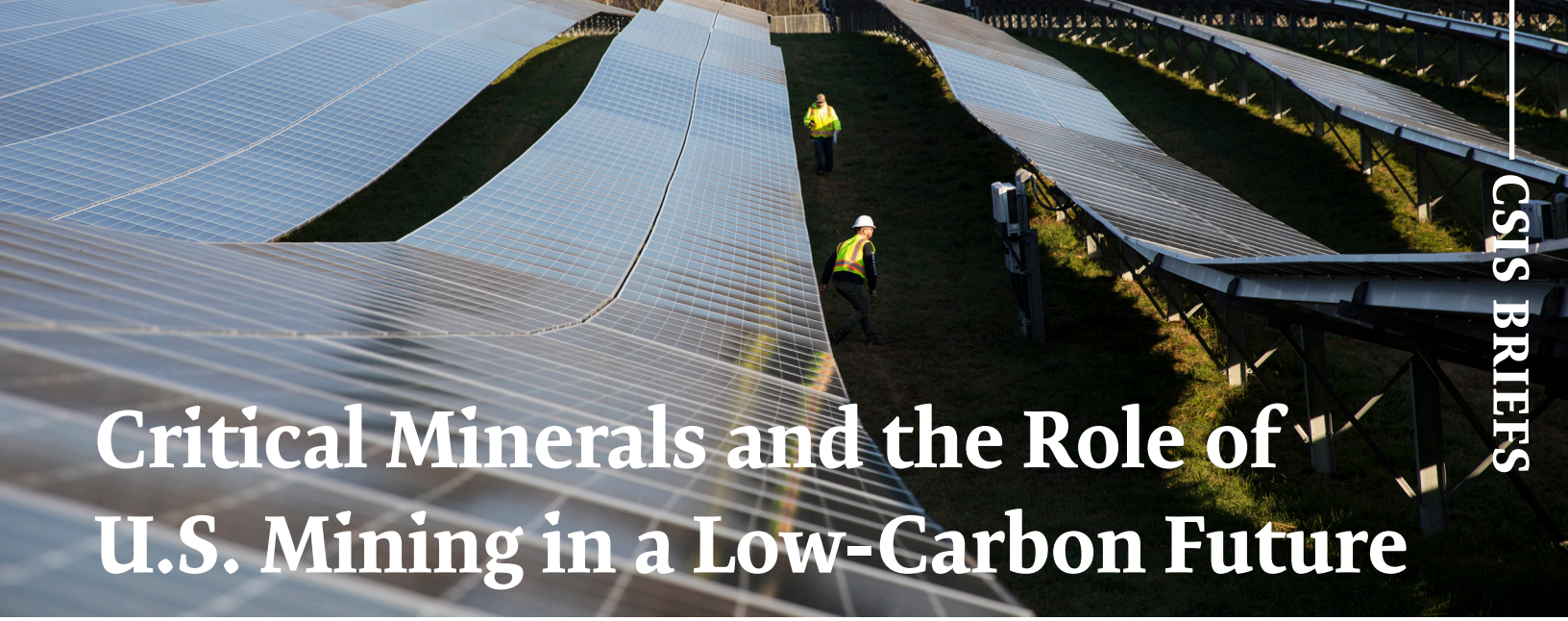

CSIS BRIEFS

Critical Minerals and the Role of U.S. Mining in a Low-Carbon Future

By Sarah Ladislaw, Lachlan Carey, and Hillary Bright

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THE ISSUE

Critical minerals are an essential component of the transition to a low-carbon and clean energy future. Today, the United States lacks strategies for responsibly mining these materials at home, for developing sustainable supply chains for their incorporation into the clean energy economy, and for leading through example and cooperation with other nations that seek to mine and develop these resources in safe, environmentally responsible, and socially inclusive ways.

BACKGROUNDER

In June 2019, the Center for Strategic and International Studies (CSIS) and the Blue Green Alliance (BGA) brought together a group of engaged stakeholders from the mining, labor, environmental, and think tank communities for a workshop to begin the process of building consensus on a path forward for a critical minerals strategy. Participants in the conversation recognized the need for a more fully developed narrative around the importance of critical minerals; a multi-stakeholder effort to create principles to underpin a critical minerals strategy that can guide policymakers; and a more extensive consensus-building and outreach process to open dialogue with affected communities and relevant constituencies. The Chatham House rule discussion produced several important points for policymakers:

- **Demand is growing:** Critical minerals are necessary to all of the key energy technologies of the future, including solar, wind, energy storage, and electric vehicles (EVs).
- **The United States is falling behind:** Despite having abundant reserves, most critical minerals are not mined in the United States. Moreover, the United States is virtually absent from the global supply chains for these minerals.
- **Recycling is a vital component:** To complement the mining of critical resources, the recycling industry will need stronger domestic market signals and greater demand.
- **Policy is in its early days:** There remains a lot of scope for developing clear industry standards and public policy that prepares for a low-carbon future while protecting workers, local communities, and the environment and driving domestic growth.
- **Stakeholder engagement matters:** An inclusive, multi-stakeholder approach to coalition building is an important avenue for addressing the issue of sustainable mining in a low-carbon future and building durable support for a path forward.

The following brief summarizes this productive and inclusive conversation in this area, though the workshop only scratched the surface. We hope the discussion prompts further work on this important issue.

THE LOW-CARBON TRANSITION AND DEMAND FOR CRITICAL MINERALS

Mining is, and will continue to be, essential to the livelihood, development, and progress of billions of people around the globe. As mining patterns shift in response to changing demand, industry and policymakers cannot lose sight of the need for responsible mining.[1] It is both a complex and significant issue, with a perplexing array of minerals coming from mines all over the world—often as byproducts or coproducts of other processes—and ending up as core components in almost every essential technology of a low-carbon future.

Furthermore, the United States currently imports most of its critical mineral commodities, creating potential strategic vulnerabilities for its economic prosperity and national security. The United States currently imports more than 50 percent of its annual consumption in 31 of 35 critical minerals, with China dominating the production of rare earth metals and Australia leading the production of Lithium, for example (Figure 1). Fourteen of these minerals have no domestic production at all.[2] Yet with many of these global supply chains still being in very nascent stages, it is not too late for the United States to get in the game, secure its domestic supply, and catalyze the industries of the future.

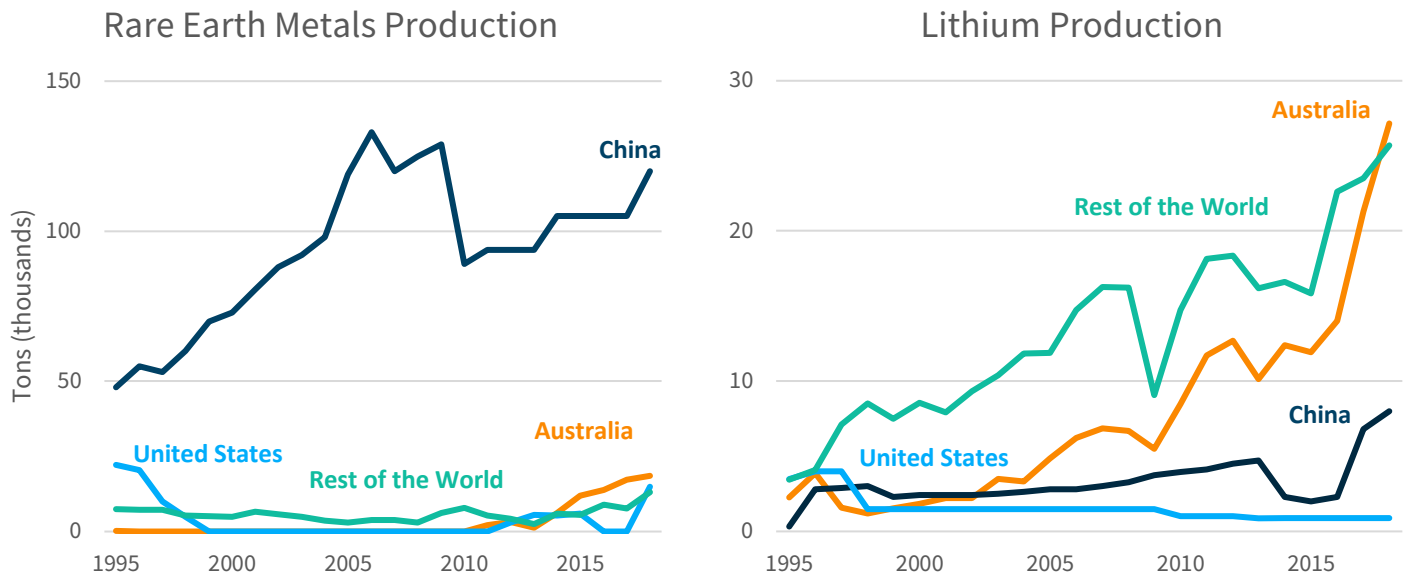
As renewable energy and storage capacity increase as part of global climate mitigation efforts, so too will the demand for critical minerals. Even under a scenario where global average temperatures increase by 4 degrees Celsius, the World Bank expects global wind capacity to increase three-fold and solar capacity to increase five-fold by 2050. These numbers jump to 450 percent and 1,000 percent for wind and solar, respectively, under a 2-degree scenario.

Wind power technology uses copper, aluminum, rare earth elements, zinc, and molybdenum, while solar PV cells contain aluminum, silicon, copper, silver, tin, and lead. Similarly, growth in electric vehicles and power grids with storage capacity drives increases in demand for lithium-ion batteries, which in turn rely on key minerals such as lithium, nickel, manganese, and cobalt. For example, under a 2-degree scenario, demand for relevant minerals in electric storage batteries—aluminum, cobalt, iron, lead, lithium, manganese, and nickel—are all expected to increase by over 1,000 percent.

In addition to keeping up with demand, another difficulty is ensuring responsible mining practices, particularly given the current geographic distribution of critical mineral reserves. For example, the Democratic Republic of Congo currently supplies over 65 percent of global cobalt and has been widely criticized for using child labor and other irresponsible mining practices.

With these significant changes in low-carbon technologies and the supply chains that support them, industry and policymakers alike will have to be more adaptable than ever. The history of renewable energy forecasts is relatively poor, due to the ever-present possibility of faster-than-expected growth or unforeseen technological disruptions.

Figure 1: Critical Minerals Global Production Levels



Source: BP, *BP Statistical Review of World Energy, 2019* (London: 2019), https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf.

Even as industry experts expect lithium-ion batteries to be locked in as the storage solution for cars over the next 30 years, it is impossible to predict whether any of the budding alternatives in grid storage will significantly shift demand patterns or the composition of the lithium-ion battery away from higher-priced commodities. Additionally, broad changes in societal and economic structures—such as a move away from the individualized vehicle to mass transit—may affect the trajectory of all these technologies. Critically, while there is broad agreement that penetration of clean energy technologies will continue to grow in the coming decades, achieving the projected growth associated with 2-degree target scenarios will require much more policy action and low-carbon investment than is occurring to date.

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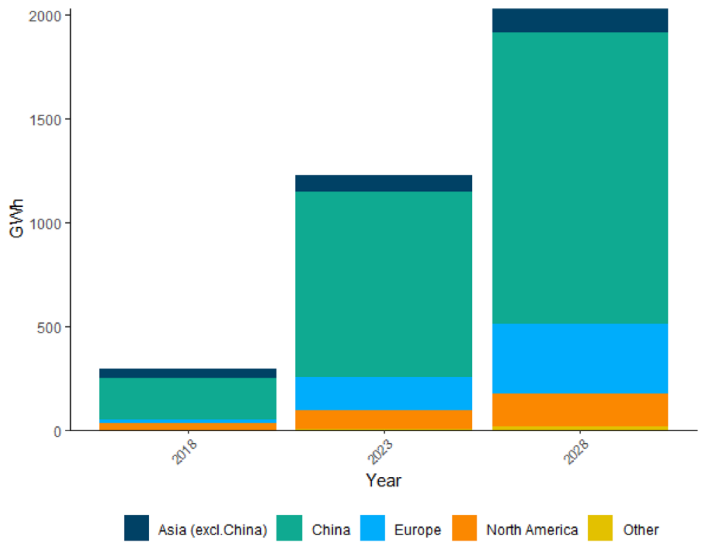
THE LITHIUM-ION BATTERY SUPPLY CHAIN

As the key enabling technology for EVs and smart grids, investment in lithium-ion batteries has skyrocketed over the last 12 months, as has demand for their component, critical minerals. As companies have invested in battery megafactories, global capacity has increased from just 57 gigawatt hours (GWh) in Q1 2015 to 1.9 terawatt hours (TWh) in Q2 2019, a 32-fold jump. The International Energy Agency's scenario for 2-degree warming requires 200TWh in automotive energy storage alone by 2050. Today, China is the dominant player, accounting for roughly 67 percent of global capacity, a role that is expected to remain stable over the next decade. Europe is also becoming an important manufacturer, too, with expectations to double its share of global capacity from 7 percent to 16 percent by 2028. By comparison, the share manufactured in the United States is expected to fall from 10 percent to 8 percent over the same period (Figure 2).

If EVs and other low-carbon technologies are going to go from the niche to the mainstream, the cost of their batteries will be the decisive factor. For example, 27 percent of the cost of a Tesla Model 3 is its battery pack. Raw materials make up 79 percent of the cost of EV batteries, especially lithium, cobalt, nickel, and graphite. In addition to expanding supply, these prices could be driven down at any of the 15 steps in the global supply chain, which runs from the mine through to the factory floor. At each of these points, there is a range of actors who can affect prices and stymie the supply of critical materials and, by extension, the growth of low-carbon technologies like EVs.

Figure 2: Lithium-ion Battery Production Capacity



Source: Benchmark Mineral Intelligence, *Lithium Ion Battery Megafactory Assessment* (August 2019), https://www.benchmarkminerals.com/megafactories/.

Critically, the United States is largely absent from most steps of this supply chain, with virtually no mining or chemical processing of these materials happening domestically. A simple yet important explanation for this is the combination of U.S. reliance on global markets to supply these materials and the relative absence of a U.S. strategic push to grow this industry. China has so far led the pack by subsidizing the market for lithium-ion battery products—namely EVs—through a deliberate and costly strategy to grow the domestic market for EVs and facilitate the growth of the supply chain to develop those vehicles. This type of industrial strategy tends to run counter to the free-market approach of the United States, although the United States does have subsidies for the purchase of EVs and does support the development of battery technology through federal research and development funds. Europe, on the other hand, is adopting a hybrid model, with the German and French governments creating a "European Battery Alliance," tasked with guiding over $100 billion into the battery manufacturing value chain. As it attempts to reduce its reliance on battery imports, Europe has also attracted considerable investment from Asia into its production capacity.

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VIEW FROM THE COPPER MARKET

Copper is another key enabling resource since renewable energy and increasing electrification are likely to require copper than fossil-fuels. Copper is also a critical component of energy-efficiency improvements. An important feature of the copper market is the extent to which recycling plays a key role, with some 35 percent of global supply coming from recycling. In the European Union, that figure is as high as 50 percent. However, even if 100 percent of copper were to be recycled, this would only meet about 25 percent of global demand.

Unlike other critical minerals, however, adequate supply is not a significant issue for copper. There are at least 40 years of mineable reserves available, as well as over 700 years of total reserves, much of which is in Australia and Latin America (Figure 3). The greater difficulty is in tapping these reserves in a way that is profitable, sustainable, and responsible.[3] U.S. production of copper has declined of late, with an estimated 5 percent decrease in 2018, although its total value of approximately $8 billion remains essentially unchanged from $7.92 billion in 2017. The United States is the world's fourth-largest producer of copper and has the seventh-largest supply of reserves.

RECYCLING

Recycling has been a burgeoning industry in recent years, but a global reliance on the Chinese market has made it susceptible to changes in the Chinese policy environment. Recent restrictions have hurt the industry, with China no longer buying scrap commodities. This has pushed down prices and disincentivized the recycling of critical materials.

Once again, a domestic market for the end-use of these products is a critical first priority, as commodities must reach a critical mass to become profitable to recyclers. For example, currently, there is negligible recycling of critical minerals in technologies like lithium-ion batteries in the United States, as the market for EVs is still too small. As the market grows, EVs represent a bigger share in scrapyards, and new technologies for disassembling parts are developed, the recycling industry will adapt. Additionally, end-use products can be better designed to be recyclable, but, once again, incentives to do this generally rely on the price of the commodity and the volume in scrapyards.

OPPORTUNITIES AND CHALLENGES FOR RESPONSIBLE MINING IN THE UNITED STATES

THE SOCIAL COMPACT[4]

The U.S. mining industry is recognized internationally for its technical capacities, skilled workforce, and technological prowess, but in recent years, its social compact has begun to erode domestically. As public opposition to natural resource development continues to grow, an increasingly important question will be how the industry can strengthen its social compact with stakeholders at all levels.

The first step will be to reward, support, and highlight the mining companies that are being responsible corporate citizens. Part of the problem arises from the few "bad apples" that receive media attention and diminish the reputations of companies that are genuinely investing in a more sustainable future.

There are a number of services dedicated to evaluating the practices of mining, including the Responsible Mining Foundation, which publishes an annual index that profiles 800 mine sites around the world and rates them on five categories. Unfortunately, the index does not yet include any mine sites in the United States. Further resources will need to be dedicated to such initiatives in the future if there is to be truly global comparisons and accountability.

Another issue is the quality of safety standards against which mines can be judged. The best standard is generally considered to be the International Labour Organization's (ILO) Convention 176, which the United States has adopted. This is an important step. However, organizations like the ILO do not have enforcement capabilities and rely on local institutions

Figure 3: Major Copper Production and Reserves

Country (2017)	Chile	Peru	China	USA	Congo	Australia	Zambia	Indonesia	Mexico
Production (Mt)	5.8	2.4	1.6	1.2	1.2	0.95	0.87	0.78	0.76
Reserves (Mt)	170	83	26	48	20	988	19	51	50

Source: *USGS, Minerals Yearbook (2019)*, https://www.usgs.gov/centers/nmic/copper-statistics-and-information

to step in. Furthermore, every serious incident or accident erodes confidence in these standards and practices, while cases of continued safe operation attract little attention.

Forging a two-way social compact between U.S. miners and its communities requires grassroots communication, genuine dialogue, and the inclusion of true stakeholders. This includes frontline communities, indigenous groups, environmentalists, miners, operators, and other affected parties. This is of course easier said than done, with many industry participants reporting difficulty in finding the right grassroots organizations to partner with.

An increasingly important question will be how the industry can strengthen its social compact with stakeholders at all levels.

Ultimately, the basic tenants of the social contract are dialogue, credibility, and trust. Unfortunately, these elements are often missing in the relationships between the mining industry and the communities in which they work, creating a credibility gap. This needs to be overcome so that parties can work toward general agreement on what a localized social compact entails.

LABOR CONDITIONS

There is broad agreement among stakeholders that the top concern in any mine should be safety. Across the board, a great deal of progress has been made to make mines safer workplaces, and the voice of the labor community has done much to advance this cause, as well as to improve the environmental conditions in mining. Despite all this progress, each additional fatality puts another stain on the industry and can prevent further progress.

It should be remembered that there is no single mining industry but instead a heterogeneous mix of companies and practices, most engaging with the transition to a low-carbon future in different ways. In recent years, industry leaders have embraced the pursuit of a sustainable low-carbon future as a key part of their corporate strategy and commitment to responsible social performance. These market participants that develop best practices go well beyond abiding by regulations and have shown that being responsible can also be profitable. While there is a perception that regulations represent best practices, they are often outdated. The optimal approach to responsible mining suggests that most mining companies can, and indeed should, meet industry best practices, aiming well above and beyond regulations wherever possible.

This is not to say regulations should not continue improving by adopting new and evolving industry best practices and societal expectations. For example, it is estimated that over a million children are forcibly put to work in mines around the world. While this practice has long since been outlawed in the United States, there remains little accountability for purchasers of commodities mined by children or through other methods of labor exploitation.

Labor unions have played an important role in demanding better working conditions and environmental performance in mines and are a critical constituency to engage in order to assess current shortcomings and drive future strategies for change. For example, unions have consistently noted that existing responsible mining codes, for the most part, do not include strong language on worker safety or other conditions of work. There needs to be an assessment of labor conditions in the mining industry and, where such assessments exist, they should be better highlighted, promoted, and implemented.

U.S. COMPETITIVENESS

The United States has been assessed as a top 10 jurisdiction for "mining friendliness"—a term referring to the geological attractiveness for minerals and metals and the extent to which government policies encourage or deter exploration and investment. This is reflected in its strong production levels of many traditional commodities.

However, the United States remains absent in many up-and-coming markets, such as supply chains for lithium-ion batteries. Currently, to build a profitable lithium-ion mine in the United States, you need to go downstream into conversion and upgrading processes. The United States used to have integrated supply chains where products were manufactured using metals mined domestically. This is largely no longer the case. Strategic partnerships in critical minerals will be essential in a low-carbon future, and both policy and industry practices should be working toward this eventuality.

The mining industry has always been characterized by uncertainty and risk. For example, one potential challenge for the United States is the lengthy time period required to get a mine up and running, which runs contrary to the need to respond to rapidly evolving commodity markets. Another uncertainty is how many jobs will remain unchanged or be created in a future mining sector based on critical minerals. These uncertainties can be partially addressed through government-backed geological surveys and development strategies that highlight economic and labor force impacts.

MODELS FOR ADVANCING RESPONSIBLE MINING AT HOME AND ABROAD

The United States has no shortage of companies and initiatives that demonstrate how mining can be sustainable, responsible, and profitable. The key strategic question is how to build upon these examples both at home and abroad. The CSIS-BGA workshop in June discussed two important examples that participants agreed could be learned from and expanded upon in a range of contexts. Though of course not applicable to every organization and every mine, both the Initiative for Responsible Mining Assurance (IRMA) and the North Plains Council-Stillwater Mining Company "Good Neighbor Agreement" are positive steps for the industry that should be more widely discussed and emulated.

INITIATIVE FOR RESPONSIBLE MINING ASSURANCE (IRMA)

IRMA was founded more than a decade ago as an organization to promote responsible mining through a voluntary mine site certification system. They use independent, third-party auditors to ensure that mines respect human rights and provide safe, healthy workplaces. Furthermore, mines are incentivized to participate due to reputational benefits and market value improvements that come with superior evaluations.

IRMA is designed to complement rather than replace existing laws but hopes to serve as a template for how regulations could look moving forward. The initiative establishes a best practice standard for responsible mining in industrial-scale mines and ensures that its certification is a high bar across all potential mining issues. In particular, it advocates for environmental and labor values and has found that both purchasers and investors have demonstrated a keen interest in rewarding best practice standards.

As successful as IRMA has been so far in demonstrating proof of concept, there are challenges in scaling to the size required for transformative impact. There are of course multiple competing schemes for companies to join and little clarity for the industry in choosing where to best spend compliance efforts. As a result, the cost of compliance for engaging with multiple schemes can be prohibitive, leading to a lack of industry participation.

THE GOOD NEIGHBOR AGREEMENT

Inspired by the unpredictability of litigation and regulation, and a desire to resolve uncertainties between the Stillwater Mining Company and the Northern Plains Council, an environmental coalition of local conservation groups in Montana, the Good Neighbor Agreement is a negotiated agreement to extend protections beyond state requirements and protect community assets while allowing mining to proceed. Constructed through open dialogue and careful planning, a commitment to the flow of information between mines and oversight committees, transparency, and trust have been critical to the agreement's success.

The legally binding agreement has five key elements, including:

1. the agreed-upon values of the members;
2. the commitment and engagement of grassroots members;
3. the process for communication, transparency, and engagement (meetings two or three times per month);
4. technical support and resources, which provide water quality results, safety tests, early access to the mine planning process, and the science-based nature of the agreement; and
5. the will to be credible, as the credibility of the NGO community can speak for the greater goals of the organization and make them easier to achieve.

The Stillwater Mining Company noted that it has not just been beneficial to the local community but also valuable to its business for three reasons:

1. **Social license:** This entails ownership and investment by the community. The speakers said that in many cases the community is often the biggest advocate of the GNA, and they own the outcomes and decisionmaking process.
2. **Freedom from litigation:** Mines involved with the GNA have enjoyed 19 years without any litigation.
3. **Innovation and diversity of thought:** Involvement forces the participants to think differently and bring new ideas to the table.

Broadly, the Good Neighbor Agreement is a commitment to the belief that both mining companies and communities benefit from being proactive and preventative rather than reactive and punitive.

Indeed, this belief arguably underpins each and every issue discussed in this report and throughout the workshop: a commitment to getting out in front of an issue, planning accordingly, and providing the best possible chance of success rather than reacting to changes as they come. In an industry of constant change combined with long lead

times for investment and regulatory approval, this has always been important. But today, in a world of accelerated technological and environmental changes, it is more critical to keep in mind than ever.

THE ROLE OF MINING IN A TRANSITION TO A CLEAN ECONOMY

MOVING THE CONVERSATION FORWARD

Very few forums manage to bring together the disparate interests of industry, academia, labor, politics, and environmentalism, yet such a multi-stakeholder approach is the only way of effectively resolving complex problems and creating inclusive solutions. Having the right people around the table is an important step, but it must also lead to action. Creating a working committee comprised of key stakeholders that can meet more regularly should be the next step. Furthermore, these stakeholders should include citizens of affected communities, miners whose livelihoods are being discussed, and environmentalists on the frontlines of these issues.

There is no single policy solution that can address this multifaceted issue, but there is scope for bipartisan progress on incremental steps. Though far from an exhaustive list, the following were a set of possible policy options that emerged from the CSIS-BGA workshop.

- **Agreeing on the scale of the problem and need for action:** This sends important signals to the mining industry, whose firms are the best positioned to act and invest.[5] It will also help highlight the issue for other key stakeholders, such as labor groups, environmentalists, and indigenous organizations.
- **Setting clear, tangible goals:** Further research is needed to identify which goals for U.S. mining and global supply chains are both environmentally substantive and commercially realistic. Possible illustrative targets suggested (but not agreed upon) at the workshop included a goal of 1TWh lithium-ion battery capacity in the United States by 2030 or a 100 percent EV production target.
- **Prioritizing the U.S. Geological Survey (USGS):** The USGS provides critical information on available resources and the potential for future expansion.
- **Improving the regulatory environment:** There is an urgent need to develop a faster and more predictable regulatory environment for the approval and oversight of the right mining projects domestically.
- **Generating new demand:** Developing local supply chains will require local demand. Fostering this could include investing in infrastructure, expanding renewable energy, upgrading to smart technologies, and implementing energy-efficiency improvements.
- **Building consensus on social license:** To truly encourage the growth of responsible mining in the United States, stakeholders' many interests need to be identified and universally acknowledged in order to create the social license for mining to be accepted in a given community.

Each of these policy options needs to be developed through multi-stakeholder and multisectoral discussions that include key players, such as auto and battery manufacturers, local communities, indigenous organizations, environmentalists, and others.

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CONCLUSIONS AND NEXT STEPS

Mining is often cast in binary terms. Either you can mine for precious resources or you can protect the environment, but you cannot have both. This view of the world is outdated, both when it comes to mining specifically and the environment-growth nexus more generally. Mining, when conducted irresponsibly, can indeed present significant risks to the environment, the sanctity of local communities, and even the health and future livelihoods of mining industry workers. However, when mining is pursued with an open dialogue, transparency, and a proactive mindset, the social compact that emerges can help fuel the low-carbon technologies of the future while maintaining the communities and precious environments.

This joint workshop was a useful reminder of these complexities for all the stakeholders at the table, but it cannot be the last word on this critical issue. There is a lot more work to be done. As discussed in the opening section of the report, next steps include designing a more comprehensive assessment of a clean future enabled by critical minerals; developing a strategy for the United States to take a leadership role; implementing clearly defined measures to build confidence on sustainable mining

practices in the United States; and building a stakeholder engagement process to create and carry out this strategy. These proactive, preventative solutions can help avoid reactionary mistakes and punitive actions only if we begin to build the multi-stakeholder coalitions now. ■

Sarah Ladislaw *is a senior vice president and director and senior fellow of the Energy and National Security Program at the Center for Strategic and International Studies (CSIS) in Washington, D.C.* ***Lachlan Carey*** *is an associate fellow of the CSIS Energy and National Security Program.* ***Hillary Bright*** *is the director of special projects at the BlueGreen Alliance.*

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ENDNOTES

1. Further details can be found in World Bank, *The Growing Role of Minerals and Metals for a Low Carbon Future* (Washington, DC: 2017), http://documents.worldbank.org/curated/en/207371500386458722/pdf/117581-WP-P159838-PUBLIC-ClimateSmartMiningJuly.pdf.

2. Further details can be found in "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," U.S. Department of Commerce, June 4, 2019, https://www.commerce.gov/news/reports/2019/06/federal-strategy-ensure-secure-and-reliable-supplies-critical-minerals.

3. Downstream industries and investors, as well as environmentalists and civil rights organizations, are increasingly demanding that the industry takes a responsible approach to sourcing.

4. Also known as the "social license" or sometimes "social contract."

5. While the Department of Commerce put out a "Critical Minerals Strategy," it should include a more comprehensive policy for a low-carbon future.