

# Research on Safety and Life Management of New Energy Vehicle Batteries

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**Abstract:** This paper delves into the issues of safety and life management of batteries in new energy vehicles. Firstly, it provides an overview of the main types of batteries used in new energy vehicles and their characteristics, including lithium-ion batteries, lead-acid batteries, nickel-metal hydride batteries, and fuel cells. Subsequently, it analyzes in detail the safety issues associated with new energy vehicle batteries during production and usage, and proposes corresponding solutions. Additionally, it explores the key factors influencing battery life and presents strategies to extend battery usage. These strategies include enhancing battery research and design, improving battery manufacturing processes, implementing proper usage and maintenance practices, and considering battery usage environments. Through this research, the aim is to provide technical support for the healthy development of the new energy vehicle industry and promote the advancement of green transportation.

**Keywords:** New Energy Vehicles; Battery Safety; Battery Life; Lithium-Ion Batteries; Lead-Acid Batteries; Nickel-Metal Hydride Batteries.

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## 1. Introduction

With the increasing global energy crisis and environmental pollution, new energy vehicles have gradually become the new favorite in the automotive market due to their unique environmental advantages and energy-saving characteristics. However, the widespread promotion and application of new energy vehicles heavily rely on the performance improvement and safety assurance of their core component - the battery. This paper conducts an in-depth study on the safety and life management of batteries in new energy vehicles, discussing the main types of battery technologies, safety issues, solutions, as well as the key factors influencing battery life and strategies to extend it. By comprehensively understanding the performance characteristics and management methods of batteries in new energy vehicles, our aim is to promote the healthy development of the new energy vehicle industry and provide more reliable technical support for green transportation.

## 2. Overview of New Energy Vehicle Battery Technologies

The main types of batteries used in new energy vehicles include lithium-ion batteries, lead-acid batteries, nickel-metal hydride batteries, and fuel cells. Lithium-ion batteries are widely used in new energy vehicles and are characterized by high voltage and high energy density. They are primarily composed of positive and negative electrodes, electrolytes, separators, and casings. Lithium-ion batteries have advantages such as long service life, no environmental pollution, fast charging capability, no memory effect, and high-performance potential. They can operate stably over a wide range of temperatures and are considered a green and clean energy source. However, lithium-ion batteries also have some drawbacks. Research by Zhang Wei [1] found that the capacity degradation of lithium-ion batteries is more severe compared to other energy devices due to the insertion of lithium near the positive or negative electrode plates,

resulting in the release of a significant amount of heat during charging and discharging. The high operating voltage of lithium-ion batteries makes voltage measurement challenging, and their low discharge rate leads to a shorter cycle life. Additionally, the characteristics of lithium ions make them possess metallic properties and solubility in alkaline solutions, posing certain environmental hazards.

Lead-acid batteries were the earliest type of batteries used in new energy vehicles. They have advantages such as low cost and good stability but suffer from low energy density and limited charging cycles. Lead-acid batteries primarily consist of positive and negative electrodes and an electrolyte, along with connecting wires, casings, terminals, battery covers, and battery slots. Xue Yuanyuan et al. [2] pointed out that although lead-acid batteries are mature and can be produced on a large scale due to their low cost and high-power discharge capability, they have low energy, power density, and limited speed and range for electric vehicles.

Nickel-metal hydride batteries have reached a mature stage and represent the commercially viable hybrid battery systems, accounting for 99% of the market share, with Toyota's Prius being a notable example. Zhang Zhenli [3] states that nickel-metal hydride batteries have higher energy density, enabling them to store more electrical energy and provide longer driving ranges for vehicles. They also have a longer cycle life, allowing multiple charge and discharge cycles without significant performance degradation. Nickel-metal hydride batteries can operate within a relatively wide temperature range and exhibit strong tolerance to overcharging and overdischarging. Moreover, they have a relatively smaller environmental impact as they use recyclable materials. Despite these advantages, nickel-metal hydride batteries have some drawbacks. For example, they have a slower charging rate and require special charging equipment. The higher price of nickel-metal hydride batteries limits their usage in certain fields.

Fuel cells are a type of battery that generates electrical energy through the reaction between hydrogen and oxygen. They have advantages such as high energy density,

environmental friendliness, and short refueling time. However, their technological maturity is insufficient, and they are relatively expensive. Compared to other batteries, fuel cell vehicles are characterized by high efficiency, low emissions, and short refueling times, making them have significant market potential in the field of new energy vehicles. Significant progress has been made in the application of fuel cell vehicles in the new energy vehicle sector. Research by Li Shaoyuan [4] indicates that major global automakers are actively developing fuel cell vehicles and establishing supporting infrastructure such as hydrogen refueling stations. China, Japan, and South Korea are the main drivers of the global fuel cell vehicle market. Japan is one of the earliest countries to develop fuel cell vehicles, and China and South Korea have also accelerated the research, development, and promotion of fuel cell vehicles in recent years.

### **3. Research on Safety Issues and Solutions for New Energy Vehicle Batteries**

#### **3.1. Analysis of Safety Issues**

##### **3.1.1. Safety Issues in the Production Process**

The safety management during the production of batteries for new energy vehicles has a decisive impact on their safety. If this process lacks strict monitoring and sufficient testing and verification, it can lead to safety hazards and potentially result in severe accidents. Taking China's new energy vehicle subsidy policy as an example, the subsidy period is one year, which does not align with the product development cycle of automobile manufacturers. Particularly in the application of chemical materials, system improvements and optimizations often require more than a year. However, in order to seize the opportunity of subsidies, companies may rush into production and shorten the necessary testing and verification processes, which undoubtedly compromises the safety of the batteries. Research by Wu Jingbin et al. [5] found that some companies, in order to expedite product development, may make physical adjustments, such as reducing the thickness of battery separators or increasing the thickness of active materials. While these measures can increase the energy density of batteries to some extent, they also sacrifice safety, posing risks for their subsequent safe usage.

##### **3.1.2. Safety Issues in the Usage Process**

Thermal runaway of batteries is a significant safety issue during usage. In recent years, China's new energy vehicle industry has developed rapidly, with the "2020 State Council Government Work Report" emphasizing the strengthening of new infrastructure and new information networks, promoting the diversified application of 5G technology, and planning the construction of data center systems. The report also proposes increasing the number of charging stations and battery swap stations to further promote new energy vehicles. During the popularization of new energy vehicles, lithium-ion batteries, as the primary energy storage components, face significant safety challenges despite their advantages of high energy density and long lifespan. According to investigations by Chen Zeyu et al. [6], from 2016 to 2020, incidents of spontaneous combustion caused by thermal runaway of batteries have been frequent, posing serious threats to road and personal safety. This is primarily due to the gradual aging and performance degradation of the internal components of

power batteries after long-term use. In such a state, overcharging or overdischarging can easily trigger thermal runaway. From a theoretical perspective, prolonged battery usage leads to an increase in internal resistance, resulting in more heat generation. When the temperature reaches 90-120°C, the solid electrolyte interface (SEI) film begins to decompose and release heat. As the temperature further rises, the separator may melt and close. When the temperature exceeds 150°C, the internal electrolyte decomposes, releasing more heat. When the temperature surpasses 200°C, the positive electrode material decomposes, releasing heat and gas, leading to a continuous temperature rise. When the temperature exceeds 300°C, the reaction between the lithiated negative electrode and the electrolyte becomes intense, especially with oxygen, making thermal runaway more likely to occur.

The improper design of charging equipment is also a significant concern. Some suppliers, in pursuit of cost savings, do not sufficiently prioritize the charging safety of batteries for new energy vehicles. They fail to strictly comply with relevant national regulations and establish standardized construction of charging facilities for new energy vehicles, making it difficult to ensure the stability and safety of batteries during the charging process. Additionally, some manufacturers have shortcomings in the design and implementation of the safety management system for power batteries, such as the lack of automatic power cutoff function in charging equipment for power batteries. More concerning is that the majority of new energy vehicle companies have not rigorously implemented testing and verification work regarding insulation voltage of power battery charging circuits, insulation function of charging station facilities, and battery temperature rise function. This further exacerbates safety hazards during the usage of power batteries.

#### **3.2. Solutions to Safety Issues of New Energy Vehicle Batteries**

Firstly, automotive companies should conduct diverse promotional activities to educate consumers about the functionalities of the batteries. Detailed information materials should be provided, including in-depth analysis of the performance of new energy vehicle batteries. Additionally, companies should organize specialized promotional events to visually demonstrate the performance and advantages of new energy vehicle batteries to consumers. In terms of utilizing information technology, companies can present various battery data to consumers in the form of charts or other visual formats, enabling them to have a more intuitive understanding of the products. Through these efforts, consumers' knowledge and understanding of new energy vehicle batteries will be enhanced. Wang Zhenpo et al. [7] suggest that companies should also engage in knowledge dissemination and advocacy to emphasize the importance of vehicle maintenance and encourage regular troubleshooting. This approach aims to cultivate good habits among consumers regarding vehicle maintenance and timely identification of potential issues, ensuring the safe usage of new energy vehicles.

Secondly, in the context of the continuous development of the new energy vehicle industry, government authorities must actively intervene and strengthen the regulation of new energy vehicle products. This includes adjusting the accountability mechanism to ensure the improvement and completeness of policy and regulatory systems, as well as enhancing supervision and management of relevant personnel.

Through these measures, the government aims to rectify the neglect of automotive companies towards safety performance and guide them to prioritize enhancing vehicle safety performance. For companies producing new energy vehicle products that fail to meet safety performance standards, the government will hold them accountable and impose appropriate economic penalties for non-compliance with production regulations, ensuring the healthy development of the industry [8].

## **4. Battery Life Management for New Energy Vehicles**

### **4.1. Key Factors Affecting Battery Life**

Although China's new energy vehicle industry started relatively late, it has developed rapidly. However, the technological level of new energy vehicle batteries still needs improvement. While significant progress has been made in the design of batteries for new energy vehicles, there are still issues regarding battery range, and the battery technology itself remains a major factor limiting the development of new energy vehicles. Battery usage methods and environmental factors also play a significant role in battery life.

Battery usage methods and the environment in which they are used are important external factors that determine battery lifespan. The maintenance practices of users directly determine the length of battery service life, while the environment in which the battery operates directly affects its cycle life. Research by Wayne [9] found that the main cause of failures in China's new energy vehicles is battery-related issues, with improper operation and a lack of maintenance and care being the main contributing factors to battery failures. Additionally, new energy vehicle batteries have specified requirements for the current during charging and discharging. If the current does not match the battery's specifications during charging, the battery can be affected. User maintenance and care practices also impact battery lifespan. Some vehicle owners focus on external and hardware maintenance, neglecting battery maintenance. For batteries, the charging and discharging process leads to material consumption. In the absence of real-time monitoring and maintenance of batteries during new energy vehicle usage, it becomes difficult to detect battery faults in a timely manner. This indirectly increases usage costs and reduces battery lifespan.

Temperature is another important factor affecting battery lifespan. Stable temperature has a positive effect on prolonging the use of new energy vehicle batteries. High temperatures can damage batteries and ultimately shorten their lifespan. When the temperature of a new energy vehicle battery rises, the internal structure and materials of the battery can be compromised, leading to issues such as short circuits and explosions. This affects the overall performance of the battery, resulting in a shortened lifespan or even rendering the battery unusable. Furthermore, external environmental temperature, as well as the type and model of the battery, have an impact on battery operation. Different battery types and models have different temperature requirements, and the battery needs to operate within an appropriate temperature range. Excessively high or low temperatures can both affect battery lifespan.

## **4.2. Strategies to Extend the Battery Life of New Energy Vehicles**

### **4.2.1. Strengthen Battery Research and Development, Improve Battery Manufacturing Processes**

To extend the battery life of new energy vehicles, it is necessary to increase investment and costs in battery design and manufacturing. Currently, new energy vehicles are in a continuous development phase, and there is a need to continuously improve battery usability, durability, and performance. This involves introducing new technological advancements and refining battery structures to prolong battery life. Lu Chen [10] suggests that during battery design, researchers should pay attention to the selection of positive and negative electrode materials, electrolyte quantity allocation, as well as the distribution of adhesives and conductive agents. For example, in electrolyte configuration, researchers should thoroughly consider the composition of additives and continuously test the impact of additives on battery performance, minimizing factors that affect battery cycle life. The application of physical and chemical materials in batteries should be closely monitored to ensure high quality and compliance with national standards. During battery assembly, meticulous attention should be given to ensure scientific and rational installation, guaranteeing battery ventilation performance and protecting the battery from adverse external factors, thereby improving battery life.

### **4.2.2. Proper Battery Usage and Scientific Maintenance**

New energy vehicle batteries are consumables, and each charging and discharging process consumes energy. Although batteries have a certain cycle life and are not "perpetual motion machines," the method of use can intervene in battery life. Using batteries correctly can achieve the specified lifespan or even exceed it, while incorrect usage can prematurely terminate battery life. Therefore, the key to extending battery life lies in users' proper usage. Li Lina [11] suggests that during the installation of batteries in new energy vehicles, external dust should be cleaned, and the tightness of the positive and negative electrode connections should be appropriate. Anti-vibration pads should be placed at the bottom of the battery to prevent collisions during road bumps. High-current and prolonged charging should be strictly prohibited, and if the vehicle fails to start multiple times consecutively, the battery should be promptly inspected.

### **4.2.3. Pay Attention to Battery Usage Environment and Design Battery Enclosures Appropriately**

Although the quality of new energy vehicle batteries has significantly improved and they can adapt to certain special environments, it is undeniable that adverse environmental factors can still pose a serious threat to battery life. Zhang Pengxiao [11] points out that while conventional environments generally do not affect battery life, extreme environments can potentially impact battery lifespan. For example, if new energy vehicles are parked under intense sunlight for a long time during the summer, the high temperature can affect the battery enclosure and cause issues such as battery swelling. Therefore, when using new energy vehicle batteries, attention must be paid to the battery environment. Vehicle owners should create a favorable storage space for the battery, avoiding interference from adverse external factors. The battery storage enclosure should be well-ventilated, intact, dustproof, and waterproof. When designing the vehicle battery enclosure, the ventilation grille should be appropriately designed to ensure waterproof,

dustproof, and sand-proof properties without compromising battery heat dissipation. Since batteries may experience interference from external factors during long-term storage in the enclosure, vehicle owners should conduct regular inspections and promptly seek maintenance at an automotive repair shop when battery issues are detected. Additionally, prolonged battery usage under adverse environmental factors can lead to corrosion and rust at the battery terminals. Therefore, during vehicle usage, users should correctly charge and discharge the battery, conduct real-time battery checks and monitoring.

## 5. Conclusion

With the increasing global emphasis on environmental protection and energy conservation, the development of new energy vehicles has become an irreversible trend. As the core component of new energy vehicles, battery safety and lifespan management are of paramount importance. This article provides an in-depth analysis of new energy vehicle battery technology, revealing the main types of batteries and their advantages and disadvantages. It also discusses the root causes of battery safety issues, solutions, key factors affecting battery lifespan, and strategies to extend battery life.

In terms of battery safety for new energy vehicles, safety management in the production process and during usage is crucial. Automotive companies should strengthen monitoring and testing of the battery production process to ensure battery safety. Additionally, government regulatory agencies should enhance supervision of new energy vehicle products, guiding companies to improve vehicle safety performance. During usage, consumers should use and maintain batteries correctly to avoid safety accidents caused by improper operations.

Regarding battery lifespan management, this article proposes strategies such as strengthening battery research and development, improving battery manufacturing processes, proper battery usage and scientific maintenance, and paying attention to battery usage environments. Implementing these strategies will help extend the battery life of new energy vehicles, reduce usage costs, and promote the sustainable development of the new energy vehicle industry.

In conclusion, the safety and lifespan management of new energy vehicle batteries is a comprehensive endeavor that requires joint efforts from the government, companies, and consumers. By enhancing technological research and

development, improving regulatory policies, and raising consumer awareness, we can collectively drive the healthy development of the new energy vehicle industry and provide reliable technological support for green transportation.

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