BUILDING A SUSTAINABLE ELECTRIC VEHICLE BATTERY SUPPLY CHAIN: FREQUENTLY ASKED QUESTIONS

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BerkeleyLaw
UNIVERSITY OF CALIFORNIA
Center for Law, Energy & the Environment

AUTHORS

Ethan N. Elkind

Director, Climate Program, Center for Law, Energy & the Environment

Patrick R. P. Heller

Advisor, Natural Resource Governance Institute

Senior Visiting Fellow, Center for Law, Energy & the Environment

Ted Lamm

Climate Law & Policy Fellow, Center for Law, Energy & the Environment

CONTACT

Center for Law, Energy & the Environment (CLEE)

UC Berkeley School of Law

390 Simon Hall

Berkeley, CA 94720

clee.berkeley.edu

Natural Resource Governance Institute (NRGI)

80 Broad Street, Suite 1801

New York, NY 10004

resourcegovernance.org

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ABOUT CLEE

The Center for Law, Energy & the Environment (CLEE) channels the expertise and creativity of the Berkeley Law community into pragmatic policy solutions to environmental and energy challenges. We work with government, business, and the nonprofit sector to help solve urgent problems that require innovative and often interdisciplinary approaches. Drawing on the combined expertise of faculty, staff, and students across UC Berkeley, we strive to translate empirical findings into smart public policy solutions that better our environmental and energy governance systems.

ABOUT NRGI

The Natural Resource Governance Institute (NRGI) helps people to realize the benefits of their countries' endowments of oil, gas and minerals. We do this through technical advice, advocacy, applied research, policy analysis, and capacity development. We work with innovative agents of change within government ministries, civil society, the media, legislatures, the private sector, and international institutions to promote accountable and effective governance in the extractive industries.

INTRODUCTION

As governments and private actors across the world seek to reduce greenhouse gas emissions from transportation (which exceed 15 percent of global emissions and over 40 percent of California emissions[1]), they are predominantly turning to battery electric vehicles (EVs) as a solution. When fueled by an increasingly renewable electrical grid, EVs offer the potential to significantly reduce carbon emissions compared to internal combustion engine vehicles.

A global transition from fossil fuel-powered vehicles to EVs will require the production of hundreds of millions of EV batteries, along with concerted efforts across policy, financing, and technological development to support demand.[2] Such a massive deployment raises concerns about the availability of the minerals needed for these batteries, such as cobalt, lithium, and nickel, and the potential impact of new demand for these minerals on the lives of people in the mineral-producing countries. If managed effectively and in the public interest, the growth in these minerals can boost national development in several developing and emerging economies. But realizing this potential comes with challenges, and mismanaged mineral supply chains can exacerbate local environmental and governance difficulties, while potentially undermining the EV market via supply shocks and consumer shifts away from EV brands.

In response, regulators and civil society organizations have launched efforts to increase the sustainability and transparency of the EV battery supply chain. Stakeholders across industry and government are seeking greater certainty around these efforts and what they can do to support them.

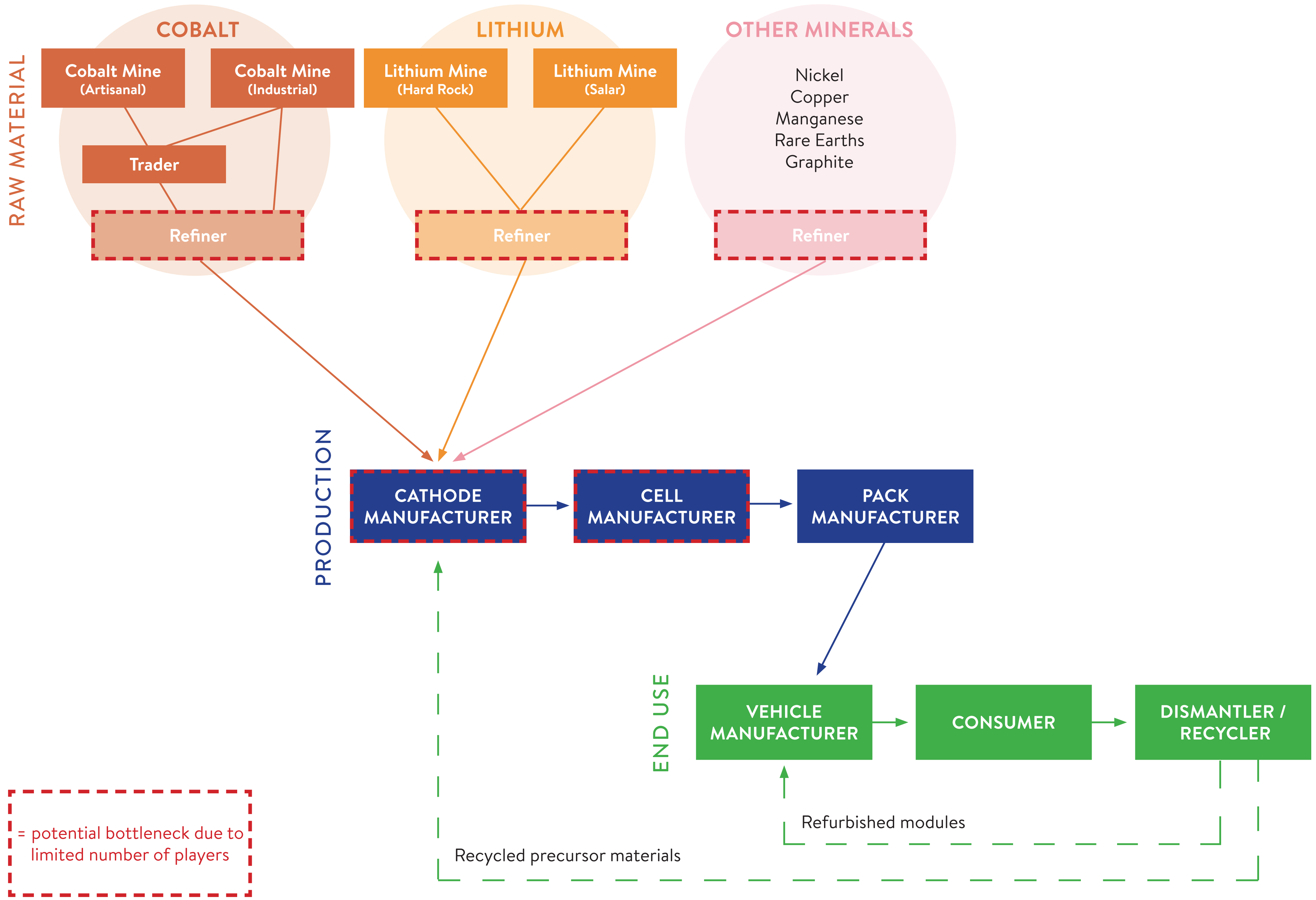
To address these questions, UC Berkeley School of Law's Center for Law, Energy & the Environment (CLEE) and the Natural Resource Governance Institute (NRGI) are collaborating on a stakeholder-led research initiative focusing on the key barriers to, and top opportunities for, achieving greater sustainability in the EV battery supply chain.

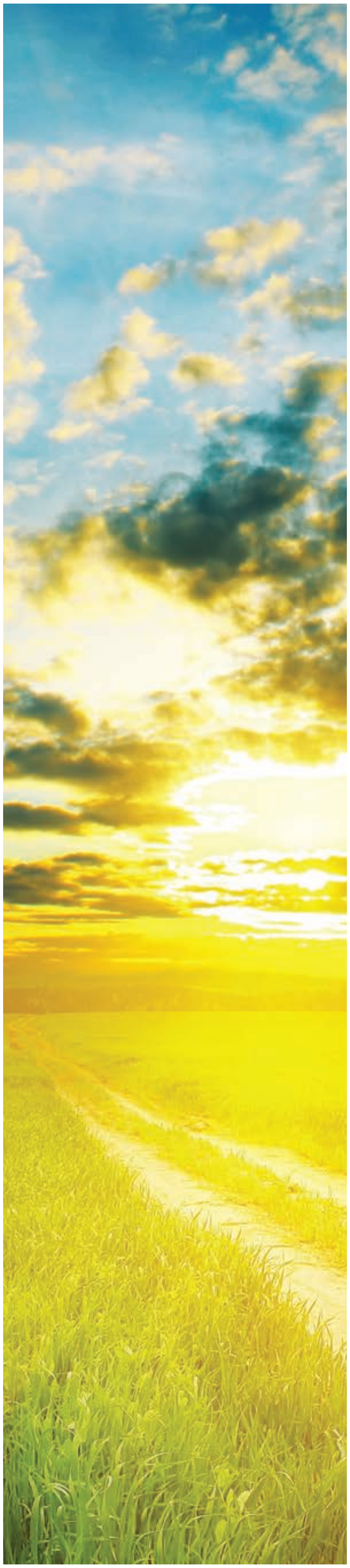
CLEE and NRGI now offer this brief to educate decision makers and the general public about the basic informational building blocks needed to understand sustainability in the context of the EV battery supply chain. Specifically, this brief addresses the following questions (focusing in some cases on cobalt and lithium as 'case study' examples to highlight key issues):

- What does the supply chain for EV batteries comprise?
- How do carbon emissions from EVs compare to traditional internal combustion engine (ICE) vehicles?
- What are the most significant challenges associated with managing the mineral extraction processes necessary for the EV supply chain, and what sustainability and human rights initiatives apply to these challenges?

Ultimately, this brief is a preview of a full report that CLEE and NRGI will produce to identify key barriers and actionable, high-priority solutions for industry actors and government leaders to ensure a sustainable EV battery supply chain. This brief is based on existing research resources and consultation with experts throughout the EV battery ecosystem, including automakers, battery manufacturers, mining leaders, and international human rights and sustainability organizations.[3]

WHAT DOES THE EV BATTERY SUPPLY CHAIN LOOK LIKE?





ARE EVs GREENER THAN GASOLINE VEHICLES?

Since EVs do not rely directly on combustion of fossil fuels to operate, they hold a significant greenhouse gas emission advantage over traditional internal combustion engine vehicles. EV production and use is not entirely free of greenhouse gas impacts: extracting and processing minerals for batteries, producing the batteries, and generating electricity to charge them require energy inputs (often derived from fossil fuel sources) which emit greenhouse gases.

Variations in fuel sources for electricity generation where EVs are charged and driven cause significant differences in greenhouse emissions, but studies have firmly established the overall emissions advantage of EVs. Overall, 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.[4] 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).[5] In the US, the average EV may achieve the emissions equivalent of approximately 88 miles per gallon while operating, which is far better than the average internal combustion engine vehicle (with significant state-by-state variation depending on electricity mix).[6] Overall, 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.

Differences in battery materials and production techniques, including the location and energy mix of production, also affect the emissions profiles of different EVs.[7] A battery produced in a jurisdiction using coal-fired electricity, for example, will have significantly higher emissions than one produced using cleaner power. The structure of the supply chain itself—how far battery materials are shipped from mines to refineries to manufacturing facilities—also adds to batteries' life-cycle emissions, just as it does for petroleum. In total, analyses of battery production (including the extraction of component minerals) suggest that emissions from manufacturing an EV battery are roughly equivalent to the emissions from manufacturing the rest of the vehicle. Some experts have suggested that these emissions represent approximately 5-15 percent of the total life-cycle emissions of an EV in many places, although these estimates can vary widely.[8]

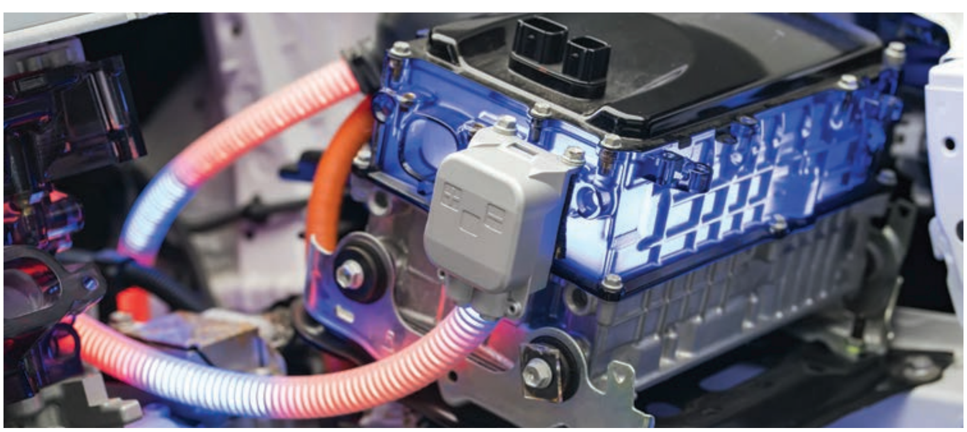
In addition, EV batteries' potential use in smart charging and vehicle-to-grid applications, and the potential for second-life energy storage applications of used batteries, could play a key role in deep decarbonization of the electrical grid by enabling greater integration of renewable energy sources.[9] 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.[10] 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.[11] In terms of other harmful air pollutants, EVs are responsible for a fraction of the harmful pollutants such as nitrogen oxide and particulate matter that ICE vehicles emit.[12]

ARE THERE ENOUGH MINERALS TO BUILD ALL THE BATTERIES THE WORLD NEEDS?

EV batteries require a number of mineral components to store and utilize electricity as fuel. Some of these 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.[13] Expert opinions differ on how likely a long-term shortage 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.[14] For example, the U.S. Geological Survey estimated global production of cobalt at 140,000 metric tons in 2018. This compares to global reserves (i.e. those that are economically feasible to extract) of 6.9 million metric tons and terrestrial resources (i.e. known and reasonable for future extraction) of 25 million tons.[15] Worldwide lithium reserves are estimated at 14 million metric tons, compared to 2018 production of 85,000 tons (and global resources of 62 million tons).[16] On the other hand, analysis published in the scientific journal Nature shows 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[17]. And the World Economic Forum has identified the potential for short-term supply crunches as the mining industry strives to keep pace.[18]

Furthermore, the process of converting mineral reserves in the ground to extracted minerals available for use in batteries involves complex legal, financial, and community factors. Developing a mine requires extensive capital investment, regulation and oversight, and a system for mitigating citizen concerns and managing stakeholder relationships in mining communities. Therefore, governance of mining and supply chains will have a major impact on the stability with which industry can bring in-ground resources to market.[19]

The pace of technological progress on materials recovery and recycling will also 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. 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.[21]



WHERE DO KEY BATTERY MINERAL INPUTS COME FROM?

COBALT: RESERVES BY COUNTRY, 2018

RANK	COUNTRY	RESERVES (TONNES)	GLOBAL SHARE
1	Dem. Rep. Congo	3,400,000	49%
2	Australia	1,200,000	17%
3	Cuba	500,000	7%
4	Philippines	280,000	4%
5	Zambia	270,000	4%
= 6	Canada	250,000	4%
= 6	Russia	250,000	4%
8	Madagascar	140,000	2%
9	China	80,000	1%
10	Brazil	73,500	1%

Data Source: US Geoglogical Survey Cobalt Mineral Commodity Summary 2020.

COBALT: PRODUCTION BY COUNTRY, 2018

RANK	COUNTRY	PRODUCTION (TONNES)	GLOBAL SHARE
1	Dem. Rep. Congo	94,445	68%
2	Australia	5,492	4%
3	Russia	5,334	4%
4	Philippines	4,600	3%
5	Canada	4,136	3%
6	Cuba	3,846	3%
7	Papua New Guinea	3,275	2%
8	Zambia	3,008	2%
9	Madagascar	2,850	2%
10	New Caledonia	2,404	2%

Data Source: S&P Metal and Mining Database*

COBALT: RESERVES BY COMPANY, 2018

RANK	COMPANY	RESERVES (TONNES)	GLOBAL SHARE
1	Glencore Plc	716,500	10%
2	Katanga Mining Limited	510,000	7%
3	China Molybdenum Co., Ltd.	468,800	7%
4	Gécamines SA	343,590	5%
5	Cubaniquel	341,000	5%
6	Vale S.A.	189,095	3%
7	Jinchuan Group Co., Ltd.	161,000	2%
8	Jinchuan Group International Resources Co. Ltd	146,630	2%
9	Metals X Limited	122,622	2%
10	Element ASA	80,340	1%

Data Source: S&P Metal and Mining Database; U.S. Geological Survey Cobalt Mineral Commodity Summary 2020.

COBALT: PRODUCTION BY COMPANY, 2018

RANK	COMPANY	PRODUCTION (TONNES)	GLOBAL SHARE
1	Glencore Plc	35,444	26%
2	China Molybdenum Co. Ltd.	10,498	8%
3	Gécamines SA	8,345	6%
4	Katanga Mining Ltd.	8,334	6%
5	Shalina Resources Ltd	6,650	5%
6	PJSC MMC Norilsk Nickel	5,694	4%
7	Vale S.A.	4,619	3%
8	BHR Newwood Invt Mgmt Ltd	4,499	3%
9	Jinchuan Grp Intl Rsrc Co. Ltd	3,758	3%
10	Nickel Asia Corp.	2,915	2%

Data Source: S&P Metal and Mining Database*

COBALT: RESERVES BY PROJECT, 2018

RANK	PROJECT	LEAD COMPANY	COUNTRY	RESERVES (TONNES)	GLOBAL SHARE
1	Kamoto	Katanga Mining Limited	Dem. Rep. Congo	680,000	10%
2	Mutanda	Glencore Plc	Dem. Rep. Congo	619,000	9%
3	Tenke Fungurume	China Molybdenum Co., Ltd.	Dem. Rep. Congo	586,000	8%
4	Punta Gorda	Cubaniquel	Cuba	341,000	5%
5	Cameroon East	-	Cameroon	177,000	3%
6	Musonoi	Jinchuan Group International Resources Co. Ltd	Dem. Rep. Congo	165,000	2%
7	Jinchuan	Jinchuan Group Co., Ltd.	China	161,000	2%
8	Goro	Vale S.A.	New Caledonia	140,100	2%
9	Clean TeQ Sunrise	Clean TeQ Holdings Limited	Australia	132,000	2%
10	Las Camariocas/Cupey	Government of Cuba	Cuba	123,000	2%

Data Source: S&P Metal and Mining Database; U.S. Geological Survey Cobalt Mineral Commodity Summary 2020.

COBALT: PRODUCTION BY PROJECT, 2018

RANK	PROJECT	LEAD COMPANY	COUNTRY	PRODUCTION (TONNES)	GLOBAL SHARE
1	Kamoto	Katanga Mining Limited	Dem. Rep. Congo	680,000	10%
2	Mutanda	Glencore Plc	Dem. Rep. Congo	619,000	9%
3	Tenke Fungurume	China Molybdenum Co., Ltd.	Dem. Rep. Congo	586,000	8%
4	Punta Gorda	Cubaniquel	Cuba	341,000	5%
5	Cameroon East	-	Cameroon	177,000	3%
6	Musonoi	Jinchuan Group International Resources Co. Ltd	Dem. Rep. Congo	165,000	2%
7	Jinchuan	Jinchuan Group Co., Ltd.	China	161,000	2%
8	Goro	Vale S.A.	New Caledonia	140,100	2%
9	Clean TeQ Sunrise	Clean TeQ Holdings Limited	Australia	132,000	2%
10	Las Camariocas/Cupey	Government of Cuba	Cuba	123,000	2%

Data Source: S&P Metal and Mining Database

*S&P Global Market Intelligence is a division of S&P Global. "Market Intelligence Metals & Mining" accessed through S&P Global portal, https://platform.marketintelligence.spglobal.com/.

LITHIUM: RESERVES BY COUNTRY, 2018

RANK	COUNTRY	RESERVES (ICE* TONNES)	GLOBAL SHARE
1	Chile	45,777,800	30%
2	Bolivia	39,000,000	26%
3	Australia	14,904,400	10%
4	Argentina	9,049,100	6%
5	China	5,323,000	3%
6	USA	3,353,490	2%
7	Canada	1,969,510	1%
8	Zimbabwe	1,224,290	1%
9	Brazil	505,685	0%
10	Portugal	319,380	0%

Data Source: US Geological Survey Lithium Mineral Commodity Summary 2020; S&P Metal and Mining Database.

LITHIUM: PRODUCTION BY COUNTRY, 2018

RANK	COUNTRY	PRODUCTION (ICE* TONNES)	GLOBAL SHARE
1	Australia	292	60%
2	Chile	97	20%
3	Argentina	37	8%
4	China	35	7%
5	Brazil	9	2%
6	Zimbabwe	6	1%
7	USA	6	1%
8	Namibia	3	1%
9	Portugal	1	0%
10	Canada	1	0%

Data Source: S&P Metal and Mining Database

LITHIUM: RESERVES BY COMPANY, 2018

RANK	COMPANY	RESERVES (ICE* TONNES)	GLOBAL SHARE
1	Corporacion Minera de Bolivia	39,000,000	34%
2	Lithium Americas Corp.	1,939,525	2%
3	Pilbara Minerals Limited	1,326,000	1%
4	Ganfeng Lithium Co., Ltd.	1,082,925	1%
5	Bacanora Lithium Plc	1,068,400	1%
6	Chengdu Tianqi Industry Group Co., Ltd.	878,220	1%
7	Mineral Resources Limited	712,000	1%
8	Liontown Resources Limited	603,600	1%
9	Galaxy Resources Limited	584,150	1%
10	Cadence Minerals Plc	547,200	0%

Data Source: US Geological Survey Lithium Mineral Commodity Summary 2020; S&P Metal and Mining Database.

LITHIUM: PRODUCTION BY COMPANY, 2018

RANK	COMPANY	PRODUCTION (ICE* TONNES)	GLOBAL SHARE
1	Albemarle Corp.	1531.91	20%
2	Mineral Resources Ltd.	1,483	19%
3	Chengdu Tianqi Industry Grp Co	876	11%
4	Sociedad Quimica y Minera	799	10%
5	Ganfeng Lithium Co. Ltd.	381	5%
6	Galaxy Resources Ltd.	354	5%
7	FMC Corp.	343	4%
8	Pilbara Minerals Ltd.	334	4%
9	Yichun Tantalum Co Ltd	179	2%
10	Qinghai Salt Lake Industry Co.	157	2%

Data Source: S&P Metal and Mining Database

LITHIUM: RESERVES BY PROJECT, 2018

RANK	PROJECT	LEAD COMPANY	COUNTRY	RESERVES (TONNES)	GLOBAL SHARE
1	Uyuni Salt Flat	Corporacion Minera de Bolivia	Bolivia	39,000,000	34%
2	Salar de Atacama	Sociedad Quimica y Minera de Chile S.A.	Chile	18,000,000	16%
3	Chaerhan Lake	Qinghai Salt Lake Industry Co.,Ltd	China	5,600,000	5%
4	Sonora	Bacanora Lithium Plc	Mexico	1,824,000	2%
5	Salar del Hombre Muerto	Livent Corporation	Argentina	1,800,000	2%
6	Wodgina	Albemarle Corporation	Australia	1,780,000	2%
7	Greenbushes	Chengdu Tianqi Industry Group Co., Ltd.	Australia	1,722,000	2%
8	Cauchari-Olaroz	Lithium Americas Corp.	Argentina	1,470,000	1%
9	Mt Holland - Lithium	Wesfarmers Limited	Australia	1,413,000	1%
10	Pilgangoora	Pilbara Minerals Limited	Australia	1,326,000	1%

Data Source: US Geological Survey Lithium Mineral Commodity Summary 2020; S&P Metal and Mining Database.

LITHIUM: PRODUCTION BY PROJECT, 2018

RANK	PROJECT	LEAD COMPANY	COUNTRY	RESERVES (TONNES)	GLOBAL SHARE
1	Greenbushes	Chengdu Tianqi Industry Grp Co, Albemarle Corp.	Australia	108,316	22%
2	Wodgina	Albemarle Corp., Mineral Resources Ltd.	Australia	69,499	14%
3	Mount Marion	Mineral Resources Ltd., Ganfeng Lithium Co. Ltd.	Australia	55,693	11%
4	Salar de Atacama	Sociedad Quimica y Minera	Chile	50,400	10%
5	Salar de Atacama	Albemarle Corp.	Chile	37,681	8%
6	Mt Cattlin	Galaxy Resources Ltd.	Australia	22,319	5%
7	Salar del Hombre Muerto	Livent Corp.	Argentina	21,597	4%
8	Pilgangoora	Pilbara Minerals Ltd.	Australia	21,044	4%
9	Salar de Olaroz	Orocobre Ltd., Toyota Tsusho Corp., Jujuy Energia y Mineria	Argentina	12,413	3%
10	Yichun	Yichun Tantalum Co Ltd	China	11,293	2%

Data Source: S&P Metal and Mining Database

*lce = lithium carbonate equivalent

HOW DOES EV BATTERY PRODUCTION IMPACT HUMAN RIGHTS, LOCAL GOVERNANCE, AND ECONOMIC DEVELOPMENT IN MINERAL-PRODUCING COUNTRIES?

The growth in demand for the mineral components of EV batteries has the potential to boost public revenues and economic development in countries that are home to these mineral resources, and governments in mineral-rich countries are assessing opportunities to take advantage of a potential boom. Mineral extraction has also been associated with human rights and governance challenges, however, and mining of EV battery materials is no exception. In recent years, mining operations around the world have been linked to human rights impacts such as long-term health risks and dangerous conditions for workers, child labor and underpayment, forced evictions, police detentions and armed conflict.[22] These problems do not permeate all mining projects, of course, and the global mining industry has taken steps in recent years to enhance its approach to health, safety, security and community relations.[23]

These acute human rights impacts link in many cases to a deeper set of governance challenges that have allowed corruption to persist and made it difficult for many citizens in resource-rich countries to access the economic opportunities associated with the mining sector. Many mineral-rich developing countries lack adequate policy frameworks, accountability processes, and government capacity to enforce strong protections for citizens and manage the sector in the public interest.[24]

Certain risks are particularly connected with mining for minerals used in EV batteries. Specifically, the heavy concentration of global cobalt reserves in the Democratic Republic of Congo (DRC, where more than half of global cobalt production originates) has dramatic impacts on the human rights risks associated with the battery supply chain due to significant governance challenges in the country. Unregulated artisanal cobalt mining (i.e., small-scale mining performed by groups of individuals using hand tools) in the DRC is linked to regular risk of injury and death due to mine collapses, lung disease from particle inhalation, and child labor concerns, with weak enforcement of health and safety standards or child labor rules.[25] International observers and NGOs have reported that state agents belonging to Congolese state entities have been involved in corrupt practices and failed to enforce child labor requirements, and they have linked public officials to rogue elements of security forces that control artisanal mine sites and trading centers.[26] However, a small number of more formal artisanal mine sites are making notable progress in improving conditions. Meanwhile, numerous NGOs and journalists covering industrial mining of cobalt have identified large-scale public corruption wherein public officials have steered financial benefits from the Congolese population into the hands of privileged elites. One type of scheme involves the granting of 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. This practice has sparked investigations of major mining companies from the U.S., Canadian and British governments.[27]

Concerns regarding the lithium sector are not as widely reported as for cobalt. Overall, the quality of mining sector governance varies widely among countries with large known lithium reserves. The 2017 Resource Governance Index, which measures transparency and accountability in public management of the sector, assessed several countries with reserves that rank among the world's largest. Among the findings, researchers concluded that Chile (second in global reserves) exhibited "good" overall performance, and Australia (third-largest) and Mexico (sixth-largest) exhibited "satisfactory" governance. However, in some cases indigenous residents of lithium mining areas have protested mining operations over inequality and lack of consent in siting operations.[28] Natural resource governance in Bolivia—which is not currently producing commercial lithium, but hosts some of the world's largest reserves and may be a significant future source—could pose significant challenges; the Resource Governance Index did not assess the Bolivian mining sector, but Bolivia has experienced significant political turmoil and analysts have raised concerns about the governance and viability of mineral projects in the country.[29]

The sustainability of the EV industry requires that industry actors, governments, researchers and civil society address the human rights and governance challenges associated with the extraction of battery minerals, while looking for win-win solutions that bolster global supply and promote development within the producer countries. This brief discusses below several initiatives that tackle these challenges. In considering the net impact of a transition from fossil fuels to electric vehicles, however, it is important to note that fossil fuel exploration and extraction has also been associated with some of the most severe problems of human rights abuse, conflict and corruption in the world.[30] The average scores on the Resource Governance Index for oil-producing countries (47 out of 100) and mineral-producing countries (48 out of 100) are virtually identical, signaling that mis-governance remains a challenge in both sectors. A recent Organization for Economic Co-operation and Development (OECD) survey of officials from state-owned enterprises identified mining as the industry with the second-highest incidence of corruption, with 50 percent of respondents saying they had observed corrupt acts. The sector with the highest incidence of corruption was oil and gas, at 63 percent.[31]

HOW DOES EV BATTERY PRODUCTION IMPACT THE LOCAL ENVIRONMENT IN PRODUCING REGIONS?

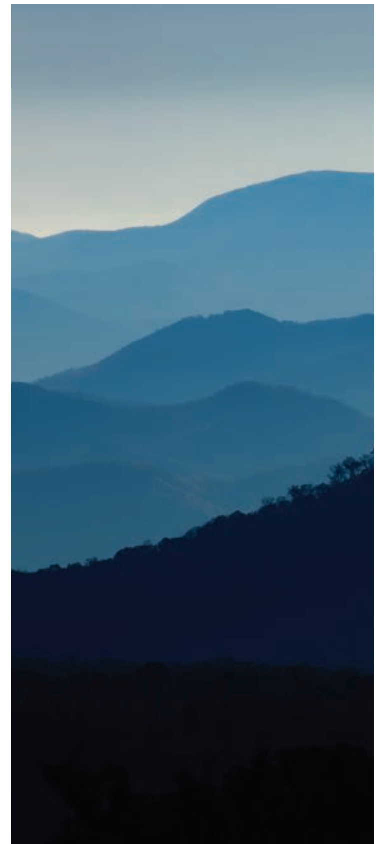
Local (i.e. non-greenhouse gas) environmental risks to air, water, and ecosystems are an unavoidable result of mineral extraction operations. Extraction of mineral resources used in industries from electronics and basic consumer items to jewelry and heavy industry has long impacted the health of local residents, disrupted natural environments, and used significant energy and water resources.[32] Both EV battery component minerals and fossil fuels are part of this story.

For example, salar-based lithium extraction, which takes place primarily in the "lithium triangle" (covering the Andean regions of Chile, Argentina, and Bolivia, which as noted earlier is not currently producing large quantities) uses and discharges significant quantities of water, which can negatively affect neighboring farms and communities by diminishing and polluting supplies.[33] Cobalt mining in Congo can cause water pollution, air quality impacts, and possible radioactive exposure, affecting both miners and surrounding communities.[34] Nickel mining operations around the world have been responsible for toxic air pollution and other harms.[35] At the same time, the mining industry has invested significant resources to address the environmental footprint of mining operations, and many mining companies work closely with public officials and communities to try to manage the local impacts of extraction.[36]

Oil and gas extraction, meanwhile, has triggered some of the most well-known environmental disasters in history. In the United States, events like the 1969 Santa Barbara oil spill, the 1989 Exxon Valdez spill, and the 2010 Deepwater Horizon explosion have had significant policy and social impacts. These offshore oil drilling- and transportation-related spills can destroy marine species and habitats and damage coastal economies. And even in areas with strong environmental regulations like California, onshore oil and gas production is associated with reduced air quality, groundwater contamination, habitat disruption, and human health risks including asthma and cancers.[37] (Onshore spill events are typically lower-profile and less disastrous than offshore events, but hundred thousand-gallon spills still occur with some regularity.)[38]

Given the wide range of mining techniques, host countries, and regulatory regimes applicable to the extraction of oil and hard minerals, analysts face challenges comparing the direct local environmental impacts. But as consumers and vehicle manufacturers shift toward more sustainable transportation options, identifying and addressing these impacts—through both regulation and voluntary action—will become increasingly important, regardless of vehicle type.

ARE COMPANIES AND GOVERNMENTS IN THE EV BATTERY MATERIALS SUPPLY CHAIN MANAGING SUSTAINABILITY RISKS?



As governments, companies, and civil society organizations increase their awareness of sustainability challenges throughout the minerals supply chain—including but not limited to the EV battery materials supply chain—they have begun to develop a number of initiatives and regulatory regimes to address key sustainability risks. These requirements overlap substantively in many cases, with measures relating to human rights and labor, corruption and payments to government, environmental harms, and more. However, they vary in the entities to which they pertain and that are responsible for application, as well as the minerals they cover and the mechanisms for compliance. The result is a patchwork of standards that creates a strong template for comprehensive supply chain management but may not invite straightforward compliance. Key standards and initiatives include, but are not limited to:

- The OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas;
- The Extractive Industries Transparency Initiative;
- The Voluntary Principles on Security and Human Rights;
- The Responsible Minerals Initiative's Responsible Minerals Assurance Process;
- The Initiative for Responsible Mining Assurance's Standard for Responsible Mining;
- The Cobalt Institute's Cobalt Industry Responsible Assessment Framework;
- The London Metal Exchange's Responsible Sourcing Requirements;
- The International Council on Mining and Metals' Mining Principles; and
- The World Economic Forum's Global Battery Alliance.

Key legal regimes and regulations include, but are not limited to:

- Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010;
- The EU Conflict Minerals Regulation;
- The DRC Mining Ministry Circular of September 2011;
- The French Devoir de Vigilance;
- The U.S. Foreign Corrupt Practices Act;
- The UK Bribery Act 2010;
- The French Sapin II Law;
- The U.S. Global Magnitsky Act;
- The UK Modern Slavery Act 2015;
- The Canadian Corruption of Foreign Public Officials Act of 1998; and
- The Dutch Child Labor Due Diligence Act.

A structured map or taxonomy defining and classifying these standards would offer actors throughout the supply chain a streamlined method to determine their most feasible pathway for comprehensive compliance.

CONCLUSION: EV BATTERY SUPPLY CHAIN SUSTAINABILITY CHALLENGES AND FURTHER NEEDS

As governments, businesses, and consumers move to increase adoption of EVs, questions around the sustainability of the supply chain will grow. The resources and information in this brief may help highlight key areas in need of industry and policy action to increase sustainability. They may also address some of the biggest challenges of supply chain management and answer some of the most common questions about EVs in relation to their fossil fuel-powered alternatives. CLEE and NRGI's research initiative will offer additional recommendations in a forthcoming report, building on the facts contained in this brief.

REFERENCES

1. See World Resources Institute, "World Greenhouse Gas Emissions: 2016," available at https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-2016; California Air Resources Board, California Greenhouse Gas Emissions for 2000-2017, available at https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2017/ghg_inventory_trends_00-17.pdf.

2. See World Economic Forum (WEF) and Global Battery Alliance (GBA), A Vision for a Sustainable Battery Value Chain in 2030 (September 2019), available at http://www3.weforum.org/docs/WEF_A_Vision_for_a_Sustainable_Battery_Value_Chain_in_2030_Report.pdf.

3. For a short description of the convening that served as one of the major inputs into this document, see Westenberg et al., "Electric Vehicle Supply Chain Presents Opportunities and Risks for Mineral Producers" (December 2019), available at https://resourcegovernance.org/blog/electric-vehicle-supply-chain-opportunities-risks-mineral-producers.

4. International Council on Clean Transportation (ICCT), "Effects of Battery Manufacturing on Electric Vehicle Life-Cycle Greenhouse Gas Emissions" (February 2018), available at https://theicct.org/sites/default/files/publications/EV-life-cycle-GHG_ICCT-Briefing_09022018_vF.pdf; Transport & Environment (T&E), "Life Cycle Analysis of the Climate Impact of Electric Vehicles" (October 2017), available at https://www.transportenvironment.org/sites/te/files/publications/TE%20-%20draft%20report%20v04.pdf; Union of Concerned Scientists (UCS), Cleaner Cars from Cradle to Grave (November 2015), available at https://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf.

5. WEF and GBA, A Vision for a Sustainable Battery Value Chain in 2030, p. 20.

6. UCS, "Are Electric Vehicles Really Better for the Climate? Yes. Here's Why." (February 11, 2020), available at https://blog.ucsusa.org/dave-reichmuth/are-electric-vehicles-really-better-for-the-climate-yes-heres-why.

7. Qiang Dai et al., "Life Cycle Analysis of Lithium-Ion Batteries for Automotive Applications," Batteries 2019, 5, 48, available at https://www.mdpi.com/2313-0105/5/2/48/htm; T&E, "Life Cycle Analysis of the Climate Impact of Electric Vehicles"; ICCT, "Effects of Battery Manufacturing on Electric Vehicle Life-Cycle Greenhouse Gas Emissions"; UCS, Cleaner Cars from Cradle to Grave.

8. Hanjiro Ambrose and Alissa Kendall, "Effects of battery chemistry and performance on the life cycle greenhouse gas intensity of electric mobility," Transportation Research Part D 47, 182-194 (2016), available at https://www.sciencedirect.com/science/article/pii/S1361920915300390; ICCT, "Effects of Battery Manufacturing on Electric Vehicle Life-Cycle Greenhouse Gas Emissions." The relative emissions footprint attributable to battery production varies depending on both the location of battery production (determining the battery-specific emissions "numerator") and the location of vehicle use (the life-cycle "denominator"). Thus, for an EV driven in an average US jurisdiction, the battery could represent 5-15 percent of life-cycle emissions, while for an EV driven in a country like Norway—with an extremely high level of carbon-free electricity—it could be closer to 50 percent, since emissions attributable to vehicle use would be far lower. In both cases, however, the life-cycle emissions of the EV appear to be lower than those of a comparable ICE vehicle.

9. See, e.g., Hanjiro Ambrose et al., "Driving rural energy access: a second-life application for electric-vehicle batteries," Environmental Research Letters 9, 094004 (2014), available at https://iopscience.iop.org/article/10.1088/1748-9326/9/9/094004/pdf.

10. WEF and GBA, A Vision for a Sustainable Battery Value Chain in 2030, pp. 27-28.

11. Id.; Auke Hoekstra, "The Underestimated Potential of Battery Electric Vehicles to Reduce Emissions," Joule 4, 1404 (June 2019), available at https://www.sciencedirect.com/science/article/pii/S2542435119302715.

12. See, e.g., S.L. Winkler et al., "Vehicle criteria pollutant (PM, NOx, CO, HCs) emissions: how low should we go?" npj Climate and Atmospheric Science 1, 26 (2018), available at https://www.nature.com/articles/s41612-018-0037-5.

13. See Indra Overland, "The geopolitics of renewable energy: Debunking four emerging myths," Energy Research & Social Science 49 (2019), 36-40, available at https://www.sciencedirect.com/science/article/pii/S2214629618308636; Benjamin K. Sovacool et al., "Sustainable minerals and metals for a low-carbon future," Science Vol. 367, Issue 6473 (Jan. 3 2020), 30-33, available at https://science.sciencemag.org/content/sci/367/6473/30.full.pdf.

14. T&E, "Electric vehicle life cycle analysis and raw material availability" (Oct. 2017), available at https://www.transportenvironment.org/sites/te/files/publications/2017_10_EV_LCA_briefing_final.pdf.

15. United States Geological Survey (USGS), Mineral Commodity Summaries 2019, pp. 50-51, available at https://www.usgs.gov/centers/nmic/mineral-commodity-summaries,

16. Id. at 98-99.

17. See Kostiantyn Turcheniuk et al., "Ten years left to redesign lithium-ion batteries," Nature (July 25, 2018), available at https://www.nature.com/articles/d41586-018-05752-3/.

18. WEF and GBA, A Vision for a Sustainable Battery Value Chain in 2030, p. 29; see Stella Soon, "As electric vehicle production ramps up worldwide, a supply crunch for battery materials is looming," CNBC (July 26, 2019), available at https://www.cnbc.com/2019/07/26/electric-car-production-rises-supply-crunch-for-battery-metals-looms.html.

19. Several international initiatives are being developed to target governance considerations and reduce potential supply bottlenecks that could impede the global energy transition. See, e.g., U.S. Department of State Bureau of Energy Resources, Energy Resource Governance Initiative, 2019, https://www.state.gov/wp-content/uploads/2019/06/Energy-Resource-Governance-Initiative-ERGI-Fact-Sheet.pdf.

20. See, e.g., Turcheniuk et al.

21. Benjamin K Sovacool et al.; T&E, "Electric vehicle life cycle analysis and raw material availability"; see Gavin Harper et al., "Recycling lithium-ion batteries from electric vehicles," Nature 575(7781), 75-86 (November 2019), available at https://www.nature.com/articles/s41586-019-1682-5.pdf; WEF and GBA, A Vision for a Sustainable Battery Value Chain in 2030, p. 30-31.

22. See, e.g., Amnesty International, Profits and Loss: Mining and Human Rights in Katanga, Democratic Republic of the Congo (2013), available at https://www.amnesty.org/download/Documents/12000/afr620012013en.pdf; Amnesty International, Mining in Guatemala: Rights at Risk (2014), available at https://www.amnesty.org/download/Documents/4000/amr340022014en.pdf; Human Rights Watch, "What...if Something Went Wrong?": Hazardous Child Labor in Small-Scale Gold Mining in the Philippines (2015), available at https://www.hrw.org/report/2015/09/29/what-if-something-went-wrong/hazardous-child-labor-small-scale-gold-mining; Human Rights Watch, "No Year without Deaths": A Decade of Deregulation Puts Georgian Miners at Risk (2019), available at https://www.hrw.org/report/2019/08/22/no-year-without-deaths/decade-deregulation-puts-georgian-miners-risk.

23. As examples of the mineral industry's evolving approach to human rights and other impacts, The International Council provides several guidance documents for mining companies: on such topics as Understanding Company-Community Relations, Voluntary Principles on Security and Human Rights: Implementation Guidance Tools, Good Practice Guide on Indigenous Peoples and Mining, and Demonstrating Value: A Guide to Responsible Sourcing. See https://guidance.miningwithprinciples.com/ for these and other documents.

24. For an overview of major governance challenges associated with extractive industries, see Natural Resource Governance Institute, Natural Resource Charter (2014), available at https://resourcegovernance.org/approach/natural-resource-charter.

25. See Amnesty International, This Is What We Die For (2016), pp. 22-24, available at https://www.amnesty.org/download/Documents/AFR6231832016ENGLISH.PDF.

26. Enough Project, Powering Down Corruption (October 2018), p. 19, available at https://enoughproject.org/wp-content/uploads/PoweringDownCorruption_Enough_Oct2018-web.pdf; Amnesty International, This Is What We Die For, pp. 34-35; Organization for Economic Co-operation and Development (OECD), Interconnected supply chains: a comprehensive look at due diligence challenges and opportunities sourcing cobalt and copper from the Democratic Republic of the Congo, available at https://mneguidelines.oecd.org/interconnected-supply-chains-a-comprehensive-look-at-due-diligence-challenges-and-opportunities-sourcing-cobalt-and-copper-from-the-drc.htm.

27. Resource Matters, See No Evil -- Poorly Managed Corruption Risks in the Cobalt Supply Chain (2019), available at https://resourcematters.org/see-evil-speak-evil-poorly-managed-corruption-risks-cobalt-supply-chain; Kadhim Shubber and Neil Hume, "Glencore under investigation by US commodities regulator," Financial Times (Apr. 25, 2019), available at https://www.ft.com/content/f73b3906-6781-11e9-9adc-98bf1d35a056; Julia Kollewe and Simon Goodley, "Serious Fraud Office investigates Glencore over suspected bribery," The Guardian (Dec. 5, 2019), available at https://www.theguardian.com/business/2019/dec/05/serious-fraud-office-investigates-glencore-over-suspected-bribery.

28. See, e.g., Eniko Horvath and Amanda Romero Medina, "Indigenous people's' livelihoods at risk in scramble for lithium, the new white gold," Ethical Corporation (April 9, 2019), available at http://www.ethicalcorp.com/indigenous-peoples-livelihoods-risk-scramble-lithium-new-white-gold.

29. See, e.g., Laura Millan Lombrana, "Bolivia's almost impossible lithium dream," Blomberg (December 3, 2019), available at https://www.bloomberg.com/news/features/2018-12-03/bolivia-s-almost-impossible-lithium-dream.

30. For a recent survey of some of the most severe governance challenges associated with oil extraction, see Alexandra Gillies, Crude Intentions: How Oil Corruption Contaminates the World (2020).

31. OECD, State-owned enterprises and corruption: What are the risks and what can be done? (2018), p 28, available at https://www.oecd-ilibrary.org/governance/state-owned-enterprises-and-corruption_9789264303058-en.

32. See. e.g., USGS, Environmental Considerations Related to Mining of Nonfuel Minerals (2017), available at https://pubs.usgs.gov/pp/1802/b/pp1802b.pdf; Earthworks and Oxfam America, Dirty Metals: Mining, Communities and the Environment (2004), available at https://earthworks.org/cms/assets/uploads/archive/files/publications/NDG_DirtyMetalsReport_HR.pdf.

33. See, e.g., Datu Buyung Agusdinata et al., "Socio-environmental impacts of lithium mineral extraction: towards a research agenda," Environmental Research Letters 13(2018), available at https://doi.org/10.1088/1748-9326/aae9b1; Amit Katwala, "The spiralling environmental cost of our lithium battery addiction," Wired (August 5, 2018), available at https://www.wired.co.uk/article/lithium-batteries-environment-impact.

34. See, e.g., Lena Mucha et al., "The hidden costs of cobalt mining," Washington Post (February 28, 2018), available at https://www.washingtonpost.com/news/in-sight/wp/2018/02/28/the-cost-of-cobalt/.

35. See Max Opray, "Nickel Mining: the hidden environmental cost of electric cars," The Guardian (August 24, 2017), available at https://www.theguardian.com/sustainable-business/2017/aug/24/nickel-mining-hidden-environmental-cost-electric-cars-batteries.

36. For examples of some initiatives that aim to promote innovative and responsible environmental management of mining projects, see the International Council on Mining & Metals' Water Stewardship Framework (2014), available at https://www.icmm.com/website/publications/pdfs/water/2014_water-stewardship-framework.pdf; Metals Environmental Risk Assessment Guidance (2016), available at https://www.icmm.com/website/publications/pdfs/chemicals-management/merag/merag-overview-2016.pdf; and Good Practice Guide for Mining and Biodiversity, available at https://guidance.miningwithprinciples.com/good-practice-guide-mining-biodiversity/. The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development provides guidance for governments seeking to enhance their procedures for mitigating environmental impacts of mineral projects, see, e.g., Guidance For Governments: Improving Frameworks for Environmental and Social Impact Assessment and Management – Consultation Draft (September 2019), available at https://www.iisd.org/sites/default/files/publications/igf-guidance-for-governments-esia-en.pdf.

37. See, e.g., California Council on Science and Technology (CCST), An Independent Scientific Assessment of Well Stimulation in California, Vol. II (July 2015), available at https://ccst.us/wp-content/uploads/160708-sb4-vol-II.pdf; Los Angeles County Department of Public Health (LACDPH), Public Health and Safety Risks of Oil and Gas Facilities in Los Angeles County (February 2018), available at http://publichealth.lacounty.gov/eh/docs/PH_OilGasFacilitiesPHSafetyRisks.pdf.

38. See, e.g., Los Angeles Times, "Chevron spills 800,000 gallons of oil and water in Kern County canyon" (July 12, 2019), available at https://www.latimes.com/local/lanow/la-me-california-oil-spill-20190712-story.html.

Natural Resource Governance Institute

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Center for Law, Energy & the Environment