

# Power Battery Cascade Utilization Reverse Supply Chain Literature Review

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**Abstract:** In the 21st century, the development prospects of new energy vehicles are broad, and the next few years are expected to continue to maintain rapid growth. However, with the continuous expansion of the new energy vehicle market, the recycling problem of power batteries has gradually become prominent. The power battery contains precious metals and harmful substances that may cause environmental pollution, which will lead to waste of resources and environmental pollution if the recycling is not properly handled. Therefore, taking the right recycling measures is essential to protect the environment and save resources. This paper mainly studies the reverse supply chain recycling of power batteries, including the following aspects: supply chain recycling channels, government participation in recycling, research on cascade utilization of power batteries, and puts forward prospects for future research on cascade utilization of power batteries.

**Keywords:** Power battery recycling, reverse supply chain, government subsidies, cascade utilization.

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## 1. Introduction

With the rapid development of the electric vehicle market, the consumption of power batteries is also growing. However, the life of power batteries is limited, and when the battery capacity drops to a certain extent, they will not be able to meet the driving needs of electric vehicles. This leads to the generation of a large number of waste power batteries. If the waste battery is not handled properly, it will not only waste resources, but also cause serious pollution to the environment.

Therefore, how to deal with and utilize these waste power batteries reasonably and efficiently has become an important research topic. The cascade utilization of power battery is a solution proposed in this context. Through cascade utilization, waste power batteries can continue to play their residual value in other areas, such as energy storage, low-speed electric vehicles, etc., so as to maximize the utilization of resources, but also help reduce environmental pollution and save energy.

Reverse supply chain refers to a series of activities to recycle, treat and reuse waste products. In the case of cascade utilization of power batteries, reverse supply chain involves recycling used batteries from consumers or other links, testing, classification, treatment and other links, and finally redistributing batteries to new uses. The importance of reverse supply chain is that it can ensure the reasonable, safe and efficient treatment and reuse of waste power batteries, thereby reducing environmental pollution, improving resource utilization, and promoting sustainable development. In addition, a good reverse supply chain can also bring competitive advantages to enterprises, such as reducing raw material costs, improving product quality, and enhancing brand image. In order to ensure the effective recovery and reuse of used batteries, it is necessary to establish an efficient recycling system and optimize all aspects of the reverse supply chain.

## 2. Literature Review

### 2.1. Research on supply chain recycling channels/mechanisms

Xie Jiaping[1] et al. applied the revenue-sharing contract to the closed-loop supply chain system composed of a single manufacturer and a single retailer, analyzed the whole process from sales to recycling and re-manufacturing and then re-sales, and optimized the profits of all participants. Aiming at the closed-loop supply chain model composed of a manufacturer (remanufacturer) and a retailer and consumers, Chen Jun[2] et al. analyzed the changes of order price, order quantity and income of all parties under two different recycling modes, and obtained the optimal recycling mode choice for manufacturers and retailers in the face of price changes. Gong Yande[3] et al. built two closed-loop supply chain models of mixed recycling of manufacturers and retailers and mixed recycling of manufacturers, retailers and third parties, and got the conclusion that manufacturers should motivate retailers and consumers to recycle through incentive means. Lu Yingjin [4] et al. established a closed-loop supply chain dual-channel recycling structure decision-making model composed of manufacturers, retailers and third parties, discussed the influence mechanism of the strength of the third-party economies of scale effect on the supply chain channel structure decision-making, and found that the improvement of third-party benefits can force manufacturers and retailers to adjust their own decision variables to form a new supply chain equilibrium. Using game theory, Fu Xiaoyong[5] et al. built a game model of competition between two reverse supply chains for the recycling of waste electronic products, and found that under the three modes, the quantity of recycling, the profit of the processor and the profit of the reverse supply chain are inversely proportional to the coefficient of recycling competition. Yao Fengmin[6] et al. considered the pricing decision-making and coordination problems of retailer competition and third-party recycling closed-loop supply chain, and established closed-loop supply chain optimization models under centralized and

decentralized decision-making modes respectively.

## 2.2. Government participation in recycling supply chain related research

Zhao Jinghua[7] et al.adopted different subsidy target strategies for the government (consumers, retailers, manufacturers or third-party recyclers). Through the comparative study of the closed-loop supply chain sales channel pricing index, recycling channel pricing index and the profit distribution of channel members under different subsidy objects, the influence coefficient of different subsidy objects on the pricing decision and profit of channel members was analyzed. Wang Wenbin[8] et al. paid attention to the decision-making problem of closed-loop supply chain under the guidance of the government. By establishing centralized decision-making, decentralized decision-making without reward and punishment mechanism, and closed-loop supply chain decision-making model considering manufacturer competition under the mechanism of reward and punishment, they concluded that the government reward and punishment mechanism played an effective role in coordinating the member enterprises of the closed-loop supply chain to actively recycle and remanufacture waste products. Wang Wenbin[9] et al. considered the reverse supply chain composed of two manufacturers, one recycler and consumers, and studied the effective ways that the government reward and punishment mechanism of the reverse supply chain can effectively guide manufacturers and recyclers to improve the recovery rate of waste products under the competitive environment of manufacturers, and found that the government should implement the reward and punishment mechanism with greater force on manufacturers in the competitive environment of manufacturers is a better choice. Not only is the recovery rate higher, but the retail price of the new product is also lower. Zhou Rui[10] et al. considered the supply chain model without government participation, the supply chain model under the government subsidy mechanism and the supply chain model under the government reward and punishment mechanism, and found that the government's adoption of the reward and punishment mechanism can more effectively stimulate the recovery and coordination of the supply chain. Li Xinran[11] et al. took into account the dual intervention of government remanufactured product replacement subsidy and reward and punishment for waste product recycling, and constructed a dual sales channel closed-loop supply chain model under the intervention of no government intervention, remanufactured product replacement subsidy intervention, reward and punishment intervention for waste product recycling and dual intervention of government respectively. Zhu Qinghua[12] et al.established a three-stage game model considering product greenness and government subsidy analysis in green supply chain management. Xia Xiqiang [13] et al. adopted game theory to build a game model between recyclers and processors under different government subsidy strategies based on two recycling modes, and found that processors should choose to recycle waste products by themselves or through recyclers according to consumers' environmental awareness. Considering the closed-loop supply chain system composed of a single manufacturer, a single retailer and a single third party, Lin Guihua[14] et al. found that the less government subsidies, the more inclined decision makers are to choose retailers for recycling. The more government subsidies, the more likely policymakers are to choose third-

party recycling.

## 2.3. Research on cascade utilization of power battery

Yu Haijun[15] et al.believe that radio frequency identification tags and power battery coding technology can make the use of power batteries more safe and standardized, which is of great benefit to promoting the recycling and echelon utilization of waste power batteries. Xu Yifei[16] et al. qualitatively analyzed various power battery recycling systems, including but not limited to reverse logistics recycling modes of automobile enterprises. Tao Zhijun [17] et al., through the actual investigation and analysis of the power battery recycling industry of Saidemei, also found that battery recycling alone could not maximize economic benefits, and it was necessary to conduct chemical recycling of ternary battery and step utilization of lithium iron phosphate battery. Xu Xinhui[18] et al.built an economic evaluation model of decommissioned power batteries under various energy storage scenarios and solved it through genetic algorithm. The example results showed that the cascade utilization in a single energy storage scenario could make greater use of the residual value of power batteries. Xu[19]et al. analyzed the chemical properties of lithium iron phosphate batteries and studied the characteristics of batteries in different applications. The results showed that the capacity retention rate and capacity recovery rate of such batteries were close to 97% and 99% respectively after 28 days of disuse. It can still be used. YUE GUAN[20] et al. built a differential game model of the closed-loop supply chain dynamic system under the scenario that enterprises and manufacturers share the innovation cost of cascade utilization of government subsidies, studied the equilibrium strategy of each game participant under the dual mechanism of government subsidies and cost sharing, and analyzed the influence of each parameter on the decision-making of the main body through numerical simulation. Yang Kangkang[21] et al. analyzed and compared the optimal decisions of all parties in the supply chain and the recovery rates of decommissioning power batteries under the three situations of non-government intervention, government subsidy mechanism and government reward and punishment mechanism. Liu Juanjuan [22]et al. studied the effects of subsidy object, subsidy amount and scale effect of recyclers on node variables and profit distribution in the supply chain under four models: no subsidy, subsidy recycler, subsidy echelon user and subsidy manufacturer. Zhang Chuan[23]et al. analyzed the effects of subsidy object, scale effect and remanufactured power battery ratio on the optimal decision and profit of members under the four scenarios of no subsidy, subsidy retailer, subsidy manufacturer and subsidy third-party recycler, and realized the coordination of closed-loop supply chain. Zhang Zijian[24] et al. introduced a wind power plant and precious metal recycling station as a model structure to explore the closed-loop supply chain pricing decision and coordination mechanism of power battery gradient utilization under the EPR system. Lu Chao [25]et al. considered the demand risk from the market and the quality risk from the recycling channel in the recycling of power batteries, and built a two-stage decentralized and centralized pricing model of reverse supply chain. Zongwei[26] Liu et al. analyzed the strategic value of power battery reuse, analyzed the main modes of battery reuse, built an economic benefit model of echelon utilization and recycling of power batteries, and analyzed the economic benefits of lithium iron phosphate

batteries and ternary lithium batteries under different reuse modes.

### 3. Conclusion

At present, there are many researches on closed-loop supply chain, which involve more government subsidies and rewards and punishments. The recycling of waste products is a social problem involving the government, enterprises and consumers, and the guiding role of the government is very important. At present, there are few papers on the supply chain direction in the field of new energy vehicle power battery recycling, and there are also few studies involving cascade utilization. It is necessary to study cascade utilization and recycling of power battery. At present, the closed-loop supply chain has become a hot topic in the academic and business circles, and the research involving government subsidies and rewards and punishments has occupied a considerable proportion. The recycling of waste products is a social problem involving the government, enterprises and consumers, and the government's guiding role plays an important role in this process. The government needs to promote the development of the waste recycling industry by formulating relevant policies and providing financial support, and promote the active participation of enterprises and consumers.

However, in the field of new energy vehicle power battery recycling, there are still relatively few research papers in the direction of supply chain, especially on echelon utilization. The cascade utilization of power batteries refers to the process of reusing discarded batteries, which not only helps to extend the service life of batteries, reduce environmental pollution, but also helps to save resources and reduce costs. Therefore, it is of great significance to study the problem of cascade utilization and recycling of power batteries.

Through in-depth research on the problem of cascade utilization and recycling of power batteries, it can promote the sustainable development of the new energy automobile industry, improve the efficiency of resource utilization, reduce environmental pollution, and promote the green development of the economy. In addition, the study of cascade utilization and recycling of power batteries also helps to improve the competitiveness of enterprises and promote the transformation and upgrading of industries. Therefore, it is necessary to strengthen the attention and research in this field in order to achieve better development in the future.

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