costs and increased market response speed, but also promoted the development of local economies.

Last but not least, there are also facing many challenges. First of all, there is the risk of the industrial supply chain. The dependence of NEVs on key raw materials makes the security of the supply chain an important issue. Due to the extremely uneven geographical distribution of many raw materials, factors such as geopolitical tensions and trade frictions will largely lead to price fluctuations and even supply interruptions of raw materials, which will in turn affect the stable development of the industry. For example, the trade war between China and the United States and conflict minerals in the Congo region. The second issue is the cost. Even though the production cost of NEVs has gradually decreased with technological innovation and scale expansion, the price is still higher than that of traditional fuel vehicles, which to a certain extent restricts the further popularization of the market. Besides, the uncertainty of industrial economic policies. There are differences in the intensity and direction of policy support in different countries and regions. On the one hand, it may lead to insufficient penetration in domestic market, and on the other hand, it may lead to special tariff policies in other countries when exporting NEVs, thereby hindering the globalization of industries and economies.

In conclusion, the sustainable development of economy of NEVs industry has a great significance globally. At present, it is necessary to affirm the important contribution of NEVs to promoting climate change and promoting the green economic transformation. However, in the face of a series of uncertain challenges, both the government and companies need to formulate scientific and reasonable strategies to ensure the long-term sustainable development of the NEVs industry.

6.3. Environmental

NEVs industry has shown significant advantages and potential benefits in terms of the environment, it greatly reducing greenhouse gas emissions, and thus playing a positive role in mitigating global climate change. However, if the life cycle assessment of the entire product is taken into account, there are still many challenges and many areas that need improvement, such as battery production and recycling, energy use structure, etc.

First of all, NEVs have played a major role in reducing greenhouse gas emissions. The

traditional fuel vehicles produce a large amount of carbon dioxide and other greenhouse gases during driving, and with the increasing demand for cars, it has gradually led to global climate change. In contrast, NEVs emit almost zero carbon dioxide during driving, especially pure electric vehicles, which only need to use electricity to drive and do not directly produce tail gas emissions. According to the International Energy Agency (IEA), the popularization of NEVs worldwide in 2023 has reduced carbon dioxide emissions by about 500 million tons, equivalent to reducing emissions from 130 million traditional fuel vehicles, especially the electric vehicles contributed the half the reduction[44]. As the proportion of renewable energy in the power structure continues to increase, providing a greener charging method for pure electric vehicles, its indirect carbon emissions will also be further reduced.

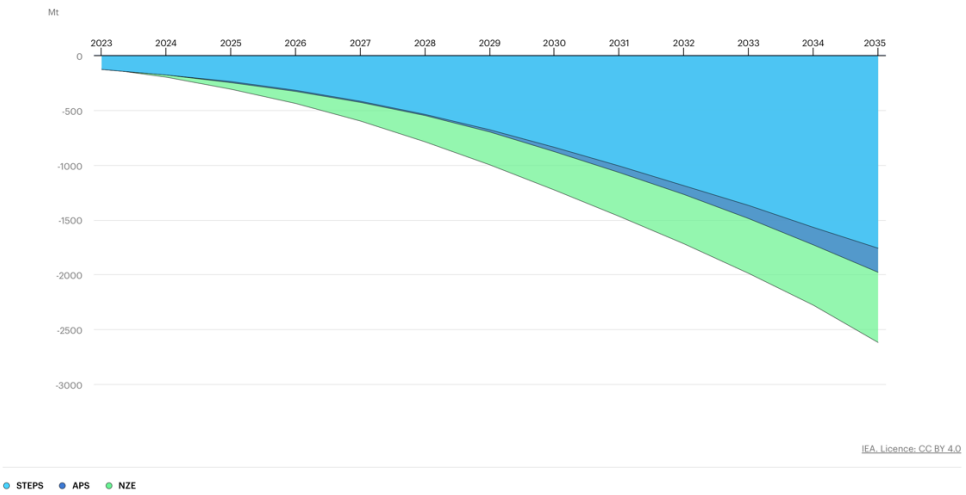


Figure 23: Net avoided well-to-wheel greenhouse gas emissions from electric vehicle deployment, 2023-2035 (source: IEA)

In addition, NEVs also help reduce urban air pollution. The exhaust of traditional fuel vehicles contains a large number of harmful substances, such as carbon monoxide, nitrogen oxides and particulate matter. These pollutants will cause the urban air quality to decline and threaten the health of residents. However, thanks to NEVs not emit these harmful substances and can effectively reduce urban pollution. For example, Beijing, China has always suffered from poor air quality. After the explosive increase of NEVs in 2018, the urban air quality has greatly improved. Although there is still space for improvement, the PM2.5 concentration has dropped significantly. This is of great significance for improving the quality of life of residents and reducing the incidence of respiratory diseases.

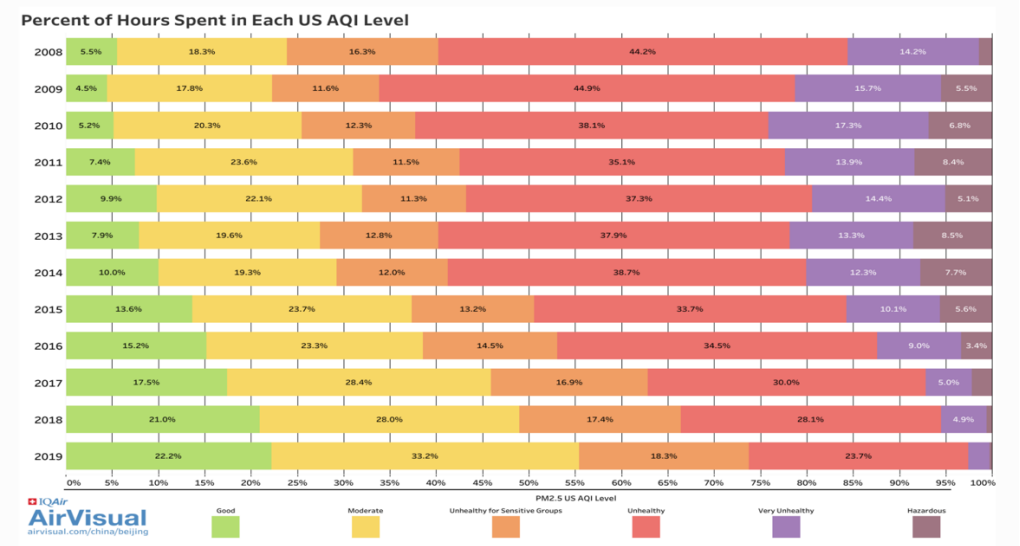


Figure 24: Annual distribution map of Beijing PM2.5 hourly concentration (source: IQAir)

Moreover, the promotion and application of NEVs is not only for its own industry green development, but also helps to improve environmental protection technology and the green development and transformation of many other related industries. It has indeed driven innovations and breakthroughs in many fields such as battery technology, intelligent driving technology, and lightweight materials. These technologies have not only improved the performance and environmental benefits of NEVs, but also helped these industries themself pay more attention to green development. For example, the improvement of battery technology has accelerated the popularization of NEVs and can also be applied to renewable energy storage systems to improve storage efficiency. The application of intelligent driving technology helps to optimize traffic management, help to reduce the driver fatigue driving, and can also reduce traffic congestion and ineffective fuel consumption of energy. The use of lightweight materials can reduce vehicle energy consumption, improve efficiency and expand vehicle life.

However, there are some challenges that are inevitable. The first is the core issue, the production and recycling of batteries. The core component of NEVs is the battery, and its production process involves a lot of resource consumption and pollution emissions. The mining and processing of key raw materials such as lithium, cobalt, and nickel will cause certain damage to the environment, such as water pollution, soil erosion, and ecological damage. If they are improperly or excessively mined, they may threaten the lives of local residents. In addition, energy consumption and exhaust emissions in the battery production process also need

to be effectively controlled. For example, whether the energy structure used by the factory can be improved to renewable energy. Besides, the most important issue is that, just as a large number of scrapped car factories cannot be properly treated now, the recycling of waste batteries. In the point of global view, there has been no very effective way to deal with waste batteries. Although the development of the waste battery recycling industry has become a global consensus, it still lacks strict standardization. Since waste batteries contain harmful substances, which will cause huge pollution to the environment if not handled properly. Therefore, establishing a complete battery recycling system and green production process is crucial to the sustainable development of NEVs.

Furthermore, the impact of the energy use structure of NEVs on the environment cannot be ignored. Even though NEVs do not produce direct emissions during driving, if the electricity they use comes from fossil fuel power generation, it will still indirectly lead to greenhouse gas emissions and environmental pollution. Therefore, the greening of the energy structure has also a great impact on the environmental. While vigorously promoting NEVs, countries also keep accelerating the adjustment of energy structures and increasing the proportion of renewable energy. For example, the United States vigorously promotes wind power generation, China has built large-scale photovoltaic power generation projects, and European countries have also vigorously developed wind and solar energy. At present, wind and solar energy have become the cheapest renewable energy sources in many countries. These measures will help reduce the overall carbon footprint of NEVs and develop their sustainability.

In addition, the use of NEVs is inseparable from the construction of supporting infrastructure. For example, the construction of infrastructure such as charging, and battery swap stations requires a lot of resources and energy. Therefore, the impact on the environment during the site selection and construction process also needs to be considered in the life cycle assessment of NEVs. It is necessary to use green construction technology and environmentally friendly materials to minimize damage to the ecological environment.

6.4. Social

The sustainable development of the NEVs industry also has a wide range of impacts on the social level. It not only changes people's travel methods and living habits, but also promotes social innovation and progress, and more important is that it brings huge new employment opportunities. Meanwhile, it also enhances citizens' environmental awareness and promotes social equity. However, in this process, it is also necessary to solve some problems such as consumer cognition, traffic management and some other aspects.

First of all, the popularity of NEVs has changed people's travel methods and has gradually become one of the main choices for people's daily travel. With the development of technology, the performance and range of NEVs are no longer reasons for some people to refuse, and they can meet the needs of most people in daily commuting and short distances travel. In addition, the improvement of infrastructure has improved the convenience of charging, which also makes up for the shortcomings of medium and long-distance travel. Compared with traditional fuel vehicles, NEVs can be more silent and reduce noise pollution, especially when driving at high speed, it can effectively reduce the sound of wind, in order to improve the driving experience. What's more is that it also reduces the noise pollution caused to the surrounding living environment. In addition, the intelligent technologies equipped with NEVs, such as automatic driving and intelligent navigation, have brought more convenience and safety to drive, and especially for people who commute to work, they can also prevent dangerous driving after a day of fatigue. In the long term, it also promotes the construction of intelligent transportation systems, optimizes traffic management, and reduces traffic congestion.

Secondly, the development of the NEVs industry has brought a large number of employment opportunities, which can not only promote the local economy, but also promote social stability. These benefits are not only for NEVs companies. Considering the whole supply chain, from raw material acquisition and processing to product production and sales, as well as subsequent maintenance and infrastructure construction, a large number of labour forces are required, thus creating a large number of diverse jobs. In the front end, for example, fields such as battery manufacturing, motor research, and charging pile research and construction require the senior technical talents, which can attract much knowledge-based talents to come over and

inject vitality into the local area. In the back end, such as production assembly, sales, etc., more various talents are needed. According to statistics, due to the large population base in China, the NEVs industry has created millions of jobs, covering all aspects from R&D, production to after-sales service. For example, Tesla's factory in the suburbs of Shanghai has driven the development of the suburbs and helped it keep up with the rapid development of Shanghai. In the United States, with the growth of Tesla and the launch of NEVs by other brands, a large number of employments are needed. The same situation also happened in Europe. Tesla's factory in Berlin can not only promote the local economy, but also indirectly increase the professional talents needed for the transformation of traditional cars. As a consequence, the sustainable development of the NEVs industry can promote the establishment of a training system for employees, cultivate more talents with professional knowledge and skills, and improve the overall quality of the workforce.

Thirdly, the promotion of NEVs helps to enhance the society's environmental awareness and sustainable concept. In recent years, the continuous occurrence of extreme high temperatures has significantly increased people's attention to environmental protection and emission reduction. Therefore, as NEVs that can effectively reduce greenhouse gas emissions, it has won the favour of more and more consumers, and people are willing to pay more efforts and costs for green travel. For example, in some developed countries and regions in Europe and the United States, NEVs have become a symbol of high-end environmentally friendly travel and are widely praised by social elites and environmentalists. This trend will not only gradually change consumers' purchasing behaviour, but also gradually enhance the overall environmental awareness of the society, forming a social atmosphere that advocates green and pursues sustainable development.

However, it is inevitable that there are also some challenges in this regard. The first issue is of consumer cognition and acceptance. Even though many advantages NEVs have mentioned above, it is still difficult to convince more people to change their ideas because the price is still high. Moreover, charging stations is obviously not as convenient as gas stations, and the problems exposed by the range naturally further reduce people's desire to purchase. Therefore, improving the cost-effectiveness of NEVs and improving the charging infrastructure at the same time, then gradually increasing consumers' awareness and acceptance are important task. The

second issue is that adaptation of traffic management and regulations. The popularization of NEVs requires a supporting traffic management and regulatory system, such as parking policies, charging facility planning, vehicle registration and use specifications, etc., which requires the government and relevant departments to constantly adapt and adjust. The third issue is that the fair and legal allocation of social resources. The development of the NEVs industry requires a large amount of resources and capital investment, such as the mining of important raw materials, etc., to ensure that the sources of these resources and funds are reasonable and legal and avoid new social disputes and waste of resources.

6.5. Conclusion

In conclusion, the performance of the NEVs industry in the past decade has undoubtedly demonstrated its great sustainability in the three aspects of economy, environment and society.

On the one hand, there are several advantages. From the economic aspect, the NEVs industry has promoted economic growth, promoted the upgrading of related industries and created a large number of employment opportunities. From the environmental aspect, NEVs have reduced greenhouse gas emissions and improved urban air quality, making important contributions to the improvement of the global environment. From the social aspect, NEVs have changed people's travel habits and improved the quality of life. Meanwhile, they have also improved people's environmental awareness and sustainable concepts, so that more consumers can enjoy the convenience and environmental benefits brought by NEVs.

On the other hand, there are some shortcomings. Economic issues such as supply chain risks and cost pressures, environmental issues such as battery production and recycling, energy use structure, and social issues such as consumer cognition and social resource allocation.

In order to effectively and efficiently solve the current problems and achieve sustainable development, it needs the joint efforts of the government, enterprises and all sectors of society. The government should formulate scientific and reasonable policies to further promote the technical R&D and market promotion. Enterprises should strengthen technological innovation and improve product performance, as well as service quality. All sectors of society should

enhance environmental awareness and actively support the development of NEVs. Only through close cooperation among multiple parties can the NEVs industry achieve more comprehensive and sustainable development.

Conclusion

As an important part of the future transportation and energy fields, the NEVs industry is attracting widespread attention around the world. This article aims to provide a comprehensive perspective to deeply understand this booming industry through the analysis of the different sections.

In the first chapter, it introduces the development status of NEVs in major economies around the world. Both developed and developing countries are gradually beginning to pay attention to the development of this industry. As the world's largest market, China's NEVs industry has developed rapidly as a rising star, thanks to the government's strong support and policy incentives. In the United States, thanks to the concentration of high-tech industries, companies represented by Tesla have made continuous technological breakthroughs, which has promoted the popularization of NEVs. In Europe, besides of the premise of policy encouragement, there are many strictly environmental protection policies, which has indirectly promoted the increase in the market penetration rate of NEVs.

The second chapter introduces that the business game in the NEVs industry is not only reflected in the competition for market share between enterprises, but also includes the competition at the geopolitical level. On the one hand, NEVs face market competition from traditional fuel vehicles, high costs, technical shortcomings and other issues. On the other hand, they also face political games between major economies. As an emerging industry, all countries want to get a piece of the pie and do not want to be strangled. Therefore, supply chain, raw materials and other global issues also need to be paid attention to at all times.

The third chapter introduces the policies of various governments that play the vital role in the development of NEVs. Whether it is monetary policy measures such as subsidies and tax incentives, or non-monetary measures such as infrastructure construction, environmental protection regulations and carbon emission standards, they have effectively promoted the development of NEVs, while also helped to reduce carbon emissions, improve environmental quality, and promote the green transformation of the national economy.

The fourth chapter introduces the international cooperation of the NEVs industry in today's global context. Meanwhile, based on the above chapters and taking Tesla and BYD as examples,

it introduces their specific development, the challenges they faced, and the impact of various policies on them. It also shows that cross-border cooperation not only helps companies expand their market share, but also promotes the advancement of global NEVs technology.

The fifth chapter analyses consumers' attitudes toward NEVs and several factors that affect consumers' purchasing behaviours. Thanking to Deloitte's survey data, its report shows that consumer behaviours will be affected by many factors, among which the most influential is the current high purchase price of NEVs. Besides, other factors such as infrastructure, vehicle range, and consumers' own educational background may also have an impact on the promotion of NEVs. Therefore, by deeply understanding consumers' purchasing behaviours, companies can formulate more effective market strategies to meet the needs of different markets.

The sixth chapter introduces the sustainability of NEVs development. The sustainability is not only related to the economic development of the company itself, but also to environmental protection and the impact on society. The chapter shows that the current economic development of NEVs is in a good situation, which can effectively reduce the pollution of traditional cars to the environment and air, and also create positive externalities for society. However, some aspects still need to be paid attention to, such as supply chain sustainability, effective recycling of batteries, and raising social environmental awareness.

In conclusion, the development of NEVs, as an important direction for future green transportation, faces both technical and market challenges and unprecedented development opportunities. The world economies that led by the three major economies of China, the United States and Europe, have performed well in this field, providing valuable experience for the development of the global NEVs industry. In the future, with the continuous advancement of technology and policy support, NEVs will surely be more widely used around the world, while promoting the green transformation and sustainable development of the global transportation system, and making greater contributions to the improvement of environment around the world.

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