



ZERO EMISSION
TRANSPORTATION
ASSOCIATION

July 11, 2022

Michael S. Regan, Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue NW, 1101A
Washington, DC 20004

Re: Response to Request for Information (RFI) No. EPA-HQ-OLEM-2022-0340: Development of Best Practices for Collection of Batteries To Be Recycled and Voluntary Battery Labeling Guidelines

Please find the Zero Emission Transportation Association (ZETA's) response to the Environmental Protection Agency (EPA's), EPA-HQ-OLEM-2022-0340: Development of Best Practices for Collection of Batteries To Be Recycled and Voluntary Battery Labeling Guidelines. Responses to specific questions in the RFI are detailed below.

ZETA is an industry-backed coalition of 55 member companies advocating for the shared goal of achieving 100% electric vehicle (EV) sales in the United States by 2030. Our members represent the entire domestic EV supply chain and include vehicle manufacturers, charging companies, critical mineral producers, battery recyclers and utilities. As a result, we have a robust understanding of the need for improved lithium-ion battery recycling processes and welcome the opportunity to comment.

Background:

The Infrastructure and Investment Jobs Act (IIJA) provides EPA with \$10 million to establish best practices for battery collection and \$15 million to develop voluntary labeling guidelines to improve battery reuse and recycling. These programs will help us reduce our dependence on foreign nations for minerals, encourage the growth of the battery recycling industry, and provide access to a domestic stockpile of minerals.

Increasing the collection of used batteries is a crucial first step to expanding up the nation's battery recycling program. Robust federal policies will ensure a sufficient and guaranteed stream of recycled materials to justify continued private-sector investment in the battery recycling industry. Improved recycling processes will not only reduce dependence on other sources of critical minerals but will increase safety: these processes prevent potentially hazardous materials from entering the conventional waste stream.

ZETA offers the following recommendations relating to the guidance on best practices and establishing a program to promote battery recycling.

Section A

What types of battery handlers in the reuse and recycling system should be included in the best practices for the collection of batteries for recycling?

Gathering information from all parties involved in the generation and handling end-of-life (EOL) batteries is critical when developing best practices for battery recycling. This includes battery manufacturers, consumer electronic OEMs, vehicle OEMs, vehicle/battery dismantlers, battery refurbishers and repurposers, vehicle retailers and service centers, and battery recyclers. Each of these parties could inform and potentially be responsible for proper disposal of an EV battery, so they should be included in conversations on battery collection and recycling.

What are the recycling markets for batteries? Which battery types/chemistries serve as feedstock into manufacturing new batteries?

The value of the market for EV battery recycling alone is estimated to reach \$8.6 billion in the next five years.¹ This growth is largely driven by the growing number of EVs approaching their EOL. The volume of EOL batteries from EVs and large storage applications is less than 2GWh today but could reach 100 GWh by 2030 and 1.3TWh by 2040.² Battery recycling companies like ZETA members Li-Cycle, Redwood Materials, ABTC, and 6k take in end-of-use batteries to preserve the value of the minerals. Similarly, Tesla has successfully installed the first phase of their cell recycling facility at Gigafactory Nevada for inhouse processing of both battery manufacturing scrap and end-of-life batteries. By the end of 2021, this facility achieved a production rate of over 50 tons of recycled material per week. The types of batteries that can be used as feedstock depends on the recycler in question; US-based recyclers currently utilize a wide array of recycling methodologies and thus have different acceptable feedstock specifications. That said, the most commonly used and commercialized chemistry formats (e.g., NMC, NCA, LFP, LCO) are generally accepted. As the first generation of electric vehicles—predominantly the Toyota Prius—is retired, Redwood Materials has partnered with Toyota to create a closed-loop battery recycling system.

Cathode metals such as nickel, cobalt, aluminum, iron, and lithium can be recovered, refined, remanufactured, and sold directly to battery producers. Furthermore, as the market for electric vehicles grows, analysts project the demand for critical minerals to expand exponentially. As it stands, current mineral production in the U.S. is not capable of meeting 100% of demand. Fortunately, the recycling and reuse of existing battery materials can drastically expand the supply of critical minerals. Today, Redwood Materials receives the equivalent of up to 80,000 electric vehicle batteries per year in materials for recycling. By 2040, EV battery recycling can recover around 10% of total material supply needs.³ As the demand for battery materials continues to grow, the market for recycling batteries will similarly see an increase in supply and demand.

Beyond EV and utility-scale storage batteries, smaller consumer electronics batteries make up the majority of batteries recycled today.

¹ [Global Electric Vehicle Battery Recycling Market \(2022 to 2027\) - Industry Trends, Share, Size, Growth, Opportunity and Forecasts - ResearchAndMarkets.com | Business Wire](#)

² [Reliable supply of minerals – The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA](#)

³ [Reliable supply of minerals – The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA](#)

Section B

What are the barriers to recycling and reuse of batteries?

Under current regulations, the material handling, packing, transporting, storage of lithium-ion batteries (LIBs) is costly. Transportation logistics account for over half of the cost of recycling an EV battery;⁴ As a Class 9 hazardous material, LIBs require special handling for transportation when not installed in a vehicle, increasing the costs and complicating the recycling process. Fortunately, companies are developing innovative techniques to address the transportation issue. Li-Cycle, a ZETA member, uses a “hub and spoke” model for their recycling business. In this process, batteries will be collected in large quantities at spoke facilities across the country, where they are broken down into three main components and either sold as is or transported to a central hub to separate each metal.⁵

Additionally, the lack of mutually agreed upon industry-standard best practices for material packing, labeling, and transportation often complicate the recycling process. Providing a set of holistic best practices to lithium battery generators that provides guidance for the totality of the activities involved in the management of EOL materials (e.g., on-site storage, material packing, labeling, safe transportation measures, etc.) would remove friction and cost for recyclers. Standardizing safety across the industry could allow for much more efficient engagements between generators and recyclers thereby reducing cost.

It can be difficult to know the appropriate recycling stream without knowing the battery’s chemical composition; labeling batteries would ensure the entity responsible for recycling the product is supplied with the appropriate information on the battery pack to properly recycle it.

What are the concerns and challenges with battery recycling faced by each entity in the battery recycling chain?

The primary challenges include safety concerns, proprietary battery information, and accessing the materials in the battery pack. Because batteries are compact and come in a variety of compositions, they are currently not well-suited for disassembly. Opening the battery pack to retrieve the valuable materials inside can be costly and time-consuming. Additionally, there are a variety of battery chemistries unique to different producers and OEMs. Understanding the components of each unique battery can be difficult without clear labeling. One solution is implementing a labeling standard to facilitate easier recycling processes at EOL.

Economic factors present another challenge. Many potential investors are wary of battery recycling. Their hesitancy stems from the unpredictability of prices for the raw materials in batteries.⁶ Should prices of battery inputs drop considerably, battery recyclers would face difficulties in competing against newly mined materials on the market.

What types of batteries (e.g., small consumer batteries, large format vehicle and grid energy storage batteries, and industrial batteries) and chemistries are targeted for collection?

⁴ [Alliance for Automotive Innovation - Recycling Policy Framework Lithium-Ion EV Battery](#)

⁵ [Amazon, Panasonic, and recycling start-ups prepare for battery wave tsunami](#)

⁶ [Chemical and Engineering News: “It’s time to get serious about recycling lithium-ion batteries”](#)

Recyclers generate revenue from the component materials they are able to collect from and re-sell into markets. Because of this, batteries that contain higher-value commodities like nickel and cobalt tend to be prioritized by recyclers. These high-value commodities can be present in all battery format types, regardless of industry. ABTC and other recyclers are relatively agnostic to the form factor of the battery and thus target the collection and processing of materials from all industries that use lithium ion batteries in their products.

Moreover, cathode active material and copper foil make up nearly 65% of the cost of a battery because of the critical minerals they require. Specifically, the nickel and cobalt in battery cathodes are targeted by most recyclers as they fetch the highest resale prices.⁷ As such, lithium-ion battery recycling focused on the cathode materials and battery copper foils can drastically reduce the cost of lithium-ion battery manufacturing. Today, these materials are not produced in the United States at scale, and battery recycling offers the opportunity to manufacture these products domestically.

When do original equipment manufacturers take back or retain ownership of batteries at end-of-life?

There are a variety of circumstances where an OEM takes back ownership of a battery at EOL. At present, most batteries are still under warranty. If a battery has to be replaced under warranty, an OEM can take the battery back and determine the next steps, including remanufacturing of the battery pack or second life uses. Sometimes, an OEM will accept a battery that isn't under warranty, such as in the case of a totaled vehicle. In the rare case that no one else wants the battery, OEMs can take it back. All of that said, not all OEMs have a system in place to accept batteries, so the policy for battery collection will vary by OEM.

EPA should consider additional policies as it gains knowledge on battery recycling. In addition to the requirement that OEMs handle batteries that are still under warranty, core exchange with a vehicle backstop and producer take-back are two policies that can guide potential recyclers. Building on existing industry standards, the core exchange and vehicle backstop policy outlines three pathways for out-of-warranty batteries.⁸

1. If an EV is still in service and a battery replacement is needed prior to EOL, the party selling the battery, either **refurbisher or manufacturer**, is responsible for replacing the battery and ensuring the used battery is properly managed. The **party removing the battery** is responsible for ensuring proper reuse, repurposing, or recycling of the battery.
2. At EOL, when a dismantler gains ownership of the vehicle, the **dismantler** is responsible for ensuring proper reuse, repurposing, refurbishment, or recycling of the battery. If the battery is reused for another vehicle without changes, the still-in-service pathway applies. If the battery is refurbished or repurposed, the **refurbisher or repurposer** becomes responsible for the battery.
3. If a licensed dismantler does not acquire or remove an EOL EV OEM-certified battery, the OEM is responsible for the proper dismantling of the vehicle and ensuring proper reuse, refurbishment, or recycling of the battery.

⁷ [Millions of electric cars are coming. What happens to all the dead batteries? | Science](#)

⁸ [Lithium-ion Car Battery Recycling Advisory Group Final Report](#)

The second policy proposal is producer take-back, which places the ultimate responsibility on the OEM to ensure proper reuse, repurposing, or recycling of the EV battery.⁹ In the case that no other entity wants the battery or takes possession of it, OEMs would be required to figure out the proper disposal of their vehicles' EOL EV batteries. In the case that the battery is to be repurposed, the repurposing company becomes responsible for coordinating the logistics of the battery's transport, paying recycling costs, and documenting the disposal. To ensure that consumers are aware of this process, OEMs should supply consumers with educational materials through various outlets, such as in-service manuals and online, that explain how to return EOL EVs and their batteries.

Which used batteries are designated for second life or refurbished?

Of the potential options for a battery facing retirement, such as reuse, restore, recycle, incineration, or disposal, all methods except reuse involve dismantling and discarding parts of the battery pack. The reuse method allows retired battery packs to have a second life in various places, such as low-speed electric bikes and cars or even renewable energy generation and grid applications. When a battery pack arrives at a reuse company, the company registers its history, including age and composition of the battery, OEM, and reasons for retirement. Based on this analysis, the reuse company will estimate the salvage value of the battery and decide which disposal method fits the battery pack the best. The figure below highlights the full assessment process used to evaluate retired lithium-ion batteries.

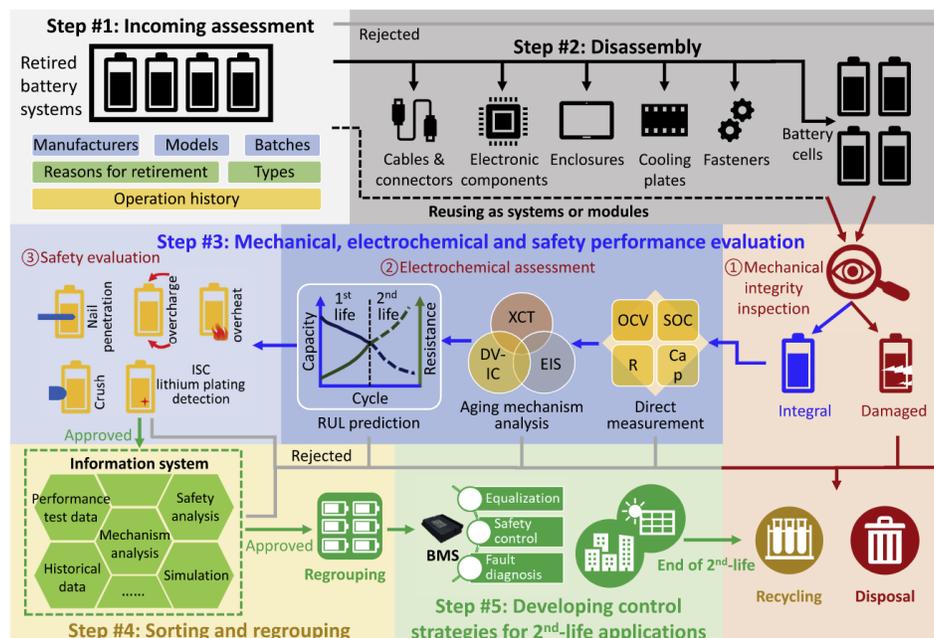


Figure 4. Assessment procedure of retired lithium-ion batteries
This is an exemplary illustration that summarizes information from different publications.^{13,21,67,69,70,71} Real-world applications may vary from one another. However, a common feature is that the entire procedure involves many costly human-aided steps with inevitable uncertainties.

Eventually, all second-life batteries will reach EOL, at which point they are most likely dismantled and their component parts recycled. That said, remanufacturing or repurposing for second life is usually considered prior to recycling, as it extends the life cycle of the battery packs while saving costs and benefiting the environment.

⁹ [Lithium-ion Car Battery Recycling Advisory Group Final Report](#)

What are the markets for second life and refurbished batteries?

Once a battery reaches the end of its useful life for vehicle applications, it usually retains a significant storage capacity. This opens the door for second-life applications including use cases such as on-site storage at transit depots, solar fields, or charging stations. On-site storage can provide additional value to larger fleets, transit agencies, and school districts by reducing their peak electricity demand on the grid.

Larger battery packs, such as those for electric buses and long range light-duty vehicles, can serve a second life as stationary storage. This provides additional revenue for the vehicle owner, who can sell the battery at the end of its useful vehicle life. When a battery has degraded so much that it is no longer useful for any application, it can be recycled.

How does the pre-processing technology impact the amount of the materials recovered from the used batteries?

Redwood Materials is capable of recovering an average of 95% of battery materials like nickel, cobalt, lithium, and copper. By 2025, Redwood Materials will manufacture enough copper foil and cathode material to produce more than one million electric vehicles, and by 2030 will be able to supply over 5 million electric vehicles.¹⁰ Other ZETA member recycling companies, Li-Cycle and ABTC, recover lithium-ion battery materials and achieve this at a lower cost than newly mined and refined material.¹¹

Pre-processing techniques may impact contamination rates within the products sold by recyclers (e.g., ferrous/non-ferrous metals, black mass, and cathode-grade sulfates). More advanced pre-processing has the potential to reduce and/or eliminate contaminants reducing refining costs.

What technologies are utilized to recycle batteries?

Recycling facilities utilize various technologies to recycle lithium-ion batteries. The three major categories of technologies used include pyrometallurgy, hydrometallurgy, and electrochemical extraction.¹² Pyrometallurgy is a method where a facility utilizes high temperatures and evaporation to remove organic material while causing reactions in the cathode and anode to extract lithium. Hydrometallurgy, the most commonly used technology, utilizes acids and bases to ionize lithium before ultimately leaching the material to make the lithium extractable. Lastly, electrochemical extraction involves splitting up lithium and pre-treated active materials through a lithium-selective transmissive membrane to extract the lithium. This method extracts up to 95% of the lithium, and can even extract lithium metal with purity of 99%. Also, this method does not require increased temperatures or chemicals for resource extraction, making it an eco-friendly alternative to prior technologies. That said, electrochemical extraction has only been proven in a laboratory setting.

There are also emerging technologies in this space. DOE's ReCell Center recently discovered direct cathode recycling. This process directly recovers cathode material instead of metal salts, offering the most potential for cost-effectiveness. 6K Energy endorses a direct recycling process with its UniMelt plasma process, which ensures that EOL cathodes regain lost lithium, thermally heal from mechanical damage,

¹⁰ [Written Testimony of JB Straubel, CEO of Redwood Materials, before US Senate Committee on Energy and Natural Resources](#)

¹¹ [New Flyer Electric Bus Batteries Recycled with Li-Cycle. A first pilot](#)

¹² [Technologies of lithium recycling from waste lithium ion batteries: a review](#)

and receive current generation chemistry.¹³ Also, ultrasonic delamination of electrodes is a relatively new recycling method that uses ultrasonic technology and mild solvents to extract critical minerals such as lithium and cobalt.¹⁴ Because this process completes electrode separation rather than battery shredding, this method is a faster, less energy-intensive way of recovering critical minerals while retaining a high level of purity.¹⁵

Section C

What should be the goals of developing voluntary labeling guidelines for batteries (e.g., increase critical minerals recovery, provide information to consumers about recycling and where they should bring their batteries; provide information to sorters and/or recyclers about the chemistry in the batteries; provide information to entities in the vehicle management chain – dealerships, repair shops, auction houses, dismantlers, entities that repurpose electric vehicle batteries, refurbishers, and scrap yards about vehicle battery recycling)?

Labeling batteries facilitates cell identification, which makes the recycling process safer for all parties across the vehicle management chain. When parties know the chemical composition of the batteries, they will be able to quickly and safely identify the critical minerals to facilitate recovery. Labeling the battery pack's chemistry is crucial for safe handling, dismantling, and recycling.

The California Air Resources Board (CARB) Advanced Clean Cars II proposal, which is described in more detail below, outlines specific labeling requirements that aim to make ZEVs serviceable and support consumer confidence in these vehicles as they replace ICEVs.¹⁶ By providing specific battery information on the labels, parties across the supply chain will have the knowledge and confidence to properly reuse, refurbish, repurpose, recycle, or dispose of EV batteries.

What considerations should be accounted for in developing labeling guidelines for batteries that will be widely adopted for use by battery producers/manufacturers?

ZETA recommends standardizing battery labels at the federal level. If states are left to develop their own standards, it will be difficult for companies to comply with the varying patchwork of standards across states.

Regarding a physical battery label, it is important to list the information that helps parties identify the battery pack chemistry. For that reason, battery labels include information such as the chemical composition, anode and cathode types, OEM, and manufacture date following SAE J2984 standards.¹⁷ Battery labels should also include minimum voltage, rated capacity based on SAE J2288 standards, and a digital identifier/QR code that links to a website with all of the aforementioned information. Since these labels are similar to those used in internal combustion engine vehicles (ICEVs), there should be little

¹³ [Disrupting materials design and production for Li-ion batteries | 6K Energy](#)

¹⁴ [Electrode Recycling - Highly Efficient with Ultrasonic Delamination](#)

¹⁵ [Electrode Recycling - Highly Efficient with Ultrasonic Delamination](#)

¹⁶ [CARB's Advanced Clean Cars II Proposed Amendments to the Low Emission, Zero Emission, and Associated Vehicle Regulations Standardized Regulatory Impact Assessment \(SRIA\)](#)

¹⁷ [CARB's Advanced Clean Cars II - Proposed Regulation Order: Battery Labeling Requirements](#)

incremental costs associated with labeling. On average, CARB estimates labeling costs to be around five cents per vehicle while the physical label costs one cent per label.¹⁸

OEMs should include a QR code as part of the battery labeling. This QR code requirement, suggested in CARB's Advanced Clean Cars II proposal, would link to a website with information on the EV battery.¹⁹ The website should contain all of the information listed on the physical battery.

Section D

How do battery producers think about reusing and recycling critical minerals from used batteries?

The EV battery market is projected to surpass 2.4 million metric tons of lithium carbonate equivalent (LCE) in 2030, a 259% increase from current demand.²⁰ With that projected market growth, battery producers are looking for ways to meet the demand, including recycling EOL batteries.

While recycling is going to be an important part of the EV supply chain, it should not be seen as the sole source of critical minerals. The Department of Energy recently stated that they hope that 40 percent of the raw supply chain will eventually come from recycled EV batteries. It is important to acknowledge that critical mineral extraction remains necessary, because overemphasizing recycled material usage could needlessly delay transportation electrification. For example, policies like minimum recycled content standards could cap EV adoption by limiting production volumes and increasing battery cell costs.

ZETA member company Proterra designs its batteries with second life use and recycling in mind. At EOL, Proterra's batteries retain a lot of energy which can be used for stationary energy storage. The battery packs are stackable, which is also useful for storage systems, and the materials are suitable for outdoor weather conditions. Proterra prioritizes finding second-life use for its batteries before recycling them, as it extends the life of the battery by providing additional utility. If the batteries cannot be reused, the batteries are equally suited for recycling. In fact, 100% of the battery pack's aluminum is recyclable, and Proterra works with recycling companies to recover 99% of the precious metals in the batteries.²¹

Two ZETA member companies, Redwood Materials and Panasonic, have entered into a partnership to incorporate more recycled materials into Panasonic's batteries.²² The copper foil recovered at the Redwood Materials facility in Carson City, Nevada is transported to Panasonic's nearby facility to be used in cell production.

¹⁸ [CARB's Advanced Clean Cars II Proposed Amendments to the Low Emission, Zero Emission, and Associated Vehicle Regulations Standardized Regulatory Impact Assessment \(SRIA\)](#)

¹⁹ [CARB's Advanced Clean Cars II - Proposed Regulation Order: Battery Labeling Requirements](#)

²⁰ [EVO Report 2022 | BloombergNEF | Bloomberg Finance LP](#)

²¹ [Battery Technology | Proterra](#)

²² [Panasonic to use Redwood's recycled materials in battery cell production at Tesla gigafactory | TechCrunch.](#)