Retired Battery Recycling Status and Countermeasures

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Abstract. China's new energy vehicle (NEV) sector has experienced explosive growth in recent years, accompanied by a dramatic surge in retired power battery volumes. However, the concurrent development of China's power battery recycling industry faces multiple urgent challenges, including immature recycling technologies, elevated operational costs, and non-standardized recycling channels. Through systematic analysis of the current status of power battery deployment and the obstacles within China's recycling ecosystem, this study proposes strategic countermeasures: constructing an integrated recycling network, intensifying technological R&D investments, optimizing cost-efficiency frameworks, and establishing unified national standards. The paper emphasizes that achieving sustainable industry development requires collaborative governance among governmental bodies, industrial enterprises, and social stakeholders. Effective implementation of these strategies would maximize retired battery recovery rates, reduce dependence on virgin mineral resources, mitigate ecological impacts through pollution control, and extend battery service life cycles—ultimately fostering a circular economy model for the global NEV supply chain.

Keywords: Retired Batteries; Power Batteries; Circular Economy; Industrial Sustainability

1 Introduction

In recent years, the new energy vehicle industry has flourished, with a sharp increase in the number of new energy vehicles in China. As of the end of 2024, the number of new energy vehicles reached 31.4 million, and China has been leading the world in power battery installations for many years. As the first batch of new energy vehicles reaches over 10 years of use, a "retirement wave" is approaching, with a large number of power batteries entering the replacement period. In December 2024, the Ministry of Industry and Information Technology revised and issued the "Comprehensive Utilization Industry Standards for Retired Power Batteries of New Energy Vehicles (2024 Edition)," which sets new regulations on industry technical requirements. On February 21, 2025, the State Council executive meeting reviewed and approved the "Action Plan for Improving the New Energy Vehicle Power Battery Recycling System," emphasizing the importance of comprehensively enhancing the capacity and level of power bat-

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tery recycling and making specific deployments. These policies have brought development opportunities to the retired battery recycling industry, while also imposing higher requirements for standardized industry development. However, the current retired battery recycling industry still faces numerous challenges. In-depth research into its current status and the proposal of effective countermeasures are of great significance for promoting the healthy development of this industry.

2 Status of Retired Battery Recycling

2.1 Industry Development Overview

The surge in NEV sales has accelerated the growth of retired batteries, with China expected to generate over 1 million tons by 2025, creating a 33B yuan market. By 2030, the power battery recycling sector is projected to exceed 100B yuan. Since 2018, China's MIIT has released five batches of "white list" enterprises (156 by end-2024) meeting retired battery recycling standards. These policies drive industry standardization, enhance resource reuse, mitigate pollution, and align with sustainability goals by promoting eco-friendly, efficient recycling practices [1].

2.2 Technological Advancements

China has achieved progress in retired battery recycling, focusing on cascade utilization (e.g., energy storage systems) with an average efficiency of 85% and cost-effectiveness of ¥6,000/ton, and dismantling recycling (metal extraction) with 75% efficiency but higher costs of ¥8,500/ton due to complex processes. In comparison:

Europe: Germany's Redux Recycling employs pyrolysis technology for lithium batteries, achieving 92% efficiency at ¥7,200/ton, supported by centralized logistics networks that reduce transportation costs by 25% .

Japan: Panasonic and JX Metals use hydrogen reduction for nickel-cobalt recovery, achieviVng 88% efficiency at ¥6,800/ton, leveraging regional hubs to limit transport distances to <150 km [2]. In brief, Table 1 consolidates these comparisons, highlighting the trade-offs between efficiency, cost, and regional implementation strategies.

Table 1. Recycling Technology Efficiency and Cost Comparison

Technology	Efficiency (%)	Cost (¥/ton)	Key Region/Example
Cascade Utilization	85	6,000	China (State Grid)
Dismantling Recycling	75	8,500	China (GEM)
Pyrolysis	92	7,200	Europe (Redux Recycling)
Hydrogen Reduction	88	6,800	Japan (Panasonic/JX)

2.3 Market Size and Competitive Landscape

The retired battery recycling market is expanding due to the growing volume of batteries reaching their end-of-life. However, the market remains fragmented, with numerous

SMEs and small workshops operating with varying levels of technological capability and environmental compliance, which hinders quality. Leading enterprises like CATL and BYD dominate the market with their advanced technology, extensive networks, and established channels, enabling efficient retired battery reuse. Table 2 illustrates the business layouts of various enterprises in this sector. Automobile manufacturers like Tesla and BYD are establishing global and national recycling networks, respectively, aiming for high recycling rates and closed-loop industrial chains. Energy and material enterprises such as CATL and GEM are expanding globally and forming strategic partnerships to enhance resource efficiency. Environmental protection and resource recycling enterprises like Guanghua Technology are pioneering innovative recycling technologies. Third-party platforms like BASF Recycling are collaborating internationally to advance lithium-battery recycling and support closed-loop systems. These enterprises collectively drive the industry toward a more sustainable and efficient future[3].

Table 2. the layout of some enterprises in the retired battery recycling business.

Type of Enterprise	**Enterprise Name**	**Business Layout**
Automobile Manufacturer	Tesla	Establishing battery production site collection systems, achieving over 90% recycling rate globally, aiming for 100% lithium-ion battery recovery.
	BYD	Utilizing tech, sales, and channel strengths, it built a national recycling network with 51 outlets, forming a closed-loop industrial chain through dismantling, recovery, and regeneration.
Energy & Material Enterprise	CATL	Acquiring Brunp and expanding, it established recycling bases globally, forming a closed-loop chain from battery collection to material recovery, aiming for resource efficiency.
	GEM	Establishing 5 domestic centers & 2 overseas JVs, forming a global network for battery cascade utilization and recycling.
Environmental Protection & Resource Recycling Enterprise	Guanghua Technology	Leveraging hydrometallurgical tech, it pioneered $LiFePO_4$ battery recycling, targeting 50kt capacity expansion. Strategic partnerships with automakers/battery firms drive full-component reuse and circularity.
Third-party Recycling Platform	BASF Recycling	BASF collaborates with Iveco, Stena Recycling, and Chinese firms to advance lithium-battery recycling, supporting closed-loop systems in Europe and China for resource reuse.

3 Challenges Facing Retired Battery Recycling

3.1 Immature Recycling Technology

China's retired battery recycling technology faces significant challenges. The overall technology is immature, with diverse battery specifications and a lack of unified standards complicating the recycling process. Dismantling procedures are intricate, and equipment adaptability is limited, making automated, large-scale recycling difficult. Emerging technologies like solid-state batteries, with solid electrolytes resisting traditional separation methods, necessitate costly cryogenic grinding or laser cutting, increasing R&D expenses by 30-40% while achieving only 65% efficiency. Similarly, sodium-ion batteries, with iron/manganese-based cathodes conflicting with lithium recycling lines, require 20-25% equipment modification costs and yield less than 70% sodium recovery, underscoring the need for further R&D[4].

3.2 High Recycling Costs

High retired battery recycling costs significantly hinder industry growth. The process involves multiple steps, including transportation (classified as dangerous goods, requiring special measures), dismantling, and material separation, all of which demand significant investment. In China, a geographic mismatch exists, with 70% of batteries located in coastal areas, while 60% of recycling facilities are inland. This results in an average transport distance of 800 km, costing ¥0.8/km·ton. In contrast, Japan's regional hub model limits transport distances to approximately 200 km, reducing costs by 35% and offering a valuable example for China to emulate in optimizing its recycling network.[5].

3.3 Irregular Recycling Channels

At present, China's retired battery recycling channels are not standardized, with a low market entry threshold. This has led to a large number of retired batteries flowing into illegal channels, which lack the necessary qualifications and standardized equipment. These illegal operations adopt crude manual dismantling methods, causing significant resource waste and environmental pollution. Moreover, the hazardous materials involved pose serious health threats to operators. To address this issue, strengthening regulatory oversight and raising market entry thresholds are crucial steps to eliminate illegal channels and promote a sustainable recycling industry.[6].

3.4 Policy and Regulatory Challenges

Despite government efforts, China's retired battery recycling sector faces policy and regulatory hurdles. Local implementation often lacks resources or expertise, widening the policy-practice gap. Regulatory gaps enable illegal operations, undermining legitimate businesses. Standard formulation lags behind tech advancements, causing safety risks during recycling. Additionally, international policy differences add complexity, requiring Chinese firms to navigate diverse regulations while complying domestically, posing a challenging task.

4 Countermeasures for Retired Battery Recycling

4.1 Establish and Improve the Recycling Network System to Enhance Recycling Efficiency and Coverage

Governments should guide enterprises to jointly build a nationwide "Internet + recycling" network, integrating online platforms for information collection and offline door-to-door recycling, while encouraging diversified cooperation between automakers, battery manufacturers, and third-party recyclers. Deploy regional sorting centers in high-density areas (e.g., Yangtze River Delta), reducing transport distance to 300 km and logistics costs by 30%. Adopt the EU's EPR model, mandating automakers to set up collection points within 50 km of sales networks, like BMW i3 in Germany.

4.2 Increase Investment in Technological Research and Development to Promote Technological Innovation and Industrial Upgrading

The government should establish dedicated R&D funds to support universities, research institutions, and enterprises in advancing retired battery recycling technologies, prioritizing industry-academia-research collaboration to overcome technical challenges. Key areas include enhancing battery detection accuracy, developing advanced dismantling equipment, and exploring eco-friendly material separation methods, especially for solid-state batteries. For instance, CATL's blockchain pilot project tracks battery lifecycle data, reducing illegal recycling by 18%, while BYD's IoT-AI smart warehouses improve sorting accuracy by 25% and cut storage losses by 15% through real-time health monitoring[7].

4.3 Cost Optimization and Standardization Strategies

To reduce recycling costs and promote industry standardization, enterprises should prioritize large-scale production, technological innovation, and industrial chain integration to lower unit costs. Advanced dismantling technologies (e.g., AI automation) and upstream-downstream collaboration enhance resource recovery efficiency. Governments must lead the formulation of unified recycling standards by convening industry stakeholders, aligning technical specifications with future trends, and establishing certification systems. These measures ensure cost-efficient operations while fostering a standardized, sustainable retired battery recycling sector.

5 Conclusion

The retired battery recycling sector in China exhibits vast development prospects and substantial market potential. Nevertheless, the industry currently confronts numerous challenges. To foster its sound advancement, collaborative endeavors from government, enterprises, and society are imperative. Governments ought to intensify policy support and refine legal frameworks and standardization systems. Enterprises must bolster technological R&D and innovation capacities to enhance recycling efficiency and resource recovery rates. Society needs to strengthen public awareness campaigns and media guidance to elevate public understanding and engagement in battery recycling. Looking ahead, with continuous technological progress and policy refinement, the retired battery recycling industry is anticipated to enter a more regulated and efficient developmental phase, making significant contributions to the sustainable growth of the new energy vehicle (NEV) sector, resource recycling, and environmental preservation.

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