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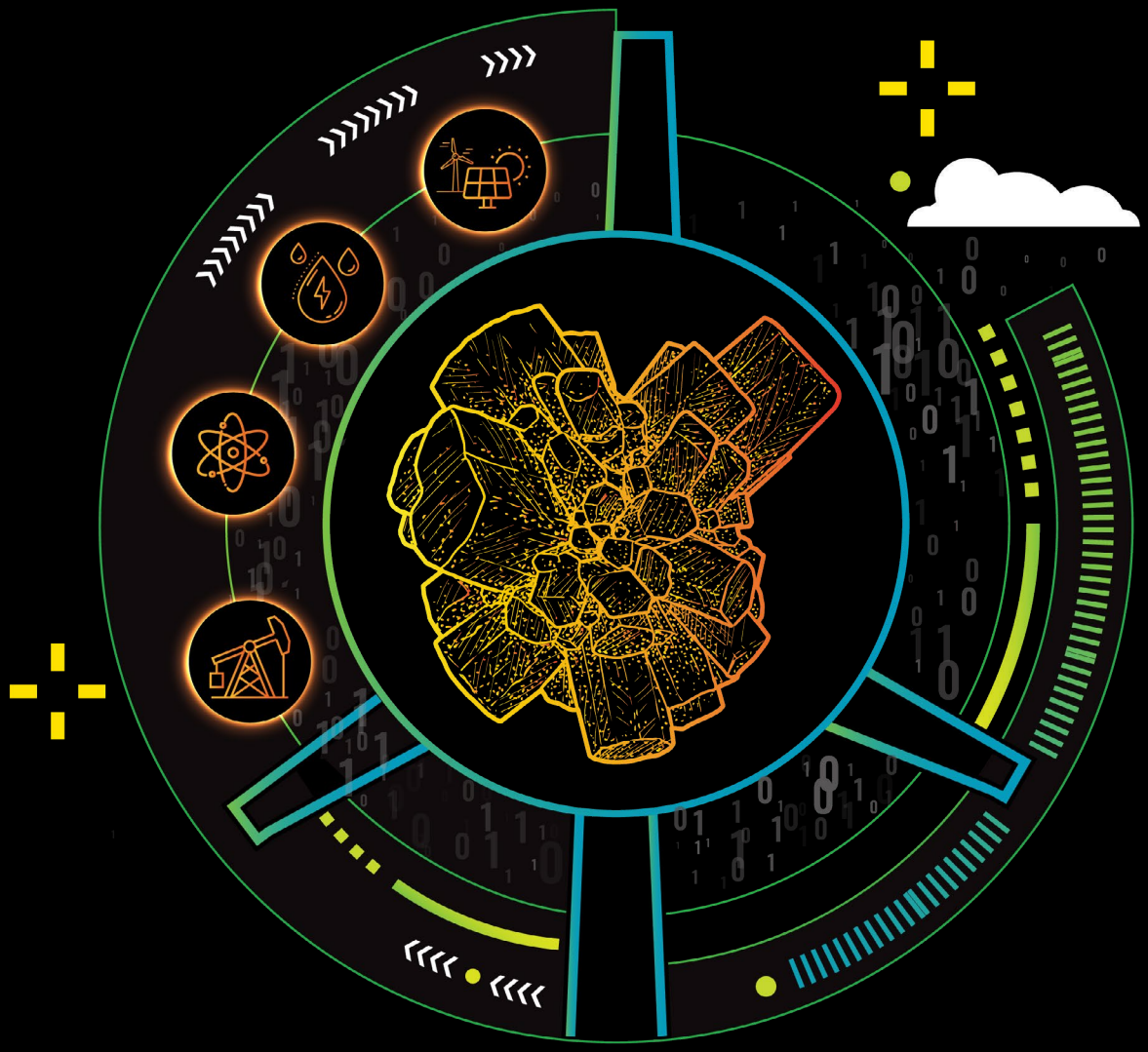

Africa's role in a clean energy future

October 2022

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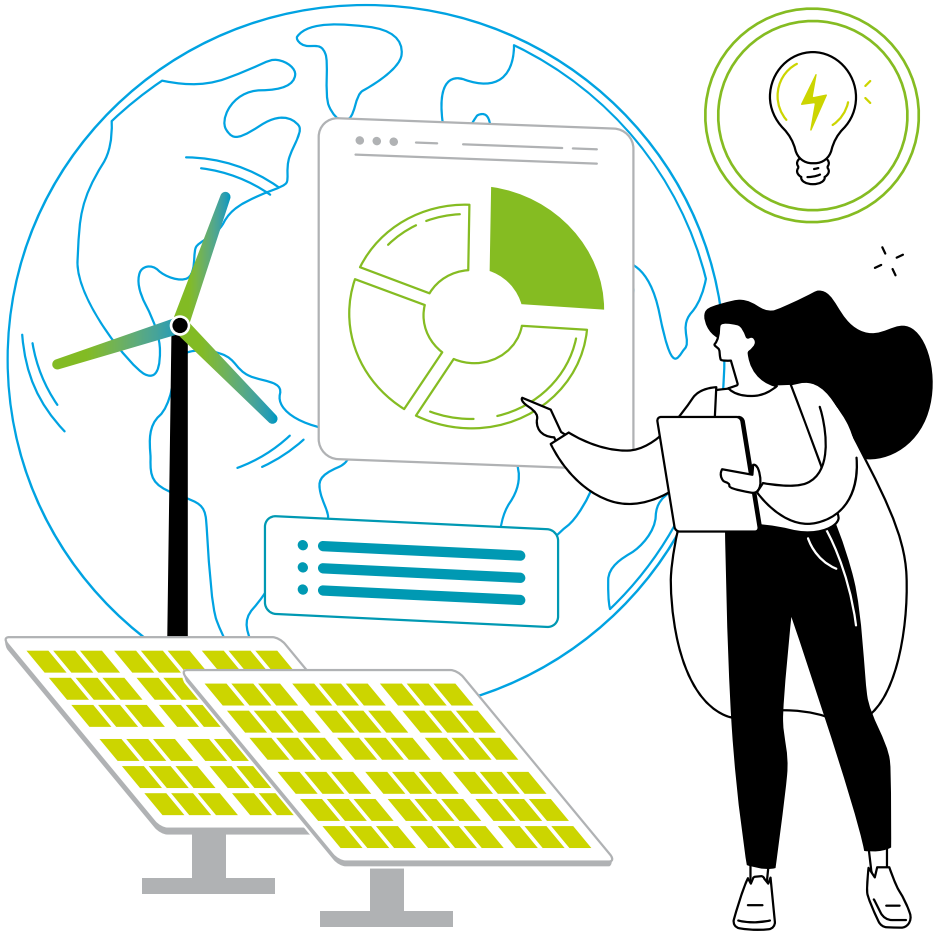
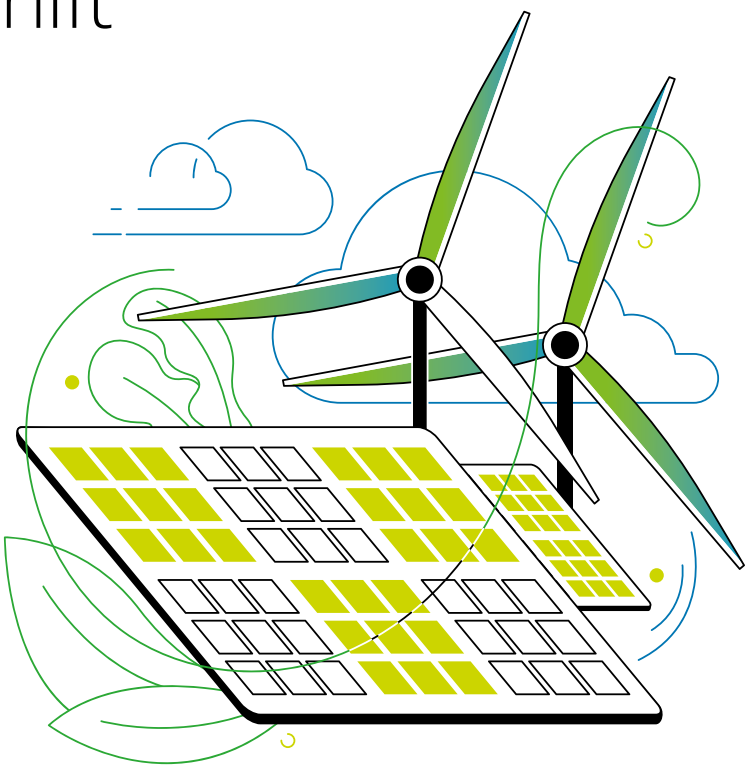
Contents



Accelerating the shift to clean energy



For decades, there has been a progressive trend towards cleaner energy sources. While until relatively recently moving at a pedestrian pace, the shift away from fossil fuels has accelerated radically in recent years.

Although clean energy investments were driven by the steady reduction in the cost of renewable technologies post the signing of the Paris Agreement in 2015, clean energy investments only grew by 2% a year to 2020. But the COVID-19 pandemic, resultant supply chain disruptions (exposing a disproportionate reliance on China), policy-driven moves in major markets from internal combustion engines (ICE) to new energy vehicles (NEVs), and net-zero commitments of the world's foremost economies have accelerated this trend. Since 2020, clean energy investment growth has increased to 12% per year.[1]

This year, Russia's invasion of Ukraine, which developed into a full-scale, drawn-out war, has given further impetus to this trend. High prices, coupled with energy security concerns, have accelerated several governments' commitments to invest in renewables, while also increasing the need to diversify concentrated sources of supply.

As such, demand, driven by investments in electric vehicles (EVs), batteries, and renewable technologies, chiefly solar and wind energy generation, together with the changing geopolitics of supply, have shifted the security of supply dynamics for commodities such as copper, cobalt, lithium, nickel, platinum group metals (PGMs), vanadium, rare earth elements (REEs), and even natural gas – all critical resources that Africa can supply.

A unique opportunity for Africa

As the world looks for supply source alternatives to Russian energy, Africa, arguably, has the potential to reshape the supply chain for many clean energy options. Some African economies could even become pivotal suppliers of energy minerals and natural gas in the immediate term.[2] This is a unique opportunity for commodity-driven African economies – particularly as the mining sector continues to provide an important foundation for economic diversification and improving the lives of Africans.[3]

To attract investment for downstream value addition in commodities important for the green future, and to boost industrialisation, Africa needs to build its strategic position to supply those, while balancing the risk of being dangerously exposed to commodity price fluctuations.

As the world considers what the future resource mix will be, and how the unfolding energy crisis will play out, industry players and policy makers need answers. This paper singles out some of the commodities that are essential to the clean energy future that Africa can supply, their applications, significant mining jurisdictions, and important investments and developments already underway. It also provides some considerations for African policy makers and industry players to help best take advantage of the current and emerging opportunities.

Key commodities for a clean energy future

Africa holds considerable resources and is already a significant producer of commodities vital to a clean energy future. These include commodities essential in renewable energy-generation technologies (such as solar and wind), as well as battery-associated materials, namely bauxite (a precursor to aluminium), cobalt, copper, graphite, lithium, nickel, PGMs, REEs, and vanadium. Several of these have been deemed to be "critical" and of "strategic importance" by many governments and research institutes (refer to Table 1).

Table 1. Minerals deemed critical and of strategic importance

Mineral/metal	Selected applications	Critical for select clean energy technologies	EU critical minerals list (2020)	US critical minerals list (2022)
Aluminium (bauxite)	Multi-sector	Solar photovoltaics (PV), concentrated solar power (CSP), electricity networks, EVs and stationary energy storage	X	X
Cobalt	Electrochemical batteries, superalloys	EVs and stationary energy storage	X	X
Copper	Multi-sector	Solar PV, wind, bioenergy, electricity networks, EVs and stationary energy storage		
Graphite	Electrochemical batteries, fuel cells, lubricants	EVs and stationary energy storage		X
Lithium	Electrochemical batteries	EVs and stationary energy storage	X	X
Nickel	Electrochemical batteries, stainless steel, alloys	Geothermal, EVs and stationary energy storage, hydrogen		X
PGMs	Catalytic agents in hydrogen electrolysis and fuel cell applications	Hydrogen: water electrolysis and fuel cells	X	X
REEs	High-tech devices, defence, clean energy	Permanent magnets in electrical motors for wind turbines and EVs	X	X
Vanadium	Alloying agent	Stationary energy storage	X	X

Sources: Adapted from IEA, 2022;[4] USGS, 2022;[5] and European Commission, 2020[6]

Copper

While not on the critical minerals lists of the EU and US, copper has wide applications in clean energy technologies. It is used in wind and solar technology, and in EVs, battery storage, and electricity networks. Given its conductive, ductile, efficient, and recyclable qualities, copper is a vital input for wiring, cabling, heat exchangers, motor coils, turbines, and transformers.[7] Chile and Peru are significant miners of copper, and China and Chile leading refiners.[8]

With recent supply disruptions in Peru and Chile, some analysts expect a decade of demand outstripping supply.[9] The fundamental supply challenges facing major South American copper producers are caused by the declining ore quality, higher production costs, social unrest, labour issues, and high levels of climate and water stress.[10] The potential shortage is compounded by rising demand as different energy transition scenarios forecast increases of between 40% and 70% from the current levels. A conservative scenario sees the demand for refined copper at 40Mt by 2040, largely due to its growing role in electromobility applications.[11]

In 2021 the Democratic Republic of the Congo (DRC) and Zambia were the fourth and seventh-largest copper producers, respectively. The DRC was also the fourth-largest producer of refined copper.[12] The African Copperbelt spanning the DRC and Zambia could thus become an even more important source of global copper supply.

Cobalt

The DRC is also the world's most important producer of cobalt and the only country where cobalt is mined as a primary commodity. Most of the world's terrestrial cobalt resources are in sediment-hosted stratiform copper deposits in the DRC, which produce 70% of the world's cobalt. Pre-war, Russian contributions accounted for around 6%.[13] Alternative supplies will depend on developments in both copper and nickel, given that cobalt is a by-product of these.[14]

The leading application of cobalt is in lithium-ion batteries used in EVs, renewable energy storage, and mass-produced consumer electronics. China is responsible for over 80% of global cobalt consumption linked to the rechargeable battery industry. China is also the world's primary producer of refined cobalt, produced from imported cobalt concentrates.[15]

The risks associated with the security of cobalt supply, its high cost, and volatile pricing drive the effort to reduce cobalt content in batteries and the search for suitable substitutes, of which nickel is currently the leading option. Depending on the evolution of battery chemistry, cobalt could see anything between six and 30 times more demand between now and 2040.[16]

Nickel

With primary applications in EVs and battery storage, as well as in hydrogen and geothermal technologies, nickel has a vital role in the clean energy future. Demand could more than double by 2040, with some analysts expecting nickel demand to outpace the demand for lithium – another critical input for battery manufacturing.[17]

Sanctions on Russia, previously producing 11% of the world's nickel, have increased concentration risk and reliance on Indonesia by nickel importers. One such importer is the US, which recently added nickel to its critical minerals list. Indonesia produced an estimated 37% of nickel in 2021.[18]

In Africa, nickel is mainly mined in South Africa, Madagascar, Zambia, Côte d'Ivoire, and Zimbabwe.[19] Notably, South Africa and Zimbabwe produce a significant volume of nickel as a by-product of the PGM smelting and refining processes; this nickel can be processed relatively easily to battery grade.[20]

Nickel sulphide resources, like those in East Africa's nickel belt, provide the continent with a potentially significant competitive advantage in producing class 1 nickel suitable for battery applications. The nickel mining jurisdictions located in the tropical belt of laterite nickel deposits are more suitable for pig iron production. This difference is mainly due to the lower capital intensity, relative ease, lower energy requirements and environmental impact of sulphide ore processing, which appeals to ESG-conscious investors and producers in the battery-metals value chain.[21]

Not all nickel is made equal

Nickel is processed into high-purity class 1 products (around 45% of global nickel production, including briquettes, cathodes and sulphates) and low-purity class 2 products (about 55% of global nickel production, including mainly ferronickel and nickel pig iron).[22] On average, sulphide operations (mostly nickel class 1) cost less than laterite operations (mostly nickel class 2), due to processing techniques being relatively simple and production costs often being spread out over the multiple by-product commodities, such as copper, cobalt, PGMs, gold, silver, and scandium.

Nickel sulphate, derived from class 1 nickel, is required by lithium-battery producers as it is mixed with other sulphates to produce metal hydroxides that are precursors to manufacturing battery cathodes. The nickel quality specification in stainless steel applications is far more relaxed. During the refining of nickel, the processing pathway diverges once an intermediate nickel product has been made. Producers can either use electrolysis to produce refined nickel for stainless steel and alloy end-uses, or leaching and crystallisation to produce nickel sulphate for the battery and plating markets. This step can either occur at the mine site or well down the value chain, depending on a specific producer's level of integration. The cost of converting the nickel to nickel sulphate is represented in the premium paid above the benchmark nickel price.

Class 2 nickel could also be utilised to produce nickel sulphate, but it is very expensive to transform these products to satisfy growing demand from the battery sector. Over the last few years, nickel pig iron has been the main form of new nickel supply growth, which is one reason why nickel prices have been weak until recently. A consequence has been curtailments in class 1 nickel capacity and companies delaying capital expenditure as class 1 nickel is expensive to grow. In the longer term, however, there will be a need for new class 1 capacity to meet increasing demand from the growing battery sector. This is more capital-intensive and will require higher nickel prices.

Lithium

With three quarters of lithium demand going to rechargeable lithium-ion batteries for EVs and energy storage applications, lithium's importance has considerably increased in recent years.[23] While intense research on a myriad of battery electrochemistry technologies is being carried out globally, lithium-ion battery technology is the current technology of choice, benefiting from a long history of scientific research and development, and a dramatic cost reduction due to applications at scale. Depending on the future choices for the preferable battery electrochemistry, lithium demand could grow from 13 to 50 times by 2040.[24]

Lithium production has been concentrated in Australia, Argentina, Chile, and China, with other countries contributing relatively smaller shares to global output. Zimbabwe has the largest lithium resources in Africa, but it remains a relatively insignificant lithium producer.[25] The other African mining jurisdictions endowed with mineral-based lithium resources include Ghana and Mali in West Africa, along with the DRC. The development of lithium opportunities in Africa stands to benefit as technology companies across Asia, Europe, and the US look wider to secure access to the available lithium supply.[26]

Graphite

Graphite is known for its metallic properties, including thermal and electrical conductivity, and non-metallic properties such as inertia, high thermal resistance, and lubricity. These properties make graphite highly suitable for industrial applications such as high-temperature lubricants, brushes for electrical motors, friction materials, pencils, steel manufacturing, and electronics. The most important application of graphite is in the anodes of lithium-ion batteries, where there is actually 10 to 30 times more graphite than lithium.[27] Mainly due to graphite's importance in electrochemical batteries, demand is forecast to grow anywhere between six and 30 times by 2040.[28]

Graphite is predominantly produced in China, which is responsible for about 70% of global output.[29] China's production of graphite is primarily from amorphous and flake deposits. Amorphous or powder graphite is largely used in refractories and foundries, whereas high-purity flake graphite is in demand in the automotive industry, as the key component for electric, hybrid, and fuel-cell vehicles.[30]

In Africa, Tanzania and Mozambique hold significant graphite reserves where large graphite deposits are being developed. Significant deposits are also found in Namibia and Madagascar. The Balama Graphite Project in northern Mozambique is reportedly the world's largest graphite deposit, with an expected life of mine of 50 years.[31] The flake and vein graphite deposits of Mozambique and Madagascar are suitable to produce high-grade graphite for lithium-ion batteries. Almost half of the graphite projects in Mozambique and Madagascar are either in an advanced stage of development or in production and could supply the market in the near and medium term.[32]

Bauxite/Aluminium

Bauxite, a sedimentary rock, is the world's main source of both aluminium and gallium. Global resources of bauxite are estimated to be between 55 billion and 75 billion tonnes and are sufficient to meet world demand for metal well into the future. More than half of the world's aluminium is smelted in China, but Russia, India and other countries also play a significant role.[33]

Aluminium weighs only one-third of steel, and as such it is more frequently used in car production and in the construction industry. Lighter cars use less power and are more environmentally friendly, while aluminium framing helps to improve the energy efficiency of built structures.

Guinea is by far the largest producer of bauxite in Africa and was the world's third-largest bauxite miner after China and Australia in 2021.[34] The three West African countries of Guinea, Ghana and Sierra Leone hold at least one-third of the world's proven bauxite reserves.[35]

Vanadium

Vanadium is extracted from vanadium-bearing ore predominantly found in China, Russia, South Africa, and Brazil, while secondary sources (oil, fly ash, and spent catalysts) are found in North America, Europe and East Asia. All vanadium is converted into either vanadium pentoxide or trioxide, with most vanadium pentoxide further processed into ferrovanadium (FeV) for use in steel alloying.[36]

China was the world's biggest vanadium producer in 2021, accounting for more than 60% of global supply, followed by Russia (about 17%), with both countries producing vanadium almost exclusively as a co-product of iron ore for processing into steel. South Africa (8%) and Brazil (6%) host the world's only three primary vanadium mines. Around 60% of primary vanadium, mined directly from vanadium-bearing ore, originates from South Africa. The Bushveld Complex in South Africa has some of the highest-grade vanadium mineralisation in the world. Co-production is generally regarded as more expensive due to the economics of also producing steel.[37]

Vanadium is primarily used in steel alloys, which currently account for almost 90% of total vanadium demand. The remaining 10% is consumed in chemical processing, aerospace alloys, and vanadium redox flow batteries (VRFBs). These areas of demand are expected to be the most rapidly growing in the near future, notably the battery segment in large grid-scale energy applications. The demand for vanadium is expected to increase by 110% by 2031 and 189% by 2050.[38]

Vanadium redox flow battery technology

VRFB technology offers a commercially viable large-scale energy storage solution that can compete with lithium-ion batteries, the current technology of choice across the spectrum of applications. VRFBs are proven to be longer lasting, more affordable (both in terms of capex and cost per kWh), and preferred in less portable, more permanent, grid-scale installations for municipalities, industrial sites, villages, residential estates, and microgrids, all of which are particularly important in the African context. A vanadium electrolyte represents the highest cost component of a VRFB, accounting for more than 30% of its value, a significant single raw material cost compared to other battery technologies.[39]

Platinum Group Metals (PGMs)

PGMs include six elements: platinum (Pt), palladium (Pd), rhodium (Rh), ruthenium (Ru), osmium (Os), and iridium (Ir). The bulk of global PGMs are mined in Southern Africa and Russia. South Africa's Bushveld Complex has the largest reserves of PGMs, with Zimbabwe holding the third-largest reserves after Russia. South Africa is also the largest producer of platinum and palladium, followed by Russia and Zimbabwe.[40]

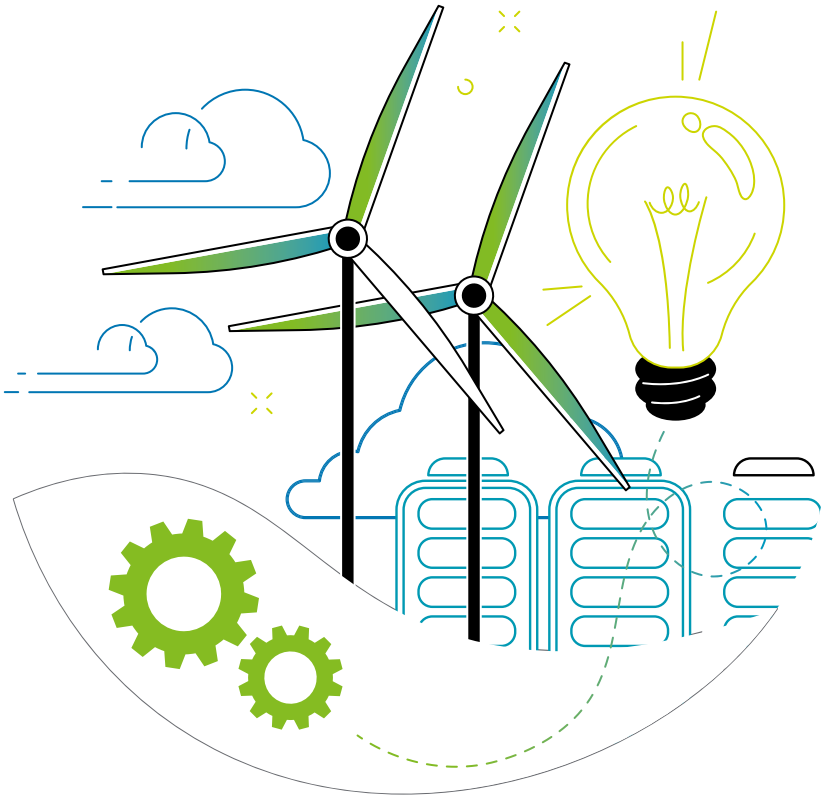
PGMs are generally used in applications which require their unique properties, such as corrosion resistance, biocompatibility, high melting temperature, good conductivity, and electronic and catalytic properties. By far, the largest demand for PGMs is for all forms of catalysis, with the largest demand in auto catalysis. In fact, the biggest driver of demand and price for platinum, palladium, and rhodium is auto-emission regulation, which has driven auto-catalyst design. A significant volume of platinum is also used in manufacturing jewellery.[41]

As the next-generation energy technologies for hydrogen production, such as electrolysers and fuel cells for stationary energy storage and transport applications, are maturing, the demand for PGMs is expected to further increase, particularly for platinum, palladium, and iridium, used as catalysts.[42] The significant use of PGMs in the large global auto industry is likely to continue into the foreseeable future, but the long-term transition towards electromobility will certainly have an impact on the demand profiles.[43]

South Africa's unique opportunity to participate in the global hydrogen economy

Hydrogen is exceptionally energy dense and a versatile medium. If it is produced with renewable energy (green hydrogen), it can decarbonise a wide spectrum of sectors and applications. Hydrogen can be used as a fuel in transportation, generate heat and power for buildings, provide industrial heat and chemical feedstocks, and efficiently store, convert, and transfer energy.

South Africa has a significant competitive advantage in producing green hydrogen energy for export and to transform its domestic economy. The country has world-class solar and wind power-generation resources that can be used to produce green hydrogen in the water-electrolysis process. Moreover, South Africa is also endowed with PGM resources, with platinum, palladium and iridium the necessary catalysts in the water-electrolysis process and hydrogen fuel-cells. South Africa could reap remarkable benefits from the global energy transition with green hydrogen production.[44]



Rare Earth Elements (REEs)

REEs are a group of 17 elements including the 15 lanthanides, lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), and lutetium (Lu); as well as scandium (Sc) and yttrium (Y). REEs are necessary components of more than 200 products across various high-tech and clean energy applications. However, only a handful of REEs, including neodymium, dysprosium, europium, terbium, yttrium, and erbium, are considered critical because of their importance in technology applications and demand significantly exceeding available supply.[45]

Deposits of REE ores are not rare, if compared to precious metals, but the metals themselves can be considered scarce, because of an almost complete domination of this market by China. In the early 1990s, the US was one of the largest suppliers of rare earth metals but allowed its mining industry to decay because of environmental concerns and market changes. Mining activity and processing and refining know-how then gradually shifted to China.[46]

Extraction from primary ore deposits accounts for most REEs' production, but a complex and potentially environmentally harmful process of concentration, separation and refining of individual elements is the most sensitive part of the value chain. The mining and production of REE concentrate yields relatively low-value products, with significantly more value captured by downstream beneficiation of individual elements.

REEs do not have many adequate substitutes in most of their applications, with the anchor application being in permanent magnets, used as part of EV motors and wind turbines (close to 30% of global demand). Neodymium, dysprosium, and terbium are the key elements applied in magnets. Applications in clean technologies are responsible for close to 50% of the global demand for REEs.[47]

There are very few significant REE operations outside China. The largest active REE projects can be found in Australia, Canada, the US, Japan and Greenland. In Africa there are REE projects in Tanzania, South Africa and Namibia.[48]

Energy transition minerals supply is highly concentrated

Current production of some of these energy transition minerals is more geographically concentrated than oil or natural gas. This is particularly true for cobalt, copper, graphite, lithium, nickel, platinum and REEs. Similarly, processing concentration risk for cobalt, copper, lithium, nickel and REEs is high (see Table 2 and Table 3). Concentration risk due to Western sanctions on buying Russian energy and mineral commodities post Russia's invasion of Ukraine (Russia previously was a top-three producer of aluminium, cobalt, nickel, PGMs and vanadium) has further increased the risk to supply security.[49]

Table 2. Share of top three producing countries for selected fossil fuels and minerals, 2019

		Fossil Fuels		Minerals						
		Oil	Natural Gas	Copper	Nickel	Cobalt	Graphite	REEs	Lithium	Platinum
Top three producers	1st	US	US	Chile	Indonesia	DRC	China	China	Australia	South Africa
	2nd	Saudi Arabia	Russia	Peru	Philippines	Russia	Mozambique	US	Chile	Russia
	3rd	Russia	Iran	China	Russia	Australia	Brazil	Myanmar	China	Zimbabwe
Combined share of top three producers		~43%	~47%	~50%	~55%	~78%	~82%	~85%	~87%	~92%

Source: Adapted from IEA, 2022[50]

Table 3. Share of top three countries by processing volume for selected minerals, 2019

		Copper	Lithium	Nickel	Cobalt	REEs
Top three processors	1st	China	China	China	China	China
	2nd	Chile	Chile	Indonesia	Finland	Malaysia
	3rd	Japan	Argentina	Japan	Belgium	–
Combined share of top three processors		~56%	~95%	~58%	~79%	~99%

Source: Adapted from IEA, 2022[51]

Bridging resources: immediate supply gaps in the transition to a clean energy future

Although the transition to cleaner energy sources has gained momentum, there are regions that require access to and a greater supply of fossil resources such as natural gas (and even coal) as "bridging" measures. As countries invest in alternative supplies, there is a need to balance short-term supply security challenges with their long-term energy transition plans.

Natural gas

The Russia-Ukraine war and the resultant energy crisis have posed a massive risk to Europe's economic outlook. After progressively reducing supply, Russia's Gazprom shut down Nord Stream 1 towards the end of August 2022, stopping gas deliveries to Germany for three days due to unexpected maintenance. Contract disputes have also seen Gazprom deliveries to France put on hold.[52] European gas prices have quadrupled in recent months.[53]

Cutting off gas supplies could severely affect leading European economies.[54] As outlined in the European Commission's REPowerEU programme, this possibility has increased Europe's efforts to seek alternative sources of supply, to accelerate renewables investments, and to decarbonise industry.[55]

Alternative natural gas supplies have seen several developments: Poland aims to quadruple its gas import capacity with a new pipeline from Norway, while Germany is acquiring a floating terminal to receive liquefied natural gas (LNG). The terminal is under construction and expected to be completed in record time, starting operations in 2023.[56] The EU's recently signed gas deal with Azerbaijan could bring relief, although the full effects of the deal may only be felt in five years.[57]

Discussions on the sidelines of the Portugal-Mozambican Business Forum held in Maputo in early September 2022 signalled the potential for Mozambican natural gas exports to Europe via Portugal,[58] in particular, through installing a second floating platform to extract and process gas in the deep-water Rovuma Basin.[59]

With more than 100tcf in gas resources, Mozambique holds Africa's third-largest proven gas resources, after Nigeria and Algeria.[60] The country could attract an estimated US$128bn in investments over the next decade as part of developing three major gas projects off the shores of Cabo Delgado province.[61]

Despite the region's unstable security situation, which has stalled some project developments, natural gas production is expected to commence at the Coral LNG terminal in October 2022.[62] As Europe diversifies its sources of gas supply, Mozambique has an unprecedented opportunity to position itself as an attractive alternative supplier.

Coal resurgence – a flash in the pan?

The EU's April 2022 ban on Russian coal is also changing the dynamics of coal trading. As coal is an affordable and available power source, many countries have revised their stance on coal-fired power, even if only temporarily, to meet energy needs since the ban was implemented in August 2022.[63]

South African coal producers are benefiting from the Russian coal ban, mainly due to high export coal prices. Since the Russian invasion of Ukraine, at the end of February 2022, seaborne coal prices jumped above US$400 per tonne and since remain at high levels. This is more than four times above the US$50-100 per tonne band within which coal was trading for more than the past decade.[64] These benefits could be significantly larger if not for the severe constraints on the South African rail logistics network, which is plagued by persistent underperformance due to frequent breakdowns, essential maintenance backlog and theft and vandalism. Despite those constraints, European countries, including Germany, Poland, and Spain, which for long did not buy coal from South Africa, collectively imported around 700,000 tonnes between January and May 2022 and are still looking to secure further supplies.[65] Meanwhile, Germany, France, and Austria have announced plans to reopen some of their coal-fired power plants.[66]

While the Russia-Ukraine war provided an added impetus for clean energy transition strategies in Europe,[67] it may also cause significant structural shifts in global seaborne coal trading, of a depth and extent yet difficult to quantify. Recent global energy scenarios show a great diversity of opinion around the future of coal, ranging from coal consumption falling by 70% over the coming two decades, to increasing by 30%. South Africa is likely to be the only coal-producing region able to increase coal exports under both business-as-usual and sustainable scenarios, enabled by growing markets in the rest of Africa, strategic connections to both Atlantic and Pacific markets and falling domestic demand in South Africa.[68]

Current developments and investments

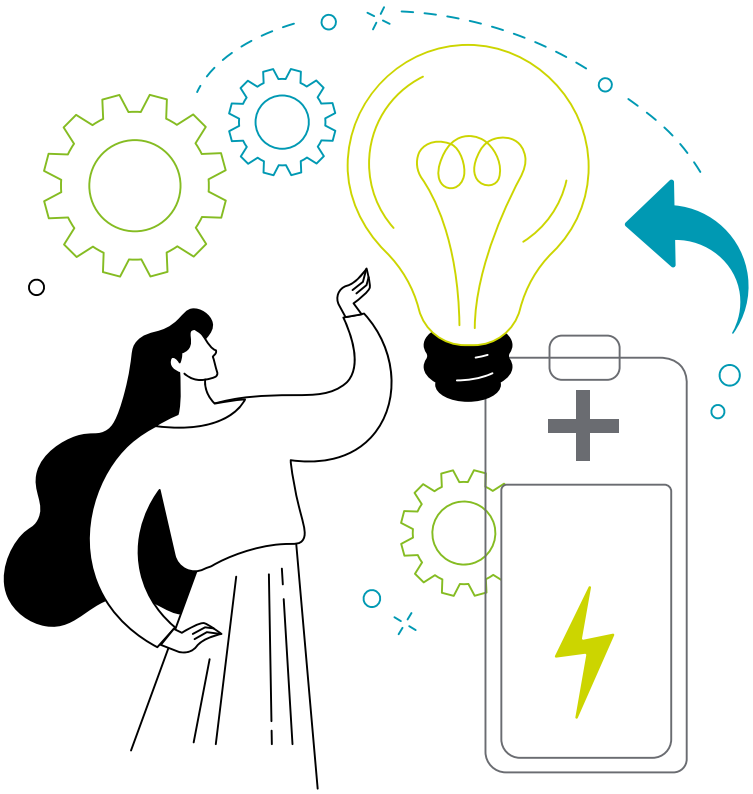
The need to bring on stream alternative and new sources of supply to meet the commodities demand in a clean energy future is evident. One forecast calculates that over 370 new graphite, nickel, lithium, and cobalt mines will be required to meet the demand for battery-related materials by 2035.[69]

Several African mining jurisdictions have a role to play in terms of production and downstream value addition. Short-term supply shortages of key raw materials have seen mines and consumers moving towards fixed-price contracts – also an opportunity for African producers.[70]

In the medium to long term, developing new supply capacity in Africa will be important, given the expected tenuous global supply-demand balance. But lengthy lead times for new mine development could tip the market into shortages for some key commodities required for the green energy transition.

For example, an International Energy Agency (IEA) analysis of major mining projects between 2010 and 2019 found that from discovery to first production takes, on average, about 16 years.[71] Such timelines may be longer in African jurisdictions due to a range of risks and uncertainties persisting on the continent.

Nonetheless, Africa's promise of new world-class discoveries of ore bodies with exceptional quality, grade and size, continues to whet mining companies' appetite for risk. Africa's mineral wealth also extends into attractive brownfield developments or tailings reclamation projects that present cost-effective opportunities for production of some scarce commodities and valuable by-products. Some illustrative examples of projects and opportunities in green energy minerals across selected African jurisdictions are briefly discussed.



Projects in Southern and East Africa

DRC

Copper and cobalt production, as well as the potential to supply lithium, are prime opportunities for the DRC. In mid-2021 the Kamoa-Kakula copper mine came online, with planned expansion phases to 2024, making this the third-largest copper mine in the world.[72] The expansion of cobalt operations at Kinsevere is also planned. First cobalt production is expected in 2023 and copper cathode production in 2024, given investments of about US$500-US$600m in that mine's extension.[73]

With cobalt a significant input, the DRC signed an agreement with Zambia in April 2022 to partner on the production of lithium-ion batteries.[74] Furthermore, the Manono lithium mine project, two peripheral exploration projects launched earlier in 2022, and another early-stage exploration project look to develop lithium capacity in the DRC.[75] However, factors such as the country's fragile political situation, corruption, human rights violations, governance challenges, security issues, and weak infrastructure are likely to hinder further investment.[76]

Zambia

In Zambia, a mining-friendly government has encouraged mining companies to commit to expansion and development projects. This was highlighted by the US$1.2bn capital commitment recently announced by First Quantum Minerals (FQM), mostly allocated to the expansion of Kansanshi, one of the world's largest copper mines.

A further US$120m has been allocated to the development of FQM's Enterprise Nickel Project. Opened in July 2022, the mine will lower the cost of nickel production through leveraging adjacent copper-mining infrastructure. Once in full production, the project will be the biggest nickel producer in Africa, with a total reserves base of 34.7Mt of nickel.[77] Furthermore, project preparations to develop the above-noted lithium-ion battery manufacturing plant (in partnership with the DRC), will be funded by the African Export-Import Bank.[78]

Zimbabwe

Zimbabwe has ramped up platinum production in recent years and there are several late-stage platinum exploration projects which could quickly become development projects, including Bokai and Darwendale.[79] In the case of Darwendale, Russian owners withdrew from the project after an unsuccessful attempt to raise capital to develop the project.[80]

In June 2022, the expansion of existing operations at the Bikita mine, Zimbabwe's largest lithium mine, was announced. The US$200m investment will include building a lithium plant, thus increasing processing capacity, to position the country in the battery minerals supply chain.[81] The country has seen deals of more than US$700m in the lithium sector, largely funded by Chinese mining companies.[82]

New underground mining equipment purchases due for delivery at the nickel mining operations of Bindura Nickel Corporation will increase nickel production, as some operations transition to a lower-grade, high-volume production strategy.[83] Furthermore, nickel potential discovered at a gold project in Bulawayo could also increase the country's nickel reserve base.[84] But economic and financial instability, power shortages and rising political instability could hinder the mining industry from attracting further investment.[85]

South Africa

Although there is insufficient investment into mineral exploration, which continues to support a shrinking mining industry, South Africa remains a diversified mining destination, with relatively good supporting infrastructure, despite power shortages and long-overdue structural reforms in essential sectors such as network industries. South Africa could see notable benefits from the expansion of capacity and related investments in key commodities and downstream industries.

Last year, for example, refining of nickel sulphate, a by-product of PGMs, commenced at Thakadu Battery Materials' US$20m nickel sulphate refinery using a locally-developed proprietary process. The refinery positions South Africa in the downstream processing value chain for battery-grade nickel.[86]

Commercial production at the Platreef Mine, expected to come online in 2024, will help increase South Africa's PGM production, with plans to expand the mine to become one of the largest and lowest-cost PGM producers in the world.[87] Leading PGM-producing regions are also being considered for hydrogen hubs given the role of PGMs in green hydrogen and hydrogen fuel cells.[88] PGMs are beginning to play a major role in improving local alkaline electrolysers performance – a significant breakthrough that signals unique opportunities, as PGMs are not generally used in this space.[89] Furthermore, a recent breakthrough in hydrogen solutions developed in South Africa in 2021 achieved a cost-effective hydrogen generation process that elevates the use of PGMs.[90]

In terms of vanadium, Bushveld Minerals announced mid-2022 that it was completing an expanded prefeasibility study of two mines to determine the most capital-efficient method to increase vanadium production. The aim is to increase production by 50% by end-2022.[91] Bushveld Minerals also commenced with the construction of a facility that will produce an electrolyte for VRFBs in South Africa. Other development projects are in progress at Steelpoortdrift and Mokopane. The success of the investment at Steelpoortdrift should help to make it the biggest vanadium mine in the world.[92]

South Africa hosts notable REE deposits. Historically mined in the late-1950s, Steenkampskraal now is the most advanced REE project in the country, reaching feasibility stage. Despite the presence of all 15 lanthanides, Nd and Dy account for 70% of the economic value. The latest technical report indicates that the mine will benefit from low capital expenditure due to pre-existing investment and infrastructure. Shallow mine depths and high-grade ore are forecast to keep mining costs low.[93] A less advanced REE project is Zandkopsdrift. With a prefeasibility study undertaken in 2015, it is one of the largest, undeveloped deposits globally, with impressive Total Rare Earth Oxide (TREO) grades. While this project benefits from good regional infrastructure, conceptually proven metallurgical processing and well-understood geology, it has failed to significantly advance in recent years.[94]

Tanzania

Last year, Tanzania had four nickel projects under development, the highest number in Africa. In January 2021, UK-firm Kabanga Nickel Company entered a joint venture (JV) with the Tanzanian government to develop the largest global deposit of battery-grade nickel-sulphide.[95] In January 2022, a US$40m investment at Kabanga Nickel was announced, which should start production in 2025.[96] A further US$10m investment in a processing technology that is more cost efficient than smelting will position Tanzania to beneficiate the battery-grade metal.[97]

Several active graphite projects are being developed with Australian investment, including at Bunyu, Chilalo, Epanko, Nachu and Lindi Jumbo.[98] The Lindi Jumbo project is likely to be among the first to be commissioned and to commence production.[99] The Bunyu graphite project is the country's largest graphite mineral resource. A 2018 feasibility study is currently being updated.[100]

The country also has one of the largest and highest-grade Nd-Pr deposits in the world – the Ngualla REE Project. A recent feasibility study indicates a low-cost mine with low strip ratio is possible as well as a 20+ year life of mine with ore reserves of 18.5Mt.[101]

A notable driver for projects in Tanzania will be the completion of the standard railway gauge, which will facilitate exports, especially of nickel, via the port of Dar es Salaam. Such infrastructure projects together with structural reforms bode well for attracting mining investment to the country.[102]

Mozambique

Mozambique's security situation has deteriorated in recent months. Threats by Islamist insurgents pose a serious risk to the development of natural gas projects and related infrastructure. The government has prioritised stabilising security, including obtaining assistance from major foreign economies and regional partners to deploy troops to secure the gas projects.[103]

Three gas projects have been under development. The first – the Coral LNG terminal – will commence production in October 2022, at a capacity of 3.4 million tonnes per year.[104] Development of the other two projects (Area 1 and Area 4) has been postponed. Construction at the Area 1 LNG project is likely to resume in 2023 once security risks are contained. Production could commence in 2027 at 12.9 million tonnes. Area 4's final investment decision is expected in 2024. The latter could bring another 15.2 million tonnes of annual capacity by 2028.[105]

Despite issues of security, further investor interest and offshore exploration activity of the country's gas reserves are expected. In November 2021, the long-overdue sixth exploration licensing round (initially expected in 2018) auctioned off 16 oil and gas blocks. However, the development of new offshore assets is unlikely to materialise before 2026.[106]

Mozambique's graphite deposits will also play an important role in future graphite supply. Mozambique ranks among the top five countries in global production of graphite and in global graphite mineral reserves.[107] While a small fraction of China's contribution to the market, the deposits (two in operation and a further two under construction) in Mozambique have the advantage of noteworthy quality, uniformity, purity or grade (carbon content), commanding a premium price in markets.[108]

The recently signed International Monetary Fund (IMF) support package, together with the Coral LNG project coming on stream, should help boost Mozambique's economic growth and attract foreign investment. However, the country's relatively poor business environment, remnants of the debt scandal from a few years ago, corruption, and patchy governance continue to challenge investor confidence.[109]

Projects in West Africa

Ghana

Despite overwhelming interest in gold in West Africa, the push toward a low-carbon economy has led to a move towards the exploration and development of other critical metal deposits. Ghana is a prime example of this shift, with an increase in lithium exploration and the development of lithium projects, most notably the Ewoyaa Project. This project is set to be Ghana's first lithium mine and benefits from pre-existing infrastructure in a mature, mining-friendly jurisdiction, reducing the perceived investment risk and capital requirement.[110]

Mali

Like Ghana, Mali has also experienced a significant drive in lithium exploration over the last five years, concentrated in the southern part of the country, evidenced by a five-fold increase in lithium exploration permits being granted by the end of 2018.[111] The two most advanced projects are Goulamina and Bougoni. The Goulamina Project has recently undergone a Definitive Feasibility Study, indicating a reserve estimate of 52Mt and a life of mine of 21 years.[112] The nearby Bougoni Project is on track to becoming the first lithium mine in Mali. A feasibility study conducted in 2020 indicated a low-cost capital investment of about US$120m, and a life of mine of 8.5 years, producing a total of 1.94Mt of spodumene (a key lithium-bearing mineral) concentrate.[113]

Mali has also become a prospective source of bauxite, although these deposits are not necessarily new to the region. Several discoveries have been made over the last 20 years, including the Falea Project, which has reported estimates of 1.6 billion tonnes of bauxite reserves. With Chinese-funded rail infrastructure, this landlocked African country could conceivably transport bauxite ore to the nearest port and become a significant exporter.[114]

Guinea

Guinea has been a leading producer of bauxite for some decades, producing 87Mt in 2021.[115] The country boasts the world's largest bauxite reserves and some of the highest-quality ore, spread out across several world-class bauxite deposits. Geographically, Guinea is well-positioned to supply global markets, and over the last decade, has even become the largest source of bauxite for Chinese smelters, despite other producers such as Australia and Indonesia being located much closer.[116] This has led to even more interest from junior companies to explore and develop bauxite deposits.

Côte d'Ivoire

Côte d'Ivoire is a minor nickel producer through small-scale operations, despite extensive resources, including the nickel-cobalt laterite deposits of Sipilou and Foungouesso.[117] The country's most promising nickel project is the advanced-stage Samapleu project, characterised as a sulphide-rich, geologically rare nickel deposit.[118]

Taking advantage of the unique opportunity

As the world transitions to a green energy future in tougher market conditions than anticipated until relatively recently, Africa will continue to be an exciting mining jurisdiction and supplier of key commodities. However, to effectively take advantage of emerging opportunities, African policy makers and business executives need to step up their leadership to face and address several challenges and potential obstacles to further progress.

Improving attractiveness of the continent as a preferred mining investment destination, continuous development of the necessary industrial and logistics infrastructure, promoting regional networks and alliances, and embracing emerging new business models, are just a few of those challenges briefly discussed below.

Improving Africa's attractiveness as a mining investment destination

Various risks, both real and perceived, slow down mining investments in Africa. These differ by region and jurisdiction, but may include corruption, patchy governance and political instability, policy uncertainty and permitting and licensing delays, minimal regional cooperation, poor safety and security issues, inadequate infrastructure, and a challenging business environment.

Ensuring clear, transparent, and consistent policy, and maintaining a stable regulatory environment in Africa's most prominent mining jurisdictions is key to attracting international mining capital at a scale commensurate with the continent's potential. Building on that foundation, solid governance, transparency, minimum red tape, an enabling business environment and trust among industry players and stakeholders will help to change common perceptions about Africa.

Botswana, Ghana, South Africa, and Zambia, amongst others, have declared themselves as "open for business" to mining companies and foreign investment, and demonstrate that openness by their overhaul of mining legislation, and visible stakeholder engagement efforts, even as perceived investment attractiveness remains low.[119]

The perception of investment attractiveness among Africans themselves also needs to be improved. A narrative demonstrating responsible mining practices, inclusive development and showcasing the benefits of investing in critical minerals and metals, for mining investors, host countries and their local communities needs to be broadcast to the world consistently.

Overcoming supply-side constraints: bridging the infrastructure gap

Africa's minimum infrastructure needs have been estimated at up to US$170bn per annum. At least half of this is unfunded.[120] While China has been a significant financier of infrastructure projects in Africa since the 2000s,[121] its funding commitments have reduced due to debt sustainability challenges in several African economies.[122] Development finance institutions (DFIs) continue to play an important role, together with national governments, which remain the largest financiers of infrastructure projects.[123] Increased emphasis on infrastructure funding also has been seen from more traditional partners. G7 leaders recently pledged to raise US$600bn in infrastructure financing for developing countries, especially in Africa, over the next five years.[124]

For the mining sector, infrastructure bottlenecks such as logistics and transportation, and power and water challenges remain. Although transport continues to receive the largest financing commitment[125] and has seen the largest number of projects underway in Africa,[126] the financing gap for that sector has widened.[127] On aggregate, sub-Saharan Africa (SSA) has been underinvesting in infrastructure as a share of GDP.[128]

Infrastructure projects can be slow to get off the ground. As partnerships are important to help prepare and develop infrastructure projects, greater private participation in network infrastructure and private-sector co-investment and support to help set-up, package and fast-track projects will need to go together with more infrastructure financing to bridge Africa's infrastructure gap.[129]

Attracting downstream investment and building regional value chains

The commodities sector is important for growth, foreign exchange earnings, and employment in several African countries. Unfortunately, activities are concentrated in upstream production, which limits Africa's benefits: only an estimated 10-15% of the total value generated in the end-to-end commodity supply chain remains in Africa.[130] Furthermore, unprocessed mining, oil, and gas exports accounted for 60% or more of the merchandise export basket of 24 African economies in 2021.[131]

As Africa positions itself to supply inputs into a clean energy future, it should seize opportunities to diversify and expand into greater value-adding, downstream activities. But it is often not feasible to localise all segments of a value chain in-country because it might not have the scale required to attract major investments. Regional integration and building cross-border regional value chains can offer a pragmatic framework to enhance regional collaboration and to attract downstream investment.[132] For example, to achieve shared benefits of regional collaboration in battery manufacturing, a hub-and-spoke model could be applied where different countries in a region (spokes) provide the key mineral inputs into the country that manufactures the battery (hub).

This, however, requires improved regional industrial policy coordination, a good understanding of countries' competitiveness, shared economic benefits, and agreements on specialisation and the resultant division of labour. It is also essential to identify and address challenges that hinder regional value chain creation,

including impediments to intra-regional trade, such as transport costs, tariff and non-tariff barriers, as well as the trade-offs associated with specialisation.[133] The African Continental Free Trade Area (AfCFTA) agreement will play an important role in promoting the building of regional value chains and markets, as well as reducing transaction costs, attracting investment, while supporting economic diversification and industrialisation.

Planning strategically and considering alternative business models

Over the next decade, the battery industry is poised to become one of the most significant sectors. However, there are growing concerns that the supply of input raw materials may not meet the exploding demand unless capital investments in new mines accelerate significantly. Even in the most optimistic scenarios, where all existing operations expand aggressively, and the entire pipeline of new material mining projects comes onstream, the supply of several lithium-ion "battery metals" (predominantly lithium, cobalt, and nickel) will fall dramatically short of demand.[134] This shortage is not due to limited mineral resources, but due to unsatisfactory levels of capital investment to build future mines. When investment does take place, it carries huge capital costs and extended development time. The financial risks of new mining ventures are further compounded by the price volatility of battery metals.

The insufficient supply of battery metals could significantly slow the rise of electromobility. The current problem with supplying automotive industry semiconductors may indicate a possible future in the battery metals space. Concerns about supply security and high prices drive automaker original equipment manufacturers (OEMs) increasingly upstream in the value chain, with some, like Tesla, considering moving into mining and refining scarce metals at scale for their own needs.[135] Moreover, OEMs are increasingly looking to the producers of battery metals as materials services companies, able to provide a basket of the required input commodities, reliably, long-term, and to specific OEM's requirements, rather than undifferentiated sources of individual metals and minerals.

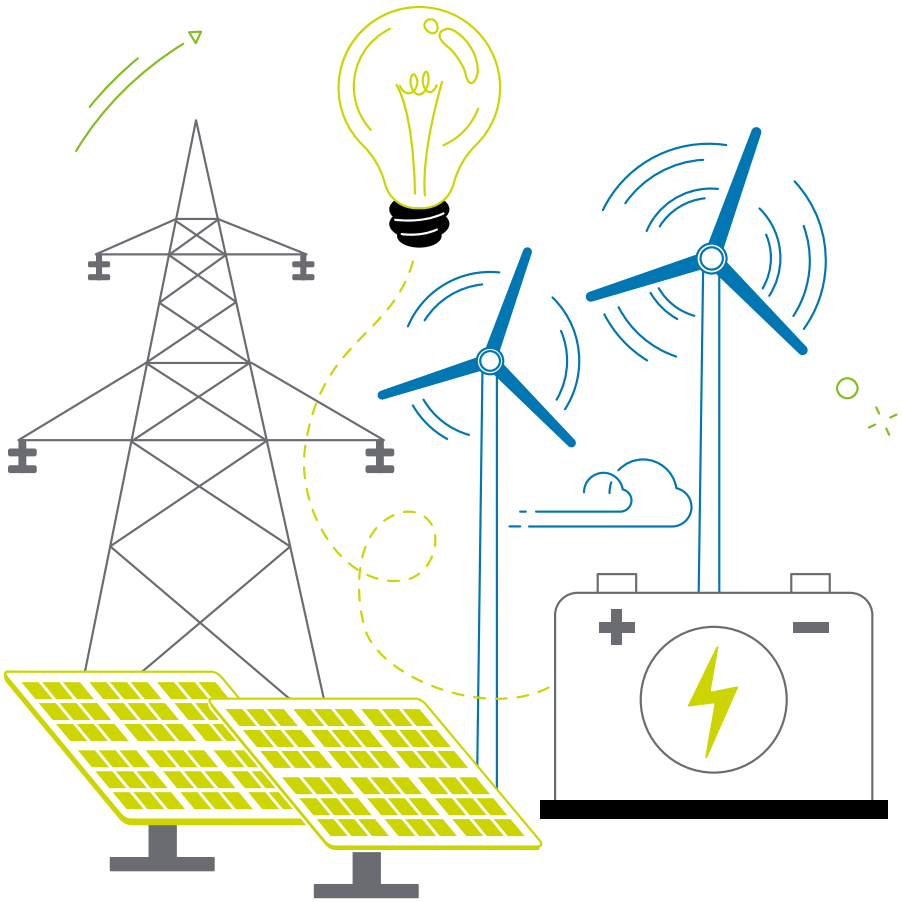
Concurrently, many significant miners of battery metals are increasingly pursuing downstream value-capturing initiatives. They get actively involved in recycling and, in the case of some metals, offer a lease option as an alternative to straight purchase – some vanadium producers and electrolyte and redox flow battery manufacturers offer to lease the vanadium-rich electrolyte until the end-of-life of a VRFB and recycle the vanadium content for re-use in other applications.

This scramble to secure battery metals supplies has resulted in the current flurry of memoranda of understanding, JVs, partnerships, equity investments, and mergers and acquisitions. New relationships and alliances are being forged to mitigate value-chain complexities, reduce risks, and leverage individual companies' strengths. Such relationships can also provide access to larger markets, increase manufacturing capacity, improve knowledge, broaden technology, and create new avenues for strategic financing. There are exciting prospects ahead for African miners of the critical input materials. However, they must act swiftly, while the window of opportunity is still open, and cooperate to create the scale that merits their rightful place in the global value chain of scarce metals and minerals.

Top-down leadership must drive action

As the key cooperation framework for the continent, the African Union's (AU) African Mining Vision (AVM), adopted by heads of state in 2009, is Africa's plan to unlock and harness the continent's mineral wealth for its own sustainable development.[136] However, progress on implementation of the vision remains slow. Common visions and high-level regional strategies are good starting points, but African leaders need to take responsibility for ensuring that this vision and Africa's potential to harness the fast-evolving opportunities in a clean energy future are realised.

Fast-tracking the implementation of the vision needs to include strong top-down leadership, greater cross-country collaboration, and enhanced cooperation between industry, government, DFIs and relevant continental institutions. Integrating the vision into regional industrial policies and aligning it with other instruments under the AU's industrialisation policy toolkit will be necessary to identify regional cooperation opportunities, generate local benefits in downstream industries, and create jobs.



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