UC Berkeley Center for Law, Energy & the Environment

A POLICY BLUEPRINT FOR ENSURING *Sustainable* BATTERY SUPPLY CHAINS

Lessons from the EU's Sustainable Batteries Regulation

FEBRUARY 2025
Policy Report

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Lessons from the EU's Sustainable Batteries Regulation

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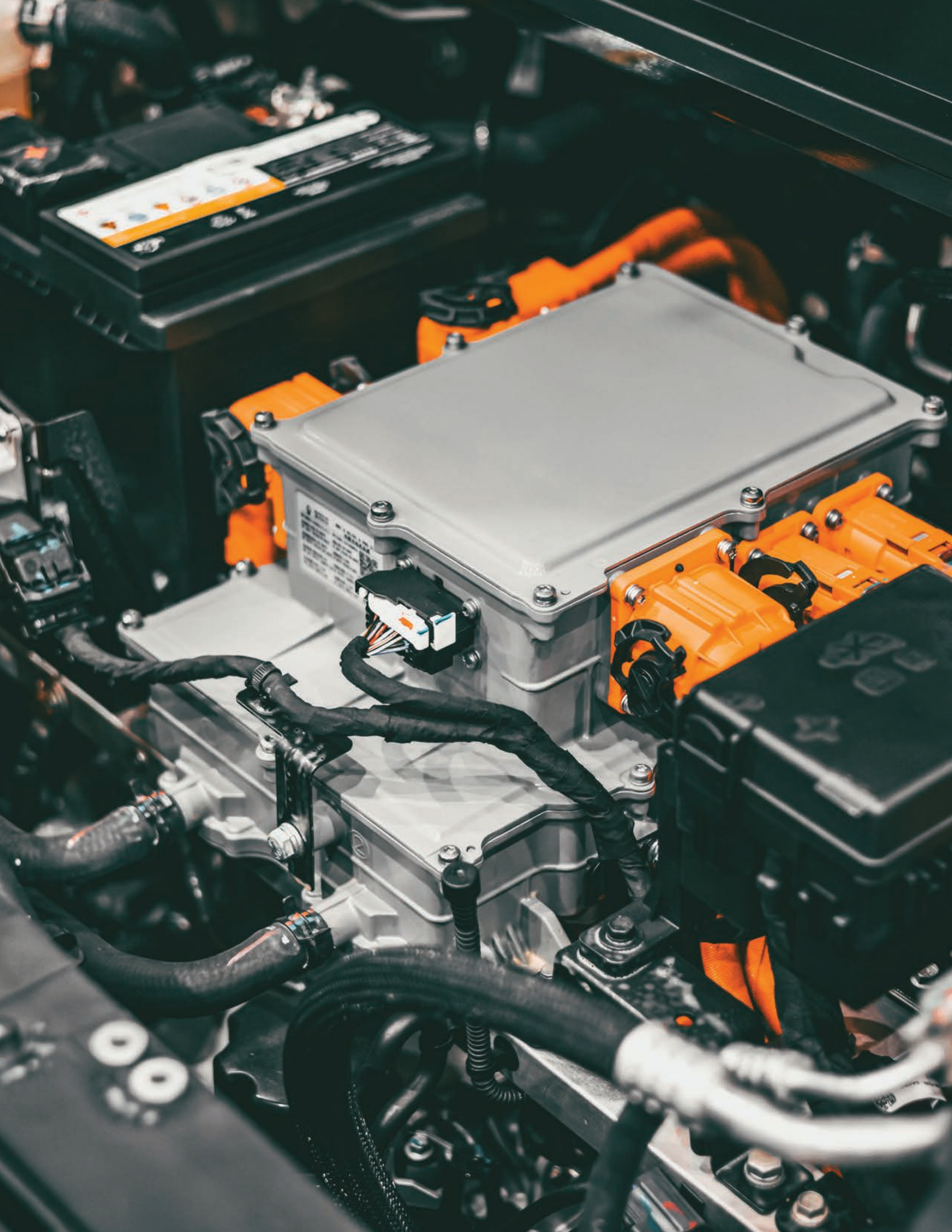

I. INTRODUCTION

Rapid global deployment of electric vehicles (EVs) of all types, including cars, trucks, buses, and trains, is crucial for shifting the transportation sector away from oil consumption and meeting long-term climate goals. However, the accelerating growth of the EV market is placing increasing pressure on battery supply chains, which start with mineral extraction and refining processes that have local environmental and social impacts. To ensure supply chains grow in a sustainable and low-carbon manner, governments, policymakers, and public and private sector leaders around the world will need to take action to improve and reform these supply chains.

This policy brief provides a blueprint for a model battery supply chain policy, based on the European Union's (EU) Sustainable Batteries Regulation[1] (which was adopted by the European Parliament and Council in 2023) that leaders around the globe in primarily consumer nations could consider adopting. It outlines key challenges in the battery supply chain, from mining and refining to battery traceability and end-of-life management, and it provides recommendations targeted to decision makers in jurisdictions involved in and affected by all phases of the battery supply chain.

OVERVIEW OF THE BATTERY SUPPLY CHAIN

The EV battery supply chain begins with mining key raw minerals like lithium, cobalt, and graphite. These materials are then refined, traded, and processed into battery components. Cathode and cell manufacturers assemble the inputs into battery cells, which are then combined into packs for EVs of all types, including cars, trucks, buses, and trains. At the end of their lifecycle, batteries are then ideally either repaired, remanufactured, repurposed, or recycled to recover valuable materials. While raw materials and processes have changed with evolving technologies, the overview in Figure 1 represents the basic supply chain cycle today.

FIGURE 1: VISUALIZING THE EV BATTERY SUPPLY CHAIN

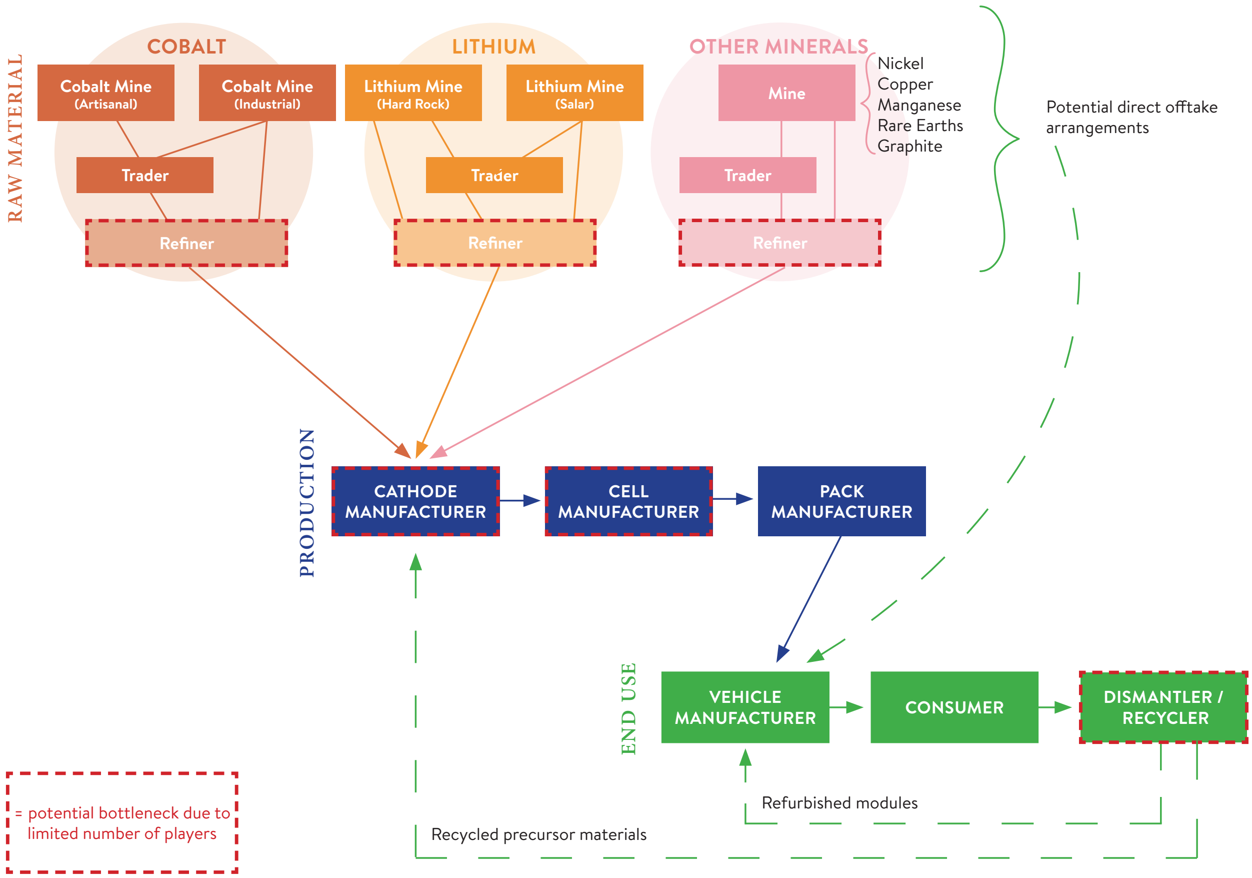

Figure 1. Battery supply chain overview[2]

II. MINING AND PROCESSING

The supply chain begins with mining and the processing of those minerals. Current mining capacity for transition minerals is largely centralized in a few countries. Lithium mining occurs primarily in Australia (52%) and Chile (22%), nickel largely comes from Indonesia (33%), cobalt is concentrated in the Democratic Republic of the Congo (69%), and most graphite is located in China (64%).[3] However, as demand increases, supply chains now also rely heavily on countries with lower production volumes, including Argentina and the U.S. (particularly Nevada, but also North Carolina) for lithium, as well as Brazil and Russia for nickel.

The reliance on a limited number of mining regions raises significant sustainability issues. Many of these regions face well-documented political, environmental and human rights challenges, including unsafe working conditions, habitat destruction, and high water usage. Furthermore, mineral processing also poses significant environmental challenges, including high water and energy consumption, pollutant emissions, and waste generation. As demand increases and supply chains expand within mining and processing regions and similarly situated ones, concerns among advocates, affected residents, investors and consumers may only increase, underscoring the need for reforms that prioritize sustainable and responsible mining and processing practices.

RECOMMENDATIONS TO ADDRESS MINING CHALLENGES

To address these mining and processing challenges, the EU's Sustainable Batteries Regulation establishes strict environmental and social standards for the entire battery life cycle, from sourcing and production to recycling. It requires battery manufacturers to meet due diligence obligations for ethical sourcing, carbon footprint transparency, and material recovery targets. EU leaders are implementing this regulation in stages over time,[4] employing a number of strategies that other consumer-heavy jurisdictions could consider adopting, including boosting local production, reuse and recycling, and traceability of batteries to ensure supply chain transparency and adherence to international standards.

The regulation operates in parallel to the EU's Critical Raw Materials Act,[5] which aims to secure access to essential materials like lithium and cobalt by boosting domestic extraction, processing, and recycling. The EU Critical Raw Materials Act identifies a list of 34 critical metals and minerals, including those commonly used in EV batteries, and sets 2030 goals for domestic extraction (10%), processing (40%), and recycling (25%). It also requires that no more than 65% of the EU's annual consumption of a raw mineral material (for any processing stage) can come from any one country outside the EU. A key element of the Critical Raw Materials Act includes provisions to expedite the operational and administrative side of permitting while upholding key environmental safeguards. Member states would be required to adopt and implement national measures aimed at enhancing the collection and recycling of critical raw materials.

Based on the EU's Sustainable Batteries Regulation and the Critical Raw Materials Act, governments and jurisdictions across the world that represent predominantly consumers could consider adopting the following strategies, which emphasize sustainable sourcing, ethical practices, and environmentally responsible processing to build a more resilient and equitable battery supply chain.

1. Sustainable Sourcing of Raw Materials:

- **Governments and policymakers could:**
    - **Mandate transparency and traceability requirements** for sourcing critical minerals, such as lithium, cobalt, graphite and nickel, through regulations and supply chain audits to ensure responsible mining practices and minimize human rights and environmental impacts. These requirements could focus on creating a digital record of a battery's material constituents, state of health, usage history, and life-cycle carbon, environmental, and social impacts. The Global Battery Alliance through its Battery Passport initiative, exemplifies this approach, as well as through the EU's Battery Regulation.
    - **Encourage the development of domestic mining industries** where feasible, while promoting responsible sourcing from countries adhering to international labor, human rights and environmental standards. This approach has the potential to enhance supply chain security, ensure sustainable and ethical practices (given that major consumer countries often have higher environmental and labor standards than mineral-producing countries), and derive economic benefits by creating jobs and stimulating economic growth within the country.[6]
    - **Adopt robust certification schemes or standards** for responsible mineral extraction, incorporating social, environmental, and human rights considerations. For example, governments could incorporate the Initiative for Responsible Mining Assurance (IRMA),[7] an independent third-party standard-setting organization that promotes responsible international mining practices, as a template for improving laws and

regulations. The EU Sustainable Batteries regulation references IRMA, along with Cobalt Industry Responsible Assessment Framework, as voluntary standards to require adherence to sustainable sourcing practices. Such schemes can help ensure improved human rights and environmental outcomes by the mining industry, though they do not replace due diligence. While not all schemes are governed equally, the 'multistakeholder' governance recognized by the Critical Raw Materials Act represents an important safeguard. But the Act also recognizes that voluntary standards will still need robust and transparent governance mechanisms.

2. Environmentally Responsible Processing:

- **Regulators could develop rules to minimize the environmental footprint of both their own mineral processing and imported minerals**, including limits on water usage, energy consumption, and pollutant emissions, as well as mandating the use of best available techniques. Drawing inspiration from the Critical Raw Materials Act, agencies could further require comprehensive measurement of the environmental footprint of battery raw materials. The data could then serve as a foundation for establishing maximum permissible thresholds.
- **Governments, research institutions, and industry stakeholders could collaborate to** develop and implement innovative, sustainable mineral refining technologies—such as hydrometallurgical techniques and by-product recycling—by investing in research, providing financial support, and exploring alternative materials to reduce the environmental impact of battery processing.

III. BATTERY TRACEABILITY

Battery traceability requires collecting and exchanging data across supply chain actors, which is a complex task with several key challenges. First, companies must balance protecting commercially sensitive data with providing information in the public interest. Companies also require standardized metrics to integrate data from diverse global supply chains. In addition, the companies need a common infrastructure to prevent fragmented systems, necessitating open-source, interoperable solutions developed through multi-stakeholder collaboration. Finally, traceability entities need to develop benefit and cost sharing structures that encourage participation while ensuring local communities and small enterprises receive economic benefits and support for data provision within a digital passport system.

Greater transparency and traceability in the EV battery supply chain and life-cycle impacts could drive sustainable practices by equipping buyers and other stakeholders with the information needed to prioritize purchases from companies that make responsible decisions about battery sourcing, usage, and disposal. At present, the development of traceability systems for EV batteries is still in the beginning stages. This nascency is largely because battery supply chain stakeholders are numerous, diverse, and global, making the collection and exchange of these data an enormous and complex task.

RECOMMENDATIONS TO OVERCOME TRACEABILITY CHALLENGES

The provisions in the EU Sustainable Batteries Regulation related to traceability include requirements for mineral sourcing, lifecycle emissions, recycling, and information sharing through a digital "battery passport." Those provisions related to traceability include:

- **Carbon footprint disclosure:** Companies that place EV batteries in the EU market must include and report information on the batteries life-cycle carbon footprint. Based on the information from carbon footprint declarations, the commission will identify maximum carbon footprint thresholds for EV batteries.
- **Supply chain due diligence:** Companies that place EV batteries in the EU market must develop supply chain due diligence policies over the coming years (with full implementation by 2030 at the latest) that are aligned with international standards and principles, such as those in the United Nations Guiding Principles on Business and Human Rights and the Organisation for Economic Cooperation and Development (OECD) Guidelines, and incorporate them into supplier contracts. These policies aim to identify and address social and environmental risks associated with battery production. The regulation requires robust management systems, traceability to the mine level, grievance mechanisms, risk assessments, supplier engagement strategies, and independent verification of due diligence systems. The regulation also highlights specific areas of focus based on risk categories, including human rights, human health, and safety, occupational health and safety, labor rights, community life, water use, soil protection, air pollution, and biodiversity.
- **Battery passport and improved labeling:** At present, EV batteries lack readily accessible, standardized information critical to recycling or repurposing, such as the remaining state of health, chemistry, and basic components. For both recycling and second life, batteries must go through various states of disassembly. Modules and cells not designed to be disassembled and with a large diversity of design can add expense and time to repair and recycling processes. To address this logistical challenge, the EU regulation requires batteries to include information on: (1) battery removal, disassembly, and dismantling; (2) waste collection, second life preparation, and recycling; and (3) performance and durability (e.g. state of health). Starting in 2026, all EV batteries must have a digital battery passport which should include the above standards and requirements. This digital passport for batteries will provide detailed information on each battery, aiding in the tracking and management of batteries throughout their lifecycle.

To advance battery traceability and optimize end-of-life management, jurisdictions could adopt the following strategies:

1. End-of-Life Management:

- **Governments and regulators could implement mandatory due diligence requirements** aligned with international standards, ensuring they are integrated into supplier contracts for key transition minerals to identify and address social and environmental risks in battery production.

2. Sustainability alliances and organizations:

- **Battery manufacturers, electric vehicle makers, government agencies and other policymakers** could collaborate with sustainability-focused organizations, such as the Global Battery Alliance (GBA), to develop and adopt standardized battery passport systems. By aligning regulations and industry practices, they can promote transparency, responsible sourcing, and a circular battery supply chain based on auditable and comparable data.

- **Mining companies could participate in organizations like the GBA** to ensure that raw material sourcing aligns with sustainability and ethical standards, providing data to support responsible mining practices. In addition, mining companies could commit to opening their sites to third party verification and audits based on robust standards like IRMA.
- **Large corporate EV fleets could become GBA members** to support data sharing and to amplify support for GBA and thereby increase GBA's ability to effectively engage other supply chain actors. Corporate fleets are significant stakeholders in the EV supply chain, and their collective voice and purchasing power can inform policy agendas and industry priorities. **Buyers of raw materials could consider joining the Initiative for Responsible Mining Assurance**, in order to show the market that their suppliers of mined materials will need to undergo an assessment based on the IRMA standard.

IV. SECOND-LIFE AND RECYCLING

Battery recycling and second-life markets can help lessen environmental impacts by minimizing waste and reducing demand for new raw materials. Additionally, repurposing used batteries for secondary applications extends their lifespan, promoting a more sustainable and circular economy. Battery recycling and second-life markets have significant opportunities for innovation and technological advancement. Growth will hinge on supportive policy and industry coordination to overcome technology and logistical barriers. These challenges include lack of life-cycle tracking and responsibility, disparate battery design and labeling approaches, the logistics of hazardous waste, and low critical mineral recovery rates.

RECOMMENDATIONS TO ADDRESS SECOND LIFE AND RECYCLING CHALLENGES

The EU Sustainable Batteries Regulation contains a number of provisions to promote these markets, including:

- **Extended producer responsibility and reporting:** Without mechanisms to trace and/or designate responsibility for end-of-life batteries, policy makers cannot ensure they will be collected, increasing the odds that batteries end up in landfills or offloaded to low-income economies, where they may become contamination hazards and a waste of mineral resources. The EU regulation requires vehicle manufacturers to ensure retired batteries are collected for reuse, repurposing, or recycling. Producers must report the recycling rates of retired batteries, promoting accountability and encouraging second-life applications. Additionally, the regulators require producers to meet waste management responsibilities, including financing and organizing the separate collection and treatment of end-of-life batteries, reporting recycling rates and related data to competent authorities, and providing transparent information on battery end-of-life aspects. These measures promote accountability, encourage second-life applications, and support the sustainable management of battery resources.

- **Mandatory recycling recovery rates:** Starting in 2027 in the EU, recycling processes for any battery sold in the EU must ensure that material recovery rates reach 90% for cobalt, nickel, and copper, and 50% for lithium, increasing to 95% and 80% respectively by 2031. In addition to the element-specific recovery rates, industry will need to recover 65% of all material (by weight) in a battery by 2025, which increases to 70% by 2030.
- **Mandatory recycled content standards:** Battery manufacturers and companies placing batteries on the EU market, including EV manufacturers, battery producers, and suppliers, must include recycled material in new batteries starting in 2031, with at least 16% of the cobalt, 6% of the lithium, and 6% of the nickel constituting recycled material. Those amounts increase to 26%, 12%, and 15% respectively in 2035.

Effective implementation of second-life and recycling strategies will require innovative approaches to battery design, manufacturing, repairability, and regulatory compliance, as well as risk reduction to avoid harms from potentially hazardous industrial processes. The following recommendations emphasize enhancing sustainability, safety, and efficiency across the battery lifecycle.

1. Battery Pack Assembly, Manufacturing and Lifecycle:

- **Governments and regulatory bodies could promote the use of high-quality, durable materials in battery pack construction**, such as external casings and packaging, to extend product lifespan and maximize energy efficiency. They can also require labeling requirements for ease of repair. The ultimate goal is to maximize the first-life value of the battery and delay the need for expensive, energy intensive repurposing or recycling.
- **Governments and regulators could establish standards for recovering metals from recycled batteries, particularly from 'black mass'** (which is the residual material from lithium-ion battery production process that requires processing and drying in order to recycle).[8] For example, some advocacy organizations have urged the European Commission to include specific waste codes for lithium-ion batteries and their intermediate waste streams, such as 'black mass,' in the European List of Waste. They also recommend classifying these intermediate waste streams as hazardous waste, in order to regulate their export outside the EU more effectively.[9]
- **Government leaders could support programs to help aggregate second-life applications** to facilitate market demand for used battery deployment, such as for stationary energy storage facilities.
- **Industry associations and manufacturers could establish standards for the safe handling and assembly of battery packs**, including guidelines for worker safety, fire prevention, and transportation safety.

- **Vehicle manufacturers, dealers and resellers could ensure retired batteries are collected to be reused, repurposed, or recycled**, and report on how many retired batteries are transitioned to recycling.
- **Governments and regulators could mandate the establishment of collection and recycling schemes for spent batteries** to prevent environmental contamination and recover valuable materials.
- **Governments and regulators could implement extended producer responsibility frameworks**, placing the onus on battery manufacturers to finance and manage the collection and recycling of their products.

2. Innovation in Recycling Technologies:

- **Governments and funding agencies could incentivize innovation in battery recycling technologies**, and direct recycling methods, to improve efficiency and resource recovery rates.

3. Advocacy for Ambitious Domestic Policy:

- **Large fleets and major companies could engage in advocacy to support the advancement of end-of-life industries**, such as battery recycling companies. This approach could include direct engagement with policymakers with a potential policymaker audience of state and federal legislators, regulators, and executive offices responsible for electric utilities, hazardous waste, industrial policy, energy, transportation, and innovation.

V. CONCLUSION

A robust battery supply chain policy is essential for promoting sustainability, ethics, and innovation in the rapidly growing battery industry. Governments and international organizations could support capacity-building initiatives in developing countries to enhance their regulatory frameworks and technical capabilities for sustainable battery supply chain management. Policymakers and industry leaders could encourage industry engagement and stakeholder participation in policy development and implementation processes to foster consensus and ensure effective execution. By drawing inspiration from the European Union's Sustainable Batteries Regulation, jurisdictions worldwide can tailor and adopt this blueprint to address their specific contexts and challenges, thereby advancing the transition towards a greener and more sustainable future.

REFERENCES

1 European Union, Regulation (EU) 2023/1542 of The European Parliament and of the Council, available at https://eur-lex.europa.eu/eli/reg/2023/1542/oj

2 Ethan Elkind et al., *Sustainable Drive Sustainable Supply: Priorities to Improve the Electric Vehicle Battery Supply Chain*, UC Berkeley Law Center for Law Energy and the Environment, Natural Resource Governance Institute (2020), available at https://resourcegovernance.org/publications/sustainable-drive-sustainable-supply-priorities-improve-electric-vehicle-battery

3 IEA (2021), Share of top producing countries in extraction of selected minerals and fossil fuels, available at https://www.iea.org/data-and-statistics/charts/share-of-top-producing-countries-in-extraction-of-selected-minerals-and-fossil-fuels-2019

4 European Commission, 'Batteries' (webpage), available at https://environment.ec.europa.eu/topics/waste-and-recycling/batteries_en

5 European Commission, Critical Raw Materials Act (webpage), available at https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en

6 Notably, a shift to more production in consumer countries like within the EU means reduced income for developing countries that rely on the export of raw materials for export revenues and economic opportunities. Additionally, not all consumer countries have available mineral resources and will still need to rely on imports, which underscores the importance of international cooperation and trade agreements to ensure a fair and stable supply chain.

7 Initiative for Responsible Mining Assurance (webpage), available at https://responsiblemining.net/

8 Barry Perlmutter, "Unlocking the Bright Side of Black Mass in Lithium-Ion Battery Recycling," Chemical Processing (Jan 5, 2024), available at https://www.chemicalprocessing.com/voices/barry-on-batteries/article/33016466/unlocking-the-bright-side-of-black-mass-in-lithium-ion-battery-recycling

9 Transport & Environment, 'Europe needs to act over black mass, Commission told' (September 28, 2023), available at https://www.transportenvironment.org/articles/europe-needs-to-act-over-black-mass-commission-told

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