



22-16 Building Downstream Capacity for Critical Minerals in Africa Challenges and Opportunities

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INTRODUCTION

Demand for critical minerals—bauxite, cobalt, copper, lithium, nickel, and other minerals that underpin solar, wind, geothermal, and other forms of renewable energy and electric vehicles—is already booming and is projected to continue to grow at a rapid pace. Global production for many critical minerals will need to increase by a factor of 3–42 to meet the renewable energy obligations established by the Paris Agreement, according to the International Energy Agency (IEA 2021). Demand for lithium, graphite, cobalt, and nickel are set to grow the most rapidly, largely because of increased demand for electric vehicles and battery storage. Demand for other industrial metals, including rare earths, molybdenum, copper, and silicon, is also set to rise.

Africa's mineral-rich developing economies could benefit greatly from this increase in demand. Many African economies have vast critical mineral reserves, and their nascent industrial sectors imply vast export potential, even as/if these economies industrialize. To do so, however, they need to improve their infrastructure, investment climate, and governance and learn to navigate an increasingly complicated geopolitical environment.

These countries could increase the benefits they reap from these minerals by building downstream capacity in processing—the steps that turn mined ore (bauxite, iron ore) into refined intermediate goods (aluminum, steel). Processed materials command significant price premia over unrefined ore. Domestically producing refined products would also reduce input costs for infrastructural and

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industrial development, provide good manufacturing jobs, and stimulate service sector development in host communities.

Developing Africa's capacity would also serve Western geopolitical ends. For Western importing countries, diversifying supply chains and developing refining capacity are critical to energy and national security. Critical minerals underpin renewable energy systems but are also key inputs in military technology, ranging from vehicles to weapons and communications systems.

In many ways, China is the world's refinery for critical minerals. It accounts for two-thirds of the world's aluminum refining and smelting capacity,¹ 80 percent of global lithium refining capacity,² two-thirds of global cobalt refining capacity,³ more than 80 percent of global graphite production and refining, and large shares of refining capacity for many other minerals (USGS 2022). Although the green energy provisions of the US Inflation Reduction Act and other policy initiatives are chipping away at China's position in lithium and solar-related materials, US refining capacity lags significantly, as does refining capacity in the European Union and the advanced economies of Asia. There are therefore clear energy and national security rationales for Western governments and the private sector to catalyze downstream capacity development outside China.

The solution, however, is not simply for advanced Western economies to onshore downstream capacity. Doing so would impose large environmental costs and encounter significant hurdles in permitting and establishing social license to operate. Like mining, mineral refining has negative local environmental impacts. China has emerged as the world's refinery partly because of its greater tolerance for adverse environmental impacts. If advanced economies are serious about promoting development in Africa, they should not foreclose opportunities for it to move up the critical mineral value chain by attempting to widen supply chains only through investment at home.

Mineral wealth is neither an unalloyed blessing nor a guarantor of good development outcomes. Many resource-rich economies are poor despite (and in part because of) their mineral wealth. Mineral-rich governments are in a race against time to forestall or attenuate these ills by strengthening governance institutions and avoiding supply chains that are so constrained—and prices so high—that renewable energy producers innovate away from heavy reliance on critical mineral inputs. High prices have encouraged electric vehicle makers to cut the amount of cobalt in their products, although the market for cobalt continues to grow.⁴

This Policy Brief assesses the challenges facing four critical mineral-rich developing African economies: Guinea (bauxite); the Democratic Republic of Congo, or DRC (cobalt); Madagascar (graphite and nickel); and Mozambique (graphite). Common challenges include inadequate energy infrastructure and elevated political risk, which make securing capital investments difficult. Country-

1 Statista, Countries with Largest Smelter Production of Aluminum in 2021, <https://www.statista.com/statistics/264624/global-production-of-aluminum-by-country/> (accessed on September 29, 2022).

2 "China Dominates the Lithium-ion Battery Supply Chain, but Europe Is on the Rise," BloombergNEF, September 16, 2020.

3 "Cobalt Supply Chain: China and DRC to Maintain Dominance, Growth Potential in Australia—Report," Mining.com, October 8, 2021.

4 "Battery-Makers Slash Cobalt Intensity in Face of Accelerating Demand," S&P Global Market Intelligence, August 29, 2022.

specific challenges include the ongoing armed conflicts in or near resource-rich areas in the DRC and Mozambique and the lack of government and policy stability in Guinea and Madagascar. Many of the challenges these countries face exist in other mineral-rich economies in Sub-Saharan Africa, where the solutions proposed here would also apply.

The Policy Brief first provides an overview of these challenges before turning to solutions, which include (a) embracing hydropower potential—which is vast in these countries—while paying attention to social costs and distributive impacts, (b) exempting refinery-related capital goods and industrial inputs from import duties, (c) locating downstream capacity in areas of relative stability, and (d) leveraging external policy anchors to provide policy stability and transparency.

THE CRITICAL MINERALS

The four countries studied are among the Sub-Saharan African countries with the largest proven reserves of bauxite, cobalt, graphite, and nickel, all of which are critical to the global energy transition.⁵ Bauxite is the primary source of alumina ore, a key component of plans to help the construction, energy, and vehicle sectors cut greenhouse gas emissions. Cobalt and lithium are used primarily in the construction of the lithium-ion batteries used in electric vehicles and grid-scale storage. Graphite is used in a variety of applications, including batteries and solar panels. Nickel is important for improving the durability and weldability of steel deployed in dams and wind turbines and as a component of lithium-ion batteries.

For some metals, these countries are globally crucial. Guinea has 23 percent of the world's proven bauxite reserves and accounted for 55 percent of global exports in 2020 (USGS 2022). The DRC produced 71 percent of the world's cobalt and accounted for 48 percent of global cobalt exports in 2020 (USGS 2022, OEC 2022). Madagascar and Mozambique are important producers of graphite, ranking third and sixth in global production in 2020 (the other countries in the top six are China, Brazil, India, and Russia). Madagascar's nickel exports are still relatively modest, despite the fact that Madagascar is home to the Ambatovy Project, one of the world's largest integrated nickel mines and refineries. African producers are responsible for smaller production shares of other minerals but are important exporters, because other key producers consume significant shares of their domestic production.

THE CHALLENGES

Energy Infrastructure

None of the four countries has the energy infrastructure needed to expand refining capacity. Industrial mining can consume relatively little energy (bauxite mining, for example, consumes only 34 kWh per metric ton).⁶ In contrast, the processes that turn mined ore into refined products are highly energy intensive.

5 All four countries also mine other minerals, including gold, diamonds, coal, iron ore, and copper. I focus on bauxite, cobalt, graphite, and nickel because of both projected growth in demand and nascent downstream capacity development.

6 The average US home consumes 30 kWh of electricity per month. The energy consumed to generate 1 ton of refined alumina could power an average US home for over eight years.

Bauxite refining requires over 3,000 kWh per metric ton of refined product on average, and cobalt requires almost 4,700 kWh per metric ton (Farjana, Huda, and Mahmud 2019). Most of the world's largest mineral refineries are in places with abundant and low-cost energy, including hydropower (Brazil, Canada); coal (Australia, China); and natural gas (Bahrain, United Arab Emirates). Thus both current capacity and future generating potential—a function of natural endowments (hydrocarbons, powerful river systems) and the availability of investment capital—figure heavily in siting decisions.

All four countries have significant renewable generation potential, but their installed capacity is not adequate for powering large expansions in downstream processing (table 1). Current generating capacity does not come close to meeting current demand, with Guinea, the best-performing country of the four, providing electricity to just 45 percent of its population. The Guinean government's aspirational alumina refining capacity—11 million tons per year⁷—would require nearly 10 times the country's total current generation capacity.

In the DRC, just 19 percent of the population has access to electricity. Coverage in the country with the most installed capacity per capita (Mozambique) has only 56 percent the average of frontier and developing Asia (Bangladesh, Cambodia, the Lao People's Democratic Republic, Mongolia, Myanmar, Nepal, and Sri Lanka), another world region where significant portions of the population still lack access to reliable electricity. The low level of access in Africa is one reason why the share of mines self-supplying energy via small, often diesel- and heavy fuel oil-powered generators tripled between 2000 and 2020 (Signé and Johnson 2021): national grids are not up to the challenge.

The good news is that all of these countries have vast renewable energy potential, particularly hydropower. The bad news is that energy infrastructure is underdeveloped and will require significant additional financing to construct. A reasonable fear is that refining project-specific generating capacity—a feature of many notional plans to develop downstream capacity—will widen inequalities between the mineral sector and host communities and impose large environmental and social costs.

To supply energy to transform their mineral sectors, African governments should embrace renewable energy technologies and avoid investing heavily in hydrocarbon-based energy infrastructure. All four countries have hydropower potential that surpasses 6,100 kWh/year per capita, with three (the DRC, Madagascar, and Mozambique) surpassing 13,200 kWh/year (Hoes et al. 2017). There is more than enough hydropower potential to meet these countries' ambitious desires to build downstream capacity and provide universal access to electricity for their populations. However, attracting private sector investment is more challenging for utility-scale projects than for refining and/or smaller, mine- or refinery-specific power plants.

7 "Guinea Extends Deadline for Bauxite Miners to Present Refinery Plans," Reuters, June 10, 2022.

Table 1
Installed capacity, generation, and access to electricity in the Democratic Republic of Congo, Guinea, Madagascar, Mozambique, and frontier and developing Asia, 2020

Country	Installed capacity (MW)		Generation (GWh)		Access to electricity (percent of population)
	Total	Per million inhabitants	Total	Per million inhabitants	
Democratic Republic of Congo	2,919	31.6	11,952	129.4	19.1
Guinea	992	73.5	3,203	237.3	44.7
Madagascar	583	20.5	1,976	69.3	33.7
Mozambique	2,765	86.0	19,344	601.7	30.6
Frontier and developing Asia ^a	45,772	153.9	175,621	590.5	91.6

a. Frontier and developing Asia includes Bangladesh, Cambodia, the Lao People's Democratic Republic, Mongolia, Myanmar, Nepal, and Sri Lanka.

Sources: World Bank (2022) and IEA (2021).

The African Development Bank and the World Bank have provided catalytic financing for industrial-scale projects. These financing mechanisms need to be better capitalized and expanded. More advantageous would be for advanced and high-emitting economies to commit to fiscal support for climate mitigation and adaptation costs in developing- and middle-income countries that would include financing for sustainable energy development, available through centralized funds or bilateral grants and/or debt relief (Bolton et al. 2022). Some substantial portion of these funds could be channeled through support for multilateral development banks like the African Development Bank, which could help diffuse best practices and technical knowledge across the continent.

Investing heavily in legacy energy sources like liquefied natural gas (LNG)—or even worse, diesel and heavy fuel oil—is a bad idea. These power sources contribute to global carbon emissions and have significant adverse environmental impacts on local air quality. The merits of LNG-supplied power (the least environmentally unsound source of hydrocarbon power) include its smaller geographic footprint and ability to fuel refinery- or mine site-specific power plants that do not require access to national or regional power grids.

These merits are considerable, but they come with several large costs. First, recent turbulence in world energy markets resulting from the war in Ukraine cast serious doubt on whether LNG is a safe and stable bet as a reliable energy source for a developing country with no or limited domestic hydrocarbon reserves (the

DRC, Guinea, Madagascar). Mozambique stands out in this group, as it has the third-largest natural gas reserves in Africa.⁸ Nevertheless, it would still be more sensible to source industrial-scale power from hydro and export LNG, an energy resource that will still be a valuable part of both the global and regional energy mix for some time. Second, locking the mineral sector into hydrocarbon-based power systems may curtail its attractiveness to investors that increasingly seek sustainable investment opportunities.

All four countries have made strides in expanding hydropower capacity—in fits and starts. The DRC has notional plans to develop an astounding 40,000 MW of additional capacity—twice the capacity of China’s Three Gorges Dam, the world’s largest hydro facility—along the Congo River. But progress has been slow and racked by concerns about financial viability and the cost of transporting power from the dams to southeastern Congo to power mining and mineral processing.⁹ Guinea’s Souapiti dam, which entered service in 2021, added 450 MW of capacity, doubling the country’s renewable energy capacity. Mozambique is currently soliciting offers for development stakes in its Mphanda Nkuwa project, which has already received support from the African Development Bank and the World Bank.¹⁰ A joint British-Norwegian public-private partnership is developing a 120 MW facility in eastern Madagascar.¹¹ Of these projects, the DRC project would be the only true game-changer, albeit with risks proportional to its potential benefits.

Financing and Political Risk

Current market conditions are mixed with respect to prospects for securing financing for large downstream projects. On one hand, prices for critical minerals are at or near 10-year highs, and forecasted demand is very strong. On the other, the push to develop African downstream capacity is coming at a time when global interest rates are rising in attempts to curb inflation. Because of the highly globalized nature of capital markets, these largely uncoordinated interest rate hikes risk overshooting their inflation targets and pushing the global economy into a deep recession, which would further restrict the availability of capital (Obstfeld 2022).

Mining companies have constrained choices when investing in extractive capacity (the process of harvesting minerals from their deposits). The locations of mineral ore deposits are determined by geology, not political economy. The underlying assets are immobile. Mining companies often work in areas of weak governance and political instability, both because the mine sites themselves can be causes of (or at least conducive to) conflict and because mines cannot be relocated, making them the default sector in many active conflict zones (UNDP 2011).

8 US Energy Information Agency, “Mozambique,” EIA Country Report, <https://www.eia.gov/international/overview/country/MOZ> (accessed on October 20, 2022).

9 “Congo Picks Australia’s Fortescue to Develop Giant Hydro Project,” Reuters, June 15, 2021.

10 “Mozambique: 7 Companies Run for the Mphanda Nkuwa Hydroelectric Mega Project,” *Afrik 21*, October 12, 2022.

11 “Africa: BII Invests \$200m in Hydropower with Norfund and Scatec,” *Afrik 21*, June 24, 2022.

Downstream capacity is different. Bulk shipping allows refining capacity to be located thousands of miles from mine sites, in places with more favorable energy supplies; more tolerance for, or ability to mitigate, environmental impacts; and greater policy and political stability. At the margin, these decisions are also affected by the costs of importing the capital goods necessary to build refineries. Despite having either no or limited domestic capital goods industries, all four countries impose official import duties on industrial inputs, a practice that tends to discourage investment in processing and encourage the export of raw materials.

Policy and political stability are the most fundamental factors, because they affect the ability to build supporting energy and transportation infrastructure, mitigate, and/or remediate environmental impacts; they are also associated with higher-quality human capital (Henisz and Zelner 1999, Collier et al. 2003, Gates et al. 2012). Macro-indicators in the four countries, such as the rule of law, control of corruption, and political stability, give reason for pause. All four score in the bottom quartile of the World Bank's Governance Indicators Rule of Law and Control of Corruption measure, suggesting that rent-seeking is common and property rights for investors are weak (World Bank 2022). Of the four countries, Madagascar and Mozambique perform best, with the DRC a distant fourth.

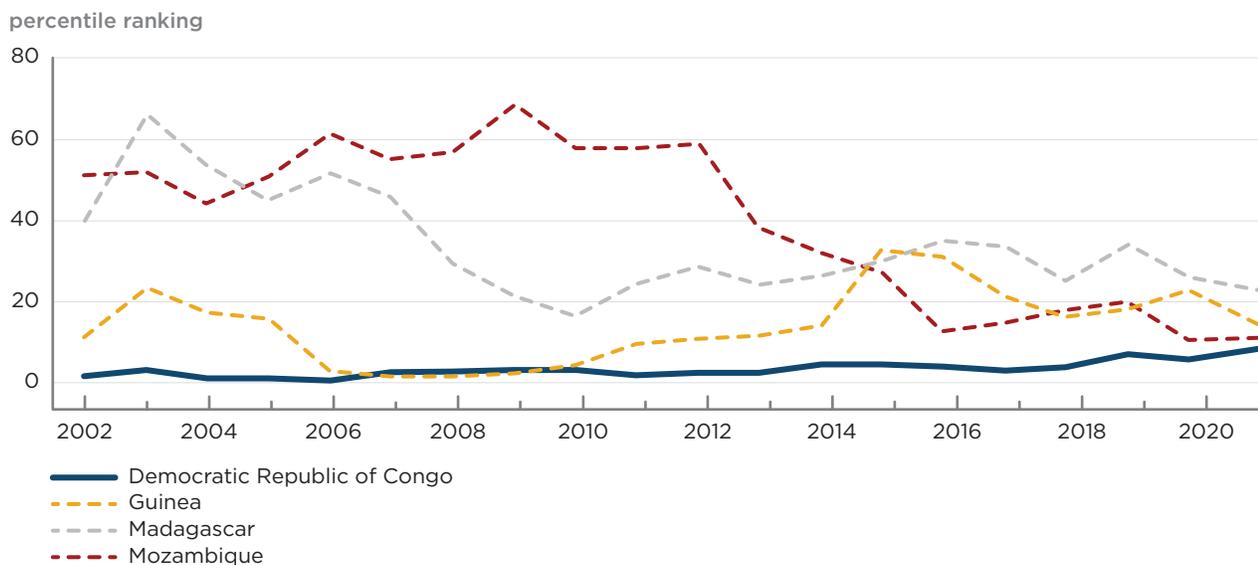
As of 2021, all four countries were also in the bottom quartile of the World Bank's Political Stability/Absence of Violence indicator, which captures "perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism" (World Bank 2022, figure 1). The DRC has consistently ranked near the bottom on this indicator for decades, because of seemingly pervasive violence and instability in its eastern provinces (Ituri, North and South Kivu, and Tanganyika), the regions rich in tantalum, tin, tungsten, and gold (the 3TG targeted by the Dodd-Frank Act). The country's cobalt deposits are in the stabler southeastern provinces of Lualaba and Haut-Katanga. The DRC's past success in developing copper refining capacity in the region—more than 80 percent of Congolese production is refined in country—suggests that governance challenges to downstream development are not insurmountable if the proximate environment is relatively politically stable.

After nearly three decades of stability, Mozambique has descended back into civil war, albeit (so far) a highly localized one. Government and South African Development Community (SADC) forces are attempting to neutralize a violent insurgency waged by an arm of the Islamic State in Mozambique's mineral-rich Cabo Delgado province. Perhaps not coincidentally, Cabo Delgado is home to some of Mozambique's richest mineral deposits, including graphite, natural gas, and rubies. Although graphite and ruby mines have been targets of Islamic State attacks in the region,¹² production has continued, albeit with some interruptions. Processing occurs abroad, however, and plans for installing new capacity do not include Mozambique. Syrah Resources, the parent company of Mozambique's most productive graphite mine, received a loan of about \$102 million from the US Department of Energy to build additional refining capacity—in Vidalia, Louisiana.¹³

12 "ISIS Claims the Attack on Graphite Mine in Mozambique," SABC News, June 18, 2022.

13 "DOE's Shaw Ready to Promote New \$250B Energy Investment Loan Program," S&P Global Market Intelligence, September 15, 2022.

Figure 1
World Bank Index of Political Stability/Absence of Violence in the Democratic Republic of Congo, Guinea, Madagascar, and Mozambique, 2002-21



Source: World Bank (2022).

Madagascar and Guinea face different political stability-related challenges. Neither has experienced a large-scale civil war in the past several decades.¹⁴ However, both have histories of partisan violence and violent seizures of power centered on presidential politics. In 2009-10, clashes erupted between supporters of Andry Rajoelina, then mayor of Antananarivo, and then-president Marc Ravalomanana. Ravalomanana ultimately resigned under duress, with Rajoelina assuming power with the support of the Malagasy military in what was widely viewed as a *coup d'état*.

In 2021, Guinea's elected president, Alpha Condé, was deposed in a military coup that brought Mamady Doumbouya to power. Guinea's military government sees itself as a caretaker, albeit a long-term one: In May, interim president Doumbouya announced that the military planned to hand power back to elected leaders in three years and that no members of the ruling junta would be allowed to stand for election.¹⁵ No date has been set for elections, however.

These types of instability—coups and sporadic partisan rioting—are far less detrimental to human development than civil wars and insurgencies (Gates et al. 2012). But they may be just as detrimental in terms of their effects on courting foreign direct investment in large projects with massive initial capital costs and multi-decadal time horizons.

14 Guinea was for a time involved in counterinsurgent operations in the early 1990s and early 2000s, largely because of spillovers from much larger armed conflicts in neighboring Liberia and Sierra Leone.

15 "Guinea to Move to Civilian Rule in Three Years," BBC News, May 1, 2022.

One positive with respect to geopolitical risk regards the nature of underlying resources. Whether natural resources tend to generate conflict dynamics, like those in the 3TG-rich Eastern Congo, is determined in large part by the nature of the resources themselves. Bauxite, lithium, and graphite are mined profitably only at industrial scales, and bauxite and graphite have comparatively low value-to-weight ratios. Both attributes make these resources less exploitable by nonstate armed groups like rebel armies and militias (Hendrix and Noland 2014). Market prices for lithium are substantially higher, but the technological and capital requirements associated with their extraction also place it outside the category of “conflict minerals.”

Cobalt is more complicated, as it can be mined both artisanally and industrially. Artisanal mining is responsible for up to 20 percent of the DRC’s cobalt production, with the remainder sourced from large open pit mines that also produce copper. Despite the prevalence of conflict around artisanally mined gold and other conflict minerals in eastern Congo, the DRC’s artisanal cobalt mines have not been targets for armed actors. Its cobalt industry has been implicated in exploiting child workers in dangerous conditions, however, with abuses most prevalent in the artisanal sector (US Department of Labor 2021).

THE SOLUTIONS

To develop downstream capacity, African governments must address challenges in power generation and provide more policy stability and insurance against disruptions from armed conflict. Though considerable, these challenges can be overcome. They should be met in ways that ensure sustainable access to power over the long term and a viable social license to operate in affected communities.

- *Embrace hydropower potential—which is vast in these countries—but pay attention to social costs.* The high costs of developing hydropower have slowed its expansion. Unless situated in extremely remote areas, hydro projects displace entire communities and impose localized economic costs in the form of reduced economic activity, “greenness,” and ecosystem function in the Global South (Fan et al. 2022). To ensure that these projects are not simply foisted on the most marginalized people, countries should conduct comprehensive environmental impact and social impact assessments and use the results to develop compensation schemes for disproportionately affected communities (Moran et al. 2018, Markkanen and Anger-Kraavi 2019). Investors should require independent auditing of government relocation, resettlement, and compensation processes to help ensure fairness and forestall popular discontent. Doing so would help build and sustain lasting social license to operate.
- *Exempt refinery-related capital goods and industrial inputs from tariffs.* Developing countries often rely on trade taxes, such as import and export duties, as key sources of government revenue. For capacity-constrained governments, trade taxes are attractive because ports provide a convenient tax handle that makes evasion difficult. The marginal benefits of imposing import duties on industrial inputs must be weighed against both the benefits of developing downstream capacity and the effects such taxes may have on siting decisions by multinational corporations. Exempting

refinery- and associated infrastructure-specific capital goods and industrial inputs from taxation should reduce barriers to investing in in-country downstream capacity.

- *Locate downstream capacity in areas of greater domestic stability.* Many armed conflicts in Africa, including those in the DRC and Mozambique, are highly localized. Pockets of opportunity—areas and populations in conflict-affected and fragile states that benefit from better access to infrastructure and greater stability—often exist (Hendrix and Anderson 2021). These pockets are usually located near areas of significant government presence near major cities, ports, and transportation hubs. Slurry pipelines can be used to transport mined ore long distances (sometimes hundreds of kilometers) from fragile locations for processing in stabler areas. Doing so reduces the costs and vulnerabilities associated with overland trucking or rail transport in fragile contexts. Pipelines are no panacea, as they can be sabotaged, but they do reduce exposure of mine and refinery staff to the dangers of operating in insecure environments.
- *Leverage external policy anchors to provide policy stability and transparency.* External policy anchors are commitments to external actors—foreign governments, intergovernmental organizations, or civil society organizations—that help “lock in” policy reforms by enhancing international scrutiny of domestic practices and increase the costs of renegeing/failing to act according to agreed-upon standards. When domestic checks on corruption and property rights protections are weak, external policy anchors can serve as partial substitutes.

One such anchor is the bilateral investment treaty (BIT), which establishes the terms for private investment by foreign nationals and companies. BITs include provisions for channeling disputes through international arbitration rather than the host state’s legal system. They are particularly relevant for investment in extractives and linked industries, because the underlying assets are immobile, eliminating or massively increasing the costs of using capital flight as a mechanism to keep host governments honest.

The four countries have a patchwork of BITs with the economies that are home to most of the world’s largest extractive firms (table 2). All four have signed BITs with China, although the DRC and Guinea have failed to ratify theirs. The United States has BITs with the DRC and Mozambique. Guinea is the only one of the four countries to have a BIT with Canada, and only Mozambique has a BIT with the United Kingdom. None of the countries has a BIT with Australia. To court downstream investment, African governments should prioritize establishing BITs with a wider array of Western partners.

The four countries are active participants in regional economic blocs, including the Economic Community of West African States (ECOWAS [Guinea]), the East African Community (the DRC), and the South African Development Community (Madagascar, Mozambique; since 2019, Guinea has been subject to ECOWAS’s Common Investment Code). However, Guinea is also under ECOWAS sanctions stemming from the military coup.

Not all external anchors are intergovernmental in nature. All four countries participate in the Extractives Industries Transparency Initiative (EITI), which affects investor confidence indirectly by establishing double-entry accounting mechanisms and convening multistakeholder certification and reporting mechanisms intended to combat corruption. Both the DRC and Guinea are categorized as “high” in terms of their compliance status, although the coup in Guinea has cast doubt on its designation.¹⁶ Madagascar and Mozambique are categorized as having made “meaningful progress” in complying with EITI’s transparency standards. Achieving high compliance should be a top priority.

Table 2
Bilateral investment treaties of the Democratic Republic of Congo, Guinea, Madagascar, and Mozambique with five major economic powers

African country	Major economic power				
	<i>Australia</i>	<i>Canada</i>	<i>China</i>	<i>United Kingdom</i>	<i>United States</i>
Democratic Republic of Congo	No	No	No (signed, never ratified)	No	Yes
Guinea	No	Yes	No (signed, never ratified)	No	No
Madagascar	No	No	Yes	No	No
Mozambique	No	No	Yes	Yes	Yes

Source: UNCTAD (2022).

Building the sustainable energy systems of the future will require much larger, more resilient supply chains for the critical minerals that underpin green technology. African economies will be key actors in this process as producers of raw materials. Whether they can move up the value chain by developing more local mineral processing capacity will depend on how successful they are in tapping their vast hydropower resources, being mindful of the costs imposed on local communities, and addressing or mitigating governance challenges that act as barriers to investment.

¹⁶ “Statement from the EITI Board Chair on the Situation in Guinea,” EITI, September 7, 2021.

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