

The Development of New Energy Vehicles in China and the Future of Sustainable Transportation

Yishan Deng

New York University, New York, 10012, United States

Abstract. With the increasingly serious global energy issues and environmental pollution, new energy vehicles, as a clean, efficient, and low-carbon mode of transportation, have become an important development direction for the global automotive industry. This paper explores the technological development, market status, and impact on sustainable transportation of new energy vehicles in China through comprehensive literature research and data analysis. The paper believes that the widespread promotion and application of new energy vehicles are of great significance for achieving environmental friendliness, energy efficiency, and sustainable economic development in urban transportation.

Keywords: new energy vehicles; Technological development; Market status; Sustainable transportation.

1. Introduction

New energy vehicles have gradually developed in the context of global energy and environmental issues. Over the past few decades, global greenhouse gas emissions have led to serious climate change issues, such as extreme weather events and sea level rise. Traditional fuel vehicles are one of the main sources of greenhouse gas emissions, making it urgent to find alternative modes of transportation to reduce adverse impacts on the climate. Traditional fuel powered vehicles mainly rely on petroleum as their energy source, and the reserves of petroleum resources are limited and unevenly distributed. In order to reduce their dependence on imported oil, many countries have begun to seek alternative energy sources, such as electricity, to promote the development of the automotive industry. However, the transition from electric vehicles to electric vehicles was not achieved overnight, with higher technical requirements. In recent years, the rapid development of battery technology, electric drive technology, and intelligent technology has provided a technological foundation for the implementation of new energy vehicles. The emergence of high-performance lithium-ion batteries has gradually increased the range of electric vehicles, accelerating the commercialization process of electric vehicles. With the increasing awareness of environmental protection and the promotion of renewable energy, consumers' demand for more environmentally friendly and energy-efficient transportation methods is gradually increasing. New energy vehicles have met the expectations of some consumers for clean and low-carbon modes of transportation, and have also accelerated the process of electric vehicles occupying a place in the consumer market.

2. Technological Development of New Energy Vehicles

2.1 Battery Technology Progress and Range Improvement

The continuous progress of battery technology is of great significance for the development of the electric vehicle industry, with one of the most significant impacts being the significant increase in range. With the improvement of battery energy density and the innovation of key components such as positive and negative electrode materials and electrolytes, the working efficiency of batteries has significantly improved. Currently, the range of pure electric vehicles is between 100-400 miles (160-640 kilometers), and some high-performance electric vehicles or specific models of electric vehicles may have a range of over 400 miles (640 kilometers).

2.2 Construction of charging infrastructure

The construction of charging infrastructure is a key link in promoting the development of the electric vehicle market. A comprehensive charging infrastructure network can reduce users' charging anxiety, improve the practicality and market acceptance of electric vehicles, and thus promote the development of sustainable transportation^[1]. The number of public charging stations in China increased from 57000 in 2015 to 516000 in 2019, with a compound annual growth rate of 72.89%; The number of private charging stations increased from 8000 in 2015 to 703000 in 2019, with a compound annual growth rate of 206.17%. In recent years, the construction speed of private charging piles has increased, with the proportion increasing from 12.16% in 2015 to 57.67% in 2019. From a regional perspective, the development of China's charging infrastructure has shown strong regionalism and significant agglomeration effects. Public charging stations are concentrated in the eastern region, especially in the Yangtze River Delta, Beijing Tianjin Hebei, and Pearl River Delta urban agglomerations, which have become the main gathering places for public charging stations. In contrast, the construction progress in Northeast, Northwest, Southwest and other regions is significantly behind that of the eastern urban agglomeration. As of June 2020, the proportion of charging infrastructure ownership in the top ten provinces and regions reached 73.2%. As of June 2023, the national ownership of public charging stations has reached 2.15 million, and the country is still increasing its efforts in charging infrastructure construction.

2.3 Application of Intelligent Driving Technology in New Energy Vehicles

The application of intelligent driving technology in new energy vehicles is gradually changing the landscape of the automotive industry. These technologies not only enhance the convenience and safety of driving, but also help optimize energy utilization, improve driving efficiency, and better promote the goal of sustainable development. Autonomous driving technology enables vehicles to complete driving tasks without human intervention. In scenarios such as urban congestion and highways, intelligent driving systems can optimize and coordinate traffic flow through communication and data sharing between vehicles, and intelligently plan paths based on road conditions and traffic flow, achieving smoother driving and reducing energy consumption. In terms of accident prevention, intelligent driving systems can predict potential dangerous situations through sensors and data analysis, take timely braking or avoidance measures, reduce the occurrence of traffic accidents, and improve driving safety.

2.4 Material Innovation and Lightweight Design

The introduction of new materials, such as carbon fiber composite materials, high-strength steel, aluminum alloys, etc., can reduce the weight of vehicles, improve their energy efficiency and range. These materials have excellent strength and lightweight performance, suitable for applications in different parts, such as car bodies, chassis, etc. In addition, utilizing the characteristics of different materials, such as the combination of lightweight metals and composite materials, can achieve more optimized structural design. This multi material structure can fully utilize the advantages of various materials in different parts, achieving the best lightweight effect. Through material innovation and lightweight design strategies, electric vehicles can achieve higher energy efficiency and longer range, making significant contributions to the development of sustainable transportation.

3. Current Situation and Prospects of the New Energy Vehicle Market

3.1 Overview of the Development of the New Energy Vehicle Market

According to statistics from the National Bureau of Statistics, the new energy vehicle manufacturing industry has made significant breakthroughs in the past nine years. In 2022, the production of new energy vehicles was 7.003 million units, about 100 times that of 2014, with a compound annual growth rate of 65%. The growth in 2021 was particularly prominent, reaching

143.48%, and the growth rate in 2022 was 97.55%^[2]. This trend shows that the new energy vehicle market has strong development momentum. Fuel powered vehicles have always accounted for a significant proportion in the overall production of automobiles. Since 2017, the production of fuel vehicles has shown a decreasing trend year by year, while the production of new energy vehicles has shown a rapid upward trend. New energy vehicles are gradually eroding the market share of fuel vehicles and have great potential for growth.

3.2 Consumer Acceptance and Purchase Intention

The intended purchase share of new energy vehicles in 2022 is as high as 27%, further compressing the market share of fuel vehicles. Among them, the increase in the share of intention to purchase new energy cars is more significant. In the segmented market of new energy vehicles, the intention to purchase rate of medium-sized pure electric vehicles has the largest increase, while the intention to purchase rate of small pure electric vehicles has the largest decrease. The consumption upgrading trend in the new energy vehicle market is obvious^[3]. The intention to purchase new energy SUVs has significantly increased, jumping from 11% last year to 16%, which is already on par with the intention to purchase new energy sedans. In the future, while the penetration rate of new energy vehicles increases, the trend of consumption upgrading is significant. Among the new energy vehicles that consumers are most considering to purchase, the intention to purchase luxury plug-in hybrid and medium/large SUVs have the highest growth rates, with increases of 6% and 5.5% respectively; The intention to purchase compact pure electric and medium-sized pure electric sedans has significantly decreased, with a decrease of 7.5% and 5.4%, respectively. In terms of customer base, potential customers with high education and high budget have a higher acceptance of the sales model of battery swapping and battery leasing. Among them, potential consumers who are willing to pay for the electricity exchange model have a more sufficient budget and a stronger willingness to purchase new energy vehicles.

3.3 Development Trends of the New Energy Vehicle Industry Chain

The upstream of the new energy vehicle industry chain is the metal industry, while the downstream is the metal industry. On the upstream side, the production of new energy vehicles poses a large demand for metal materials such as lithium, copper, magnetic materials, aluminum, nickel, sodium, etc., promoting commercial exchanges between China and exporting metal countries and the development of China's metal smelting industry. Downstream, according to data from the China Automobile Association, the wholesale sales of new energy passenger vehicles in China reached 6.536 million units in 2022, a year-on-year increase of 96.7%. In December, the monthly sales volume was 756600 units, a year-on-year increase of 51.92%. From a general perspective, the new energy vehicle industry covers multiple links, including battery manufacturing, component production, and vehicle manufacturing. Collaborative innovation between various links in the industrial chain will drive the improvement of the entire industry, accelerate technological maturity and market promotion. Among them, sustainability is an important consideration factor for the development of the future industrial chain. The focus on environmental protection and social responsibility will encourage enterprises to adopt more environmentally friendly measures in production and operation. Overall, the new energy vehicle industry chain will exhibit trends such as technological innovation, intelligence, diversification, sustainability, and international competition.

4. The impact of new energy vehicles on sustainable transportation

4.1 Environmental benefits: reducing exhaust emissions and air pollution

New energy vehicles have played an important role in reducing exhaust emissions and improving air quality^[4]. The exhaust emissions generated by traditional fuel vehicles are one of the important sources of air pollution and environmental problems, and the electrification and zero emission characteristics of new energy vehicles help to improve this situation: pure electric vehicles and fuel

cell vehicles do not produce emissions during driving because they do not rely on burning fossil fuels to generate power. This means that these vehicles will not release harmful substances in the exhaust gas, such as nitrogen oxides (NO_x), volatile organic compounds (VOCs), and particulate matter, making a significant contribution to reducing air pollution.

According to statistics, the average annual PM_{2.5} concentration of the sixth ring road in Beijing can decrease by 0.5, 1.3, and 2.3, respectively $\mu\text{G}/\text{m}^3$, the concentration reduction within the three rings is more significant, and the PM_{2.5} reduction can reach 3.0-3.3 under extreme electrification in the region $\mu\text{G}/\text{m}^3$. Policy scenarios can help 67% of areas exceeding standards achieve compliance; Implementing a comprehensive regional electrification strategy can reduce PM_{2.5} concentration in high concentration areas by 3.5 to 4.0 $\mu\text{G}/\text{m}^3$, helping all areas exceeding the standard meet the standard. The reduction of annual NO₂ concentration in densely populated areas of Shenzhen under three scenarios reached 4.1, 11.3, and 12.5, respectively $\mu\text{G}/\text{m}^3$. For nearly 176km² of NO₂ concentration exceeding the standard, policy scenarios can help 55% of the exceeding areas meet the standard; The extreme electrification strategy can help all areas that exceed standards meet standards. During the peak period of O₃ concentration in summer, the policy scenario resulted in a decrease of 4.3 to 7.0 and 0.5 to 2.3 in the monthly average daily maximum 8-hour O₃ concentration in the high O₃ concentration areas of Beijing and Shenzhen, respectively μ . Under the scenario of extreme electrification in a region of g/m³, the reduction amounts reach 21-31 and 17-24 respectively $\mu\text{G}/\text{m}^3$. For urban and port areas with denser road networks and higher levels of transportation activity, electrification has more significant air quality improvement benefits.

4.2 Resource efficiency: reducing dependence on oil

The popularization and promotion of new energy vehicles can help reduce dependence on oil, thereby achieving diversification and sustainable development of the energy structure. Pure electric vehicles and plug-in hybrid vehicles do not require the use of traditional fuel, but rely on batteries to store energy. Fuel cell vehicles use hydrogen as fuel, and the only emission generated during the combustion process is water vapor. This technology reduces dependence on petroleum fuels, and hydrogen can be prepared through various renewable energy sources, further reducing environmental impact. Some hybrid vehicles can use alternative fuels such as natural gas and biofuels. These fuels can partially or completely replace traditional petroleum fuels, reducing the demand for oil. New energy vehicles can gradually reduce their dependence on oil, promote changes in energy structure, and achieve a more sustainable transportation and energy future^[5].

4.3 Economic benefits: promoting industrial upgrading and innovative development

The popularization and promotion of new energy vehicles not only have a positive impact on transportation modes and the environment, but also can promote the upgrading and innovative development of the entire industry. Firstly, the field of new energy vehicles needs to cover innovation in multiple fields such as battery technology, electric drive technology, and intelligent driving technology. These technological innovations will drive the development of the entire industry, driving technological breakthroughs for research institutions, manufacturers, and supply chain enterprises. Secondly, the emergence and popularization of new energy vehicles will bring a series of new industrial chains, covering multiple fields such as battery manufacturing, charging equipment, electric drive systems, and intelligent transportation systems. These new industrial chains will promote the rise and development of related industries. Furthermore, new energy vehicles are not only a transformation of the vehicle itself, but also involve the application of intelligence and interconnection technology. The development of technologies such as intelligent driving, vehicle networking, and autonomous driving will give birth to new business models and market opportunities. Finally, the new energy vehicle market is international, and companies worldwide are vying for market share. This encourages enterprises to strengthen cooperation and competition in technology, brand, and market, promoting global upgrading of the industry.

4.4 Social benefits: improving urban traffic congestion and quality

New energy vehicles are usually equipped with intelligent driving and navigation technologies, which can obtain real-time traffic information and plan routes based on traffic conditions. Intelligent navigation systems can help drivers avoid congested road sections, optimize driving paths, and reduce traffic congestion.

5. Challenges and Solutions

5.1 Insufficient construction of charging infrastructure

In section 2.2, we mentioned an increase in the number of charging stations, but under today's significantly increasing market demand, the supply of charging stations still exceeds demand. The ratio of domestic new energy vehicles to new energy vehicle charging stations is only 3.4:1, with a ratio of only 7.3:1 compared to public charging stations. The vehicle to station ratio clearly fails to support the development of China's new energy vehicles, and infrastructure remains a weakness that restricts the development of China's new energy vehicle industry. Moreover, problems such as difficulty in entering residential areas, long charging time, unreasonable installation locations, and imbalanced regional development seriously affect the high-quality and green development of China's new energy vehicle industry^[6].

5.2 Balance between cost and performance of new energy vehicles

The balance between cost and performance of new energy vehicles is a key challenge in driving the development of the electric vehicle industry. While pursuing higher performance and longer range, it is necessary to control manufacturing costs to maintain competitiveness and meet the needs of consumers. We focus on the following three points: (1) Battery cost. Batteries are one of the most expensive components in new energy vehicles. Although battery technology continues to improve, batteries still account for a significant portion of car manufacturing costs. Balancing cost and performance requires exploring cheaper battery materials, manufacturing processes, and design methods without sacrificing the energy density and lifespan of the battery. (2) Lightweight materials. The use of lightweight materials such as carbon fiber and aluminum alloy can reduce vehicle weight, improve operational efficiency and range. However, these materials are usually more expensive, which increases manufacturing costs. Finding body materials with higher cost-effectiveness can help reduce manufacturing costs while ensuring car performance. (3) Component costs. The quality of automotive components directly determines the basic quality of the entire vehicle. The current automotive parts industry is highly developed, and the prices in the industry are basically transparent. Smaller scale production often leads to cost increases due to the difficulty in achieving economies of scale. Mass production can reduce component procurement costs and manufacturing efficiency.

5.3 Reconstruction of the automotive industry ecological chain

The development of new energy vehicles has driven the reconstruction of the automotive industry ecosystem to adapt to the trend of electrification and intelligence in future transportation. The reconstruction of the automotive industry ecosystem involves multiple aspects, including the supply chain of key automotive components, the production and recycling of lightweight materials, batteries, and the innovation and maintenance of intelligent technologies.

5.4 Security Risks and Privacy Issues of Intelligent Technology

New energy vehicles are increasingly relying on intelligent technology, but this also brings security risks and privacy issues. Firstly, new energy vehicles typically have functions such as remote control and internet connectivity, making them vulnerable to network attacks. Hackers may attempt to invade the electronic systems of vehicles, control vehicles, or steal sensitive information. Secondly, smart cars can be connected to personal smart devices, such as smartphones, to provide more

functions. However, this may lead to the risk of personal information leakage, as data generated by vehicles may be shared with third parties such as advertisers, application developers, etc. If data sharing is not controlled, users' privacy may be violated. The solution includes establishing strict security standards, using encryption technology to protect user privacy, and increasing user education awareness.

6. Conclusion and Prospects

The development of new energy vehicles in China has made significant progress, but still faces a series of challenges. In terms of technology, the continuous progress of battery technology and the improvement of range, the construction of charging infrastructure, the application of intelligent driving technology, and the development of material innovation and lightweight design have provided a solid foundation for the sustainable development of new energy vehicles. In terms of the market, the new energy vehicle market is developing rapidly, with increasing consumer acceptance and gradually improving the industrial chain. In terms of sustainable transportation, new energy vehicles have brought multiple benefits to the environment, resources, economy, and society, and are expected to become the main mode of urban transportation in the future. However, we must also face the challenges in the development of new energy vehicles. The insufficient construction of charging infrastructure, the balance between cost and performance, the reconstruction of the automotive industry ecosystem, and the security and privacy issues of intelligent technology all need to be seriously addressed.

In summary, the future position of new energy vehicles in sustainable transportation will be indispensable. With the increasing awareness of environmental protection, the issues of exhaust emissions and air pollution are becoming increasingly prominent. As a zero emission transportation tool, new energy vehicles will play a crucial role in improving urban air quality and reducing carbon emissions. By overcoming challenges and constantly innovating, China is expected to play a leading role in the global field of new energy vehicles, promote sustainable transportation, and bring more benefits to the environment, economy, and society. The government, industry, and academia need to work together to formulate appropriate policies and strategies to promote the sustainable development of the new energy vehicle industry.

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