SUSTAINABLE DRIVE SUSTAINABLE SUPPLY

Priorities to Improve the Electric Vehicle Battery Supply Chain

JULY 2020

Berkeley Law
Center for Law, Energy, & the Environment

Natural Resource Governance Institute

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This report and its recommendations are solely a product of the Center for Law, Energy & the Environment and the Natural Resource Governance Institute *and do not necessarily reflect the views of all individual convening participants or reviewers.*

ACKNOWLEDGMENTS

CLEE and NRGI thank Claudia Becker (BMW), Mark Caffarey (Umicore), Jennifer Diggins (Albemarle), Michelle Michot Foss (Rice University), Ellen Lenny-Pessagno (Albemarle), Michael Liu (BYD), Mike Maten (General Motors), Descartes Mponge Malasi (NRGI), Daniel Mulé (Oxfam), Dennis Pan Xuexing (CATL), David Parham (Sustainability Accounting Standards Board), Julia Poliscanova (Transport & Environment), Payal Sampat (Earthworks), Mathy Stanislaus (Global Battery Alliance/World Economic Forum) and Erica Westenberg (NRGI) for participating in the November 2019 convening that informed this report and their helpful contributions to the final document. Several additional reviewers provided feedback on the content of this report, including Elisabeth Caesens (Resource Matters), Lorena de la Puente Burlando (NRGI), Benjamin Katz (Organization for Economic Cooperation and Development), Luca Maiotti (Organization for Economic Cooperation and Development), David Manley (NRGI) and Flavien Moreau (International Monetary Fund). We also thank Brendon Browner and Naomi Spoelman (JD candidates, UC Berkeley School of Law) for their research assistance.

CLEE and NRGI thank the ClimateWorks Foundation for its generous support of this initiative.

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DESIGN

Layout **Odd Moxie**

Template **Studio Clear**

Photography Licensed from **Adobe Stock**

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Key Takeaways

- **Sustainable management of the supply chain for electric vehicle batteries is critical in order to achieve global climate goals and promote the well-being of people in mineral-rich countries.**
- **Shortcomings in coordinated action, accountability, and information access across the supply chain are root causes of supply chain mis-governance.** Addressing this requires stronger national and international mechanisms to improve data transparency and promote neutral and reliable information-sharing. This can help level the playing field between actors across the supply chain and between governments and companies.
- **A number of standards and initiatives seek to promote supply chain sustainability. But coordination and data sharing across multiple supply chain standards is weak, hindering adherence.** Supply chain actors could develop stronger systems to prioritize and coordinate across these standards, as well as a stronger set of incentives for rigorous application, would promote more consistent application.
- **Regulatory and logistical barriers impede progress on battery life extension, reuse, and recycling, which will be essential to long-term supply chain sustainability.** Priority responses include designing batteries proactively for disassembly for recycling and reuse, building regional infrastructure for battery recycling and transportation, and creating regulatory certainty for recycling.

INTRODUCTION AND SUMMARY

Battery electric vehicles are central to global efforts to combat climate change. Greenhouse gas emissions from transportation exceed 15 percent of the global carbon footprint. In advanced economies, such as California's, these emissions exceed 40 percent of the total.[1] When fueled by increasingly clean electricity generation, electric vehicles (EVs) offer significant carbon emission reductions compared to internal combustion engine vehicles.[2]

This global transition will require producing hundreds of millions of EV batteries. Global sales of EVs are anticipated to reach tens of millions per year by 2030.[3] Such a massive deployment raises concerns about the availability of minerals needed for these batteries, as well as the ability to reuse and recycle existing batteries to help meet demand. By some estimates, production of graphite, lithium, and cobalt will need to grow by over 450 percent by 2050 to meet global climate targets.

This new demand, even with maximum reuse and recycling, implicates a range of environmental issues and the lives of people in mineral-producing countries.[4] These mines and supply chains often overlay areas at high risk of human rights abuses, corruption and weak rule of law, and localized environmental hazards. All of these challenges can be exacerbated by mineral extraction.

For the EV and battery industries, the potential human rights and environmental threats associated with mineral extraction and production create additional operational risks and consumer-side threats to their brands. Instability and poor governance in mineral-producing regions can lead to mine shutdowns and large fluctuations in availability of supplies and price.

At the same time, EV and battery companies throughout the supply chain face intense scrutiny and expectations over sustainability practices, in many cases disproportionately to their fossil fuel competitors. These companies also face challenges in coordinating their approaches and navigating proliferating regulatory standards on battery reuse and recycling. And near-term delays in new investments due to the current coronavirus crisis might exacerbate these risks by disrupting extraction and production processes across the chain, further entrenching a few suppliers' dominance and limiting market pressure to prioritize sustainability.[5]

However, if managed effectively and in the public interest, the growth in demand for these minerals can boost national development in several developing and emerging economies. A number of governments have announced ambitious plans to use the growth in production of these minerals as generators of substantial revenue to fund public services and as a driver of local private sector development.

For these ambitions to be realized, regulators and civil society organizations have launched efforts to increase the sustainability and transparency of the EV battery supply chain. Private players in the mineral, battery and vehicle industries have organized various initiatives to reduce abuses in the supply chain and pursue long-term economic outcomes that benefit players along the chain. Private players are also scoping opportunities for expanding reuse and recycling. Industry and government stakeholders seek greater certainty around these private sector efforts and what they can do to support them.

In order to promote positive development outcomes, reduce the risks of supply chain bottlenecks, and mitigate governance and human rights risks, UC Berkeley School of Law's Center for Law, Energy & the Environment (CLEE) and the Natural Resource Governance Institute (NRGI) developed a stakeholder-led research initiative focusing on the key barriers to and headline opportunities for achieving greater sustainability in the EV battery supply chain.

Defining Supply Chain Sustainability

This report defines a sustainable EV battery supply chain as one that addresses all risks—including human rights, governance and corruption, equity and balance of benefits, and local environmental impacts—that threaten the long-term ability to produce EV batteries at a scale sufficient to meet global climate needs and in a manner that limits negative impacts to people, institutions and the environment. As mineral production grows to meet that need, expanding cooperation and implementation capacity across industry, government and civil society will become essential to manage sustainability risks. In general, no single existing definition of supply chain "sustainability" connects all these individual issue areas. Leading international sustainability efforts focus on respecting human rights; avoiding contribution to conflict and financial crimes; supply chain due diligence; contributing to improvement of socioeconomic conditions, including optimizing battery reuse and recycling; and enhancing transparency in extractive processes to promote sustainable economic growth and resource management for the benefit of host country residents.[6]

CLEE and NRGI convened automobile, battery, and mining industry representatives, nonprofit leaders and government officials in November 2019 to identify major challenges to effective collective action around battery supply chain sustainability. Participants represented a diversity of perspectives meant to generate cross-cutting approaches. These approaches were not necessarily limited to the challenges and opportunities of one specific initiative, industry segment, geography or stakeholder group.

This report discusses major challenges identified in that discussion and follow-up research. It also presents critical responses to address these challenges, based on the participant discussion, outreach to other experts and stakeholders, and a review of the growing suite of literature on how to achieve a sustainable electric vehicle battery supply chain. Summary findings include the following:

Key Challenges to Ensuring Battery Supply Chain Sustainability through a Multi-Stakeholder Approach

- Lack of coordinated action, accountability, and access to information across the supply chain hinder sustainability efforts
- Inadequate coordination and data sharing across multiple supply chain standards limit adherence
- Regulatory and logistical barriers inhibit battery life extension, reuse, and recycling

Priority Responses:

- Industry leaders could **strengthen mechanisms to improve data transparency** and promote neutral and reliable information-sharing to level the playing field between actors across the supply chain and between governments and companies
- Industry leaders and third-party observers could **ensure greater application of supply chain sustainability best practices by defining and categorizing existing standards and initiatives** to develop essential criteria, facilitate comparison and equivalency, and streamline adherence for each segment of the supply chain
- Governments and industry leaders could **create new incentives for supply chain actors to participate in and adhere to existing standards and initiatives**, which may include sustainability labeling and certification initiatives
- Industry leaders could **design batteries proactively for disassembly** (enabling recycling and reuse), and industry leaders and governments could collaborate to **build regional infrastructure for battery recycling and transportation** and create regulatory certainty for recycling

The following sections present more details on these and other responses, along with background information on the current state of the EV battery supply chain. Section II provides background on the mineral supply chain, emphasizing features of supply chain players, minerals and countries most relevant to the challenges and opportunities prioritized in the CLEE-NRGI November 2019 convening and associated outreach. Section III describes the most pressing challenges identified in the process and the ideas generated by convening participants on how to address them. Section IV provides concluding thoughts on policy implications and next steps.

Are EVs greener than gasoline vehicles?

The lack of transit-related emissions, coupled with the potential to utilize and support renewable energy sources, gives EVs a significant emission advantage over internal combustion engine vehicles. Some estimates place EV life-cycle emissions at approximately 50 percent fewer greenhouse gases per kilometer traveled than internal combustion engines, ranging from 25-28 percent lower in jurisdictions in which electricity supplies are fossil fuel-reliant, up to 72-85 percent lower in areas with high renewable energy penetration.[9] Others estimate an emissions benefit between 19 percent at the low end (for large vehicles in China) and 60 percent at the upper end (for small vehicles in Europe).[10]

Importantly, the potential greenhouse gas benefits of EV use will grow as firms develop new production technologies and as the overall electrical grid becomes less carbon-intensive.[11] Some experts anticipate a 50 percent reduction in the life-cycle emissions of an average EV by 2030, and by one estimate of a fully renewable future grid, EVs could eventually produce at least 90 percent fewer life-cycle greenhouse gases than ICE vehicles.[12]

Differences in battery materials and production techniques, including the location and energy mix of production, also affect the emissions profiles of different EVs.[13] In addition, EV batteries' potential use in smart charging and vehicle-to-grid applications, and the potential for second-life energy storage applications of used batteries, could play a key role in deep decarbonization of the electrical grid by enabling greater integration of renewable energy sources.[14]

For more background information, see CLEE and NRGI's FAQ report.

ELECTRIC VEHICLE BATTERY SUPPLY CHAIN: OVERVIEW AND KEY MINERAL INPUTS

EV batteries use complex electrochemistry to store electricity drawn from the power grid and convert it into energy to power the vehicle. Battery technology and design are constantly evolving, but the most common format—lithium-ion technology—relies on a range of component minerals, which typically include lithium, cobalt, nickel, graphite and manganese.[7] Manufacturers use these minerals to construct battery cells consisting of electrolytic cathodes and anodes; package multiple cells into a single case with electrical terminals known as a module; and connect multiple modules into a single battery pack for use in a vehicle. The specific mineral components, chemical composition and size of batteries vary widely by manufacturer, power and range. Different manufacturers play major roles at each stage throughout the process.[8]

While battery technologies and materials are diverse and certain to change over time, two minerals essential in most existing battery formats offer illustrative examples of the nature and scope of the sustainability challenges that can confront the supply chain.[15]

Cobalt, which is integral to many lithium-ion battery chemistries, is predominantly mined from hard-rock deposits in the Democratic Republic of Congo and refined in China, giving rise to concerns around human rights, corruption and governance in extractive areas, as well as potential supply bottlenecks (due to the dominant market shares of these two countries).[16] Lithium, another essential component, is found in a broader, but limited, number of countries—hard-rock deposits in Australia and China and brine (known as salar) deposits in the Andean nations of Argentina, Chile, and Bolivia. Mining in these areas raises potential concerns around political and price stability as well as high water consumption and displacement of local and indigenous populations.[17]

Cobalt and lithium do not represent the entire supply chain or the entire range of risks faced. Many of the challenges they present are shared widely across the mining sector. But they are critical, representative components of current battery technologies that highlight many of the key concerns that inform efforts to improve sustainability risk management. As such, this section provides a brief overview of major issues associated with cobalt and lithium supplies.

OVERVIEW: COBALT

Cobalt is an essential component in many of today's lithium-ion batteries. Demand for batteries—half of cobalt use goes to batteries—has accelerated worldwide demand for the mineral. The cobalt market now produces over 100,000 metric tons per year, with estimates of over 200,000 metric tons annually by 2025.[18] For reference, by some measures, approximately 7,075 metric tons of raw cobalt demand are needed to produce 500,000 large-format EV batteries (or approximately 30 pounds to produce the refined material for each battery).[19] Up to 60 percent of global cobalt production and more than half of global reserves (i.e., known resources that are economically feasible to produce) are located in the Democratic Republic of the Congo (DRC).

Other leading producers include Australia, Canada, China, Cuba, Madagascar, the Philippines, Russia and Zambia. Production and reserves in any of these countries are multiples smaller than those of DRC.[20] China, in turn, produces nearly half of the world's refined cobalt, followed by Canada, Finland, Japan, Norway and Zambia, among other countries. In light of longstanding governance weaknesses, the dominance of DRC and China in the cobalt sector may prompt

Are there enough minerals to build all the batteries the world needs?

Many EV battery component minerals, such as lithium, cobalt, nickel, graphite, copper, manganese, and rare-earth elements like neodymium, are "critical" minerals for which substitutes are limited or nonexistent and supplies are geographically concentrated.[23] Expert opinions differ on how likely a long-term shortage of these minerals could be, particularly given changing battery technologies and chemistries that may become less reliant on these raw materials. Some experts have determined that long-term mineral supply shortages are unlikely to occur,[24] but other analyses show that demand for essential battery components could exceed supply within decades (by 2030 for cobalt and 2037 for nickel) without further developments in battery mineral composition.[25] Coronavirus-related supply chain disruptions may have the potential to create multi-year supply deficits for key minerals.[26]

The pace of technological progress on materials recovery and recycling will impact the shape of future minerals demand. This innovation offers the possibility of extending and diversifying supply chains. The automotive and battery industries are also investing to develop new technologies that rely on more plentiful (and cheaper) minerals.[27] Ultimately, while demand for key minerals may grow exponentially with the market—by more than 300 percent for graphite, more than 500 percent for cobalt, and more than 900 percent for lithium by 2050—experts cannot project with certainty how technological change will impact supply chains. As a result, the potential impact of mineral supply bottlenecks in the future remains unknown.[28]

For more background information, see CLEE and NRGI's FAQ report.

greater scrutiny of sustainability risks, even as manufacturers seek to develop low- and zero-cobalt battery technologies and other countries seek to ramp up production.[22]

DRC's economy is highly dependent on mining. Minerals made up 99 percent of the country's exports and 30 percent of GDP in 2018. Cobalt generated about 35 percent of the country's mineral sales that year.[29] The government has targeted cobalt as a strategic growth sector and created mechanisms to try to ramp up public revenue and economic activity associated with it as demand rises.[30]

Political instability and conflict have long affected DRC, with the mining sector in general and cobalt mining in particular associated with a range of human rights, environmental and corruption concerns. Meanwhile, Chinese ownership of mineral production and refining capacity (both domestically and in DRC) has increased in recent years, raising the potential that other countries could have limited mineral access in the future.[31] The distinct sustainability concerns associated with each country have significant implications for the overall battery supply chain.

Cobalt mining in DRC occurs in two forms: industrial (i.e., large-scale mining carried out by large national and international entities as part of government-licensed projects) and artisanal and small-scale (i.e., mining carried out by individuals or groups with little to no mechanization and varying degrees of government approval).[32] Some producers may operate in both contexts, and while extractive processes are different in the earliest upstream stages—artisanal cobalt often first moves from mines to intermediate traders and middlemen before processing and refining—the minerals are largely commingled once they are refined.[33]

Typically, cobalt refining or processing is broken down into two stages: initial processing into crude cobalt hydroxide, which may take place in DRC; and secondary processing, which results in product-grade cobalt and usually takes place in China.[34] While artisanal and industrial cobalt are indistinguishable by the time they are processed, their different production methods and the sustainability risks entailed merit distinct consideration.

Artisanal and Small-Scale Cobalt Mining

Artisanal and small-scale mining by individuals or small cooperative groups is responsible for approximately 20 percent of total cobalt production in DRC, with estimates of the number of individual miners (known as "creseurs") involved ranging from 100,000 to over 250,000—some of them children.[35]

The DRC mining code defines artisanal mining, established the Artisan Mining Zones (ZEAs) in which it may be practiced legally, and includes limited provisions relating to safety equipment or health hazards. The government created the Assistance and Management Service for Artisanal and Small-Scale Mines (Service d'Assistance et d'Encadrement du Mines Artisanales et de Petit Echelle or SAEMAPE) in 1999, a chronically under-resourced agency. Its mandate: to regulate artisanal mine operations (including monitoring the flow of material from extraction to sale, ensuring tax collection and monitoring security). However, in cobalt and copper mining areas, the lack of economically viable ZEAs has pushed many miners into illegal or under-regulated activity.[36]

Reports from international observers and Congolese nongovernmental organizations show artisanal cobalt miners rarely (if ever) benefit from health-and-safety protections. They live with the ongoing risk of negative health impacts, injury and death, with weak enforcement of health and safety standards by regulators, including SAEMAPE.[37] These risks include lung disease linked to particulate inhalation; physical injury from a lack of load-lifting equipment, lax operating standards and a lack of protective clothing; infections due to poor sanitary conditions; and mine collapses.[38]

Reports indicate that agents of Congolese state entities including SAEMAPE have been involved in corrupt activity, such as engaging in extortionary practices along with state security

forces at artisanal mine sites and trading centers.[39] This form of corruption can subject individual miners to regular bribery demands and steer miners to dig unsafe, illegally deep pits in exchange for payments. It also results in a failure to enforce child labor requirements. Artisanal miners protesting working conditions or lack of protections can face violent punishment from a range of parties.[40]

Despite all these risks, artisanal mining offers many an opportunity to earn a living. By some estimates, up to 60 percent of residents—hundreds of thousands of individuals—in Congo's main copper and cobalt-producing province, Katanga, rely on artisanal mining to survive. This employment dwarfs jobs available in the large-scale mining sector. Artisanal miners earn significantly more than workers in other fields, in some cases more than tenfold.[41]

Artisanal miners typically sell raw materials to middlemen and traders who aggregate material to sell to licensed buying houses, which are located close to the mines or in nearby town centers. (The DRC government is currently seeking to centralize the artisanal mining trade through a single consolidated buyer.[42]) These buying houses, many run by or associated with large foreign refining operations, then sell aggregated product to processors, some of which are part of vertically integrated companies.[43] The DRC mining code requires licensed artisanal miners to sell via cooperatives only to licensed traders and buying houses (and vice versa).

But there are significant gaps and inconsistencies in the due diligence practices of companies on conditions of extraction and the use of child labor. So the supply chain is muddied. In many cases, even DRC-based processors might not fully know the source of artisanal cobalt they purchase. While buying houses offer a crucial link between independent artisanal miners and the global market for their goods, they also typically pay low prices. Low prices translate to risk, and can contribute to unsafe conditions and corrupt practices.[44]

Various efforts are underway to formalize the artisanal cobalt sector in DRC. In late 2019, the Congolese government established a new subsidiary of state-owned mining company Gécamines tasked with the control and marketing of artisanal cobalt.[45] The revisions to the mining code included new measures to define and regulate artisanal activities.[46] Various companies and public-private partnerships are also engaged in pilot efforts to formalize and organize artisanal mining, in large part to address sustainability concerns.[47] The involvement of vertically integrated companies at the purchasing level can also deliver more resources and capacity to advance responsible sourcing goals, such as a DRC pilot project between Trafigura and Chemaf.[48]

Industrial Cobalt Mining

Industrial cobalt mining in DRC, executed by large multinational companies with heavy equipment at sophisticated mine sites, presents a related but distinct set of issues.

Cobalt mining (both industrial and artisanal) in DRC is conducted via mines that produce both cobalt and copper—the economics and industrial processes of the two minerals are intimately intertwined. The Congolese state owns all underground minerals and Gécamines historically ran most mining operations. However, after the company collapsed in the 1990s, it now operates primarily through agreements and joint ventures in which multinational mining companies are granted extraction licenses in exchange for royalty payments and other terms. An increasing number of mining projects now operate without Gécamines's involvement.[49]

Corruption is a major concern in the Congolese industrial cobalt sector and comes at a huge cost to the country's citizens. While the DRC mining code lays out governing principles for the issuance of exploration and extraction licenses, as well as royalties and taxation, international observers and journalists have documented cases of large-scale public corruption in the allocation and regulation of industrial mining concessions.

Investigations have illustrated the practice by Gécamines and other state-owned enterprises of granting stakes in mineral licenses at below-market value to well-connected intermediaries,

who then sell them for a profit and distribute kickbacks to top officials. These relationships have sparked investigations of major mining companies led by law enforcement agencies in Canada, the United Kingdom and the United States.[50] The payments and royalty fees made to the intermediaries can amount to tens of millions of dollars. In a sharp contrast, the losses to the host government treasury can reach billions of dollars.[51]

DRC has taken meaningful steps on transparency, including the disclosure of some mining contracts and extensive information on company tax payments. But significant shortcomings remain in terms of public disclosure of local impacts from the sector, the activities of state-owned enterprises and how mining revenue is distributed across different levels of government.

The board of the Extractive Industries Transparency Initiative (EITI) decided in 2019 that the country had made "meaningful" progress in implementing the EITI Standard, but that remaining gaps in disclosures were substantial. EITI gave the country an additional 18 months (i.e., until April 2021) to carry out "corrective actions" or face suspension from the initiative.[52] In the 2017 Resource Governance Index (which measures transparency and accountability in extractives-dependent countries across the world), DRC's mining sector scored a "poor" 33 points out of a possible 100, ranking it 75th out of the 89 country-sectors surveyed.[53]

Amendments to the mining code in 2018 had an important impact on several elements of sector governance in DRC. The reforms included royalty payments as high as 10 percent for "strategic" minerals, including cobalt; a "super profits" tax on mining companies that applies when prices exceed forecasts by more than 25 percent; requirements that mine contractors be majority owned by Congolese shareholders and that a minimum proportion of raw materials be refined in DRC; and commitments of portions of royalties to a long-term investment fund and portions of company profits to local community development projects.[54] International mining companies have opposed the measures, arguing that they will harm the economic viability of their projects. Amendment advocates are concerned that the government may weaken implementation or conduct back-door compromises with large players.[55]

On top of these concerns, the growing dominance of Chinese mining, refining and manufacturing interests has a significant impact on the broader cobalt supply chain, in infusion of capital and expertise and leverage in dealing with the Congolese government and private-sector mining and vehicle companies worldwide. By one estimate, Chinese companies control one third of global intermediate cobalt production and one half of global refining capacity. As their ownership shares have grown significantly in recent years, this geographic concentration could threaten global access to mineral supplies, should Chinese government policy direct these resources toward exclusively domestic producers.[56]

The OECD has cautioned supply chain players and observers not to assume that the division between artisanal and industrial mining is complete or impermeable. Large-scale miners often source some production from artisanal miners, and production from large-scale and artisanal mines is frequently intermingled at trading depots. Artisanal activities also often take place within the concession areas formally controlled by large-scale miners. Thus, a comprehensive approach to reducing risks in the cobalt supply chain must account for the challenges in both production mechanisms and their interconnections.[57]

OVERVIEW: LITHIUM

Lithium is another essential component in lithium-ion batteries. As with cobalt and other mineral inputs, the majority of key deposits are concentrated in a small group of countries separate from battery and vehicle manufacturer home countries. Lithium reserves exist in two primary forms: mineral-rich brines (also known as salar), located primarily in South America's "lithium triangle" covering Argentina and Chile (in addition to Bolivia, which hosts major potential resources but is not currently producing commercial quantities[58]); and hard rock mines, located primarily in Australia and China. These four nations are responsible for over 90

percent of current global production.[59] Analysts have identified major potential resources in China, the United States (including California), DRC, and throughout Europe, as well as Bolivia, but whether or when these will prove economically viable is unclear.[60]

Lithium extraction is overwhelmingly industrial-scale, with a narrower set of human rights concerns than are generally reported for cobalt. International observers have reported concerns around local water supply contamination, community compensation, inequality and lack of consent in siting operations, particularly for indigenous populations.[61] Price volatility and its impact on the sustainability of production operations is also a persistent concern.[62]

One of the most important determinants of the future structure of the mineral supply chain will be the efforts of lithium-rich nations to exert greater control over deposits and move up the production value chain. According to some analyses, by 2025, global value of refined lithium products may exceed or even double that of raw lithium, and the value of finished batteries may be ten or more times greater than that of refined products.[63] Mineral host nations are responding to this market opportunity. For example, Chile's government has recently conditioned new mining concessions and expansion projects on agreements to support local refining and battery manufacturing operations.[64] Western Australia is attempting to develop a manufacturing hub to use locally produced lithium.[65] Chinese companies are moving to gain a larger share of the extraction market to accompany their leading position in refining and battery component production.[66] And in Bolivia, which is still producing at pilot scale, mining sector nationalization is a consistent concern for private actors. (Bolivia's major lithium deposit, the Salar de Uyuni, might also be especially costly to develop.)[67]

Government efforts to retain greater shares of overall mineral value through value-addition are important components of their responsibilities to create economic opportunities for their citizens. But they also highlight a tension between the efficiency of consolidating value chains in mineral-producing countries and of locating midstream and end-use manufacturing near each other. In many cases, governments face challenges in assessing how economically viable different pathways to value addition may be. Negotiations around these economic linkages can be a sticking point with mining companies, which can cause short-term supply chain disruptions.

These attributes of the cobalt and lithium supply chains demonstrate some of the scope of sustainability risks facing the broader supply chain. In principle, the surge in demand for battery minerals can represent an important economic opportunity for producing countries. And indeed, some countries – including Chile itself, as well as Botswana and Australia – have historically harnessed the mining sector as a driver of growth and development.

Before the current battery-powered lithium boom, Chile was long the world's largest copper producer. As a result, the country's leaders have developed world-class expertise in the industry, including via the state-owned company Codelco. The government has had success regulating the sector, captured significant fiscal benefits from mining, invested heavily in education, and practiced stable macroeconomic management, helping the country significantly grow income levels and human development outcomes (although recent protests have shed light on broader economic inequality concerns).[68] Mining companies have also begun to strike voluntary revenue-sharing agreements with indigenous communities.

Countries with significant deposits of battery minerals see potential for new opportunity with a battery boom. However, the mining sector has also failed to live up to outsized expectations in many countries and has often been a source of instability and harm to communities. Human rights risks in mining communities, while by no means unique to the battery supply chain, create multiple threats to the stability and growth of EVs. Labor or community unrest can lead to supply chain disruption. If consumer perception of EVs sours, demand could diminish. The governments in host countries can use regulatory powers to constrain production. Local environmental concerns, such as water usage in salar-based lithium operations, could threaten

long-term water supply availability. These environmental concerns impact the sustainability goals those seeking a shift from fossil fuel-powered vehicles to EVs are seeking to elevate.[69]

The concentration of mineral resources in a small number of countries means the supply chain is vulnerable to governance challenges at the national level and disputes between companies and host governments. The concentration of refining and processing operations in China also means that decisions made there have outsized impacts on the stability and governance of the overall supply chain. And the coronavirus pandemic has demonstrated how susceptible supply chains dominated by a small group of countries are.[70] In each case, the complexity of both the sustainability issues and the supply chain itself call for more comprehensive, collaborative approaches that draw coordinated action from players across the supply chain.

SUPPLY CHAIN PLAYERS

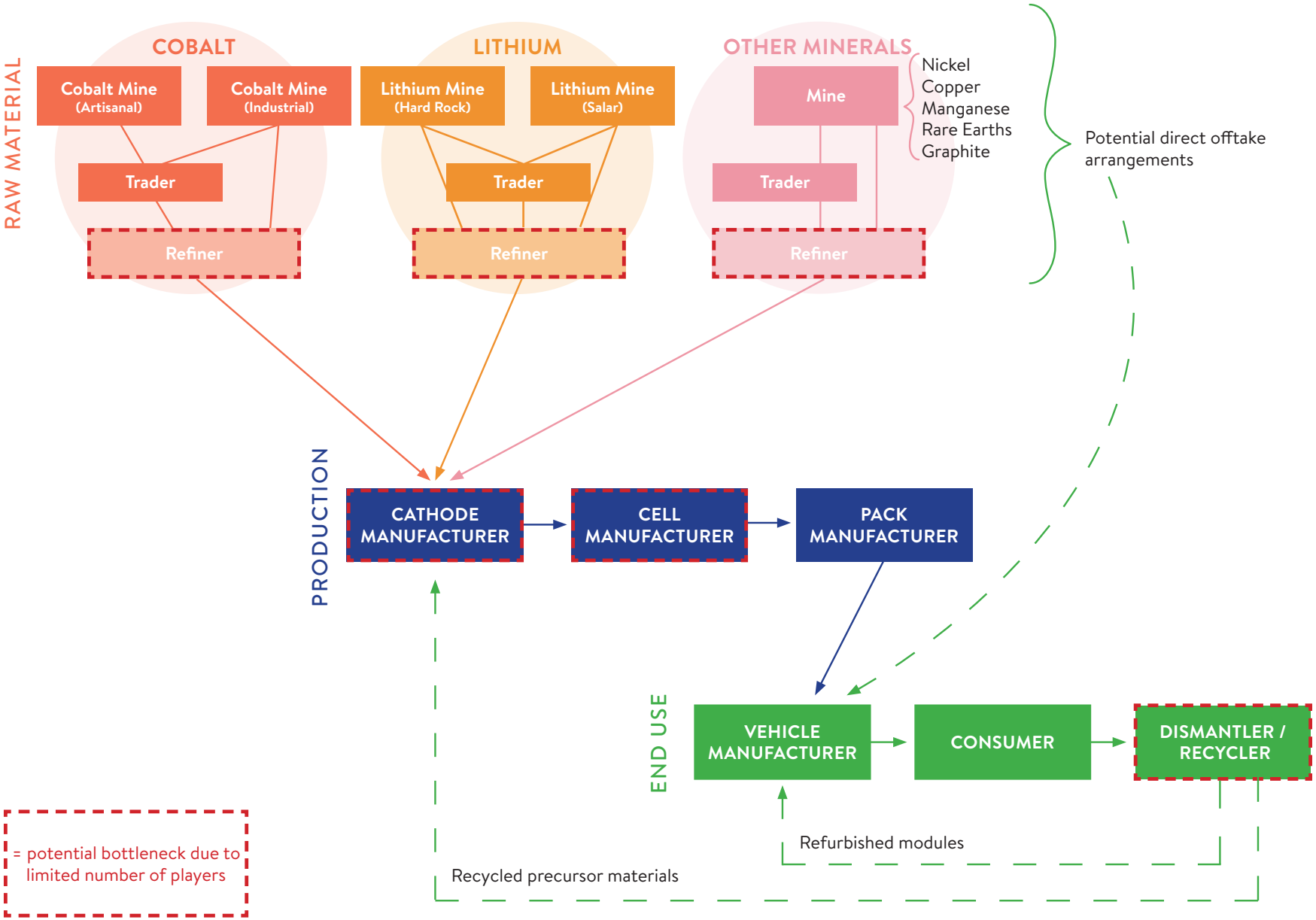
Once raw materials are mined, the supply chain involves multiple stages. Mineral refiners convert raw materials into usable form; international traders move commercially viable material toward refining and manufacturing stages; cathode manufacturers craft them into the positive and negative components of batteries that direct electricity flows; cell manufacturers use these components and chemical solutions to form individual battery cells; pack manufacturers combine hundreds or thousands of individual cells into battery packs for vehicle manufacturers to use in EVs; and battery repair, remanufacturing and recycling facilities harvest used batteries for reuse or recycling.

Supply chain experts, including many convening participants, describe a "bottleneck" at the middle of this process that has the potential to threaten sustainability. Each stage of the supply chain has a limited number of major players. But the refining, cathode manufacturing and cell manufacturing stages are dominated by a small number of companies that are largely concentrated in Japan, South Korea, and, especially, China, with the potential to control material flows or enter restrictive agreements with individual suppliers and buyers. The market analysis firm Benchmark Mineral Intelligence estimated that in 2019, Chinese actors controlled the following shares of global production across the EV supply chain: [71]

- 23 percent of upstream mining (of lithium, cobalt, graphite and manganese)
- 80 percent of chemical refining
- 66 percent of cathode and anode production
- 73 percent of lithium-ion battery cell manufacturing

See **Figure 1** on the following page for a depiction of the battery supply chain.

FIGURE 1: VISUALIZING THE EV BATTERY SUPPLY CHAIN



EXISTING SUPPLY CHAIN STANDARDS AND INITIATIVES

International efforts to increase supply chain transparency and risk management among the various entities and stages of battery production have expanded in recent years. This has resulted in a network of related due diligence and disclosure standards. These requirements overlap substantively in many cases, with measures relating to identification and mitigation of human rights, conflict, corruption and environmental impacts.

However, these standards vary in the entities they apply to, the entities responsible for application and the minerals they cover. They are mostly limited to voluntary adherence. The result is a patchwork containing core components of comprehensive supply chain management, but which risks sowing confusion among participating businesses and regulators.

Perhaps the most widely referenced international standard is the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas ("OECD Guidance"), which focuses on assessing, mitigating and reporting supply chain risks.[72] These measures are meant to guide the actions of companies throughout the mineral supply chain, via five core steps:

1. Adopting a management system for transparency throughout mineral supply chains
2. Identifying and assessing risks within the supply chain (including verifying chain-of-custody information and conducting on-the-ground assessment of high-risk locations or suppliers)
3. Managing risks to improve suppliers' behavior, including by suspension of business relationships
4. Auditing due diligence practices at control points across the supply chain
5. Publicly reporting on all due diligence efforts on an annual basis.[73]

The OECD Guidance offers a 14-point model supply chain policy for operations in conflict-affected and high-risk areas (identified by "political instability or repression, institutional weakness, insecurity, collapse of civil infrastructure" and/or "the presence of armed conflict, widespread violence or other risks of harm to people"[74]), which includes commitments such as:

- Refusing to tolerate, profit from, contribute, assist with, or facilitate torture, inhuman or degrading treatment, forced labor, internationally condemned forms of child labor, gross human rights violations, or war crimes
- Refusing to tolerate direct or indirect minerals-related support of non-state armed groups, such as through payment to parties illegally in control of mines or transport routes
- Discontinuing engagement with any suppliers identified with such abuses
- Requiring security forces to comply with human rights principles and implementing risk management policies regarding upstream suppliers' use of security forces
- Refusing to give or demand any bribes, disguise origins of minerals, or misrepresent taxes or royalties
- Supporting efforts to eliminate money laundering
- Ensuring all taxes, fees, and royalties are paid to governments and disclosed in accordance with Extractive Industries Transparency Initiative requirements (described below).[75]

The guidance is a government-supported standard that lays out practical recommendations for companies and is attached to a Recommendation of the OECD Council, an international legal instrument. The guidance itself otherwise lacks binding enforcement. However, various national and supranational legislation and regulatory frameworks reference the guidance. A number of standards promoted by industry initiatives operationalize it.

Other international supply chain standards and initiatives, such as the Responsible Minerals Assurance process, the Extractive Industries Transparency Initiative, the Cobalt Industry Responsible Assessment Framework and underlying legal requirements create a network of overlapping and complementary frameworks. These are described in detail in the following section. Together, these standards, initiatives, and regulations present a broad, diverse, and encouraging picture of supply chain sustainability. Individually and collectively, they offer a range of means for managing the human rights, governance and environmental risks facing the industry, as well as battery reuse and recycling. However, while they are collectively sufficient to promote good sustainability practice, their breadth and diversity also creates a significant coordination challenge in tracking adherence, comparing performance, and exchanging information across multiple initiatives.

A SUSTAINABLE ELECTRIC VEHICLE BATTERY SUPPLY CHAIN: KEY CHALLENGES AND RESPONSES

To develop recommendations for policymakers and industry leaders to better coordinate responses to the wide range of sustainability risks facing the EV battery supply chain, CLEE and NRGI convened expert stakeholders from across the battery ecosystem. These stakeholders included representatives of mining companies and battery and auto makers; nongovernmental organizations and advocacy groups; and some of the existing standards and initiatives described above. Their combined expertise represents a significant cross-section of the battery supply chain, from mineral extraction and component production to vehicle manufacture and third-party oversight to battery reuse and recycling, marshaling a thorough understanding of how supply chain players can and should assess and improve sustainability practices.

CLEE and NRGI began the convening by asking these stakeholders to identify the top barriers preventing supply chain players, governments and civil society from improving sustainability practices.

The experts' discussion, therefore, focused on challenges limiting the efficacy and application of current efforts. The difficulties revolved around three issues: a lack of coordination among supply chain actors (inhibiting information flows and the creation of a level playing field); inadequate coordination across existing standards (inhibiting broad compliance and user-friendliness); and barriers to battery reuse and recycling (inhibiting key strategies to develop a sustainable, circular supply chain). Stakeholders then proposed a set of responses to these individual challenges, recognizing that they represent only a subset of the challenges facing supply chain actors, and focusing on actionable measures that could achieve near-term results.

The diverse group of perspectives meant there was not complete consensus. This report summarizes the top recommendations the experts developed for policymakers and industry leaders, supplemented by additional research and outreach to experts.

Challenge 1: A lack of coordinated action, accountability, and access to information across the supply chain hinders sustainability efforts.

Key Takeaway

A lack of coordinated action, accountability, and access to information across the supply chain is an important root cause of supply chain mis-governance. Addressing this requires stronger mechanisms to improve data transparency and promote neutral and reliable information-sharing, to level the playing field between actors across the supply chain and between governments and companies.

Participants in the meeting cited the lack of a shared understanding of the roles, responsibilities and opportunities of actors across the supply chain as one of the most important root causes of mis-governance that perpetuates the risks of conflict and supply chain disruption discussed above. Stakeholders at every link of the chain have distinct goals and assumptions about what the battery industry or its constituent parts can offer and the most important steps to reach its potential. This divergence can exacerbate tensions among companies, governments and communities; create information gaps that corrupt actors fill with misleading and self-serving misinformation; dash efforts to formalize artisanal mining, which could reduce risks to laborers; and impede trusted and effective enforcement of regulations.

The priorities of different players across the supply chain diverge in meaningful ways. Within producing countries, citizens, local businesses and local governments in host communities tend to prioritize the creation of jobs, opportunities for private companies and protection from environmental harm and abusive labor practices. National governments (including ministries and state-owned enterprises) might prioritize foreign direct investment, generation of fiscal revenues through mineral taxation and opportunities to boost national industry and companies via processing or other value-addition activities.[76]

Among private-sector actors, mining companies prioritize efficient and stable operations, good relationships with communities and a fair and stable tax system that enables them to manage risk and capture a sufficient share of profits associated with their activities. Cell and battery manufacturers prioritize a stable and predictable flow of raw materials, efficient systems for transporting and processing materials, and good relationships with suppliers upstream from them on the supply chain and the purchasers further downstream. Vehicle manufacturers prioritize stability in production of inputs, cost control, efficient technological processes and consumer opinion. Industry attention to battery reuse and recycling needs is still in an early phase.

While these goals intersect in many ways (and all of these actors have an interest in a stable and conflict-free supply chain), the overlap in priorities among the different actors is less than complete and sometimes can move in opposite directions.

Participants in the meeting, as well as the broader group of experts and stakeholders consulted by CLEE and NRGI, indicated that a lack of common understanding of one another's perspectives and of the underlying market and political dynamics results in misplaced expectations, poor communication and accountability failures. The lack of credible information-sharing mechanisms between governments and companies along various stages of the supply chain is also a significant problem. For example, mining company officials indicated that "local content" rules set by mineral-producing governments sometimes included unrealistic targets that damaged the prospects of project viability without creating meaningful opportunities. Automobile manufacturer (also known as original equipment manufacturer, or OEM) representatives found that the expressed goals of many producer-country stakeholders to "move up the supply chain" or otherwise extract higher value from their mineral production did not adequately account for the thin profit margins in the EV market and risked derailing the industry. And resource governance specialists emphasized the significant confusion and frustration in producing countries among citizens who had been led to believe that they would see quick and direct results from the growth in the sector.

Adding to the long-term uncertainty, the supply chain is undergoing changes, particularly as companies that have traditionally been further down the chain are reportedly making efforts to source their minerals directly (including BMW and Tesla).[77] Other companies are taking equity stakes in ventures further up the supply chain than where they traditionally sit. Volkswagen, for example, recently became the largest single shareholder of the China-based battery maker Guoxuan High-Tech Co., and CATL purchased an 8.5 percent share of Australian lithium miner Pilbara Minerals.[78] This consolidation could create benefits by more directly linking decisions in the upstream parts of the supply chain to the pressures and priorities of the consumer-facing brands, thereby strengthening the market pressures for sustainability in mining. On the other hand, a more geographically consolidated supply chain, placing everything from battery manufacturing to recycling closer to EV consumers, could potentially leave less investment in the long term for lower-income, resource-rich countries. For their part, activists who are focused on community rights and environmental protection said companies further down the supply chain have failed to adequately account for fundamental problems of weak regulation and corruption. These factors impede the impact of any on-paper effort to generate economic benefits.

Among the private-sector players on the chain, there was a view that there is a disjuncture in accountability between players at different links on the chain. Consumer pressure has been brought to bear most directly on OEMs, whose representatives felt their ability to pressure suppliers to insist upon good governance and traceability is limited. At the same time, suppliers may feel limited in their ability to take on potentially costly sustainability measures without explicit direction from downstream buyers. Representatives of several international initiatives and nongovernmental organizations active on these issues indicated that they believed downstream companies could be more influential and have greater impact on on-the-ground

behavior in mining countries if they exerted more coordinated pressure on their suppliers on a range of issues, including how to combat corruption.[79]

Some participants cited the divergence in approaches of Western- and Asia-based companies as an important issue of emphasis. For example, some participants from Western-based companies indicated a frustration that companies at the beginning and end of the supply chain are subject to intense consumer and financial pressure, while they perceived little such pressure on the Asia-based companies that dominate the middle of the supply chain. These participants indicated that they feel this divergence represents a fundamental limitation of efforts to promote good governance and generate leverage on actors within resource-rich countries.

Others noted that China-based companies might be willing to participate in global initiatives to clean up the supply chain where consumers or the downstream market demand it. But they may be leery of having to join too many efforts simultaneously or to take on responsibility for broader governance matters. Exacerbating the divide, participants cited inefficiencies and a lack of coordination between two initiatives that may be competing to provide the dominant standard for due diligence: the Responsible Minerals Initiative (dominated by Western companies) and the Responsible Cobalt Initiative (dominated by Eastern companies).

For years, many mining companies have participated in various initiatives designed to promote transparency and good governance. Several industry-led efforts to promote best practice on issues such as environmental safety and strong relationships with host communities are ongoing.[80]

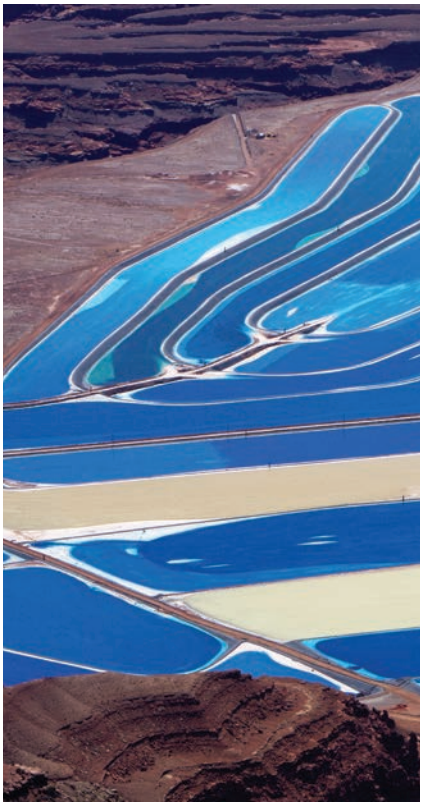
Response: Thoroughly document and disseminate a complete picture of what the supply chain actually constitutes and create stronger mechanisms for neutral and reliable information sharing.

The meeting underscored the importance of developing reliable systems for sharing information among players at different stages of the chain. As a starting point, broadly disseminating a clear picture of the entire supply chain (including the steps from mine to vehicle, the players and their value drivers, and geographic and financial flows) in a way that is digestible to various stakeholders would inform decision-making at all levels.[81]

More broadly, participants cited the potential value of efforts to share and disseminate market information on demand scenarios, costs and technological evolutions across value chain participants. Such efforts at information sharing would reduce information asymmetries, clear up common misconceptions and enable stakeholders to negotiate and develop policy/negotiation approaches from a position of shared (or at least mutually-intelligible) assumptions.

This knowledge could help states to make smarter choices about where to direct value-addition efforts and regulatory authority in a maximally effective and also realistic way. In short, governments will need to identify what steps are feasible and which are not. Because of the divergent priorities of different actors, it may be difficult for information issued by one party on its own to garner trust from other stakeholders. This disconnect suggests a role for third parties, research institutions and multi-stakeholder collaboratives to play as “translators” of market information that can be trusted.

Beyond the dissemination of market analysis, similar potential exists in the dissemination of information and analysis of governance risks at different stages of the supply chain, in a neutral way that can be trusted by all actors. Companies indicated that they often find themselves in a position of having to respond to questions about nuanced governance challenges going on in places where they have little direct information or connection.



Response: Proactively communicate the full picture of the EV battery supply chain, not just react to specific stories based on negative incidents.

Some of the company participants in the meeting expressed concern that the public focus on battery supply chains has overwhelmingly focused on negative incidents and risks. The companies have an opportunity to help shift the narrative by strategically communicating the positive potential of the EV industry, both in terms of the reduction of global emissions and the potential to support development in mineral-producing countries.

For example, Albemarle has made significant commitments to improving environmental performance and community participation in connection with lithium operations in Chile. These efforts could serve as examples for sharing with the broader public. For their part, activists cited the need for governments and companies to publicly engage around questions of the long-term economic relationships between the industry and the host countries and how companies are working with communities and mitigating risk. Activists explained that building more stable relationships over the long term is about more than just public relations, and that tackling challenges head-on to deliver long-term benefits to producing countries must be a core component of stakeholders' approach and messaging.

The common thread between these points of view is the importance of a more proactive approach to communication. One of the longstanding challenges associated with the mineral industry has been opacity and inconsistent communication strategies. As the EV market continues to evolve, industry leaders and advocates have an opportunity to avoid this trap with a more proactive approach to communication and information dissemination.

Response: Leverage automakers' experience and capacity in traceability and sustainability.

EV supply chain governance to date has placed the overwhelming share of the burden for managing relationships with host-country stakeholders on miners, traders and refiners. Most of the global standards in the sector explicitly or implicitly place primary responsibility for responsible business practices with these upstream actors. The principal requirements are to "know their suppliers," avoid procuring from the worst offenders, and develop strong policies and practices to manage risks.[82]

To cite one prominent example, the OECD Guidance (particularly the detailed Supplement on Tin, Tantalum and Tungsten, which the OECD has cited as an important reference for cobalt) provides recommendations broken down by where a company sits on the supply chain. Principal responsibility lies with the upstream companies for managing relationships with miners and governments; creating information on original mineral sources; respecting host country rules on tax, governance and accountability; refraining from corrupt practices; addressing community grievances; setting up environmental management practices; and other direct impacts on mineral-producing communities and countries.

The guidance for companies further downstream focuses on gathering and tracking information on the actions of upstream suppliers; identifying risks; weeding out suppliers who fail to meet certain thresholds; helping suppliers raise their capacities; and reporting to the public.

None of the participants questioned the appropriateness of this basic division of responsibilities, in line with the idea that each party on the supply chain has limited influence. Some participants argued that automakers could potentially do more to use their existing toolkits to play a more proactive role in the due diligence process (though not all participants shared this view, noting that supply chain bottlenecks at the refiner/smelter level may limit automaker influence). These companies have deep experience in managing complex supply chains, and participants speculated that they could do more to apply existing supply chain traceability and management tools to impact sustainability in upstream stages of the mineral production and refining processes. This diligence would serve the companies' interests because corporate actors bear

responsibility to consumers. This could also enable companies to play a more active role in the management of their own supply risks.

One opportunity to put these tools into practice may come from the emerging practice of automakers to "cut out the middleman" by signing direct sourcing agreements with mines, as BMW and Tesla have recently been reported to be doing (as previously mentioned).[83] These efforts have the potential to implicate OEMs more directly in processes occurring within mineral-producing countries. As such, they create a more direct set of responsibilities for these companies to support good governance (or at a minimum, avoid harm) and the opportunity for them to bring their tools to bear in mining operations.

The discussion at the convening did not go into detail on ways in which this more proactive OEM role to influence the upstream end of the supply chain might evolve, and a more detailed discussion would be a valuable future step. The following are possible modes of action that could warrant further exploration:

- More concerted pressure by downstream companies to push for deep changes in policy or practice by their supplier mining companies, such as taking a direct public stance against supplier corruption or developing stronger internal anticorruption procedures.[84]
- Deeper engagement by downstream companies in EITI or other initiatives with direct influence on standards of governance in producer countries.
- Downstream companies' taking more direct stakes in mining ventures or direct offtake agreements with mining projects in order to have more ability to influence the venture's approach to government and community relations, taxation and procurement (recognizing the potential limits of automakers' ability to enter this market more directly due to incumbent resistance and the lack of in-house expertise to manage this complex sector).

Key Takeaway

A number of standards and initiatives aim to promote supply chain sustainability. Coordination and data-sharing across multiple supply chain standards is weak, which can hinder adherence. Stronger systems to help supply chain actors prioritize and coordinate across these standards, along with a stronger set of incentives for rigorous application, would promote more consistent application.

Challenge 2: Inadequate coordination and data-sharing across multiple supply chain standards limit adherence.

A robust set of existing international standards and initiatives are providing models for integrating due diligence, transparency and sustainability focused requirements into mineral supply chain management. Compliance with these efforts can substantially improve upstream and downstream entities' performance with regard to human rights, environmental, labor, governance and other factors. To the extent that multiple such standards are capable of enhancing supply chain sustainability, systematic application of standards throughout the EV battery supply chain could yield significant benefits for electric vehicle manufacturers, local mining communities and host governments. In addition to the OECD Guidance described in the prior section, these standards and initiatives include (but are not limited to):

The **Responsible Minerals Initiative's Responsible Minerals Assurance Process**, which involves company-level agreements to undertake voluntary third-party audits of smelter/refiner supply chain management systems and sourcing practices.[85] The audits are designed to meet OECD Guidance standards, Dodd-Frank requirements and EU Regulation 2017/821 requirements (described below).

The **Initiative for Responsible Mining Assurance's Standard for Responsible Mining**, a multi-mineral, voluntary compliance standard focused on a comprehensive set of issues including human rights due diligence, revenue and payments transparency, environmental impact assessment and management, community support and benefits, and fair labor standards, with independent third-party assessment.[86]

The **Cobalt Institute's Cobalt Industry Responsible Assessment Framework**, a cobalt-specific framework focusing on management of environmental, human rights, labor/occupational and community benefits issues.[87]

The **London Metal Exchange's Responsible Sourcing Requirements**, which will require all brands listed on the exchange (the world's largest commodity futures market for many key metals) to implement transparency-based and substantive supply chain requirements based on the OECD Guidance and international environmental, safety and conflict area standards.[88]

The **Extractive Industries Transparency Initiative**, an initiative with over 50 participating nations based on compliance with a standard covering national-level disclosure on payments by mineral companies to governments; contracts between mineral companies and host governments; transfers by and to state-owned enterprises; the beneficial ownership of companies active in the sector; allocation of revenues; and social and economic outcomes. EITI is not exclusively a supply-chain initiative. It is, however, the leading standard for global mining transparency, with relevance to governance in member countries including DRC and Argentina. Implementation takes place through multi-stakeholder groups of government, industry and civil society members, both within implementing countries and at the global board. The EITI board assesses participating nations' implementation against the standard's requirements.[89]

The **China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters' Chinese Due Diligence Guidelines for Responsible Minerals Supply Chains**, which seeks to provide "guidance and support to companies" around risks of conflict, "serious human rights abuses" and "serious misconduct."[90]

The **Voluntary Principles on Security and Human Rights**, which involve assessment and management of risks relating to human rights abuses by public and private security forces employed by companies at extraction sites.[91]

The **Global Battery Alliance**, a World Economic Forum initiative seeking to establish a public-private platform for a sustainable battery supply chain, including the creation of a "circular" supply chain through comprehensive recycling practices, in support of emission reduction and economic development goals.[92]

These initiatives interact and correspond with a number of national and international legal standards and regulations governing the behavior of supply-chain players, including (but not limited to):

U.S. Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 Section 1502 (Dodd-Frank § 1502), which requires all companies listed on U.S. exchanges to a) disclose whether any tungsten, tantalum, tin (known as the 3T minerals) or gold necessary to their supply chains originate in DRC or neighboring countries, and b) if so, submit to the Securities and Exchange Commission annual reports describing supply chain due diligence efforts including certified third-party audits.[93] The requirements do not technically apply to cobalt, copper, nickel or other key EV battery minerals, but the reporting framework nonetheless informs many international supply chain due diligence efforts.

EU Conflict Minerals Regulation, which creates EU-wide supply chain due diligence requirements for 3T minerals and gold, based on the standards of the OECD Guidance.[94]

DRC Mining Ministry Circular of September 2011, which requires all entities involved in the mining and trading 3T minerals and gold to implement their due diligence in accordance with the recommendations of the OECD Guidance for Responsible Mineral Supply Chains.

French Devoir de Vigilance, which requires French companies to adopt supply chain due diligence policies focused on human rights-related risks at supplier companies.[95]

U.S. Foreign Corrupt Practices Act (FCPA), which bars companies listed on U.S. exchanges and their personnel from bribing foreign government officials.[96] It has been replicated in many international jurisdictions.

French Sapin II Law, which aligns French anti-corruption law with the FCPA and the U.K. Bribery Act, including mandatory adoption of compliance programs and policies.[97]

U.S. Global Magnitsky Act, which allows the federal government to sanction identified human rights offenders, including seizure of assets.[98] It has been replicated in many international jurisdictions.
U.K. Bribery Act 2010, which imposes criminal penalties for a wide range of bribery offenses by U.K. citizens and companies, regardless of where they occurred or what other parties were involved, giving it wider application than the FCPA.[99]
Dutch Child Labor Due Diligence Act, which requires all companies selling goods to Dutch consumers (regardless of company origin) to conduct due diligence on child labor risks throughout their supply chains.[100]
U.K. Modern Slavery Act 2015, which requires U.K. businesses to audit and report on human trafficking throughout their supply chains.[101]

However, achieving comprehensive and systematic application has proven challenging. These standards have proliferated with overlapping requirements, variable application and enforcement mechanisms, different value-drivers and varying participants. Governments, industry actors and civil society entities have limited capacity to manage participation in multiple initiatives and might elect to adhere to one or more standards based on a wide range of needs. Substantive gaps in specific areas of focus can result. Increasing uptake will depend on streamlining, creating new incentives for adherence and developing standardized and accessible data to facilitate adherence to the standards.

Response: Define and categorize existing standards to develop essential criteria, facilitate comparison and equivalency, and streamline adherence.

Achieving comprehensive and systematic application will require, at a minimum, the development of a readily understood classification or taxonomy of the many standards' requirements and applications. This is necessary both to allow participants to readily define and compare commitments across the supply chain, and to allow observers to review individual supply chain players' participation and commitments to determine where substantive gaps exist. (See Figure 2 for an example of a potential classification matrix.) Convening participants agreed that while there is no need to create new supply chain standards—existing standards are sufficiently numerous and substantively robust, though some gaps may persist—any standard or standards supporting universal adherence would need to satisfy at least four key criteria:

- **Widely accepted.** Parties across the EV battery ecosystem (government, industry and civil society in producing and consuming regions) and the supply chain (extractors, refiners, battery makers, and vehicle manufacturers) accept the standard's legitimacy and substantive requirements.
- **Multi-stakeholder.** The standard includes participation mechanisms applicable to all relevant parties.
- **Independently verified.** The standard includes independent third-party verification of participant adherence.
- **Transparent.** The standard's requirements are defined and set based on generally agreed upon criteria, and the implementing entity makes key information and adherence results publicly available.

The OECD Guidance, for example, has achieved wide acceptance, with recognition in SEC regulation under Dodd-Frank § 1502, EU Regulation 2017/821 and independent frameworks such as the LME Responsible Sourcing Requirements and the RMAP audit requirements, among other international examples.[102] It was developed from a multi-stakeholder process including government, industry and civil society representatives, and contains adherence frameworks for both upstream and downstream supply chain entities.[103] Adherence relies heavily on both independent third-party audits of due diligence efforts and public disclosure of findings, including a participant information portal to facilitate implementation.[104] Other standards, such as EITI, offer similar levels of stakeholder acceptance, verification and transparency. Further refining and defining these key elements could offer a valuable lens for assessing (and/or certifying) individual standards as part of a universal adherence regime, allowing supply chain actors to base participation on agreed minimum criteria.

Beyond these general characteristics, classifying existing standards by their substantive components is necessary for supply chain actors to effectively craft comprehensive participation and for observers to effectively track global risk management efforts. Developing a taxonomy of standards could concretize their substantive requirements, illuminate links and overlap between initiatives and facilitate a common data-based approach to demonstrating adherence. Perhaps more importantly, the taxonomy could identify what entities and levels of the supply chain are responsible for different types of adherence and where key gaps exist. The purpose of such a taxonomy would not be to evaluate or rate individual standards or initiatives, but to facilitate assessment of supply chain players' performance—which substantive issues, minerals and regions they are tracking, the depth of their efforts and the entities they are reporting to.

This substantive taxonomy would address questions including:

- **Content.** What sustainability risks or issues does the standard/initiative cover?
- **Participants.** What types of entities participate?
- **Implementation.** What does the standard/initiative require of participants?
- **Application.** What stages of the supply chain are covered?
- **Scope.** What minerals and geographies are covered?
- **Enforcement.** What are the consequences for non-adherence, if any?
- **Sponsor.** What type of body is responsible for organizing the standard/initiative?
- **Links.** What other standards or regulations does the standard/initiative rely on or incorporate?

Classifying initiatives along these measures would allow supply chain actors and outside groups to determine what participation or compliance constitutes; what commitments peer entities have made; and where individual entities, governments, or entire sectors may be failing to support supply chain sustainability targets. This could in turn accelerate the development of incentives to drive compliance and data protocols to facilitate it, as well as comparison of supply chain players' sustainability performance.

Figure 2 on the following page provides a simple example of what the core of such a classification system could look like. Users could employ such a tool in order to track the coverage of the various standards they are implementing or to follow and compare supply chain actors' performance.

FIGURE 2: EV BATTERY SUPPLY CHAIN STANDARDS TAXONOMY

The questions below outline the categories of substantive coverage, application, and enforcement satisfied by a given standard or initiative. By filling in the relevant boxes on the following page, observers could assess the coverage of individual standards or initiatives; and by comparing the standard(s) and/or initiative(s) in which a supply chain player participates, observers could assess their performance and identify gaps to address.

Content: What sustainability risks or issues does the standard/initiative seek to address?

- Human rights (i.e., democratic rights, indigenous rights, displacement)
- Violent conflict
- Labor rights (i.e., wages and bargaining power)
- Transparency and corruption
- Local economic benefits
- Local environmental impact (i.e., air quality, water quality, toxic pollutants, and site reclamation)
- Climate change impact (i.e., GHG emissions of operations and supply chain)
- Reuse and recycling of battery materials

Participants: What types of entities participate or are covered?

- Industry (i.e., mining, minerals refining/processing, midstream cell/pack manufacturers, or downstream manufacturers/OEM)
- Government (i.e., federal/national or state/local level)
- Civil society (i.e., national and international NGOs/organizations and local affected communities)
- Investors and financiers (i.e., equity or debt)

Implementation: What does the standard/initiative require of participants?

- Supply chain diligence policy adoption
- Comprehensive supply chain/corporate management policy or code of conduct adoption
- Internal risk reporting
- Third party risk reporting
- Public risk reporting
- Best practices training/partnership formation
- Active disengagement from bad actors
- Complaint/grievance mechanism (implemented by industry)
- Enhanced oversight (implemented by governments)
- Sanctions (implemented by governments)

Application: What stages of the supply chain are covered?

- Mining
- Trading
- Refining and processing
- Cathode manufacturing
- Cell manufacturing
- Battery assembly
- Vehicle manufacturing
- Battery recycling

(Note: Standards and initiatives may apply to more than one stage distinct from the participant's own stage, i.e., a vehicle manufacturer may be required to report on sustainability of its upstream suppliers.)

Scope: What minerals, extraction methods (i.e., artisanal or industrial), and geographies are covered?

Enforcement: What are the consequences for non-compliance, if any?

- Legal/regulatory sanction
- Loss of certification/membership
- Grading/rating system downgrade
- Reputational (consumer, investor, marketplace, or government)

Sponsor: What type of body is responsible for organizing the standard/initiative?

- State/government (direct)
- State/government (international organization)
- Industry/trade association
- Civil society/NGO
- Public-private partnership

Links: What other standards/initiatives/regulations is it linked to?

- Directly incorporates or is incorporated by
- Partially references or is referenced by

SAMPLE EV BATTERY SUPPLY CHAIN STANDARDS TAXONOMY MATRIX

STANDARD NAME: _____

CONTENT			
Human Rights	Violent Conflict	Labor Rights	Transparency & Corruption
Local Economy	Local Environment	Climate Change	Reuse & Recycling

PARTICIPANTS				
Government	Industry		Civil Society	Investors
Federal / National	Mining	Midstream	National	Equity
Local / State	Refining / Processing	Downstream	International	Debt
			Local Community	

IMPLEMENTATION								
Government			Industry / Investors + Finance			Civil Society		
Diligence Policy	Corporate Management	Training / Partnership	Diligence Policy	Corporate Management	Training / Partnership	Diligence Policy	Corporate Management	Training / Partnership
Internal Reporting	3P Reporting	Public Reporting	Internal Reporting	3P Reporting	Public Reporting	Internal Reporting	3P Reporting	Public Reporting
Active Disengagement	Sanctions	Oversight	Active Disengagement	Compliance / Grievance		Active Disengagement		

APPLICATION			
Mining	Trading	Refining	Cathode Manufacturing
Cell Manufacturing	Battery Assembly	Vehicle Manufacturing	Battery Recycling

SCOPE
Universal
Limited Minerals / Geography

ENFORCEMENT			
Consumer Reputation	Investor Reputation	Market Reputation	Government Reputation
Legal Sanctions	Decertification	Downgrade	

SPONSOR		
State Government	International Organization	Trade Association
Civil Society	Public Private Partnership	

LINKS
Incorporates:
Incorporated By:
References:
Referenced By:

Response: Create new incentives for compliance with agreed standards.

While the lack of clear and comparable information on existing standards may have hindered supply chain sustainability efforts to date, a lack of strong incentives for compliance presents a more formidable barrier. The standards have received widespread recognition from governments and key industry players. But only financial, operational, or reputational incentives (currently limited in the existing environment) can drive deeper compliance with the requirements that government, industry and civil society members identify as sufficient to manage the EV battery supply chain's sustainability needs.

These incentives could take a range of forms, and multiple types of incentives might ultimately be necessary to reach different supply chain actors and adherence needs. In particular, how an incentive exerts leverage (e.g., regulatory mandate or market-driven initiative) and where it exerts it (e.g., on downstream vehicle manufacturers or at all points of the supply chain) will determine its effectiveness.

A number of possible mechanisms stand out as worthy of further discussion:

Industry-standard certification of adherence and accompanying vehicle for disclosure

Supply chain actors—particularly downstream customer-facing companies—could take on a voluntary effort to create an industry-wide certification process for adherence with an agreed supply chain sustainability standard or set of standards. Industry members could help create an independent board or council with input and members from regulatory and advocacy sectors. The resulting body would be tasked with identifying an adherence scale and scoring or grading companies' efforts. Stakeholders consulted on this issue expressed varied opinions on what the content of such a certification standard could include, with some suggesting that the object of certification should be to confirm the conformity of company processes with global standards for due diligence. Others aspired to certifying that the mineral content of a particular battery is "clean." To avoid creating additional layers of bureaucracy, this board or council could evolve from an existing standard, initiative, or body.

The U.S. Green Building Council, which implements the Leadership in Energy and Environmental Design (LEED) building rating system, offers a compelling example. The over 7,000-stakeholder group offers four levels of certification ("certified" to "platinum") based on third-party verification of building design, construction, operations, and maintenance. Property developers and owners design buildings to achieve the certification and advertise their adherence level.

An EV supply chain certification could offer similar certification levels for automakers based on analysis of their adherence with the full network of applicable standards across environmental, human rights, labor and other factors. Automakers could display this certification as part of the vehicle sales package. While the LEED standard has faced some criticism that its approach does not reach across the entire construction industry, it has reached hundreds of thousands of structures and is widely accepted and understood both within and outside industry. The Global Battery Alliance's "battery passport," a developing effort to label all batteries' key sourcing information, could contribute to such a certification by digitally conveying applicable environmental, social, governance and battery identity information. Certification could also potentially encompass access to key data necessary for different stakeholders to create economic value, in particular battery chemistry data necessary for reuse and recycling.

Industry leaders could support the score- or certification-based system by tasking the above-mentioned entity with establishing consistent, comparable, and reliable supply chain sustainability disclosure recommendations. Many of the core elements of such a recommendation could be drawn from existing initiatives. Firmly establishing the scope and depth of acceptable disclosure could set a standard for investors, lenders, and customers to employ in comparing industry competitors. In addition, it would improve the quality and quantity

of data available to inform government and civil society efforts to improve industry practices. The Task Force on Climate-Related Financial Disclosures (TCFD), a financial industry-led initiative designed to improve access to climate risk data and enhance decision-making and risk management throughout the industry, is one successful example of such an effort. While the initiative is still young, it has grown to cover firms with assets over USD 100 trillion and is driving material increases in disclosure levels, with the potential to incentivize actions that reduce the long-term costs of climate risks.[106] By similarly formalizing disclosure of sustainability risks, EV battery industry actors (working in engagement with public sector leaders) could promote further adherence to existing standards designed to manage those risks.

Investment- or trade-based mechanisms

Institutional investors and major lending institutions could also take a leadership role in driving adherence by proactively divesting from or refusing to lend to supply chain actors that fail to meet an agreed standard or set of standards. They might also support efforts by actors to improve their practices. Project financiers could also assess individual projects against agreed minimum standards.

Major supply chain actors rely heavily on access to international capital markets and many are publicly traded. As a result, any limitation in the financial entities they can work with could materially harm business. Lenders and investors have recently exerted this type of pressure, including major pension funds' divestment from Brazilian mining assets following a deadly mine collapse, leading asset managers' divestment from fossil fuel companies, and certain insurers' refusal to cover thermal coal projects. Similar action in the EV battery market, measured against adherence to agreed standards, could have a dramatic and positive impact.

Global bilateral funders such as the World Bank could potentially take the lead by placing supply chain sustainability conditions on loans they issue. Accounting standards for sustainability in battery supply chain operations, which could build upon existing on existing mineral-sector sustainability standards such as those established by the Sustainability Accounting Standards Board, could facilitate this type of investment-based action.[107]

In addition to action by investors, trading platforms and exchanges with market influence at various stages of the supply chain could bolster adherence to standards by including them as requirements for participation. The most prominent example of this model to date is the effort by the London Metals Exchange to require companies to comply with its Responsible Sourcing Requirements in order to be able to access the exchange.[108]

Internal industry mechanism

Automakers and battery manufacturers could institute internal risk management mechanisms that match or exceed what the standards like the OECD Guidance require, setting supply chain sustainability-related key performance indicators for managers throughout the business. Assessing the performance of individual managers, not just companywide performance, against the substantive and procedural actions required by leading supply chain standards could enhance accountability and solidify adherence throughout an organization's structure.

Regulatory mandate

Beyond industry-led options, governments and regulators also hold the authority to mandate adherence to a particular standard or choice of standards. Codifying the terms of a standard could present challenges in the future, should that standard evolve. However, such codification—particularly if undertaken at a multi-lateral level—offers the surest method for enforcing adherence (via potential penalties or sanctions) and necessarily involves public action through the government. The European New Car Assessment Program (NCAP), a car safety assessment and certification program, is an example of a government certification effort that

began as a third-party nonprofit, representing a possible pathway for existing standards to become co-opted and enforced as law.

Consumer relations

In combination with the mechanisms above, industry leaders could initiate a consumer relations campaign to advertise the newly created adherence regime and their leadership within it. This campaign would raise public awareness of new initiatives and combat potential misinformation from the oil and gas sector, potentially influencing consumer preferences toward EVs. Leading automakers could integrate a well-advertised adherence certification into their broader vehicle advertising programs.

The design of any of the above-mentioned incentives should be shared among multi-stakeholder actors across the supply chain, in order to maximize completeness and accessibility regardless of organization type and capacity. But participants suggested that leading companies at the downstream end of the supply chain could take special responsibility for the consumer-facing elements of these efforts, such as developing the core proposed content for an adherence certification system. These companies have the most experience assessing and shaping public EV demand and the greatest direct interest in publicly demonstrating the benefits of EV uptake. As a result, they may be most able to craft sustainability measures that appeal to consumers' needs.

This approach could potentially offer the quickest path to begin advancing supply chain sustainability public outreach efforts. In the long run, increasing public awareness of how EV manufacturers are addressing a broader range of sustainability risks could eventually spread to the entire market.

At the same time, there may be a direct relationship between flexibility of adherence and effectiveness of incentives. Standards and incentives that allow for varied engagement (i.e., measuring success against not only the substantive requirements, but also a participating entity's financial and organizational capacity to meet them) might be inherently more inclusive and drive uptake more effectively than those based on all-or-nothing adherence. (However, any varied engagement regime would need to become stricter over time to support real sustainability improvements.) Creating appropriately scaled levels of achievement or recognition to account for the differences in capacity across supply chain segments and geographical regions could present the greatest likelihood of universal adherence.

In addition, participants described a strong eagerness to more closely connect efforts related to supply chain due diligence and resource governance/accountability, while guarding against the risk of "initiative fatigue." Several participants were enthusiastic about more closely linking efforts to promote better in-country resource governance and transparency with supply chain efforts. In particular, participants acknowledged the need to flesh out the approaches of these standards to the evolving global transparency movement. Several of these standards make vague references to transparency and governance without well-defined content or approaches. Participants expressed strong consensus that there is not a need for new initiatives on supply-chain governance—the key is to better link the existing standards.

Response: Develop data and data-sharing protocols to facilitate adherence.

Any effort to achieve more systematic adherence with supply chain sustainability standards will rely on the ready availability of comprehensive and comparable data on key sustainability criteria. Availability, in turn, will rely on two distinct developments: compilation of verified, granular data at each level of the supply chain and agreement on protocols for sharing the data throughout the supply chain.

For example, cobalt refiners could require artisanal traders to develop a uniform practice for tracking and disclosing the rates they pay the miners from whom they buy. This practice could inform knowledge of sustainable labor practice compliance throughout the supply chain, similar to EITI-required disclosure of tax and royalty payments. Aggregating such data across the supply chain—from certified original provenance of minerals to water use at salar lithium mines to royalty rates paid under government concession agreements—would in turn promote universal adherence. But doing so across multiple substantive indicators at multiple supply chain levels will require a significant increase in coordinated action and secure disclosure opportunities.

Convening participants agreed that much detailed supply chain sustainability data—on labor conditions and payments, government contracts and concession agreements, taxes and royalties, environmental indicators, and more—already exists and is compiled for proprietary use by supply chain actors. Industry trade secret protections and inconsistent data collection and disclosure formats, however, can inhibit sharing with third parties.

Developing an independent and secure data-sharing platform could promote disclosure while protecting companies' interests in proprietary information. One example of such a platform is the Information Sharing and Analysis Center (ISAC) model, which uses public-private partnerships to foster information sharing in critical infrastructure sectors.[109] Industries including aviation, financial services, and oil and gas have created ISACs to share information, primarily focused on risk and threat assessment, which is not amenable to public disclosure without consensus protocols (such as, for example, anonymizing data prior to sharing with industry members and requiring consent before disclosing data to regulators).[110] This type of industry-led organization could bring together actors throughout the battery supply chain, or separately at each level of the supply chain, to compile data sets for private and public use without risk of unintended disclosure. Several efforts are afoot to try to enhance mechanisms for assembling and sharing standardized data sets, such as the Consolidated Autonomous Due Diligence Framework developed by BetterChain.[111]

Key Takeaway

Regulatory and logistical barriers impede progress on battery life extension, reuse and recycling, all of which can reduce demand for mining. Priority responses include designing batteries proactively for disassembly for recycling and reuse, building regional infrastructure for battery recycling and transportation, and creating regulatory certainty for recycling.

Challenge 3: Regulatory and logistical barriers inhibit battery recycling and reuse.

Unlike petroleum fuel and internal combustion engines, electric vehicle batteries can be modified or repaired for extended life, repurposed for use in a "second life" application (assuming that the batteries removed from the vehicles still have adequate capacity), or recycled to harvest their raw materials for reuse in a new battery. The advantage of reuse is that the batteries can continue to have economically productive functions while potentially offering consumers an inexpensive product. Extending battery life through reuse, as well as optimizing the recovery of battery materials through recycling, could help reduce overall battery costs as well. Reuse also means less demand for new batteries, while recycling similarly reduces the need for harvesting raw minerals from around the world. The recycling operation can also be centralized or co-located with production, to minimize the need for international or long-distance transport of raw materials.

However, challenges abound. Most prominently, many laws and regulations, from hazardous waste shipment rules (particularly transboundary regulations) to liability standards, might prevent repurposing or recycling facilities from being economically viable. Some of these rules were intended to prevent the mismanagement of shipped materials and dumping waste in developing countries. The rules may not effectively distinguish between new types of transactions designed to increase value, such as shipments for refurbishment or deployment as second use batteries for energy storage, versus for disposal. In addition, the processes may require multiple thousands of batteries from all over the country and world to be removed and shipped to facilities, requiring a major logistical challenge and investment. And participants noted that while battery industry leaders anticipate a robust recycling supply chain in the

future, relatively few dismantlers and recyclers currently operate in the marketplace—creating another potential bottleneck. Yet success at repurposing and recycling batteries could mean greatly diminished need for an expansive supply chain footprint, reducing the environmental and human rights concerns and pressures from these new processes.

Response: Manufacturers can design batteries proactively for recycling and reuse disassembly.

Currently, each battery producer and automaker creates batteries according to their particular recipe for form, materials, and chemistry. For example, two of the more prominent electric vehicles sold in the U.S., the Chevrolet Bolt and Tesla Model 3, utilize different battery pack construction, design, and cooling methods, along with distinct cell chemistries: the Bolt features pouch-type cells from LG Chem, while the Model 3 has cylindrical cells from Panasonic.[112] While some recyclers can handle a mix of chemistries, this lack of standardization among vehicles makes it challenging for some industry actors to design facilities to repurpose or recycle batteries, as each battery type could require a different recycling process. Policy makers and industry leaders could convene to explore options for manufacturing batteries that can be more easily disassembled for reuse or recycling. Ultimately, an ideal approach to battery design would enable standardized disassembly to extract individual battery modules from the larger battery pack to be re-combined or recycled.

Response: Manufacturers and government can develop systems to make battery data available at all stages of the battery life cycle.

The lack of standardized and available data about battery performance and health could make it more challenging for the industry to repurpose and recycle these batteries. Industry leaders will need to know at what point a battery should be removed from the vehicle, given ongoing degradation, and where these batteries are located for coordinating shipping to a centralized facility. The Global Battery Alliance "Battery Passport" proposal could potentially encourage action on coordinating data and logistics, given its focus on repurposing and recycling batteries. Alliance leaders envision the passport concept to be a "quality seal" on a global digital platform—it will share value chain data for various batteries, pursuant to 10 key principles for supply chain sustainability endorsed by 42 global organizations.[113] The passport could include provisions requiring transparent and accessible data on battery health to facilitate a recycling and repurposing market.

Response: Government and industry can partner to build regional infrastructure for battery recycling and transportation

Repurposing and recycling batteries will require a significant deployment of logistical operations, from battery removal from the vehicle and shipping to centralized facilities to conduct the work. Government and universities can assist by hosting pre-competitive convenings, in which industry competitors collaborate through discussions that avoid anti-trust concerns and allow them to share early stages of research on this issue to avoid redundant investment in the future. Government and universities can also host discussions with industry leaders to help identify priority, geographically distributed sites near customers for gathering used electric vehicle batteries and potentially repairing and redeploying or repurposing some of them, as well as for readying batteries to be shipped to nearby recycling facilities. These sites could also serve as nodes to collect and recycle other lithium-based batteries, such as from personal electronics, stationary storage, or other second-use applications.

Similarly, government can work collaboratively with industry to identify priority sites for constructing recycling centers, address local stakeholder concerns with respect to local environmental impacts, and promote recycling technologies that avoid or mitigate those impacts. The public sector can assist with faster permitting (typically requiring the involvement

of state and local decision-makers) for the technologies with the least impact or in the high-priority, "least-conflict" (i.e., least chance of political opposition or litigation) areas, potentially convening stakeholders to help identify these areas in advance. As a potential model, CLEE convened stakeholders and solar photovoltaic industry leaders to identify least-conflict land in California's San Joaquin Valley for potential streamlined permitting and other incentives. The action resulted in legislative and regulatory efforts to minimize environmental review for conforming projects and direct transmission line investments in these areas.[114] Third-party entities, such as universities or nonprofits, could convene EV battery stakeholders for similar discussions with stakeholders to streamline and optimize siting.

Response: Government can create regulatory certainty for recycling (without stifling innovation).

Recycling batteries could provide significant benefits for the environment. Industry will need opportunities to experiment with pilot projects for recycling, along with certainty regarding potential regulatory barriers to recycling, such as hazardous waste management and transportation rules that may impede battery shipping to these facilities.[115] Government and industry can explore permitting and other regulatory barriers to implementing this work and develop stakeholder-based solutions. In addition, participants noted that recycling processes right now are governed on a state-by-state basis in the United States and could benefit from a uniform national standard, potentially issued by the U.S. Environmental Protection Agency under existing authority of the Resource Conservation and Recovery Act (RCRA), for states to adopt or meet on their own. These standards could also include centralized agency permitting instead of the current diffuse number of agencies (possibly as many as 23 in the US, according to one participant) involved.

Response: Government and manufacturers can use incentives and community and social engagement to drive consumer behavior toward recycling.

Companies that recycle and repurpose electric vehicle batteries could potentially benefit from a decentralized network of consumers who are encouraged to participate. Drivers all over the United States and the world will need to have easy access to information and opportunities for removing batteries from vehicles and replacing them with newer batteries, or for recycling/repurposing the batteries along with the vehicles. Government and industry leaders will need to educate customers, dealers and others around this network on opportunities and options for recycling. That educative process could involve targeted outreach to customers, dealers and others to develop a workable process for initiating recycling, including basic logistics on how consumers can deliver used batteries and obtain replacements; how dealers or other recyclers can safely ship used units to the nearest facility; how local environmental, health and safety regulators can track shipments and facilities; and what incentives (such as changes in existing regulations regarding transport of hazardous waste and product liability that may inadvertently hinder recycling) and third-party assistance are available to ensure completion. As a potential point of comparison, advocates and policymakers could examine the lead acid battery recycling program, which features "cradle-to-grave" rules and point-of-sale incentives. In particular, states like California with vehicle or storage incentive programs may wish to provide an added incentive for the use or recycled minerals, including lithium, to support a more sustainable and lower-cost supply chain. Finally, government regulations can help create a market for recycled EV battery products by developing recycling targets or mandates, giving industry and consumers greater financial incentive to participate.

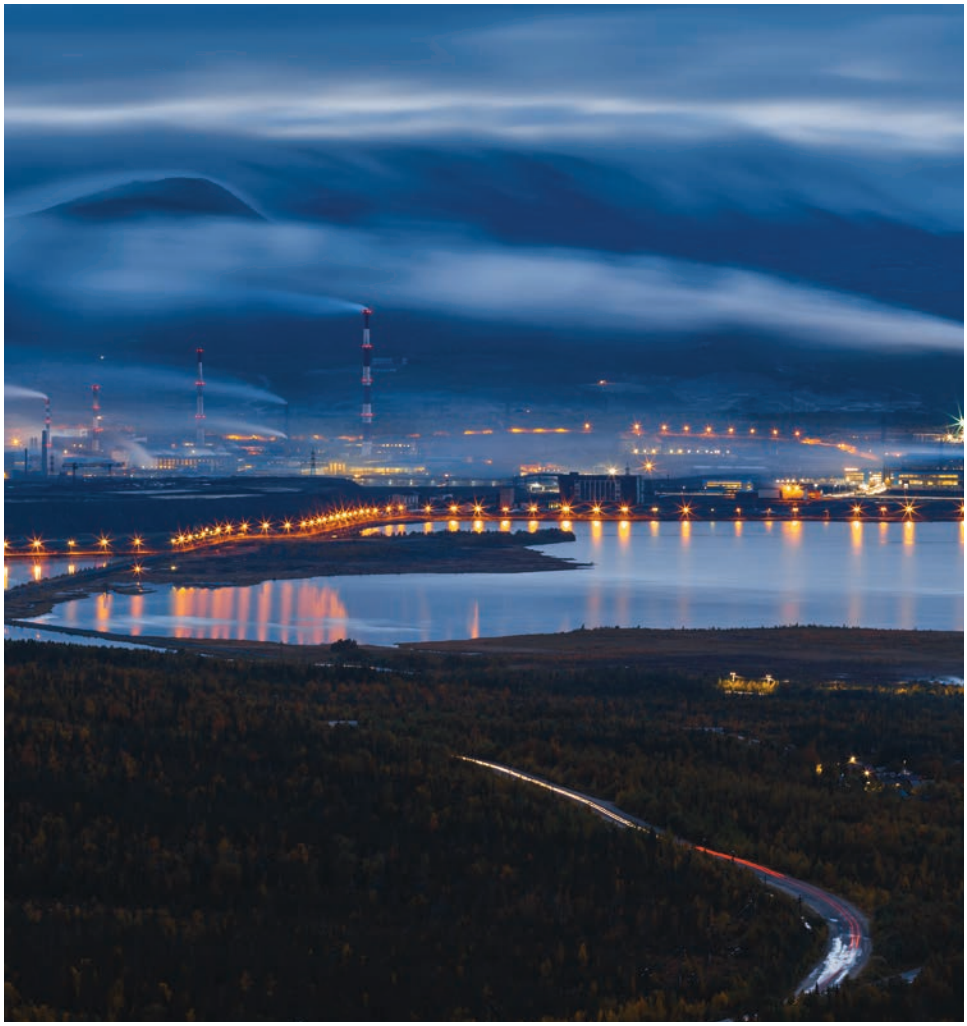
CONCLUSION

Ensuring a sustainable EV battery supply chain—one that benefits mineral-producing countries, consumers, and industry alike—will require long-term, coordinated action by stakeholders across the globe. These steps, in turn, will depend on information sharing, industry investment and policy alignment, among other factors.

Because so many of the sustainability concerns related to local environmental impacts and human rights involve country-level actions, much of the progress on sustainability will require improving and supporting governance reforms in mineral-producing countries.

In-country leaders will need the tools to enact meaningful reforms that benefit local populations, while global stakeholders will require an understanding of how they can most effectively support these steps.

The responses to the supply chain challenges outlined in this report seek to provide guidance on the initial actions stakeholders can take to make this broader vision of implementation a reality, ensuring a more robust future for communities around the globe as well as for all-important electric vehicle adoption to meet climate change goals.



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