CREATING A CIRCULAR ECONOMY FOR CRITICAL MATERIALS IN OHIO

C2ES CLIMATE INNOVATION 2050

by

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Global demand for electric vehicles is expected to continue growing in the coming decades. With that, demand for critical materials like lithium, manganese, copper, silicon, and others is set to rise significantly. Recent electric vehicle battery and recycling investments in Ohio build on the state's existing competencies throughout the automotive and scrap recycling supply chain, making Ohio a key player in the U.S. battery recycling economy of the future. At the same time, legislation like the Bipartisan Infrastructure Law and the Inflation Reduction Act have invested in growing American battery recycling capacity and innovation, creating incentives for domestic recycling through the EV tax credit. This brief provides insights from a C2ES roundtable hosted in Columbus, Ohio, in December 2023 that explored the critical materials recycling opportunity in Ohio and provides policy recommendations for federal, state, and local policymakers to take advantage of this opportunity developed with participants during and following the discussion.

INTRODUCTION

REGIONAL ROUNDTABLES

Efforts to facilitate the transition to the low-carbon economy of the future are accelerating across all sectors of the economy. To chart a pathway to sustainable and long-term prosperity, communities must be able to leverage their unique strengths and capitalize on emerging economic opportunities while addressing barriers that are often poorly understood outside of their communities. To that end, the Center for Climate and Energy Solutions (C2ES) hosts regional roundtables to bring together local, state, and federal policymakers; businesses of all sizes; community organizations and nonprofits; academics and issue experts; trade associations; investors; economic development organizations; and others. These conversations are meant to elevate the perspectives of a diverse set of stakeholders who are deeply embedded in their communities and uniquely positioned to speak to the needs of their states and regions. They are also meant to create opportunities to integrate local perspectives into state and federal policy decisions and,

importantly, identify concrete steps to better align the long-term vitality of these communities with the urgent task of reaching net-zero emissions economywide.

Our December 2023 roundtable, held in Columbus, Ohio, brought together approximately 40 participants representing companies, industry groups, local, state, and federal government, nonprofits, community groups, academics, and labor. This brief summarizes key takeaways from the discussion and—building on insights from the event and other conversations with local stakeholders—provides C2ES recommendations meant to advance the electric vehicle (EV) battery and critical materials recycling industry in the state in a way that achieves both climate and economic development goals.

THE CASE FOR A CIRCULAR ECONOMY FOR CRITICAL MATERIALS

One of the chief anticipated challenges of the ongoing transition to clean energy and climate technologies will be the availability of critical materials and minerals. The production of established and emerging clean technologies—from renewables like solar panels and wind turbines, to batteries for energy storage and EVs—requires the use of minerals and metals like lithium, cobalt, copper, and nickel. As the demand for and production of clean energy technologies increase over the coming decades, corresponding demand for these critical materials will reach unprecedented levels.[1]

Currently, these materials are mined through extractive processes that can, without proper safeguards, lead to environmental degradation and human health effects, running counter to sustainability and climate goals.[2] Sourcing these materials through mining alone at the levels required to meet projected demand will create supply chain constraints due to economic, social, and environmental challenges. For example, in Guinea, bauxite mining is responsible for the conversion of "hundreds of square miles once used for farming…[and locals and rights activists say] villagers have received little or no compensation."[3] In South African manganese mines, "workers…say they have experienced memory loss, slurred speech and other physical impairments tied to ingesting the mineral's fine dust."[4]

Some companies address these potential harmful social and environmental impacts of mining by ensuring the materials needed for clean energy technologies are responsibly sourced. While individual company procurement standards are important to avoid harmful practices, policymakers and regulators have a clear role to play: establishing environmental standards, creating project appraisal systems, and implementing transparency and due diligence requirements for mining operations. These actions can reduce the environmental impacts of mining and increase accountability and community engagement to ensure mining is a positive force for local economic development; however, even with reformed mining practices, the demand for these critical materials is still projected to outpace supply.[5] As the United States continues to build out production capacity for clean energy and low-carbon technologies, companies are looking to shore up supply chains that secure critical materials.

At present, the most convenient and cost-effective method to source critical materials is through recently mined "virgin" material.[6] In many cases, after a virgin-material product meets the end of its useful life, it is discarded into a landfill, removing it from the supply chain and harming the environment. However, many of the critical materials within clean energy products can be reclaimed and repurposed, reducing environmental harm and alleviating supply chain concerns of virgin mining.[7] A 2022 World Wildlife Fund report estimates that scaling recycling technologies to recover critical materials from low-carbon technologies could supply 20 percent of total demand between 2022 and 2050.[8] A 2021 International Energy Agency report estimated that by 2040, recycling copper, lithium, nickel, and cobalt from batteries could reduce primary supply needs by 10 percent, though it emphasizes that the benefits of recycling are far greater in regions with wide deployment of clean technologies due to economies of scale.[9]

This process of reclaiming materials from discarded products and repurposing them to serve a new useful life is the basis of the circular economy. A circular economy for critical materials will be less resource intensive and environmentally extractive. It could also simplify supply chains by creating secure loops within industries and regionalities with large clean-technology industries. One such industry cluster driving a large demand increase for critical materials is EV battery manufacturing.

In 2022, EV batteries accounted for 60 percent of global lithium demand.[10] Meanwhile, the recycling rate of lithium is estimated to be less than 1 percent.[11] EV battery recycling could play an important role in securing the domestic EV supply chain; however, many barriers remain to increasing the proportion of batteries recycled, including lack of public awareness regarding how to recycle, limited recycling capacity, high cost of transporting reclaimed battery materials, and a regulato-

ry structure that fails to internalize the external costs of mining. In spite of these barriers, recyclers are optimistic about the technical potential of recovery rates from EV batteries, with one recycling pilot demonstrating over 95 percent efficiency in recovering critical metals within battery packs.[12]

The automotive manufacturing industry could benefit significantly from the incorporation of circular sourcing practices for critical materials. Sourcing the quantity of critical minerals used in EV batteries—such as lithium, cobalt, manganese, and nickel—from mining alone may prove untenable in the face of political, social, economic, and logistical challenges.[13] To overcome these challenges, automotive original equipment manufacturers and the regions that host their production facilities will need to find creative solutions to source these critical materials.

FRAMING THE CIRCULAR ECONOMY DISCUSSION IN OHIO

Vehicle manufacturers and battery makers have announced more than $210 billion in investments into U.S. facilities by 2030, representing almost a quarter of global announced investment into the sector.[14] In Ohio, more than 15 companies have announced investments totaling more than $3.8 billion for EV and battery manufacturing and recycling facilities in the state since 2019.[15]

As of 2022, 75 percent of North American EV and hybrid-vehicle assembly and announced U.S. EV battery manufacturing facilities were located within a 500-mile radius of Columbus—the range that a freight truck can realistically travel in a single day.[16] Given its centralized location within this growing industry, Columbus and the south-central region of Ohio are well positioned to take the lead as a logistical hub for the recycling and repurposing of critical materials used in the manufacturing of EVs and batteries.

In addition to the announcements of new original equipment manufacturer facilities for EV and batteries in Ohio, critical material recycling startups and companies have also announced plans to open and expand facilities in Ohio. Nth cycle, a critical metals extraction and refining company, is commissioning a refining facility in Fairfield, Ohio, to turn metal scrap, electronics waste, and potentially lithium-ion batteries into nickel and cobalt, among other critical materials.[17] Cirba solutions announced in early 2023 that it would be expanding its lithium-ion processing facility in Lancaster, Ohio, with an investment of more than $200 million. The investment is expected to create 150 jobs and produce 200,000 EVs worth of recycled materials annually.[18] Cirba also has a public agreement with General Motors to recycle EV lithium-ion battery and cell scrap from select facilities through 2024, an example of a private sector partnership that forms the basis of closed loop material sourcing processes.[19]

Ohio state agencies are already working to facilitate the sharing of critical materials among additional private sector partners. For example, the Ohio Environmental Protection Agency (Ohio EPA) launched the Ohio Materials Marketplace, an online platform where businesses, non-profits, and government can advertise and acquire critical materials that may otherwise be discarded.[20] Ohio state government should continue to support creative solutions to encourage recycling partnerships while also investing the necessary infrastructure to take advantage of the State's existing competitive advantages in critical material recycling.

THE U.S. EV BATTERY RECYCLING INDUSTRY

Battery recycling facilities in the United States

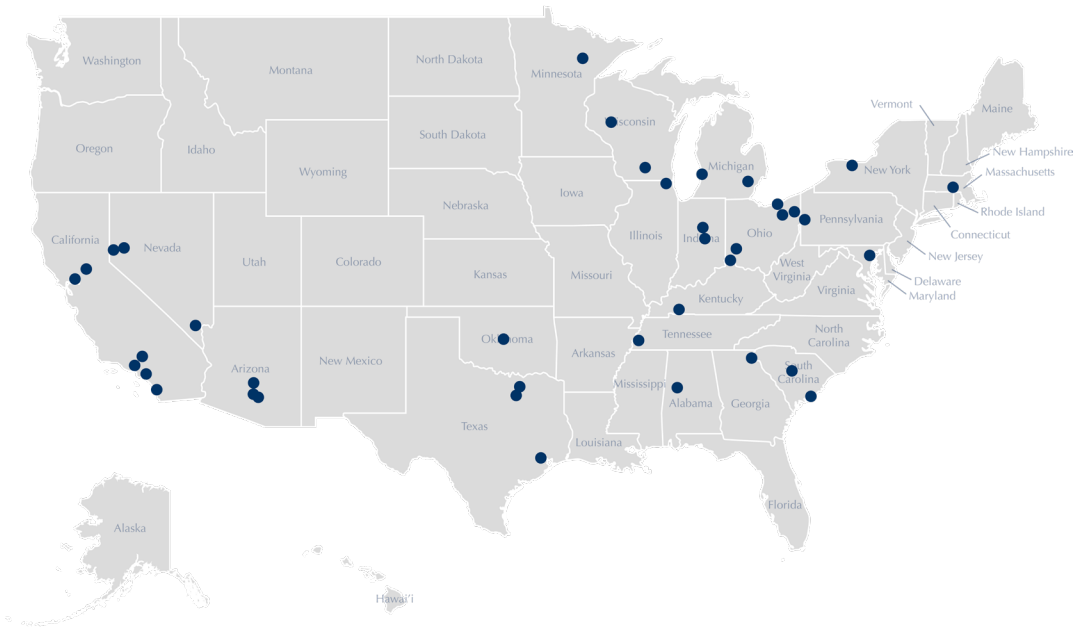
To date, 43 battery recycling facilities are operational or planned in the United States, ranging in capacity from the equivalent of 10,000 EV batteries to 200,000 EV batteries (See Figure 1).[21] For comparison, almost 1.2 million EVs were sold in the United States in 2023.[22] Federal policy supporting domestic manufacturing and recycling of EVs and batteries has largely driven much of this recent investment, and several states have passed or are developing policies to support EV battery recycling.

Domestic content requirements

Provisions under the 2022 Inflation Reduction Act (IRA) are driving much of the recent investment in domestic EV and battery production facilities. The IRA updated the clean vehicle consumer tax credit, which offers up to $7,500 to purchasers of qualified battery- and hydrogen-electric vehicles, to add a "domestic content" eligibility provision. [23] This new provision requires that an increasing percentage of critical materials in the vehicle's battery must be produced or recycled in the United States or in a country with which the United States has a free trade agreement to be eligible for the credit.

Following the passage of the IRA, automakers have accelerated announcements of new domestic investments in battery production and recycling, including in Ohio.[24]

FIGURE 1: Map of Planned and Operational Battery Recycling Facilities in the United States



Source: BlueGreen Alliance Foundation, "EV Jobs Hub," accessed June 12, 2024, https://evjobs.bgafoundation.org.

Because it is difficult to open new critical materials mining and processing operations in the United States—particularly under the current decades-long permitting process—many automakers are looking to increase domestically recycled content in their batteries to keep their vehicles eligible for tax credit and to reduce their reliance on mined virgin materials.[25] As evidenced by the rapid construction of recycling facilities in recent years, permitting timelines are significantly shorter for these facilities than for new mines.

Battery recycling and the Bipartisan Infrastructure Law

The 2021 Infrastructure Investment and Jobs Act (IIJA or Bipartisan Infrastructure Law) created new programs within the U.S. Environmental Protection Agency (U.S. EPA) to support battery recycling. While much of the provisions are aimed at consumer electronics and portable lithium-ion batteries, some provisions are directed toward EV batteries, as well. Some of these provisions include:

- The IIJA requires U.S. EPA to develop **Battery Collection Best Practices and Battery Labeling Guidelines**, including for EV batteries. In 2022, U.S. EPA conducted research on the current state of battery recycling and labeling efforts around the United States. The agency is currently developing a report to Congress on best practices for battery collection, to be published in 2024. Subsequently, U.S. EPA will produce best practices for collection and recycling of batteries for state, tribal, and local governments, with plans to produce a final toolkit by 2026.[26]
- The **Battery Materials Processing and Battery Manufacturing & Recycling Program** provides $2.8 billion for a portfolio of projects to support new and expanded commercial-scale facilities to accelerate the production of EV batteries. Eligible projects include processing facilities for graphite, lithium, and other materials; component manufacturing; and demonstration projects for new approaches like manufacturing components from recycled materials. To date, the U.S. Department of Energy (DOE) has awarded funding to one recycling facility under this program: Cirba Solutions in Lancaster, Ohio.[27]
- The **Electric Drive Vehicle Battery Recycling and Second Life Applications Program** provides $73.9 million for a portfolio of projects supporting research and development aimed at accelerating EV battery materials separation, scale-up, and reintegration, as well as second-life demonstration projects for EV batteries.[28]

State EV battery recycling policy proposals

New Jersey

In January 2024, New Jersey became the first state to pass legislation specifically targeting recycling for EV batteries, through the Electric and Hybrid Vehicle Management Act. The new law does three key things: it creates an extended producer responsibility (EPR) program for EV and hybrid batteries, prohibits the disposal of these batteries as solid waste, and establishes a battery labeling program.[29] Under New Jersey's EPR program, the entity taking the vehicle or battery out of service is the party responsible for ensuring the battery is recycled. This means that if a vehicle's battery is replaced, the person performing the replacement is responsible for properly handling the old battery; if the vehicle is sent to a recycler, the recycler is responsible for the battery; and if the vehicle is not taken to a recycler, the person who takes the vehicle out of service is responsible for the battery.[30]

The law also requires producers of EV and hybrid batteries sold in the state to develop a battery management plan, including developing a take-back program, whether for the complete vehicle or just the battery. Under the law, this management plan should include methods for collection, storage, and transportation of batteries, as well as plans for financing all of the above. The battery management plan must also include a strategy for educating consumers, EV owners, repair facilities, and dismantlers about how to "manage propulsion batteries, the environmental impact of the improper handling or disposal of used propulsion batteries, and the mechanisms for the management of propulsion batteries that are available pursuant to the plan."[31]

California

Beginning in 2019, California convened a task force with experts and representatives from the industry to produce policy recommendations in support of EV recycling.[32] The group also focused on producer responsibility and made two recommendations on this issue. First, it recommended that the EV manufacturer should be responsible for ensuring the batteries from their vehicles are recycled at the end of their useful life. The second recommendation was that, alternatively, the recycler or dismantler should be responsible for recycling the battery if the vehicle and battery reach end of life outside of the manufacturer's warranty. This second policy alternative received greater support from members of the task force, particularly those representing recyclers, because of the value of the materials inside of the battery. To date, California has not yet enacted EPR legislation for EV batteries.

KEY THEMES FROM THE DISCUSSION

Four main themes emerged from the roundtable discussion on the circular economy for EV batteries in Ohio.

First, participants emphasized that—in comparison to mining virgin critical materials for battery production—the economics of recycling for EV batteries are not currently favorable. In part, this is due to the lack of collection, transport, and recycling infrastructure, itself a function of the relatively low volume of EV batteries in circulation. Roundtable participants indicated that various actions are needed to enhance the industry's economic viability, including: funding support for the development of this infrastructure and technology, incentives to consumers and businesses for recycling, and regulatory measures encouraging increased rates of recycling.

Second, participants highlighted that to reduce the costs of extracting critical materials from batteries, they must be designed with recyclability in mind. Battery standardization across models and manufacturers can also help recyclers more efficiently recover materials. Design for recyclability was a central, cross-cutting issue participants raised in the discussion of several topics—economics, worker safety, innovation, and the ability of regulations like recycled content standards—to be effective.

Third, roundtable participants agreed that education and outreach to consumers, businesses, workers, and policymakers is crucial to prepare the automotive supply chain with the relevant knowledge to handle EV batteries safely, skillfully, and properly for recycling. Education for all should include information about collection points and recycling protocols. Businesses and workers, specifically, would need safety information on properly dismantling batteries, handling high-voltage batteries, and identifying damaged batteries.

Finally, while participants expressed optimism that new battery recycling facilities could create jobs and bring economic value to Ohio communities, there was some concern around community engagement. They highlighted the need for recycling facility developers to engage proactively, transparently, and comprehensively with communities to ensure their needs are met in the design and construction of new facilities. They suggested that municipalities could support companies on this engagement, but that additional funding and capacity support is needed from the state and federal government to facilitate this work.

BOX 1: Policy Recommendations

Facilitate recycling, improve recyclability, and promote second life applications

- **Congress** should direct **U.S. EPA** to commission a study to explore the implications of enacting federal-level extended producer responsibility for electric vehicle batteries. This report should identify essential elements of policy design, including whether battery manufacturers or automakers should be responsible for battery recycling or safe disposal, and to what extent responsible parties should fund collection and recycling. The study should include an advisory group with representation from battery manufacturers, automakers, recyclers, and community leaders.
- **National Highway Traffic Safety Administration (NHTSA)** should enact transparent national minimum safety standards for workers interacting with, repairing, and dismantling electric vehicle batteries and other mobility related high voltage batteries. These should build upon NHTSA's Battery Safety Initiative and be enforced across the United States.
- **U.S. EPA** should enact minimum recyclability standards for EVs that support consistent design and ease of battery removal. In the absence of standards developed directly by U.S. EPA, the agency should support the development of a third-party multi-stakeholder consensus-based standard that both the federal government and industry can use.
- **Congress**, through the Federal Trade Commission and in consultation with **U.S. EPA**, should create an official minimum definition of "recycled content" as it applies to components within EV batteries.
- In the next revision of Ohio's Learning Standards, the **Ohio Department of Education and Workforce** should build competencies on recycling and waste management into science standards at every grade level. Building on the high-school level environmental science standard ENV.GP.9, "Waste management (solid and hazardous)," science concepts based on identifying waste and recyclable materials and correctly sorting and disposing of them should be integrated to "Nature of Science" standards for each grade level.
- The **Ohio state legislatur**e should direct and fund **Ohio EPA** to provide guidance to municipalities on best practices for reducing waste and growing the circular economy, periodically updated to include best practices from municipalities across the state.
- **Ohio EPA** should offer grants to community organizations to support outreach and education of consumers on proper recycling best practices.

Promote data transparency and information sharing

- **Congress** should require EV batteries sold in the United States to include a digital battery passport indicating battery composition, recycled content, and pertinent information for safe dismantling. Further, **Congress** should require **U.S. EPA** to facilitate this data sharing through a secure platform. **Congress** should provide funding to EPA to support the development and administration of this program, and to explore alignment with the EU Battery Pass initiative.
- When providing guidance for EV battery collection and labeling, as directed by the IIJA, **U.S. EPA** should include guidelines for identification of proper battery dismantling procedures based on the location of key components in the battery.
- **U.S. EPA** should renew and expand the *Solid Waste Infrastructure for Recycling Grants for Communities* program to provide funding for additional communities to develop accessible recycling infrastructure and data collection. Congress should expand this program, authorized under the Bipartisan Infrastructure Law, to include specific funding for end-of-life battery collection and recycling.
- **Congress** should provide funding through **U.S. EPA** to support the development of materials marketplace programs, similar to the Ohio Materials Marketplace convened by Ohio EPA, across all 50 states, as well as coordination among the programs via U.S. EPA.

BOX 1: Policy Recommendations (cont.)

Support innovation & attract investment

- **Innovate Ohio** should lead an effort to convene utilities, startups, and battery manufacturers to identify opportunities for end-of-life EV batteries to serve as grid storage resources.
- **JobsOhio** should add critical materials recycling and circular economy to the targeted industries included covered under its R&D Center Grant program.
- **Congress** should increase funding for Battery R&D within the Vehicle Technologies Office, to include, at a minimum, the new research priorities identified in DOE's FY 2025 budget request.
- **Cities and counties across Ohio** should set sustainability targets, including emissions reduction and recycling goals. These goals help guide companies and communities toward sustainability improvements and make federal grant applications more competitive (especially under the IRA/BIL). Having sustainability targets can inform a city's economic development plans and support alignment with local businesses. Additionally, a sustainable purchasing policy can demonstrate leadership and kickstart both emissions reductions and demand that can help scale emerging industries locally.

Onshore Critical Materials Capacity

- The **Ohio state legislatur**e should create a tax credit for battery manufacturers to use recycled content in their products.
- **Ohio EPA** should partner with big box retailers and auto mechanics to create accessible, visible collection points for end-of-life lithium-ion batteries, including those in small electric mobility devices like scooters and e-bikes, and electric vehicles.
- **Congress**, through DOE's Advanced Materials and Manufacturing Technologies Office, should support the development of critical materials recycling hubs, similar to other models like hydrogen hubs and tech hubs, promoting the geographic co-location of collection, recycling infrastructure, processing, and utilization. Building on the work of the Critical Materials Innovation Hub, these hubs could provide targeted financial support to develop the industry in tandem with the battery production industry, reducing costs and spurring development. The geographic locations of these hubs should be selected through a competitive process prioritizing key metrics such as the presence of existing recycling infrastructure, processing, utilization, and/or manufacturing capacity.
- **Local economic development organizations** should facilitate partnerships between companies to enable economical end-of life collection, transportation, dismantling and recycling of EV batteries.
- The **Ohio state legislature** should establish a tax rebate for the recycling of end-of-life electric vehicle batteries equivalent to the average estimated value of the critical minerals contained within it.

Comprehensively and Proactively Engage Communities

- **Congress** should create a funding program through the **Council on Environmental Quality** to support municipalities' capacity to facilitate community engagement. This program should support additional staffing or contract support for municipal governments to conduct community outreach and engagement activities with developers ahead of new projects.

Promote Workforce Development and Safety

- **NHTSA** and the **Occupational Health and Safety Administration (OSHA)** should set minimum safety standards for battery collection, transport, dismantling, disposal, repair, and processing. These should be consistent for workers across the industry and trainings for certifications in these standards should be widely accessible.
- **Companies** should offer workforce development programming, including recruitment and training of new entrants to the field; safety training for workers in adjacent industries to be prepared to safely service, remove, and dismantle EV batteries; and diversity, equity, and inclusion efforts to support workers of all backgrounds.

FACILITATE RECYCLING, IMPROVE RECYCLABILITY, & PROMOTE SECOND-LIFE APPLICATIONS

COORDINATED FEDERAL POLICY

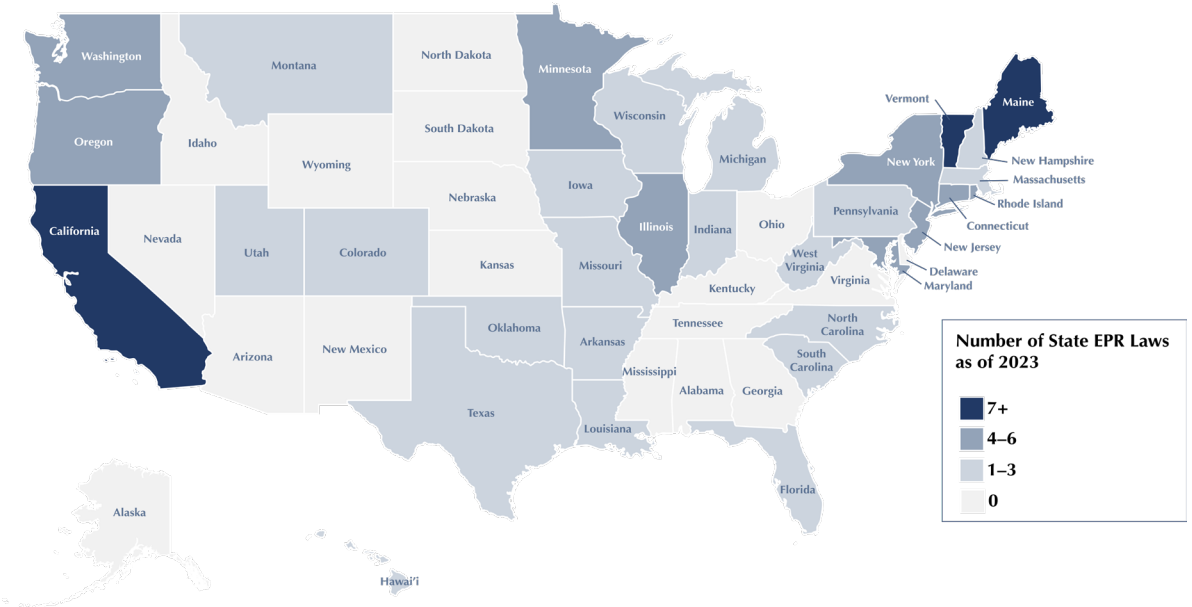
Throughout the roundtable, participants agreed that coordinated federal policy, rather than a patchwork of policies varying across states, would be most conducive to the development of the circular economy in the United States. While several states, including New Jersey and California, are currently developing regulations facilitating battery labeling or requiring producers to be responsible for their products at end-of-life, the U.S. automotive industry is interconnected across state lines. In order to provide regulatory certainty for producers and to make compliance less burdensome, participants supported a coordinated federal regulatory regime surrounding EV battery recycling as the most effective course.

Extended producer responsibility

Participants were largely in favor of some sort of an extended producer responsibility policy or program; however, there were concerns that a patchwork of state-level EPR legislation would create new challenges for the industry. These challenges include tracking down the geographic location of the vehicles and batteries at end of life in states without EPR laws. Referencing California's proposed EPR legislation specifically, participants expressed concern about the additional hardship on manufacturers in California's already more stringently regulated market. And though New Jersey's legislation had not yet passed at the time of the roundtable, participants indicated their interest in seeing the outcomes of its implementation.

Other industries have successfully navigated EPR regulations. For example, Pennsylvania's Covered Device Recycling Act of 2010 requires manufacturers to administer programs to collect and recycle consumer electronics including desktop computers, laptops, monitors, and televisions sold to consumers in the state.[33] In the automotive industry, Vermont requires retailers selling lead-acid batteries to accept used lead-acid batteries for recycling and share information with customers on proper disposal of batteries.[34] See Figure 2 for a map of states with EPR laws for batteries and electronics.

FIGURE 2: Map of States with Extended Producer Responsibility Programs



Source: Product Stewardship Institute, "Number of State EPR Laws," accessed June 14, 2024, https://productstewardship.us.

Worker safety

Safety for workers was a major area of focus for roundtable participants. With any new technology comes the necessity for new safety measures, and EV batteries are no exception. Workers across many industries—not just battery manufacturers and vehicle assembly workers, but also scrapyard and recycling facility workers, first responders, and service technicians—will need specific training on how to interact with high-voltage batteries and how to handle damaged lithium-ion batteries, including how to recognize and assess when the batteries are damaged.

Currently, the Institute of the Motor Industry (IMI) offers levels of accreditation for EV battery safety that are accepted by employers in the United States and Europe, but these standards are voluntary.[35] The Institute of Scrap Recycling Industries (ISRI) also offers online and multi-day safety trainings for recyclers online and in-person in Columbus.[36]

Roundtable participants from across the industries expressed a preference for a federal agency like the Department of Transportation (DOT) or OSHA to centralize worker safety certifications and requirements for consistency across all 50 states. In addition, participants highlighted that greater education and outreach is necessary for companies that may not often handle EVs. Scrapyards, for example, recycle thousands of internal combustion engine vehicles per year but may only recycle a handful of EVs, meaning that workers are much less familiar with the specific needs of EVs and the locations of all lithium-ion batteries within the vehicle.

At present, NHTSA is beginning this coordinating work by establishing its Battery Safety Initiative for Electric Vehicles.[37] Through this program, NHTSA chaired the development of the Global Technical Regulation (GTR) No. 20 for Electric Vehicle Safety, established under the United Nations World Forum for the Harmonization of Vehicle Regulations.[38] A second phase of work is currently underway, and NHTSA is participating in its development. These safety standards are a start but only address safety provisions built into the vehicle, not the high level of safety trainings needed for workers throughout the industry. Further work is necessary to make standards more comprehensive and supportive.

Defining "Recycled Content" and setting minimum recyclability standards

Roundtable participants from across the industries agreed that a standard definition of "recycled content" specific to EV batteries and a minimum recyclability standard for EV batteries are necessary. Additionally, to ensure these standards are upheld consistently across the industry, there must be an enforcement mechanism to ensure the minimum standard is met. Having a consistent, enforceable definition is essential to building consumer trust in recycled products and supporting the added sustainability value of utilizing recycled content.

Currently, the Federal Trade Commission (FTC) regulates claims of recycled content across other industries. To maintain consistency with the existing regulatory regime, this authority should be extended to explicitly include coverage of EV batteries.

A minimum recyclability standard is more difficult to set as it requires better design for recyclability from the ground up. However, participants highlighted the diversity in battery design across manufacturers and indicated that the relatively nascent industry has to date not had any regulatory indicators that design should prioritize the recoverability of critical materials at end of life. Setting a minimum recyclability standard could create an important signal to adjust battery design and make batteries easier to recycle, with global market implications for battery manufacturers. As an example, the European Union's legislation mandates that 50 percent of the lithium in a battery must be recoverable at end of life by 2027.[39] Ensuring access to the EU market, and other markets that may impose similar future standards, should be a key objective for state and federal policymakers.

In the consumer electronics industry, electronics recyclers can be certified under two independent, third-party accreditations: the Responsible Recycling (R2) Standard for Electronics Recyclers and the e-Stewards Standard for Responsible Recycling and Reuse of Electronic Equipment (e-Stewards).[40] While U.S. EPA does not administer these certifications, the agency recognizes them as the industry standard and encourages all electronics recyclers to become certified by one of them. The EV battery recycling industry could follow this model to set recyclability standards through an independent third-party, or U.S. EPA could develop these standards and regulate them.

Policy Recommendations

- **Congress** should direct U.S. EPA to commission a study to explore the implications of enacting federal-level extended producer responsibility for electric vehicle batteries. This report should identify essential elements of policy design, including whether battery manufacturers or automakers should be responsible for battery recycling or safe disposal, and to what extent responsible parties should fund collection and recycling. The study should include an advisory group with representation from battery manufacturers, automakers, recyclers, and community leaders.
- **NHTSA** should enact transparent national minimum safety standards for workers interacting with, repairing, and dismantling electric vehicle batteries and other mobility related high voltage batteries. These should build upon NHTSA's Battery Safety Initiative and be enforced across the United States.
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- **Congress**, through the **Federal Trade Commission** and in consultation with U.S. EPA, should create an official minimum definition of "recycled content" as it applies to components within EV batteries.

EDUCATION

Roundtable participants claimed the lack of public awareness of recycling for all kinds of products was inhibiting growth in the state's recycling industry. They agreed unanimously that education for businesses, policymakers, and consumers is essential to building a culture of recycling. For all products, but particularly EVs, business actors and consumers must equally be aware of how and where to properly dispose of products at their end of life. In addition to ensuring that batteries are recycled, consumer education can support improved safety and reduce the risk of fire from improperly disposed batteries.

Roundtable participants also emphasized that the best way to begin training consumers on appropriate recycling protocols is to start with the K-12 curriculum to reach students in schools. These teachings can naturally become part of a household's habits as children share their learnings with their caretakers. To complement this education and support broader knowledge building, participants suggested that local agencies should create and share educational materials through a variety of information pathways, such as social media, local news, direct mail, community organizations, and local events.

One example of a national program supporting community-level education and recycling programs is the Solid Waste Infrastructure for Recycling Grants program, funded through the Bipartisan Infrastructure Law and administered by U.S. EPA. This program provides funding to states, territories, municipalities, and tribes across the United States to improve post-consumer materials management programs and implement the National Recycling Strategy.[41] While this funding is helpful to recycling program administrators at the state and municipal level, it is not sufficient to support widespread business or consumer education and outreach to improve access and utilization of these recycling programs. Additionally, this program is focused on municipal waste rather than EVs and their batteries, making it more conducive to increase the recycling of consumer products and less applicable to meet the unique needs of end-of-life EV collection and recycling. Additional federal funding, both expanded in scale and broadened in scope to include EVs and batteries, is necessary to enable this program to address many of the challenges raised above.

At the state level, a coordinated effort to share best practices for recycling, particularly of EVs and batteries, could help to meet the additional recycling program design and stakeholder outreach needs. Ohio EPA or another state agency should provide guidance for cities, counties, towns, and villages to implement recycling programs reflective of their size and infrastructure assets.

It is important to recall that education about proper recycling protocols can only be effective with a robust infrastructure in place. To ensure products are recycled to the fullest extent possible, outreach to businesses and consumers must happen simultaneously with the build-out of collection, recycling, and processing infrastructure.

Policy Recommendations

- In the next revision of Ohio's Learning Standards, the **Ohio Department of Education and Workforce** should build competencies on recycling and waste management into science standards at every grade level. Building on the high-school level environmental science standard ENV.GP.9, "Waste management

(solid and hazardous)," science concepts based on identifying waste and recyclable materials and correctly sorting and disposing of them should be integrated to "Nature of Science" standards for each grade level.[42]

- The **Ohio state legislature** should direct and fund **Ohio EPA** to provide guidance to municipalities on best practices for reducing waste and growing the circular economy, periodically updated to include best practices from municipalities across the state.
- **Ohio EPA** should offer grants to community organizations to support outreach and education of consumers on proper recycling best practices.

DATA TRANSPARENCY & INFORMATION SHARING

At present, there is little information about EV batteries accessible to actors outside the original manufacturer on the chemical content and composition, proportion of recycled content, and unique dismantling and recycling needs. Roundtable participants highlighted that this lack of transparency—driven in part by the understandable desire to protect proprietary information and a lack of requirements to disclose this information—inhibits the development of a circular economy for EV batteries. Access to information about a battery's manufacturing and previous use history will help recyclers more safely and economically dismantle and process the battery, support ease of integration into second life applications, and facilitate improved consumer choice.

Battery passport

In the European Union, efforts are underway to implement a program requiring manufacturers to disclose relevant data relating to carbon footprint, supply chain and materials sourcing, resource efficiency, performance and durability, and responsibility and liability. The consolidation of this information is called the battery passport.[43] The battery passport is an official document, stored digitally and accessible via QR code, that would accompany each battery (including but not limited to portable batteries, industrial batteries, light-transport batteries, and EV batteries) produced in the European Union throughout its lifecycle.[44] It is intended to be used both by consumers—to provide greater transparency about the sustainability metrics of the battery and enable customers to signal a preference for lower-carbon products—as well as relevant actors like installers, service technicians, dismantlers, and recyclers. Access to the most commercially sensitive information will be restricted to only those actors that represent a "legitimate interest."[45] The program will go into effect in August 2025.[46]

In the United States, New Jersey has passed the first U.S. law requiring labeling for EV batteries, which will go into effect on January 1, 2027.[47] The New Jersey Department of Environmental Protection will set the rules and regulations for the labeling program through a forthcoming rulemaking process.[48]

Roundtable participants emphasized that battery labeling policies are important to facilitating sustainable practices and can help make recycling more economical, but raised concerns that a patchwork of state labeling policies will be less effective and could be more burdensome to manufacturers than a coordinated federal policy. Many participants supported the kinds of information covered by the EU battery pass initiative, though indicated interest in seeing the results of its implementation before making a judgment on whether the EU approach would work in the United States.

Participants also noted that it would be easier for battery manufacturers operating in both the EU and U.S. markets to comply with a single set of battery labeling requirements rather than multiple state regimes. Additionally, some companies raised concerns that proprietary information would not be adequately protected without strict safeguards on data security. They emphasized that any federal battery labeling policy must include provisions to protect commercially sensitive information.

Materials Marketplace

Peer-to-peer recycling and reuse programs have already seen success in Ohio. The Ohio Materials Marketplace is a digital platform that connects organizations across the state to find reuse and recycling solutions for their byproducts and surplus materials.[49] Platform users offer and reuse all kinds of products, from steel drums to e-waste. The platform connects almost 1,500 members across Ohio and has diverted more than 130 million pounds of materials from Ohio landfills to date, producing cost savings of more than $300,000.[50] The program is facilitated by Ohio EPA and the platform is administered by Rheaply.

Roundtable participants celebrated the success of the Materials Marketplace program and identified it as a prospective venue to facilitate EV battery and component recycling. Additionally, they emphasized the platform's ability to facilitate second-life applications like small-scale stationary energy storage or backup power.

Currently, Materials Marketplace programs exist in 5 states—Texas, Tennessee, Michigan, Washington, and Ohio—as well as in Ontario, Canada.[51] More than 2,200 organizations engage through these programs, according to Rheaply. Participants were optimistic about the possibilities to expand programs to all 50 states and expressed interest to collaborate between geographically linked states as more programs come online.

Policy Recommendations

- **Congress** should require EV batteries sold in the United States to include a digital battery passport indicating battery composition, recycled content, and pertinent information for safe dismantling. Further, **Congress** should require **U.S. EPA** to facilitate this data sharing through a secure platform. **Congress** should provide funding to EPA to support the development and administration of this program, and to explore alignment with the EU Battery Pass initiative.
- When providing guidance for EV battery collection and labeling, as directed by the IIJA, **U.S. EPA** should include guidelines for identification of proper battery dismantling procedures based on the location of key components in the battery.
- **U.S. EPA** should renew and expand the Solid Waste Infrastructure for Recycling Grants for Communities program to provide funding for additional communities to develop accessible recycling infrastructure and data collection. Congress should expand this program, authorized under the Bipartisan Infrastructure Law, to include specific funding for end-of-life battery collection and recycling.
- **Congress** should provide funding through **U.S. EPA** to support the development of materials marketplace programs, similar to the Ohio Materials Marketplace convened by Ohio EPA, across all 50 states, as well as coordination among the programs via U.S. EPA.

INNOVATION & ATTRACTING INVESTMENTS

An innovative and straightforward solution for recycling EV batteries at the end of their useful life powering vehicles is to repurpose them for energy storage. An EV battery pack is considered at end of life when its capacity lowers by 20–30 percent. Although it may no longer be considered suitable to power a vehicle, these batteries are still left with ample storage capacity for integration into larger stationary storage systems. Applications for repurposed EV batteries include supporting renewable energy grids or serving as backup power for commercial and personal applications.[52] Reuse of EV batteries for energy storage is less demanding than its initial function of propelling a vehicle and can extend the useful life of the product without the need to recycle the materials within.

Several challenges need to be addressed to unlock the potential market for EV battery reuse for energy storage. These challenges include wide variation among battery chemistry and design limiting integration of different models, falling cost of new batteries compared to repurposed batteries, a lack of standards for battery management systems and state-of-health disclosures, and a lack of regulation delineating responsibility for an EV battery at end of life.[53] Addressing these challenges will require coordinated efforts among battery manufacturers, second-life battery companies, utilities, and regulatory agencies to develop industry standards and information disclosure. This coordination can help create certainty for market actors to help facilitate the growth of a promising solution to both battery recycling and renewable energy storage.

Another key driver of innovation in the battery recycling space is increased public funding for research and development efforts to create more cost-effective recycling technologies and efficient reuse of batteries leading to reductions in market uncertainties. To support the reuse of batteries, government funded research, development, and demonstration (RD&D) efforts can improve battery diagnostic and monitoring technologies to gauge the condition of retired batteries, identify proper second life applications, and certify the performance and safety of demonstration projects.[54] The development of diagnostic and monitoring technologies will help ease consumer concerns by providing technical guidance for safely repurposing batteries.

There are existing government programs to help boost RD&D efforts in the battery recycling space. Federal programs such as the DOE's Lithium-Ion Battery Recycling Prize are designed to incentivize industry actors to develop innovative and scalable processes to enable cost effective recycling of lithium-ion batteries in the United States.[55] The program has a target of profitably capturing 90 percent of all discarded or spent lithium-ion batteries.

To help the industry design scalable processes and improve the economics of recycling for EV batteries, RD&D efforts can focus improving the design of batteries for

recyclability; the infrastructure needed to collect, sort, store, and transport batteries; and the battery recycling process itself.

Categories of RD&D efforts needed to scale battery recycling include:

- **battery design for recyclability**: innovating cell design, material composition, and battery pack design to allow for easier disassembly
- **recycling infrastructure**: identifying needs to increase the current system's compatibility with battery handling, storage and transport requirements as well as conducting geospatial analysis for the efficient siting of battery collection and recycling facilities
- **battery recycling**: developing cost-effective recovery methods to extract large quantities of high-purity critical materials from all portions of the battery including the cathode, electrode, anode, and black mass.[56]

These advancements in research and development for the reuse and recycling of EV batteries will be crucial to catalyze private investment in the battery industry. Improvements to the monitoring of repurposed batteries increase investor confidence in reusing EV batteries for stationary or mobile battery energy storage. Maximizing the efficient placement of battery collection and recycling facilities will help companies profitably collect all end-of-life EV batteries. Designing batteries for recycling and reuse and developing more efficient recycling technologies will help improve the cost efficiency of repurposing batteries or recapturing the critical materials within. These technological and logistical advancements will help attract investment needed to facilitate the growth of the circular economy for critical materials.

Creating a positive business environment for sustainability related projects is another important consideration to attract investment in the battery recycling industry. Roundtable participants highlighted that cities can create positive business environments for battery recycling by enacting municipal climate action plans, which can help guide local companies' investment into priority areas that align with community goals.

For example, Columbus's Climate Action Plan sets a greenhouse gas reduction target of 45 percent by 2030 and 100 percent by 2050; and a reduction in recyclable waste landfilled of 40 percent by 2030 and 95 percent by 2050.[57] Cleveland's Climate Action Plan sets a target of reducing residential and commercial energy use 50 percent and industrial use by 30 percent by 2030; a 25 percent renewable energy target by 2030 and 100 percent by 2050; and a landfill diversion rate of at least 50 percent by 2030.[58] These targets set a clear signal regarding a community's priorities that companies can use to inform their investment decisions.

Policy Recommendations

- **Innovate Ohio** should lead an effort to convene utilities, startups, and battery manufacturers to identify opportunities for end-of-life EV batteries to serve as grid storage resources.
- **JobsOhio** should add critical materials recycling and circular economy to the targeted industries included covered under its R&D Center Grant program.
- **Congress** should increase funding for Battery R&D within the **Vehicle Technologies Office**, to include, at a minimum, the new research priorities identified in DOE's FY 2025 budget request.[59]
- **Cities and counties across Ohio** should set sustainability targets, including emissions reduction and recycling goals. These goals help guide companies and communities toward sustainability improvements and make federal grant applications more competitive (especially under the IRA/BIL). Having sustainability targets can inform a city's economic development plans and support alignment with local businesses. Additionally, a sustainable purchasing policy can demonstrate leadership and kickstart both emissions reductions and demand that can help scale emerging industries locally.

ONSHORE CRITICAL MATERIALS CAPACITY

INFRASTRUCTURE, TRANSPORT, AND COLLECTION ACCESSIBILITY

The U.S. DOT currently classifies lithium-ion batteries as hazardous materials, due to their inclusion of a flammable electrolyte, high energy density, and potential for thermal runaway (e.g., a chemical reaction that causes the temperature of the battery to increase uncontrollably).[60] This classification creates a host of challenges to the collection and transportation of EV batteries. DOT regulations for transporting hazardous materials by highway or rail include packaging specifications to avoid spark creation or heat generation, marking relevant packages as hazardous, documentation of all hazardous materials on board, and hazardous material training for all employees.[61] Collection facilities face similarly stringent hazardous waste and universal waste requirements for storing a lithium-ion battery before its recycle or disposal.[62]

Complying with these hazardous material requirements, while necessary, can be financially burdensome and logistically challenging, drastically impacting the economics of critical material recycling. Participants emphasized that the additional costs of handling hazardous materials places the battery recycling industry at a disadvantage to recover and sell critical materials to battery manufactures compared to their procurement of virgin materials. Providing incentives, such as a tax credit, to businesses using recycled content in their manufacturing process could help bridge this price premium.

The collection of end-of-life batteries is another primary challenge limiting the growth of the EV battery recycling industry. Several factors hinder an effective collection process for these batteries. First is a lack of consistent take-back options for car owners to return their batteries at end of life. Next, a lack of education limits consumers knowledge about the need and options available to recycle their end-of-life EV batteries.[63] Finally, there is a lack of information sharing along the supply chain to allow for batteries to be traced throughout their lifetimes.

Without a sufficient collection system for EV batteries, it is unlikely that the circular economy for critical materials will reach the scale necessary to meet the needs of the automotive manufacturing sector. Instead, vehicle owners may either store vehicles long past the end of their useful life or simply send their vehicles to scrapyards for disposal, causing many of the critical materials within to lay unclaimed or be discarded. It is important to provide clear locations for the collection of EV batteries. Participants suggested the potential for big box retailers or auto shops to serve as collection facilities for end-of-life lithium-ion batteries from EVs, e-bikes, and e-scooters, pending sufficient storage space and the collection shops' abilities to send the batteries to recyclers in a timely manner.

Many of the listed challenges to establishing a circular economy can be addressed through the geographic concentration of a recycling industry near inputs and outputs on the battery supply chain. The centralization of the recycling industry allows for reduced logistical challenges between transporting the battery from the collectors to the recyclers and transportation of the refined materials from the recyclers to the manufacturers. This increased coordination between players on the value chain will help improve the economics of the battery recycling industry.

A model for this type of centralization is the Economic Development Administration's (EDA) Tech Hubs and the DOE's Energy Innovation Hubs.[64] The hubs programs are designed to utilize federal funding to boost investment in regions with the potential to become globally competitive in future industries, like critical materials recycling. The programs create a consortium of public, private, and economic partners to drive innovation in critical emerging technologies and inclusive regional economic growth.[65] In October 2023, President Biden designated 31 Tech Hubs to catalyze technological advancements and create jobs in communities across America. Separately, the EDA awarded 29 strategic development grants, which are designed to help communities increase local planning and coordination to make themselves more competitive for future funding opportunities.[66]

One Tech Hub designee can serve as a template for the creation of a similar hub program to support the development of critical material recycling in Ohio: The Nevada Lithium Batteries and Other EV Material Loop (Loop Tech Hub), a project designed to build a circular lithium lifecycle industry from extraction and processing to manufacturing and eventually recycling.[67] This program offers an opportunity to produce learnings for other states like Ohio and a replicable model as they look

to become a key player in the critical material recycling industry of the future.

At the local level, economic development agencies have a role to play to facilitate partnerships and coordination among industry actors to create efficiencies between key components of the supply chain. For example, the Greater Cleveland Partnership's Council of Smaller Enterprises offers resources to small businesses such as networking with other small businesses and cost-effective group purchasing programs.[68] This program, or another similar program in the state, could be expanded to facilitate specific partnerships between companies across the battery supply chain.

Policy Recommendations

- The **Ohio state legislature** should create a tax credit for battery manufacturers to use recycled content in their products.
- **Ohio EPA** should partner with big box retailers and auto mechanics to create accessible, visible collection points for end-of-life lithium-ion batteries, including those in small electric mobility devices like scooters and e-bikes, and electric vehicles.
- **Congress**, through DOE's Advanced Materials and Manufacturing Technologies Office, should support the development of critical materials recycling hubs, similar to other models like hydrogen hubs and tech hubs, promoting the geographic co-location of collection, recycling infrastructure, processing, and utilization. Building on the work of the Critical Materials Innovation Hub, these hubs could provide targeted financial support to develop the industry in tandem with the battery production industry, reducing costs and spurring development. The geographic locations of these hubs should be selected through a competitive process prioritizing key metrics such as the presence of existing recycling infrastructure, processing, utilization, and/or manufacturing capacity.
- **Local economic development organizations** should facilitate partnerships between companies to enable economical end-of life collection, transportation, dismantling and recycling of EV batteries.

INCENTIVIZING CONSUMER BEHAVIOR

The success of recycling systems depends on the effectiveness of collection processes, to which consumer behavior is integral. Roundtable participants agreed that while consumer outreach and education is the highest priority in enabling them to support battery recycling, additional incentives are necessary to encourage action.

Tax rebates

Currently, much of the U.S. EV industry is incentivized by consumer EV purchase tax credits, which are contingent on the size of the battery, its material composition, and the vehicle's total cost.[69] Research has shown that access to this tax credit is a significant determining factor in a consumer's choice to purchase an EV.[70] Roundtable participants suggested that a similar consumer tax credit, based on the value of the materials within the battery, could similarly incentivize consumers to recycle their EV batteries at end of life.

Roundtable participants pointed to some companies' payments to consumers for recycling electronics as a possible analogue for the effectiveness of this tax credit. They raised that consumers prefer to be compensated for their end-of-life devices because they believe their product has monetary value, even if it is no longer useful to them.

Deposit programs

In other industries, deposit programs can be an effective means of incentivizing recycling. For example, ten states and Guam operate deposit programs for containers, collecting between two and ten cents at the point of purchase and returning it to the consumer at the point of recycling.[71] Roundtable participants highlighted how these programs encourage both the original purchaser of the product to recycle, as well as provide an incentive for others to collect discarded containers and bring them in for recycling. They suggested that a deposit program for batteries, particularly for micromobility products like e-bikes and e-scooters, would be an effective way to drive consumers to collect and return these batteries for proper recycling.

A drawback of deposit programs is that they raise the up-front cost of the product. In the case of a soda bottle with a 2–10¢ deposit that can be recovered within days,

the impact on the consumer's ability to pay is negligible. However, for larger, higher-priced items, especially EVs that are already several thousand dollars more expensive up-front than internal combustion engine vehicles, an added deposit of even a few percent can be cost prohibitive to the consumer and will not be recouped until many years later. Participants suggested that alternative means of funding such a deposit would be necessary to keep EVs and micromobility products accessible to consumers of all income levels. One suggestion in Ohio was to make the state's $200 EV registration fee a refundable deposit contingent on the proper recycling of the vehicle at end of life in the near-term until EV recycling and collection infrastructure and widely accessible in the state.[72]

Policy Recommendations

- The **Ohio state legislatur**e should establish a tax rebate for the recycling of end-of-life electric vehicle batteries equivalent to the average estimated value of the critical minerals contained within it.

COMPREHENSIVELY AND PROACTIVELY ENGAGE COMMUNITIES

Effective, transparent, comprehensive community engagement from the beginning of the project development process is essential to ensuring communities' needs are met as new projects are built. This process can build buy-in early on from communities that might otherwise oppose projects because of environmental or community impacts. Roundtable participants highlighted the need for effective community engagement throughout the permitting process for new facilities to ensure communities' needs are met and questions are answered as the project is developed, as well as the need for comprehensive and ongoing community engagement throughout the development process.

PERMITTING

Permitting for new facilities can take a decade or more under the current process through the National Environmental Policy Act and relevant state agencies. In the case of new battery recycling facilities, roundtable participants reflected wariness on the part of many residents to have a new facility dealing with materials classified as hazardous materials by U.S. EPA in their communities. Additionally, they shared that many residents are unfamiliar with the processes used in EV battery recycling and may associate "recycling" with negative impressions of trash like ugliness, bad smells, and pests. They pointed to examples of successful efforts by communities to prevent new recycling facilities from being built using municipal-level zoning requirements.

In one example, the City Council of Youngstown, Ohio, issued a one-year moratorium on development of facilities to perform pyrolysis and combustion of tires, plastics, and electronic waste in response to residents' concerns about the construction of a new chemical recycling facility in their community.[73] Residents organized against the facility because they did not feel they had enough information about how the developer was proposing to mitigate environmental and public health impacts from the chemical recycling process. Stronger community engagement from the beginning may have helped the developer to hear these concerns and address them before the city council's moratorium.

Participants emphasized that responsible siting of these facilities can minimize environmental impact, whether by building on brownfields or by geographically locating in close proximity to other parts of the supply chain to minimize emissions from transporting materials to and from the recycling facility.

To overcome community opposition to facilities and speed permitting process resolution (whether approval or denial), roundtable participants emphasized that community engagement around new facilities should begin early in the planning stage of the project and should bring in members of the community often, transparently, and in a decision-making capacity.

MUNICIPAL CAPACITY

Roundtable participants suggested that municipalities, particularly cities and counties, can support companies' community engagement efforts by leading outreach, hosting town halls and meetings, and providing a plat-

form to leaders within the community. Municipalities are often best positioned to lead this outreach because they have relationships with community leaders, access to information networks to reach residents, and in many cases have an established level of trust with the community, adding a level of accountability. Additionally, they can interface directly with developers while representing the interests of the community. In this way, they can help developers conduct deeper, more comprehensive engagement with communities in the development of facilities. That said, many historically underserved and marginalized communities are not already part of municipal outreach and may not have access to services or information networks. Community engagement processes must therefore include extra targeted efforts to intentionally reach all impacted residents.

This kind of deep outreach and engagement can be costly and requires a significant amount of municipal staff time. Roundtable participants pointed out that often counties and smaller towns do not have the funding or staff resources to engage in these processes. Large-scale projects like battery factories and recycling facilities may only be built in these communities once in a generation, making it unsustainable to keep constant levels of staffing ready to support community engagement efforts. Dedicated state and federal funding, outreach, and other levels of support are crucial to giving municipalities access to the resources they need to lead community engagement.

In addition to community engagement around new facilities, municipalities and other trusted community organizations like schools, faith-based organizations, and mutual aid organizations can be effective sources of information for residents on how to properly handle and recycle end-of-life batteries. Particularly in communities where trust in government agencies is low, community organizations can serve as a trusted source of information.

Policy Recommendations

- **Congress** should create a funding program through the **Council on Environmental Quality** to support municipalities' capacity to facilitate community engagement. This program should support additional staffing or contract support for municipal governments to conduct community outreach and engagement activities with developers ahead of new projects.

PROMOTE WORKFORCE DEVELOPMENT AND SAFETY

As with any new technology, developments in the EV industry require new skills and safety competencies among workers across the sector. From scrapyards to dedicated battery recycling facilities, workers collecting, dismantling, separating, and recycling EVs and batteries must be prepared to identify where in the vehicle the main propulsion battery and smaller lithium-ion batteries are located, properly handle and store high-voltage batteries, assess batteries for damage from collision or submersion, and properly respond to leakage and thermal runaway. In addition to workers in these facilities, other workers—service technicians, first responders, tow truck drivers, and anyone who may come into contact with the vehicle—must be aware of the risks and be properly trained to handle them.

Examples of potential safety considerations raised during the roundtable include chemical off-gassing, thermal runaway, electric shock, and fire. These can be caused by: physical damage to the battery through puncture, compression, or submersion; over-charging the battery; improper storage; and improper handling of the high-voltage battery. These are avoidable with proper protocols and monitoring equipment but could present hazards to workers or consumers unfamiliar with proper handling.

Roundtable participants emphasized that federal agencies should set minimum safety standards for the handling of EV batteries to ensure that these standards are consistent across states and different segments of the automotive and recycling industries. However, without

access to appropriate information and trainings or certifications for workers, these standards will be impossible to comply with. They highlighted the need for significantly more, and accessible, training offerings across the United States. Additionally, a centralized certification program would help employers to confirm that incoming employees are properly certified in relevant safety competencies. Roundtable participants suggested IMI accreditation levels be used as the basis for these certifications in the United States.

Finally, roundtable participants expressed optimism about the opportunities for the workforce of building out a U.S. EV battery recycling industry. They highlighted new job opportunities for workers, especially in communities that have been historically reliant on the internal combustion engine supply chain, which may face headwinds in the transition to electric vehicles.

In order to attract and retain talented workers in this emerging industry, roundtable participants highlighted the need for wraparound support in the form of access to childcare, transportation, workforce development initiatives, and other opportunities to make employment more inclusive of workers. With low levels of unemployment, they emphasized that recruitment efforts must specifically address the needs of workers often left behind, such as single parents, formerly incarcerated people, people with disabilities, and historically marginalized groups. Roundtable participants emphasized the need for integration of diversity, equity, and inclusion (DEI) efforts throughout the business to support these efforts. Studies have shown the integration of DEI efforts not only supports expanded recruitment but is linked to improved profitability and cash flow. One 2018 McKinsey study found gender diverse companies were 21 percent more likely to perform above the industry median, and ethnically/culturally diverse companies were 33 percent more likely.[74]

Policy Recommendations

- **NHTSA** and **OSHA** should set minimum safety standards for battery collection, transport, dismantling, disposal, repair, and processing. These should be consistent for workers across the industry and trainings for certifications in these standards should be widely accessible.
- **Companies** should offer workforce development programming, including recruitment and training of new entrants to the field; safety training for workers in adjacent industries to be prepared to safely service, remove, and dismantle EV batteries; and diversity, equity, and inclusion efforts to support workers of all backgrounds.

CONCLUSION

This is a pivotal moment for Ohio's automotive industry, as companies make plans to build electric vehicle and battery manufacturing facilities and grow the EV supply chain in the state and across the Midwest. Ohio is poised to become a leader on battery recycling, with benefits to both the state's economic competitiveness and the nation's ability to secure a domestic supply of critical materials. Participants in our December 2023 regional roundtable were optimistic about this opportunity, while emphasizing that much more work is necessary to truly take advantage of its offerings. They highlighted the need for expanded collection, transport, and recycling infrastructure; significant levels of consumer, business, and policymaker education; investments in worker safety and training; research and development initiatives to improve the economics and recyclability of batteries; and policy development to incentivize and coordinate recycling practices across the industry.

Additional C2ES Resources

Regional Roundtables
https://www.c2es.org/accelerating-the-us-net-zero-transition/regional-roundtables/

Reaching for 2030: Climate and Energy Policy Priorities
https://www.c2es.org/document/reaching-for-2030-climate-and-energy-policy-priorities/

Accelerating Vehicle Electrification in Michigan
https://www.c2es.org/document/accelerating-vehicle-electrification-in-michigan/

Manufacturing a Decarbonized Future in Southwestern Pennsylvania
https://www.c2es.org/document/manufacturing-a-decarbonized-future-in-southwestern-pennsylvania/

Cities Advancing Climate Action: Unlocking the Potential of the IRA
https://www.c2es.org/document/cities-advancing-climate-action-unlocking-the-potential-of-the-ira/

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ENDNOTES

1 International Energy Agency (IEA), The Role of Critical Minerals in Clean Energy Transitions (Paris, France: IEA, 2022), *https://iea.blob.core.windows.net/assets/ffd2a83b-8c30-4e9d-980a-52b6d9a86fdc/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf*.

2 Ibid.

3 Aaron Steckelberg et. al, "Clean cars, hidden toll: The underbelly of electric vehicles," The Washington Post, April 27, 2023, *https://www.washingtonpost.com/world/interactive/2023/electric-car-batteries-geography/*.

4 Ibid.

5 IEA, Introducing the Critical Minerals Policy Tracker (Paris, France: IEA, 2022), *https://www.iea.org/reports/introducing-the-critical-minerals-policy-tracker*.

6 Ziong, Siquin, Junping Ji, and Xiaoming Ma, "Environmental and economic evaluation of remanufacturing lithium-ion batteries from electric vehicles," Waste Management 102, 2020: *https://doi.org/10.1016/j.wasman.2019.11.013*.

7 Dominish, E., N. Florin, and R. Wakefield-Rann, Reducing new mining for electric vehicle battery metals: responsible sourcing through demand reduction strategies and recycling (Sydney, Australia: Institute for Sustainable Futures, University of Technology Sydney for Earthworks: 2021), *https://earthworks.org/resources/recycle-dont-mine/*; World Health Organization, "Electronic waste (e-waste)," World Health Organization, fact sheet, October 18, 2023, *https://www.who.int/news-room/fact-sheets/detail/electronic-waste-%28e-waste%29*.

8 Simas, Moana, Fabian Aponte, and Kirsten Wiebe, The Future is Circular: Circular Economy and Critical Minerals for the Green Transition (Trondheim, Norway: World Wildlife Fund, 2022), *https://wwfint.awsassets.panda.org/downloads/the_future_is_circular___sintefmineralsfinalreport_nov_2022__1__1.pdf*.

9 IEA, The Role of Critical Minerals in Clean Energy Transitions (Paris, France: IEA, 2021), *https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary*

10 IEA, Global EV Outlook 2023: Trends in batteries (Paris, France: IEA, 2023), *https://www.iea.org/reports/global-ev-outlook-2023/trends-in-batteries*.

11 Dominish, E., N. Florin, and R. Wakefield-Rann, Reducing new mining for electric vehicle battery metals: responsible sourcing through demand reduction strategies and recycling (Sydney, Australia: Institute for Sustainable Futures, University of Technology Sydney for Earthworks: 2021), *https://earthworks.org/resources/recycle-dont-mine/*. Note: the exact recycling rate of lithium globally is unknown.

12 Dow, Jameson, "Tesla cofounder's Redwood shows 95 percent efficiency in battery recycling pilot," Electrek, March 2, 2023, *https://electrek.co/2023/03/02/tesla-cofounders-redwood-shows-95-efficiency-in-battery-recycling-pilot*

13 Tracy, Brandon S., Critical Minerals in Electric Vehicle Batteries (Washington, D.C.: Congressional Research Service, 2022), *https://crsreports.congress.gov/product/pdf/R/R47227*.

14 Gabriel, Noah, "$210 Billion of Announced Investments in Electric Vehicle Manufacturing Headed for the U.S.," Atlas EV Hub, blog, January 12, 2023, *https://www.atlasevhub.com/data_story/210-billion-of-announced-investments-in-electric-vehicle-manufacturing-headed-for-the-u-s/*.

15 BlueGreen Alliance Foundation, "EV Jobs Hub," accessed March 5, 2024, *https://evjobs.bgafoundation.org/*.

16 Deb Scherer, "The Future of Hybrid & Electric Vehicle Manufacturing Is in the Columbus Region", The Columbus Region (blog), updated September 21, 2023, https://columbusregion.com/content-hub-article/ev-hybrid-hydrogen-vehicles/.

17 Nth Cycle, "The First Domestic Nickel and Cobalt Production Facility in Fairfield, Ohio," press release, June 27, 2023, *https://nthcycle.com/news/nth-cycle-opens-first-domestic-nickel-and-cobalt-production-facility-ahead-of-inflation-reduction-act-requirements/.*

18 Cirba Solutions, "Cirba Solutions Expands Ohio Lithium-ion Processing Facility," press release, accessed March 5, 2024, *https://www.cirbasolutions.com/cirba-solutions-expands-ohio-lithium-ion-processing-facility/.*

19 Cirba Solutions, "Cirba Solutions and General Motors Extend Collaboration on EV Battery Recycling," press release, November 2, 2022, *https://www.cirbasolutions.com/cirba-solutions-and-general-motors-extend-collaboration/.*

20 Ohio Environmental Protection Agency Division of Environmental and Financial Assistance Office of Compliance Assistance and Pollution Prevention, Ohio Materials Marketplace – Year Two Report (Columbus, OH: Ohio EPA, 2019), *https://epa.ohio.gov/static/Portals/41/OMM/OMM%20Year%20Two%20Report.pdf.*

21 BlueGreen Alliance Foundation, "EV Jobs Hub," accessed March 5, 2024, *https://evjobs.bgafoundation.org/.*

22 Cox Automotive, "A record 1.2 million EVs were sold in the U.S. in 2023, according to estimates from Kelley Blue Book," release, January 9, 2024, *https://www.coxautoinc.com/market-insights/q4-2023-ev-sales/.*

23 Inflation Reduction Act of 2022, Pub. L. No. 117-169 §13401.

24 Lepre, Nicole, Spencer Burget, and Noah Gabriel, U.S. Investments in Electric Vehicle Manufacturing (2023) (Washington, D.C.: Atlas Public Policy, 2023), *https://atlaspolicy.com/wp-content/uploads/2023/05/U.S.-Investments-in-Electric-Vehicle-Manufacturing-2023.pdf.*

25 Carey, Nick, Paul Lienert, and Victoria Waldersee, "Dead EV batteries turn to gold with US incentives," Reuters, July 21, 2023, *https://www.reuters.com/business/autos-transportation/dead-ev-batteries-turn-gold-with-us-incentives-2023-07-21/.*

26 U.S. Environmental Protection Agency, "Battery Collection Best Practices and Battery Labeling Guidelines," accessed March 5, 2024, *https://www.epa.gov/infrastructure/battery-collection-best-practices-and-battery-labeling-guidelines.*

27 U.S. Department of Energy, "Bipartisan Infrastructure Law Battery Materials Processing and Battery Manufacturing & Recycling Funding Opportunity Announcement," fact sheet, November 1, 2022, *https://www.energy.gov/sites/default/files/2022-11/DOE%20BIL%20Battery%20FOA-2678%20Selectee%20Fact%20Sheets.pdf.*

28 U.S. Department of Energy, "Electric Drive Vehicle Battery Recycling and 2nd Life Apps," accessed March 5, 2024, *https://www.energy.gov/infrastructure/electric-drive-vehicle-battery-recycling-and-2nd-life-apps.*

29 New Jersey Senate Bill No. 3723 (2023), *https://www.bdlaw.com/content/uploads/2024/01/3723_R3-5.pdf.*

30 New Jersey Senate Bill No. 3723 (2023), §5, *https://www.bdlaw.com/content/uploads/2024/01/3723_R3-5.pdf.*

31 New Jersey Senate Bill No. 3723 (2023), §7, *https://www.bdlaw.com/content/uploads/2024/01/3723_R3-5.pdf.*

32 Dunn, Jessica, "California's Progress Toward Recycling Policy for EV Batteries," Union of Concerned Scientists, blog, September 20, 2022, *https://blog.ucsusa.org/jessica-dunn/californias-progress-toward-recycling-policy-for-ev-batteries/.*

33 Pennsylvania Department of Environmental Protection, "Electronics Recycling: Covered Device Recycling Act," accessed March 5, 2024, *https://www.dep.pa.gov/Business/Land/Waste/Recycling/Electronics/Pages/default.aspx.*

34 Vermont V.S.A. Title 10 § 6621c *https://legislature.vermont.gov/statutes/section/10/159/06621c.*

35 See Institute of the Motor Industry, "Electric Vehicle Qualifications," accessed March 5, 2024 *https://tide.theimi.org.uk/learn/qualifications/electric-vehicle-qualifications.*

36 See Institute of Scrap Recycling Industries, "ISRI Battery Safety Courses," accessed March 5, 2024, *https://www.isri.org/battery-safety-courses.*

37 National Highway Safety Administration, "Battery Safety Initiative," accessed March 5, 2024, *https://www.nhtsa.gov/battery-safety-initiative.*

38 United Nations, Global Technical Regulation on the Electric Vehicle Safety (EVS), 2018, available at *https://unece.org/fileadmin/DAM/trans/main/wp29/wp29wgs/wp29gen/wp29registry/ECE-TRANS-180a20e.pdf.*

39 Council of the European Union, "Council adopts new regulation on batteries and waste batteries," press release, July 10, 2023, *https://www.consilium.europa.eu/en/press/press-releases/2023/07/10/council-adopts-new-regulation-on-batteries-and-waste-batteries/.*

40 U.S. Environmental Protection Agency, "Certified Electronics Recyclers," accessed March 5, 2024, *https://www.epa.gov/smm-electronics/certified-electronics-recyclers.*

41 U.S. Environmental Protection Agency, "Solid Waste Infrastructure for Recycling Grant Program," Accessed March 5, 2024, *https://www.epa.gov/infrastructure/solid-waste-infrastructure-recycling-grant-program.*

42 See Ohio Department of Education, Ohio's Learning Standards and Model Curriculum: Science (Columbus, OH: Ohio Department of Education, 2018), *https://education.ohio.gov/getattachment/Topics/Learning-in-Ohio/Science/Ohios-Learning-Standards-and-MC/SciFinalStandardsMC060719.pdf.aspx?lang=en-US.*

43 European Parliament and Council of the European Union, Regulation (EU) 2023/1542 of the European Parliament and of the Council concerning batteries and waste batteries, 2023, available at *https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1542*; EU Battery Pass consortium, Battery Passport Content Guidance Executive Summary (Berlin, Germany: Battery Pass, 2023), *https://thebatterypass.eu/assets/images/content-guidance/pdf/2023_Battery_Passport_Content_Guidance_Executive_Summary.pdf.*

44 EU Battery Regulation Briefings, "What is a Battery Passport," accessed March 5, 2024, *https://www.batteryregulation.eu/battery-passport.*

45 European Parliament and Council of the European Union, Regulation (EU) 2023/1542 of the European Parliament and of the Council concerning batteries and waste batteries, 2023, paragraph 124, available at *https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1542*

46 Council of the European Union, "Council adopts new regulation on batteries and waste batteries," press release, July 10, 2023, *https://www.consilium.europa.eu/en/press/press-releases/2023/07/10/council-adopts-new-regulation-on-batteries-and-waste-batteries/.*

47 New Jersey Senate Bill No. 3723 (2023), *https://www.bdlaw.com/content/uploads/2024/01/3723_R3-5.pdf.*

48 Ibid.

49 Ohio Environmental Protection Agency, "Materials Marketplace," accessed March 5, 2024, *https://epa.ohio.gov/divisions-and-offices/environmental-financial-assistance/about-defa/materials-marketplace.*

50 Ibid.

51 Rachal, Maria, "Reuse tech startup Rheaply targets C&D waste with Materials Marketplace acquisition," Waste Dive, October 10, 2022, *https://www.wastedive.com/news/rheaply-acquires-materials-marketplace-reuse-platform/633650/.*

52 Rokion, "What happens after an electric vehicle battery dies?," blog post, July 4, 2022, *https://rokion.com/ev-battery-dies*.

53 Engel, Hauke, Patrick Hertzke, and Giulia Siccardo, "Second-life EV batteries: The newest value pool in energy storage," McKinsey & Company, article, April 30, 2019, *https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/second-life-ev-batteries-the-newest-value-pool-in-energy-storage*.

54 Curtis, Taylor L., et al., A Circular Economy for Lithium-ion Batteries Used in Mobile and Stationary Energy Storage: Drivers, Barriers, Enablers, and U.S. Policy Considerations (Golden, CO: National Renewable Energy Laboratory, 2021), *https://www.nrel.gov/docs/fy21osti/77035.pdf*.

55 Ibid.

56 Ibid.

57 City of Columbus, Columbus Climate Action Plan (Columbus, OH: Sustainable Columbus, 2021), *https://www.columbus.gov/sustainable/cap/*.

58 City of Cleveland, Cleveland Climate Action Plan 2018 Update (Cleveland, OH: Sustainable Cleveland, 2018), *https://www.sustainablecleveland.org/climate_action*.

59 *https://www.energy.gov/sites/default/files/2024-03/doe-fy-2025-budget-vol-4-v5.pdf*

60 U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration, "Transporting Lithium Batteries," accessed March 5, 2024, *https://www.phmsa.dot.gov/lithiumbatteries*.

61 Curtis, Taylor L., et al., A Circular Economy for Lithium-ion Batteries Used in Mobile and Stationary Energy Storage: Drivers, Barriers, Enablers, and U.S. Policy Considerations (Golden, CO: National Renewable Energy Laboratory, 2021), *https://www.nrel.gov/docs/fy21osti/77035.pdf*.

62 Ibid.

63 Dominish, E., N. Florin, and R. Wakefield-Rann, Reducing new mining for electric vehicle battery metals: responsible sourcing through demand reduction strategies and recycling (Sydney, Australia: Institute for Sustainable Futures, University of Technology Sydney for Earthworks: 2021), *https://earthworks.org/wp-content/uploads/2021/09/UTS-EV-battery-metals-sourcing-20210419-FINAL.pdf*

64 See U.S. Economic Development Administration, "Regional Technology and Innovation Hubs (Tech Hubs)," accessed March 5, 2024, *https://www.eda.gov/funding/programs/regional-technology-and-innovation-hubs*; and U.S. Department of Energy, "Hubs," accessed March 5, 2024, *https://www.energy.gov/hubs*.

65 U.S. Economic Development Administration, "Regional Technology and Innovation Hubs (Tech Hubs)," accessed March 5, 2024, *https://www.eda.gov/funding/programs/regional-technology-and-innovation-hubs*.

66 U.S. Economic Development Administration, "Biden-Harris Administration Designates 31 Tech Hubs Across America," press release, October 23, 2023, *https://www.eda.gov/news/press-release/2023/10/23/biden-harris-administration-designates-31-tech-hubs-across-america*.

67 U.S. Economic Development Administration, "Nevada Lithium Batteries and Other EV Material Loop," accessed March 5, 2024, *https://www.eda.gov/funding/programs/regional-technology-and-innovation-hubs/2023/Nevada-Lithium-Batteries-and-Other-EV-Material-Loop*.

68 Greater Cleveland Partnership, "About COSE," accessed March 5, 2024, *https://www.greatercle.com/aboutcose/*.

69 Inflation Reduction Act of 2022, Pub. L. No. 117-169 §13401.

70 Jenn, Alan, Katalin Springel, and Anand R. Gopal, "Effectiveness of electric vehicle incentives in the United States," Energy Policy Vol. 119, 2018, *https://doi.org/10.1016/j.enpol.2018.04.065*.

71 National Conference of State Legislatures, "State Beverage Container Deposit Laws," last update March 13, 2020, accessed March 5, 2024, *https://www.ncsl.org/environment-and-natural-resources/state-beverage-container-deposit-laws*.

72 Ohio Bureau of Motor Vehicles, "Vehicle Registration," accessed March 5, 2024, *https://www.bmv.ohio.gov/vr-firstissuance.aspx*.

73 Marusic, Kristina, "Paused Ohio chemical recycling plant puts spotlight on Appalachia as 'prime target' for the controversial practice," Environmental Health Sciences, March 25, 2024, *https://www.ehn.org/chemical-recycling-youngstown-2667485311.html*.

74 Hunt, Vivian et al., Delivering through Diversity (McKinsey & Company, 2018), *https://www.mckinsey.com/~/media/mckinsey/business%20functions/people%20and%20organizational%20performance/our%20insights/delivering%20through%20diversity/delivering-through-diversity_full-report.pdf?shouldIndex=false*.

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