White Paper Summarizing the Findings from the U.S. Environmental Protection Agency's Battery Labeling Outreach and Research (2021 to 2024)

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Contents

Abbreviations

BIL	Bipartisan Infrastructure Law
DOE	The U.S. Department of Energy
EOL	end-of-life
EPA	U.S. Environmental Protection Agency
EPR	extended producer responsibility
LIB	lithium-ion battery
MRF	materials recovery facility
QR	quick response
RFI	request for information

1 Introduction

A clean energy transformation is underway. As the United States rapidly transitions away from fossil fuels, renewable energy sources are seeing unprecedented growth. Batteries are playing a central role in this transformation. They power everything from cars and trucks to electric bikes (e-bikes) and consumer electronics. They are also used in many industrial applications, from powering construction and agricultural equipment to providing backup power for critical infrastructure and storing energy for renewable power generation. As battery use increases globally, so does the demand for critical materials needed to manufacture single-use and rechargeable batteries.

To reduce global reliance on the mining of virgin raw materials, including cobalt and lithium, the United States will need to increase the recovery of these critical materials from end-of-life (EOL) batteries. However, increasing these recovery rates will require overcoming the current technological, economic, regulatory, and social barriers to the safe collection and recycling of batteries. Today, many batteries are disposed of in municipal solid waste or recycling because consumers lack information on how or where to properly manage them. Products containing embedded batteries are often disposed of in municipal solid waste because consumers are unaware of the presence of a battery.

Sections 70401 and 40207 of the Bipartisan Infrastructure Law (BIL) direct the U.S. Environmental Protection Agency (EPA) to address these challenges along the battery life cycle through the development of voluntary battery labeling guidelines, battery collection best practices, consumer education materials, and a national extended producer responsibility (EPR) framework for batteries drafted in close coordination with the U.S. Department of Energy (DOE).[1] Together, these efforts will help state, local, and Tribal governments establish and improve battery collection programs and help consumers more easily participate in proper battery EOL management, reducing the frequency of safety incidents from improper battery disposal (e.g., fires at waste management facilities).

By developing new voluntary battery labeling guidelines, EPA seeks to increase consumer awareness of the presence of batteries in products and to empower consumers to properly dispose of them, depending on their local collection programs. Additionally, EPA aims to increase the proper identification and handling of batteries in battery collection, sorting, and processing facilities, which should improve the safety of facility staff and increase the recovery of critical materials within the developing U.S. battery recycling infrastructure. These activities are essential to advancing the circular economy for batteries and strengthening the U.S. supply chain for critical materials.

Between 2021 and 2024, EPA undertook several research and outreach activities to learn about battery collection, recycling, labeling, and education in the United States and internationally.

These efforts included:

- An analysis of lithium-ion battery (LIB) fires in waste management and recycling, published in a 2021 report.
- A workshop in 2021 to identify solutions to prevent fires and increase recycling of small and large format LIBs.
- Eleven virtual feedback sessions in 2022 for interested parties to discuss BIL activities around improving battery collection and recycling and the voluntary guideline development effort.

Battery Categories

For the purposes of EPA's battery labeling and collection efforts, EPA placed batteries into three categories:[2]

- **Small format consumer electric and portable batteries,** which include single-use and rechargeable batteries.
- **Mid-format batteries,** which include batteries for e-mobility devices and outdoor power equipment.
- **Large format vehicle and stationary storage batteries.**

- A request for information (RFI), issued by EPA in 2022, on the EOL management of all batteries, including collection, recycling, reuse, and labeling considerations.
- Four virtual working sessions in 2024 on small format battery collection and recycling.
- A two-and-a-half-day in-person working session in June 2024 focused on current labeling requirements, standards, challenges, and opportunities for small format batteries.

This white paper summarizes the key findings related to battery labeling that resulted from those research and outreach activities. The information in the white paper serves as foundational research to inform the development of the forthcoming voluntary battery labeling guidelines as mandated by BIL Section 70401(c). By synthesizing the key findings from EPA's research and outreach activities, the white paper provides context and ensures transparency as the Agency develops the voluntary battery labeling guidelines and other materials to improve the safe collection and recycling of batteries.

This white paper is not a policy declaration by EPA, nor does it set forth any voluntary or required labeling standards, recommendations, or guidelines. These findings are not intended to present all challenges, barriers, and opportunities for battery labeling, but rather reflect what was shared by experts and interested parties in the process.

2 Analysis of Lithium-ion Battery Fires in Waste Management and Recycling (2021)

In response to the growing number of LIB fires in waste management and recycling operations and the lack of national data on these fire events, EPA collected and analyzed publicly available data on fire incidents caused by mismanagement of EOL LIBs. Using information from local news sources, eyewitness accounts, and other government records, EPA identified 245 fires linked to LIBs at 64 waste management facilities in the United States, including 68 fires at materials recovery facilities (MRFs), 15 at transport facilities, 139 at landfills, and 23 at other facilities between 2013 and 2020.[2] EPA's analysis found that the annual number of LIB fires reported and the number of facilities impacted increased dramatically, from two fires reported at a single facility in 2013 to 65 fires reported at 16 facilities in 2020.[2] In its report, EPA acknowledged the difficulty in capturing the total number of LIB fires due to the large number of fire incidents that are not made public. Thus, the report does not represent a complete count of LIB fires in the United States between 2013 and 2020.

While the report indicates that LIB fires are occurring throughout the waste management process, MRFs seem to be facing the gravest impacts. According to report findings, of MRFs that experienced a LIB fire in the previous seven years, 78 percent contacted emergency responders at least once.[2] In addition, 22 percent of MRFs from the report's dataset experienced injuries to workers, 43 percent experienced monetary impacts, and 39 percent had to temporarily or permanently suspend operations. These findings show that MRFs are the most susceptible to the negative impacts of LIB fires compared to other facility types in the waste management stream.

The report also emphasizes how the lack of standardized labels in the United States for LIBs can impact various audiences across the LIB life cycle. Specifically, LIBs are sometimes labeled with the "chasing arrows" symbol and the crossed-out wheeled bin symbol, which can confuse consumers and result in disposal of LIBs in municipal trash and recycling. Workers at waste management facilities also experience confusion about LIBs. For example, an operations manager at a single scrap metal facility expressed the need for LIBs to be more easily identified during the sorting process. A label that workers can instantly recognize could help workers spot LIBs and pull them off the belt before the batteries get crushed.[2]

Read the full report here.

3 Lithium-Ion Battery Disposal and Recycling Workshop (2021)

In 2021, EPA held a two-session workshop that included participants from across the life cycle of a LIB. The goal of the workshop was to gather viewpoints about two issues: (1) how to prevent fires from EOL management of LIBs, and (2) how to promote more battery recycling. Labeling and education were among the topics discussed during the first session, which focused on fire prevention. Workshop participants highlighted the need for improved battery labeling to help educate consumers and workers who handle batteries. Labeling can help consumers make better decisions when managing EOL batteries, which should increase the rate of battery collection and recycling.

Effective labeling can also protect workers, enable them to identify different types of batteries more easily, and provide them with appropriate guidance for reuse and recycling. Workshop participants discussed the challenges associated with labeling and brainstormed solutions. They also discussed the importance of clarity and consistency with international labeling standards, as well as additional approaches to improving battery recovery and recycling, including policy approaches such as EPR. Box 1 summarizes the key labeling objectives identified by the workshop participants. Read the full workshop summary here.

Box 1: Workshop Participants' Top Objectives for Labeling[3]

- Remove LIBs from trash and recycling bins.
- Improve waste stream sorting.
- Identify when a product contains a LIB.
- Identify the battery chemistry for recycling efficiencies (cathode and anode identification).
- Include danger and/or hazard warnings.

4 Virtual Feedback Sessions and Request for Information on Bipartisan Infrastructure Law Activities (2022)

In 2022, EPA held 11 virtual feedback sessions with the public and other interested parties to discuss BIL funding and learn about participants' unique concerns. The meetings ranged from large public sessions to smaller group sessions focused on unique concerns. More than 780 participants joined these virtual feedback sessions, several of which included discussions about improving battery collection and recycling and about the voluntary guideline development effort. Through the sessions, EPA gathered information about consumer confusion around labels and about the barriers to battery labeling for manufacturers, collection and sorting facilities, and recycling facilities.[4] Learn more about the virtual feedback sessions here.

EPA also issued an RFI, asking for information on existing battery labeling standards and requirements, including how long they have been enacted, rate of adoption, and mechanisms for administration. EPA received 59 unique comments from across the battery life cycle, including from manufacturers, state and local governments, and recyclers and processors. Respondents identified the lack of labeling standards as a hindrance to growing the recycling market for LIBs. In addition to feedback on existing standards, respondents also provided recommendations for information to include on battery labels, such as battery chemistry, cathode, and anode (for LIBs), and recycling symbols or "no landfill" messaging. EPA also received comments on the potential goals for the voluntary guidelines and on factors that would affect the adoption of the guidelines by battery producers and manufacturers. Commenters shared details about existing communication materials that can serve as useful models for producer and consumer educational materials on EOL battery management and the reuse and recycling of critical materials from batteries. Read the RFI and all the comments received here.

Box 2 highlights the key takeaways pertaining to battery labeling.[5]

Box 2: Key Takeaways from RFI Responses and Virtual Feedback Sessions[4,5]

- Battery labeling challenges include lack of consistent information on labels, overuse of the chasing arrows symbol, and difficulties with physically placing labels on batteries due to their size.
- Recommendations for improving battery labeling include suggestions on how to format labels, where to place labels, and what information should be included on labels depending on the audience. Commenters also suggested using innovative labeling such as quick response (QR) codes.
- Communications materials should be tailored to the different audiences across the battery life cycle (e.g., consumers, governments, collection facilities, industry).

5 Bipartisan Infrastructure Law Battery Collection and Labeling Working Sessions (2024)

From March to July 2024, in coordination with other federal agencies and industry groups, EPA planned and hosted a series of working sessions to solicit public and expert input on improving the collection and recycling of small format batteries. These working sessions were the first of a planned sequence of sessions designed to gather public and industry input on the development of the battery collection best practices and voluntary labeling guidelines. After completing the small format battery working sessions, EPA will host working sessions on mid-format and large format batteries. EPA engaged parties across the entire battery life cycle to attend the working sessions and provide input, including battery manufactures and other industry players; representatives of companies involved in EOL battery management; researchers; federal, state, Tribal, and local agencies; community groups; nongovernmental organizations; and international organizations.[6]

The small format battery series included four virtual working sessions and one in-person working session. The virtual sessions focused on collection systems and locations, safe collection, storage and transport, and battery collection education and outreach. The discussions reinforced the potential benefits of battery collection when different audiences across the battery life cycle have the necessary information to properly manage the battery at end of life. Virtual speakers included representatives from a variety of nonprofits, industry organizations, and federal, state, and local governments. Speakers discussed specific challenges, successes, and needs related to battery collection and labeling. Throughout the working sessions, participants also shared their thoughts and questions on small format battery collection and labeling.

Additionally, in June 2024, EPA hosted a two-and-a-half-day in-person working session in Arlington, Virginia, that focused specifically on small format battery labeling. The objectives of the working session were to:

- Define what success looks like with respect to small format EOL battery management.
- Identify key information needs for different audiences.
- Identify how to convey this information to each audience.
- Discuss what the final labeling guidelines might look like in the context of current requirements, standards, and barriers.
- Identify additional factors that may influence battery collection and recycling, such as technology and policy changes.[7]

Throughout the in-person working session, participants engaged in both plenary and breakout discussions about the information needs for audiences across the battery life cycle, including consumers, collection sites, MRFs, sorters, and manufacturers. The meeting structure facilitated cross-discipline discussions to inform the development of the voluntary labeling guidelines and potential messaging for consumer education materials. To

ensure that EPA's activities are aligned with current activities happening across industry, participants in both the in-person and virtual working sessions were asked to share information on programs or policies they are currently working on that may have an impact on battery labeling or recycling. Participants described initiatives such as packaging programs, emergency response guidebooks, and message testing in different residential communities. Box 3 highlights the concerns and potential solutions that emerged from the discussions.

Learn more about the working sessions here.

Box 3: Potential Concerns and Solutions for Small Format Battery Labeling[7]

Consumers must be able to identify whether the product is or has a battery.

- To make informed decisions about EOL battery management, consumers need to identify that their product is or has a battery. A new symbol may help to clearly identify products with batteries.

There should be one harmonized message for information indicating that the product is or has a battery.

- Consumers would benefit if the information identifying that the product is or has a battery is consistently placed in one physical location, so it is easy for them to find. This location could be on the battery, the packaging, the manufacturer's website, or the retailer's website, or it could be in-store.

A standalone symbol about EOL management, such as the chasing arrows symbol, is confusing for consumers.

- Participants shared ideas on how to improve clarity around the use of the chasing arrows symbol, such as adding text that tells consumers what or what not to do with the battery at EOL.
- Additionally, adding symbols with accompanying text to garbage and recycling bins may help indicate that consumers should not throw batteries or battery-containing products in these bins.

Batteries and battery-containing or -embedded products have limited real estate for additional labeling.

- Participants emphasized that as batteries and battery-containing products (products containing a battery that is not intended to be removed by the consumer) become smaller, it becomes more difficult for manufacturers to follow all labeling requirements due to size restrictions.

Consumers need information that is clear and consistent yet tailored to different audiences.

- Participants highlighted the need to provide the same message on EOL battery management to all consumers as a way of minimizing confusion, but to tailor the message based on demographics such as age and geography.
- Participants recommended that the voluntary guidelines align with existing federal guidelines and state or local campaigns.

Labeling guidelines should seek to provide information via a variety of physical mediums, such as in manuals, on packaging, on the product label (if it is large enough), on websites, or using QR codes.

- Participants highlighted the need to reinforce messaging on the shipping packaging, product packaging, and/or device; in the product manual; and across multiple locations such as retailers, apartment buildings, and schools.
- Some consumers may not have internet access or may live in remote locations with limited access to brick-and-mortar stores.

Additional research on consumer behavior and messaging is needed.

- Consumers must have a general knowledge of how to identify a battery or battery-containing device, but more research is needed to understand how to communicate the presence of a battery to different audiences.
- More research is needed to understand how consumers engage in EOL management of batteries and battery-containing products. Participants diverged on whether consumers should separate their EOL batteries by chemistry or let the collection site handle the battery sorting. Participant opinions also differed on whether consumers should tape battery terminals before drop-off.

Manufacturers need substantial time to implement new labeling guidelines for products and packaging.

- From a manufacturing perspective, the time and cost burden that may come from adding color or text or changing existing symbols on labels is a major barrier to adoption of new voluntary labeling.

6 Synthesis of Findings on Audiences and Their Information Needs for Battery Labeling

To effectively collect and recycle batteries, all audiences would benefit from having clear information about the batteries and battery-containing products they handle—and some of this information could appear on a label. Since each audience has a different role in the life cycle of a battery, information needs vary between manufacturers, retailers, collection sites, consumers, MRFs, and recyclers.

Table 1 summarizes the key audiences in the battery life cycle and the key information needs for each audience regarding proper disposal and recycling. The information needs in the table apply to all battery formats and are based on feedback gathered from the LIB workshops, feedback sessions, RFI comments, and small format in-person working session.

Table 1: Information Needs for Key Audiences in the Battery Life Cycle

Audience	Information Needs
Manufacturers and integrators, who design battery-containing products and packaging	• Need clear, comprehensive guidance for compliance with international, national, and state labeling requirements for batteries and battery-containing products.
Retailers, who may provide collection services and signage about battery recycling	• Need information about proper handling, storage, and transport to reduce fire risks.
Consumers and users of batteries and battery-containing products	• Need ways to identify that a product is a battery or contains a battery. • Need information on where and how to dispose of batteries and battery-containing products. If this information is not on the label, consumers need a mechanism to find disposal instructions and collection centers.
Battery collection sites, which collect, sort, store, and transport EOL batteries	• Need ways to easily and quickly identify products with embedded batteries. • Need ways to identify battery chemistry and type beyond just looking at a product. • Need information for safe handling.
MRFs, which receive batteries unintentionally from waste collectors and transporters	• Need ways to identify embedded batteries and battery-containing devices and identify battery chemistry and type. • Need information for safe handling and storage, including hazardous material designations.
Refurbishers and reusers, who create new uses out of EOL batteries	• Need ways to easily and quickly identify products with embedded batteries. • Need ways to identify battery chemistry. • Need safety information for proper handling. • Need information on the battery's state of health to determine if it is still usable (primarily for large format batteries).
Processors and recyclers, who break down batteries into chemical components to use in the making of new batteries and products	• Need ways to quickly identify battery chemistry, sub-chemistry, and type for safe handling and dismantling. • Need additional information on battery composition and the presence of chemicals of concern or hazardous materials, as well as safety information and precautions.

7 Next Steps

Moving forward, EPA will continue engaging with parties across the battery life cycle to develop the voluntary battery labeling guidelines as required by the BIL. Specifically, in 2025, EPA will host working sessions on mid-format and large format batteries in partnership with other federal agencies, battery manufacturers, retailers, industry leaders, and state, local, and Tribal governments. The goal of these sessions is to build on feedback received on effective label content and design considerations from the small format battery engagement sessions. EPA will assess this feedback to inform the development and implementation of the guidelines. The guidelines will focus on standardizing necessary information for different audiences to identify batteries and battery-containing products and increase proper EOL management.

To bolster adoption of the voluntary battery labeling guidelines and increase their effectiveness, EPA will conduct additional research on consumer education and messaging based on feedback gathered from working session participants. EPA will develop and test messaging to ensure that the labeling guidelines resonate and meet the needs of priority audiences, including municipalities, consumers, and recyclers. Additionally, EPA will create a collection best practices toolkit to accompany the voluntary guidelines, which will help to improve EOL battery management by increasing access to collection sites. EPA will also, in coordination with DOE, develop a battery EPR framework that addresses battery recycling goals, cost structures for mandatory recycling, reporting requirements, product design, collection models, and transportation of collected materials.

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