

Technical Research on the Echelon Utilization of Decommissioned Power Batteries for New Energy Vehicles

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Received: 11 March 2024; **Accepted:** 31 March 2024; **Published:** 30 April 2024

Abstract:

New energy vehicles are the key to solving the emissions and energy problems of traditional fuel vehicles. However, with the expansion of the new energy vehicle market, the recycling and reuse of power batteries have become increasingly prominent. This study aims to explore and study the recycling and cascade utilization technology of power batteries for new energy vehicles. Through in-depth research on the physical characteristics, chemical composition, and technical challenges in the recycling and reuse process of power batteries, it will provide strong support for future research in the field of power battery recycling and reuse.

Keywords:

New Energy Vehicles, Cascade Utilization, Decommissioned Batteries, Energy Storage

1. Introduction

The National Energy Administration specifically mentioned the “power battery cascade utilization technology” in the “2020 Energy Work Guidance” and included it in the scope of the national key research and development plan in 2018. Since then, the cascade utilization of decommissioned power batteries has become a focus area of attention for many researchers. When the capacity of a power battery degrades to less than 80% of its initial capacity, it reaches its designed effective service life [1]. The effective service life of electric passenger car batteries is 4-6 years. According to this calculation, 800,000 tons of decommissioned lithium-ion batteries (134.39GWh) will be produced in 2025. The first batch of power batteries will be eliminated on a large scale soon. How to properly handle waste batteries, make use of the “waste heat” of power batteries, and effectively carry out cascade utilization are important issues that the industry has been thinking and discussing [2].

2. Relevant Concepts of Decommissioned Battery Cascade Utilization

2.1. Echelon utilization

Echelon utilization refers to the process of conducting necessary inspection and testing, classification, disassembly, battery repair, or restructuring of used power batteries into echelon products, making them applicable to other fields. For example, these batteries can be used in household energy storage systems as a supplement to renewable energy. This can both extend the life of the battery and reduce environmental pollution. Secondly, they can be used in industrial fields, such as mobile power sources in mines and ports. In addition, decommissioned batteries can also be used for regulating and stabilizing power systems, as well as providing power in remote areas. Therefore, echelon utilization of used power batteries will have broad application prospects [3].

In fig.1, when the battery capacity is greater than or equal to 80%, that is, the power battery meets the requirements for use in electric vehicles, it can be used as a normal energy battery in the vehicle. When the battery usage capacity is between 60% and 80%, it can be selected for echelon utilization or packaging and recycling. The former can be applied to energy storage, communication base stations, solar energy, low-speed electric vehicles, etc. When the available capacity of the battery decays to 20%-60%, it can be recycled and disassembled by professional manufacturers into single batteries, which can be reconfigured in various combinations in series and parallel. The reconstituted batteries are mainly used in microgrids. When the available capacity decays to less than 20%, the battery can be scrapped. Only the internal parts and rare chemical components of the battery need to be refined and recycled, and the metal elements can be recovered.

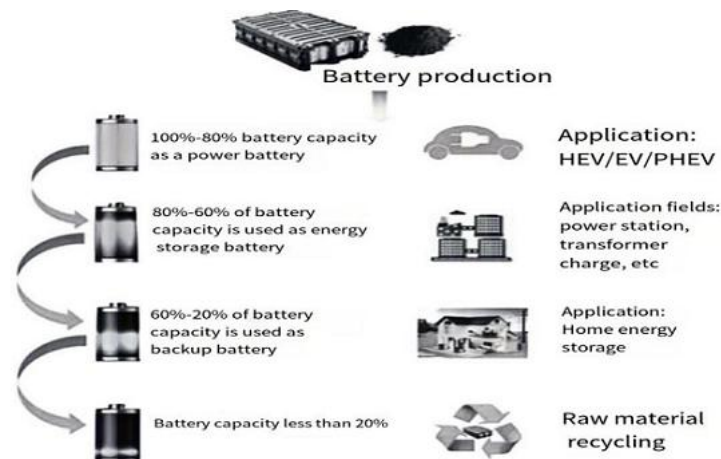


Figure 1. Battery echelon utilization and scenario flow chart.

In practice, from the perspective of enterprises, the mainstream participating enterprises include battery manufacturers represented by Ningde Times and Honeycomb Energy that have self-built recycling systems, third-party professional recycling and dismantling enterprises represented by GEM, Bonpu, and Saidemei, and raw material providers represented by Ganfeng Lithium, Ganzhou Haopeng, Huayou Recycling, Tianci Materials, etc. From a technical perspective, some domestic automotive technology research institutes have started R&D cooperation with overseas universities and battery testing companies in related fields. For example, the University of Birmingham in the UK signed a four-party joint development agreement

with Jiangsu Industrial Technology Research Institute, Tsinghua University Suzhou Automotive Research Institute, and Qingyan Precision, an intelligent electric vehicle testing service provider, to jointly explore solutions for the echelon utilization of power batteries. From a regional perspective, the recycling and utilization of decommissioned batteries are mainly concentrated in the Beijing-Tianjin-Hebei region, the Yangtze River Delta region, and the Pearl River Delta region where the number of new energy vehicles is relatively large.

2.2. The necessity of the use of decommissioned batteries in the ladder

From the perspective of environmental protection, improper disposal of used power batteries poses a significant environmental risk. Chemical substances with certain toxicity and non-degradable materials may damage the ecosystem and ultimately harm human health. In addition, power batteries contain a large amount of rare and precious metals such as lithium, cobalt, and nickel, which are expensive to extract and non-renewable. Echelon utilization can extend the service life of batteries and reduce the dependence and consumption of these precious resources.

From the perspective of economic benefits, it is estimated that by 2025, the decommissioning volume of China's power lithium batteries will exceed 730,000 tons, of which 70% can be used in echelon, with a market size exceeding 20 billion yuan. It is estimated that by 2030, the global lithium demand will reach 1.79 million tons/year, nearly four times higher than the current 429,000 tons/year, and the market size of echelon utilization is conservatively estimated to reach 4 billion US dollars. The promotion and application of power battery echelon utilization can also promote the development of related industries, such as energy storage systems, smart grids, microgrids and other fields.

2.3. Technical route and application scenario of decommissioned battery cascade utilization

At present, the types of power batteries installed can be roughly divided into two camps: ternary and lithium iron phosphate. Ternary batteries have the disadvantages of low cycle times, poor safety performance, and high cost. Lithium iron phosphate is the opposite. It is characterized by low cost, high safety, high-rate charging and discharging characteristics, and long cycle life. Ternary lithium batteries contain a large amount of nickel, cobalt, and manganese metals, which have high recycling benefits. Coupled with its limited cycle times, the value of echelon utilization is not great, making it more suitable for direct recycling. Therefore, the main type of battery for echelon utilization is lithium iron phosphate [4].

There are currently two main technical routes for the use of batteries in echelons. The first is the use of whole packs, which does not require consideration of the consistency of various types of cells from different manufacturers, and even does not require specialized equipment and storage areas. The development process can be greatly shortened, making it the best entry point for start-ups. However, it requires knowledge of the communication interface protocol of the native BMS, and many battery manufacturers do not want to open the interface to third parties, making development more difficult. The second is disassembly, screening, and reorganization, which does not require knowledge of the interface and algorithm shortcomings of the native battery BMS, but requires multiple steps such as disassembly, testing, screening, and reorganization. Currently, screening technology needs to be broken

through, and the parameters such as voltage, internal resistance, and capacitance of batteries produced by various manufacturers are not the same.

The application scenarios of echelon utilization mainly include two types: static and dynamic scenarios. In fig.2, the static scenario mainly refers to chemical energy storage, which is applied to energy storage at the power generation side/distribution side/user side, backup power supply for communication base stations, household/commercial energy storage, distributed power generation/microgrid, etc. The dynamic scenario mainly refers to the replacement of lead-acid batteries for electric bicycles, low-speed mobility vehicles, logistics vehicles, urban sanitation vehicles, etc.

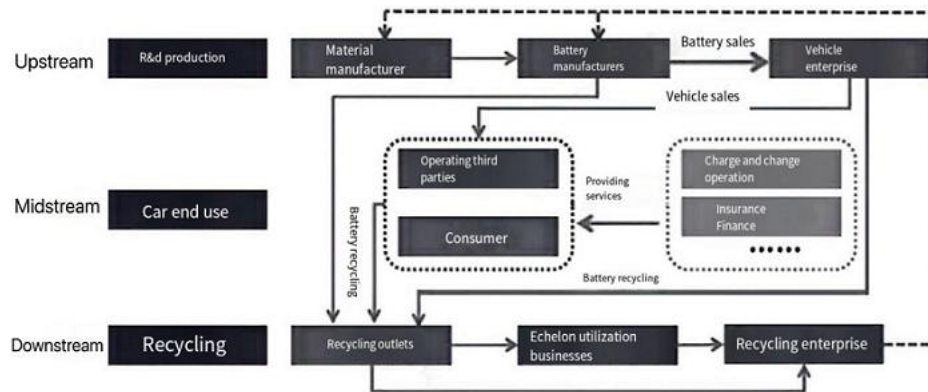


Figure 2. Power battery recycling process diagram.

3. Difficulties Faced by the Current Use of Decommissioned Batteries

3.1. Key technologies to be broken through

Compared to newly produced batteries, the safety and performance of decommissioned batteries vary greatly depending on their usage conditions. Therefore, before their use in subsequent stages, it is necessary to assess the value of their state, evaluate their remaining life and safety, and determine the appropriate use areas for them based on the costs of subsequent stages. For batteries that have no value for subsequent use, they should be scrapped and recycled.

3.2. Incomplete battery information

It is difficult to trace the information of power batteries currently on the market. After the recycling and reuse of batteries, it is found that there are many difficult-to-obtain information, such as the year of battery retirement and the capacity before retirement. This brings certain difficulties to the subsequent work [5].

3.3. The industrial chain has not formed a positive interaction

The use of batteries in echelons involves multiple enterprises, including car companies, battery companies, recycling and dismantling companies, and battery testing companies. At present, there is no effective linkage between enterprises at all levels of the industrial chain, and the non-standardized production of batteries also provides some resistance to cooperation between enterprises. How to coordinate the relationship between all parties, promote cooperation among all enterprises, and open up the overall echelon utilization industrial chain is also a major difficulty.

4. Conclusions

The development trend of new energy vehicles is irreversible. Whether forced or actively chosen, most traditional automotive manufacturers are already making the transition to electrification, and consumers' habits are slowly changing. The rapid development of electrification also brings the problem of how to deal with decommissioned batteries. Based on the consideration of maximizing resources, the industry believes that the best place for decommissioned power batteries is to be used in echelon. With the continuous improvement of technologies in testing, battery recycling and dismantling, screening and restructuring, system integration, and reutilization, as well as the outbreak of the total amount of decommissioned power batteries, the use of decommissioned batteries in echelon as a solution for power battery recycling has great potential for development.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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