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Research on the Impact of New Energy Vehicles on Environmental Changes

Yupu Yang

Faculty of Arts, University of British Columbia, Vancouver, Canada
victoryang2018@gmail.com

Abstract. With the significant impact of human industry on the Earth's ecology since the late 20th century, important environmental issues such as global warming have become increasingly significant international topics. The new energy vehicle industry has become one of the most notable industries contributing to environmental sustainability. The research topic of this paper is how the new energy vehicle industry affects climate and environmental outcomes. The research method is to analyze the impact of the production, use, and other lifecycle stages of new energy vehicles on global warming. The research questions of this paper will focus on the extent to which new energy vehicles reduce tailpipe emissions. After providing evidence and analysis, it is concluded that new energy vehicles effectively mitigate environmental changes in various aspects, thereby strongly supporting the cause of global environmental protection. With the vigorous development and rapid promotion of new energy electric vehicles in China, their concrete contributions to climate and environmental outcomes are examined in detail, such as the impacts across the production, use, and recycling stages. The use of batteries as the power system in new energy vehicles, which is different from traditional fuel vehicles, focuses on the environmental protection implications of battery production and disposal. Based on this, how to effectively manage and subsequently utilize batteries becomes the key to the extent to which new energy vehicles can improve environmental issues, such as climate change.

Keywords: New energy vehicles (NEVs), Global warming, Vehicle electrification and intelligence, NEV Battery technology, Environmentally sustainable industries

1. Introduction

The development of modern human civilization has consistently been accompanied by significant alterations to the world's natural environment and unprecedented environmental degradation. As the impact of human production activities on the Earth's ecosystems reached a critical stage, various measures to mitigate environmental crises began to emerge. New energy vehicles (NEVs), as an innovative technology designed to replace conventional fuel sources, have emerged as a key sector in the context of global environmental protection. NEVs can be divided into several different modes: pure electric vehicles, extended-range electric vehicles, hybrid vehicles, fuel cell electric vehicles, and hydrogen-powered vehicles. The common goal of all these different modes of electric vehicles is to reduce the atmospheric pollution emissions of traditional vehicles and the extraction of

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traditional fuels. These efforts are an indispensable part of China's "dual carbon" strategic goal of addressing climate change challenges—peak carbon dioxide emissions and carbon neutrality. The reduction of air pollution by NEVs helps them contribute to the scientific solution of the international problem of global warming as a green and environmentally friendly society.

NEVs, as the name suggests, are cars that use a battery as the main power fuel instead of traditional fuels, thus no longer using petroleum combustion for driving as has been the case for many years in the automotive sector. The production and recycling of batteries immediately become an important area of research for whether new energy electric vehicles can achieve environmental improvement. Recent studies on battery technologies, powertrain systems, and recycling policies have received significant attention, providing insights into how the development of NEVs can influence environmental outcomes. The findings from these studies will largely determine the research route and conclusion of this thesis.

2. China's policies and environmental goals for NEVs

In response to the growing conflict between climate change and ecological crises, China has made firm commitments to environmental governance. Future pathways for energy conservation and environmental protection are framed within the "dual carbon" strategy (carbon neutrality and carbon peaking). Although closely related, the two concepts differ in target orientation: carbon peaking refers to the point in a specific year when carbon dioxide emissions reach their peak and then gradually decline, while carbon neutrality emphasizes achieving net zero emissions of greenhouse gases through energy conservation and emission reduction, carbon capture and negative emission technologies, and achieving a dynamic balance between the carbon cycle in the atmosphere.

2.1. Government policy framework and strategic positioning

Under the "carbon neutrality" strategy framework, the Chinese government positions the NEV industry as a crucial driver for reducing carbon emissions in the transportation sector. To promote the industry development, the government has carried out long-term strategic planning and layout through the promulgation of a series of central policies. For instance, "in June 2023, the Ministry of Finance, the State Taxation Administration, and the Ministry of Industry and Information Technology issued the Announcement on Continuing and Optimizing the Vehicle Purchase Tax Exemption Policy for NEVs, supporting the development of the new energy vehicle industry. Subsequently, the General Office of the State Council issued the Guiding Opinions on Further Building a High-Quality Charging Facility Infrastructure System, providing strong support for the development of the new energy vehicle industry" [1]. Through the policy combination of "vehicle purchase tax exemption + infrastructure construction," the Chinese government hopes to lower the applicable threshold for NEVs, expand the industry scale, and achieve multiple policy goals such as "reducing reliance on traditional energy, reducing environmental pollution, and promoting the optimization and upgrading of the economic structure" [1].

2.2. Market performance of NEVs: manifestation of policy effects

Policy support provided continuous impetus for the development of China’s NEV industry. Under the joint effect of policy promotion and consumption upgrading, the scale of China’s NEV market has significantly increased. With the deepening of the "carbon neutrality" policy, China’s NEV

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industry grew rapidly in 2021. According to the statistics of the China Automobile Association, currently, the number of NEVs in China has exceeded 6.5 million, ranking first in the world [2].

In 2022, the global number of pure electric vehicles reached 7.8 million, with a year-on-year growth of 28%; China's sales of pure electric vehicles were 5.365 million, with a year-on-year growth of 81.6%, and the market share of electric vehicles continued to increase [3]. In 2023, the new energy vehicle market in China continued the high growth trend of 2022, with total production and sales reaching 9.587 million and 9.495 million, respectively, a year-on-year growth of 35.8% and 37.9%, with a market share of 31.6%, ranking first globally for 9 consecutive years [4].

3. Battery technology and environmental benefits of new energy electric vehicles

3.1. Battery-driven system and emission reduction mechanism

NEVs choose battery power as the core driving method, which perfectly aligns with the current global concepts of energy conservation and sustainable development in multiple aspects. Unlike traditional fuel vehicles, battery energy can effectively eliminate the environmental damage caused by many traditional energy applications. Traditional fuel vehicles emit a large amount of harmful gases during combustion, such as "carbon dioxide, carbon monoxide, nitrogen oxides, particulate matter, etc., which pose a significant threat to the environment and human health" [1]. In contrast, the power source of NEVs comes from electricity; "its energy belongs to renewable resources (such as wind energy and solar energy) or low-carbon energy (such as nuclear energy and water energy), effectively reducing the emission of greenhouse gases and harmful substances" [1].

In addition, new energy electric vehicles use electric motors for driving, which have significantly less noise compared to traditional fuel engines, reducing urban noise pollution and thus enabling ordinary people to avoid the ubiquitous car noise in cities. The reduction of noise can not only improve the living environment of residents but also greatly benefit their health.

NEVs are primarily divided into pure electric vehicles, hybrid vehicles, and fuel cell electric vehicles. Among them, pure electric vehicles reduce greenhouse gas emissions due to the change in their braking system and significantly reduce the noise of the fuel engine operation. The important factors for these advancements come from the battery management system (BMS), which provides high-level guarantees for battery efficiency, safety, and stability. Its "main responsibility is to monitor key indicators such as battery voltage, temperature, and health status and perform corresponding management operations to ensure the battery operates within a safe range, avoiding overcharging, over discharging, or overheating, thereby extending the battery's service life and enhancing the overall safety performance of the vehicle" [1]. The electric motor, controller, and transmission device form the power drive system of pure electric vehicles, and their existence enables the actual operation of pure electric vehicles. Through their close cooperation, the battery energy is successfully converted into mechanical energy to drive the vehicle forward. At the same time, the used mechanical energy is not wasted but is later recycled by the motor and converted back into electricity to be stored in the battery. This repeatable cycle energy technology amplifies the advantages of battery power from multiple perspectives, such as smoothly utilizing repeated electricity to extend the lifespan of the braking system and providing excellent improvements in aspects that affect the driving quality of the vehicle, such as chassis control, driving stability, and driving assistance quality.

The power mode of hybrid vehicles is to retain both the internal combustion engine and the electric motor and to complement each other by leveraging the working characteristics and advantages of both. In the series combined power mode, "the engine and the electric motor are

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connected in series, with the engine mainly used for generating electricity and the electric motor responsible for driving the wheels" [1]. In the parallel combined power mode, "the engine and the electric motor are connected in parallel, and both can directly drive the wheels" [1]. In the hybrid combined power mode, "the engine and the electric motor can jointly drive the wheels or separately drive different wheels" [1]. When the traditional internal combustion engine and the electric motor are combined organically, the integration and energy distribution capabilities of the battery power management system can control the internal combustion engine together, achieving dual-range management and creating a new technological form of electric fuel dual power.

The operation principle of fuel cell electric vehicles is significantly different from that of pure electric vehicles and hybrid vehicles. Fuel cells use hydrogen as the main fuel for combustion, "reacting hydrogen or other fuels with oxygen to generate thermal energy and electrical energy, while only producing water as the emission, and no harmful gases or particles are produced" [1]. During the conversion of chemical energy to mechanical energy, the necessary heat energy loss generated by the traditional internal combustion engine is eliminated. The nature of electrical energy means that it does not need to undergo energy conversion through the combustion process, which ensures the clean and efficient release of energy to the external environment.

3.2. Carbon emission reduction effect from the perspective of life cycle

As NEVs are expected to reduce fossil fuel consumption and curb carbon emissions, it becomes inevitable to conduct a more systematic assessment of their actual environmental benefits. In this context, adopting the life cycle approach for conducting carbon footprint analysis is of great significance. "Currently, the calculation of carbon footprint mostly employs the Life Cycle Assessment (LCA) method. This method is a standardized and scientific approach for assessing the environmental impact of products or services, considering the inputs and outputs of the product system throughout its entire life cycle" [5].

The definition and implementation steps of the LCA method are the next step in the research. "To have a clear understanding of the environmental impact of NEVs, it is necessary to analyze their entire life cycle, from raw material extraction and processing to product production, transportation, distribution, use, maintenance, and recycling to final storage or reintegration into the environment." When the LCA is defined as a multi-criteria method, "as a multi-criteria method, the LCA method has an iterative process of four steps, including target and scope definition, inventory analysis, impact assessment, and result interpretation." The first stage of target and scope definition is the first step of the LCA method, "describing the goals and scope of the life cycle assessment, involving system boundaries, level of detail, and potential indirect impacts." The second stage of inventory analysis "is to inventory all input data such as raw materials, energy, equipment, and output data such as main products, by-products, pollutants, and wastes, as well as indirect impact data such as ecological, and social impacts and land use, within the defined system scope." After collecting all input and output data, the possible environmental impact possibilities in different stages can be classified into three categories: human health, natural environment, and resource depletion. The third stage involves selecting appropriate evaluation models and methods to classify and quantify the environmental impacts. The fourth stage involves, based on the target and scope definition, summarizing and refining the evaluation conclusions and recommendations to evaluate all environmental performance results of the entire project" [5].

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3.3. Practical application of the LCA method

"Existing research has used the LCA method to compare the environmental ecological characteristics of different automotive drive technologies such as internal combustion engines, pure electric, hybrid power, and plug-in hybrid power" [5]. The comprehensive research results show, "studies comparing the life cycle of NEVs represented by electric systems and traditional vehicles represented by fuel-powered systems have found that compared with internal combustion engine vehicles, NEVs undoubtedly can reduce exhaust emissions and help lower air pollution levels, especially in urban areas. However, the use stage of NEVs is not zero impact" [5].

Among these various types of NEVs, in addition to their all-advanced battery and motor drive technologies, the carbon reduction performance among different types of NEVs also varies.

Detailed research "found that the greenhouse gas emission intensity of battery electric vehicles (BEV) is on average about 30% lower than that of fuel-powered vehicles (ICEV). The research by Zhai et al. further quantified the carbon reduction effect of NEVs, obtained the average CO2 emissions of hybrid power vehicles (HEV), and compared it with other traditional vehicles. The results showed that the CO2 emissions generated during the operation of hybrid power vehicles were significantly lower than those of traditional vehicles. This proves the advantages of NEVs in terms of carbon reduction. Ke et al. adopted the method of LCA to comprehensively compare the environmental impacts of NEVs and fuel vehicles. The results showed that the greenhouse gas emissions of BEV might be 54% lower to 20% higher than those of ICEV, and this difference mainly depended on the efficiency of power generation and the combination of technologies used" [6]. Thus, the conclusion can be drawn: "The carbon reduction effect of NEVs is largely related to their own performance and the structure of power generation. The more detailed the classification of NEVs and fuel vehicles, the higher the accuracy and persuasiveness of counterfactual analysis" [6].

As a country where the sales volume of NEVs has reached the world's first place, China's vast and still-growing new energy market makes it the best applicable field for the life cycle evaluation method. "The sales volume of NEVs has increased from less than 500 units in 2009 to 1.35 million units in 2020 and has shown continuous explosive growth for five consecutive years. In 2024, the annual production and sales of NEVs in China reached 12.888 million and 12.866 million, respectively. The new energy vehicle sales accounted for 40.9% of the total new vehicle sales in the automotive market, ranking first globally for 10 consecutive years, and the global sales share exceeded 70.7%" [7]. "Even with such a large new energy market, based on data predictions, due to the widespread application of new energy technologies, the emission reduction effect has already been manifested. The total sum from 2023 to 2028 is 961,807.14 thousand tons of carbon dioxide. The carbon reduction effect of NEVs in the future shows a trend of rising first and then falling, reaching a peak of 197,109.78 thousand tons in 2026 and then decreasing. The carbon reduction effect in the next six years is 6.46 times that of the past nine years, significantly reducing China's carbon emissions in the transportation industry. Therefore, promoting NEVs to replace traditional fuel vehicles will effectively contribute to the realization of the 'dual carbon' goals in the transportation industry" [7].

4. Lifecycle management of battery technology and sustainability challenges

4.1. Battery management technology (BMS) and energy efficiency enhancement mechanism

Since new energy electric vehicles are powered by battery electrical energy to drive mechanical energy, the maintenance of battery equipment requires relevant expertise and skills. "The BMS plays

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a crucial role in ensuring the safe operation of batteries" [1]. Its main responsibility is to monitor the battery's charge, temperature, and health status and to perform real-time regulation and protection of the battery pack. By preventing risks such as overcharging, over-discharging, and overheating, BMS effectively extends battery life and improves overall energy efficiency and vehicle safety.

In addition, BMS also plays an important role in the energy recovery process. During braking or deceleration in electric vehicles, BMS collaborates to control the motor to work in reverse, converting kinetic energy into electrical energy and storing it in the battery, thus achieving an efficient energy cycle. This process significantly improves energy utilization efficiency, reduces energy loss during driving, and reduces carbon emissions at the power generation end. Battery energy efficiency improvement is not only reflected in range capabilities but also in the comprehensive contribution to "carbon emission reduction throughout the lifecycle." Studies have shown that with the advancement of BMS technology and optimization of battery materials, the carbon emissions of NEVs throughout their lifecycle can be reduced by approximately 30% to 50% compared to fuel vehicles [8].

4.2. Environmental transformation of the maintenance system for NEVs

As the number of NEVs continues to grow, their maintenance system faces the urgent need for environmental transformation. In addition to the environmental improvement of the battery system, other important component systems of the vehicle, especially the thermal management and cooling systems, must also undergo technical optimization to reduce the impact on the climate environment. For example, the air conditioning, refrigeration, and heat pump systems in NEVs often use hydrofluorocarbons (HFCs) as refrigerants. Although these substances do not damage the ozone layer, they have a high global warming potential (GWP) and belong to potent greenhouse gases. There are more and more examples of new automotive technologies addressing real environmental issues.

At the policy level, in 2025, with the approval of the State Council of China, "The Ministry of Ecology and Environment, the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Commerce, and the General Administration of Customs recently jointly issued the 'China National Plan for Implementing the Montreal Protocol on Substances that Deplete the Ozone Layer (2025-2030),' providing a direction for environmental management of HFCs in the new era of our country" [9]. This plan implements the framework of the Kigali Amendment and includes HFCs in the control scope and provides clear emission control and alternative material guidance for the new energy vehicle industry. At the technical level, the maintenance system for NEVs is gradually adopting environmentally friendly refrigerant replacement solutions while strengthening the recycling and reuse management of retired batteries and thermal management systems. Through the combination of policy guidance and technological innovation, the maintenance system can ensure vehicle performance while significantly reducing greenhouse gas emissions, achieving a dual improvement in economic and environmental benefits.

4.3. Research and analysis on battery recycling and reuse

The recycling and reuse of new energy battery power sources have significant environmental and economic implications. Firstly, for instance, this initiative is beneficial to environmental protection. "Reasonable recycling and processing can reduce the leakage of heavy metals and electrolytes in used batteries, minimize pollution to soil and water bodies, thereby reducing the environmental burden and avoiding resource waste" [10]. Secondly, batteries contain a large amount of scarce metals such as lithium, nickel, and cobalt. Through recycling, the intensity of resource extraction and costs can be effectively reduced, "providing raw materials for the production of new batteries and achieving resource recycling" [10]. Finally, the advancement of the battery recycling process also promotes the "research and development of key technologies such as automated disassembly, metal extraction, and purification, thereby driving technological innovation in related industries" [10].

In terms of technical approaches, the recycling of battery power sources mainly includes "two methods: secondary utilization and dismantling and recycling" [11]. The same approach is also applicable to retired lithium-ion batteries. Secondary utilization: "Currently, only lithium iron phosphate batteries can be utilized through secondary utilization" [11]. "The main reason is that lithium iron phosphate batteries have lower energy density and cycle life and are not suitable for NEVs but are suitable for use in other fields such as energy storage" [11]. Dismantling and recycling: "Improving recycling efficiency and ensuring the purity of resource recovery are the key issues at present" [11]. Rigorous technology and equipment support are necessary to ensure the safety and rate of extracting renewable resources after dismantling. Another corresponding method for extracting high-value materials from recycled batteries is mechanical physical separation. For this method, "we should accelerate the transformation of mechanical physical separation technology, develop modular and flexible automatic sorting equipment, tailor decomposition process parameters for different types and structures of battery modules, and improve material sorting efficiency and metal recovery grade" [12].

5. Conclusion

Driven by the international trend of energy transition and policy promotion, China has become the leading country in the global field of new energy electric vehicles. The large number of new energy electric vehicles in use has not only promoted the rapid progress of battery technology but also enabled China to carry out environmental benefit assessments of battery life cycles earlier. Studies generally believe that the substitution of fossil fuels with battery electrical energy significantly reduces exhaust emissions. The application of BMS, LCA methods, and efficient thermal management and refrigeration systems further improves its environmental performance. However, the existing literature is still insufficient to cover all dimensions of the environmental benefits of NEVs, and their environmental value cannot be summarized solely by a few technological breakthroughs. In the future, the battery power technology field still needs to continue to advance in aspects such as technological path innovation, improvement of the recycling system, and policy regulation coordination to ensure that the new energy vehicle industry can make long-term contributions to global environmental protection.

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