Li-BRIDGE

White Paper

Bridging the U.S. Lithium Battery Supply Chain Gap

Forum on Li-ion Battery Recycling and End-of-Life Batteries

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U.S. DEPARTMENT OF ENERGY

As widespread electrification drives demand for lithium-based batteries to power electric vehicles and stationary storage, the domestic battery supply chain must expand.

Li-Bridge is a public-private alliance committed to accelerating the development of a robust and secure domestic supply chain for lithium-based batteries.

Introduction

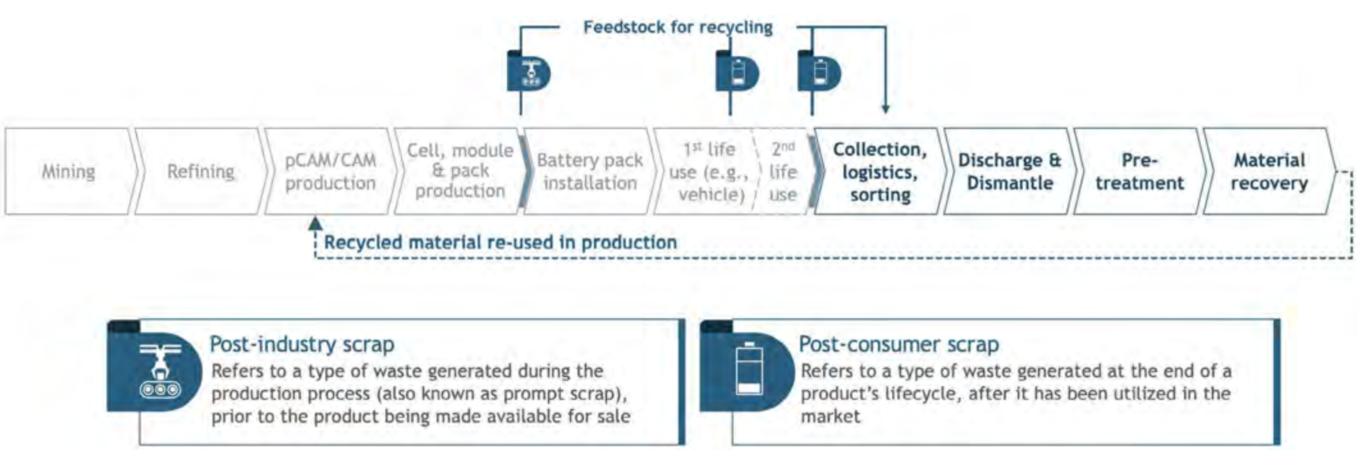
By 2030, more than 60% of new passenger vehicles sold in the U.S. are expected to be plug-ins or full hybrids outfitted with a lithium-ion battery pack and nearly one of every five passenger vehicles on the road will be electrified. Over 200 GWh of installed lithium-ion battery capacity will exist in U.S. grid and other stationary storage applications. Millions of additional lithium-based batteries will be distributed among applications ranging from off-road and commercial vehicles to consumer electronics to defense systems. Further, thousands of kilotons of scrap energy materials will come from battery cell and cell component material production—herein defined as post-industry scrap.

Each of these battery systems will eventually reach an end of life, and ideally, be recycled within the U.S. and serve as feedstock for future U.S. battery production. It is of critical economic and national security importance that the U.S. mature its lithium-ion battery recycling ecosystems in order to provide adequate feedstock for future U.S. domestic lithium-based battery manufacturing. The 100-day report issued by The White House on "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth," a prior Li-Bridge publication on "Building a Robust and Resilient U.S. Lithium Battery Supply Chain," and the CalEPA "Lithium-ion Car Battery Recycling Advisory Final Report" each identified recycled battery energy materials as a key prerequisite for a robust and sustainable domestic lithium-based battery supply chain as well as a key pillar of U.S. energy independence.

Lithium-based battery recycling in the U.S. is a relatively immature industry today, and the U.S. does not have production-level capacity along every step of the value chain to deliver a fully-closed loop domestically. Figure 1 illustrates the high-level steps in the value chain:

- Collection, logistics and sorting for subsequent warehousing
- Discharge and dismantle
- Pre-treatment and shredding of packs to black mass
- Material recovery of battery grade materials, mainly through pyrometallurgy and/or hydrometallurgy

Figure 1. Battery end-of-life represents the steps from collection to material recovery



The lithium-based battery recycling industry is still in its infancy in the U.S. At-scale facilities for sorting and pre-treatment have only recently come online, and the first at-scale material recovery facilities in the U.S. are currently being constructed. Used battery collection rates and collection center densities in the U.S. still lag behind those in other regions. Substantial new investments in the areas of safe dismantling, handling, and shipping will be required to manage the expected increase in retired battery volume that industry expects to be generated over the next several decades.

Industry actions will largely determine how, when, and where the domestic battery recycling industry evolves. Yet government policies, regulations, and rule-making will be a key determinant on the near- and longer-term success of a viable end-of-life (EOL) ecosystem for lithium-based batteries.

On September 11, 2023, Li-Bridge, a public-private alliance committed to accelerating the development of a robust and secure domestic supply chain for lithium-based batteries, organized a forum with industry and U.S. government leaders across the battery industry value chain to debate and brainstorm solutions to achieving expanded domestic recycling capabilities, a critical prerequisite for a self-sustaining circular and low-carbon battery economy. The forum brought together more than fifty senior leaders across the battery industry value chain. It was managed by Argonne National Laboratory in coordination with the Convening Associations of Li-Bridge, NAATBatt International, NY-BEST, and New Energy Nexus. The Boston Consulting Group (BCG) hosted the forum in its Detroit office and facilitated the meeting.

The objective of the forum was to generate a report that would advise federal and state policymakers about the challenges of lithium-based battery recycling in the U.S. and possible ways that those challenges might be addressed. To that end, forum participants engaged in a mix of presentations, group exercises, and small group breakouts designed to promote discussion of current industry practices; to identify successes and challenges faced today by industry in recycling lithium-based batteries; and to propose prospective policies and actions that government and industry could take to support more effective recycling of lithium-based batteries in the U.S. and the complete securing of battery energy materials produced by such recycling for the benefit of U.S.-based manufacturers.

The scope of the discussion topics in the forum was intentionally focused upon recycling of lithium-based battery materials, both post-industrial and post-consumer scrap across all applications (electric vehicles, consumer electronics, grid energy storage, etc.) that are consumed in the U.S. and more broadly in North America. Out of scope were reuse, reconditioning, and second life activities, as well as material provenance and other upstream traceability activities. Such topics are planned for discussion in following meetings.

The workshop consisted of four different sections. The first phase was an overall group exercise to visualize and understand the industry's current state and challenge. Subsequently, the participants broke into three working sessions to address the following challenges: Collection and Transport, Managing Used Energy Materials, and Economics and Advantage. At the end of each breakout, teams reported a summary of their findings to the broader group.

The workshop yielded a clear summary of the industry challenges, projected optimism to achieve the ideal industry, and generated actionable recommendations. Further details are described in the following sections.

Key Challenges

A wide range of challenges were identified and discussed in detail. At their core, most of the challenges are economic in nature and relate to price, cost (real costs and opportunity costs), and competitive advantage. Non-economic factors such as toxicity and health risk or talent were comparatively viewed as having fewer gaps to target state. Management of post-consumer batteries and battery materials was also seen as more challenging than post-industrial battery waste.

The key fundamental challenges are summarized as follows:

1. **High processing costs relative to the intrinsic value of certain battery chemistries and cell components**

   The high processing costs of recycling battery materials relative to their intrinsic value is a key determinant of economic viability for the lithium-based battery recycling industry. This challenge will only become greater as lithium-based battery cathode technology evolves, as expected, from the nickel- and cobalt-based cathode chemistries of today toward cathode chemistries with substantially lower intrinsic material values such as lithium iron phosphate (LFP). BCG anticipates these iron-based cell technologies will account for more than 50% of new battery sales in the United States across all applications by the year 2035. This transition to nickel- and cobalt-free cell chemistries will drive increasingly unfavorable cell recycling economics unless either the processing costs are reduced or the recovered components' value increases.

Additionally, other lower value cell components are rarely recycled today because of the same processing-cost-to-intrinsic-value challenge. Beyond cathode materials, two components were most discussed: anodes and electrolyte solvents. For anodes, the intrinsic value of graphite material is insufficiently high to merit payoff for large-scale recycling. Furthermore, the fact that many anodes utilize blends of natural and synthetic graphite make reintroduction of recovered anode materials into the battery supply chain technically challenging. For electrolyte solvents, the costs to process organic solvents found in electrolytes such as ethylene carbonate or dimethyl carbonate are often higher than manufacturing virgin materials.

The cost-to-value equation is also not equal across geographies. Processing costs in the U.S. are often higher than in overseas facilities that do not adhere to the same environmental standards or other best practices. Recycling materials that have lower intrinsic value are often substantially more profitable in these regions where processing costs are less. Thus, overseas facilities can often outbid US-based facilities for end-of-life energy materials.

U.S. industry will continue to be reliant on virgin sources for these materials with less intrinsic value unless the cost-to-value challenge is addressed. Further, dependence will be on the Asian-based manufacturers that dominate battery component and processing activities today. Therefore, the lack of an economically sustainable supply of domestic recycled components will only reinforce U.S. dependence on foreign countries for key virgin battery components– or at least until U.S. processing and battery component manufacturing capacity comes online. More support from the U.S. Loan Programs Office and grants created in the Bipartisan Infrastructure Law are needed to help close the local supply-demand and processing cost gaps.

2. Nascent pathways to recycle batteries in sufficiently large volumes for a fully domestic circular economy

Collection rates remain low for lithium-based batteries from consumer applications such as electronic devices. Used batteries are stored in households or end up in household trash versus being recycled into the circular economy in a timely manner. A demand signal, namely, a price that is sufficiently high to generate the used battery owner to act, is lacking to drive consumer behavior.

The recycling of lithium-based battery systems have separate determinants due to their size, weight, risks, and integration into the product. Once collected, full systems, packs and black mass are available to the highest bidder in the global market. As a result, shipment of energy materials overseas is likely to occur if the willingness to pay is more competitive by foreign-based operators than domestic-based companies. Another advantage Asian markets enjoy today that underpins their ability to compete for battery recycling materials is the fact that they have a whole 'ecosystem' to convert and consume these materials. With time, when each of the supply chain segments are established domestically, recyclers will have more off-take options at home. Given some of the structural advantages that recyclers and processers based in Asia have today, such as lower operating and capital costs than in the U.S., the outflow of both recycled and recyclable energy materials to cell component producers located offshore ("leakage") is market-driven and will remain a persistent threat.

There is a long tradition of used vehicle exports to lower income markets. In the case of electric vehicles (EVs), their battery packs are exported too. The large volume of used vehicles being exported from the U.S. are being sold at wholesale and salvage auctions. There is a strong export market for used vehicles (including EVs) because these vehicles and their batteries are being put to their highest and best use abroad. Vehicles that would otherwise be uneconomical to repair for road use within the U.S. have sizable repair markets abroad, which includes the repair and replacement of EV batteries. Favorable import incentives for salvaged cars in Romania, for example, have created a strong demand signal for the transboundary shipment of EVs.

The Inflation Reduction Act (IRA) provides a production-related incentive equivalent to 10% of the value-add of recovery through a 45X tax credit. Additionally, the IRA changed the rules for IRS Section 30D tax credits for vehicles purchased from 2023-2032 to provide$7,500 to consumers via tax credits for new, qualified EVs. Participants in the Li-Bridge forum believe the 30D credit is neither sufficiently strong nor complete without complementary signals created by the likes of recycled content standards or core charges (form of deposit held for the return of the battery) that encourage recovery. Without an aligned set of behaviors across stakeholder groups, the uptake of fully domestic recycled materials for new batteries produced in the U.S. will remain challenged.

3. High labor intensity in collection, sorting, and disassembly

Disassembly of used battery packs is often complex, varied, and labor-intensive. Intensity is driven by the near-limitless landscape of form factor, capacity, chemistry, state of charge (SOC) and state of health (SOH) that combine to make use of automation equipment with adequate speed and yield a challenge. Additionally, most battery packs are not designed for ease of disassembly.

Further complicating this challenge is the fact that the information needed to properly identify the chemical composition of retired batteries is not always readily available to U.S. recyclers. Lithium-based battery packs, especially from consumer electronic applications, are consistently mixed with other battery types such as nickel-cadmium, nickel-metal hydride, and lead-acid batteries. Each battery type has a distinct recycling stream, so mixing chemistries results in added handling time, cost, and safety challenges.The incumbent battery sorting operations are primarily done by manual processes which are labor-intensive, inefficient and/or increase downstream processing costs because they cannot achieve required purity metrics.

Intentional mislabeling to avoid import and handling regulations associated with lithium-based batteries is a persistent problem in consumer batteries that historically has led to safety hazards when haulers or shippers do not know what they are carrying.

4. Lack of customized classification frameworks for lithium-based battery storage and transport

Transportation regularly represents the highest cost item in the recycling process of a used battery pack. The consensus among Li-Bridge participants is that clearer definitions of what constitutes “hazardous waste” in the context of used batteries and black mass would help reduce transportation costs.

The inability of transporters and other handlers of used batteries easily to determine the state of health (SOH) and state of charge (SOC) of the batteries they handle adds significant cost. Limited adoption of appropriate inspection tools makes it difficult to characterize the SOH and SOC of used batteries. In cases where a battery’s SOH is unknown, first responders, municipalities or other management agencies have established requirements to treat the pack as if it was damaged, defective or recalled (DDR). This default classification adds significant and potentially unnecessary costs to packaging and transport.

Participants identified the transportation and handling of black mass as an additional problem. Today, black mass is a generic term encompassing everything from crude battery shred to processed powders containing energy materials derived from the shredding of used batteries and production scrap. Current EPA guidance requires the generator of the black mass to determine whether it contains hazardous waste characteristics. See: “Lithium Battery Recycling Regulatory Status and Frequently Asked Questions”, https://rcrapublic.epa.gov/rcraonline/details.xhtml?rcra=14957 at 11-12 (May 24, 2023). This is not always done. Compounding the complexity, the hazardous waste characteristics of black mass can change over time. Transporters and other handlers of black mass often do not know the characteristics of what they are handling and assume the black mass is hazardous. This frequently results in higher than necessary costs.

It was suggested that a better scheme of definitions for black mass might reduce these unnecessary costs. For example, “active black mass” could be a definition that warns transporters and other handlers that the subject black mass may contain hazardous characteristics. “Light or deactivated black mass” could be a separate classification that would indicate a certification by a generator that the black mass contains a level of defined actives that does not exceed certain maximums. Transporters and other handlers could rely on this second definition to avoid classifying light or deactivated black mass as hazardous waste.

5. Lack of knowledge of occupational and environmental health risks and the absence of occupational health and safety best practices

Beyond conventional occupational safety hazards and controls, unique health and safety risks are inherent to the daily activities of lithium-based battery recycling operations. These risks extend from collection, to shredding and separation, to chemical recovery, testing, refining and packaging, to potential incineration of organic waste and ash disposal. Even with automated and enclosed processes, human contact with black mass and other recycling by-products is inevitable. For example, day-to-day recycling of black mass potentially exposes workers to a wide range of respirable or dermally absorbable chemicals. Specialized intermediate extraction methods such as for nickel separation can introduce acutely hazardous reagents and intermediates (e.g., nickel carbonyl). Noise is a ubiquitous hazard that may be difficult to control given processing volumes and material compositions.

The immediate and long-term health effects and risks of inhalation or other routes of exposure to these chemical hazards are poorly understood. Human-based toxicity and epidemiological health risk data are scarce, inadequate, or altogether missing. There is not industry-specific expertise in occupational medicine and industrial hygiene commonly accessible to all companies in the industry. The experience over many decades of the lead acid battery recycling industry has shown that merely attaining the minimum threshold for regulatory compliance and over-reliance personal protective equipment (PPE) may be inadequate for effectively preventing occupational exposures to toxic substances. Additionally, communities located around battery recycling facilities must have confidence that these materials are being controlled and not emitted as pollutants to which they can be inadvertently exposed in air or drinking water.

The lack of established, disseminated, and enforced best practices for battery EOL workplace safety also increases human, environmental and reputational risk from one-off incidents such as battery fires both in the facility, and during transport of spent batteries. For example, de-energizing battery packs before they are safe for further recycling is a critical pre-treatment step to avoid safety incidents such as fires. Currently, workers in recycling facilities or automobile scrap yards decommissioning batteries often lack clear guidelines on de-energizing techniques that could be employed to effectively discharge the batteries prior to dismantling. Safe de-energizing practices are not presently ubiquitous, such as parking the vehicle at a service center and turning on the air conditioning (or heater) to drain the pack of as much energy as possible prior to disassembly. One-off but potentially high hazard events include fires at collection storage facilities or while transporting EOL batteries present unique health risks not only to workers but also first responders, firefighters,and bystanders. Emergency first responders and medical providers need to understand specific hazards and be prepared to confidently assess and treat them appropriately to mitigate serious outcomes including permanent injuries and death—and to ameliorate public misperception and media sensationalism of such events.

The lack of existing infrastructure for collection through to material recovery and reprocessing is viewed as a symptom of the above challenges as well as recycling feedstock levels only starting to reach levels that allow for the scaled build out at each step in the value chain.

Key Recommendations and Next Steps

Drawing upon the takeaways listed above and roundtable discussions, eleven critical action items emerged where the U.S. Department of Energy (DOE), U.S. Department of Transportation (DOT), and U.S. Environmental Protection Agency (EPA) can enact policies to drive a significant increase in domestic battery recycling.

1. **Establish economic structures that encourage the recycling of lithium.** Because of the rapidly changing nature of lithium-based battery chemistries, recycling policy in the U.S. should focus on the one consistent element in lithium-based battery chemistry: lithium itself. Encouraging the recapture of lithium should be the single most important focus of modern battery recycling. By focusing on lithium, recapturing nickel, cobalt, manganese, iron and other critical minerals will follow through expanded recycling of batteries as a whole. The roundtable discussions explored a number of ways to incentivize lithium recovery and reuse back into domestically-manufactured batteries. Increasing the value of the 45X production tax credit provision within the IRA for recycled battery grade lithium was one suggestion. Another suggestion was a deposit program, similar to a core charge, that could be funded by the Section 30D tax credit, for example. Core charge programs are difficult to implement, however, as they can introduce additional financial burdens on OEMs or producers and do not guarantee full value recovery when the battery is returned at EOL. For this reason, there was no consensus on the core charge program structure. Nonetheless, participants emphasized the importance of significant market-price signals to encourage recycling and the domestic re-use of recycled energy materials. A byproduct of these possible policies would likely be additional private investment in advanced recycling technologies and infrastructure.

2. **Define rules related to leakage for how batteries are permitted to exit the country, especially as it pertains to bidding at auction houses.** Minimizing ‘leakage’ of used energy materials from the U.S. to other countries, particularly in Asia, will require economic incentives and/or export controls. To the extent that the federal government subsidizes the recycling of lithium-based batteries in the U.S., the government should require that any party receiving those batteries for recycling commit to re-sell the recycled energy materials only to U.S.-based or Free Trade Agreement countries’ manufacturers, with transparency to ensure these commitments and their transactions are fulfilled. In addition, near-term measures may also be needed that limit the export of used energy materials in select forms where a market for such recyclable materials exists in the U.S. For example, such policies could include a temporary ban on the export of used EV battery packs, crude battery shred, and black mass — or limiting companies that are authorized to bid on EVs at auction. Enforcing such a ban would likely fall to a combination of different government agencies, such as the Bureau of Industry and Security as well as U.S. Customs and Border Protection, under the umbrellas of the Department of Commerce and Homeland Security, respectively. Additionally, the magnitude of the battery exporting problem coupled, with its complexity to solve, will necessitate a roundtable convened by the Federal Government to ensure there are no unintended consequences of such legislation.

3. **Update the federal EPA and DOT regulations for how battery-related waste is classified during collection, storage, and transport.** It is imperative to evolve beyond the single battery shipment economics requirement as part of the DOT hazardous materials classification. A new tiered system for labeling and packaging, for example, based on cell damage, is needed. An updated labeling system for fresh batteries, and especially at EOL, will also clarify requirements for both consumers and producers, minimizing the potential for safety-related problems associated with mislabeled reactive waste and minimizing the quantity of non-recycled waste that is generated.

4. **Require that all lithium-based batteries be clearly and conspicuously marked at production, collection, or sorting stage of life-cycle so that their basic chemistry can easily be identified by recyclers.** Reducing the mixing of lithium-based batteries into other waste streams is a critical safety issue as well as a prerequisite for efficient, low-cost recycling. Allowing battery recyclers and vehicle dismantlers to identify easily the type and basic chemical composition of the lithium-based batteries they handle would be an effective way to reduce the processing costs of battery recycling. Participants differed in what the most effective and cost-efficient way to provide this information would be. Some participants favored different types of physical labeling, while others advocated for a digital battery signature. Regardless, a comprehensive, universal labelling system at both the cell and pack level is recommended. In the near term, advanced technologies to identify and mark battery type and basic chemical composition at the collection and sorting stage should be developed due to the lack of available information for batteries already in service.

5. **Require industrial battery pack producers to publish protocols for decommissioning battery packs.** The Federal Government should require that all industrial battery packs are accompanied by decommissioning protocols authored by the producers. Independent and/or standards-based organizations such as SAE International and EPRI should develop the common frameworks under which decommissioning protocols can be written. The framework should be sufficiently comprehensive to cover a range of use cases and scenarios. Producers of lithium-based solutions should ultimately be responsible for publishing the protocols specific to their products. Following these protocols would make important information readily accessible to dismantlers, mitigating the risk of mishandling and environmental-related hazards associated with the disposal and recycling of lithium-based batteries. Federal authorities can also create guidelines for best practices in retiring cells and help to streamline and standardize processes across pack types.

6. **Author guidelines for the proper storage and transport of used batteries that are acceptable to operators and insurance agencies alike.** By implementing protocols and guidelines at the federal level for the storage and transport of used batteries, the potential risks associated with mishandling or improper storage are mitigated. The merits of such guidelines can already be seen by looking to the International Code Council, which has new storage standards for lithium batteries going into effect in 2024. Guideline subjects should include specifications on safe storage (e.g., well-ventilated isolated from potential ignition sources), temperature control, separation from potential cross-contaminants, ventilation, and fire suppression coverages. Transporting guidelines should include packaging requirements, updated labeling and documentation guidelines, and securing guidelines to prevent shifting, tipping, or damage in transit. These guidelines should be customized and/or tiered based on battery characteristics. Federal and state DOTs as well as standards-based organizations focused on building and fire code such as National Fire Protection Association (NFPA) and American Society of Civil Engineers (ASCE) are among the parties to take the lead.

7. **Enforce existing laws as they relate to improper deployment, storage and/or transport of lithium-based products.** The deployment of mislabeled or uncertified batteries and the mishandling of batteries not only poses significant environmental risks but also jeopardizes public safety associated with the transportation of recycled cells. The DOT has authority to define packaging requirements, hazardous materials training requirements, as well as enforcing compliance pertaining to the transportation of hazardous materials. The Bureau of Consumer Protection has authority to penalize companies for marketing dangerous products. By imposing fines and other penalties on violators, a strong deterrent message can be sent to ensure that those who contribute to fires and other hazardous incidents are held accountable. Such enforcement will not only safeguard our communities, but also encourage responsible disposal and recycling practices within the battery industry, reducing insurance costs.

8. **Increase R&D funding to national laboratories, academic institutions, and in private industries that bridge current knowledge with desired recycling capabilities.** Four specific areas to double-down are recommended. First, fund R&D capable of low-cost recapture of low value cathodes such as LFP or LFP derivatives and non-cathode elements in battery packs and cells. Second, invest in processing innovations that reduce the cost of low-environmental impact of lithium-based battery recycling, such as the

cost-effective conversion of sodium sulfate back into battery industry reagents such as sulfuric acid and sodium hydroxide. Third, focus on R&D opportunities related to next-generation materials such as lithium metal anodes, high-silicon content anodes, and solid-state batteries. Presently, the challenges posed by recycling high energy density cells (e.g. 450+ watt-hours per kilogram, or Wh/kg) are poorly understood. Lastly, approaches to triage batteries and estimate their SOH require development in order to facilitate best use when batteries arrive to dismantlers. This will ensure the right batteries enter the recycling stream. Research and pilots can help bridge these capability gaps before substantial flows of batteries reach end of life and future-proof the nation's recycling capabilities. The ReCell Center established within the U.S. Department of Energy should be an important partner in this research.

9. **Create and adopt scientifically-based best practice methods for toxicology, medical, and industrial hygiene information.** These include methods and tools for biological monitoring, medical surveillance, respiratory protection, and industrial hygiene monitoring and occupational exposure limit (OEL) setting. This effort is best undertaken outside the scope of traditional regulatory agencies such as OSHA or EPA, and then integrated into existing regulatory approaches and requirements to ensure consistency. Similarly, scientifically-based information and methods for first responders, emergency medicine practitioners, and other physicians is needed to effectively respond to battery fires, minimize human and environmental injury, and provide meaningful assurance to the public and governmental officials about inherent hazards.

10. **Hold an additional forum to gather ideas on circular economic initiatives beyond recycling, such as reuse, reconditioning, and second life.** Ideas and expertise pertaining to the mass scale reuse, reconditioning, and second life applications for lithium-ion batteries were not covered in this forum. Some forum participants recognized the theoretical ability of second life applications to reduce the carbon footprint of the battery supply chain and to reduce demand for virgin energy materials. Provided that the case can be made for economic and safe battery reuses, the future forum's focus areas should understand and identify: the most promising pathways for re-purposing, measures to facilitate the safe re-deployment of used batteries in the field, and the interplay between second use and recycling. It is important to understand the warranty and insurance mechanism in reuse, reconditioning, and second life applications. The experience and case-study in similar industries or more mature EV markets should be investigated and leveraged.

11. **Hold an additional forum to gather ideas and industry feedback on a program analogous to Europe's Battery Passport for the United States.** There were some concepts where no agreement was reached within industry and/or between industry and government. Differing opinions exist on concepts such as extended producer responsibility (EPR) requirements and how they should (or should not) be incorporated into the U.S. battery recycling landscape. Similarly, required use of a battery passport, as currently defined in other regions, continues to have varying levels of domestic support. There is agreement on the fundamental principles of needing proper controls and visibility into material flows. The recommended solutions, however, lack consensus.

    There is both promise and potential pitfalls with adopting some or all of the EU's prescriptive Battery Passport program in the U.S. Additional discussions are required to determine the appropriate level of transparency and traceability while not burdening the burgeoning domestic battery value chain. Traceability could be a key enabler to measuring the effectiveness of U.S. battery recycling infrastructure. U.S. government and industry must take a proactive approach to defining such a system in the U.S., else risk the EU's structure becoming a standard that is not fit for the U.S. market. Stakeholders involved in upstream mining and processing activities need to be included in this forum.

Relatedly, solutions such as recycled content requirements were generally favored but with an implementation timeline in the medium- to longer-term future and with tiered thresholds that increase over time. A recycled content requirement is viewed as more appropriate when domestic recycling capabilities have expanded, there are higher volumes of manufacturing scrap and EOL batteries entering the waste stream, and the consumption of new battery materials has leveled off to slower growth. Such a requirement today risks burdening producers with additional costs that they then pass along to end consumers, which in turn, delays adoption of lower-carbon solutions.

In conclusion, the recommendations outlined in this paper address many of the near-term challenges and create a stronger foundation for expanding domestic battery recycling capabilities. A mix of innovative strategies and sensible rule-making will make the storage, transport, and processing of used batteries in the U.S. safer and less costly. The value of domestic recycled battery materials will increase. The U.S. will benefit from more responsible resource management, economic opportunities, and technological advancements.

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BRIDGING THE LITHIUM BATTERY SUPPLY CHAIN GAP

Li-Bridge is a public-private alliance that aims to grow the U.S. energy storage ecosystem by nurturing the lithium battery supply chain, creating equitable jobs, and maintaining U.S. competitiveness.
As the demand for lithium-based batteries to power electric vehicles and stationary storage ramps up, the domestic battery supply chain must expand to achieve widespread electrification. However, the importance of storage is also being recognized worldwide, resulting in increased global competition to capture a share of the battery market. U.S. industrial competitiveness requires rapid innovation, combined with manufacturing at scale, to satisfy the growing need.