

Recycling Problem in China's Lithium Battery Export

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Abstract. Lithium batteries have become an indispensable material for energy transformation and the development of the low-carbon economy. China's lithium batteries are the world's leading high-quality materials. As the main destinations of China's lithium battery exports, Europe and America have put forward more stringent recycling requirements for imported lithium batteries, which will have a significant negative impact on China's lithium batteries export data. In addition, the scrapped lithium battery itself has a greater recycling value. If the lithium battery recycling efficiency can be greatly improved, it will promote China's lithium battery industry to a higher level. Therefore, the improvement of international lithium battery recycling standards is not only a challenge to China's lithium battery industry, but also an opportunity for China's lithium battery transformation and quality improvement. China should actively respond to the challenges, increase research on lithium battery compliance of export and recycling, and take the path of sustainable development.

Keywords: Lithium battery; Export; Recycle; Green trade barrier

1 Introduction

At the beginning of 2023, the special report submitted by The General Administration of Customs of China to The State Council for the first time proposed that the export of "new three" – new energy vehicles, lithium batteries, and photovoltaic products – is China's new foreign trade growth pillar. The core components of new energy vehicles are power batteries. Batteries are electrochemical storage devices that can store energy in the form of chemical potential difference which can be used whenever and wherever it is needed [1]. While lithium batteries themselves do not generate new energy, they can efficiently store renewable energy for prolonged periods. With no memory effect, they can be repeatedly charged and discharged. If they can achieve effective integration with photovoltaic technology, they can address the challenge of storing and transmitting renewable energy, thereby enhancing energy utilization efficiency and power release flexibility, while reducing environmental costs. The cooperation between lithium batteries and new energy vehicles can reduce greenhouse gas emissions, curb excessive dependence on petroleum energy, mitigate environmental pollution, and maintain national energy security. Therefore, lithium battery has become a key material for countries to achieve the goal of a low-carbon economy, garnering world attention.

In recent years, the global economy has experienced a slowdown in growth due to the COVID-19 pandemic and the Russo-Ukrainian War [2]. The recession has exacerbated severe volatility in the renewable energy market. As a result, renewable energy is becoming increasingly pivotal in the context of globalized interactions, significantly influencing the way nations collaborate and engage with each other. Developed countries are addressing the challenge of significant indirect GHG emissions associated with imported goods, while also safeguarding their manufacturing industries, through the implementation of green trade barriers [3]. For example, they propagate "China threat theory" and frequently adopt a variety of trade protection measures to reduce the competitiveness of Chinese products and limit China to the low-end industrial chain. In the field of lithium batteries, this trend is manifested in setting high standards of lithium battery management norms and recycling requirements, aiming to establish the independence and autonomy of Europe and the United States in the field of lithium batteries and new energy vehicles. At present, China's lithium battery production is located in the world's leading, but the lithium battery recycling industry is not mature, there are still many deficiencies. High standards of recycling requirements for China's lithium battery industry pose significant challenges.

Although the green trade barrier has temporarily suppressed the export growth of China's lithium batteries, it can force China to improve the recycling technical standards of lithium batteries and promote the application of renewable energy. In the long run, if China increases research investment in lithium battery recycling technology and improves the effective recovery rate of lithium batteries, after the painful period, it will enhance the safety and sustainability of the supply of lithium battery raw materials, which is conducive to the establishment of a closed-loop economy of lithium batteries as soon as possible, and is conducive to the realization of the world energy transformation and low-carbon economy as soon as possible.

2 China's lithium battery exports encounter recycling problems

2.1 China's lithium battery exports continue to grow

China's lithium battery industry has experienced a process from scratch, from a foil to a leader. The continuous growth of exports is inseparable from the comparative advantage of China's lithium batteries in world trade. First of all, the upstream and downstream links of China's lithium battery-related industries are smooth, and the coordinated development of the industrial chain, supply chain, and value chain has been realized. Secondly, China is rich in various types of mineral reserves, which can meet the raw material supply required for the mass production of lithium batteries. Third, all walks of life in China are very concerned about the research investment in the lithium battery industry, universities and research institutes have applied for lithium battery technology research projects. Finally, the Chinese government has implemented a series of support policies for the lithium battery and new energy vehicle industry: During the "12th Five-Year Plan" period, the goal is to vigorously develop power lithium batteries; The "13th Five-Year Plan" period called for key breakthroughs in power lithium battery key technologies; During the "14th Five-Year Plan" period, the focus is on the safety of lithium batteries, and specific measures include tax reduction and exemption, financial subsidies and project guidance, etc., while promoting the development of relevant

safety and environmental standards, providing a strong policy environment for enterprise development. All in all, at present, China's lithium battery has a complete industry chain, operates upstream and downstream smoothly, has significant competitiveness and huge production capacity. It is the world's leading high-quality materials, and has great advantages in the world market (Fig.1.).

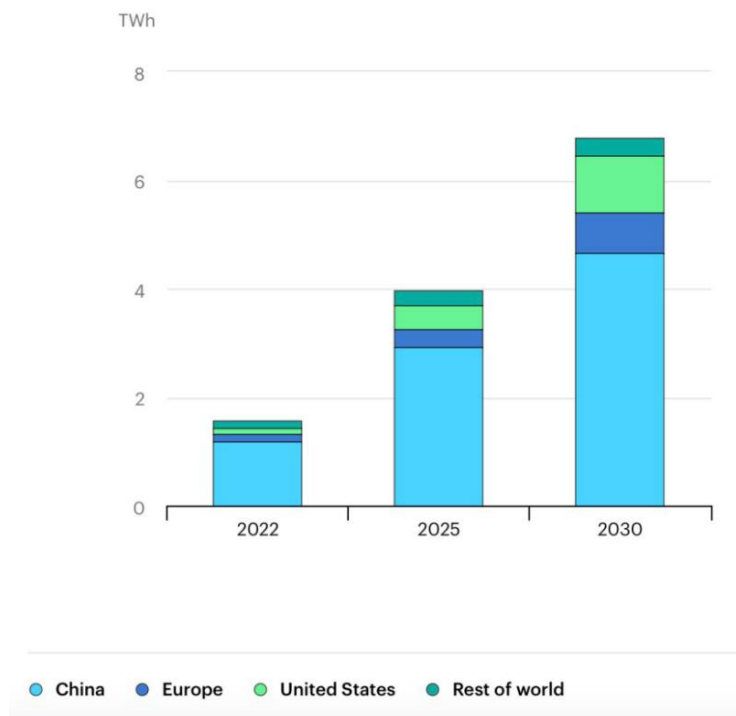


Fig. 1. Lithium-ion battery manufacturing capacity, 2022-2030

source: IEA (2023), Lithium-ion battery manufacturing capacity, 2022-2030, IEA, Paris <https://www.iea.org/data-and-statistics/charts/lithium-ion-battery-manufacturing-capacity-2022-2030>, Licence: CC BY 4.0

China has been deeply involved in the world's lithium battery-related value chain. According to the statistics of the China Industrial Association of Power Sources, in 2023, China's cumulative exports of lithium-ion batteries were 65.007 billion US dollars, which was up 27.8 percent year on year. The export market is divided by countries. The largest market is the United States, with an export amount of 13.549 billion US dollars, accounting for 20.8% of China's lithium-ion battery exports; The second largest market is Germany, with an export amount of 9.335 billion US dollars, accounting for 14.4% of China's lithium-ion battery exports; The third largest market is South Korea, with an export amount of 7.85 billion US dollars, accounting for 12.1% of China's lithium-ion battery exports. By continent, the largest market is Europe, with an export amount of 25.417 billion US dollars, accounting for 39.1% of China's lithium-ion battery exports; The second largest market is Asia, with an export

amount of 20.646 US dollars, accounting for 31.8% of China's lithium-ion battery exports; The third largest market is North America, with an export amount of 14.098 billion US dollars, accounting for 21.7% of China's lithium-ion battery exports (Fig.2).¹

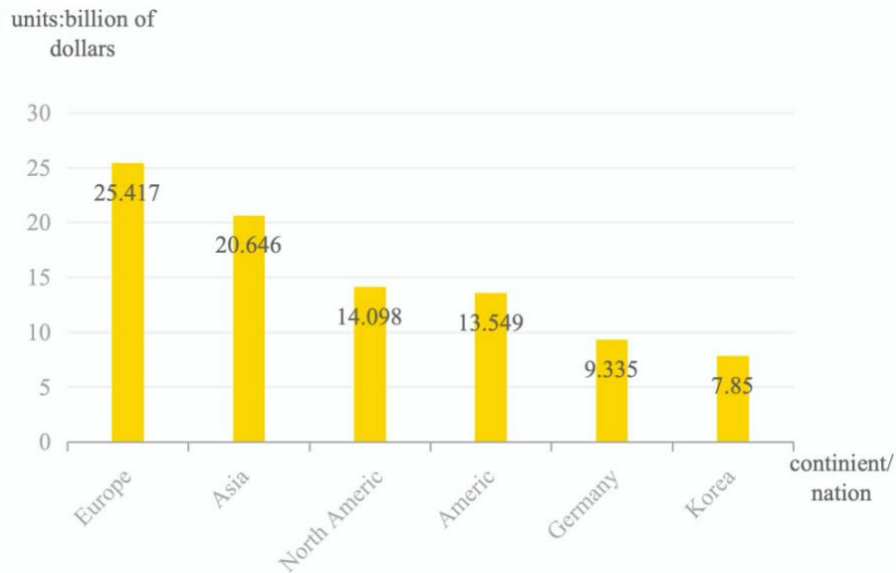


Fig. 2. The export amount of China's main export market for lithium batteries in 2023

source: China Industrial Association of Power Sources

2.2 Due to the improvement in recycling standards, China's lithium battery exports are hindered

The life of lithium batteries is generally between 5 and 8 years, and when the battery capacity is less than 80%, the battery should be replaced. At present, with the first batch of new energy vehicles entering the market during the extensive commercialization period of China's new energy vehicles (The mid-2010s) beginning to enter the decommissioning tide, the recycling of lithium batteries has been widely focused on by people. Europe and the United States have introduced regulations to strictly regulate the recycling of imported lithium batteries. On August 17, 2023, local time, the European Union's "EU Battery and Waste Battery Regulations" officially entered into force and was implemented on February 18, 2024, local time. The regulations apply to all types of batteries, including automotive, portable, and industrial batteries, as well as battery-powered vehicles and equipments. The lithium battery is included. According to the regulations, since July 2024, power batteries must declare the carbon footprint of products. And since 2027, power batteries exported to Europe must hold a "battery passport" that meets the requirements, recording the battery manufacturer, material composition, recyclable material, carbon footprint, supply chain, and other information. The power battery shall carry a clear, visible, and non-erasable label indicating the carbon footprint

¹ See the export data released by the China Industrial Association of Power Sources. <https://www.ciaps.org.cn/news/show-htm-itemid-39587.html>

of the battery and stating the carbon footprint performance level corresponding to the relevant battery model of each manufacturer. At the same time, the technical documentation should demonstrate that the full life cycle carbon footprint value declared by each manufacturer for the relevant battery model is below the maximum threshold set by the EU. Before December 31, 2025, the recycling efficiency of lithium batteries should reach 65%; Before December 31, 2030, the recycling efficiency of lithium batteries should reach 70%. The European Union's "EU Battery and Waste Battery Regulations", coupled with the previous implementation of the ban on the sale of fuel vehicles and the EU Carbon Border Adjustment Mechanism, the EU has built an integrated trade policy with "low carbon" as the core.

At the end of June 2009, the United States House of Representatives passed a "Border Tax Adjustment" bill on imported products, which has brought great pressure to developing countries. In addition, the United States promulgated the "Inflation Reduction Act" in August 2022, which required the origin of tax credit models, battery components, and origin of raw materials. From January 2024, new energy vehicles containing battery components made in China will no longer be eligible for U.S. tax credits; Even starting from 2025, key raw materials for new energy vehicle batteries will lose their eligibility for subsidies if they come from China.

Affected by relevant regulations in Europe and the United States, the export of lithium batteries and new energy vehicles has been blocked. According to China Industrial Association of Power Sources data, it shows that from January to March 2024, China's lithium-ion battery exports to Europe amounted to 5.428 billion US dollars, accounting for 42% of China's lithium-ion battery exports, 21.3% less than the same period last year; Exports to the United States amounted to 2.908 billion US dollars, accounting for 22% of China's lithium-ion battery exports, 11.2% less than the same period last year, and the number of exports decreased by 55.6%.² The implementation of green barriers has directly affected China's lithium battery export data: Europe and the United States are the main destinations of China's lithium battery exports, but China's lithium battery export data in Europe and the United States decreased significantly from January to March this year (Table 1).

Table 1 Monthly changes in lithium-ion battery exports from January to March 2024

month	Monthly exports for 2024 (million)	Monthly exports for 2023 (million)	the year-on-year growth rate	the month-on-month growth rate
1	354	301	17.60%	18%
2	241	238	1.30%	-31.90%
3	288	296	-2.70%	19.50%
Aggregate data	883	834	5.90%	

source: China Industrial Association of Power Sources

² See the export data released by the China Industrial Association of Power Sources. <https://www.ciaps.org.cn/news/show-htm-itemid-39622.html>

3 The specific challenges of the bill for lithium battery recycling in China

3.1 Increased producer responsibility

According to the European Union's "EU Battery and Waste Battery Regulations", the manufacturer of lithium batteries exported to Europe should complete the registration with the Appointed authority, and assume the responsibility of recycling. The enterprise should build, co-build, or authorize others to establish a service network, responsible for the whole process, including the collection, transportation, disassembly, classification, and reuse of scrapped lithium batteries. In the face of the sudden increase in recycling standards, large enterprises still have enough funds to support the research and invention of recycling technology and the configuration of related facilities. However, if small and medium-sized enterprises can not adjust as soon as possible, they are likely to be eliminated in the brutal market competition.

3.2 The enterprise's lithium battery recycling industry layout is insufficient

In general, the ultimate trend of scrapped lithium batteries is cascade utilization or recycling. At present, the layout of the lithium battery recycling industry of Chinese enterprises is still in the initial stag. The market access threshold is low. The leading enterprise of lithium battery recycling has not yet formed. The recycling line construction is not perfect, the recycling process has not been standardized, and the recycling channel is not smooth. The degree of systematization and automation of cascade utilization and recycling is still insufficient. The module disassembly is still mainly manual leading to, low efficiency and high error rate. Also, the error rate is high, and the evaluation of the residual value of scrapped batteries lacks a unified standard, which is difficult to cope with the next recycling tide. In addition, the correct recycling of lithium batteries also requires a large amount of investment in environmentally friendly, harmless technology and machinery, otherwise, it will still produce a large number of harmful substances that pollute the environment. Due to the lack of unified legal standards, many small businesses and small workshops attract car owners with high offers and obtain a large number of scrapped lithium batteries, they use extensive and high environmental pollution methods to deal with scrapped batteries. Put the cart before the horse. Bad money drives out good money. As the result, the scrapped lithium battery market falls into a vicious circle. The downstream second-hand market is full of recycled lithium batteries that do not meet the standards, and the security risk is high. Ultimately, it is the ecological environment and the average consumer that suffer.

Secondly, Europe and the United States have put forward information disclosure requirements for batteries, including information about battery manufacturers, battery models, raw materials (including renewable parts), the total carbon footprint of batteries, carbon footprints of different life cycles of batteries, and other information, which requires a strong data management system and monitoring system support. And for enterprises, how to strike a balance between information disclosure requirements and trade secret protection is also a huge challenge.

3.3 The economic efficiency of lithium battery recycling is low, and the willingness of enterprises to invest may not be high

To be reused, an EV battery needs to be tested, reconfigured, and fitted with a new battery-management system (BMS) suitable for the new use. This could make it more expensive than a new battery, given that prices are coming down, and its remaining life is uncertain [4]. First of all, China's lithium battery recycling industry chain is still in the process of construction, the collection, transportation, disassembly, classification, and other links of lithium batteries still need to be carried out manually, and the non-toxic and harmless treatment under specific technical and environmental conditions also has a certain amount of energy consumption, resulting in the current recovery efficiency of lithium batteries is not high and the recovery cost is high. Secondly, the ever-changing laws and the market bring uncertainty to the investment decisions of enterprises. Enterprises can only make improvements with the changes in laws and regulations, which is easy to fall into a passive state and struggle to cope with it, posing challenges to long-term and sustainable planning.

3.4 Insufficient convergence of domestic and foreign laws and regulations

The Scrapped battery recycling industry originated in the 1980s, when it was mainly concentrated in developed countries, China is relatively backward in this respect. With the development of the new energy vehicle industry and the concern for environmental protection, countries around the world will inevitably continue to introduce relevant regulations in the future, and put forward higher standards for the recycling of lithium batteries. China, as a major exporter of lithium batteries, will be affected by the uncertainty and variability of regulations in various countries. China is poorly prepared at the institutional level and has not yet effectively aligned with international recycling standards. For example, in terms of the extended producer responsibility system, China has not yet promulgated a law with a high level and strong operability. The latest relevant laws are the Measures for the Comprehensive Utilization of Power Batteries for New Energy Vehicles issued by the Ministry of Industry and Information Technology of China on December 15, 2023, and the Opinions on Accelerating the Construction of a Waste Recycling System issued by General Office of the State Council of the People's Republic of China on February 9, 2024. The former, which is still in the drafting stage, allocates the responsibility for battery recycling to new energy vehicle manufacturers and battery manufacturers, pulling the distance between scrapped new energy vehicle batteries and consumers, but the shortage is that the method does not strictly prescribe battery recycling qualifications and regulatory measures, which may lead to confusion in the battery recycling market; The latter accelerates the construction of a waste recycling system, builds a comprehensive, efficient, standardized and orderly waste recycling system by 2030, organizes and carries out lithium battery traceability management and producer recycling target responsibility system actions, and promotes the further standardization of the lithium battery recycling industry.

4 Recycling technical standards are essentially green trade barriers

After the global financial crisis in 2008, the world economy has been greatly impacted and affected. Since China joined the WTO in 2001, it has gradually occupied a dominant position

in the middle and low end of the global industrial chain by labor force, resources, and policy advantages. The rise of China has caused developed countries to worry about "China dominating the world". The "China threat theory" is rising, and trade protectionism is rising. Undoubtedly, the current rise of protectionism has induced a new challenge for the carbon reduction for both developing and developed countries [5]. Western countries, as the first subjects to form the free trade theory and benefit from the practice, blatantly violate the basic principle of free trade and lead to the strengthening of the anti-globalization trend. Environmental protection has become a "legitimate reason" for some countries to restrict and ban trade. As a result, a series of "green trade barriers" have been formed, that is, developed countries take measures to restrict the import of products from countries that have not achieved low-carbon emission reduction quotas on the grounds of environmental protection, including green environmental labels, environmental surcharges, market access requirements, green technology standards, green packaging, green hygiene measures, and green subsidies.

The emergence of green barriers has its economic and environmental factors. Reasonable green technology standards can protect the ecological environment of the country and promote the low-carbon and green of global trade. Article 20 of the former GATT granted the "environmental exception"; The WTO also explicitly stipulates in the Agreement on Technical Barriers to Trade (TBT) that "Recognizing that no country should be prevented from taking measures necessary to ensure the quality of its exports, or for the protection of human, animal or plant life or health, of the environment, or for the prevention of deceptive practices." However, a restrictive measure is often actually an imposition by a technology pioneer on a technology latecomer by their technological advantages, requiring developing countries at different stages of development to meet the technical standards and environmental standards required by developed countries. There are comprehensive provisions on the origin of imported products, key materials, health inspection and quarantine, market access, end-use, etc. These bills cooperate and complement each other, as long as one does not meet the relevant standards, it will be prohibited from import, thus building a high wall to protect the domestic industry. In addition, the green barriers of developed countries will closely integrate environmental protection with international trade, so that the essence of protectionism behind the green barriers can be hidden, in the name of "green" and "environmental protection", even if the restriction and prohibition of normal trade will eventually reduce consumer welfare, it will not be fiercely opposed by the domestic people, but will be accepted and recognized by the domestic people. To sum up, green trade barriers are concealed, extensive, opaque and formal legitimacy, which have a great impact on the export of products from developing countries.

5. The importance of improving the recycling rate of lithium batteries

5.1 It is an inevitable choice for China to deal with green trade barriers

Green trade barriers are not only a means to win space and time for the development of local industries in Europe and the United States, but also an external cause to urge China's industry to upgrade. According to the Porter Hypothesis, strict environmental regulations can induce efficiency and encourage innovations that improve competitiveness. This is because strict

environmental regulation triggers the discovery and introduction of clean technologies and environmental improvements. For China, the fundamental way to surmount green barriers is to transform traditional production and development modes [6]. Therefore, it can be said that promoting the development of the lithium battery recycling industry is the necessary way for China to cope with the current challenges of trade barriers.

5.2 It is an effective way to promote the sustainable development of China's lithium battery industry

The recycling of lithium batteries not only involves the compliance issue of the current lithium battery export, but also relates to the sustainable development of China's lithium battery industry and new energy vehicle industry. According to estimates, by 2040, the global new energy vehicle ownership may reach 300 million to 400 million, and the corresponding demand for lithium batteries is also expanding. China's key minerals and raw materials such as graphite and lithium required for the production of lithium batteries are more dependent on imports, and it is easy to be controlled by others in the trade war. For example, from 2022 to 2023, the price of lithium carbonate skyrocketed from 50,000 yuan per ton to 600,000 yuan per ton. Moreover, the impact of recycling is small in the first decades, due to rapid increases in demand and a relatively small waste stream available for recycling. On the longer term the impact of recycling increases. When substitution is applied on a large scale, this could compensate for recycling and alleviate the strain on the undersupply in the EU27 [7]. Therefore, it is necessary to adopt Circular Economy (CE), which closes the supply-chain loop through reusing, repurposing, or recycling to reduce the need for virgin materials [8]. In other words, improving the recycling rate of lithium batteries can greatly alleviate the pressure of insufficient raw materials for lithium battery production in the future, reduce the dependence on imported raw materials, reduce the production cost of lithium batteries, and also promote China's lithium batteries and new energy vehicle industry to enter a virtuous cycle.

5.3 It is a key part of promoting China's energy transformation

The temporary reduction in CO₂ emissions during lockdowns served as a stark reminder of the environmental toll linked to traditional economic activities [9]. The energy transition is imperative. The so-called energy transition is from oil and nuclear energy as the leading energy to renewable energy as the leading energy. As the largest energy producer and consumer, China plays a key role in the global energy transition [10]. On September 22, 2020, China announced at the 75th session of the United Nations General Assembly that it will strive to peak its carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060.

The two pillars of the energy transition are greater energy efficiency and a higher share of renewable energy. Currently, while fossil fuels represent a declining share of the global energy supply mix, overall supply is still over 80% [11]. Today's carbon-based energy system has negative impacts on the environment, society, and economy. In an age of population growth and rising energy demand, ongoing fossil fuel depletion and climate change call for alternative, sustainable solutions that depend on very-high shares of renewable energy (RE) [12]. Only by improving the recycling efficiency of lithium batteries, increasing the share of new energy use, reducing the dependence on single non-renewable traditional energy sources such as oil and coal, and establishing a diversified energy supply system, can carbon dioxide emissions be significantly reduced (Fig. 3.).

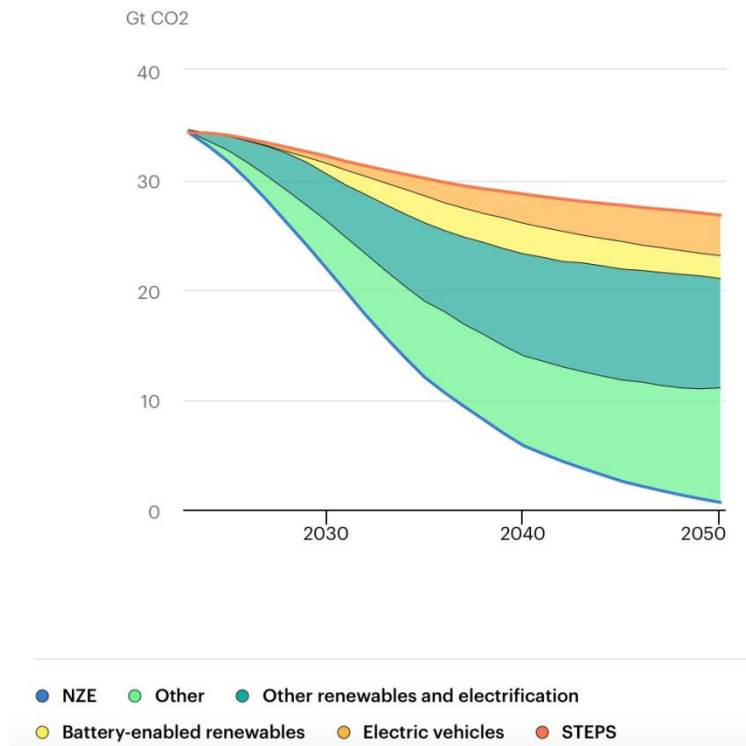


Fig. 4. CO2 combustion emissions avoided by batteries and other technologies by scenario, 2023-2050

source: IEA (2024), CO2 combustion emissions avoided by batteries and other technologies by scenario, 2023-2050, IEA, Paris
<https://www.iea.org/data-and-statistics/charts/co2-combustion-emissions-avoided-by-batteries-and-other-technologies-by-scenario-2023-2050>, Licence: CC BY 4.0

6 Countermeasures

6.1 Enterprises should improve the overseas layout of lithium batteries

The Inflation Reduction Act, signed into law by the United States in August 2022, requires that power batteries be manufactured from components mined or processed in the United States or its free trade partners to qualify for preferential treatment. Although Europe and the United States do not want to localize China's lithium batteries, because the local lithium battery industry in Europe and the United States lags in terms of technology, cost, capacity, scale, etc., the construction of the local lithium battery industry chain is incomplete, and there is still room for China's lithium batteries to enter. At present, more than 75% of lithium batteries in the world market are produced by China, and many of the raw materials required for lithium battery production are abroad, and most of the demand is also abroad. For China, if the transportation costs of raw materials and finished lithium batteries can be reduced, the international competitiveness of China's lithium batteries will be greatly improved.

Therefore, Chinese power battery companies can understand the differences in the demand for vehicle products in different countries and different companies, as well as raw materials, labor costs, investment laws, and related policies in each country, and carry out reasonable plant location and supply chain planning based on the compliance requirements of recycling technology in the target market. This can not only meet the legal requirements for the localization of lithium batteries, but also help strengthen cooperation with local enterprises, understand the personalized demands of local users, strive for more policy preferences, and establish a sound production-recycling integrated process. At present, some Chinese lithium battery and new energy vehicle companies have built or are planning to build factories overseas, mainly in Europe, Southeast Asia, the United States, and other countries. For example, in September 2021, CatL announced the establishment of a strategic partnership with BASF Europe in the field of battery material solutions to promote CatL's localization process in Europe; Byd set up a joint venture with UzAuto Motors in Uzbekistan in 2023, capable of producing 50,000 electric vehicles a year; Chery International has formed a partnership with ADM Jizzakh.

6.2 Enterprises should strengthen the development and utilization of recycling technology

The previous product development model is from the cradle to the grave, and the circular economy is to achieve from the cradle to the cradle, to achieve the closed-loop of the forward supply chain and the reverse recycling chain, and improve the certainty and reliability of the source of scrapped lithium batteries. Therefore, in the face of European and American lithium battery recycling technology standards, China should strengthen the research and invention of battery decomposition and recycling technology, improve the efficiency and quality of battery recycling facilities, ensure the controllability and sustainability of the recycling process, introduce advanced international experience, and establish long-term and close cooperative relations with the world's advanced enterprises to jointly promote the development of the battery recycling industry. In addition, enterprises should pay close attention to national policies and regulations and actively apply for subsidy projects that meet the requirements. At present, CATL and Volvo have launched in-depth cooperation in the field of battery cycle closed-loop management. At the same time, appropriate waste management systems, including logistics and infrastructure development, must be adapted to recover the valuable materials incorporated in batteries as their volume increases [13]. Through these efforts, China can turn the battery recycling problem into a new driving force for economic growth, achieving a win-win situation for economic benefits and environmental protection.

6.3 Enterprises should take advantage of the bill's buffer period to strengthen patent distribution

China's lithium industry started relatively late, except for lithium battery anode material patents, the patent layout of other materials lags behind European, American, Japanese, and South Korean companies. Europe, the United States, Japan, and South Korea used the first-mover advantage to build a "patent wall." It is foreseeable that more bills will be issued in the future to improve the technical standard requirements of lithium battery-related industries, and lithium battery manufacturing and recycling will become the focus of the patent layout of enterprises in various countries. Although the "EU Battery and Waste Battery Regulations" has made strict provisions on lithium battery recycling standards, the provisions are not effective

immediately, but take effect with the advance of time, which is conducive to China's lithium battery management and recycling enterprises to grasp the content of the regulations and study the corresponding plans during the buffer period. Especially in lithium battery recycling technology, China should increase investment in research and invention, reduce the dependence on the patented technology of developed countries, establish China's patent network, and reduce the risk of falling into overseas intellectual property disputes in the future. At the same time, the huge cost of early research can also be compensated by the revenue from patents.

6.4 Enterprises can seek diversified markets

China can also consider developing new markets for lithium battery export, such as Southeast Asia, Central and South America, the Middle East, and other regions. These areas have extensive methods of production. The electric power coverage in the region is not wide and relatively dispersed. Natural disasters are frequent. So they are actively promoting the replacement process of renewable energy for fossil energy. Therefore, the demand for lithium batteries is large, and the recycling standards are not as strict as Europe and the United States. According to data released by the International Energy Agency, in 2023, electric vehicle registrations in India increased by 70% year-on-year to 80,000 units; In Thailand, EV registrations more than tripled year on year to nearly 90,000 units, reached a remarkable 10% share of sales - on par with the US share; In Vietnam, after an extraordinary 2022 for the overall car market, car sales contracted by 25% in 2023, but electric vehicle sales still saw unprecedented growth; In Malaysia, electric vehicle registrations more than tripled to 10,000 units; In Latin America, electric vehicle sales reached nearly 90,000 units in 2023. Across Africa, Eurasia, and the Middle East, electric vehicles remain rare, accounting for less than 1% of total vehicle sales.³ However, as Chinese automobile manufacturers look for opportunities abroad, new models - including domestically produced ones - could boost sales of electric vehicles.

6.5 Accelerate the formation of synergy between the government and the industry

The low recycling fraction for lithium remains is a technical hurdle to be overcome and a political management challenge. Our simulations suggest it will stabilize around a maximum of 50% by market force mechanisms alone, which is not sufficient for solving the electrical vehicle transition challenge [14]. The lithium battery recycling industry needs the government to play a role, and the government uses administrative orders to implement the strategic goal of regeneration in the core position, carries out top-level design, and organizes enterprises and the public to act together. Therefore, the government can take the lead in establishing relevant lithium battery export support agencies, provide relevant enterprises with export compliance training and risk early warning, help enterprises improve their policy sensitivity to export places, establish a sound industry mutual assistance mechanism, promote intra-industry and inter-industry exchanges, and improve the interaction between the upstream and downstream industry chains. Under the premise of equality and mutual assistance, promote the exchange of technologies and talents in the lithium battery industry, discuss matters related to lithium battery recycling standards through dialogue and cooperation mechanisms at the international

³ See the International Energy Agency's Global EV Outlook 2024 - Trends in electric cars. <https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-cars>

level, and jointly promote the green and environmental protection of lithium battery manufacturing and recycling. In addition, the Chinese government should standardize at the height of policies and laws, learn from the relevant legislative experience of Europeans and Americans, clarify the distribution of responsibilities for lithium battery recycling, standardize the standards of various processes for lithium battery recycling, and severely crack down on the gray industry that collects, disassembles and reuses scrapped lithium batteries in violation of regulations. According to research, the higher the environmental taxation, the lower the propensity to invest in green technologies [15]. Therefore, the government can appropriately reduce and reduce the tax on lithium battery recycling enterprises, and provide appropriate subsidies to the lithium battery recycling industry, to quickly establish a compliant and environmentally friendly lithium battery recycling industry chain, form a national standard and industry standard for the lithium battery recycling industry, and standardize the lithium battery recycling market and third-party certification market. Finally, the government and enterprises should strengthen cooperation in publicity and education for the public, especially to help new energy vehicle owners establish a correct understanding of lithium battery recycling, and advocate for recycling scrapped lithium batteries through compliance channels.

7 Conclusion

This paper proposes the development direction of China's lithium battery recycling industry in the face of green trade barriers in Europe and the United States. Low-carbon economy has been considered by some scholars as the goal of the fifth Industrial Revolution. At present, the time limit for China to achieve "carbon peak" has been less than ten years, and the time to reach "carbon neutrality" after "carbon peak" is also very short. While the urban energy system of China is still heavily reliant on fossil fuels. The high consumption of coal and oil products by industry and transport have brought about significant carbon emissions and environmental pressures [16]. Compared with the financial and technological advantages of developed countries, it is difficult for China to occupy a place in the wave of low-carbon economy and green economy.

The green trade barriers in Europe and the United States warn China to see its weaknesses in the whole life cycle management of lithium batteries, and China's lithium battery industry still has many shortcomings in the recycling stage. In addition, with the retirement of the first batch of new energy vehicles, a large demand for new equipment has emerged, and there is significant recycling pressure on lithium batteries. Under the dual pressure of the external environment and the internal industry, China must establish a sound recycling industry chain to cope with these challenges.

Improving the efficiency of lithium battery recycling is not only a trade and industry requirement, but also a requirement for the sustainable development of human society. Until breakthroughs in controlled nuclear fusion lead us into an era of energy freedom, we must use clean technologies and clean energy to reduce pollution and lower carbon emissions. We need to abandon the traditional development model of sacrificing the environment for economic gain and achieve a balance between global economic development and a healthy ecological environment through green industrial upgrades. Lithium batteries must move towards a benign development path of environmental protection and sustainability. Improving the efficiency of

lithium battery recycling will reduce the import of large quantities of critical materials and natural mineral resources, decrease energy consumption and emissions in battery production, and help lower battery costs. If not recycled, the cathode active material produced by Scrapped lithium batteries - the most important and expensive part of the power battery - will become a wasted resource, which will further increase the cost of dumping or storage.

In conclusion, the recycling of lithium batteries is of great importance for resource conservation, environmental protection, energy recycling, and waste reduction. It is a crucial aspect of sustainable development. Governments, businesses, and society should work together to establish a comprehensive recycling system and regulatory framework to promote the recycling of lithium batteries. The Chinese government should actively study relevant legislation from Europe and the United States on lithium battery recycling, strengthen policy support, attract more public and private capital into the lithium battery recycling industry, advance cutting-edge legislation, and promote standardization within the lithium battery industry. Chinese companies should increase investment in research and innovation to improve lithium battery recycling efficiency, promote the gradient use and regeneration of lithium batteries, and minimize the carbon emissions throughout the entire lifecycle of lithium batteries, including production, packaging, transportation, and recycling. It is also crucial to enhance carbon footprint monitoring of lithium batteries. The Chinese lithium battery industry should accelerate the establishment of an overseas presence and patent portfolio in the recycling sector, foster leading companies in the recycling industry, align with international standards, and quickly establish unified industry and national standards. This will provide high-quality supply for China's and the world's energy transition and low-carbon economy.

If China can dominate key technological fields such as lithium battery recycling, it will significantly advance the country's low-carbon economy and the "dual carbon" strategy. Green trade barriers will no longer hinder the export of Chinese lithium batteries. Developed countries, rather than contemplating how to restrict imports from developing countries, should consider adopting appropriate policies to promote their own industrial upgrades, maintain fair competition in the global market, and foster progress in various industries through cooperation and innovation. Prioritizing long-term and overall benefits over short-term and localized gains is essential. Only through collaboration and exchange can scientific and technological advancements be achieved, benefiting both domestic and foreign interests, and realizing a win-win scenario for both the environment and the economy.

8 Shortcomings and prospects of this paper

This paper puts forward some suggestions on the construction of the lithium battery recycling industry in the macro aspect, but does not put forward specific design suggestions on the micro aspect such as the technical improvement and performance testing of lithium battery recycling. In addition, the paper does not propose a specific approach to tax policy reform - to achieve a balance between energy transition and government revenue. The consumption tax on fossil energy is one of the government's revenue sources. The continuous expansion of new energy vehicles and lithium batteries, will squeeze the market share of fossil energy. The government's corresponding tax will be reduced. The development of new energy vehicles and

lithium batteries also need policy support, including subsidies, tax incentives, loan concessions, etc., which will be a large burden.

Energy transformation and green development must be the direction of future development. After overcoming the challenges brought by the new regulations, the innovation and development of lithium battery recycling technology will enable Chinese lithium battery recycling enterprises to gain a greater competitive advantage in the global market and promote the global battery industry to be more environmentally friendly and efficient.

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