EPA Lithium-Ion Battery Disposal and Recycling Stakeholder Workshop

Summary Report | October 5 & 19, 2021

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Contents

LIST OF ABBREVIATIONS

DDR	damaged/defective/recalled
DOT	Department of Transportation
EOL	end of life
EPA	Environmental Protection Agency
EPEAT	Electronic Product Environmental Assessment Tool
EPR	extended producer responsibility
ESG	environmental, social, and governmental
EV	electric vehicle
HazMat	hazardous material
LIB	lithium-ion battery
MRF	materials recovery facility
USPS	United States Postal Service
QR	quick response
RCRA	Resource Conservation and Recovery Act
TV	television

1. Executive Summary

The demand for lithium-ion batteries (LIBs) for powering consumer electronics and electric vehicles (EVs) is growing at a near-exponential rate. With increased use, the risk of fires from improper disposal of these batteries, particularly from consumer electronics, is an increasing concern. When damaged, LIBs can short circuit and catch on fire. This hazard can lead to thermal runaway and explosion-like events and can also cause flammable materials near damaged batteries to catch fire. These fires and related events are becoming increasingly common during transportation, at materials recovery facilities (MRFs), and at other waste management facilities. At MRFs, where municipalities manage a variety of recyclable materials, many of which are flammable, the fires resulting from thermal runaway can be devastating. These events have the potential to disrupt U.S. recycling infrastructure.

In July 2021, a warehouse storing about 200,000 pounds of LIBs caught on fire in Morris, Illinois. Over 5,000 nearby residents had to evacuate.

To address this concern, the U.S. Environmental Protection Agency's (EPA) Office of Resource Conservation and Recovery hosted a two-session workshop to brainstorm solutions to

- Prevent fires at end of life (EOL) from LIB management and recycling facilities; and
- Promote recycling for both small/consumer and large format (e.g., electric vehicle or energy storage) batteries.

EPA wanted to gather a variety of viewpoints and encourage discussion among relevant stakeholders from across a LIB's lifecycle. Accordingly, EPA invited stakeholders from multiple sectors including LIB recyclers, battery collectors, hazardous and municipal waste managers, household hazardous waste managers, LIB manufacturers, device and electric vehicle manufacturers, insurance agents, and state, local, and federal government officials. The workshops were attended by 86 stakeholders (77 attended the fire prevention session, 56 attended the promoting recycling session, and 47 attended both). See Appendix A: Attendees for the complete attendee list.

The first session focused on reducing fires through public education, collection and logistics, labeling, and design. The strongest messages from participants focused on education and collection. Specifically, consumers should be educated to not throw LIBs in the trash and have knowledge of where and how to properly dispose of them to prevent fires at MRFs and other waste management operations. Improving collection ease and consistency should increase recycling at the proper facilities—battery recyclers that understand how to store and recycle the batteries safely—thereby generating fewer fires. In addition, further education and training on best practices (particularly for newer electric vehicle or energy storage batteries) should also help those collecting LIBs more safely manage LIBs at EOL.

During the workshop there were differing opinions expressed related to *labeling*: participants addressed the challenges of how labels can be used to inform people how to dispose the LIBs considering the lack of space on an LIB or device, as well as the need to be consistent with various existing international labeling standards. In addition, participants raised other potential approaches to improving battery recovery and recycling, including extended producer responsibility (EPR) and increasing the removability of batteries.

With respect to EPA's potential role in supporting solutions to address *recycling challenges*, the participants emphasized the importance of EPA understanding the two primary groups in the LIB management chain at end of life—consumers and recyclers.

In addition, EOL *collection* challenges differ for different types of batteries: small/consumer batteries are in the hands of a broad consumer public, which is disperse and may be less informed about the hazards of and best practices for managing EOL LIBs than the car dealerships and scrap yards that are part of the system for managing most EVs that contain larger EOL LIBs. To this end, some unique approaches were suggested for small/consumer LIBs as compared to larger LIBs.

Ultimately, success will come from clarity, simplicity, and consistency in messaging about what to do with the device or LIB at the end of its useful life and the existence of tools and resources for all those handling LIBs to be able to do so safely. Common themes and messages from both workshops are summarized in the table below.

Table 1. Common Themes and Messages Discussed at the Workshops.

Category	Key Message	Application to LIBs	
		Small	Large
Education	Develop education tool kits for consistent messages on the risk of fires and where/how to dispose of LIBs.	X	
	Establish education funding or grants for state/local governments to support outreach and education.	X	X
Collection	Make recycling more convenient (e.g., well-known and local dropoff sites).	X	
	Create incentives to bring batteries or devices to collection sites or otherwise get them collected (e.g., deposits, coupons, prizes, rebates).	X	
	Require a core charge/deposit/fee for LIB disposal.	X	X
	Establish more collection sites and raise awareness of them and/or create a single source for collection.	X	
Recycling	Provide exemption for waste LIBs from hazardous waste regulation up to a certain point (e.g., based on the battery's state of charge), and/or clarify when the hazardous waste classification is triggered.		X
	Clarify and streamline permitting and regulations, including updating the Universal Waste Rule to call out LIBs specifically.	X	X

Labeling	Use QR codes, color codes for repairability, and/or labels with information on how to manage LIBs (e.g., send to a specific type of recycler).	X	
Design	Provide easy access/removability of batteries and/or stronger cases or separators.	X	
	Consider EPR requirements.	X	X
	Create incentives such as environmental, social, and governance (ESG) metrics for investors.	X	X
	Create incentives for a minimum recycled content in new products or batteries.	X	X

2. Introduction and Process

EPA hosted a two-part workshop to gather stakeholder perspectives on potential solutions to LIB EOL fires and better understand the current challenges and opportunities to encouraging more LIB reuse and recycling. Each session included presentations and small group discussions.

To gather a variety of viewpoints and encourage robust discussion, EPA reached out to stakeholders from multiple sectors, including LIB recyclers; battery collectors; hazardous and municipal waste managers; household hazardous waste managers; LIB manufacturers; device and electric vehicle manufacturers; insurance agents; and state, local, and federal government officials. For the full list of attendees, see Appendix A: Attendees.

The first session, held on October 5, 2021, focused on reducing fires through public education, collection and logistics, labeling, and design. EPA began the session by introducing concerns about LIB fires during municipal solid waste collection and disposal processes and sharing the findings of their recent report on the potentially damaging impacts of LIBs in consumer devices that are improperly managed at EOL: *An Analysis of Lithium-ion Battery Fires in Waste Management and Recycling*. Attendees participated in two rounds of breakout groups to discuss one of four potential approaches to reducing fires from LIBs. The four discussion topics were:

- Education
- Collection and logistics
- Labeling
- Design

Small groups were assigned based on attendees' registration preferences and to ensure balance across stakeholder groups. Each attendee participated in two different topic discussions.

The second workshop session, held on October 19, 2021, centered around encouraging recycling and reuse of both small/consumer LIBs and large format LIBs. The session began with brief introductory remarks summarizing the previous session on preventing fires and an overview of how EPA's hazardous waste determination and recycling rules apply to LIBs. Guest speakers presented on the newly adopted International Fire Code Standards for LIB storage and the recently signed Memorandum of Understanding between the National Electrical Manufacturers Association and Argonne National Laboratory on developing a battery recyclability standard. Following the presentations, attendees participated in breakout groups on how to increase recycling of either small/consumer LIBs or large format LIBs.

Examples of common consumer LIBs.

3. Preventing Fires Session

During the first session, participants broke into small groups to brainstorm and discuss ideas on how education, collection and logistics, labels, or design could help increase proper recycling or disposal of LIBs and prevent fires in transit and at their EOL destinations.

Each participant took part in two discussion rounds, joining a different small group each time. The following section summarizes the conversations for each topic and highlights key discussion points from both rounds.

3.1. Education

The education small group focused on how to increase education and public awareness about proper LIB management and disposal. Participants brainstormed key messages and audience groups, identified appropriate campaign types and dissemination channels for various audiences, and discussed what EPA's role could be in developing an educational campaign.

In both rounds, the discussions centered around the importance of clear and consistent messaging to help the public identify LIBs, learn how to properly recycle or dispose of them, and understand the risks of improper disposal. Participants identified social media and TV ads as the most relevant channels for sharing these key messages and reaching multiple audiences. They also suggested that EPA could encourage education by funding grant programs, providing sample campaign materials, and working with manufacturers to improve battery labeling and design.

Discussion question 1: What should the education program be focused on?

Participants discussed which messages an education campaign should focus on, who the target audiences should be (e.g., consumers, collectors, recyclers, etc.) and shared additional thoughts.

Key Points from Discussion Question 1
Messaging • Communicate what LIBs are, how to identify them, and what type of batteries are commonly in which devices. • Emphasize the risk of fires. • Explain what to do with LIBs and what not to do. • Identify disposal locations for batteries and devices. Emphasize that LIBs should not go in the trash or curbside recycling bins. • Explain how to correctly package and ship LIBs if sending them through a mail-in collection option. • Increase awareness that devices are repairable—the battery can be removed/replaced.
Audience • Consumers: explain what to do with LIBs and the danger/risk of fires. • Environmental services providers: clarify correct packing and shipping practices. • First responders: educate on how to respond to LIB fires (currently there are mixed messages). • Collectors: clarify best management practices. • Recyclers: disseminate repair/disassembly information.
Other comments and suggestions • First determine the target audience, then tailor the messages. • Messaging needs to be consistent. • Consider the Department of Transportation's (DOT's) undeclared HazMat campaign as a model to raise awareness of the hazards. • Start a deposit program—this will put value on handling batteries properly in order to decrease fires and decrease time and expense for handling LIBs. • A core exchange program needs to go along with education/awareness—need to offer consumers a "carrot."

Poll question 1: What top three messages should an education campaign focus on?

Participants also responded to a virtual, interactive poll to prioritize potential key messages. Each participant submitted up to three short-answer responses to the question.

Results from Poll Question 1

Frequent answers
• Use proper disposal channels; know where users can safely bring LIBs.
  ○ *Do* give them to a dedicated electronic and/or battery collector or recycler.
  ○ *Do not* put batteries in the trash.
  ○ Find the right place to dispose of them (collection programs, local municipality, etc.).
• Batteries are hazardous, toxic, and a fire risk.
• How to handle devices or batteries.

Discussion question 2: What type of education campaign would you suggest, and what method should be used to educate the public?

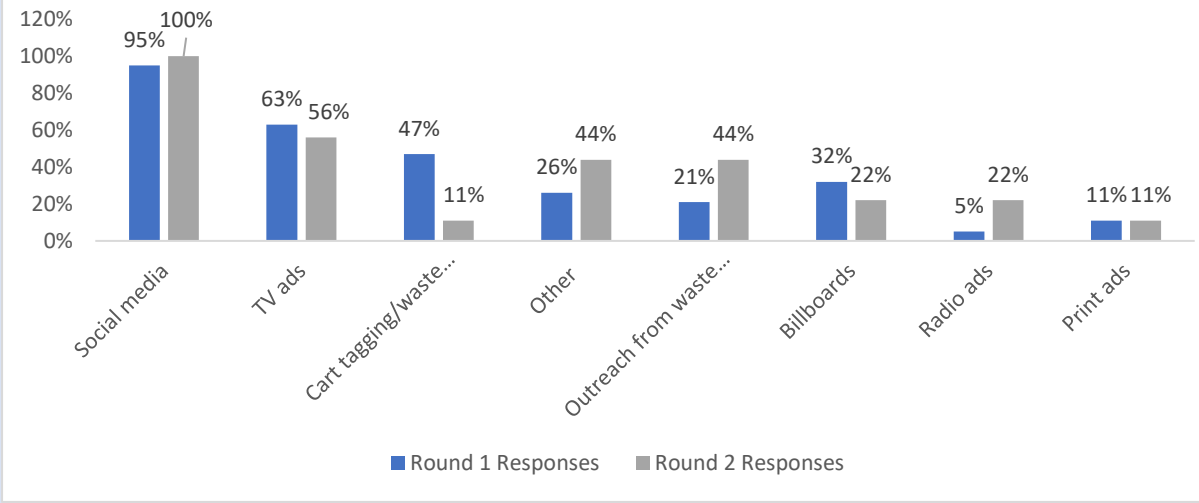
After identifying the priority messages, participants brainstormed strategies to ensure these messages reach the target audiences, such as point-of-sale reminders, digital advertising, traditional media, and large-scale events. They also suggested making messaging consistent and tailored to the audience.

Key Points from Discussion Question 2
Campaign type/method • Point-of-sale**:** create a "pause" before purchase and then follow-up with education/reminders. • Digital advertising: place targeted ads on search engines and social media based on a user's previous searches (e.g., if consumer typed in "hazmat" in Google, then later they would get the DOT hazmat ad on YouTube). This could be expensive. • Stickers on recycling bins. • National events: leverage other national events, such as National Recycling Day or Fire Safety Month. • Establish a national day dedicated to battery or electronics recycling to collect items and increase general awareness. • Public service announcements (PSAs) that get people talking. • Require manufacturer labels. • Traditional media such as TV, radio, and newspaper ads. Some states that have EPR programs have used traditional media with success. • Podcasts as an alternative to radio for advertising or outreach. • EPA educational programs—lean on existing programs. • Leverage existing educational programs to expand coverage to include proper battery disposal/recycling.
Messaging advice • Use easy-to-understand labeling and pictures. • Be more precise than just "recycle your batteries"—include a call to action for where to take them (see the new campaign in Minnesota). • Be clear on what recycling means—"no" to the blue bin, but "yes" to battery collection. • Be consistent with one message. Differences between jurisdictions' rules or battery chemistries are confusing. • Have a holistic message that includes information on solutions without being too technical. • Be more personal/informal. Hearing someone's personal experience has impact. • Consider new terminology.
Other comments and suggestions • Educate first to drive behavior change. • Use multiple methods for education because there are multiple audiences. • Establish a one-stop collection for all batteries (consumers will not sort them). • Create consumer incentives/rebates. • Require manufacturer support/contribution to fund education.

Poll question 2: What three types of education campaigns would be most useful?

Participants also responded to a virtual, interactive poll to prioritize types of education campaigns. Each participant selected up to three options. The options included TV ads, radio ads, print ads, billboards, outreach from waste haulers, cart tagging/waste rejection from haulers, social media, and other. Table 3 shows the poll results from each discussion round. Since each respondent could pick multiple answers, the total votes exceed 100 percent.

Results from Poll Question 2



Discussion question 3: What can/should EPA do?

The final discussion question asked participants to brainstorm ways that EPA could most effectively be involved in an education campaign. Participants suggested that EPA could help convene stakeholders, fund grant programs, and develop sample campaign materials.

Key Points from Discussion Question 3

EPA could

- Bring stakeholders together on neutral ground.
- Fund grants to state/local governments for education/outreach.
- Develop sample materials that local governments could customize and use.
- Partner with local fire departments for public education.
- Partner with door-to-door waste management companies to educate users.
- Mandate labeling.
- Pressure manufacturers to make batteries removable.

3.2. Collection and Logistics

The collection and logistics group discussions focused on how to increase dedicated LIB collection while implementing the necessary safety controls. Participants identified key challenges and then brainstormed ways to increase collection volumes, ensure safe storage at collection sites, encourage more collection, and leverage EPA's role in promoting collection. Both groups cited lack of consumer awareness of proper LIB recycling and limited knowledge of/access to proper disposal locations as the current largest barriers to collection. They also suggested a range of strategies for increasing collection, including building accessible collection locations/infrastructure, hosting collection drives, engaging with companies to develop EPR programs, and creating other financial incentives. Participants noted that EPA could issue guidance for collecting and transporting LIBs.

Poll question 1: What are the top two major challenges to LIB collection and logistics?

Participants began the discussion by responding to a short-answer poll asking them to identify two major challenges that LIB collection and logistics currently face.

Results from Poll Question 1
Frequent answers • Lack of consumer awareness of where to take LIBs after use. • Lack of knowledge of/access to proper disposal locations/sites. • Safety (storage and disposal options). • Costs. • Limited removability of batteries from devices. • Complexity of different disposal strategies for different products and batteries.

Discussion question 1: How do we increase collection volumes?

The participants brainstormed ways to increase the number of LIBs collected, including improving collection infrastructure and accessibility, conducting various types of outreach events and campaigns, creating financial incentives, and partnering with existing organizations/institutions.

Key Points from Discussion Question 1
Increase collection • Make collection easy, convenient, and free for consumers. • Conduct dedicated collection campaigns around big events (e.g., winter holidays). • Conduct/support household collection drives focused on LIBs (like paint collection events). • Increase consumer awareness through labeling. Create/add a label like ENERGY STAR for batteries. • Help retailers communicate that LIBs are inside devices and publicize collection options. • Make batteries removable, so consumers will be more likely to separate the battery from the device. • For some devices, it may be safer to leave batteries in the device, keep the device intact, and properly dispose of the whole device. • Create a single electronics disposal location/stream where they would have expertise in separating batteries from devices.

- Influence corporate culture—conduct outreach to companies on how to safely do their own collections.
- Partner with civic organizations to collect LIBs (e.g., local fire departments—they know how to handle
- Partner with big-box retail stores to collect LIBs (e.g., home improvement stores, grocery stores).
- Partner with local governments for e-waste drives—could donate the positive value to local community
- Consider using U.S. Postal Service (USPS) infrastructure to send batteries back for "micro aggregation" reuse/recycling. (Note, however, that USPS does not take LIBs rated at more than 100Wh, alone or in devices, and if USPS has too many fires, they may stop taking them.)
- Create financial incentives for collection drives.
- Create an incentive for manufacturers/retailers.
- Share cost/refund between the consumer and manufacturer.
- Look at Europe's best practices (Europe collects 10–15 times more than the United States).
- Provide standardized definitions/guidance on what "damaged" means—U.S. DOT does not define what "damaged" means for shipping.

Other comments and suggestions

- Collection needs to happen at the right place (e.g., for lead-acid batteries, a core value is refunded to the user at the beginning of EOL management to ensure the battery is brought back to the retailer for collection).
- LIBs need to have some value to help collectors.
- Move costs upstream—right now recyclers are taking on costs and passing them on to consumers.
- We should get away from commingled battery streams.
- Consumers will not know different chemistries, so we need to commingle for ease of collection.
- Sorting batteries is difficult/dangerous and non-electronics facilities are less likely to do it (e.g., Goodwill); once there is a fire, non-electronics facilities may stop collecting batteries.
- The cost of collection is a problem.
- Call2Recycle is a good option, but not sure they can scale up.

Discussion question 2: How do we ensure safe storage at collection sites?

Participants noted several challenges to ensuring safe LIB storage at collection sites such as liability and insurance risks.

Key Points from Discussion Question 2

- There are several safe storage products available, especially for drum collection of batteries.
- Liability is a problem—need to clarify that collectors will not be held liable for fires if they comply with general regulations.
- Challenges include insurance risks (some collection sites are seeing 3–8x increases in rates), regulatory issues, etc.

Discussion question 3: How do we encourage more entities to do collection?

The participants came up with several strategies for encouraging more entities to collect LIBs, such as improving education and awareness and making collection financially beneficial for both consumers and collectors.

Key Points from Discussion Question 3
• Encourage more public awareness, including educational advocacy and marketing campaigns around proper collection and disposal. • Make being a collection site financially beneficial. Retailers need to break even to set up collection sites, maybe through profit sharing with collection organizations. • Make collection free for consumers.

Discussion question 4: What can/should EPA do?

After discussing strategies to increase collection, the participants brainstormed ways that EPA could support collection. These included issuing clear guidance on properly storing and managing LIBs, incentivizing the value of used batteries, and standardizing labeling.

Key Points from Discussion Question 4
EPA could • Work with DOT and issue joint guidance on collection and logistics. • Consider introducing a limit on battery capacity at collection (e.g., USPS has a 100Wh limit, some airlines have a 300Wh limit above which LIBs cannot be transported). • Consider how China and the European Union are handling labeling; aim for consistent labeling globally. • Look into EPR/product stewardship. • Use legislative/regulatory approaches, similar to federal flood insurance, to help keep insurance costs down. • Design for disassembly (e.g., initiatives in Europe). • Incentivize the value of used batteries. • Develop guidance/clarity around whether LIBs are hazardous waste.

Poll question 2: In one word or short phrase, what is the most important strategy to increase collection and processing at proper locations?

At the end of each small group discussion, participants answered a virtual polling question to identify the most important strategy to increase collection and processing at proper locations. The answers were aggregated into a word cloud. Common answers/themes included consumer education and awareness; convenience, simplicity, and ease; incentives; safety; and clear directions.

Results from Poll Question 2

3.3. Labeling

The labeling small group looked at the current barriers to labeling and discussed possible solutions to overcome these challenges. The participants brainstormed and prioritized labeling goals and discussed best label placement options and messaging. During both rounds, participant comments focused on proper disposal, removal from trash and recycling bins, improved waste stream sorting, identifying when a product contains an LIB, and danger/hazard warnings as the top goals for labeling. Participants also recommended that labeling should be clear, consistent, and standardized, but noted that labels themselves could be placed in a variety of locations (i.e., on packaging, on the back of a device, on the battery itself).

Discussion question 1: What would the goals of developing a label be?

In discussing the goals for developing a label, participants identified different objectives for consumers and for recyclers. For consumers, they noted that labels should identify if a product contains an LIB, provide information on how to store LIBs, and inform consumers how to dispose of LIBs. For recyclers, the participants suggested that labels should inform workers how to sort LIBs, identify the battery chemistry, and communicate if a battery is embedded or removable.

Key Points from Discussion Question 1

For consumers

- Ensure proper disposal.
- Direct used products into the right EOL management streams (e.g., a dedicated battery stream).
- Keep LIBs out of trash and recycling bins.
- Identify LIB presence in a product. Consumers may not know if a product contains an LIB.
- Identify LIBs as hazardous; warning consumers that LIBs are dangerous may encourage them to handle them better.
- Educate about how to store LIBs.
- Communicate whether the battery is removable or embedded.

For recyclers/industry

- Improve efficiency by better communicating where LIBs go and how to manage them, starting with workers sorting them into the right process streams.
- Better segregate LIBs by specific chemistry and/or by other major chemistry families.
- Educate handlers/workers about identifying and handling LIBs.
- Train workers on how to properly store and package material based on chemistry.
- Communicate what to do if the battery is swollen or discharged and explain proper disposal procedures.
- Improve automated processing (e.g., a QR code with chemistry to allow a visual auto sort system to sort accurately).
- Create accountability for producers—educate them about what LIBs are and how they are made.
- Communicate whether the battery is removable or embedded.

Other comments and suggestions

- Labels could create increased costs for manufacturers or haulers.
- Labels only in English will not work for those who do not read the language.
- Different countries have different labeling rules.
- There is limited room on a battery or device for labels, and batteries are getting smaller.
- Some LIBs may be confused with lead batteries (e.g., car-starter LIBs and lead acid batteries look very similar). LIBs in a lead battery shredder can lead to dangerous explosions.

Poll question 1: Which goal should be the priority?

After brainstorming the goals for labels, the participants answered a word cloud poll question about which goal should be the priority. Common answers included keeping LIBs out of the trash/recycling streams, indicating the presence of the battery and identifying the battery type, assisting with waste stream sorting, identifying chemistry, and signaling the danger/hazardous nature of LIBs.

Results from Poll Question 1

Discussion question 2: For the TWO top priority goals from the word cloud/poll, where should the label be placed (on battery, on device, on packaging, in store, other location, OR no label and why)?

The participants brainstormed a variety of places to put a label, including on the shipping packaging, on the product packaging, and on the product itself. Some participants also expressed concern that some batteries or products could be too small to fit a label.

Key Points from Discussion Question 2
Label location • On the shipping packaging (state that the device contains an LIB and explain where to take it for disposal). • On the back of the device, since many have glued-in batteries and can be disposed of whole. • On both the packaging and the product. • Each location needs a different message (e.g., a label on packaging needs to tell the consumer what to do, a label on a battery needs to communicate to sorters and recyclers the chemistry of the battery). • On disposal bins—could partner with waste haulers. • Where the label is easily seen and clear. • In a standardized place.
Other comments and suggestions • The device label should be a call to action for proper disposal. • Labels should make the consumer pause and think before disposing of the device or battery and should tell them what to do with it. • There is uncertainty around products where a sticker will not stay attached (e.g., plush toys) and/or where a tag could easily be cut off and thrown away with packaging. • How to label very small batteries (e.g., button cells)? • There is not a lot of room on a battery or device for large messages on labels. • There are different manufacturers for the battery and the device/product. • Indicate if the battery is glued in. • Redundancy is good.

Discussion question 3: For the TWO top priority goals from the word cloud/poll, what should be on the label?

The participants discussed more specifics of the label and differentiated between information for consumers and information for collectors and recyclers. They also noted recommendations for all labels, including consistent messaging among all manufacturers, using universally recognized symbols instead of words due to space limitations, and using a color-coding or numbering system to easily identify LIBs.

Key Points from Discussion Question 3
For consumer action, label should include • The words "discharge before disposal" or instructions to do so, since fully charged batteries are more likely to cause fires. • A warning that the device contains an LIB. • A warning that the device or battery is hazardous and a flame image to indicate fire/burn risk. A public awareness/social media campaign could familiarize the public with these symbols. • Directions for how to properly dispose of the product, along with directions about what not to do.
For worker/handler action, labels should include • Chemistry information to help easily determine the hazard, for legal liability, and to determine the appropriate recycling stream. • Voltage and/or wattage for direct handling, training, and shipping. • Capacity. • An alert that LIBs are present. • Temperature threshold for fire risk/hazard.
Advice on messaging/label • Make it simple, clear, recognizable, and consistent across manufacturers. • Do not try to do too much with the label. • Use symbols, not words, to communicate with those who cannot read or have language barriers. • Do not use the word "recycle" or the recycle symbol (in the United States, this means "put in a curbside recycling bin"). • Using a bin with the crossed-out bin symbol (a European symbol from the Waste Electrical and Electronic Equipment Directive) gives the impression that the device does not go in the trash, which is good, but people do not understand that it does not go in the municipal recycling bin. • Developing a new symbol is expensive, and it takes time and effort to educate consumers about what it means. • Consider making the label a global standard. • Use a QR code to identify the specific lithium chemistry. • Use a numbering system (like for plastics) or letters and numbers to show chemistry and percentage of materials. • Use color coding for chemistry. • Adopt a return deposit system (like for cans) and create a deposit policy. • Use a color-coding system or colored stripes to clearly indicate to consumers what to do (e.g., black means dispose of in the trash, green means recycle, and/or red means send to a dedicated recycler/stream.

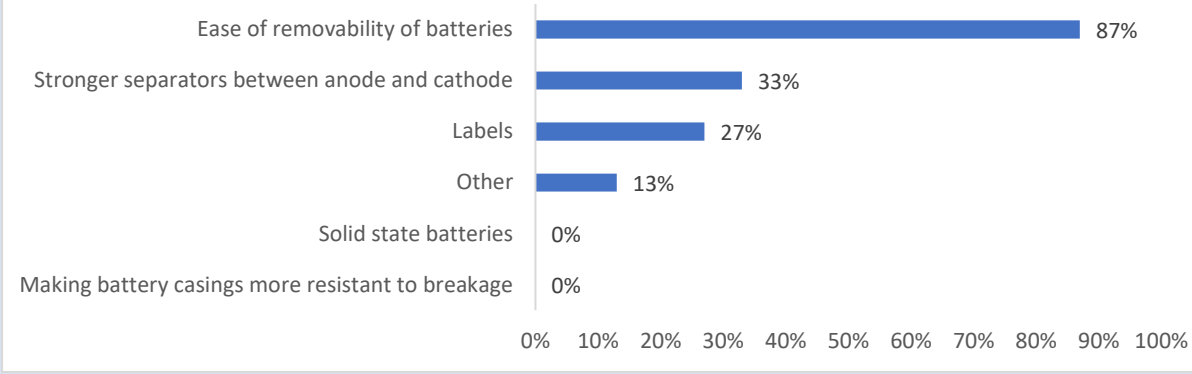
3.4. Design

The small groups on design discussed how to reduce the potential for EOL fires at the design stage for batteries and devices. The participants identified what they believe to be the most effective design options for decreasing EOL fire potential, brainstormed benefits and concerns around these design options, discussed strategies for motivating design change adoption, and considered how EPA could be involved. Participants recommended involving manufacturers from the beginning of the design process and increasing public awareness around battery best practices. They also suggested that EPA could mandate or support battery removability, labeling, and collection through existing legislation.

Poll question 1: What are the top two most effective design options for decreasing potential for fire at EOL?

Through a multiple-choice poll, participants noted their top design improvements for decreasing EOL fire potential. They chose two responses from the following list: ease of removability of batteries; making battery casings more resistance to breakage; labels; solid state batteries; stronger separators between anode and cathode; and other. Most participants agreed that making batteries easily removable from devices, creating stronger separators between anode and cathode, and improving labeling were the most effective design options.

Results from Poll Question 1



Discussion question 1: For the priority design strategies, what are the pros and cons?

After establishing ease of removability of batteries, stronger separators between anode and cathode, and labeling as the priority design strategies, participants discussed the benefits and challenges of each strategy. They also emphasized the need for consulting directly with manufacturers to better understand their considerations.

Key Points from Discussion Question 1		
Ease of removability of batteries	**Pros:** • Reduces likelihood of fires. • Consumers can remove the battery and send it to a dedicated battery recycling facility. • Gives consumers better repair options to extend the life of a device. • Easier for consumers to recycle and repair.	**Cons:** • Could hinder waterproofing (a reason manufacturers started embedding batteries). • Harder for manufacturers to achieve energy density when accounting for the extra structure needed to make batteries easily removeable (screws, etc.). • Safety concerns—batteries need a well-defined space in a device, and batteries without protruding terminals are safer.
Stronger case and/or separator	**Pros:** • Helps prevent fires without relying on consumer behavior change.	**Cons:** • Does not address issues of heat-triggered thermal runaway. • Heavy machinery at waste facilities could still damage batteries enough to trigger a fire. • Increases weight and cost for consumers.
Labeling	**Pros:** • Educates consumers from the beginning of device ownership.	
Other comments and suggestions • Manufacturers need to build in EOL considerations at the design stage. • Need more manufacturers' input—they control the design of their batteries/devices but likely have differing opinions on what the standards should be. • We need more data on the failure rate for LIBs in the waste stream, particularly when batteries are crushed by heavy machinery.		

Discussion question 2: How can changes to design to decrease potential for fires at end of life (EOL) and other interests be motivated?

Participants also brainstormed strategies for motivating design change. They suggested mandates and increased EPR along with better public awareness and outreach.

Key Points from Discussion Question 2
Motivating design change • Require a repairability score be listed with device prices (e.g., France's repairability index). Battery removability would impact the score. • Mandate battery removability. The current trend is embedded batteries. • Ban designs that create safety risks. • Create original equipment manufacturer responsibility. Manufacturers need to be invested in solving the issue.

Other comments and suggestions

- Education and ease of access are key; labels will not lead to change if it is difficult for consumers to dispose of batteries properly.
- Educate people to stop using batteries beyond warranty period.
- Lithium iron phosphate ($LiFePO_4$) batteries are a problem since they have less recycling value.
- There needs to be a framework at the local or regional government level to address EOL for stationary storage.

Discussion question 3: What can/should EPA do?

The participants thought of several ways that EPA could support LIB design changes using both existing regulations and voluntary measures. These included adding LIBs to the type of batteries covered by the 1996 Mercury-Containing and Rechargeable Battery Management Act (Battery Act), mandating labeling, supporting EPR programs, developing standards, launching voluntary programs, and providing more data.

Key Points from Discussion Question 3

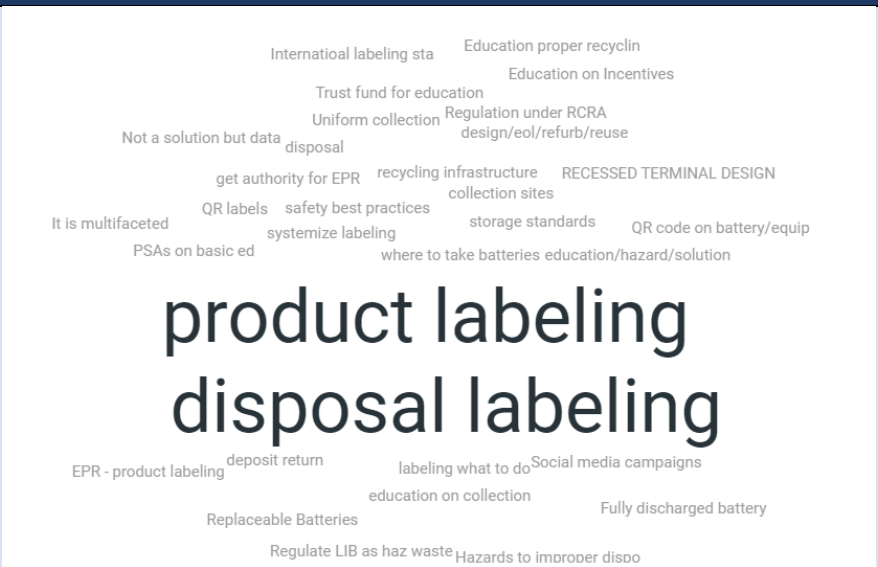
EPA could

- Mandate or support battery removability, labeling, and collection using the Battery Act authority.
- Establish or support an EPR program. (Note: EPA communicated that it is not within EPA jurisdiction to require participation in an EPR program.)
- Mandate labeling to increase consumer awareness of which devices include LIBs and present a fire hazard.
- Get producers to switch to solid state batteries (voluntarily or by mandate).
- Develop standards for a battery stability test.
- Develop a standard like ENERGY STAR for battery removability.
- Provide data about battery safety at EOL similar to what manufacturers do for batteries in use.
- Mandate an expiration date for consumer batteries.
- Establish a protocol that older batteries/devices should be discarded.
- Support a right to repair as well as a suggested system to encourage mailing devices for repair via USPS or another mail service.

3.5. Next Steps

At the end of the first workshop session, all participants responded to a short-answer poll to share their top solution for LIB EOL fire prevention. The two most frequently mentioned solutions were labeling with instructions for disposal (disposal labeling) and product labeling. Other responses included education, QR codes, social media campaigns, better recycling infrastructure, and regulations.

Results from Final Poll Question



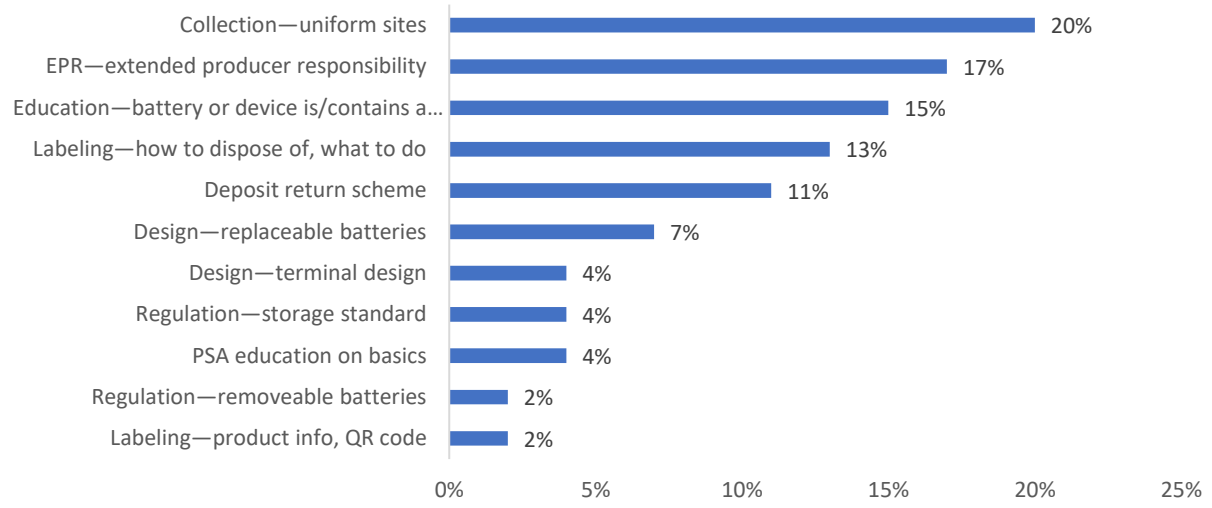
4. Promoting Recycling Session

The second workshop session was held on October 19, 2021, and focused on brainstorming ways to encourage more recycling and reuse of LIBs. In this session, participants split up into one round of small group discussions to brainstorm ideas for how to encourage recycling of small/consumer-sized LIBs or large format LIBs (for EVs or energy storage). There were two discussion groups for small LIBs and two for large LIBs. The sections below synthesize the conversations from the two groups for each discussion topic.

Poll question 1: Which approach raised in the Preventing Fires session would be effective for encouraging recycling?

Before moving into small group discussions, EPA provided a summary of the Preventing Fires Session and asked attendees to participate in a multiple-choice poll to choose which approach raised in the first session would also be effective for encouraging recycling. Each participant submitted one response. Establishing uniform collection sites, adopting EPR, conducting education and outreach, labeling with disposal instructions, and developing a deposit return scheme received the most responses.

Results from Poll Question 1



4.1. Small/Consumer Batteries

The session on encouraging recycling for small/consumer batteries focused on identifying types of incentives that encourage recycling and reuse, brainstorming strategies to improve both the market for and the value of used batteries, defining EPA's role in encouraging reuse and recycling, and determining if the current universal waste standards are appropriate for small/consumer batteries. Participants considered incentives such as EPR, increased grant funding, subsidies for recyclers, and deposit or coupon schemes. They also encouraged EPA to support standard labeling practices and amend current regulations such as the Universal Waste Rule to include LIBs.

Discussion question 1: What type of incentives would encourage recycling and reuse?

Participants first discussed various incentives that could encourage recycling and reuse of small/consumer LIBs. Ideas included EPR/producer take-back incentives, grants to local governments to fund collection operations, making recycling easier and more convenient, and conducting education and outreach.

Key Points from Discussion Question 1

Incentives

- EPR with incentives built in.
- Grants to local governments (e.g., the City of Palm Springs used a grant from the state of California to provide boxes to households for the collection of LIBs and small electronics and to operate collection sites; this has been a successful approach to collecting batteries).
- Subsidies for recyclers (e.g., return Amazon purchases to Kohl's, you get a Kohl's coupon).
- Other incentives such as deposits (e.g., as with bottles), coupons, or prizes (e.g., cereal boxes).

Other comments and suggestions
• Develop a system that allows for proper management without requiring consumers to know what type of battery they have. • Make recycling convenient for consumers (e.g., dropoff locations at retail centers or municipal facilities). • Encourage better design and removability, like EPA did with the Battery Act. • Conduct more consumer outreach and education about battery recycling and where to do it. • Create industry incentives consistent across the United States. • Encourage long-term changes through education, including educating children who can, in turn, influence their parents. • Provide more education about risks related to improper recycling.

Discussion question 2: How can the market for reuse/recycled batteries be improved? How can the value of used batteries be increased?

The participants also brainstormed several strategies for market improvements to encourage recycling and reuse, including increasing the cost of batteries, requiring minimum recycled content, and implementing EPR alongside a landfill ban.

Key Points from Discussion Question 2
Market improvements • Make batteries more expensive. • Require minimum recycled content (or revise EPEAT voluntary standards to address lithium-ion battery components more directly). • Implement EPR effectively (e.g., in concert with a landfill ban). • The lead battery collection and recycling model will not work for LIBs. The value of the lead in a lead acid battery makes it economical all along the chain, which is not true for LIBs.
Other comments and suggestions • Collection needs to be done correctly and safely before the volume of batteries being collected increases. • Considering the value of the whole electronic product, not just the value of the battery, would help to recover all materials in the product.

Discussion question 3: What should EPA's role be in encouraging recycling and reuse?

The participants recognized a variety of ways that EPA could play a role in encouraging recycling and reuse, largely through regulation. Suggested regulatory measures included amending the Battery Act to be more inclusive, adding LIBs to the Battery Act, designating LIBs as "dangerous" under fire codes, and amending the Universal Waste Rule for LIBs.

Key Points from Discussion Question 3
EPA could • Make battery identification easier through labeling—use color coding and include a statement that LIBs do not belong in the trash. • Create education tool kits with consistent messaging across multiple channels (e.g., Minneapolis/ St. Paul area MRFs put ads at bus stops, on social media, in mailings, and at point of sale). • Clarify/research recycling rates. U.S. rates are higher than reported because batteries sent within devices are not counted. • Amend the Battery Act to be more inclusive. • Add LIBs to the Battery Act, which would result in more collection locations, common labeling, etc. • There is still a question about whether EPA can use the Battery Act for LIBs; EPA would have to show LIBs are toxic. • Is there an air emissions issue through which LIBs could be identified as "toxic"? • Designate LIBs as "dangerous" such that they are handled under codes (e.g., fire codes). • Amend the Universal Waste Rule for batteries, delineate requirements for LIBs, and only make universal waste designation available for those that are directed for recycling. • Focus on batteries/cells most costly to recycle and most easily removed, such as button cells, lithium-ion 625s, and lithium-primary batteries (i.e., 18Vs and A-, B-, and C-size batteries).

Discussion question 4: Are current universal waste standards appropriate for small/consumer batteries? If not, what needs to change?

When discussing current universal waste standards, participants agreed that the standards should be updated. Before updating, however, the participants suggested developing guidance on reuse options, conducting more outreach to consumers, and addressing the fire hazard that LIBs pose.

Key Points from Discussion Question 4
• There's too low a threshold at which a handler becomes a large quantity handler of universal waste. • Standards need to be updated to address fire hazard—separate out LIBs from other batteries and make management as universal waste contingent on recycling. • Need to develop guidance on how the reuse process works with the Resource Conservation and Recovery Act (RCRA) hazardous waste regulations—specifically, the universal waste standards. • Expand outreach to clarify that under the universal waste standards, batteries cannot go in the trash—the symbols on batteries are confusing. • Educate consumers about where to take batteries to help people dispose of them properly. • Adding requirements to tape/isolate the terminals would not be necessary because that kind of regulation is covered by DOT; damaging batteries in storage is more likely than short circuiting due to non-isolated terminals.

4.2. Large Batteries

The session on encouraging recycling for large format batteries (such as EV batteries) centered around identifying current barriers to recycling and reusing large batteries, brainstorming incentives for recycling and reuse, considering EPA's role in encouraging reuse and recycling, and discussing whether the current universal waste standards are appropriate for large LIBs. Key barriers to recycling and reuse included logistical challenges, high costs, lack of battery uniformity, and lack of an existing collection framework. Participants suggested using rebates, tax breaks, and recycled content minimum standards to incentivize reuse and recommended that EPA support these initiatives. While some participants thought the current universal waste standards were appropriate for EV batteries, others disagreed and suggested the standards be updated to be more specific to this waste stream.

Discussion question 1: What are the barriers to recycling and reuse? What barriers are unique to large batteries and EV batteries, compared to small consumer batteries?

Participants identified several barriers to recycling including complex logistics, high costs, lack of battery design uniformity, and regulatory uncertainty. They also identified liability, warranties, and fire codes as obstacles to reusing large LIBs.

Key Points from Discussion Question 1
Logistics • Large LIBs take up a lot of space and can be very heavy. • Need skilled workers to remove, process, and package for shipment, etc., which requires a higher level of skill than for standard hazardous waste and universal waste. • Existing codes are challenging for the transport and storage of batteries.
Costs • More expensive to have the battery hauled away than to shred and sell the metals. • EV batteries are not made to go into a regular vehicle recycling program. • Reusing EV batteries for grid storage cannot compete economically with new, larger LIBs that have better performance.
Lack of uniformity • Varying battery and EV design, module size, and state of charge are all potential concerns for safety when removing batteries. • Differences in design of batteries from cell to cell makes recycling difficult. • Varying manners of battery construction requires specialized skills and tools to disassemble. • Number of EV battery cells make it hard to assess health of the battery.
Other recycling barriers • More complicated to break down and therefore more safety considerations. • More dangerous due to more energy stored, especially during transportation. There needs to be more restrictive packaging for transport.

- Collection concerns—small batteries can be collected in collection boxes, but EV batteries will either be a warranty product or will be coming through a non-warranty process like those from a vehicle salvage yard or a home energy storage system.
- Lack of existing framework for EV battery recycling—not enough EVs have come out of service to have an established EV battery recycling framework in place.
- Regulatory uncertainty regarding universal waste and damaged/defective/recalled (DDR) classification.

Obstacles for reuse

- Liability and warranty (how do consumers know reused battery will be safe and effective?) plus the cost of finding the appropriate application for a given large format LIB at EOL.
- Fire/safety code requirements for energy storage applications.

Discussion question 2: What type of incentives would encourage recycling and reuse?

The participants discussed several strategies for incentivizing recycling and reuse, including rebates and tax incentives for using recycled materials, core charges, EPR, recycled content minimum standards, and streamlining permitting processes.

Key Points from Discussion Question 2

Incentives

- Rebates for companies that use recycled minerals over virgin materials.
- Tax incentives for companies offering LIB recycling and logistics services.
- Requiring a core charge, which worked for lead acid battery recycling.
- Adding a digital ID for every battery pack would go well with tracking the ownership for a core charge.
- Consumers could lease the battery until it dies, and then the battery would have trade-in value.
- ESG metrics to drive corporate behavior could be applied to LIB recycled content standards.
- Recycled content minimum for new batteries.
- EPR—incorporate concepts like ESG metrics and recycled content standards through eco-modulated fees.
- Global Battery Passport (World Economic Forum's Global Battery Alliance) includes data about disassembly at end of life, information on mines, and more. Such a passport could help companies trying to source cobalt from mines not linked to human rights abuses.
- Streamline permitting and improve clarity of regulations.
- Federal funds/grants to support recycling and reuse, to improve workforce training, and/or to help move organizations with a history of internal combustion engine vehicles towards EVs.

Other comments and suggestions

- Clarify that the responsibility for reused batteries is with the company that reuses/refurbishes the battery and that they are liable for reuse repairs and improvements.
- Education is important—scrap yards will need some education on this topic.
- Continue encouraging the electrification of vehicles and the 4Rs (reuse, repair, repurpose, and remanufacture) with recycling at EOL.
- Incentivize development of domestic battery manufacturing and domestic black mass processing/refining capabilities to drive demand for recycled content. The United States lacks domestic markets for battery inputs, so even if recycling occurs, the materials may have to be exported for refining.
- The Department of Energy's ReCell Center is working on incentives to encourage recycling and reuse, such as the Lithium-Ion Battery Recycling Prize.

Discussion question 3: What should EPA's role be in encouraging recycling and reuse?

After brainstorming incentives for recycling and reuse, the participants discussed what EPA's role could be in promoting recycling and reuse. They suggested that EPA could use several regulatory and voluntary measures, including exempting LIBs as hazardous waste, developing guidance on collection and recycling liabilities, incentivizing regional recycling capabilities, and addressing policy inconsistencies.

Key Points from Discussion Question 3

EPA could

- Clarify when a battery is considered waste, which activities are considered treatment, and what requirements apply when a battery is being remanufactured.
- Explicitly state that all waste LIBs are hazardous waste for ignitability or reactivity when disposed of. (However, a participant noted that making a blanket statement that LIBs are hazardous waste would be challenging since not all LIBs are ignitable/reactive at EOL.)
- Exempt waste LIBs from regulation as hazardous waste up to a certain point in the management chain, akin to how lead acid batteries are managed. Use a technical metric (e.g., state of charge) to indicate when hazardous waste classification is "triggered."
- Develop guidance on who is responsible/liable when a battery pack catches fire under a reuse application, clarifying ownership along the chain.
- Clarify who is considered a handler and who is considered a treatment facility.
- Incentivize and expand regional recycling capabilities—lack of recycling capability is one of the biggest challenges.
- Help address inconsistency in management standards across the United States.
- Develop recommendations, best practices, and/or standards for recovery and recycling facilities.
- Facilitate information distribution and knowledge transfer (best information and best science).
- Ensure proper environmental protection from emissions associated with LIB recycling; EPA should not forego environmental protections in rush to promote LIB recycling.

Discussion question 4: Are current universal waste standards appropriate for large batteries? If not, what needs to change?

While some participants noted that the current universal waste standards could be appropriate for large LIBs, others suggested that they should be updated. Updates could include clarifying applicability, establishing a new hazardous waste category, separating the standards for EV batteries from other LIBs, and being consistent with other types of batteries.

Key Points from Discussion Question 4
• Not appropriate—many people have questions about who a handler is, etc., but an overly prescriptive standard is not the solution either. • Appropriate—neither size (small format vs. large format) nor cathode chemistry should impact whether an LIB is considered universal waste, although the battery universal waste standards were not designed with LIBs in mind. • Confusing—the standard needs to be clarified. • Revisit the universal waste standards to account for all the different uses and clarify applicability. Large battery waste is unique since it can be repaired/reused. The standards were not written for this variability at EOL. • Needs to be consistent with other kinds of batteries (e.g., lead acid). • Establish a new hazardous waste category for LIBs that could fall under the ignitability or reactive hazardous waste regulation definitions. • Separate the standards for EV batteries from consumer electronic batteries.

4.3. Next Steps

After the breakout discussions, the participants reconvened, and the facilitators gave verbal summaries of key points from each group. Following that, participants took part in a word cloud poll where they submitted one strategy or effort that EPA could do to encourage LIB recycling across all sizes/types. The most frequently reported answers included incentives, education, best practices, landfill bans, increased recycling capacity, and recycled content mandates.

Poll question: What is one thing that EPA can do to encourage/promote LIB recycling?

Results from Final Poll Question

Appendix A: Workshop Attendees

Overall, 86 people attended one or both workshop sessions, and 47 people attended both. There were 77 participants at the first session and 56 at the second session. Fifteen people registered and did not attend; of those, five people were represented by someone else from their organization who attended. At registration, attendees identified their stakeholder category from a list of 14 options (see Table 2).

Table 2. Attendees by Stakeholder Category

Stakeholder Category	Attendees
Other	13
Nonprofit organization	12
Lithium-ion battery recycling	11
Trade association	11
State government	11
Federal government	11
Academia/research	5
Lithium-ion battery reuse	2
Lithium-ion battery and/or electronics manufacturing	2
Municipal solid waste and recycling	2
Local government	2
Insurance	1
Battery collection	0
Emergency management	0

Those who identified as "other" included representatives from the following groups: automotive (4); advocacy (1); battery logistics and safety (1); freight forwarding (1); emergency and remedial response (1); hauler and recycler (1); parts-tools-manuals (1); electronics standard (1); waste management (1); and unknown (1).

Below are the specific organizations that attended the workshop.

Organization
Alliance for Automotive Innovation
Argonne National Laboratory
Battery Council International
BigBattery.com
California Air Resources Board
California Department of Toxic Substances Control
California Product Stewardship Council
Call2Recycle, Inc.
City of Palm Springs California
Consultant for National Center for Electronics Recycling (NCER,) Right to Repair
DGF
Earthjustice
Eastern Research Group, Inc. (ERG)
e-cell secure, LLC
Electric Power Research Institute (EPRI)
Energy Storage Safety Products International
Environmental Research & Education Foundation
Environmental Restoration
Eureka Recycling
Federal Trade Commission, Office of Technology Research and Investigation
Heritage Environmental Services
HOBI International
Honda Development and Manufacturing of America
iFixit
Institute of Scrap Recycling Industries, Inc. (ISRI)
Insurance Office of America (IOA)
Interstate Batteries
JSE Associates
KBI Recycling
KH Scott & Associates LLC
Lithion Recycling
Marubeni America Corporation
Metro
Minnesota Pollution Control Agency
National Center for Electronics Recycling
National Renewable Energy Laboratory (NREL)
National Waste & Recycling Association
Nevada Department of Environmental Protection (NDEP)
New York State Department of Environmental Conservation (NYSDEC)
New York State Department of Sanitation

Pacific Northwest National Laboratory
PRBA—The Rechargeable Battery Association
Retriev Technologies/Heritage Battery Recycling
Solid Waste Association of North America
Stellantis
Suppliers Partnership for the Environment
Sustainable Electronics Recycling International (SERI)
Terrapure Environmental
Toyota Motor North America
U.S. Consumer Product Safety Commission
U.S. Food and Drug Administration (FDA)
U.S. DOT National Highway Traffic Safety Administration
U.S. DOT Pipeline and Hazardous Materials Safety Administration
U.S. Environmental Protection Agency
U.S. EPA Office of Land and Emergency Management
U.S. EPA Office of Resource Conservation and Recovery
U.S. EPA Region 5
Umicore USA Inc.
United Battery Recyclers International (UBRi)
University of Michigan
University of Virginia
VMX International, LLC
Volkswagen Group of America
Waste Management Inc.
Zero Waste Washington