

Status Quo and Countermeasures of Battery Recycling Mode of New Energy Vehicles

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Abstract: On the basis of combing the concepts related to new energy vehicle battery recycling, this paper evaluates and suggests the battery recycling mode of new energy vehicles in China from the perspective of battery recycling mode. Firstly, the current situation of recycling of new energy vehicle batteries is expounded, and through relevant literature, the conclusion that China's new energy battery recycling model is not perfect is obtained through relevant literature. Secondly, the four new energy vehicle battery recycling modes are summarized, the differences of each model are compared and analyzed, and finally, through the research on the evaluation method of the new energy vehicle battery recycling mode, the advantages and shortcomings of the existing recycling mode are further understood, and the experience of the existing literature is combined to draw suggestions and prospects from them.

1. Introduction

In 2012, the development plan of energy-saving and new energy vehicle industry was released by the State Council in this year to deal with environmental pollution, fossil energy crisis and global warming [1]. In this context, the replacement of fuel vehicles by new energy vehicles powered by power batteries has become the vane of the future in the automotive field. Sales of new energy vehicles have increased year by year, by the end of 2022, China's current car retention has reached 10.01 billion [2]. However, with the advent of the "retirement tide" of power batteries, if they cannot be recycled, a series of problems caused by them will cause greater harm to resources-environment-society. First, the hazards in terms of resources. The core materials of power batteries are lithium, cobalt, nickel and other metals, and China's foreign dependence has reached 75.8 percent, 97.9 percent and 93.3 percent respectively, and the import source countries are highly concentrated [3]. And then cause social harm, Battery-grade lithium carbonate rose more than 500 percent at one point, Domestic electrolytic cobalt and electrolytic nickel quotations once increased by more than 60 percent and 110 percent year-on-year. It has a great impact on the safety of the new energy vehicle industry. Finally, there are environmental aspects. Improper disposal of waste power batteries may lead to safety and environmental protection problems such as fire and explosion, electrolyte leakage, and

organic waste emissions, and more than 20 kinds of hazardous substances contained in them are listed in the scope of China's pollutant emission control [4]. Therefore, promoting the recycling of waste power batteries is one of the key issues related to the sustainable development of the new energy vehicle industry. At present, battery recycling activities have gradually formed three recycling models, new energy vehicle manufacturers are responsible for recycling, such as 4S stores of various automobile brands. Power battery manufacturers are responsible for recycling, such as BAK batteries. Third-party recycling companies are responsible for recycling, such as Grammy [5].

2. Current Situation of Battery Recycling for New Energy Vehicles

2.1. Current Situation Abroad

In 2008, the European Union issued an environmental protection directive requiring mandatory recycling of used batteries, European countries have successively formulated corresponding national special laws [6]. For example, Germany promulgated a series of laws such as the Recycling Law and the Battery Recycling Law, It clarifies that producers bear the cost of recycling waste power batteries, and clarifies the legal obligation of consumers to recycle. Since 2019, Germany and France have led the establishment of a battery industry alliance including more than 30 industrial enterprises in 9 European countries to promote the formation of a competitive power battery recycling industry chain. The EU attaches great importance to relevant technical process research. In December 2019, the EU approved 3.2 billion euros of funds to support power battery production and research projects in seven European countries. In general, Europe implements an extended producer responsibility system that includes all entities in the industrial chain, requiring battery producers and importers to register with the government, Dealers and consumers have the obligation to organize the recycling and active return of used power batteries.

The United States makes full use of the market regulation mechanism to maximize the role of the producer extension system (the supporting system for power battery manufacturers to assume the main body of recycling). The government stipulates that consumers and battery manufacturers are charged a certain environmental surcharge at the retail sale of automobiles as a support fund for battery scrap recycling, and then the recycling companies sell the recycled raw materials to the battery manufacturers at the agreed price, so that the manufacturers can fulfill their main responsibilities and ensure the profits of the recycling enterprises. BCI also has a deposit system, which requires consumers to pay a battery deposit when buying a car. In addition, the United States attaches importance to the popularization of recycling knowledge, and the overall social awareness of recycling is strong. For example, BCI, as an authoritative third-party recycling organization, in addition to coordinating the battery recycling work in various states, also undertakes a large number of enterprise and individual recycling processes and normative guidance. The legal system for battery recycling in the United States is relatively complete. At the federal level, basic laws such as the National Energy Act have been introduced.

Due to the insufficient resource endowment, Japan attaches great importance to the recycling of used batteries. At present, Japan has established a recycling system of "production-sales-recycling-recycling" and a complete recycling network. That is, battery manufacturers use retailers, car sellers and other outlets to recycle waste batteries from consumers for free, and then hand them over to professional recycling companies. In order to stimulate the enthusiasm of battery manufacturers to recycle, the Japanese government has provided corresponding subsidy policy support.

2.2. Current Situation in the Country

In June 2009, China's Ministry of Industry and Information Technology issued the "New Energy

Vehicle Manufacturers and Products Access Management Rules", which for the first time proposed battery recycling as an access condition for new energy vehicle products[7]. After that, a number of terms and special policies were issued to clarify the responsibility of producers for recycling and strengthen the management of power battery recycling. Especially after 2018, the power battery recycling policy system has gradually matured. However, the current institutional guarantee level still needs to be improved, and the implementation of policy documents is not optimistic. China does not have a complete special law on battery recycling, and most of the relevant provisions scattered in many laws such as the Environmental Protection Law and the Law on the Prevention and Control of Environmental Pollution by Solid Waste are principled provisions[8], Relevant special policies provide guidance for China to improve the power battery recycling system, but the punitive regulations and implementation details are not specific and the enforcement force is insufficient, resulting in limited constraints in practice. In practice, most car companies adopt the method of entrusted recycling, and the recycling responsibility has not been truly implemented, The definition of consumers' recycling responsibility is not clear, resulting in their relatively weak awareness of recycling as battery ownership holders and decisive subjects in the recycling chain. Chapter 6 of the Implementation Rules for the Administrative Measures for the Recycling of Scrapped Motor Vehicles, implemented in 2020, contains punitive provisions on legal liability, but does not clarify the responsibility and boundaries of the punishment entity, and is mainly administrative penalties, and fines of not more than 100,000 yuan also lack deterrent.

3. New Energy Vehicle Battery Recycling Body

By the end of August 2022, more than 190 enterprises in China had set up 10,235 recycling service outlets in 326 prefecture-level municipal administrative districts in 31 provinces and municipalities across the country, cultivated a total of 45 backbone enterprises for echelon utilization and recycling, and initially established a recycling system[9]. At the same time, the industry is facing a severe problem of disorderly competition, unqualified "small workshop" enterprises carry out unfair competition with non-standard and environmentally friendly practices, coupled with the imperfect construction of recycling channels, a large number of waste batteries flow into informal channels in the form of "the highest price wins", However, due to limited costs and extremely low capacity utilization, it is difficult for formal enterprises to compete with informal enterprises, and they cannot form an effective market-oriented mechanism.

3.1. Producer-Led Industry Alliance Recycling Model

The industry alliance model is a more common and mature new energy vehicle power battery recycling model at this stage, which can save the pain of automobile manufacturers entering new industries, battery manufacturers, automobile manufacturers, and comprehensive utilization enterprises each perform their duties, respectively responsible for the links related to their own business in the industrial chain, and the professional division of labor ensures the integrity of the entire recycling chain. The industry alliance has a low investment in system construction and can be started quickly, because the enterprises responsible for each link have previously laid out in related fields, so the additional financial and material resources invested in the recycling link are relatively small, which provides the possibility for the rapid establishment and operation of the recycling network. There are also some problems with the industrial alliance model. First, the power battery is the core part of the new energy vehicle, belongs to the core secrets of each manufacturer, even in the end unpacking and recycling link of each enterprise is strictly controlled, in order to protect the core technology, each enterprise may form an independent alliance isolated from each other, may pose a challenge to unified and standardized management. Second, from the economic point of view, retired

power batteries still have a high residual economic value, profitable at the recycling end, although in the early stage of automobile manufacturers may be in the form of alliance rapid layout, seize the market, with the development and maturity of the industry, more automobile manufacturers may enter the recycling industry in the form of subsidiaries or joint ventures, in the form of more income while reducing external dependence.

3.2. Producer-Led Autonomous Recycling Model

The voluntary recycling model is most common among Japanese companies and is a product of Japan's laws and policies related to extended producer responsibility [10]. This model requires enterprises to have a layout in the upstream, middle and downstream of battery manufacturing, sales and recycling, and the information at the recycling end can be fed back to the manufacturing end, and the problems can be quickly found and upgraded through the self-feedback mechanism, which directly helps enterprises to launch more innovative and competitive products. In addition, the recycling chain under the same parent company can maintain a high degree of consistency and uniformity in all aspects of the recycling process, facilitate systematic management, and reduce external dependencies. In terms of costs, after a relatively difficult initial period, the fully autonomous recycling model can bring more profits to enterprises. For the initial layout, this problem is not easy to implement, and this problem is the key to the autonomous recycling model. The layout of the whole industry requires the core technology of the upstream, middle and downstream, and requires a large amount of capital investment, which is a great challenge for the enterprise itself, while the related enterprises of the automotive industry layout have great disadvantages with traditional enterprises in terms of professionalism, and their processing capacity may be different from their own output, and it is difficult to achieve scale effect in the short term, In addition, it takes a long time to establish a mature whole industry chain pattern, which is very unfavorable to emerging fields that need to quickly occupy the market.

3.3. Third-Party Recycling Model

Third-party organizations provide customers with systematic solutions from collection, storage, transportation to terminal processing and legal documents, so as to help enterprises achieve extended producer responsibility and maintain the operation of third-party institutions through corporate membership or sponsorship. The biggest advantage of this model is reflected in the fast distribution speed, large number and wide type, including not only traditional 4S stores, but also large and small dealers and stores, so that the difficulty of collecting new energy vehicle power batteries is greatly reduced, and the recycling participation rate and collection effect are improved, In addition, third-party entities exist independently of regulators and enterprises, providing greater independence and transparency. Diversified systematic solutions save enterprises the time and energy of deploying in the upstream, middle and downstream separately, and the project-based model can solve the needs of enterprises in a targeted manner. However, there are also corresponding problems in the third-party-led model, the core of which is that the authority needs to certify the qualifications and final effects of the third-party organization. The prerequisite for the third-party recycling model is the need to ensure the authority and validity of the certification so that a truly capable third party can carry out the recycling work. The executive body of this model at the front end is consumers without professional skills, which requires a third party to provide simple and effective packaging and storage equipment, and guide consumers to carry out harmless collection. Due to the diversity of the main body, it is difficult to carry out daily centralized transportation like enterprises, and it is necessary to adopt scheduled transportation or on-demand transportation, which has higher requirements for the transportation network. In the end-of-line treatment, it is more difficult to handle due to the strong

heterogeneity of the battery source. In addition, there is a large amount of capital operation in this model, which requires a third party to establish a mature fund management mechanism.

4. Analysis of the Reasons for the Lag in Battery Recycling of New Energy Vehicles

4.1. The Recycling System is not Yet Clear

In 2018, the "Interim Measures for the Management of the Recycling and Utilization of New Energy Vehicle Power Batteries" was pointed out by the Ministry of Industry and Information Technology that new energy vehicle manufacturers will bear the main responsibility for the recycling of power batteries, but the specific recycling system is not clear. China urgently needs to solve the recycling problem of a large number of power batteries, but the recycling industry is still in a relatively disorderly state, and the corresponding recycling process, technology, network construction and operation lack standards. At the same time, the cooperation mode between enterprises in the recycling process is not clear, and the construction, profitability and benefit distribution of recycling networks need to be explored. In general, China is still in the early stage of power battery recycling, and the corresponding industry standards and laws and regulations still need to be improved.

4.2. The Recycling Process Lacks Supervision

At present, there are small recycling workshops in China that disrupt the order of the power battery recycling market. Small workshops are often poorly equipped and profit-oriented, causing serious environmental pollution during the recycling process. Small recycling workshops have recycled a considerable number of power batteries at a higher price, resulting in the difficulty of forming scale effects in China's power battery recycling, and the recycling cost remains high. However, at present, China's supervision of informal recycling workshops is relatively limited, and the qualification review of power battery recycling enterprises is relatively lacking.

4.3. Lack of Subsidy Mechanisms

Due to the difficulty of power battery recycling to form scale effects and the chaos of the industry, most domestic recycling companies are difficult to achieve profitability, which has a great impact on the enthusiasm of enterprises. In order to ensure the good development of China's power battery recycling market, the government needs to provide corresponding economic subsidies for enterprises and establish a sound subsidy mechanism, and the lack of this aspect is also one of the challenges facing China's power battery recycling.

5. Conclusion and Outlook

At present, China's current new energy vehicles are gradually developing and growing, becoming the leader in the development of new energy vehicles in the world. However, there is relatively little research and development on battery recycling for new energy vehicles. The enterprise new energy battery recycling model is not mature and perfect, but with the introduction of relevant policies of the Chinese government, a large number of enterprises are actively transforming, which will fill some of their loopholes in this regard and inject power into the development of the new energy vehicle system in the future.

For different new energy vehicle battery recycling models, measures are taken based on corresponding policies and regulations. At present, European and American countries have a relatively comprehensive use of battery cascades, although there are not too many regulations and

standards to support, but their similar technical experience is relatively rich. China's battery recycling market is relatively small, and the recycling cost of batteries at this stage is high, and it is difficult for related companies to make profits, so at this time, the Chinese government introduced a part of the framework regulations to support it.

For the future, with the support of the Chinese government, should continue to vigorously develop battery recycling. Through the rational use of battery recycling, environmental pollution can be effectively reduced and the goal of green and low carbon can be achieved. The market for new energy vehicles is gradually expanding, and if the reasonable and effective recycling of batteries cannot be effectively controlled, it will cause huge hidden dangers to the environment. For different battery recycling modes, it is necessary to choose the most suitable one, and it turns out that a reasonable model will create the best economic value. For the development of new energy batteries, policies and regulations should be seriously implemented and the battery recycling market should be improved through the following points.

It is necessary to continuously improve the international system and strive to promote the formulation of laws. For the lack of superior laws and insufficient mandatory provisions in the field of power battery recycling, it is recommended to accelerate the research and formulation of special laws in the field of waste power battery recycling. By following the EPR principle, clarify the division of labor and the boundaries of rights and responsibilities of government departments in the joint management part, as well as the legal responsibilities of producers and sellers, users and recyclers and other participants in the industrial chain, increase the intensity of illegal punishment and refine punishment measures. They learn advanced experience by learning, such as implementing a recycling deposit system, subsidizing consumers and comprehensive utilization enterprises from the perspective of improving the competitiveness of compliant disposal channels, and including the recycling of waste power batteries into the scope of preferential tax policies to improve the enthusiasm of power battery recycling. At the same time, they must continue to strengthen the guidance of standards and promote the standardized operation of the whole life cycle of power batteries from design and production to echelon utilization and dismantling and recycling. In view of the current outstanding demand, priority is given to promoting the formulation and implementation of standards for power battery production and waste power battery storage and transportation, testing and screening, and recycling network layout design, and promoting the universal design of vehicle battery modules and modules in echelon utilization application fields, and strengthening coordination and docking of existing relevant standards.

Increase the research and development of key technologies and equipment and improve the level of recycling. It is recommended that the government and relevant entities increase R&D support to accelerate the "difficulties" of key technologies and preparation processes faced by battery recycling. Actively develop refined intelligent disassembly technology and equipment for power battery cells, modules and battery packs to reduce disassembly costs and losses, Focus on breaking through technical bottlenecks such as residual value status assessment, rapid lossless additional testing, sorting and recombination, etc., increase the research and development and promotion of key technologies such as electrode material recovery and valuable metal extraction rate, and improve the level of process and equipment support for waste battery recycling. Actively try to integrate the Internet, big data, Internet of Things and other new generation technologies, strengthen the collaboration of classification, packaging, transportation, storage, echelon utilization and other links, and explore a more economical and safe technical path.

Strengthen industry standard management and create a benign market competition environment. In order to curb the overexpansion of production capacity, it is recommended to strengthen the regulation of new recycling capacity according to the installed capacity of power batteries and new energy vehicle industry clusters. At the same time, focusing on strengthening and optimizing the

industrial chain, sort out and integrate the industry market, give full play to the role of industrial alliances, cultivate and strengthen backbone enterprises for secondary utilization and recycling, promote the construction of recycling networks, and realize the smooth circulation of power batteries from the scrapped end to the consumption end. Relevant departments should continue to strengthen the traceability monitoring of the whole life cycle of power batteries, encourage relevant enterprises and industry associations to jointly participate in the construction of a national platform for traceability management, and coordinate online and offline to urge relevant entities to implement responsibilities, so that the source of each battery can be checked, the destination can be traced, and the node can be controlled. Intensify the crackdown on illegal recycling, resale and dismantling of power batteries, and increase the cost of violations of laws and regulations, so that compliant enterprises have sufficient market and profit margins to promote the virtuous cycle of the industry and the sustainable development of the industry.

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