

THE MINERALS CHALLENGE FOR RENEWABLE ENERGY

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SUMMARY

One potential obstacle to a successful energy transition involves the critical minerals used in production of photovoltaic solar panels, wind turbines, electric vehicles, and batteries. A substantial portion of these will have to come from new and expanded mining operations around the world. But mining is controversial, in part due to the past failures of operators to protect communities and the environment. This Article considers how nations can responsibly identify, source, and process these minerals, and then deploy them in renewable energy products. Its scope is global, but U.S. laws and policies take center stage with a nod to the broader global aspects involved. These policy issues include the emerging commitment of private companies to environmental, social, and governance standards, and the federal government's role in authorizing mining operations, especially on public lands.

The future of renewable energy, and our capacity to meet the ambitious goal set by the Paris Agreement¹ of limiting the increase in global average temperatures to 1.5o Celsius (C), depends, to a significant extent, on our ability to access certain critical minerals² that are needed to produce photovoltaic (PV) solar panels, wind turbines, electric vehicles (EVs), and batteries for both vehicles and energy storage. Sourcing these minerals will require

Author's Note: The author is grateful for the outstanding contributions to this Article made by research assistants Tristan Fromm and Garrett Leapley, and for the helpful comments received from the 2023 University of California, Los Angeles/Colorado Summer Symposium participants.

1. See United Nations Climate Change, *The Paris Agreement*, <https://unfccc.int/process-and-meetings/the-paris-agreement> (last visited Nov. 16, 2023).
2. The Energy Act of 2020, §7002(c)(4)(A), defined critical minerals as those that

- (i) are essential to the economic or national security of the United States;
- (ii) the supply chain of which is vulnerable to disruption (including restrictions associated with foreign political risk, abrupt demand growth, military conflict, violent unrest, anti-competitive or protectionist behaviors, and other risks through-out the supply chain); and
- (iii) serve an essential function in the manufacturing of a product (including energy technology-, defense-, currency-, agriculture-, consumer electronics-, and healthcare-related applications), the absence of which would have significant consequences for the economic or national security of the United States.

Section 7002(a)(3)(B) further states, however, that “[t]he term ‘critical mineral’ does not include—(i) fuel minerals; (ii) water, ice, or snow; (iii) common varieties of sand, gravel, stone, pumice, cinders, and clay.” The U.S. Geological Survey (USGS) has used this definition to identify specific minerals that should be included on the list. In rules promulgated in 2018, USGS listed 35 critical minerals. Final List of Critical Minerals 2018, 83

new and expanded mining operations, but recycling can and should play a prominent role in making some of these minerals more readily available. Recycling will likely prove less costly and more environmentally friendly, even as it minimizes the need for new mining.

Research and technology innovations also have a significant role to play in shifting the renewables industry away from scarce and problematic minerals, including cobalt and nickel. But we will not be able to avoid authorizing new mining operations, both here in the United States and in other countries around the world, even as we know that many of these mines will prove controversial and environmentally damaging.

With that in mind, this Article asks how mineral development, processing, and sourcing can be carried out in the

Fed. Reg. 23295 (May 18, 2018), available at <https://www.govinfo.gov/content/pkg/FR-2018-05-18/pdf/2018-10667.pdf>. The agency proposed a revised list in 2021 of 50 critical minerals, but the larger number largely resulted from splitting out some minerals that were previously placed in categories. 2021 Draft List of Critical Minerals, 86 Fed. Reg. 62199, 62200 (Nov. 9, 2021):

Much of the increase in the number of mineral commodities, from 35 commodities and groups on the final 2018 list to 50 commodities on the 2021 draft list, is the result of splitting the rare earth elements and platinum group elements into individual entries rather than including them as mineral groups.

The agency did make a few important changes to the list, including the addition of nickel and zinc, which are important minerals for certain types of renewable energy technologies. In any event, while the proposed USGS 2021 list goes well beyond the list of minerals that might be important for renewable energy development, it does include all or most of the minerals of concern for that industry. An important mineral left off the list that is critical for most renewable technologies, as well as for transmission infrastructure, is copper.

most responsible way. More specifically, it addresses three aspects of the minerals challenge for scaling renewable energy development. First, it identifies the key minerals that are or may be needed to deploy the most important renewable energy technologies, including PV solar, wind, and batteries. Second, it describes the challenges in gaining access to adequate supplies of these minerals while also protecting the environmental and social values that simultaneously drive the renewables push. Finally, it examines the role of government in meeting the minerals challenge, and considers how government can advance the transition to renewables while minimizing the impacts to the environment and society from the production and deployment of renewable technologies.

One of the challenges in writing about the minerals needed for renewable energy is to define an appropriate scope for this analysis. The discussion of the minerals needed, and the supply and demand issues regarding those minerals, is necessarily more global in nature. For practical reasons, however, the discussion of the legal issues is focused more clearly on U.S. domestic law, although examples from foreign countries are occasionally offered to suggest ideas for improving U.S. laws.

I. The Minerals Needed for Renewable Energy

Before assessing future demand for the minerals that will be needed to scale renewable energy deployment at levels necessary to meet the climate challenge, it is important to acknowledge that technological advancements are likely to alter both the type and quantity of minerals needed for particular energy systems. This is especially true for batteries used for both EVs and energy storage. For example, cobalt is a key element needed for many lithium-ion (Li-ion) batteries used today, but multiple, well-funded players are engaged in substantial research focused on reducing or eliminating cobalt in these batteries. These efforts have achieved some level of success and further advancements seem likely.³

Likewise, batteries used to store energy are likely to evolve in different ways to take advantage of the fact that they do not have the same need to minimize their size and weight. Metal-air batteries, especially iron-air and zinc-air batteries, show particular promise in providing substantial storage capacity with commonly available minerals, albeit at a size and weight that would not be practical for EVs. Proponents of iron-air batteries, for example, claim that this technology can deliver electricity for 100 hours at less than one-tenth the cost of Li-ion batteries.⁴

3. Magdalena Petrova, *Here's Why Battery Manufacturers Like Samsung and Panasonic and Car Makers Like Tesla Are Embracing Cobalt-Free Batteries*, CNBC (Nov. 17, 2021), <https://www.cnbc.com/2021/11/17/samsung-panasonic-and-tesla-embracing-cobalt-free-batteries.html>.

4. News Release, Form Energy, Inc., Form Energy Unveils Chemistry of Multi-Day Storage Battery Technology (July 22, 2021), <https://www.prnewswire.com/news-releases/form-energy-unveils-chemistry-of-multi-day-storage-battery-technology-301339075.html>.

So, even as I identify the minerals needed to fuel the renewable energy economy, I recognize the possibility and perhaps the likelihood that the technologies themselves will evolve in ways that will reduce, and perhaps substantially eliminate, the demand for minerals that are the most costly, the most difficult to source, and the most problematic from the perspective of the physical and social environment. Any effort to identify the minerals needed to support rapid renewable energy deployment must also recognize the high degree of uncertainty that accompanies their contemporary use. But even if the demand for problematic minerals decreases, it seems impossible to avoid the conclusion that renewable technologies will require additional mineral resources, and that some of those minerals may be difficult to source in the quantities that are necessary to meet the challenge of transitioning rapidly to a renewable energy economy.

With that in mind, the following section addresses current expectations regarding the mineral needs for three key clean energy platforms: (1) PV solar panels; (2) onshore and offshore wind turbines; and (3) EVs and batteries used for both EVs and energy storage.

A. The Minerals Needed for PV Solar

The dominant types of solar panels available today are monocrystalline and polycrystalline silicon. These currently comprise about 95% of the market.⁵ All PV solar panels are composed primarily of aluminum-framed glass. Other key minerals used to produce these panels are relatively abundant and include copper, silver, and silicon.⁶ New types of panels that rely more heavily on certain critical minerals are becoming more prevalent, including thin-film panels such as cadmium telluride (CdTe) and copper indium gallium selenide (CIS/CIGS).⁷ Advances in PV solar technology have led to a significant reduction in the use of silver and polysilicon, which are among the most expensive materials used to produce solar panels, and further reductions in the use of these materials for solar panels are expected.⁸ In addition, substantial research is ongoing to explore the prospect of substituting perovskite cells for silicon because they are cheaper to make, potentially more efficient for producing energy, and can be employed more flexibly to generate electricity.⁹

5. U.S. EPA, *End-of-Life Solar Panels: Regulations and Management*, <https://www.epa.gov/hw/end-life-solar-panels-regulations-and-management> (last updated Oct. 23, 2023).

6. See ELSA DOMINISH ET AL., INSTITUTE FOR SUSTAINABLE FUTURES, RESPONSIBLE MINERALS SOURCING FOR RENEWABLE ENERGY 11-13 (2019), https://earthworks.org/wp-content/uploads/2019/04/Responsible-minerals-sourcing-for-renewable-energy-MCEC_UTS_Earthworks-Report.pdf [hereinafter EARTHWORKS REPORT I]; see also INTERNATIONAL ENERGY AGENCY, THE ROLE OF CRITICAL MINERALS IN CLEAN ENERGY TRANSITIONS 6 (2021), <https://iea.blob.core.windows.net/assets/ffd2a83b-8c30-4e9d-980a-52b6d9a86fdc/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf> [hereinafter IEA REPORT].

7. Tellurium, from which tellurides are formed, and indium and gallium are all listed as crucial minerals. See IEA REPORT, *supra* note 6, at 60, 248.

8. See *id.* at 56.

9. Derek Wise, *Will Perovskite Give Silicone a Run for Its Money in Semiconductor Solar Cells?*, ELECTREK (Oct. 26, 2021), <https://electrek.co/2021/10/26/solution-processed-perovskite-semiconductors-could-allow-the-material-compete-with-silicon-in-solar-cells/>.

B. The Minerals Needed for Onshore and Offshore Wind

Most wind turbines employ a standard three-blade design on towers that range between 80 and 120 meters in height. The towers are composed primarily of steel, but a turbine requires significant quantities of copper, aluminum, concrete, and carbon to operate its various components.¹⁰ Approximately 20% of wind turbines—both onshore and offshore—use direct-drive permanent magnet generators (PMGs) that use the rare earth¹¹ elements neodymium and dysprosium. These direct-drive PMGs eliminate the need for a gearbox, thereby reducing the cost of maintenance. For offshore wind turbines where maintenance costs are highest, this feature is especially welcome.¹²

C. The Minerals Needed for Batteries and EVs

Of all the renewable energy technologies, batteries are likely to see the most dramatic changes in the coming decades. Thus, as previously discussed, predicting the demand for particular minerals used to produce batteries is fraught with uncertainty. At present, the renewable energy sector is focused on batteries for two distinct needs—vehicle transport and energy storage.

At the time of this writing, the batteries used for these two applications tend to be similar and even interchangeable. Over time, however, these technologies seem likely to diverge, primarily because the need for lightweight batteries, so critical for the transport sector, does not apply to battery storage. In addition to batteries, EVs themselves require minerals not present in conventional vehicles. All three applications—minerals for vehicle batteries, minerals for storage batteries, and minerals for EVs—are briefly considered below.

1. Minerals for EV Batteries

EV batteries have received the most attention and are rapidly evolving. The dominant EV battery in use today is the Li-ion battery, but the chemistry of batteries used in EVs seems likely to change, perhaps dramatically, over time. Ongoing EV battery research efforts aim to reduce costs,

extend the useful life of these batteries, minimize the use of problematic minerals, and address safety concerns.¹³

The chief components of a Li-ion battery are the anode, the cathode, and an electrolyte that facilitates the flow of ions from the negative, electron-releasing anode to the positive, electron-capturing cathode.¹⁴ The anode is typically made of graphite with a current collector made of copper foil. The cathode, which constitutes about 90% of the battery's material value, uses a variety of chemistries that include nickel manganese cobalt (NMC), lithium iron (ferro) phosphate (LFP), nickel cobalt aluminum (NCA), and lithium manganese oxide.¹⁵

NMC is the most popular Li-ion battery type for passenger vehicles, followed by NCA. Both of these batteries contain cobalt and nickel, which are problematic from a sourcing perspective. Around 70% of the world's cobalt comes from the Democratic Republic of the Congo (DRC), which tolerates child labor and other human rights and environmental abuses, most notably at artisanal and small-scale mines.¹⁶

Nickel is prized in EV batteries because it increases the density of batteries, thereby increasing the vehicle range.¹⁷ Nickel can also reduce or eliminate the need for cobalt, although to achieve similar energy densities, EV batteries may require more nickel.¹⁸ While nickel production is more widespread across the globe,¹⁹ the indiscriminate disposal of mine tailings at nickel mines has raised significant environmental concerns.²⁰ Indonesia, the largest nickel producer by far, banned the historic practice of disposing mine waste in the ocean, which threatened marine ecosystems, but land disposal in Indonesia, with its wet climate and potential for seismic activity, remains a serious challenge.²¹

Problems raised by the more popular battery chemistries have led to greater use of LFP batteries, which have lower densities but are cheaper to produce and do not contain either nickel or cobalt. While LFP batteries lack the densi-

10. See EARTHWORKS REPORT I, *supra* note 6, at 14.

11. "Rare earth" metals comprise 17 elements on the periodic table. From a geological perspective, they are not especially rare and are found in many places around the globe. Some are as abundant as copper or tin, but they occur in low concentrations, often mixed with radioactive elements, such as uranium and thorium, and they are difficult to separate from surrounding materials. So mining rare earth metals can generate a lot of toxic waste. Science History Institute, *History and Future of Rare Earth Elements*, <https://www.sciencehistory.org/learn/science-matters/case-of-rare-earth-elements-history-future> (last visited Nov. 16, 2023). One promising source for these elements is tailings piles from existing or abandoned mines. See Mike Williams, *Rare Earth Elements Await in Waste*, RICE U. (Feb. 9, 2022), <https://news.rice.edu/news/2022/rare-earth-elements-await-waste>.

12. Adapted from EARTHWORKS REPORT I, *supra* note 6, at 14. See also CLEAN ENERGY MANUFACTURING ANALYSIS CENTER, BENCHMARKS OF GLOBAL CLEAN ENERGY MANUFACTURING (2017), <https://www.nrel.gov/docs/fy17osti/65619.pdf>.

13. U.S. Department of Energy Alternative Fuels Data Center, *Batteries for Electric Vehicles*, https://afdc.energy.gov/vehicles/electric_batteries.html (last visited Nov. 16, 2023).

14. University of Washington, *Components of Cells and Batteries*, <https://depts.washington.edu/matseed/batteries/MSE/components.html> (last visited Nov. 16, 2023).

15. EARTHWORKS REPORT I, *supra* note 6, at 8.

16. Guest Blogger for John Campbell, *Why Cobalt Mining in the DRC Needs Urgent Attention*, COUNCIL ON FOREIGN RELS. (Oct. 29, 2020), <https://www.cfr.org/blog/why-cobalt-mining-drc-needs-urgent-attention>.

17. Samsung SDI, *Technology: Cathode Materials, the Source of a Strong and Long-Lasting Battery!*, <https://www.samsungsdi.com/column/technology/detail/56458.html> (last visited Nov. 16, 2023).

18. Joey Klender, *Tesla's Nickel Problem: The Quest for Sustainable Sourcing*, TESLARATI (Sept. 1, 2020), <https://www.teslarati.com/tesla-nickel-sourcing-problem/>.

19. Melissa Garside, *Major Countries in Worldwide Nickel Production in 2022*, STATISTA (Feb. 23, 2023), <https://www.statista.com/statistics/264642/nickel-mine-production-by-country/>.

20. Anthony Milewski, *HPAL Nickel Tailings Question Still Unanswered*, ASSAY (May 26, 2021), <https://www.theassay.com/articles/analysis/hpal-nickel-tailings-question-still-unanswered-will-indonesias-toxic-tailings-do-for-nickel-what-drc-child-labour-did-for-cobalt/>.

21. Eri Silva, *Indonesia's Nickel Processing Boom Raises Questions Over Tailings Disposal*, S&P GLOB. (Apr. 17, 2023), <https://www.spglobal.com/marketing/en/news-insights/latest-news-headlines/indonesia-s-nickel-processing-boom-raises-questions-over-tailings-disposal-75180844>.

ties of NMC and NCA batteries, research has led to significant improvements in their energy density, and given their lower cost, these batteries have become attractive options.²²

The Holy Grail of EV battery technology is the solid-state battery. Virtually every major carmaker has partnered with EV manufacturers that are pursuing the development and commercialization of this technology. While the technology remains elusive, it seems only a matter of time before these batteries are commercialized. Solid-state batteries will eliminate the liquid electrolyte, thereby minimizing the risk that the batteries will overheat and catch fire. Solid-state batteries will be smaller and lighter even as they promise to deliver higher energy densities (and thus greater range) and faster charging to 80% of full charge in 10 minutes or less.²³ Despite the promise of solid-state batteries, most of the current prototypes still require many of the same metals that are used in current EV battery technologies.²⁴

2. Minerals for Energy Storage

Li-ion batteries are the most popular type of battery currently used for energy storage, accounting for more than

90% of the large-scale battery storage capacity in the United States as of 2018.²⁵ The main problem with using these batteries for storage, however, is that they are generally only capable of providing power for four to eight hours or less.²⁶

Metal-air batteries show great promise in overcoming the limitations of Li-ion for energy storage at a much lower price. Metal-air batteries use oxygen from the ambient air as an electrode and are capable of using a wide range of metals such as lithium, aluminum, iron, zinc, and manganese.²⁷

Two particular metal-air battery types—iron-air and zinc-air—appear to offer particularly significant advantages for energy storage. Iron-air battery technology works through the “reversible oxidation of iron.”²⁸ During discharge, tiny iron pellets are exposed to the air, making them oxidize or rust. When the system is charged with an electric current, the process is reversed, and the rusted pellets revert back to iron.²⁹ Unlike most other battery technologies, iron-air batteries are too heavy and bulky for use in transportation and are only practical for energy storage.

While iron-air batteries are still in the development phase and are accordingly unproven, their potential advantages could be substantial. Proponents of iron-air batteries, including a Massachusetts-based company called Form Energy, claim the technology will be able to deliver electricity for 100 hours at less than one-tenth the cost of Li-ion batteries.³⁰ A 1.5 megawatt (MW)/150 megawatt hour (MWh) iron-air pilot project for Minnesota-based Great River Energy is set to be up and running by 2024 and should help determine the viability of this technology.³¹ Additionally, Xcel Energy has partnered with Form Energy to build an iron-air battery system in Colorado and Minnesota.³² Form Energy will manufacture these batteries at a West Virginia plant that should be operational by 2024.³³

22. Tom Lombardo, *Why EV Manufacturers Are Switching From NMC to LFP Batteries*, ENGINEERING.COM (Sept. 30, 2022), <https://www.engineering.com/story/why-ev-manufacturers-are-switching-from-nmc-to-lfp-batteries>.
23. Emily Pickrell, *EV Battery Research Powers Ahead Toward Next Big Breakthrough*, FORBES (June 14, 2021), <https://www.forbes.com/sites/uhenergy/2021/06/14/ev-battery-research-powers-ahead-toward-next-big-breakthrough/>.
24. Swiss factory to produce solid-state batteries that “do not require any critical raw materials such as cobalt” in 2024. See Anna Ivanova, *Swiss Clean Battery Plans 7.6-GWh Gigafactory*, RENEWABLES NOW (Apr. 8, 2022), <https://renewablesnow.com/news/swiss-clean-battery-plans-7-6-gwh-giga-factory-780244/>. This plant will allegedly produce “7.2 million battery cells per year.” See Emiliano Bellini, *Pure Solid State Batteries From Switzerland*, PV MAG. (Apr. 8, 2022), <https://www.pv-magazine.com/2022/04/08/pure-solid-state-batteries-from-switzerland/>. In China, Svolt Energy claims to have produced solid-state battery cells that will allow vehicles to reach a range of more than 1,000 kilometers, but they still use lithium. See Phate Zhang, *Svolt Energy Develops Solid-State Battery Cells That Will Allow Vehicles to Reach Over 1,000 km Range*, CNEVPOST (July 19, 2022), <https://cnevpost.com/2022/07/19/svolt-energy-develops-20ah-solid-state-battery-cells/>. Colorado-based Solid Power is manufacturing solid-state batteries with silicone, sulfates, and lithium. See Solid Power, *All-Solid-State Battery Cell Technology*, <https://www.solidpowerbattery.com/batteries/> (last visited Nov. 16, 2023). Altech Batteries has announced their CERENERGY sodium chloride solid-state battery project will begin construction of a plant in Germany. These batteries use no lithium and will primarily be used for grid storage. See Altech Batteries, *Project: German Sodium Chloride CERENERGY® Solid State (SCSS) Battery Project*, <https://www.altechgroup.com/projects/german-sodium-chloride-solid-state-scss-battery-project/> (last visited Nov. 16, 2023). Toyota has announced they plan to incorporate fully solid-state batteries into some of their vehicles by 2027. These solid-state batteries could increase the range of EVs by 20% while reducing charge times to 10 minutes. See Yuri Kageyama, *Japan's Toyota Announces Initiative for All-Solid State Battery as Part of Electric Vehicles Plan*, U.S. NEWS & WORLD REP. (June 13, 2023), <https://www.usnews.com/news/technology/articles/2023-06-13/japans-toyota-announces-battery-electric-vehicle-initiatives>. See also Peter Johnson, *Toyota Claims Solid-State EV Battery Tech Breakthrough Could Offer +900 Miles Driving Range*, ELECTREK (June 13, 2023), <https://electrek.co/2023/06/13/toyota-claims-solid-state-ev-battery-tech-breakthrough/>. The U.S. government has also begun investing heavily into the battery supply chain via the 2021 infrastructure bill, which set aside more than \$6 billion in grant awards for expanding the U.S. battery supply chain. See Ashley Murray, *Battery Manufacturers Look to Grants in Infrastructure Bill*, GOV'T TECH. (Nov. 16, 2021), <https://www.govtech.com/policy/battery-manufacturers-look-to-grants-in-infrastructure-bill>.

25. *Most Utility-Scale Batteries in the United States Are Made of Lithium-Ion*, EIA (Oct. 30, 2019), <https://www.eia.gov/todayinenergy/detail.php?id=41813>.
26. ENVIRONMENTAL AND ENERGY STUDY INSTITUTE, FACT SHEET: ENERGY STORAGE (2019), https://www.eesi.org/files/FactSheet_Energy_Storage_0219.pdf.
27. Adeline Loh et al., *Selection of Oxygen Reduction Catalysts for Secondary Tri-Electrode Zinc-Air Batteries*, 12 SCI. REPS. art. 6696 (2022), available at <https://doi.org/10.1038/s41598-022-10671-5>.
28. See Leigh Collins, *World's Cheapest Energy Storage Will Be an Iron-Air Battery, Says Jeff Bezos-Backed Start-Up*, RECHARGE (July 23, 2021), <https://www.rechargenews.com/energy-transition/worlds-cheapest-energy-storage-will-be-an-iron-air-battery-says-jeff-bezos-backed-start-up/2-1-1044174>.
29. *Id.*
30. News Release, Form Energy, Inc., *supra* note 4; see also Form Energy, *Battery Technology*, <https://formenergy.com/technology/battery-technology/> (last visited Nov. 16, 2023).
31. Kirsti Marohn, *“Rusty” Batteries Could Hold Key to Minnesota's Carbon-Free Power Future*, MPR NEWS (Feb. 10, 2023), <https://origin-www.mprnews.org/story/2023/02/10/rusty-batteries-could-hold-key-to-carbon-free-power-future>.
32. News Release, Xcel Energy, Form Energy Partners With Xcel Energy on Two Multi-Day Energy Storage Projects (Jan. 26, 2023), <https://investors.xcelenergy.com/news-events/news-releases/news-details/2023/Form-Energy-Partners-with-Xcel-Energy-on-Two-Multi-day-Energy-Storage-Projects/default.aspx>.
33. Darrell Proctor, *Billionaire-Backed “Iron-Air” Battery Maker Picks WV Site for First Factory*, POWER MAG. (Dec. 23, 2022), <https://www.powermag.com/billionaire-backed-iron-air-battery-maker-picks-wv-site-for-first-factory/>.

One big advantage of iron-air batteries over other types of batteries, especially Li-ion, is that iron is the second most abundant mineral on earth³⁴ and can be safely recycled or discarded. While iron-air batteries hold promise for grid-scale energy storage, they remain unproven and are not yet commercially available. Still, the Minnesota- and Colorado-based utility-scale pilot projects, which appear ready to move forward, should provide important information about the commercial viability of this technology in the not-too-distant future.

Like iron-air batteries, zinc-air batteries have similar game-changing potential. A Canadian company called Zinc8³⁵ is promoting a zinc-air battery, with claims that it can store multiple days' worth of energy, that it will not degrade or explode, and that it may be as much as five times cheaper than Li-ion batteries. The zinc-air battery uses electricity from the grid to split zincate into zinc, water, and oxygen. This process charges zinc particles that can store electricity for weeks at a time. When the charged zinc is combined with oxygen from the air, it releases the stored electricity and reverts the zinc to zincate, which can then be reused to store more electricity.³⁶ While zinc is neither as abundant nor as inexpensive as iron, it is still relatively plentiful³⁷ and less costly than many of the elements used in Li-ion batteries.

If iron-air, zinc-air, or other metal-air batteries are able to displace Li-ion batteries for energy storage, this could solve two significant obstacles to cheap and reliable energy storage. Not only would they overcome the short storage times available with Li-ion batteries at a substantially lower cost, they would also free up some of the more expensive minerals used in Li-ion batteries for EVs. Although much of the more promising work on metal-air batteries is focused on iron and zinc, other metal-air candidates, including lithium, aluminum, and magnesium, could eventually become viable options for EVs as well.³⁸

Although not technically a battery, another energy storage technology that warrants mention here is the pumped storage hydro (PSH) facility.³⁹ PSH requires the construction of two reservoirs, located close together but at different elevations, with a power generation station in between. During high power demand, water is sent from the upper

reservoir to the lower reservoir through the power station, generating electricity. During periods of low demand, energy from the grid is used to pump the water from the lower reservoir back up to the higher reservoir. Thus, a PSH facility serves essentially the same function as a battery. Moreover, depending on the size of the reservoir and power plant, a PSH facility can store energy for several days.

While many PSH facilities have been built "in-stream," closed loop, off-stream facilities are far preferable and are becoming more popular because suitable sites for these facilities are abundant, and they minimize impacts to the stream environment.⁴⁰

3. Minerals Needed for EV Motors

Permanent magnet and induction motors are the two types of electric motors used in EVs. Of these, permanent magnet motors are the most efficient, but they are also the most expensive and require the use of certain rare earth elements (REEs) like neodymium and dysprosium. These are the same elements required for PMGs used in wind turbines.⁴¹ Induction motors are less efficient, but they are cheaper to produce and do not require REEs.

Induction motors are used in some very successful EVs, including several Tesla models.⁴² Recently, however, Tesla has been switching to the more efficient permanent magnet motors, presumably to increase vehicle range.⁴³ Tesla is also designing PMGs that use less rare earth minerals, with the ultimate goal of eliminating these minerals entirely from the permanent magnet motors.⁴⁴ Other EV manufacturers are likely to follow Tesla's lead, which should result in greater demand for permanent magnet motors, even as the demand for rare earth minerals for these motors declines.

II. Supply and Demand for Minerals Needed for Renewables

As detailed above, expanding markets for PV solar, wind, and various batteries needed to support renewable energy will necessarily and significantly increase demand for certain minerals. Some of these minerals are in relatively short supply, and the demand for these minerals may ultimately

34. See *So Cheap Yet So Valuable*, EARTHDATE (Nov. 19, 2018), <https://www.earthdate.org/episodes/so-cheap-yet-so-valuable>.

35. See Zinc8 Energy Solutions, *Home Page*, <https://www.zinc8energy.com/> (last visited Nov. 16, 2023).

36. Leigh Collins, *New Zinc-Air Battery Is "Cheaper Safer, and Far Longer Lasting Than Lithium-Ion,"* RECHARGE (June 3, 2020), <https://www.recharge-news.com/transition/new-zinc-air-battery-is-cheaper-safer-and-far-longer-lasting-than-lithium-ion/2-1-812068>.

37. According to the U.S. Geological Survey (USGS), zinc is the 23rd most abundant element in the earth's crust. See USGS National Minerals Information Center, *Zinc Statistics and Information*, <https://www.usgs.gov/centers/national-minerals-information-center/zinc-statistics-and-information> (last visited Nov. 16, 2023).

38. Md. Arafat Rahman et al., *High Energy Density Metal-Air Batteries: A Review*, 160 J. ELECTROCHEM. SOC'Y A1759, A1759 (2013), available at <https://iopscience.iop.org/article/10.1149/2.062310jes/pdf>.

39. See NATIONAL HYDROPOWER ASSOCIATION, 2021 PUMPED STORAGE REPORT, <https://www.hydro.org/wp-content/uploads/2021/09/2021-Pumped-Storage-Report-NHA.pdf>.

40. See Matthew Stocks et al., *Global Atlas of Closed-Loop Pumped Hydro Energy Storage*, 5 JOULE 270 (2021), available at <https://www.sciencedirect.com/science/article/pii/S2542435120305596>.

41. TAE-YOON KIM ET AL., IEA, THE ROLE OF CRITICAL MINERALS IN CLEAN ENERGY TRANSITIONS 88 (2021); IEA REPORT, *supra* note 6.

42. TESLA, MODEL 3 OWNER'S MANUAL (2023), https://www.tesla.com/ownersmanual/model3/en_us/Owners_Manual.pdf; TESLA, MODEL Y OWNER'S MANUAL (2023), https://www.tesla.com/ownersmanual/modely/en_us/Owners_Manual.pdf.

43. Models 3 and Y use permanent magnet motors for the rear and alternating current (AC) induction motors for the front. See TESLA, MODEL 3 OWNER'S MANUAL, *supra* note 42, at 210; TESLA, MODEL Y OWNER'S MANUAL, *supra* note 42, at 217. Models X and S use permanent magnet motors for both the front and rear. See TESLA, MODEL X OWNER'S MANUAL (2023), https://www.tesla.com/ownersmanual/modelx/en_us/Owners_Manual.pdf; TESLA, MODEL S OWNER'S MANUAL (2023), https://www.tesla.com/ownersmanual/models/en_us/Owners_Manual.pdf.

44. See *Tesla and Other Automakers Are in a Magnet Race to Build EVs Without Rare Earth Metals*, AUTOBLOG (Mar. 20, 2023), <https://www.autoblog.com/2023/03/20/rare-earth-metals-ev-electric-motors/>.

outstrip current production and even proven reserves. While additional reserves might be found, recycling is likely to play an important role in meeting future demand, and this fact should trigger government and corporate policies that seek to maximize recycling opportunities.

Batteries appear to offer the best opportunity for recycling, not least because batteries contain many of the minerals that are at the greatest risk of supply shortages. According to a 2021 report from the Institute for Sustainable Futures, University of Technology Sydney, effective recycling of end-of-life batteries has the potential to reduce global demand by 2040 by 55% for copper, by 25% for lithium, and by 35% for cobalt and nickel—creating an opportunity to significantly reduce the demand for new mining.⁴⁵

The International Energy Agency (IEA) has documented the expected increase in demand for each major type of energy generation.⁴⁶ Set forth below is a brief review of the key minerals and quantities that are expected to be needed to facilitate the transition to a renewable energy future. As noted previously, the demand for these minerals is likely to evolve as efforts are made to eschew minerals that are problematic in terms of supply as well as environmental and social impact.

A. Copper

Although it receives less attention than other minerals that are in short supply, virtually all energy generation facilities require copper because of its unique thermal and electrical conductivity attributes.⁴⁷ As a result, all of the renewable energy types considered here, including PV solar, onshore and offshore wind, EVs, and the various battery technologies, are projected to require a significant increase in global demand for copper. Currently, renewable energy accounts for about 24% of copper demand. Under a sustainable development scenario,⁴⁸ that could rise to as much as 45%.

Fortunately, copper deposits are abundant and widespread across the globe, and copper has high recycling potential.⁴⁹ Chile has the largest copper reserves in the world, totaling approximately 200 million metric tons, followed by Australia's 93 million metric tons.⁵⁰ The United States is in sixth place and holds reserves of approximately 48 million metric tons.⁵¹

Chile is also the largest global producer of copper, at 5.6 million metric tons annually. The United States produces around 1.2 million metric tons per year.⁵² While copper is relatively plentiful and recyclable, many of the largest copper mines are nearing peak production. Ore quality is also declining at the large mines, which leads to added costs, increased energy use, and additional depletion of the ore body.⁵³

China leads the way in global copper use, consuming 54% of the copper market. China's copper consumption has increased to present levels in a relatively short time. It held less than one-third of the market share in 2007.⁵⁴ China imports copper ore primarily for smelting and refining, allowing it to then turn and sell refined copper on the global market. The European Union (EU) consumes the second highest amount of copper globally, making up around 15% of the market. The United States uses about 8% of what is produced annually, or about two million tons.⁵⁵

Even if mines had not yet reached peak production, and even if copper ore quality was not declining, the expected rise in demand for copper largely tracks with demand for renewables and will likely lead to an increase in copper mining. For that reason, and as discussed below, maximizing opportunities for recycling these minerals must be an important part of any strategy for sourcing copper.

B. Cobalt

Cobalt tops the list as the most challenging mineral to source. Over an eight-year period from 2017 to 2025, the demand for cobalt is projected to increase by more than 60% from 136,000 tons to 222,000 tons in 2025. Demand for cobalt for batteries alone will nearly triple, jumping from 41,000 tons to 117,000 tons.⁵⁶

More than 70% of cobalt, or about 120,000 metric tons per year, comes from a single country—the DRC.⁵⁷ The DRC reportedly holds more than one-half of the world's cobalt reserves. DRC cobalt mines employ an estimated 255,000 people and, unfortunately, about 40,000 of those workers are children. Moreover, as many as 200,000 min-

45. ELSA DOMINISH ET AL., INSTITUTE FOR SUSTAINABLE FUTURES, REDUCING NEW MINING FOR ELECTRIC VEHICLE BATTERY METALS: RESPONSIBLE SOURCING THROUGH DEMAND REDUCTION STRATEGIES AND RECYCLING (2021), <https://opus.lib.uts.edu.au/bitstream/10453/159077/2/UTS-EV-battery-metals-sourcing-20210419-FINAL.pdf> [hereinafter EARTHWORKS REPORT II].

46. IEA REPORT, *supra* note 6, at 3.

47. *Id.* at 135.

48. This scenario reflects compliance with the Paris Agreement to the United Nations Framework Convention on Climate Change. United Nations Climate Change, *supra* note 1.

49. EARTHWORKS REPORT I, *supra* note 6, tbl.11, at 21.

50. Melissa Garside, *Reserves of Copper Worldwide in 2022, by Country*, STATISTA (Feb. 26, 2023), <https://www.statista.com/statistics/273637/copper-reserves-by-country/>.

51. *Id.*

52. Melissa Garside, *Major Countries in Copper Mine Production Worldwide in 2022*, STATISTA (Feb. 26, 2022), <https://www.statista.com/statistics/264626/copper-production-by-country/>.

53. IEA REPORT, *supra* note 6, at 136-37.

54. Andy Kiersz, *Here Are the World's Big Consumers of Copper*, BUS. INSIDER (Jan. 14, 2015), <https://www.businessinsider.com/copper-demand-by-region-2015-1>.

55. *Id.* See Statista, for slightly different statistics. *Distribution of Refined Copper Consumption Worldwide in 2022, by Region*, STATISTA (July 12, 2022), <https://www.statista.com/statistics/693466/distribution-of-global-refined-copper-consumption-by-region/>.

56. Melissa Garside, *Cobalt Demand Worldwide From 2010 to 2025, by End Use*, STATISTA (Aug. 2, 2018), <https://www.statista.com/statistics/875814/cobalt-demand-worldwide-by-end-use/>.

57. *The Effects of Cobalt Mining in the DRC*, BORGES PROJECT (Nov. 6, 2021), <https://borgenproject.org/cobalt-mining-in-the-drc/>. See also Melissa Garside, *Reserves of Cobalt Worldwide in 2022, by Country*, STATISTA (Feb. 18, 2023), <https://www.statista.com/statistics/264930/global-cobalt-reserves/>.

ers work at small artisanal⁵⁸ mines, which are difficult to regulate and control.⁵⁹

Over the long term, reducing or eliminating cobalt from EV batteries is probably the best strategy for reducing the humanitarian and environmental costs associated with cobalt mining. Indeed, cobalt reserves appear to be grossly inadequate to meet demand by 2050 in what is expected to be an aggressive climate regulation scenario.⁶⁰ In the short term, however, demand for cobalt will likely remain high, thus making cobalt recycling from old batteries of paramount importance.

Car and EV battery manufacturers could also commit to use cobalt only if it comes from clean sources. Mines that fail to meet appropriate environmental standards or mines that use child labor should be off-limits. Such changes would incentivize better mining and child labor practices in the DRC and other mining regions, and would also help promote cobalt mining in other countries that follow strict environmental and labor standards.⁶¹

C. Lithium

Close behind cobalt in presenting a challenge for the renewable energy industry is lithium. Australia leads the world in lithium production, with an estimated output of 55,000 metric tons. Australia is followed by Chile, which produces 26,000 metric tons, and China, which produces 14,000 metric tons per year.⁶²

Lithium is used primarily for batteries, but as of 2018, a substantial amount was also being used in industrial applications. By 2030, however, fully 93% of all lithium is expected to be used for batteries.⁶³ More specifically, lithium demand is expected to grow from 263,000 metric tons

in 2019 to 2,114,000 metric tons in 2030, mostly due to demand from battery production.⁶⁴

Because demand for lithium is expected to outstrip supply by a significant margin,⁶⁵ much research is ongoing to identify different battery chemistries that would reduce or eliminate the need for lithium in batteries. Nonetheless, current projections favor a significant increase in demand for lithium, and that will incentivize additional lithium mining and other lithium extraction methods.

Lithium has traditionally been produced in two fundamentally different ways—solar evaporation and hard-rock mining. Solar evaporation involves the pumping of groundwater into massive storage ponds. The water evaporates, often over the course of an entire year, creating lithium carbonate. The substantial pumping required by this process adversely impacts the water supply of local communities and results in substantial waste salts. These waste piles are typically left untreated, contaminating vast tracts of land surface and limiting opportunities for future uses of the land. Moreover, the process has low recovery rates of somewhere between 20% and 40%. Low recovery rates mean that solar evaporation processes require more land, more groundwater pumping, and the creation of more waste salts in order to meet production demands.

Lithium is also produced through hard-rock mining for spodumene, and a few other minerals associated with lithium deposits.⁶⁶ Lithium mines use traditional open-pit and underground mining methods, with all of their concomitant costs and environmental problems. In particular, processing spodumene requires large quantities of chemicals, and the waste rock that results is typically disposed of in tailings ponds, which pose additional risks to land and water resources, and local communities.⁶⁷ Spodumene mining is the method typically used in Australia to produce lithium.

A promising alternative to these two traditional methods that is still in the development stage is known as “direct lithium extraction” (DLE).⁶⁸ DLE is a brine extraction method that removes lithium from geothermal waters, processes the brine to remove the lithium, and then returns more than 98% of the brine back to the groundwater reservoir, thereby avoiding water resource conflicts. The DLE method also has many significant environmental and economic advantages over solar evaporation. Geothermal energy can be used to extract the brine, it can recover up to 99% of the lithium (as compared with less than 40% with solar evaporation), and it has the potential to produce

58. See Pact, *Artisanal and Small-Scale Mining*, <https://www.pactworld.org/our-expertise/mining> (last visited Nov. 16, 2023) (“Artisanal and small-scale mining, or ASM, is a largely informal economic sector that includes workers around the world who use basic tools to extract from the earth everything from gold and gemstones to vital metals such as cobalt, tin, tungsten and tantalum.”).

59. A state-backed agency intends to take over the artisanal mining sector by buying, processing, and marketing the cobalt with a goal of providing a better return to the miners. See Andy Home, *Cobalt, Congo, and a Mass Artisanal Mining Experiment*, REUTERS (May 13, 2021), <https://www.reuters.com/business/energy/cobalt-congo-mass-artisanal-mining-experiment-andy-home-2021-05-13/>.

60. EARTHWORKS REPORT I, *supra* note 6, tbl.11, at 21. The report suggests that demand in 2050 could be 423% of current reserves. The report defines “reserves” as the “estimated amount of mineral that can be economically mined under current conditions.” *Id.* at 20. This is contrasted with the term “resources,” defined as “the total known amount of a mineral for which extraction may be potentially economically feasible.” *Id.*

61. The DRC currently produces vastly more cobalt than all other countries combined. See Melissa Garside, *Major Countries in Worldwide Cobalt Mine Production in 2022*, STATISTA (Feb. 18, 2023), <https://www.statista.com/statistics/264928/cobalt-mine-production-by-country/>. While the DRC also hosts the largest cobalt reserves, substantial deposits are found in Australia and Indonesia, as well as in many other countries. See Garside, *supra* note 56. If car and battery makers were to limit their cobalt purchases to countries with good mining and labor practices, the DRC might be forced to fall in line.

62. *World Cobalt Mine Production in 2022*, *supra* note 61.

63. Melissa Garside, *Distribution of Lithium Demand Worldwide in 2018 and 2030, by Application*, STATISTA (Jan. 16, 2020), <https://www.statista.com/statistics/1080927/distribution-of-world-lithium-demand-by-application/>.

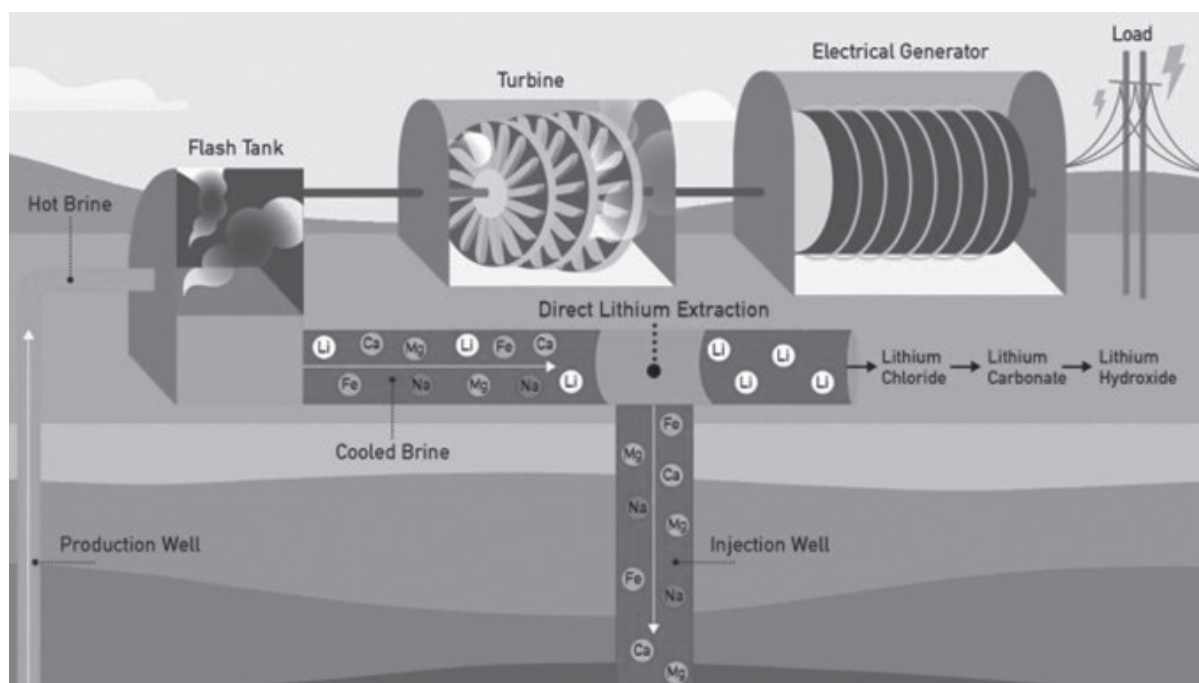
64. Melissa Garside, *Projection of Lithium Demand Worldwide From 2020 to 2035*, STATISTA (Mar. 4, 2022), <https://www.statista.com/statistics/452025/projected-total-demand-for-lithium-globally/>.

65. EARTHWORKS REPORT I, *supra* note 6, fig.6, at 21.

66. See Tian-Ming Gao et al., *Lithium Extraction From Hard Rock Lithium Ores (Spodumene, Lepidolite, Zinnwaldite, Petalite): Technology, Resources, Environment, and Cost*, 6 CHINA GEOLOGY 137 (2023).

67. *Environmental Impact of Traditional Lithium Mining vs DLE*, INT’L BATTERY METALS (July 23, 2021), <https://www.ibatterymetals.com/insights/ecological-impact-of-traditional-mining-vs-direct-lithium-extraction>.

68. *Id.* See also *Using Direct Lithium Extraction to Secure U.S. Supplies*, NAT’L RENEWABLE ENERGY LAB’Y (July 21, 2021), <https://www.nrel.gov/news-program/2021/using-direct-lithium-extraction-to-secure-us-supplies.html>.

Figure 1. Diagram of the DLE Process*

* Julie Chao, *Sizing Up the Challenges in Extracting Lithium From Geothermal Brine*, BERKELEY LAB (Nov. 29, 2021), <https://newscenter.lbl.gov/2021/11/29/sizing-up-the-challenges-in-extracting-lithium-from-geothermal-brine/>.

a higher grade of lithium that will sell at a premium. DLE is also a much faster process for producing lithium, is not dependent on weather, and because it does not require evaporation ponds, it has a much smaller environmental footprint.⁶⁹ Figure 1 offers a simple illustration of how DLE works.

Various DLE processes are being tested for the purpose of extracting lithium carbonate from the brines that underlie the Salton Sea in southern California.⁷⁰ The California Energy Commission estimates that the Salton Sea Known Geothermal Resource Area is capable of producing an estimated 600,000 tons per year of lithium carbonate, with a current market value of \$7.2 billion.⁷¹ If true, the extraction of lithium carbonate from the Salton Sea would, by itself, exceed the global production of lithium in 2021.⁷² While the Salton Sea appears to have vast potential to produce lithium, the DLE process is complex, and substantial

research and pilot programs will likely be needed before the lithium deposits found there can be commercialized.⁷³

As of May 2023, San Diego-based company EnergySource received permit approval from the county to construct the first commercial-scale brine to lithium plant on the Salton Sea, with production potentially starting as early as 2024.⁷⁴ Permitting approval was also granted for another commercial-scale DLE facility to be constructed at Clayton Valley in Nevada by Pure Energy Minerals Ltd. in early 2023.⁷⁵ These new facilities promise to expand domestic lithium production without the environmental consequences of traditional lithium extraction, specifically high water use and ground contamination.⁷⁶

D. Nickel

In 2020, the U.S. Geological Survey estimated that world nickel reserves were approximately 94 million tons,⁷⁷ with

69. *A Look at Direct Lithium Extraction ("DLE") and Some of the DLE Lithium Companies*, SEEKING ALPHA (Nov. 11, 2021), <https://seekingalpha.com/article/4468468-a-look-at-direct-lithium-extraction-dle-and-some-of-the-dle-lithium-companies>; see also Cornish Lithium, *Direct Lithium Extraction*, <https://cornishlithium.com/projects/lithium-in-geothermal-waters/direct-lithium-extraction/> (last visited Nov. 16, 2023).

70. Todd O. Maiden & Eric J. Schmoll, *Lithium Mining Around the Salton Sea: The Case for a "Win-Win" Outcome for Energy and the Environment*, LEXOLGY: HEALTH INDUS. WASH. WATCH (Mar. 25, 2022), <https://www.lexology.com/library/detail.aspx?g=19b16966-3b6d-4fa3-aaac-040a0d1fa070>.

71. SUSANNA VENTURA ET AL., CALIFORNIA ENERGY COMMISSION, FINAL PROJECT REPORT: SELECTIVE RECOVERY OF LITHIUM FROM GEOTHERMAL BRINES (2020), <https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-020.pdf>.

72. See Hector Chavira, *Will Salton Sea Lithium Dreams Come True? It Will Be Years Before We Know*, SALTON SEA WATCH (Feb. 14, 2022), <https://salton-seawatch.com/salton-sea-lithium/>.

73. Katharine Gammon, *As Lithium Drilling Advances at the Salton Sea, Researchers Work Out the Details*, KCET (Mar. 21, 2022), <https://www.pbsso-cal.org/news-community/as-lithium-drilling-advances-at-the-salton-sea-researchers-work-out-the-details>.

74. Janet Wilson & Erin Rode, *Lithium Valley: A Look at the Major Players Near the Salton Sea Seeking Billions in Funding*, DESERT SUN (May 14, 2022), <https://www.desertsun.com/story/news/2022/05/13/lithium-valley-look-major-players-near-salton-sea-seeking-billions-funding/9665978002/>.

75. *Pure Energy Minerals and SLB Receive Key Permits for DLE Pilot Plant at Clayton Valley Lithium Project, Nevada*, YAHOO FIN. (Mar. 28, 2023), <https://finance.yahoo.com/news/pure-energy-minerals-slb-receive-123000085.html>.

76. *Using Direct Lithium Extraction to Secure U.S. Supplies*, *supra* note 68.

77. Natural Resources Canada, *Nickel Facts*, <https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/nickel-facts/20519> (last modified Feb. 16, 2023).

annual consumption that year at 2.44 million tons.⁷⁸ Because nickel is important for increasing energy density in batteries and because it can help to reduce or eliminate the use of cobalt, nickel is likely to see a significant increase in demand, and that demand is likely to run up against the limited nickel reserves.⁷⁹

Most nickel today is used to produce stainless steel. Li-ion batteries account for only around 7% of nickel demand, while renewable energy as a whole accounts for about 10% of nickel demand. Under a “sustainable development scenario,” however, 60% of global nickel demand could come from renewable energy by 2050.⁸⁰ Demand could actually exceed reserves by that year if aggressive climate measures are adopted and if nickel remains a key constituent in EV batteries.⁸¹

The two largest nickel-producing countries are Indonesia and the Philippines. Indonesia accounts for the vast majority of nickel production at about one million metric tons per year and has the largest reserves at about 21 million metric tons. The Philippines produces about 370,000 metric tons annually. Six other countries—Russia, New Caledonia, Australia, Canada, China, and Brazil—each produce more than 100,000 metric tons per year.⁸² Australia and Brazil are right behind Indonesia in terms of nickel reserves with 21 million metric tons and 16 million metric tons, respectively.⁸³

Mining practices in Indonesia raise particular concerns about carbon dioxide emissions due to electricity coming from coal-fired power plants. In addition, conventional mine tailings disposal, which is problematic in most circumstances, poses particularly serious challenges in Indonesia due to the country’s wet climate and seismic activity. Deep-sea tailings disposal, which is viewed as an option, poses other serious risks to the marine environment.⁸⁴ Nonetheless, Indonesia is likely to see its nickel mining sector continue to expand, with a British consortium planning to invest \$9 billion into the nation’s mining sector as the demand for nickel continues to grow.⁸⁵

E. REEs

REEs are 17 elements that typically occur together in the same ore body but in different concentrations. Despite their name, “rare earth elements” are not especially rare, although they tend to occur in small concentrations alongside other minerals, including radioactive materials

like thorium. As a result, REEs are expensive to produce and raise a host of environmental problems. For example, they generally require large quantities of toxic chemicals for processing, and they produce substantial waste that ends up in tailings dams that threaten water supplies and downstream communities.⁸⁶ One promising development involves research on extracting rare earth minerals from existing mine tailings.⁸⁷ Such remaining operations could be designed to reclaim abandoned mined lands that have long threatened local water supplies and prevent the productive use of affected lands.

As previously described, the REEs neodymium and dysprosium are used, often in tandem, to create PMGs in some wind turbines and in EV motors. As described by one company, “[d]ysprosium is added to the neodymium magnets during its production in order to achieve better performance in high temperatures.” Dysprosium also helps neodymium magnets resist demagnetization.⁸⁸ Looking ahead, EV manufacturers are making progress in reducing the amount of neodymium and dysprosium in EV motors, using lower-cost magnetic REEs or using other elements altogether.⁸⁹

The IEA estimates that clean energy technologies currently represent about 15% of the neodymium market, but that is projected to rise to 40% under a sustainable development scenario.⁹⁰ China has been the largest producer of REEs, but its share has fallen from 95% in 2010 to about 60% today as other countries, including Australia, Myanmar, and the United States, boost their production. China, however, still dominates the processing of REEs at nearly 90% in 2019.⁹¹

F. Other Minerals of Concern

A number of other minerals, including aluminum, cadmium, gallium, indium, selenium, silver, tellurium silver, and manganese, are likely to see increased demand and thus increased mining, with all of the attendant problems that raises.⁹² Current estimates of reserves for these min-

78. Melissa Garside, *Global Nickel Mining Industry—Statistics & Facts*, STATISTA (Sept. 2, 2021), <https://www.statista.com/topics/1572/nickel/>.

79. EARTHWORKS REPORT I, *supra* note 6, tbl.11, at 21.

80. IEA REPORT, *supra* note 6, at 145.

81. EARTHWORKS REPORT I, *supra* note 6, tbl.11, at 21.

82. Garside, *supra* note 19.

83. Melissa Garside, *Reserves of Nickel Worldwide as of 2022, by Country*, STATISTA (Feb. 23, 2023), <https://www.statista.com/statistics/273634/nickel-reserves-worldwide-by-country/>.

84. IEA REPORT, *supra* note 6, at 146.

85. Stanley Widiyanto & Stefano Sulaiman, *British Consortium to Invest \$9 Billion in Indonesian Mining, EV Batteries, Minister Says*, REUTERS (May 31, 2023), <https://www.reuters.com/technology/british-consortium-swiss-glencore-indonesias-aneka-tambang-invest-9-bln-2023-05-31/>.

86. EARTHWORKS REPORT I, *supra* note 6, at 43.

87. See Sebastiaan Peelman et al., *Hydrometallurgical Extraction of Rare Earth Elements From Low Grade Mine Tailings*, in RARE METAL TECHNOLOGY 17 (Shafiq Alam et al. eds., Springer 2016), available at https://doi.org/10.1007/978-3-319-48135-7_2.

88. Magma Magnetic Technologies, *Free & Low Dysprosium Neo Magnets*, <https://www.magmamagnets.com/permanent-magnets/neodymium-rare-earth-magnets/free-low-dysprosium-neo-magnets/> (last visited Nov. 16, 2023).

89. James D. Widmer et al., *Electric Vehicle Traction Motors Without Rare Earth Magnets*, 3 SUSTAINABLE MATERIALS & TECHS. 7 (2015), available at <https://www.sciencedirect.com/science/article/pii/S2214993715000032>.

90. IEA REPORT, *supra* note 6, at 153.

91. *Id.*

92. Manganese is of particular interest given that it can be a substitute for other materials currently used in batteries, can increase the energy density of current batteries, and can be sourced more easily and ethically than other metals. See “Overlooked” Manganese of Growing Importance as EV Battery Material, AUTOVISTA24 (Jan. 16, 2023), <https://autovista24.autovistagroup.com/news/manganese-electric-vehicle-batteries/>. However, given that manganese is “hard to separate from other metals without the use of expensive organic reagents for solvent extraction” (EARTHWORKS REPORT I, *supra* note 6, at 9), it does not seem like manganese battery recycling is a priority for most actors.

erals, however, appear adequate to satisfy demand from renewable energy technologies, even under aggressive climate policies.⁹³

III. Mineral Processing

Identifying the minerals that will be needed to transition to a clean energy economy is important. But getting those minerals from the point of production to the point of end use, in ways that minimize the risk of supply chain disruptions, requires a basic understanding of the mineral supply chain.

In July 2022, the Brookings Institute published a report that describes the various stages of the mineral supply chain, with a focus on the disruptive role that China has played and may continue to play at the mineral processing and manufacturing stages of critical mineral production.⁹⁴ The report breaks down mineral sourcing into three basic stages: (1) upstream activities, primarily mining⁹⁵; (2) midstream activities, including chemical refining and processing of minerals so they can be used in manufacturing; and (3) late midstream, or the application stage, where the minerals are fashioned into products such as EV battery components.

Upstream activities, including mining, are widespread around the globe, although certain countries tend to dominate the production of certain minerals. Australia and Chile, for example, currently account for about 70% of global lithium production. As previously noted, the DRC alone accounts for about 70% of global cobalt production. Indonesia currently accounts for about 30% of global nickel production. Chile and Peru are the leading producers of copper, together accounting for more than 40% of the global production.⁹⁶ The one category where China dominates mineral production is for REEs. In 2022, China produced 63% of global REEs.⁹⁷

China's dominant role in strategic minerals, however, is not primarily at the upstream stage, but rather at the midstream stage. According to the Brookings report, China "refines 68% of nickel globally, 40% of copper, 59% of lithium, and 73% of cobalt."⁹⁸ More importantly, China processes "85 percent of rare earth elements and 92 percent of rare earth magnet production."⁹⁹ As previously dis-

cussed, REE magnets are critical components for certain EV batteries and windmills.¹⁰⁰

China also plays a substantial role at the later midstream manufacturing stage. It produces about 70% of the cathodes used in EVs, which are the most important component and can account for one-half the cost of a manufactured cell. Further, it produces 85% of the anodes, 66% of the separators, 62% of the electrolytes used in EV batteries, and 78% of the capacity for making EV battery cells.¹⁰¹

Perhaps the most obvious concern with China's dominance in the mid- and late-midstream stages is its capacity to favor its own manufacturers and limit deliveries to other countries. Increasingly, however, governments are raising concerns about responsible sourcing and meeting what are often described as "due diligence" standards.¹⁰² Human rights abuses, including child labor practices at cobalt mines in the DRC, as well as inadequate environmental standards there, have received the most attention, but similar problems have been reported at the Xinjiang Nonferrous Metal Industry Group mines, smelters, and factories in Xinjiang, in far western China, where human rights groups have accused the country of crimes against Uyghur Muslims and other ethnic groups, including through forced labor.¹⁰³

China's dominance in the rare earth sector is beginning to wane as developed countries become increasingly wary of the political and regulatory climate in China. But these developed countries will need to make significant investments if they are to make the necessary inroads into the market that supplies the critical minerals that will be needed for the renewable energy transition. The American effort is being led by MP Materials, which operates the Mountain Pass mine in California. Mountain Pass claims to be one of only 3% of mining operations, and the only one in the global rare earth industry, that recycles the water that they use to process the ore and that produces only dry stack tailings, which conserve water and eliminate the risk of catastrophic failure at the tailings facility.¹⁰⁴ MP Materials is also building a processing facility in Fort Worth, Texas, that will convert minerals from Mountain Pass mine into metals, alloys, and magnets, thus ensuring that refining of the REEs will occur in the United States.¹⁰⁵

Early efforts are also underway to develop an REE supply chain in Wyoming. Northeastern Wyoming purportedly hosts one of the largest REE deposits in North

93. EARTHWORKS REPORT I, *supra* note 6, tbl.11, at 21.

94. See RODRIGO CASTILLO & CAITLIN PURDY, BROOKINGS INSTITUTION, CHINA'S ROLE IN SUPPLYING CRITICAL MINERALS FOR THE GLOBAL ENERGY TRANSITION: WHAT COULD THE FUTURE HOLD? (2022), https://www.brookings.edu/wp-content/uploads/2022/08/LTRC_ChinaSupplyChain.pdf.

95. This stage could also include sourcing from recycling operations.

96. CASTILLO & PURDY, *supra* note 94, at 6-7. By contrast, China produces less than 10% of the global supplies of both copper and lithium. *Id.*

97. Lara Seligman, *China Dominates the Rare Earths Market. This U.S. Mine Is Trying to Change That*, POLITICO (Dec. 14, 2022), <https://www.politico.com/news/magazine/2022/12/14/rare-earth-mines-00071102>.

98. CASTILLO & PURDY, *supra* note 94, at 6.

99. Notwithstanding China's dominance, a single mine in California reportedly produces about 15% of the global supply of REEs and is poised to enter the midstream market. Seligman, *supra* note 97.

100. Of particular concern is the fact that China and Myanmar produce 100% of the world's "heavy" REEs, so-called because they sit at the higher end of the periodic table. One of those elements is dysprosium, which, as previously noted, is increasingly important for producing PMGs for some wind turbines and EV motors. Seligman, *supra* note 97.

101. CASTILLO & PURDY, *supra* note 94, at 6.

102. The Brookings report considers the prospect for addressing the supply chain challenge even as many countries demand "green" and "clean" supply chains (i.e., supply chains that avoid human rights and environmental abuses). Policies that address these concerns are often expressed as due diligence standards. CASTILLO & PURDY, *supra* note 94, at 19.

103. *Id.* at 18.

104. See Seligman, *supra* note 97; see also Tailings.info, *Dry Stacking of Tailings (Filtered Tailings)*, <https://www.tailings.info/disposal/drystack.htm> (last visited Nov. 16, 2023).

105. Seligman, *supra* note 97.

America.¹⁰⁶ The goal of this effort is to cover all stages of the REE supply chain, including mining, processing, distributing, and supplying REE to meet advanced manufacturing needs of companies in the United States. In addition, the U.S. Department of Energy is funding projects at the University of North Dakota and West Virginia University to “identify risks and costs, and . . . solidify plans for developing economically viable processes to extract, separate, and produce rare earth elements and critical minerals from the nation’s vast quantities of mining wastes that won’t be harmful to the environment.”¹⁰⁷

IV. Environmental, Social, and Governance Policies in Producing, Processing, and Sourcing Minerals

A growing number of institutional investors have embraced their responsibility to ensure that their money supports only those businesses and activities that meet their ethical obligation to protect environmental and social values. One report published in 2022 found that 96% of the world’s 250 largest companies by revenue report publicly on “environmental, social, and governance” (ESG) or sustainability matters.¹⁰⁸ Pressure to meet ethical standards comes from a wide range of stakeholders, including shareholders, investors, and consumers. Increasingly, public and private entities profess to embrace ESG obligations as part of their organizational culture.

What this means and how it translates into organizational decisionmaking for companies involved in producing, processing, or sourcing minerals is far from clear. A good place to start, however, is with a guide produced by a private company called TechTarget.¹⁰⁹ One common criticism of ESG policies is that they lack consistent, transparent, and strict content. This allows companies to greenwash, making them appear more environmentally friendly than they really are. The TechTarget guide helps to address this concern.

The guide begins by briefly describing the general content of the “three pillars” of ESG:

- **Environmental.** Examples of environmental factors include energy consumption; water usage; greenhouse gas (GHG) emissions and overall carbon foot-

print; waste management; air and water pollution; deforestation; biodiversity loss; and adaptation to climate change.

- **Social.** The social factors of ESG involve a company’s treatment of employees, supply chain workers, customers, community members, and other groups of people. Examples include fair pay and living wages; diversity, equity, and inclusion programs; workplace health and safety; fair treatment of customers and suppliers; responsible sourcing; oversight of supply chain partners; community engagement; charitable donations; and social advocacy.
- **Governance.** This involves the internal management practices, policies, and controls that govern how a company operates. Examples include the composition of senior management and the board of directors; executive compensation; financial transparency; regulatory compliance; risk management; data privacy policies; ethical business practices; and rules on corruption, bribery, conflicts of interest, and political lobbying.¹¹⁰

While not specific to the minerals industry, these suggested standards seem especially apropos to that industry. In the context of environmental concerns, for example, an ESG policy should address the company’s environmental impact by including specific information on pollution, chemical use, and climate impacts, including the carbon footprint of its operations. First and foremost, a robust ESG policy should require mining companies, mineral processing companies, and companies that use minerals in the production of goods to engage in a comprehensive, public-facing environmental and social impact assessment process.¹¹¹ The assessment should address a wide range of environmental and social issues implicated by the company’s actions, including, for example, water pollution, water resource depletion, waste disposal, tailings dam design and safety, deforestation, and the company’s plan to meaningfully engage with affected communities throughout the development and operation of the project.¹¹²

Government regulators may set standards for some of these issues, but investors and stakeholders increasingly demand that they be addressed irrespective of government requirements. In this regard, mining companies would be well-advised to commit to global standards such as those established by the Initiative for Responsible Mining Assur-

106. Amanda Stutt, *How the State of Wyoming Could Supply the US With Rare Earth Elements*, MINING.COM (Nov. 18, 2022), <https://www.mining.com/how-the-state-of-wyoming-could-supply-the-us-with-rare-earth-elements/>.

107. *Biden-Harris Administration Invests \$16 Million to Build America’s First-of-a-Kind Critical Minerals Production Facility*, U.S. DEP’T ENERGY (Apr. 4, 2023), <https://www.energy.gov/articles/biden-harris-administration-invests-16-million-build-americas-first-kind-critical-minerals>; see also Cristian Tun-su et al., *Recovery of Critical Materials From Mine Tailings: A Comparative Study of the Solvent Extraction of Rare Earths Using Acidic, Solvating, and Mixed Extractant Systems*, 218 J. CLEANER PROD. 425 (2019).

108. See TECHTARGET, *ESG STRATEGY AND MANAGEMENT: COMPLETE GUIDE FOR BUSINESSES 3* (2023), https://cdn.ttgthatmedia.com/tms/editorial/ESG_Pillar_PDFdownload.pdf [hereinafter TECHTARGET GUIDE]. That same report found “96% of the companies in the S&P 500 and 81% of the ones in the Russell 1000 Index published sustainability reports in 2021.” *Id.*

109. *Id.*

110. *Id.*

111. See, e.g., INTERNATIONAL UNION FOR CONSERVATION OF NATURE, ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) (2020), <https://www.iucn.org/sites/default/files/2022-05/esms-environmental-and-social-impact-assessment-esia-guidance-note.pdf>.

112. See BAKER MCKENZIE, *INTRODUCTION TO ENVIRONMENTAL, SOCIAL, AND GOVERNANCE (ESG) CONSIDERATIONS FOR THE MINING SECTOR: REPORTING OBLIGATIONS AND INVESTOR EXPECTATIONS*, https://www.bakermckenzie.com/-/media/files/insight/events/2020/02/bakermckenzie_miningindaba_esgconsiderationsfeb20_v2.pdf.

ance (IRMA).¹¹³ With respect to tailing facilities at mine sites, companies should commit to complying with the Global Tailings Standard,¹¹⁴ which was developed under a joint program sponsored by the mining industry, the investment community, and the United Nations Environment Programme.¹¹⁵

The social pillar of an ESG policy calls for organizations to ensure, among other things, fair pay for employees. All employees should receive a living wage commensurate with their contribution to the success of not just production goals, but also the company's ESG goals. As described in the discussion on governance, a fair employee wage should also be set to avoid the gross compensation disparities that often exist between employees and the executives running the company.

The social section of the ESG policy should also address the organization's policies on and commitment to inclusion and diversity. "Diversity," of course, can be defined in many different ways, but it should at a minimum recognize the importance of bringing in employees and managers with diverse backgrounds, and especially those who have been disadvantaged in terms of wealth and educational opportunities.¹¹⁶

Companies must also recognize the importance of sourcing minerals from places that respect human rights, eschew child labor, and meet strict environmental standards. This will incentivize countries with poor records on these issues to improve their practices or risk the loss of business.

Workplace health and safety are another major concern, especially at large mining operations. The failure of tailings dams at Brumadinho¹¹⁷ in 2019 and Samarco¹¹⁸ in 2015, both in Brazil, resulted in hundreds of deaths and massive environmental damage and put a spotlight on safe mining practices. As noted above, adherence to IRMA and the Global Tailings Standard could go a long way to avoiding these problems.

Finally, an organization's social policies should describe their outreach to the communities that they serve, including their financial and other commitments to those communities. Large organizations benefit greatly from the infrastructure that their local communities provide. These include a wide range of amenities such as schools, parks,

libraries, and water and sewage treatment. Although these amenities greatly benefit companies and their employees, they are largely subsidized by the broader community. Recognizing this, companies should commit to funding and improving local infrastructure commensurate with, and perhaps even beyond, the value that they receive from their use and reliance on that infrastructure.

Organizational outreach must include a commitment to meaningful community engagement. Among other things, this means respect for community preferences, and affording Indigenous communities the right to exercise "free, prior, and informed consent"¹¹⁹ before a project goes forward.

The governance pillar requires companies to follow the highest ethical standards. This includes an honest review of the company's policies on executive compensation, and a commitment to addressing gross disparities between executive pay and employee compensation.¹²⁰ A study by the Economic Policy Institute in 2022 found that "the ratio of CEO [chief executive officer]-to-typical-worker compensation was 399-to-1 . . . up from 366-to-1 in 2020 and a big increase from 20-to-1 in 1965 and 59-to-1 in 1989."¹²¹ The study found:

CEOs are getting ever-higher pay over time because of their power to set pay and because so much of their pay (more than 80%) is stock-related. They are not getting higher pay because they are becoming more productive or more skilled than other workers, or because of a shortage of excellent CEO candidates.¹²²

One strategy used by some companies is to tie CEO and other executive pay and bonuses to meeting ESG goals. It is not at all clear, however, that these bonuses actually advance ESG goals, and they can, of course, exacerbate pay disparities that already exist. Thus, they should not be used at all absent some evidence that they actually work.¹²³

Income inequality is a global problem and, as the data suggest, has been growing much worse over time. A reasonable goal in an ESG policy would be to drive down the ratio between executive pay and that of the typical worker.

Another important governance policy involves transparency and disclosure of information in the public interest. This has become an increasingly important issue with respect to policies that affect climate change. The Financial Stability Board created the Task Force on Climate-

113. IRMA, *Home Page*, <https://responsiblemining.net/> (last visited Nov. 16, 2023).

114. Global Tailings Review, *Global Industry Standard on Tailings Management*, <https://globaltailingsreview.org/global-industry-standard/> (last visited Dec. 11, 2023) (The author was a member of the expert panel that recommended the Global Tailings Standard.).

115. The sponsors included the International Council on Mining and Metals (<https://www.icmm.com/>), Principles for Responsible Investment (<https://www.unpri.org/>), and the United Nations Environment Programme (<https://www.unep.org/>) (last visited Nov. 16, 2023).

116. *Diversity and Inclusion Are More Than the "S" in ESG*, GLOB. DIVERSITY PRAC. (Dec. 16, 2021), <https://globaldiversitypractice.com/diversity-and-inclusion-are-more-than-the-s-in-esg/>.

117. See Shasta Darlington et al., *A Tidal Wave of Mud*, N.Y. TIMES (Feb. 9, 2019), <https://www.nytimes.com/interactive/2019/02/09/world/americas/brazil-dam-collapse.html>.

118. See Phoebe Weston, *Victims of Brazil's Worst Environmental Disaster to Get Day in UK Courts*, GUARDIAN (July 8, 2022), <https://www.theguardian.com/environment/2022/jul/08/uk-court-of-appeal-case-victims-brazil-mariana-dam-collapse-aoe>.

119. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, FREE, PRIOR, AND INFORMED CONSENT: AN INDIGENOUS PEOPLES' RIGHT AND A GOOD PRACTICE FOR LOCAL COMMUNITIES—A MANUAL FOR PROJECT PRACTITIONERS (2016), <https://www.fao.org/3/i6190e/i6190e.pdf>.

120. Kyle Peterdy, *Human Capital Management (HCM)*, CORP. FIN. INST. (June 16, 2022), <https://corporatefinanceinstitute.com/resources/esg/human-capital-management-hcm/>.

121. JOSH BIVENS & JORI KANDRA, ECONOMIC POLICY INSTITUTE, CEO PAY HAS SKYROCKETED 1,460% SINCE 1978 (2022), <https://files.epi.org/uploads/255893.pdf>.

122. *Id.*

123. Evie Liu, *CEOs Are Earning Big Bucks for Hitting ESG Goals. Is It Just Another Way to Raise Pay?*, BARRON'S (May 30, 2023), <https://www.barrons.com/articles/ceo-pay-esg-3414f9f3>.

Related Financial Disclosures (TCFD) as a voluntary tool that organizations can use to disclose information about their climate impacts.¹²⁴ A proposed U.S. Securities and Exchange Commission (SEC) disclosure rule,¹²⁵ published in March 2022, would set mandatory climate-related disclosure requirements, and the SEC used the TCFD tool in developing its proposal. If adopted, the rule would require companies to disclose in their registration statements and annual reports how they assess, measure, and manage climate-related risks. This would include disclosure of GHG emissions.

Much ink has been spilled over the question of whether the SEC disclosure rule might run afoul of the U.S. Supreme Court's newly minted major questions doctrine.¹²⁶ That doctrine denies agencies the power to regulate in areas of major political or economic significance without explicit approval from the U.S. Congress. Whether or not the rule is finally promulgated and whether it survives judicial scrutiny, ESG policies should nonetheless ensure full disclosure of all expected environmental impacts from their activities, including GHG emissions, and they should set ambitious goals for minimizing climate-related risks from their activities.

For example, mining causes significant land disturbance, uses massive amounts of energy, and can generate substantial air and water pollution. Companies should establish a baseline for these impacts and set goals to minimize pollution, and restore impacted resources. Likewise, companies should set goals for transitioning to renewable energy and reducing their GHG emissions.¹²⁷

In addition to these broad standards set forth in the TechTarget guide, several more specific ESG policies should be addressed. First, and in accordance with good governance principles, the ESG policy itself should be the product of a meaningful and transparent process. Here again, the guide offers good advice.¹²⁸ First, it emphasizes the importance of involving both internal and external stakeholders, including investors, shareholders, employees, and other interested parties. For companies engaged in mining operations or mine processing facilities, this will require special attention to the potential for local community impacts. Second, it

emphasizes the importance of focusing on the most important issues as a way of setting ESG priorities. Third, it recommends establishing baseline data so that it is easier to measure how performance has changed over time. It then lays out several recommendations for setting goals, establishing strategies for meeting those goals, measuring and reporting on their progress, and analyzing the results. The guide acknowledges the importance of establishing metrics to measure and audit that performance, but it does not offer specific guidance for how this might be done.

A sound program for assessing the success of ESG policies requires something akin to the popular SMARTIE approach (formerly SMART). SMARTIE goals have been described as “Strategic, Measurable, Ambitious, Realistic, Time-bound, Inclusive, and Equitable.”¹²⁹ Regularly measuring an organization's ESG performance with SMARTIE goals, publishing the results, adapting their policies and practices as necessary to meet those goals, and, if necessary, revising the goals to reflect new information that comes in from the monitoring program, are all critical steps in achieving an effective and meaningful ESG policy. For mining and mineral processing operations, SMARTIE goals should address all or most of the issues set forth under the guide's discussion of the three pillars—environment, social, and governance.

Finally, the guide recommends periodic review and revision of ESG policies. Review and revision should flow naturally for companies that follow something like the SMARTIE approach to measuring success in meeting the established goals. But as suggested above, ESG policies will have to be nimble and capable of adapting to new information and changing circumstances as they arise.¹³⁰

While adhering to the three pillars will impose costs, the guide sets out five reasons why compliance should be an economic winner in the long run. First, it can give companies a competitive advantage. Properly promoted, a successful ESG program will be applauded by customers and investors alike, which should improve a company's market position. Second, a sound ESG policy will make a company more attractive to investors, many of whom have established their own ESG policies. Third, ESG policies make good economic sense by reducing energy and other operating costs, and minimizing the liability risks associated with large and small disasters. Fourth, companies that adopt strong ESG policies will increase customer and employee loyalty. Customers and employees both just feel better working with companies that take corporate social responsibility seriously. Finally, good ESG policies make it easier for companies to adapt to changing legal

124. TCFD, *Home Page*, <https://www.fsb-tcfd.org/> (last visited Nov. 16, 2023).

125. Enhancement and Standardization of Climate-Related Disclosures for Investors, 87 Fed. Reg. 21334 (proposed Apr. 11, 2022) (to be codified at 17 C.F.R. pts. 210, 229, 232, 239, 249), available at <https://www.sec.gov/files/rules/proposed/2022/33-11042.pdf>.

126. See PAUL BARKET ET AL., KIRKLAND & ELLIS, THE MAJOR QUESTIONS DOCTRINE REIGNS SUPREME IN *West Virginia v. Environmental Protection Agency*—IMPLICATIONS FOR CLIMATE POLICY AND IMPACT INVESTING (2022), <https://www.kirkland.com/-/media/publications/alert/2022/07/the-major-questions-doctrine-reigns-supreme-in-wes.pdf?rev=8f13edd200fe4a26adeb03820061f563>; Bill Flook, *In Wake of Supreme Court Emissions Decision, SEC Climate Disclosures Seen on Firmer Ground Than EPA Plan*, THOMSON REUTERS (July 8, 2022), <https://tax.thomsonreuters.com/news/in-wake-of-supreme-court-emissions-decision-sec-climate-disclosures-seen-on-firmer-ground-than-epa-plan/>. The major questions doctrine was first announced in *West Virginia v. Environmental Protection Agency*, 142 S. Ct. 2587, 52 ELR 20077 (2022).

127. Mehdi Azadi et al., *Transparency on Greenhouse Gas Emissions From Mining to Enable Climate Change Mitigation*, 13 NATURE GEOSCI. 100 (2020), available at <https://doi.org/10.1038/s41561-020-0531-3>.

128. See TECHTARGET GUIDE, *supra* note 108, at 8-9.

129. SMART stands for specific, measurable, attainable (or achievable), relevant (or realistic), and time-bound goals. See Andrew Farrelly, *Get Real SMART: Setting Goals—Well*, RISING TIDE CAP. (Aug. 17, 2017), <https://risingtidecapital.org/blog/2017/08/17/get-real-smart-setting-goals-well/>. SMARTIE is an updated version that includes inclusivity and equity. See Management Center, *SMARTIE Goals Worksheet*, <https://www.managementcenter.org/resources/smartie-goals-worksheet/> (last visited Dec. 11, 2023).

130. See TECHTARGET GUIDE, *supra* note 108, at 8-9.

and physical environments, including from the impacts of climate change.¹³¹

Despite the apparent advantages of ESG programs, political blowback from conservative groups is on the rise. In the United States, several state legislatures have introduced and adopted laws that punish companies that make ESG commitments.¹³² Such laws include, for example, one that bars firms that “boycott” fossil fuel energy companies from doing new business in West Virginia.¹³³ The same political fractures that have stalled government action on climate change are now bleeding into the private sector as well, forcing corporations to carefully weigh concerns from both sides of the political aisle on the issue of ESG.

Notwithstanding this blowback, a growing number of conservative commentators have criticized the anti-ESG movement as trying to push private corporations toward certain values rather than allowing the capital markets to determine investment choices.¹³⁴ Indeed, it seems odd that states would object to efforts to promote corporate social responsibility, especially when investors, shareholders, and consumers often demand it.

ESG goals are particularly important to parties seeking to source minerals. While companies have historically relied on mines to source minerals, a greater focus on recycling could significantly reduce the need for mining. Likewise, companies that produce renewable energy products should work to increase the useful life of their products, thereby further reducing the need for additional mining. Where relevant to a company’s business, ESG goals should be set for acquiring recycled minerals and/or extending the useful life of its products. Even with best efforts to recycle and extend the life of products, additional mining will be necessary. In that case, ESG goals should establish protocols that ensure minerals are sourced from mining operations that avoid child labor, respect human rights, and follow clear standards to protect the environment and minimize GHG emissions.

Each of these issues—recycling, extending the useful life of products, and responsible sourcing—are addressed more fully below.

A. Recycling

Given the economic and human costs associated with undertaking new mining operations, ESG goals should

incentivize efforts to maximize recycling. Too often, however, countries incentivize mining and not recycling. A 2014 study comparing subsidies for the Swedish mining and recycling industries found that per ton of metal produced, “the Swedish mining sector, depending on perspective, was subsidized more highly at a rate of 7 or 700 times greater than the recycling sector.”¹³⁵ Given the external costs associated with mining that are foisted on society and rarely captured in the marketplace, policies like these should be reversed.

For metals like copper, aluminum, and nickel, recycling may come from a variety of sources. Copper is used in a wide range of applications, and most of that copper is not available for recycling because an estimated “two-thirds of the 690 million tons of copper produced are still in productive use.”¹³⁶ Still, approximately 32% of copper needs are currently satisfied from recycled copper, and as previously noted, recycled copper could satisfy 55% of copper demand by 2040.¹³⁷ Much of that copper will come from recycling old electronics equipment and wiring. For example, new processes allow the recycling of copper and aluminum from old circuit boards that currently end up in the waste stream.¹³⁸

Aluminum may be the most commonly recycled metal, and it retains its quality even when recycled over and over again. The International Aluminium Institute estimates that “[a]lmost 75 per cent of the 1.5 billion tonnes of aluminium ever produced is still in use today.”¹³⁹ Nickel is fully recyclable and recycled nickel remains of high quality. Most nickel recycling comes from stainless steel, but an increasing percentage will come from recycling spent rechargeable batteries.¹⁴⁰

Recycling opportunities for REEs also hold promise. Neodymium and dysprosium can be sourced from recycled computer hard disk drives, which frequently used these rare earth minerals. Old hard drives are potentially available in the billions.¹⁴¹

For many other minerals, the best chance for maximizing recycling will come from used batteries. Tesla recently claimed, for example, that it can recycle 92% of the materials from its EV batteries, including copper, nickel, and

131. See *id.* at 6.

132. See Charles Donefer, *State ESG Laws in 2023: The Landscape Fractures*, THOMSON REUTERS (May 31, 2023), <https://www.thomsonreuters.com/en-us/posts/esg/state-laws/>; Ross Kerber et al., *U.S. Finance Faces ESG Backlash, More to Come in 2023*, REUTERS (Dec. 27, 2022), <https://www.reuters.com/business/sustainable-business/us-finance-faces-esg-backlash-more-come-2023-2022-12-27/>.

133. Pete Schroeder, *How Republican-Led States Are Targeting Wall Street With “Anti-Woke” Laws*, REUTERS (July 6, 2022), <https://www.reuters.com/world/us/how-republican-led-states-are-targeting-wall-street-with-anti-woke-laws-2022-07-06/>.

134. Jennifer Schulp, *Anti-ESG Legislation Is Demonstrating the Peril of Meddling in Markets*, PROMARKET (June 14, 2023), <https://www.promarket.org/2023/06/14/anti-esg-legislation-is-demonstrating-the-peril-of-meddling-in-markets/>.

135. Nils Johansson et al., *Institutional Conditions for Swedish Metal Production: A Comparison of Subsidies to Metal Mining and Metal Recycling*, 41 RES. POL’Y 72, 77 (2014), available at <https://www.sciencedirect.com/science/article/abs/pii/S0301420714000324?via%3Dihub>.

136. See Copper Alliance, *Copper Recycling*, <https://copperalliance.org/resource/copper-recycling/> (last visited Nov. 16, 2023).

137. See EARTHWORKS REPORT II, *supra* note 45.

138. See, e.g., Pedro Jorge Walburga Kegelich de Buzin et al., *Development of a Physical Separation Route for the Concentration of Base Metals From Old Wasted Printed Circuit Boards*, 11 MINERALS 1014 (2021), available at <https://doi.org/10.3390/min11091014>.

139. See International Aluminium, *Recycling*, https://international-aluminium.org/work_areas/recycling/ (last visited Nov. 16, 2023). The United Kingdom uses the word “aluminium”; Americans use “aluminum.” Both refer to the metal with atomic number 13.

140. Umicore, *Nickel*, <https://www.umicore.com/en/about/our-metals/nickel/> (last visited Nov. 16, 2023).

141. James D. Widmer et al., *Electric Vehicle Traction Motors Without Rare Earth Magnets*, 3 SUSTAINABLE MATERIALS & TECHS. 7, 9 (2015), available at <https://doi.org/10.1016/j.susmat.2015.02.001>.

cobalt.¹⁴² If anything close to recycling rates consistent with this claim can be achieved industrywide, the demand for EV battery minerals from new mining operations could be significantly reduced.

Given its high potential, incentives should be offered to encourage cutting-edge research into improving the scope and scale of battery recycling.¹⁴³ Beyond basic research, governments should impose mandatory end-of-life recycling requirements for EV battery makers and EV car manufacturers with a goal of increasing the percentage of recycled metals that are recovered over time. Government agencies could also encourage or mandate end-of-life electronics recycling by the producers of electronic goods. Such programs would encourage the development of more efficient recycling processes.¹⁴⁴

Recycling could also benefit from limiting the export of e-waste. Currently, only about 35% of U.S. e-waste is recycled,¹⁴⁵ but much of what remains is exported to developing countries where it is often disposed of unsafely.¹⁴⁶ A federal law promoting e-waste recycling¹⁴⁷ could go a long way to addressing these issues but in the absence of federal legislation, some states have stepped up. At least 25 states have laws that address the e-waste problem.¹⁴⁸ Moreover, some companies, such as Staples, offer free recycling of certain electronic equipment,¹⁴⁹ and the government could partner with private companies like Staples to expand these programs.

Recycling of a wide range of other electronic equipment also holds much promise. The EU has been a leader in the field with its Waste From Electrical and Electronic Equipment (WEEE) program.¹⁵⁰ WEEE follows an extended producer responsibility principle whereby producers are responsible for the collection, treatment,

and monitoring of such equipment, including solar panels.¹⁵¹ The WEEE Directive set collection, recycling, and recovery targets for electrical goods. The standards developed for meeting these targets and their enforcement are regulated by both national governments and private nonprofit groups such as the European Committee for Standardization, the European Committee for Electro-technical Standardization (CENELEC), and the WEEE Excellence Label (WEEELABEX).

The two main standards for meeting the targets set by the WEEE Directive are the CENELEC and WEEELABEX standards. Both of these standards contain requirements that go beyond the requirements of the original WEEE Directive.¹⁵² As of 2019-2020, 630 out of 2,860 WEEE treatment plants in the EU were operating in compliance with CENELEC/WEEELABEX standards; 180 of those were issued certificates by the WEEELABEX organization while the rest were either certified by an outside auditor or by self-declaration.¹⁵³ Five EU nations—Ireland, France, the Netherlands, Slovenia, and Lithuania—have made compliance with either CENELEC or WEEELABEX standards obligatory by law.¹⁵⁴ Nine other EU States impose other legal requirements beyond those of the WEEE Directive (Ireland is in both these categories).¹⁵⁵

The remaining EU States imposed no requirements beyond those of the WEEE Directive.¹⁵⁶ This represents a policy debate of whether it is better to set WEEE standards down in law, or to tie producers' legal requirements to standards dictated by private groups such as CENELEC. Both policies have advantages and disadvantages; examining the results of these policy choices in EU countries can give other nations guidance in how to regulate their electronic waste recycling.

While all EU States require compliance with at least the WEEE Directive, the implementation of these requirements varies across Europe. Greece, for instance, has major logistical issues given that 80% of WEEE there is collected by scrap dealers in an unsorted manner.¹⁵⁷ Nonetheless, the WEEE program has been effective, with the EU recycling between 80%-84% of separately collected WEEE from 2011-2020.¹⁵⁸ The majority of WEEE collected is from large household appliances (51.8% of WEEE collected in 2019)¹⁵⁹; improving the recycling rates of critical minerals

142. Fred Lambert, *Tesla Claims 92% Battery Cell Recovery in New Recycling Process*, ELECTREK (Aug. 9, 2021), <https://electrek.co/2021/08/09/tesla-battery-cell-material-recovery-new-recycling-process/>.

143. One study suggests that “it is technologically possible to recover [cobalt, lithium, copper, and nickel] . . . at rates above 90%.” EARTHWORKS REPORT II, *supra* note 45, at ii. Current recovery rates lag well below that figure. Government mandates, perhaps coupled with economic incentives to recycle, could greatly increase recycling rates, thereby reducing demand for sourcing minerals from mining operations.

144. Yue Tan & Chunxiang Guo, *Research on Two-Way Logistics Operation With Uncertain Recycling Quality in Government Multi-Policy Environment*, 11 SUSTAINABILITY 882 (2019), available at <https://doi.org/10.3390/su11030882>.

145. Callie Babbitt & Shahana Althaf, *Mounting E-Waste Is Harming the Planet. Here's How We Solve the Problem*, WORLD ECON. F. (Jan. 18, 2021), <https://www.weforum.org/agenda/2021/01/consumer-electronics-managing-e-waste/>.

146. Amit Kumar et al., *E-Waste: An Overview on Generation, Collection, Legislation, and Recycling Practices*, 122 RES. CONSERVATION & RECYCLING 32, 38 (2017), available at <https://doi.org/10.1016/j.resconrec.2017.01.018>.

147. Renee Cho, *What Can We Do About the Growing E-Waste Problem?*, COLUM. CLIMATE SCH.: STATE PLANET (Aug. 27, 2018), <https://news.climate.columbia.edu/2018/08/27/growing-e-waste-problem/>.

148. Electronics Recycling Coordination Clearinghouse, *Map of States With Legislation*, <https://www.ecycleclearinghouse.org/contentpage.aspx?pageid=10> (last visited Nov. 16, 2023).

149. Staples, *Sustainability*, https://www.staples.com/sbd/cre/noheader/about_us/corporate-responsibility/environment/ (last visited Nov. 17, 2023).

150. European Commission, *Waste From Electrical and Electronic Equipment (WEEE)*, https://environment.ec.europa.eu/topics/waste-and-recycling/waste-electrical-and-electronic-equipment-weee_en (last visited Nov. 16, 2023).

151. EARTHWORKS REPORT I, *supra* note 6, at 47.

152. MARIA TESAR ET AL., EUROPEAN COMMISSION, STUDY ON QUALITY STANDARDS FOR THE TREATMENT OF WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE): FINAL REPORT 34 (2021), <https://data.europa.eu/doi/10.2779/69374>.

153. *Id.* at 13.

154. *Id.* at 40.

155. *Id.*

156. *Id.* at 44.

157. *Id.* at 56.

158. Eurostat, *Recycling Rate of Waste Electrical and Electronic Equipment (WEEE) Separately Collected*, https://ec.europa.eu/eurostat/databrowser/view/cei_wm060/default/table?lang=en (last updated Oct. 23, 2023).

159. EUROSTAT, ENERGY, TRANSPORT, AND ENVIRONMENT STATISTICS 118 (2020 ed.), <https://ec.europa.eu/eurostat/documents/3217494/11478276/KS-DK-20-001-EN-N.pdf/06dda8d-1745-76b5-838e-013524781340?t=1605526083000>.

will require increased collection of the renewable end uses of critical minerals such as PV solar panels.

The U.S. Environmental Protection Agency (EPA) offers advice on recycling used PV solar panels with opportunities to recycle glass, aluminum, copper, and other materials.¹⁶⁰ While such advice is welcome, mandates requiring manufacturers to recycle those parts of panels that can be reasonably recycled seem like an obvious next step.

Likewise, virtually every part of a wind turbine can be recycled,¹⁶¹ and as with PV manufacturers, wind turbine manufacturers should be required to take back and recycle old turbines. Danish wind turbine manufacturer Vestas has recently claimed to have engineered a chemical process that can break down epoxy-based turbine blades into virgin-grade material.¹⁶² This process, developed in conjunction with two Danish universities and an epoxy manufacturer, would allow for the recycling of even wind turbine blades currently sitting in landfills, as well as eliminating the need to redesign blades for sustainability purposes.¹⁶³ While wind turbine blades may already be recycled into other products, being able to recycle blades back into the blade production cycle will cut down on the resources needed to manufacture new blades.

E-waste minerals recycling also requires special attention to ensure that it is carried out responsibly. E-waste recycling processes used in some parts of the developing world pose serious health and environmental risks, with workers collecting toxic metals by hand and using dangerous acids.¹⁶⁴ These risks fall especially hard on small children and pregnant women. The World Health Organization notes that “[c]hildren are often engaged by parents or caregivers in e-waste recycling because their small hands are more dexterous than those of adults.” Further, many children live, attend school, or play near e-waste recycling centers where they are exposed to high levels of toxic chemicals, including neurotoxins like lead and mercury.¹⁶⁵

Expectant mothers who work with e-waste face stillbirths, premature births, and low birth weights. Children born to these mothers typically face a host of behavioral and neurological problems and impaired cognitive development.¹⁶⁶

160. U.S. EPA, *Solar Panel Recycling*, <https://www.epa.gov/hw/solar-panel-recycling> (last updated June 20, 2023).

161. *Can Wind Turbines Be Recycled?*, ENGIE (Sept. 8, 2021), <https://www.engie.com/en/activities/renewable-energies/wind-energy/recycling-wind-turbines>.

162. Michelle Lewis, *A Danish Wind Turbine Giant Just Discovered How to Recycle All Blades*, ELECTREK (Feb. 8, 2023), <https://electrek.co/2023/02/08/wind-turbine-recycle-blades/>.

163. Press Release, Vestas Wind Systems A/S, Vestas Unveils Circularity Solution to End Landfill for Turbine Blades (Feb. 8, 2023), <https://www.vestas.com/en/media/company-news/2023/vestas-unveils-circularity-solution-to-end-landfill-for-c3710818>.

164. EARTHWORKS REPORT I, *supra* note 6, at 44.

165. News Release, World Health Organization, Soaring E-Waste Affects the Health of Millions of Children, WHO Warns (June 15, 2021), <https://www.who.int/news/item/15-06-2021-soaring-e-waste-affects-the-health-of-millions-of-children-who-warns>.

166. *Id.* Informal e-waste recycling can also contaminate water supplies and soils. For example, in the Mandoli industrial area in India, “elevated contents of heavy metals at an alarming rate [were found] in environmental samples collected from an e-waste recycling area.” Jatindra Kumar Pradhan & Sudhir Kumar, *Informal E-Waste Recycling: Environmental Risk Assessment of Heavy*

All of this points to the need for ESG policies that prioritize sourcing of recycled minerals while at the same time ensuring the recycled minerals are not being produced at the expense of children, pregnant women, or the environment.

B. Increasing Product Life, Especially for Batteries

Extending the life of PV panels and wind turbines by even a few years would result in significant savings of minerals. Government standards that ensure high-quality production methods could help guarantee increased longevity for these products. While technological advances, in the long run, may be a bigger factor in replacing these products, the old devices could perhaps be repurposed if they are still capable of producing electricity.

Increasing the life-span of products is especially important for EV and storage batteries. EV batteries are projected to last between 100,000 and 200,000 miles, or about 15 to 20 years.¹⁶⁷ Further, researchers are finding ways to extend battery life by 15 years¹⁶⁸ and as much as 30%.¹⁶⁹ In an effort to push these strategies, the California Air Resources Board has proposed degradation limits that would require all 2026-and-later battery-EVs sold in the state to be designed to maintain 80% of their certified range for either 15 years or 150,000 miles.¹⁷⁰ Longer battery life necessarily translates into less demand for new batteries and the metals they require.

With this in mind, companies should consider ESG goals that would lead to an extension of the useful life of renewable energy products over time. So, for example, an ESG goal might be for batteries to maintain 80% of their certified range for 15 years and 150,000 miles by 2026, then 20 years and 200,000 miles by 2030.

C. Responsible Sourcing

While recycling and recovery of minerals from end-of-life renewable equipment and other electronics, along with extending the useful life of renewable energy devices, will help reduce the demand for virgin minerals, a certain amount of new mining seems inevitable and probably necessary to achieve renewable energy goals. But following ESG principles, manufacturers and end-users can demand that virgin minerals come from sources that meet mini-

Metal Contamination in Mandoli Industrial Area, Delhi, India, 21 ENV'T SCI. & POLLUTION RSCH. 7913 (2014), available at <https://doi.org/10.1007/s11356-014-2713-2>.

167. EV Box, *How Long Do Electric Car Batteries Last?*, <https://blog.evbox.com/ev-battery-longevity> (last updated May 7, 2023).

168. *Electric Car Battery Life Extended by a Revolutionary Polymer Coating*, ASM INT'L (Apr. 21, 2023), <https://www.asminternational.org/electric-car-battery-life-extended-by-a-revolutionary-polymer-coating/>.

169. Stephen Edelstein, *Research Could Help Extend EV Battery Life by 30%, Slow Degradation*, GREEN CAR REPS. (Jan. 12, 2022), https://www.greencarreports.com/news/1134713_research-could-help-extend-ev-battery-life-by-30-slow-degradation.

170. Bengt Halvorson, *How Long Will My EV Battery Last? California Proposes Degradation Limits*, GREEN CAR REPS. (May 27, 2021), https://www.greencarreports.com/news/1132401_how-long-will-my-ev-battery-last-california-proposes-degradation-limits.

mum standards for avoiding child labor, protecting human rights, and insisting that mining operations conform with essential environmental and safety standards.

As previously noted, IRMA established a Standard for Responsible Mining that aligns with ESG principles.¹⁷¹ In addition to setting strict standards, IRMA audits mines that apply for certification to ensure their compliance. At present, only a handful of mines have even applied for certification, so it is presently impractical to demand IRMA certification when sourcing minerals. Nonetheless, the IRMA standard can provide companies looking to source minerals with parameters to guide responsible mining practices.

Companies interested in responsible mineral sourcing have no shortage of other guidance and resources, including the Organisation for Economic Co-operation and Development's (OECD's) Due Diligence Guidance for Responsible Supply Chains for Minerals From Conflict-Affected and High-Risk Areas,¹⁷² the Responsible Mineral Initiative,¹⁷³ the Responsible Cobalt Initiative,¹⁷⁴ and the Global Industry Standard on Tailings Management.¹⁷⁵ In the aggregate, these standards and guidance documents can also help government regulators to evaluate the adequacy of mine permit applications, thereby minimizing the likelihood that renewable energy companies may either choose to or unknowingly source minerals from mines that fail to meet minimum standards.

V. The Role of Government in Mineral Development

Government plays an important role in bringing new renewable energy facilities online. Most such facilities require approvals from federal, state, and local government agencies to operate, and the government approval process can create a logjam that stymies development. As developers ramp up the construction of new facilities to meet climate goals, they will impose an enormous administrative burden on government agencies. To meet this challenge, the government will have to find ways to streamline the approval process without unduly jeopardizing compliance with important environmental standards.

Obviously, the role of government in mineral development varies widely from jurisdiction to jurisdiction, and a comprehensive look at mineral development laws in multiple countries is beyond the scope of this Article. That does not, however, diminish the important role that government

plays in authorizing and overseeing mining operations in their countries. With that in mind, this section focuses on the role played by the government in developing minerals in the United States. While drawing parallels with the practices followed in other countries will be imperfect, the basic principles of mine regulation are likely to be similar in many jurisdictions. One important exception to the notion of parallel practices is the General Mining Law of 1872. Although it is an anachronism, it remains critically important to mineral development in the United States. For that reason, this analysis begins with that law.

A. The General Mining Law of 1872

Most hard-rock mining,¹⁷⁶ which includes mining for nearly all of the critical minerals used in renewable energy development,¹⁷⁷ occurs in the western United States on federal public lands.¹⁷⁸ For more than 150 years, mineral development in the West has been carried out largely under the terms of the General Mining Law of 1872.¹⁷⁹ That law invites mineral prospectors to enter federal public lands and search for valuable minerals. If they find a valuable deposit, they can locate a mining claim after completing certain formalities.¹⁸⁰ Historically, miners could even obtain a patent to the land, whereby they received fee title from the federal government.¹⁸¹ In 1994, however, Congress imposed a moratorium on mineral patents, and that moratorium has been in place ever since.¹⁸²

Notwithstanding persistent and long-standing reform efforts,¹⁸³ the General Mining Law remains the principal law governing hard-rock mineral development on pub-

171. IRMA, *supra* note 113.

172. OECD, OECD DUE DILIGENCE GUIDANCE FOR RESPONSIBLE SUPPLY CHAINS OF MINERALS FROM CONFLICT-AFFECTED AND HIGH-RISK AREAS (2d ed. 2013), https://www.google.com/books/edition/OECD_Due_Diligence_Guidance_for_Responsible/gxWPM6PA3YC?hl=en&gbpv=1&printec=frontcover.

173. Responsible Minerals Initiative, *Home Page*, <https://www.responsiblemineralsinitiative.org/> (last visited Nov. 16, 2023).

174. Responsible and Ethical Private Sector Coalition Against Trafficking, *Responsible Cobalt Initiative (RCI)*, <https://respect.international/responsible-cobalt-initiative-rci/> (last visited Nov. 16, 2023).

175. Global Tailings Review, *supra* note 114.

176. Hard-rock mining is, as the name implies, mining for rocks that are hard. These are typically igneous and metamorphic rocks that contain metals like nickel. This is in contrast with soft-rock mining that focuses on ores like coal. See *Quick Guide to Hard Rock Mining*, UNDERGROUND MINER (Jan. 28, 2021), <https://anundergroundminer.com/blog/quick-guide-to-hard-rock-mining>.

177. "Hard rock mining is mainly concerned with metallic ores." See JACK DE LA VERGNE, STANTEC CONSULTING, *HARD ROCK MINER'S HANDBOOK 2* (2008), https://www.stantec.com/content/dam/stantec/files/PDFAssets/2014/Hard%20Rock%20Miner's%20Handbook%20Edition%205_3.pdf. Metallic ores are principal sources of iron, copper, zinc, manganese, and critical minerals. See Geeks for Geeks, *Metallic Minerals—Definition, Types, Ores, Examples*, <https://www.geeksforgeeks.org/metallc-minerals-definition-types-ores-examples/> (last updated Aug. 16, 2023).

178. See John Leshy, *The Future of Mineral Development on Federal Lands*, in *THE EVOLUTION OF NATURAL RESOURCES LAW AND POLICY 346* (Lawrence MacDonnell & Sarah F. Bates eds., American Bar Association 2010).

179. General Mining Law of 1872, 17 Stat. 91.

180. The mining law states that there must be a finding of "valuable minerals." General Mining Law §29. This has been interpreted using a "prudent-man test" from *United States v. Coleman*, 390 U.S. 599, 602 (1968). This test asks whether "a person of ordinary prudence would be justified in the further expenditure of his labor and means, with a reasonable prospect of success, in developing a valuable mine." *Id.*

181. Pub. L. No. 103-332, §112, 108 Stat. 2499 (1994). In order to obtain a patent, miners needed to complete certain additional requirements as well as pay a nominal fee of either \$2.50/acre for a placer claim or \$5.00/acre for a lode claim. 30 U.S.C. §42.

182. See Bureau of Land Management (BLM), *Patents*, <https://www.blm.gov/programs/energy-and-minerals/mining-and-minerals/locatable-minerals/patents> (last visited Nov. 16, 2023).

183. See U.S. Department of the Interior Office of Congressional and Legislative Affairs, *Mining Law Reform*, <https://www.doi.gov/ocl/mining-law-reform> (last visited Nov. 16, 2023).

lic lands today. While mining claimants may no longer be able to patent lands, they can still locate claims and develop valuable minerals on those claims if they can make a reasonable profit doing so.¹⁸⁴

Judicial decisions can also play a role in how the General Mining Law applies to public lands mining operations. For example, *Center for Biological Diversity v. U.S. Fish & Wildlife Service (Rosemont)*¹⁸⁵ involves one of the thorniest issues facing mine operators (i.e., where to dispose of their mountains of mine tailings and waste rock). The developers of the proposed Rosemont Copper mine in Arizona want to place their 1.9 billion tons of waste rock on 2,447 acres of national forest land where it would remain in perpetuity. The mining company held mining claims on the lands where the waste rock would be placed, but the U.S. Court of Appeals for the Ninth Circuit held that these mining claims are not valid because no valuable minerals have been found on them.¹⁸⁶

One alternative available to mine operators on public lands is to locate “mill sites”¹⁸⁷ on lands that are not mineral in character. Mill sites are authorized for “mining and milling purposes,” and this can include waste rock disposal. But mill sites may not be larger than five acres, and while the Bureau of Land Management’s (BLM’s) current regulations allow multiple mill sites for each mining claim,¹⁸⁸ those rules are currently being challenged in the U.S. Court of Appeals for the District of Columbia (D.C.) Circuit.¹⁸⁹

In a legal opinion issued shortly after the *Rosemont* decision, the U.S. Department of the Interior (DOI) solicitor affirmed the holding in that case, and pointed out several alternatives to mill sites that a mine operator might seek for waste rock disposal.¹⁹⁰ These include obtaining a permit, lease, right-of-way, purchase, or exchange of land, as autho-

ized by the Federal Land Policy and Management Act (FLPMA)¹⁹¹ and its implementing regulations.¹⁹² Unlike mill sites, however, these alternatives are discretionary with the agency, and could involve significant costs to the operator since they would be proposing the permanent occupation or use of public lands.¹⁹³

B. Environmental Standards Applicable to Mining Operations

Both BLM and the U.S. Forest Service have promulgated rules that establish permitting requirements for public land mining operations. For the most part, the BLM and Forest Service rules track one another. Both require a plan of operations (POO) to be submitted prior to the start of operations.¹⁹⁴ Upon receipt of the POO, the relevant agency must prepare a draft and final environmental assessment (EA) or environmental impact statement (EIS) to comply with the National Environmental Policy Act (NEPA),¹⁹⁵ and must ensure compliance with other relevant laws. Information and documentation relevant to complying with these other laws is typically included in the EA or EIS. Mining companies are also required to post a bond adequate to cover the projected cost of reclaiming the land after mining has been completed.¹⁹⁶

NEPA and some additional legal requirements are triggered by federal agency action. Like NEPA, for example, consultations under the Endangered Species Act (ESA)¹⁹⁷ and the National Historic Preservation Act (NHPA)¹⁹⁸ apply only where there is federal agency action. Additional federal permits may also be required for mining operations, such as a discharge permit for pollutants or for dredged and fill material. Indeed, a requirement to obtain discharge permits is generally enough to trigger the obligation to comply with NEPA, the ESA, and the NHPA even if the mining operation is occurring on nonfederal land.

As suggested above, NEPA compliance is generally required for all mining operations that involve some level of federal agency action, even if they are not conducted on federal lands. Among other things, NEPA created the Council on Environmental Quality (CEQ), which has promulgated NEPA rules that bind all federal agencies.¹⁹⁹

Mining for the kinds of minerals used in renewable energy will almost always have significant environmental

184. See *Coleman*, 390 U.S. 599:

Under the mining laws Congress has made public lands available to people for the purpose of mining valuable mineral deposits and not for other purposes. . . . Minerals which no prudent man will extract because there is no demand for them at a price higher than the costs of extraction and transportation are hardly economically valuable. Thus, profitability is an important consideration in applying the prudent-man test

BLM (43 C.F.R. subpt. 3809) and the Forest Service (36 C.F.R. pt. 228) have adopted fairly detailed regulations to address the environmental impacts of mining, but states can impose additional requirements on mining so long as they are not inconsistent with federal standards. See *California Coastal Comm’n v. Granite Rock Co.*, 480 U.S. 572, 17 ELR 20563 (1987).

185. 33 F.4th 1202, 52 ELR 20056 (9th Cir. 2022).

186. *Id.* at 1208. Indeed, had valuable minerals been found on those claims, it is not clear that *Rosemont* could have used the mine as a waste dump. As the Court noted in the *Coleman* case, referenced above, “Congress . . . made public lands available to people for the purpose of mining valuable mineral deposits and not for other purposes.” *Coleman*, 390 U.S. at 601.

187. General Mining Law §15.

188. 43 C.F.R. §3832.32.

189. *Earthworks v. U.S. Dep’t of the Interior*, 496 F. Supp. 3d 472, 50 ELR 20243 (D.D.C. 2020), *appeal pending*.

190. See Memorandum from Solicitor, U.S. Department of the Interior, to Director, BLM, M-37077, Use of Mining Claims for Mine Waste Deposition, and Rescission of M-37012 and M-37057 (May 16, 2023), <https://www.doi.gov/sites/doi.gov/files/m-37077-use-of-mining-claims-for-mine-waste-deposition-508.pdf>. Among other things, this opinion rescinds two prior legal opinions that were inconsistent with *Rosemont* and the new opinion.

191. 43 U.S.C. §§1701-1785, ELR STAT. FLPMA §§102-603.

192. See, e.g., 43 U.S.C. §§1713, 1716, 1719, 1761. See also 43 C.F.R. subpt. 2920.

193. In the case of a purchase or exchange, the land would, of course, no longer be federal, but the process for securing land under these provisions could prove difficult.

194. 36 C.F.R. pt. 228 (Forest Service rule); 43 C.F.R. §§3809.11, 3809.21 (BLM allows for there to be a notice of intent for smaller-scale projects and a POO for larger projects.).

195. 42 U.S.C. §§4321-4370h, ELR STAT. NEPA §§2-209.

196. 36 C.F.R. pt. 228 (Forest Service rule); 43 C.F.R. §§3809.500-599 (BLM rule).

197. 16 U.S.C. §§1531-1544, ELR STAT. ESA §§2-18.

198. 54 U.S.C. §§300101-307112.

199. Exec. Order No. 11991, 3 C.F.R. 124 (1978). See also *Andrus v. Sierra Club*, 442 U.S. 347, 351, 9 ELR 20390 (1979).

impacts, which generally means that the lead agency will have to prepare an EIS when considering a mine permit application on federal lands, and likely when considering whether to approve other significant permits for projects that do not implicate federal lands. The CEQ rules lay out the basic elements of an EIS.²⁰⁰ Among the most important of these is the obligation to consider reasonable alternatives to the proposed project.²⁰¹ For a major mining project, reasonable alternatives might include considering different mining methods, different methods and locations for disposing of waste rock, or even sourcing the needed minerals from recycling, or from other mines that might pose a less significant environmental impact.²⁰²

To be sure, the Supreme Court has repeatedly held that NEPA does not dictate any particular result, including the environmentally preferable result,²⁰³ but agency decisions remain subject to the “arbitrary and capricious” standard under the Administrative Procedure Act. So, an arbitrary rejection of an environmentally preferable alternative might still be enjoined under that standard.²⁰⁴

One strategy for efficiently addressing reasonable alternatives in the context of mining, where multiple proposals are likely to arise, would involve preparation of a “programmatically” EIS.²⁰⁵ Lithium offers a good example of how this might work.

While lithium is an abundant mineral, the wide variety of lithium mining methods, and the disparate environmental impacts associated with those methods, suggest the need for a comprehensive and holistic study that analyzes alternative mining methods and their likely impacts. This would serve at least two important purposes. First, it would guide operators toward preferred lithium mining options that maximize mineral recovery and minimize environmental harm. Second, it would allow an EIS for a particular lithium mine to tier²⁰⁶ to the programmatic study, thereby obviating the need to look at mine development alternatives in the EIS for that mine.

Another important aspect of NEPA is the obligation to engage the public. This includes an obligation to be transparent and afford the public an opportunity to offer comments and otherwise engage agency decisionmakers on a draft EIS.²⁰⁷ Meaningful engagement requires agencies not merely to accept public comments, but to respond to significant comments that they receive. As the D.C. Circuit once noted, “a dialogue is a two-way street: the opportunity to comment is meaningless unless the agency responds to significant points.”²⁰⁸

During the NEPA process, the lead agency must also address other legal requirements. These include most notably two laws that establish somewhat parallel obligations to those established under NEPA. These two laws are the ESA²⁰⁹ and the NHPA.²¹⁰

Like NEPA, certain ESA requirements are triggered by federal agency action.²¹¹ Under the ESA, if a listed species might be present in the action area, then the action agency must prepare a biological assessment to determine if the species or its habitat is likely to be affected by the action.²¹² If so, then the action agency must “consult” with the U.S. Fish and Wildlife Service (FWS).²¹³ By rule, FWS allows most consultations to be handled informally. In this situation, the action agency informally agrees to structure the proposed action to avoid jeopardy to a listed species or adverse modification of its critical habitat.²¹⁴ If the action agency cannot satisfy the informal consultation requirements, then it must proceed to formal consultation.

Under formal consultation, FWS prepares a biological opinion (BO) for the purpose of determining whether the proposed action will jeopardize a listed species or result in adverse modification of critical habitat. If FWS finds jeopardy or adverse habitat modification, then it must suggest reasonable and prudent alternatives that will not cause jeopardy.²¹⁵ In general, a proposed action that jeopardizes a listed species may not go forward unless it receives an extremely rare exemption.²¹⁶ In this way, the ESA has a much stronger substantive bite than NEPA.

The ESA can also impact projects when an action results in the “taking” of a listed species. The term “taking” is very broadly defined in the ESA to encompass any action that results in some injury or harm to a listed species. Limited takings, however, can be allowed if authorized under an FWS BO²¹⁷ or if the proponent of the project obtains

200. 40 C.F.R. §1502.10.

201. *Id.* §1502.14.

202. An example would be analyzing DLE as an alternative to conventional lithium mining with evaporation ponds. Due to the early stages of DLE, it is unlikely a project for traditional lithium mining would be stopped because of the potential for DLE, but as the technology advances, we may start to see DLE as a strongly preferred alternative to traditional lithium mining.

203. “NEPA does set forth significant substantive goals for the nation, but its mandate to the agencies is essentially procedural.” *Vermont Yankee Nuclear Power Corp. v. Natural Res. Def. Council, Inc.*, 435 U.S. 519, 558, 8 ELR 20288 (1978). “NEPA itself does not mandate particular results, but simply prescribes the necessary process.” *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 350, 19 ELR 20743 (1989).

204. *See* *Baltimore Gas & Elec. Co. v. Natural Res. Def. Council, Inc.*, 462 U.S. 87, 97-98, 13 ELR 20544 (1983).

205. *See* CEQ, Final Guidance for Effective Use of Programmatic NEPA Reviews, 79 Fed. Reg. 76986 (Dec. 23, 2014).

206. 40 C.F.R. §1501.11(b) (2022):

When an agency has prepared an environmental impact statement or environmental assessment for a program or policy and then prepares a subsequent statement or assessment on an action included within the entire program or policy (such as a project- or site-specific action), the tiered document needs only to summarize and incorporate by reference the issues discussed in the broader document.

207. 40 C.F.R. §1506.6.

208. *Home Box Off., Inc. v. Federal Commc’ns Comm’n*, 567 F.2d 9, 36 (D.C. Cir. 1977).

209. 16 U.S.C. §§1531-1544.

210. 54 U.S.C. §§300101-307112.

211. The U.S. Fish and Wildlife Service rules appear to limit such agency actions to “major construction activities,” defined as a major federal action under NEPA. No such limit, however, appears in the ESA, so the requirements described here arguably apply to any action that is likely to affect a listed species. *Compare* 50 C.F.R. §§402.2 and 402.12(b)(1), *with* 16 U.S.C. §1536(c).

212. 16 U.S.C. §1536(c).

213. *Id.* §1536(a)(2); 50 C.F.R. §402.14.

214. 50 C.F.R. §402.13.

215. 16 U.S.C. §1536(b).

216. *Id.* §1536(e)-(p).

217. *Id.* §1536(b)(3).

approval for a habitat conservation plan.²¹⁸ In both cases, FWS must ensure that the species will not be worse off if the takings occur.

Mining decisions also often implicate the NHPA.²¹⁹ The NHPA establishes NEPA-like procedures for protecting historic properties, and much like the ESA, documentation of these procedures and public engagement on that documentation is typically handled through the NEPA process. Whenever a federal agency has direct or indirect jurisdiction over a proposed federal “undertaking,” it must consider its impact on any “historic property,” which is defined as “any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on, the National Register of Historic Places.”²²⁰

Federal agencies must make a good-faith effort to identify historic properties, but if it finds that the undertaking will have no effect on such properties, then it must simply notify the state historic preservation office (SHPO) and any relevant tribal historic preservation officer (THPO).²²¹ If neither the SHPO nor THPO objects, the undertaking may proceed. On objection, however, or where an effect is found, then it must consult with the SHPO and THPO. If the agency finds that the effect is not adverse and the SHPO and THPO concur, then the undertaking can proceed.²²² If, however, the undertaking causes adverse impacts, then the agency must notify the Advisory Council on Historic Preservation and consult with the SHPO and THPO to find ways to avoid or mitigate the adverse effects.²²³

Mining operations typically impact large tracts of land, and for that reason, they often adversely impact historic properties. Thus, the NHPA can pose a significant obstacle to mineral development.

In addition to statutes that impose procedural requirements, like NEPA, the ESA, and the NHPA, several substantive laws are often implicated as well. These include, most prominently, the Clean Air Act (CAA) and the Clean Water Act (CWA).²²⁴ The CAA will likely require an emissions permit for fugitive dust emissions and from emissions from heavy machinery. The CWA will likely require pol-

lution discharge permits for disposing of contaminated water from the mining operation, stormwater runoff from the mine area, and releases from mine tailings impoundments.²²⁵ In addition, if the mining operation requires a discharge of dredged and fill materials into regulated waters or wetlands, a separate permit is required.²²⁶

C. Streamlining the Mine Approval Process

Compliance with these myriad legal requirements for opening new mines obviously takes time, and can trigger delays that compromise efforts to meet renewable energy production targets. To be sure, delays are sometimes caused when mining companies fail to provide agency decisionmakers with adequate documentation of their plans.²²⁷ On the other hand, agencies that lack sufficient staff and agency officials who face competing demands on their time may find it daunting to manage the mine approval process efficiently.

In 2015, in an effort to address the delays caused by inefficient government processes, Congress passed the Fixing America’s Surface Transportation (FAST) Act. Title XLI of the FAST Act²²⁸ establishes procedures for streamlining permitting decisions for certain large infrastructure projects. These procedures followed many of the key elements of a 2012 Executive Order that had previously been issued by President Barack Obama.²²⁹

FAST-41 creates the Federal Permitting Improvement Steering Council headed by an executive director appointed by the president. For projects covered by FAST-41, federal agencies must use a permitting dashboard that provides transparent, online timetables for completing various permitting and environmental requirements.²³⁰ Agencies tend to meet their timelines perhaps because agencies must provide a written justification if they miss a deadline, something that they would prefer to avoid.²³¹

Quantitative evidence suggests that the program works. In 2021, agencies missed only two deadlines. In 2022, just one deadline was missed.²³² Further, while deadlines were sometimes extended, most often that was due to the project sponsor or other factors beyond the government’s control.²³³

As originally enacted, the FAST Act covered projects “involving construction of infrastructure for renewable or

218. *Id.* §1539.

219. 54 U.S.C. §§300101-307112.

220. 54 U.S.C. §300308. The Secretary of the Interior maintains a list of properties on the National Register. *Id.* §302101. Eligible properties are those that meet the detailed listing criteria at 36 C.F.R. §60.4.

221. 36 C.F.R. §§800.4(b), 800.5(b). In many cases, an undertaking will not implicate tribal interests, and even when it does, not all tribes have a THPO.

222. *Id.* §§800.5(d), 800.8(a). The agency must notify all consulting parties, including Indian tribes and Native Hawaiian organizations, and make the documentation available for public inspection prior to approval. *Id.*

223. *Id.* §800.5(e).

224. 42 U.S.C. §§7401-7671q; ELR STAT. CAA §§101-618; 33 U.S.C. §§1251-1387, ELR STAT. FWPCA §§101-607. Certain types of mining operations, such as those that use toxic chemicals for leaching, may also need to comply with the Toxic Substances Control Act (TSCA), 15 U.S.C. §§2601-2692, ELR STAT. TSCA §§2-412. Generally, mining operations produce high-volume, low-hazard wastes that are exempt from the “cradle-to-grave” management system that otherwise applies to hazardous waste under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. §§6901-6992k, ELR STAT. RCRA §§1001-11011. See generally American Geosciences Institute, *What Are Environmental Regulations on Mining Activities?*, <https://www.americangeosciences.org/critical-issues/faq/what-are-regulations-mining-activities> (last visited Nov. 16, 2023).

225. 33 U.S.C. §1342. These National Pollutant Discharge Elimination System (NPDES) permits are typically issued by state agencies, which have received permitting authority from EPA.

226. *Id.* §1344. These “dredge and fill” permits are typically issued by the U.S. Army Corps of Engineers.

227. Jamie Pleune & Edward Boling, *This Permit Reform Already Works. Why Aren't More Mining Projects Using It?*, 53 ELR 10463, 10475 (June 2023), available at <https://www.elr.info/articles/elr-articles/permit-reform-already-works-why-arent-more-mining-projects-using-it>.

228. The permitting provisions are generally referenced as FAST-41 because they come from Title 41 of the Act.

229. Exec. Order No. 13604, *Improving Performance of Federal Permitting and Review of Infrastructure Projects*, 77 Fed. Reg. 18887 (Mar. 28, 2012).

230. 42 U.S.C. §4370m-2.

231. FAST Act, 42 U.S.C. §4370m-2(c)(2)(F)(ii)(I) (2016).

232. See Pleune & Boling, *supra* note 227, at 10469. This article contains an excellent discussion of the potential for using FAST-41 in the mining sector.

233. *Id.* at 10470.

conventional energy production, electricity transmission, surface transportation, aviation, ports and waterways, water resource projects, broadband, pipelines, manufacturing, or any other sector as determined by a majority vote of the Council.²³⁴ In January 2021, pursuant to this authority, the Council approved a final rule adding mining to the list of projects covered by the law.²³⁵ As of July 2023, however, only one mine had applied for review under FAST-41.²³⁶ Companies concerned about possible delays in permitting a new mining project would be well-advised to seek review under FAST-41.

In 2023, Congress passed the Fiscal Responsibility Act, which, in addition to increasing the debt ceiling, included provisions designed to further streamline the NEPA process. For the most part, the changes to NEPA are modest and reflect long-standing CEQ rules. For instance, the changes require reviewing agencies to designate a “lead agency” to operate as a manager of the permitting process,²³⁷ something that is already required under CEQ rules.²³⁸

Nevertheless, one provision that could compromise the integrity of the EIS process in the name of expedited permitting allows the lead agency to shift the burden of preparing the environmental document to the project sponsor subject to agency procedures, assistance, and review.²³⁹ Although the provision requires the agency to take ultimate responsibility for the contents of the document, a project sponsor has an unavoidable conflict of interest. In particular, the sponsor lacks incentive to analyze all reasonable alternatives to a proposed action, especially those that may be outside the scope of their development interests.

In the context of mining, for example, the proponent of a proposal to develop a conventional lithium mine is unlikely to want to analyze the alternative of developing the significant lithium deposits in the brines of the Salton Sea, notwithstanding the fact that those might be developed more cheaply and with a far less significant environmental impact.²⁴⁰ The agency procedures should nonetheless insist that the proponent prepare a robust alternatives analysis and do it well. Indeed, while the project sponsor may be able to prepare a compliant document faster than the agency, an inadequate document might result in legal challenges that could cause far more significant project delays than if the agency had prepared the documents under the provisions of FAST-41. As noted previously, one strategy for addressing this issue would be for the government to prepare programmatic EISs on particular mining types like lithium mining as a way to allow the project sponsor to prepare an EIS on their proposed project while tiering to the programmatic EIS.

234. 42 U.S.C. §4370m(6)(A). The statute sets out certain criteria for covered projects that must also be met.

235. 86 Fed. Reg. 1281, §1519.4 (Jan. 8, 2021); 40 C.F.R. §1900.2(a).

236. See Permitting Dashboard, *South32 Hermosa Critical Minerals Project (Arizona)*, <https://www.permits.performance.gov/permitting-project/fast-41-covered-projects/south32-hermosa-critical-minerals-project> (last visited Nov. 16, 2023).

237. Fiscal Responsibility Act, Pub. L. No. 118-5, §107 (2023); 42 U.S.C. §4336a(a).

238. 40 C.F.R. §1501.7.

239. Fiscal Responsibility Act, §107; 42 U.S.C. §4336a(f).

240. See *supra* notes 67-77 and accompanying text.

Importantly, “FAST-41 does not supersede, amend, or modify any federal statute,”²⁴¹ such as NEPA. As such, it continues the “grand bargain” that has allowed development projects to go forward, so long as an adequate review and assessment of impacts have occurred, and adverse impacts have been avoided or mitigated as required by substantive environmental laws.²⁴² The nagging question, however, that is receiving more and more scrutiny from policymakers and legal commentators is whether this grand bargain will permit sufficient progress toward the renewable energy goals deemed necessary to meet the daunting climate change challenge.²⁴³

D. *The Special Problem of Waste Rock Disposal*

Despite what would seem like a comprehensive set of environmental laws, the difficult issue of waste rock disposal on public lands remains unsettled. Because most large hard-rock mining operations occur in the western public land states and involve patented or unpatented mining claims located under the General Mining Law, mine operators have historically and successfully claimed a right to dispose of their massive waste rock and place their tailings ponds on nearby public lands. Often, however, these operators have a questionable claim to occupy these lands with their massive waste piles in perpetuity. This issue came to a head in a legal dispute over the Rosemont Copper mine in Arizona.

Rosemont Copper held valid mining claims on 955 acres of national forest land on which it proposed to develop an open-pit copper mine.²⁴⁴ In order to operate the mine, the company needed access to additional land where it could dump its estimated 1.9 billion tons of waste rock.²⁴⁵ Its proposed solution was to use 2,447 acres of national forest land where it had located additional mining claims.²⁴⁶ This public land would have been buried under 700 feet of waste rock. The Forest Service initially approved this plan because it believed that the Forest Service Organic Act of 1897 and the Multiple-Use Sustained-Yield Act of 1955 (MUSYA) gave Rosemont a legal right to dispose of its waste on national forest land.²⁴⁷ Further, the Forest Service presumed that the

241. 42 U.S.C. §4370m-6(d)(1).

242. See J.B. Ruhl & James Salzman, *The Greens' Dilemma: Building Tomorrow's Climate Infrastructure Today*, 73 EMORY L.J. 1 (2023), <https://scholarly-commons.law.emory.edu/cgi/viewcontent.cgi?article=1510&context=elj>.

243. *Id.* at 48-59 (discussing streamlining strategies for complying with NEPA). J.B. Ruhl and James Salzman also cite efforts by progressive Sens. Chris Murphy (D-Conn.) and Sheldon Whitehouse (D-R.I.), for example, to promote permitting reform and make it easier to build transmission lines. They also describe the massive scale of the challenge by pointing out that “[t]o meet even a middle-road renewable energy scenario would require bringing online two new 400 MW solar power facilities—each taking up at least 2,000 acres—every week for the next thirty years.” *Id.* at 9, 15.

244. See *Center for Biological Diversity v. U.S. Fish & Wildlife Serv.*, 33 F.4th 1202, 1211, 52 ELR 20056 (9th Cir. 2022).

245. *Id.* at 1212.

246. *Id.*

247. *Id.*

mining claims located on the 2,447 acres were valid and thus available for waste rock disposal.²⁴⁸

The district court rejected both arguments. First, the court held that neither the Organic Act nor the MUSYA grant additional rights to use public land beyond those that are granted under the General Mining Law.²⁴⁹ Further, the court found no basis for concluding that valuable minerals had been discovered on the 2,447 acres of additional mining claims and that, accordingly, Rosemont had no right to use that land for waste rock disposal.²⁵⁰

The Ninth Circuit affirmed. Specifically, the court rejected the government's claim that it could presume the validity of Rosemont's mining claims. According to the court, "[u]ndisputed evidence in the record shows that no valuable minerals have been found on Rosemont's claims. Because the discovery of valuable minerals is essential to the validity of a claim, Rosemont's claims are necessarily invalid."²⁵¹

Two subsequent federal district court decisions in Nevada have followed the holding in *Rosemont*,²⁵² and the DOI solicitor has also weighed in with a formal legal opinion that largely tracks the *Rosemont* decision.²⁵³ Of particular importance for authorizing mining on public lands, the Solicitor's Opinion outlines five different options for securing a site for disposing of waste rock from public land mining operations. These include (1) submitting evidence of discovery on the claims to be used for waste disposal; (2) locating mill sites on non-mineral land; (3) obtaining a lease or permit under FLPMA; (4) obtaining rights-of-way under FLPMA; and (5) making an exchange of public lands for private lands under FLPMA, or an outright sale of public lands to support a community or economic development.²⁵⁴

The third, fourth, and fifth options would all return some potentially significant value to the federal government in the form of either land or revenue, but a land exchange or sale is probably the best option since it ensures that the permanent waste rock is located on the company's private land rather than tying up public land.

At first blush, the mill site option might appear to be the most plausible, since it allows the location of five-acre mill sites for mining or milling purposes on non-mineral land. But Rosemont would need multiple five-acre mill sites for every mining claim, and the question of whether a mining company can locate more than one mill site per claim has been hotly disputed.

The district court upheld a DOI rule that allows multiple mill sites for each claim, applying *Chevron* deference.²⁵⁵ That decision, however, is currently on appeal to the D.C. Circuit.²⁵⁶ The decision is likely to turn on the court's interpretation of the statutory language, which provides that "[w]here nonmineral land not contiguous to the vein or lode is used or occupied by the proprietor of such vein or lode for mining or milling purposes, such nonadjacent surface ground may be embraced and included in an application for a patent for such vein or lode . . ." The section goes on to make clear, however, that "no location made . . . of such nonadjacent land shall exceed five acres . . ."²⁵⁷ It is not clear what meaning the five-acre limitation has if a mining company can locate multiple mill sites for each of its mining claims.

VI. Conclusion

The renewable energy industry holds great promise for helping countries around the world meet the highest targets for addressing GHG emissions and greatly mitigating the negative effects of the climate crisis that earth currently faces. But many of the minerals currently needed to achieve these necessary goals are in short supply, with many sourced from mines that raise serious human rights, environmental, and safety concerns. As we strive to move away from fossil fuels and toward a green energy future, we must demand that companies in the renewable energy industry maximize opportunities for recycling while concurrently minimizing risks to people and the environment. Only in that way will we achieve a green energy outcome of which we can truly be proud.

248. *Id.*

249. *Id.* at 1215.

250. "[T]he administrative record shows no basis upon which the Forest Service could find Rosemont discovered a valuable mineral deposit within the facilities, tailings, and waste rock areas. In fact, the evidence in the [final EIS] shows the absence of any such deposit within those lands." Center for Biological Diversity v. U.S. Fish & Wildlife Serv., 409 F. Supp. 3d 738, 760, 49 ELR 20130 (D. Ariz. 2019).

251. Center for Biological Diversity, 33 F.4th at 1222.

252. Great Basin Res. Watch v. U.S. Dep't of the Interior, No. 3:19-cv-00661-LRH-CSD, 53 ELR 20056 (D. Nev. Mar. 31, 2023); Bartell Ranch LLC v. McCullough, No. 3:21-cv-00080-MMD-CLB, 53 ELR 20023 (D. Nev. Feb. 6, 2023), *aff'd sub nom. on other grounds*, Western Watersheds Project v. McCullough, Nos. 23-15259, 23-15261, and 23-15262 (9th Cir. June 27, 2023).

253. Memorandum from Solicitor, U.S. Department of the Interior, *supra* note 190.

254. *Id.*

255. Earthworks v. U.S. Dep't of the Interior, 496 F. Supp. 3d 472, 50 ELR 20243 (D.D.C. 2020), *appeal pending*.

256. *Id.*

257. 30 U.S.C. §42(a). While mineral patents are no longer issued, a mining claimant may still file mill site claims.