



Democratic Republic of the Congo

Country Economic Memorandum

Case Study 1: Mining Value Chains

Democratic Republic of the Congo

Country Economic Memorandum

Case Studies

***Case Study 1:
Mining (EV battery) Value Chains***

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Acronyms and Abbreviations

ASM	<i>Artisanal and Small-Scale Mining</i>
AZES	<i>Agence des Zones Economiques Speciales (Agency of Special Economic Zones)</i>
BCC	<i>Banque Centrale du Congo (Central Bank of Congo)</i>
CAEB	<i>Centre Africain d'Excellence pour la Batterie (Africal Excellency Center for Battery)</i>
CAGR	<i>Compound Annual Growth Rate</i>
CAMI	<i>Cadastre Minier (Mining Cadastre)</i>
CAFI	<i>Central African Forest Initiative</i>
CCA	<i>Climate Change Adaptation</i>
CE	<i>Country Examples</i>
CIFOR	<i>Center for International Forestry Research</i>
CMOC	<i>China Molybdenum Company</i>
CTC	<i>Certified Trading Chain</i>
DRC	<i>Democratic Republic of the Congo</i>
EGC	<i>Entreprise Generale du Cobalt (General Enterprise for Cobalt)</i>
EV	<i>Electric Vehicle</i>
FCPF	<i>Forest Carbon Partnership Facility</i>
GCS	<i>Global Comparative Study</i>
GDP	<i>Gross Domestic Product</i>
GEF	<i>Global Environment Facility</i>
GHG	<i>Greenhouse Gas</i>
GISTM	<i>The Global Industry Standards for Tailings Management</i>
GM	<i>General Motors</i>
GWh	<i>Gigawatt hours</i>
ICGLR	<i>International Conference of the Great Lakes Region</i>
IEA	<i>International Energy Agency</i>
IFC	<i>International Finance Corporation</i>
IPIS	<i>International Peace Information Service</i>
IRENA	<i>International Renewable Energy Agency</i>
IRR	<i>Internal Rates of Return</i>
JV	<i>Joint Venture</i>
LSM	<i>Large-Scale Industrial Mining</i>
MAVCAP	<i>Malaysia Venture Capital Management</i>
MettelSat	<i>National Agency for Meteorology and Remote Sensing</i>
MIGA	<i>Multilateral Investment Guarantee Agency</i>
MW	<i>Megawatt</i>
NAP	<i>National Adaptation Plan</i>
NDC	<i>Nationally Determined Contribution</i>
NGO	<i>Non-Governmental Organization</i>
NMC	<i>Nickel, Manganese and Cobalt</i>
NMCA	<i>Nickel, Cobalt, Manganese and Aluminum</i>
NCA	<i>Nickel, Cobalt and Aluminum</i>
NGCP	<i>North Congolese Gold Project</i>
NPV	<i>Net Present Value</i>
NSDP	<i>National Strategic Development Plan</i>

OZ	<i>Ounce</i>
pCAM	<i>Precursor Material for batteries</i>
PSPA-CC	<i>Policy, Strategy, Action Plan for Climate Change</i>
PV	<i>Photovoltaic</i>
REDD+	<i>Reducing Emissions from Deforestation and Forest Degradation and Increasing Carbon Sequestration</i>
REE	<i>Rare Earth Element</i>
RCP	<i>Representative Concentration Pathways</i>
SADC	<i>Southern African Development Community</i>
SGBV	<i>Sexual and Gender-Based Violence</i>
SEZ	<i>Special Economic Zones</i>
S&P	<i>Standard and Poor</i>
SME	<i>Small and Medium Enterprise</i>
STEM	<i>Science, Technology, Engineering and Mathematics</i>
3T	<i>Tantalum, Tin and Tungsten</i>
TADF	<i>Technology Acquisition and Development Fund</i>
TVET	<i>Technical Vocational Education and Training</i>
UNECA	<i>United Nations Economic Commission for Africa</i>
UNFCCC	<i>United Nations Framework Convention on Climate Change</i>
UNICEF	<i>United Nations Children's Fund</i>
VAT	<i>Value Added Tax</i>
VC	<i>Value Chain</i>
WB	<i>The World Bank</i>
WDI	<i>World Development Indicators</i>

Acknowledgements

This Country Economic Memorandum (CEM) was produced by a multidisciplinary team of World Bank staff and external experts led by Sandra El Saghir (Senior Economist, TTL-Lead Author) and Jean-Christophe Maur (Senior Economist, Co-TTL) under the guidance of Abha Prasad (Practice Manager) and Albert Zeufack (Country Director).

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- Chapter 3: Jean-Christophe Maur, Maryla Maliszewska (Senior Economist), Carmen Estrades Pineyrua (Consultant)

For the two complementary Illustrative Case Studies of Regional Value Chains:

- Case Study 1 (mining (EV battery) value chain): Martin Lokanc (Senior Mining Specialist), Lois Hooge (Consultant), Nils Handler (Consultant), Kimberly Ann Berman (Consultant). The team is grateful for the collaboration with Cina Vazir and Abdurrehman Naveed from Harvard Kennedy School, who provided much of the insights into copper value chains.
- Case Study 2 (agribusiness-cassava value chain): Sandra El Saghir, Ilias Hamdouch (Consultant), Lisa Michelle Choux (Strategy Officer), Fanja Ravoavy (Senior Operations Officer), Natalia Agapitova (Senior Economist), Cheikh Amadou Tidiane Dia (Senior Agriculture Specialist), Patience Balomba Mpanzu (Agriculture Economist), Ando Irina Rabarijohn (Consultant)

Comments and suggestions from peer reviewers Chadi Bou Habib (Lead Economist), Richard Record (Lead Country Economist), and Cesar Calderon (Lead Economist) are gratefully acknowledged.

The Team is thankful for the guidance and support from Hassan Zaman (Regional Director), Asad Alam (Regional Director), Vivek Suri (Previous Practice Manager), Sebastien Dessus (Practice Manager), Malick Fall (Country Manager), Douglas Pearce (Practice Manager), Guillemette Jaffrin (Program Leader), Philip Schuler (Lead Economist), and Frederico Gil Sander (Practice Manager). Lydie Ahodehou (Senior Program Assistant), Karima Laouali Ladjo (Program Assistant), and Jeannine Nkakala (Program Assistant) provided excellent operational and administrative support.

The team would also like to thank numerous government officials for their collaboration in providing invaluable comments and suggestions, mainly within the Ministry of Finance, Ministry of the Budget, Ministry of Planning, Ministry of Mining, Ministry of Industry, and Ministry of Trade. Special thanks also to COPEMECO, FEC, and members of academic institutions for their valuable comments and contributions throughout the preparation of the CEM.

This study was partially financed by the Umbrella Facility for Trade and the Climate Support Facility Trust Funds. Editorial review, typesetting, and translation services were provided by JPD Systems.

Executive Summary

Case Studies of the DRC Country Economic Memorandum: Regional Value Chains

The two case studies discussed in the complementary reports are intended to better illustrate the opportunities and challenges described in the Country Economic Memorandum and considered important for economic diversification and job creation through structural transformation and stronger trade and regional integration. The focus is on two key potential growth-driving sectors (mining and agri-business) that offer substantial opportunities for expansion in the context of global energy transition, food insecurity, and further regional integration. While opportunities and constraints specific to the EV battery-related mining and cassava value chain are presented (and include a climate dimension), most of the challenges and recommendations could also apply to several other products or sectors of the economy (e.g., maize or any other manufactured or processed product). The purpose of the illustrative case studies is to highlight how the business environment in general is not attractive to private investment, SME expansion, or product competitiveness.

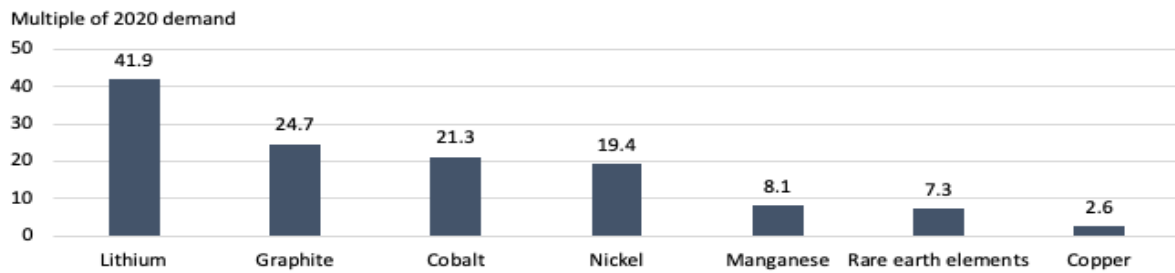
Case Study 1: Mining Value Chains

With the global energy transition, DRC must seize the opportunity to capitalize on its mineral wealth and lay the foundations for rapid, resilient and clean development of EV battery-related mining supply value chains.

The international mining industry is undergoing deep transformation due to the global energy transition. This transition presents opportunities for companies and host governments as interest increases in developing supplies of energy transition minerals, but it also poses regulatory and technological challenges as countries and companies also seek to decarbonize their value chains in support of the Paris Agreement commitments. In a world where end consumers and manufacturers producing renewable energy technologies are increasingly seeking to produce clean products, where “green” credentials are measured throughout value chains, the DRC is well positioned to be a supplier of choice. In fact both the DRC and Zambia have some of the cleanest copper and cobalt on the planet. This is partly due to the large degree of renewable (hydro) power used in their production but also because of the high grades of deposits.

Demand for “battery minerals” is expected to grow tenfold over the next decade, and the DRC is well positioned to supply a significant percentage of these minerals provided the right enabling conditions are met. Analysis of public data and projections released by global automakers indicate that they will produce 5,819 GWh of battery capacity and 55 million cars with a total investment of USD 1.2 trillion by 2030.

For some minerals, this represents massive increases in demand (and corresponding supply) by 2040 from 2020 levels. Both lithium graphite and cobalt will see the highest multiples of increased demand, albeit from a small 2020 production base. While copper is likely to see only a small multiple increase of 2.6, this starts from a very large base and presents a significant industry challenge as it cannot be substituted for by other minerals.



Mineral demand growth from 2020 to 2040 for Sustainable Development Scenario (as a multiple of 2020 demand)

The contribution of mining to DRC GDP, exports, and fiscal receipts has been substantial and is increasing. According to EITI, revenues collected from the DRC mining sector surpassed those of the oil and gas sector in 2010, when 63 percent of the USD 875 million came from mining companies. In 2017, the sector generated USD 1.68 billion, accounting for 17.4 percent of GDP, 55 percent of total government revenues, 99.3 percent of total exports, and a quarter of total employment. In 2019 the mining sector’s fiscal contribution increased to USD 1.78 billion and reached about USD 4.0 billion in 2021.

Yet the DRC remains poor, and mining sector governance remains a challenge. A new Mining Code was adopted in 2018 after many debates with both the private sector and civil society. While fiscal provisions were revised to ensure greater financial benefits from mining, the Code also created some issues in this regard. Above all, as in many developing countries, capacity is limited for fully applying the new Code. Institutional capacity to implement policies, monitor, or enforce the law remains low, as is the government’s ability to leverage the sector in order to grow and diversify the economy.

As the DRC’s mining sector prepares itself for a new wave of investments and a transition to higher energy intensity operations, the time has come to lay the foundations for a resilient, responsible, and clean supply chain. The ownership composition of the sector is changing and diversifying, with more companies considering taking on more risk. Furthermore, the deepening of existing mines will result in new geology and trigger a wave of new, higher energy intensity investment.

An enabling environment needs to be created for the sector to: (i) decarbonize itself before the industry locks itself into carbon-intensive technologies; (ii) attract a new wave of investment to support existing operations; and (iii) allow the DRC to benefit from development in previously unexplored parts of its territory. Improved governance, stability, predictability, and energy and transport infrastructure are key building blocks in supporting this transition by diversifying the economy in clusters and along economic corridors in order to promote long-term, sustainable, inclusive growth.

Attention to the socioeconomic and environmental issues caused by unregulated artisanal mining will need to be increased. The impact of artisanal and small-scale mining (ASM) is linked to poverty, lack of rural development, and low levels of government control and management. The country’s overall risk rating is negatively affected by these factors, and investment in the development of critical minerals through a large-scale mining sector may be jeopardized if these challenges are unmet.

<p>Opportunities</p>	<p>Overall, climate change and the energy transition present diverse opportunities for the DRC:</p> <ul style="list-style-type: none"> ● <i>Providing additional supply of energy transition minerals necessary to mitigate climate change</i> ● <i>Diversifying global supply chains through local value addition</i> ● <i>Contributing to two global public goods and creating domestic public good</i> ● <i>Providing low-carbon inputs to global supply chains of renewable energy technologies</i> ● <i>Making transformational investments in transport infrastructure</i> ● <i>Making energy infrastructure a crucial enabler for the DRC's mining sector and value addition beyond mining as large investments can help alleviate energy poverty in the DRC, if done correctly.</i> ● <i>Leveraging sector growth and support for value addition to improve human capital formation, particularly skills.</i>
<p>Challenges</p>	<p>The key challenges for the DRC to address as it seizes the opportunity arising from energy transition include:</p> <ul style="list-style-type: none"> ● <i>The opportunities identified above related to infrastructure (transport and energy), skills, which all present challenges for the DRC</i> ● <i>Cobalt, the most at risk commodity in the battery supply chain, with price volatility and concentration of resources in the DRC is the sole reason why researchers have been working to engineer it out of the battery value chain.</i> ● <i>Access to competitive finance, which remains a constraint not only for value chain development but also for all domestic investments in the DRC.</i>

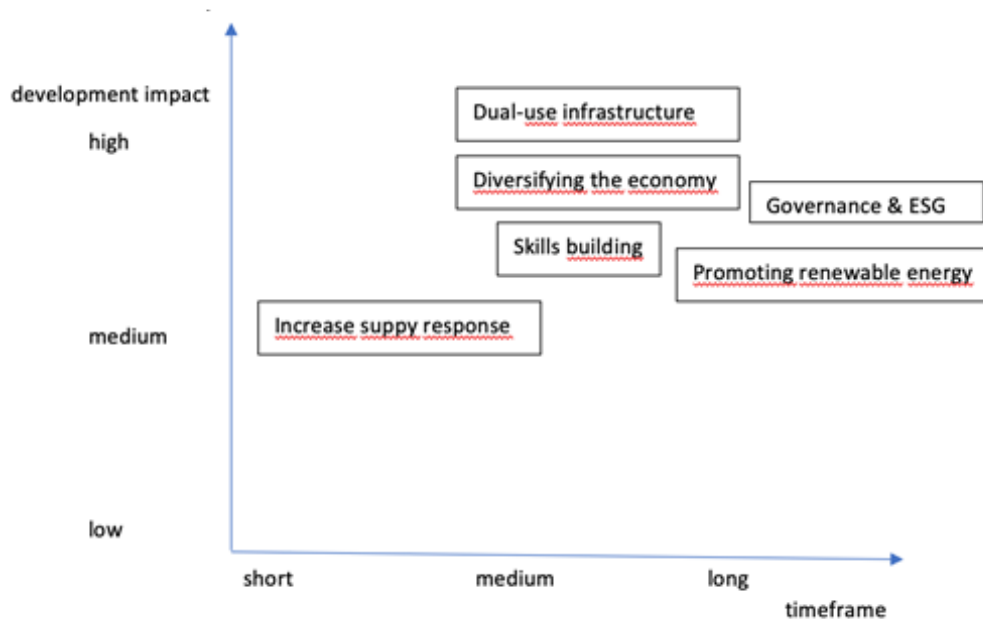
Recommendations

The DRC stands to benefit greatly from the energy transition if it is supported in seizing that opportunity. In response, a six-point agenda for mining and value addition in the DRC is proposed to support the country in seizing this opportunity. Beyond the generation of foreign exchange, fiscal revenue, local procurement, value addition, and jobs, rising demand for critical minerals significantly increases potential benefits from the sector. Furthermore, investing in the DRC's ability to seize mineral value chain opportunities aligns with the Paris Agreement, supporting the global decarbonization agenda while leveraging a considerable development opportunity. thanks to its scale and multiple development agencies, the World Bank Group is uniquely positioned to support the following six-point agenda for mining and value addition in the DRC:

1. Increase the DRC's supply response capabilities through support for mining investments.
2. Unlock long-term transformational development opportunities through strategic, mineral resources–anchored transport infrastructure investments.

3. Support investments in renewable energy to decarbonize mineral value chains, achieve the DRC's nationally determined contributions (NDC), and alleviate rural energy poverty.
4. Support value addition beyond mining in order to capture more value for the DRC (and Africa) and diversify the economy and global value chains in favor of energy transition minerals.
5. Invest in human capital formation to allow the DRC's population to seize income opportunities from the booming sector, its downstream value chain, and economic diversification.
6. Strengthen governance, mining-impacted communities, and environmental stewardship to ensure that mining and metals development inclusively benefit the DRC and its citizens within a context of sustainability.

Below is a table prioritizing the above six recommendations in terms of potential speed of realization and development impact:



Adoption of the six-point agenda can yield multiple benefits for the DRC. Some of these will be captured entirely by the DRC itself, such as domestic revenue mobilization and macroeconomic benefits, good quality employment opportunities, and economic diversification, others will be shared internationally as they generate global public goods such as improved global ability to mitigate climate change, improve the resilience of energy transition minerals, reduced emissions intensity in value chains, and improved integration into the global economy.

Specific Recommendations for Enabling Value Addition in the Copper and Cobalt Value Chains

Cobalt and copper are essential components of the energy transition value chain and have established mining production in the DRC. While expanding the value chains of these industries should be a top priority for job creation and exports, value addition will contribute very little in terms of additional tax revenue. Two particular areas of interest are the manufacturing of copper wiring and precursor mineral processing for EV batteries.

The first value addition option for the DRC would entail the development of copper-based manufacturing in the ex-Katanga region, with a focus on transforming the region into a manufacturing cluster with a local concentration of similar or complementary industries. In comparison with smelting and refining, manufacturing copper products requires less energy. Moreover, as demonstrated by existing operators, manufacturing is already economic and technically feasible in the DRC.

Opportunities in the copper value chain range from the production of electrical products, starting from copper wires, cables, and other semis and eventually move into products such as electric motors, transformers, renewable energy, and potentially copper foils used in EV battery cells. The production of USD 500 million of copper-based products per annum would result in USD 112 million in additional exports and 1,300-2,000 additional employment opportunities but only USD 9 million in annual taxable revenue as margins are small.

On the other hand, the EV battery value chain is much more complex and difficult to enter, requiring highly technical skills along much of the value chain, though it has the potential to quadruple the end value of battery minerals mined in Africa. Developing the full value chain will require a regional approach – with each country in Southern Africa contributing in terms of specific metals and capabilities in order to undertake complex manufacturing and attract the necessary investment.

For the DRC, precursor production of cobalt hydroxide is a necessary small step in a much longer and more complex journey. The jump from developing the capabilities to make precursors to developing the capabilities needed to manufacture batteries is considerable. However, the production of precursors is a first and very important step toward this ambition, and although it may help generate a small cost advantage in the short term, it will set the stage for longer-term production for other value chain products.

To achieve this, the DRC needs to overcome specific challenges in terms of skills gap, access to finance, and infrastructure such as energy and transport. To address the skills gap, a multi-pronged strategy is required, which will include: (i) facilitating access to skilled foreign workers with commensurate requirements for skills transfer programs and obligations; and (ii) reinforcing the DRC's own pipeline of skills, starting with STEM skills, with an inclusive focus on women, girls, and the disabled, in order to building vocational skills capabilities, and finally improving the pipeline of quality graduates.

If these challenges are addressed, building a battery precursor plant in the DRC could be economic. However the main concerns will be the minimum adjusted rate of return required along with environmental, social, and governance (ESG) risks associated with the sourcing of cobalt ores. While economic and political risks can be mitigated through sound operations and risk insurance, ESG risks are more difficult to mitigate and currently constitute a major deterrent not only to investment in the DRC but also a threat to the use of cobalt EV battery chemistry in the long term.

Looking through the various opportunities, constraints, and country case studies, several specific key recommendations emerge that could support the DRC in capturing greater value addition in the copper and cobalt value chains. These are listed below and detailed along with country examples (CE) in the Recommendations section at the end of the Mining Case Studies chapter.

Improve Infrastructure and Logistics: Invest in infrastructure development, including transport networks, power supply (by leveraging green resources), and logistics to facilitate the movement of raw materials and finished goods (CE: China and Vietnam).

Accelerate the Development of the Kinsevere Special Economic Zones dedicated to copper and cobalt processing and manufacturing: These zones should offer incentives such as tax breaks, streamlined regulations, and access to reliable utilities to attract both domestic and foreign investors. Where infrastructure gaps exist, policy makers should be in dialogue with the international community with a view to aligning projects designed to support the government's objectives (CE: China, Ethiopia, Singapore, Mexico).

Encourage Technology Transfer and Research and Forge Public-Private Partnerships: Promote technology transfer by partnering with international companies or institutions to facilitate knowledge exchanges and enhance local capabilities in copper and cobalt processing and invest in research and development to improve extraction techniques, metal refining processes, and product development for higher value-added applications. The leading European battery manufacturer Northvolt has expressed an interest to the World Bank in developing a relationship with the DRC government, and this could constitute an area of cooperation together with the skills development agenda discussed in the next paragraph. Engage with industry associations, research institutions, and foreign governments to leverage their expertise, networks, and funding opportunities (CE: South Korea, India).

Enhance Skills and Workforce Development: Invest in technical and vocational training programs to develop a skilled workforce capable of operating advanced machinery, managing production processes, and conducting research. A good way to do this will be to collaborate with educational institutions and industry experts to design training programs that align with the needs of the copper and cobalt value chains (CE: Germany, Malaysia).

Support Access to Financing: Facilitate access to financing for small and medium-sized enterprises (SME) involved in value addition activities by establishing specialized funds, grants, or loan programs to support entrepreneurs and businesses interested in establishing copper wire and foil production facilities or cobalt-based component manufacturing for electric vehicle (EV) industries (CE: Malaysia, Brazil).

Strengthen Environmental and Social Standards: Complying with international sustainability standards will enhance the DRC's reputation and attract ethical investors. Operationalization of government plans for the formalization of cobalt mining together with traceability programs could feature as activities under this recommendation (CE: Norway, Costa Rica).

Promote Local Processing and Manufacturing: Outside the law on special economic zones, the government should encourage local processing and manufacturing by providing incentives for companies to establish production facilities within the DRC. This could be achieved by implementing policies that prioritize domestic procurement for copper wire, foils, and cobalt-based components to promote value addition and create employment opportunities for the local population (CE: Brazil, Thailand).

Support Domestic Market Development and Work Regionally: Facilitate market development by actively promoting the DRC's value-added copper and cobalt products, first regionally through participation in international trade fairs, and work collaboratively across the Southern African Development Community (SADC) region to support other country's value addition ambitions. Leverage the forthcoming shift in South Africa's automobile manufacturing sector to secure continental demand for the DRC's future value-added products in the EV battery value chain. Explore opportunities for strategic partnerships with EV manufacturers and battery producers (CE: Germany, Kenya).

Establish Clear Regulations and Policies: Develop clear and consistent regulations and policies that support value addition in the copper and cobalt value chains by providing a transparent, comprehensive and easy-to-access framework for investment and industry growth (with guidelines on licensing, taxation, and export procedures) to create an investor-friendly environment and foster long-term stability in the sector. Ensure that any contracts to be negotiated are standard to avoid unnecessary uncertainty and allow investments into the DRC (CE: United Kingdom, South Africa).

Case Study 1: Mining EV battery Value Chains

1. Mineral Sector: Overview and Outlook

1.1. Overview

1. **The international mining industry is undergoing deep transformation due to the global energy transition.** While this transition presents opportunities for companies and host governments as interest increases in developing supplies of energy transition minerals, it also poses regulatory and technological challenges as countries and companies equally seek to decarbonize their value chains in support of the Paris Agreement commitments. In a world where end consumers and manufacturers producing renewable energy technologies are increasingly seeking to produce clean products and green credentials are measured throughout the value chain, the DRC is well positioned to be a supplier of choice. Both the DRC and Zambia have some of the cleanest copper and cobalt on the planet. This is partly due to the large degree of renewable (hydro) power used in production but also to the high grade of deposits. Demand for battery minerals is expected to grow tenfold over the next decade, and the DRC is well positioned to supply a significant percentage of these minerals if the right enabling conditions are met. Analysis of public data and projections released by global automakers indicate that they could produce 5,819 GWh of battery capacity and 55 million cars, with a total investment of USD 1.2 trillion by 2030.¹

2. **The contribution of mining to DRC GDP, exports, and fiscal receipts has been large and is increasing.** According to the Extractive Industries Transparency Initiative (EITI), revenues collected from the DRC mining sector surpassed those of the oil and gas sector in 2010, when 63 percent of the USD 875 million came from mining companies. In 2017, the sector generated USD 1,68 billion, accounting for 17.4 percent of GDP, 55 percent of total government revenues, 99.3 percent of total exports, and a quarter of total employment. In 2019, the mining sector's fiscal contribution increased to USD 1.78 billion and is estimated to have reached about USD 4.4 billion in 2022.

3. **Yet the DRC remains poor, and the mining sector governance remains a challenge.** A new Mining Code was adopted in 2018 after many debates with both the private sector and civil society. While fiscal provisions were revised to ensure greater financial benefits from mining, the Code also created some issues in this regard. Above all, as in many developing countries, capacity is limited to fully apply the new Code. Institutional capacity to implement policies, monitor or enforce the law remains low, as is the government's ability to leverage the sector in order to grow and diversify the economy.

4. **As the DRC's mining sector prepares itself for a new wave of investments and a transition to higher energy intensity operations, the time has come to lay the foundations for a resilient, responsible, and clean supply chain.** The ownership composition of the sector is changing and diversifying, with more companies considering taking on more risk. Furthermore, the deepening of existing mines will result in new geology and trigger a wave of new, higher energy intensity investment.

¹ Based on Reuters numbers, this translates into materials demand for EV battery packs only (75kWh), while the industry needs 15.5Mt of Nickel Sulphate, 1.35Mt of HP Manganese Monohydrate, 1.35Mt of Cobalt Hydroxide, 1.35Mt of Lithium Carbonate or Hydroxide, 2.7Mt of Copper Sheet and Wire, 4Mt of Aluminium Sheet and extrusions, and 814Kt and 540kt of Graphite Active Anode Materials.

5. **An enabling environment needs to be created for the sector in order** to: (i) decarbonize itself before the industry locks itself into carbon-intensive technologies; (ii) attract a new wave of investment to support existing operations; and (iii) allow the DRC to benefit from development in previously unexplored parts of its territory. Improved governance, stability, predictability, and energy and transport infrastructure are key building blocks in supporting this transition and diversifying the economy in clusters and along economic corridors in order to promote long-term, sustainable inclusive growth.

6. **Attention to the socioeconomic and environmental issues caused by unregulated artisanal mining will need to be accelerated.** The impact of artisanal and small-scale mining (ASM) is linked to poverty, lack of rural development, and low levels of government control and management. The country's overall risk rating is negatively affected by these factors, and investment in the development of critical minerals throughout a large-scale mining sector could be jeopardized if these challenges are unmet.

1.2. Outlook

7. **The DRC has vast untapped gold, copper, cobalt, and lithium reserves, which have only just started attracting significant interest.** This will boost the country's mining growth outlook. The solid gold production growth outlook is due to rising prices, foreign mining interest, low production costs, and an increased government stake in mining projects. Large copper and cobalt reserves give the country substantial leverage and will attract significant interest from foreign investors due to the use of this metal in lithium-ion batteries given that the DRC accounts for more than 50 percent of global cobalt reserves.

8. **Accelerating mining production will see net exports continue to drive growth.** Established mines are in place and largely owned by international firms such as Glencore, Ivanhoe, CMOC Group, Eurasian Resources Group, Zijin Mining Group, and of course the state-owned Gécamines.² While strong demand is expected for capital goods imports as mining firms continue to invest in the country, this will be more than offset by higher copper output and subsequently by exports. Copper production, which accounted for 65.0 percent of the DRC's exports in 2021, to grow by 13.5 percent in 2023, up from an estimated 9.2 percent in 2022, with numerous mining firms looking to increase production. For example, Ivanhoe Mines reported in January that it planned to implement debottlenecking at its flagship Kamo-a-Kakula copper mine in Q2-23, allowing for a strong uptick in output, while in December 2022, Eurasian Resources Group and Gécamines announced the restart of operations at Boss Mining, with the aim of reaching peak production in March 2023. In consequence, net exports will contribute 3.3 percent to headline growth in 2023, albeit down from 5.0 percent in 2022 as import growth remains high amid dependency on capital goods and services imports.³

9. **Solid high-grade copper deposits, with grades averaging around 2-3 percent compared with a global average of approximately 0.8 percent, will boost company profit margins.** It is expected that the production of copper, which accounted for 65.0 percent of DRC exports in 2021, will grow by 13.5 percent in 2023, up from an estimated 9.2 percent in 2022, with numerous mining firms looking to increase production.⁴

² <https://www.globaldata.com/data-insights/mining/democratic-republic-of-the-congo--five-largest-mines-in-2090645/>

³ Fitch, 2023

⁴ Fitch, 2023

10. **In addition to minerals destined for the low-carbon economy, the DRC has considerable further mineral wealth.** The DRC is widely considered one of the most resource-rich countries in the world, with vast deposits of copper, cobalt, zinc, iron, and uranium in the south, diamonds in the west, and gold in the north. The largest mines in the country are situated in Katanga Province, where all the DRC's copper and the majority of the world's cobalt is extracted. The sheer size of these copper and cobalt deposits and massive operations such as those of Glencore and Eurasian Resources Group and Ivanhoe's Kamao-Kakula mine dwarf many early-stage projects in Europe, Canada, and Australia. The province holds some of the world's highest-grade copper deposits, many of which are estimated to have an average ore grade of five to six times the global average, thus contributing to robust economics. The DRC is also home to Manono, Africa's largest undeveloped lithium deposit and owned by AVZ Minerals.

11. **Given these high grades, the relative cost of mining production per unit of mineral recovered in the DRC is considered low, and this, combined with hydropower, gives the DRC's copper and cobalt production one of the lowest greenhouse gas footprints in the world.** For those with the risk appetite to invest in developing mining in the DRC, this has rewarded them with mines that are relatively resilient to fluctuations in commodity prices and contributed to their long lives. In fact, many of the DRC's copper- and cobalt-producing operations are located in the lower half of the supply curve, the "cash cost" curve, as it is known within the industry.

12. **On the downside, pressures related to security and human rights abuses arising from 3TG conflicts and child labor in artisanally mined cobalt have negatively affected the reputation of the country.** Increasing ESG concerns over human rights abuses such as child mining within the artisanal mining sector, primarily cobalt, could impact investment attractiveness. Concerns in the US and Europe over importing minerals from the DRC have led to due diligence legislation, including the Dodd-Frank Act and the EU Regulation on Conflict Minerals. However, these regulations have inadvertently led to an increase in costs for 3TG products due to the cost of compliance these measures have generated, particularly for small-scale or artisanal miners. These regulations have required importer companies to undertake due diligence in order to identify risks throughout the value chain and to refrain from sourcing from illegal mines or those known to fund local militia. While these issues pertain most directly to the ASM sub-sector, the overall reputational risk from security issues, particularly in the eastern part of the country, remains high.

2. The DRC Mining Sector: Potential, Driving, and Restraining Forces

2.1. Mineral Potential

13. **The Democratic Republic of the Congo (DRC) is one of Africa's most richly endowed countries in terms of mineral wealth.** The country hosts numerous major deposits of diamonds, gold, copper, cobalt, tin, tantalum, and lithium. Mining is of high significance for the country's economic development in terms of poverty reduction, employment opportunities, GDP contribution, government revenue generation, and export earnings. Minerals mined in the DRC are also of critical importance for the global manufacturing of products such as the lithium-ion batteries used for electric vehicles containing cobalt), electronic devices (containing tantalum, tin, and gold), and infrastructure (copper for transmission lines).

14. **Mining is a major source of employment in the DRC. The formal large-scale industrial mining (LSM) sector currently employs about 120,000 people, although this number may fluctuate in response to international commodity cycles.** In addition, the mostly informal ASM sector employs 500,000 to 1 million people and plays a major role in income generation in mostly underdeveloped

regions of the DRC. However, while mining in the DRC is important for national economic development and global mineral supply, a range of sustainability challenges also need to be addressed.

15. **Mining activities in the DRC comprise large-scale industrial mining (LSM) as well as artisanal small-scale mining (ASM), both associated with particular sustainability challenges.** In the LSM sector, governance, taxation, and transparency questions play a critical role in enabling the sector to contribute to sustainable economic development. Meanwhile, the ASM sector is subject to various risks, including conflict financing, smuggling, child and forced labor, unsafe working conditions, and detrimental environmental impacts. Moreover, to promote the sustainable development of both sectors, it is necessary to look at impacts beyond mining and consider the full cycle from exploration through mining to mine closure, reclamation, and post-mining business opportunities.⁵

16. **Katanga holds some of the world's highest-grade copper deposits, many of which are estimated to have an average ore grade of over 3 percent, far higher than the global average of between 0.6 and 0.8 percent and some as high as 5 percent.** The source of cobalt and copper riches is the Central African Copperbelt, which straddles the border between Zambia and the DRC. Following DRC independence in 1960, existing mines in the Copperbelt were nationalized, but minimal scientific work was conducted in the following decades. To the north and south of the Zambian Copperbelt is a central elevated area with steep sides. This belt hosts mineralized deposits, mainly copper and cobalt as a stratiform unit, with associated manganese, which companies may not necessarily want, as well as iron that is not economical to mine. There are also contaminants such as cadmium and uranium, which exploration companies struggle to separate from the copper.⁶

⁵ https://www.bgr.bund.de/EN/Themen/Min_rohstoffe/CTC/Mineral-Certification-DRC/CTC_DRC_node_en.html

⁶ <https://www.gbreports.com/article/the-drcs-unparalleled-resource-potential>

Figure 1 – Minerals Map of the DRC



17. In addition to copper, production of other important minerals includes cobalt, diamonds, and gold. Cobalt, one of the key metals in the production of electric vehicles, places the DRC in a strategic position for the energy transition. In 2020, the DRC was the world’s largest cobalt miner, with a production of 95,000 tons, or nearly 41 percent of the world’s cobalt. In the same year, the DRC was also the sixth largest producer of industrial diamonds, with a production of 3.7 million carats. The DRC’s gold mining sector is also witnessing renewed interest from mining companies. In 2021 the production of mining resources increased from 10,000 tons to nearly 1 million tons. Virtually every region of the DRC possesses minerals or metals (see Annex 1 of Chapter 4 for the list of minerals by province).

2.2. Driving Forces

18. To a degree, the extent of the vast mineral wealth of the DRC will attract investors and offset political risk factors. Undeveloped resources include 44.6 million tons of proven lithium reserves. High-quality copper deposits. Large cobalt reserves give the country significant leverage and will attract significant interest from foreign investors due to this metal’s use in lithium-ion batteries. The DRC accounts for more than 50 percent of global cobalt reserves. Global demand for critical minerals will accelerate lithium development and the further expansion of copper and cobalt.

19. A normally negative trend toward “resource nationalism” could work in favor of the value-added sector as a result of the population’s and politicians’ desire for extracting greater value from mineral resources. A government-stated commitment to value addition to increase resource value can pave the way for the downstream manufacturing sector (the lithium-ion battery value chain).

20. **National Action Plan Climate Change commitments will positively affect the industrial sector.**⁷ The country's greenhouse gas (GHG) goals will motivate companies to switch to EVs, reduce use of fossil fuels, and in the transition, increase requirements for battery minerals. The plan includes commitments that will affect the mining sector in the areas of energy, water, and transport. The plan also commits to improving access to drinking water, sanitation of wastewater and sustainable waste management, improving infrastructure, and strengthening institutional capacities.

21. **Given demand for critical minerals to support the global transition to a green economy, DRC's mineral sector is well-positioned to seize upcoming opportunities.** Copper forms a large part of this increased demand. Excluding electrification, the world is estimated to need another 700 million tons of copper over the next 22 years, equivalent to the total amount of copper mined in human history to date.

22. **Including electrification as part of the energy transition, this amount is expected to double over the same period.** The DRC is the world's fifth largest copper producer and produces more than 70 percent of the global output of mined cobalt. Compared to conventional coal and gas power generation, wind (especially offshore) and solar photovoltaic sources are far more metal-intensive, relying on both aluminum and copper. The generation of 1 MW of electricity from solar and wind offshore uses, on average, 12 times more metals compared to coal and gas.⁸

23. **The DRC's lower costs of production and plans to improve infrastructure will increase investment exposure for miners seeking alternatives to South Africa.** Increased Chinese-funded infrastructure is planned through the Belt and Road Initiative and will benefit the broader mining sector. The DRC is seeking an additional USD 17 billion in investment from China under the terms of a 2008 infrastructure-for-minerals deal. The original agreement was reached between the government of Joseph Kabila, who left office in 2019, and contractors Sinohydro and China Railway Group. According to its terms, the state-owned Chinese companies would build roads, railways, schools, hospitals, and dams in exchange for a 68-percent stake in Sino Congolaise des Mines (Sicomines), a joint venture with the DRC's state-owned mining company Gecamines. To date, only about USD 800m has been spent.⁹ A potential export corridor between the southern DRC and the Angolan port of Lobito could significantly reduce the logistical issues that restrict mine expansions in the DRC, with some reports stating that it can take a month to export DRC copper through the South African port of Durban. This would boost exports and subsequently growth. However, the completion of the Lobito corridor is dependent on heavy infrastructure investments, economic and feasibility requirements, cooperation with Angola, and most likely private sector participation.

2.3. Challenges: Restraining Forces

24. **By increasing poverty, displacement, and immobility and eroding social networks, conflicts contribute to the vulnerability of marginalized populations.** Moreover, climate change could be a contributing factor to future conflicts, especially with regard to the scarcity of productive land and the lack of water.¹⁰ As noted earlier, rising concerns in the US and Europe over importing minerals from

⁷ National Action Plan, DRC 2022-2028. https://unfccc.int/sites/default/files/resource/DRC-NAP_EN.pdf

⁸ Fitch (220929)_Energy Transition Means More Metals.pdf

⁹ <https://www.globalconstructionreview.com/drc-demands-17bn-for-infrastructure-from-china>

¹⁰ UNFCCC. National Action Plan, DRC. https://unfccc.int/sites/default/files/resource/DRC-NAP_EN.pdf

the DRC due to the history of mineral revenues funding local militias in central African countries could be a further deterrent to investment.

25. **It will be challenging for supply to keep up with demand in green economy minerals because developing a producing mine takes time.** Mining projects have long lead times and require large investments. According to the International Energy Agency (IEA), average lead times from resource discovery to production averages 17 years: 12.5 years from discovery to feasibility and 4.5 years for planning and construction. Copper, cobalt, and nickel projects have the longest lead times. By comparison, lithium deposits have shorter lead times (around 7 years). Estimates suggest that most markets for low-carbon economy metals will remain balanced over the medium-term as committed and probable projects come online. However, supply gaps might emerge after 2025 since the pipeline of new projects is not yet synchronized with the expected rise in demand created by the energy transition.

26. **Along with estimates of demand and return on investments, the commissioning of new projects will depend on the availability of funding.** For large capital-intensive mining projects, large amounts of funding, either internally generated or borrowed, are required. Over the past decade, the financial discipline of most miners has improved, providing sufficient headroom for future investments. At the same time, a prolonged period of low commodity prices might result in delayed investment decisions.

27. **The quality of mineral resources is declining. Miners tend to work with lower-grade, technologically challenging pipelines with smaller deposits compared to those currently in operation.** This results in higher capital and operating costs for new mines, including higher electricity requirements to process the ore. However, innovations in mining technology partly mitigate the pressure on costs and allow the processing of lower grade reserves, including from tailings, which were considered not to be extractable, as well as increasing metal recovery rates.

28. **Political risk remains elevated in the DRC, with the uncertain business environment posing risks to current and potential investment.** The ongoing process of reviewing existing mining contracts could have the effect of weakening investor interest. According to the Fitch 2023 copper forecast, this has been identified as the most significant risk.

29. **The current government is renegotiating previous arrangements that were not honored and opened up the prospect of less attractive investment terms.** President Félix Tshisekedi has argued that deals made by his predecessor Joseph Kabila did not represent value for the DRC and has sought to review them. As a result, there have been rising risks of resource nationalistic measures since his election in January 2019. The renegotiations include the infrastructure for minerals” deal originally signed in 2007 with Chinese investors. The USD 6.2 billion deal was negotiated by Kabila and gave Chinese firms mining rights for cobalt and copper deposits in return for constructing core infrastructure projects, including urban roads and hospitals. Tshisekedi's government is also looking to renegotiate mining contracts with China Molybdenum, and in April 2022, Glencore's Mutanda mine was added to a list of contracts subject to further scrutiny. Three of Mutanda's four permits expired in 2022, and government sources have suggested that the renewal process for the permits could be used to renegotiate terms. Finance Minister Nicolas Kazadi has highlighted the importance of raising greater revenues from the mining sector, and the primary focus of the renegotiations will be to increase government revenues or secure a larger stake in key projects (Fitch, 2022).

30. **Some regulatory and export policy changes have created uncertainty, particularly for the copper sector.** On July 31, 2020, the DRC made the decision to suspend VAT exemption on imports

previously enjoyed by mining firms since 2016. The government's decision, which was made without discussions with impacted companies, will constrain the finances of mining firms. Additionally, in May 2021, the DRC reinstated its export ban on copper and cobalt concentrates. However, the country will continue to authorize concentrate exports for mining companies that possess waivers pending application. In October 2020, the DRC government enacted a six-month waiver to the export ban on copper concentrate. Though the DRC is Africa's largest copper producer, limited smelting capacity has caused the country to rely on other countries such as Zambia to process its mined copper.

31. **A new mining charter and the 2018 mining code imposing significant rises in royalties on copper and cobalt increased the government's stake in mining projects.** Under the new code, royalties have been raised from 2.0 to 3.5 percent for copper and from 2.5 to 3.5 percent for gold. Other key measures include the removal of a clause that protected miners from changes to the fiscal and customs regime for 10 years and the creation of a 50 percent tax on windfall profits. Additionally, 10 percent of the capital is to be held by DRC citizens for the purpose of creating a mining company (Fitch, 2022).

32. **Security remains of key concern in the DRC, especially in Katanga Province, where much of the mining activity occurs.** Miners in the DRC face a huge and unpredictable range of security threats. Intervention in the mining industry by non-state militias is a danger. The International Peace Information Service (IPIS) has reported on security issues in the Eastern DRC, where mining-related clashes are commonplace though mostly related to ASM. Overall, the IPIS finds that units of the DRC army are the main proponents of armed interference, affecting 66 percent of mining sites in the 2016-2018 sample of 265 mines.¹¹ Since the country's growth will largely be supported by the mining sector, any constraints on mining production, for example through insecurity spreading from the volatile east to copper-producing regions in the south, would severely impact exports as well as investor sentiment and weigh on growth going forward (Fitch, 2023).

33. **Currency volatility in the DRC is a problem for financial projects as there is a large informal foreign exchange market that is unregulated and has a tendency to offer different exchange rates from the official rate set by the Banque Centrale Congolaise (BCC).** The economic performance of a country depends on its competitiveness in international trade. The effects of exchange rate volatility on economic growth have always been a controversial issue in the economic literature. With an extroverted, dollarized, and commodity-dependent economy, the exchange rate is an important determinant of the DRC economy. Since the early 1990s, the DRC economy has suffered from continuous depreciation of its national currency due to its dependence on the outside world, which has made economic activity unstable. Empirical findings show a significant impact of exchange rate volatility on economic growth. These results suggest that the resilience of the DRC economy should be strengthened by diversifying economic activity in order to boost its international competitiveness. For international mining companies that rely on local suppliers to provide goods and services, currency unpredictability is a cost risk factor.¹²

34. **Corruption impacting foreign investment may affect the country's investment attractiveness. Glencore will pay USD 180 million to the DRC to settle a corruption case.**¹³ Despite the promise of change from the Tshisekedi government, uncertainty looms. The President has

¹¹ <https://www.theafricareport.com/15009/glencores-drc-mining-disaster-signals-continued-security-risks-ahead>

¹² <https://www.scirp.org/journal/paperinformation.aspx?paperid=117562>

¹³ <https://www.bbc.com/news/business-63858295>

appointed the head of the state-owned mining company Gécamines, Sama Lukonde Kyenge, as Prime Minister. The DRC's resources have historically been mismanaged by state-owned enterprises. In the DRC, state-owned enterprises play a critical role in the management of natural resources, especially mining. Historically, the governance of these companies has been problematic. Human rights groups have stated that they fear the advent of a new generation of cronyism.¹⁴

35. Climate Dimension: Competition between mining companies and communities for access to water and land resources due to flooding, drought, and deforestation could worsen. Future climate projections indicate that temperatures will continue to rise in the DRC. The country is expected to experience an increase in the frequency and duration of heat waves, and cold days and nights may decrease by 6 to 10 percent by the end of the century. While rainfall projections are more uncertain, future rainfall is likely to increase in variability, with projections indicating higher frequency of extreme events and increases of heavy rain intensity of up to 27 percent. Heavy rains could lead to increased runoff from the Congo River system by as much as 50 percent under a high-emissions Representative Concentration Pathway (RCP) 8.5 scenario, leading to increased flood risk throughout the basin. Dry spell duration and drought frequency as well as natural disasters driven by more frequent and intense floods are also expected to increase. Future flooding risk as well as wildfire risk driven by dryness) are high throughout the country.

3. Minerals for the Energy Transition

3.1. Overview of Trends and Forecasts of Demand for Minerals to Support the Energy Transition

36. The following subsection explores the DRC's potential supply response opportunities in the context of global demand for particular energy transition minerals. The minerals critical to the energy transition as well as those that play a significant role in the DRC's mining sector are copper, cobalt, lithium, gold, diamonds, rare earth minerals, and coltan. This case study will focus on copper and cobalt as they are among the country's top five exports. A thorough analysis of the trends and forecasts for demand for minerals to support the energy transition as well as a discussion on the remaining minerals (lithium, gold, diamond, rare earth minerals, and coltan) is found in Annex 2 of Chapter 4.

- [Summary of Current Market Output and Potential¹⁵](#)

37. The DRC's top five exports are refined copper and unwrought alloys, cobalt, unrefined copper, copper ores or concentrates, and crude oil. Together, this quintet of major exports represents 92.2 percent of the country's total exports by value. The latest available data by country show that 97 percent of DRC's exports were purchased by importers in the following countries: Mainland China (41 percent of the world total), Tanzania (11.8 percent), Zambia (8.8 percent), South Africa (7.7 percent), Singapore (7.2 percent), the United Arab Emirates (6 percent), Switzerland (5.7 percent), Mozambique (4.8 percent), Vietnam (1.6 percent), Hong Kong (1 percent), Belgium (0.6 percent), and Malaysia (0.6 percent).¹⁶

¹⁴ <https://african.business/2021/03/energy-resources/can-tshisekedi-clean-up-drcs-mining-sector>

¹⁵ Further information on this topic is covered under the analysis of commodities in a later section.

¹⁶ <https://www.trade.gov/country-commercial-guides/democratic-republic-congo-market-overview>

Figure 2 – Estimated DRC 2021 Production of Selected Commodities¹⁷

Production by Commodity - 2021			
Commodity	Production	Unit	Global Production Share (%)
Cobalt	122,394	(tons)	71.997
Copper	1,816,734	(tons)	8.507
Gold	1,854,373	(oz)	1.765
Lead	2,020	(tons)	0.045
Silver	149,192	(oz)	0.017
Tin	10,969	(tons)	NA
Zinc	16,079	(tons)	0.120

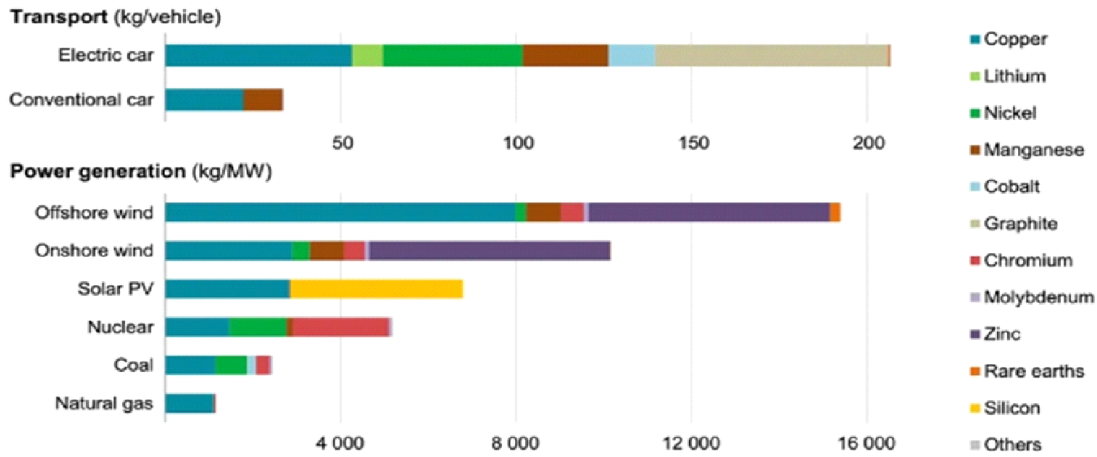
38. **Cobalt is a mineral used in a variety of industries, and, as noted frequently in this report, is a critical mineral for the future global energy transition.** Today’s rechargeable batteries powering devices such as cameras, mobile phones, and laptops all rely on cobalt. Even small amounts of this metal help regulate a battery’s temperature. It makes them safer, last longer, and store more power. These are the qualities that make cobalt so important in the much larger batteries of renewable energy technologies and electric vehicles. Cobalt also finds applications in medical imaging technologies, and, as a superalloy, is used in aircraft engines and in hard metals used as sharp cutting edges or for drilling.¹⁸

¹⁷ Source: S&P Mining Intelligence

¹⁸ <https://www.glencore.com/what-we-do/metals-and-minerals/cobalt>

Figure 3 - Minerals Used in Selected Renewable Energy Technologies¹⁹

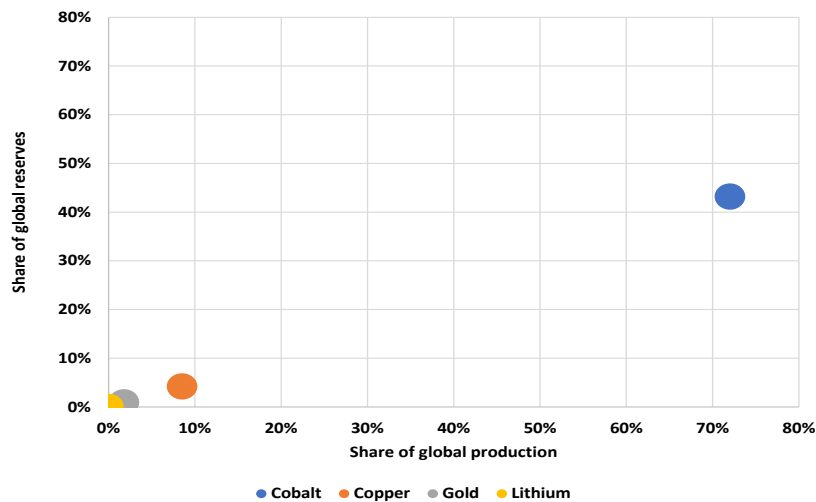
Renewable energy technologies are far more mineral-intensive than fossil fuel technologies...



Source: IEA, 2021

39. **Copper also forms a large part of this increased demand. Excluding electrification, the world is estimated to need another 700 million tons of copper in the next 22 years, equivalent to the total amount of copper mined in human history to date.** Given the growth of renewables and EVs, this amount is expected to double if net-zero emissions are to be achieved over the same period.⁴ Finally, the DRC is the world’s fifth largest copper producer and produces more than 70 percent of the global mined output of cobalt and is—and will continue to be—an essential part of the high-nickel cathode formulations (NMC, NMCA, NCA) favored by American and European automakers.

Figure 4 - DRC’s Share of Global Production and Reserves by Key Commodities

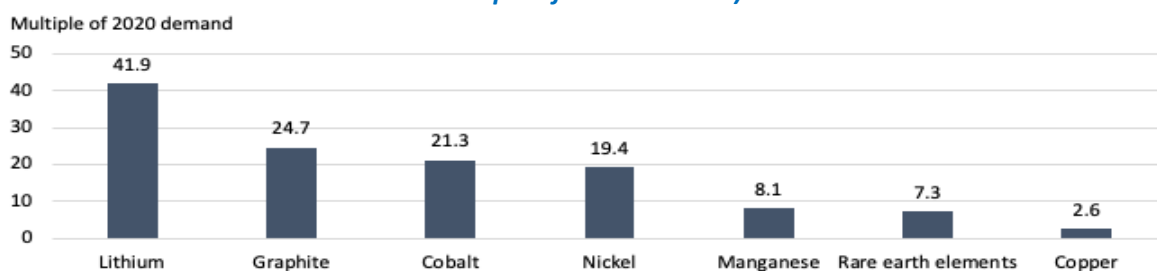


¹⁹ Source: International Energy Agency, 2021): <https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions>

40. **The shift to a clean energy system is set to drive a huge increase in the requirements for these minerals.** In a scenario that meets the Paris Agreement goals, clean energy technologies’ share of total demand rises significantly over the next two decades to over 40 percent for copper and rare earth elements, 60-70 percent for nickel and cobalt, and almost 90 percent for lithium. EVs and battery storage have already displaced consumer electronics to become the largest consumer of lithium and are set to take over from stainless steel as the largest end user of nickel by 2040 (IEA, 2021).

41. **The DRC is known to contain some of the richest ore deposits on earth, including the copper and cobalt deposits in the Central African Copperbelt, lithium and coltan (tantalum: 20-65 percent of global reserves), and niobium.** In addition, the DRC is known to contain tin as well as some rare earth deposits of interest. The DRC accounts for over 70 percent of cobalt production and 43 percent of known reserves. Under the sustainable development scenario, by 2040, the cumulative demand for cobalt is expected to increase 21.3 times from 2020 levels. Annex 2 of Chapter 4 provides a detailed assessment of global demand for specific energy transition minerals, i.e., lithium, rare earth minerals, copper, cobalt, and coltan.

Figure 5 – Mineral Demand Growth from 2020 to 2040 for Sustainable Development Scenario (as multiple of 2020 demand)



3.2. DRC Supply Opportunities

This section provides an analysis of the DRC’s supply opportunities in two of its most important critical minerals: copper and cobalt. A detailed analysis of the potential of its other key minerals, i.e., lithium, coltan, gold, and diamonds, is available in Annex 3 of this chapter.

- **Copper**

42. **The DRC’s mining sector is on track to maintain the same level of production of its main metals and to do even better than in previous years for copper despite the unprecedented negative shocks caused by the Covid-19 pandemic.**²⁰ The Kamoakakula mine will be the main driver of copper production growth, which is forecast to grow by 13.5 percent in 2023.²¹ Production will be enhanced by the mine’s high-grade copper ore, which is expected to average over 6 percent. Recent additional investments, including a February 2022 announcement of a USD 50 million upgrade and a November 2021 approval of USD 769 million on a new smelter for the mine’s copper, will help boost growth. The first two project phases will result in annual copper production of 400Kt, with the company envisioning further expansion detailing copper production in excess of 800 Kt per annum (Fitch, 2022).

²⁰ US Trade Department: <https://www.trade.gov/country-commercial-guides/democratic-republic-congo-mining-and-minerals>

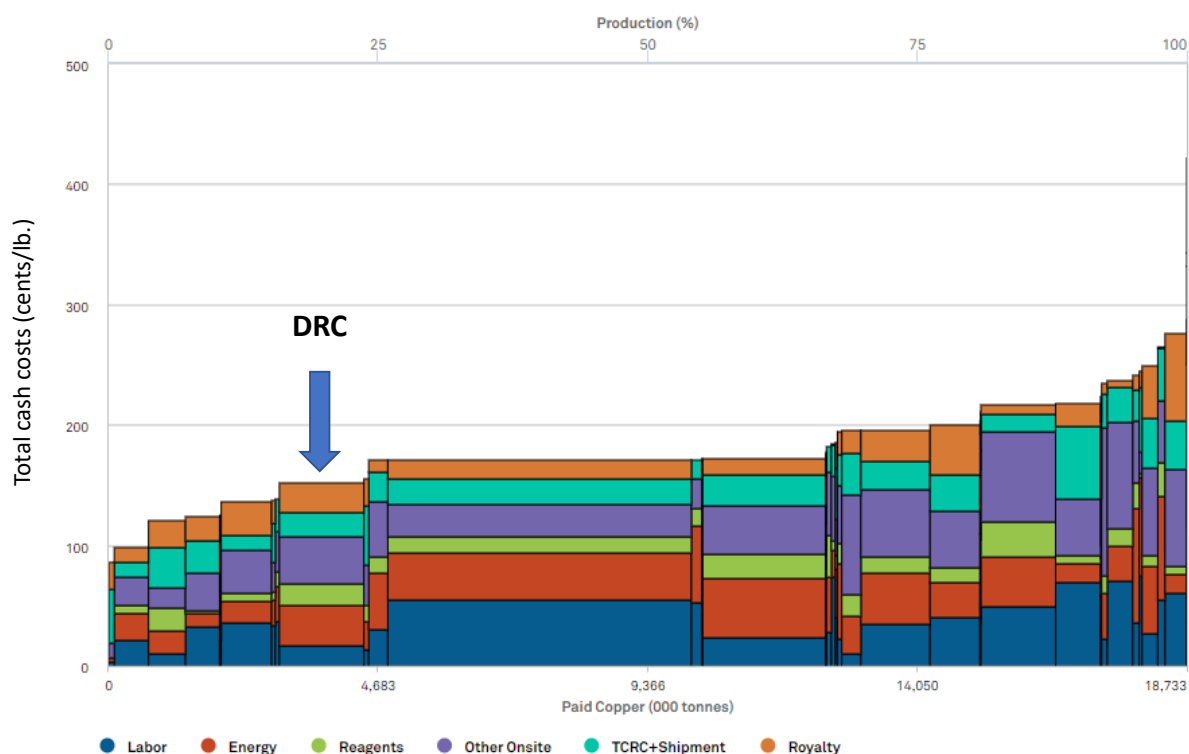
²¹ Kamoakakula is a joint venture owned by Ivanhoe Mines, Zijin Mining, Crystal River Global, and the DRC government.

43. The DRC’s copper mining sector is well positioned to withstand price cycles, and given its competitive positioning, it can be a potential major source of economic rents for the government. Although each mine is positioned differently in terms of global competitiveness, as shown in Figure 6, on average the DRC’s copper producers are located in the first quartile of the cash cost curve.

Figure 6 – Competitive Positioning of the DRC's Copper Mines

2022 Copper Production Ranked on Total Cash Cost Grouped by Country*

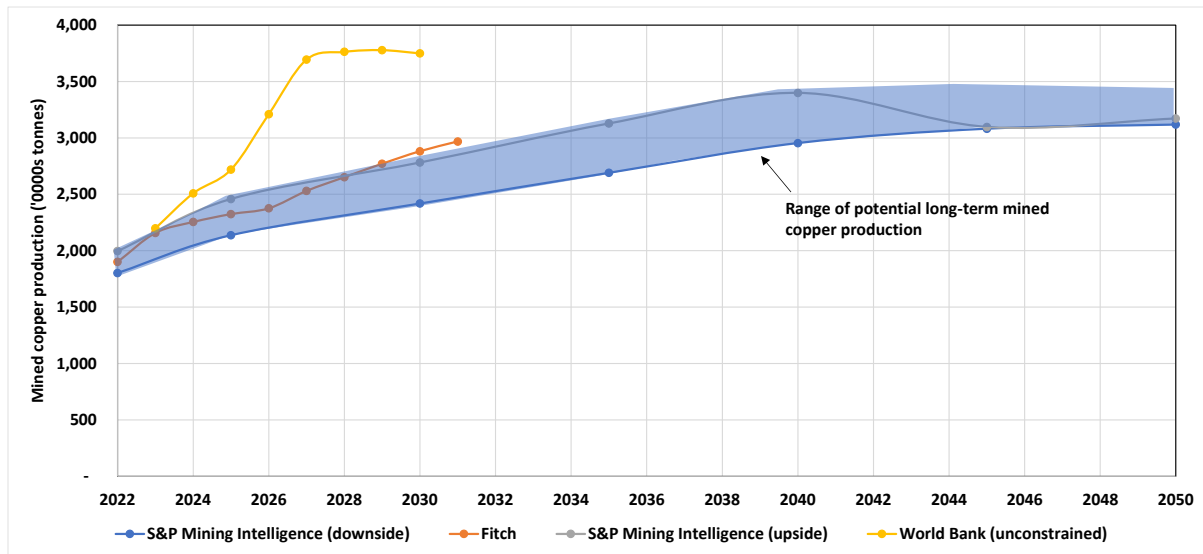
Scenario: Market Intelligence 2021 Constant USD



44. Overall, regardless of potential scenarios, the DRC’s copper production (and associated co-product cobalt production) is forecasted to significantly increase in the short to long term. As depicted in Figure 7, mined copper production is forecast to increase from the current ~2.2 million tons to between 2.4 and 2.8 million tons by 2030 and could grow up to 3 or 3.5 million tons by the mid-2040s. A much more optimistic, unconstrained scenario was developed to highlight the potential upside in the event that the DRC’s investment climate improved to make it comparable with other large copper producing nations such as Peru and Chile. In this event, copper production could grow to about 3.75 million tons by 2030.²² Looking further under this scenario, if prices and the business climate remain strong, it is likely that the country could exceed 5 million tons of production by 2040.

²² This forecast is based on current production figures, announced increases, and projects under construction or post-feasibility study likely to be commissioned before 2030. Copper production in the DRC increased by an average of 14 percent annually from 2017 to 2022, growing from about 1 to 2.2 million tons. The ramp up of the Kamo-a-Kakula project remains an important element of copper production growth over the next few years.

Figure 7 - Forecasted DRC mined copper production under varying scenarios



■ Cobalt

45. **Cobalt occurs in a range of different deposits, including sediment hosted, such as those across the Central African Copperbelt and magmatic sulfides such as those in South Africa.** Cobalt is generally mined as a by-product of copper and nickel (Fu et al., 2020), with most of the production from copper-principal mines.

46. **The cobalt market is highly concentrated, with more than 70 percent mined in the DRC (USGS, 2022), and almost half of the cobalt refined in China (Brink et al., 2020).** Africa as a whole accounts for almost 60 percent of the world's pre-mined resources and 55 percent of proven and probable reserves (Guj et al., 2022). Production in the DRC generally comes from copper-principal mines, with almost twenty large-scale mines producing the material (S&P, 2022). There are also twelve mines in Zambia producing cobalt as a co-product. Across both countries, there is a major role for Chinese-ownership, accounting for over 40 percent of mines in the DRC and almost 30 percent in Zambia compared to much lower roles for local ownership, at just 13 and 15 percent, respectively. In fact, 2017 numbers indicate that China is responsible for 58 percent of refined cobalt, 91 percent of which originates in the DRC (Fu et al., 2020).

47. **Projected growth in demand for the mineral due to booming EV production has led to a substantial pipeline of pre-production projects across southern Africa, with over 50 potential mines in various stages of development.** The majority of these are in the DRC, with a significant share in Indonesia and Zambia and also new projects in Tanzania, Namibia, and Botswana.²³

48. **The resumption of operations at Glencore's Mutanda mine has been the primary driver of recent cobalt production growth in the DRC.** Prior to its being idled, Mutanda was a major contributor to the country's cobalt output, accounting for approximately 25.1 percent of total output in 2019. Glencore placed the cobalt and copper mine on care and maintenance in November 2019 for a period of no less than two years after prices for the battery metal collapsed and costs at the project increased. While the mine's closure was the major driver of output declines, increased restrictions on mining

²³ The Cobalt Alliance predicts that Indonesia's share of cobalt is set to increase tenfold from the current 5 percent to potentially 50 percent.

activity due to COVID-19 added further headwinds. The mine reopened in 2021 and in 2022 it started producing 14,700 tons of cobalt, down from approximately 25,000 tons prior to it being closed.²⁴

49. **Growth will also come from other projects in the pipeline.** Shalina Resources' Mutoshi mine is set to start production in 2023 and will produce 16Ktpa of cobalt hydroxide equivalent. Previously, in April 2020, the processing plant had been put under care and maintenance and production at the Mutoshi artisanal cobalt mining site halted as a result of Covid-induced market and operational conditions. Other, smaller operations will also contribute to growth. For instance, in March 2021, the Chinese mining firm Wanbao Mining announced the first production of cobalt hydroxide at the firm's Pumpi copper and cobalt mine, which has a production capacity of 5Ktpa.

50. **An increase in supply contracts will further support domestic cobalt production.** In January 2021, Swiss commodity trader Telf AG entered into an agreement to sell cobalt hydroxide from Eurasian Resources' DRC operations. During January, First Cobalt also announced a binding 5-year supply deal with Glencore for cobalt hydroxide produced by Glencore's Kamoto Copper operation. Additionally, First Cobalt reported a Memorandum of Understanding with China Molybdenum for cobalt supply from the Tenke Fungurume mine during the same 5 years beginning in Q4 2022 (Fitch, 2022).

51. **The DRC's industrialized cobalt mining sector is well positioned to withstand price cycles, particularly as a co- or by-product of copper, and given its competitive positioning, it can also be a potential major source of economic rents for the government.** Although each mine is positioned differently in terms of global competitiveness, as shown in Figure 8, on average, the DRC's cobalt producers are located in the first quartile of the cash cost curve. As depicted in the Figure, Mined cobalt production is forecast to increase from the current ~115 million tons to between 140 and 160 tons by 2030 and could grow to 175 to 190 tons by the mid-2040s. A much more optimistic, unconstrained scenario was again developed (linked to copper production profiles) to highlight a potential upside in the event that the DRC's investment climate improved to make it comparable with other large copper producing nations such as Peru and Chile. In this event, cobalt production could grow to over 200 tons by 2030.²⁵

52. **Much of this growth will not result from cobalt price signals.** With the exception of artisanally mined supply, cobalt is produced as a by-product of copper and nickel mining, and the ability of producers to respond to changes in market demand is therefore hampered, causing periods of oversupply and shortages. Though artisanally mined cobalt acts as a swing producer, helping to buffer price volatility, it is insufficient. The result is that cobalt prices will remain volatile, and artisanal mining of cobalt is likely to come in waves, with more miners extracting the mineral when prices are high and seeking other income generation opportunities when prices are low.

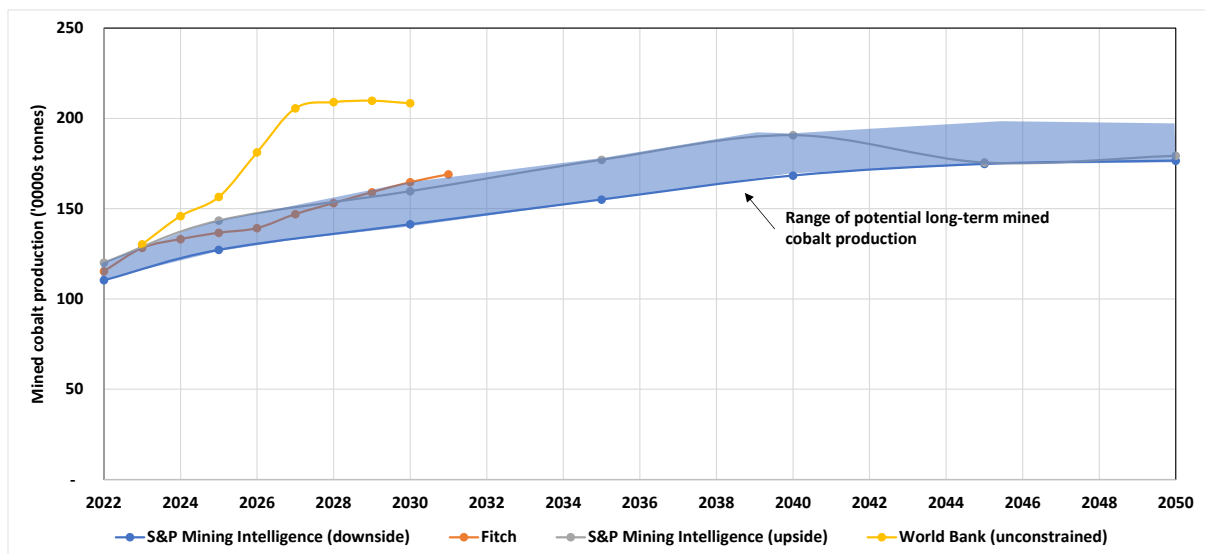
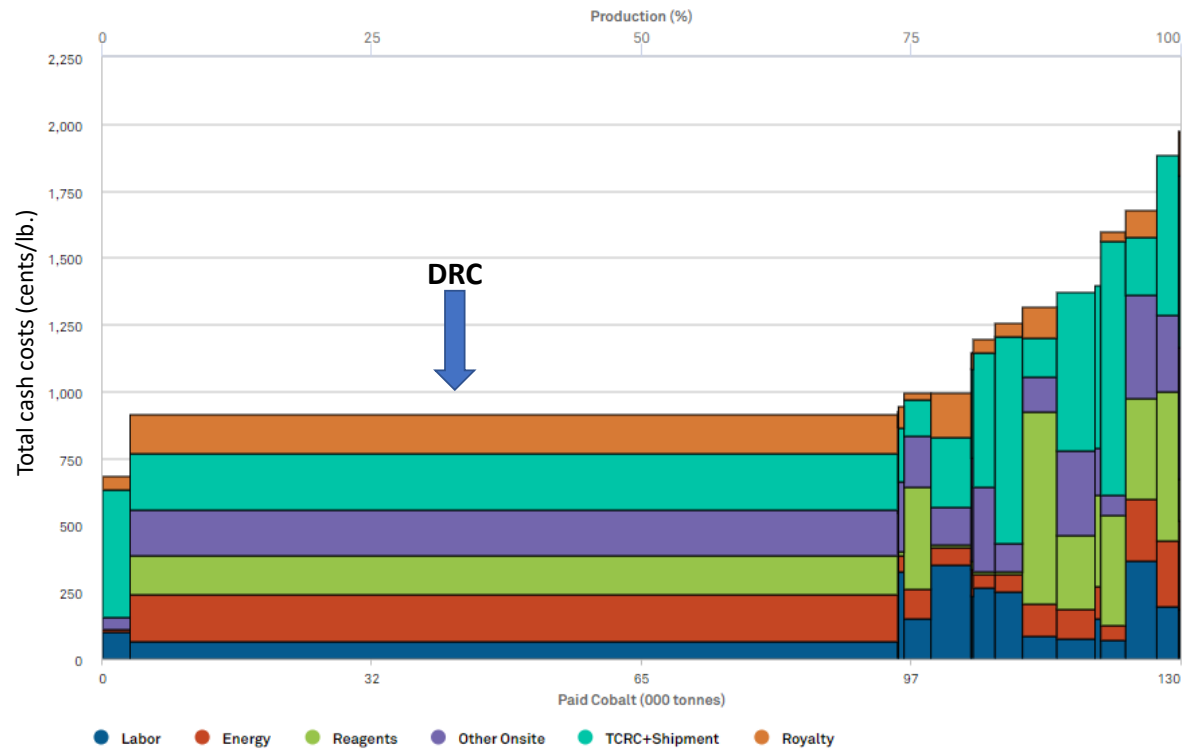
²⁴ There are risks involved in Mutanda's restart. In April 2022, the mine was added to a list of contracts subject to further scrutiny. Three of Mutanda's four permits were due to expire in 2022, and government sources have suggested that the renewal process for the permits could be used to renegotiate terms. The status of the permits and contract review are currently unknown.

²⁵ This forecast is based on current production figures, announced increases, and projects under construction or post-feasibility studies likely to be commissioned before 2030. Copper production in the DRC increased by an average of 14 percent annually from 2017 to 2022, growing from about 1 to 2.2 million tons. The ramp up of the Kamoa-Kakula project remains an important element of copper production growth over the next few years.

Figure 8 – Ranking and Forecast DRC Mined Cobalt Production under Varying Scenarios

2022 Cobalt Production Ranked on Total Cash Cost Grouped by Country*

Scenario: Market Intelligence 2021 Constant USD



▪ **Cobalt and ASM**

53. A significant share (approximately 20 percent) of the DRC’s production comes from artisanal and small-scale mining (ASM). ASM mining varies massively in scale and impact – from mechanized operations down to itinerant individuals working with rudimentary tools. The sector is one of the largest sources of non-farm rural incomes across sub-Saharan Africa, providing incomes and employment to millions. However, ASM sourcing of cobalt has been criticized in the wider literature due to its potential to have negative health, social, and environmental consequences (Faber et al.,

2017; Cremer, 2019; Sovacool, 2021). This sector of the industry is associated with high degrees of informality and illegality, poor health and safety conditions, lack of regulation and use of child labor. Studies have placed estimates at between 40,000 and 150,000 child workers in the sector (Tsururkawa et al., 2011; Amnesty International, 2016). A detailed analysis of the DRC's ASM sub-sector through economic, social, and formalization lenses is provided in Annex 4 of Chapter 4.

54. **The reputational risks of sourcing cobalt from potentially illegal and ethically challenging environments is one of the reasons for a general move away from cobalt in lithium-ion batteries.** However, there could be benefits to an ASM sector in cobalt should positive benefits such as local employment and income generation and potentially more responsive increases in supply (Mancheri et al., 2018) be realized without their negative impacts being dominant. Policies such as formalization, use of cooperatives, regulation and monitoring, and incentives for improved uses of technology could help in this regard.

55. **Cobalt is the most at risk commodity in the battery supply chain, and price volatility and concentration of resources in the DRC is the sole reason why researchers have been working to engineer it out of the battery value chain.** Depending on commodity prices, battery raw materials constitute 40-50 percent of the cost of NMC cathodes, and according to several forecasting providers, the most at risk input is cobalt. It has been noted that if cobalt supply chains from the DRC became more predictable and transparent, research efforts would likely pivot toward making other chemistry improvements rather than myopically focusing on engineering cobalt out of the battery system.

4. Mining Sector Governance

56. **The regime for mineral exploitation has seen various changes in the last three decades.** Prior to the mid-1990s, the exploitation of copper and cobalt was monopolized by the state-owned Générale des Carrières et des Mines (Gécamines). During the 1996-97 civil war, a rebel movement captured the copper belt region and began selling off the assets of Gécamines and awarding exploitation rights to private investors. To end this disorderly process, a new Mining Code was enacted in 2002 in the context of a country emerging from government collapse and civil war. The country was desperate to attract foreign investment and offered very generous terms to entice investors to a high-risk environment. Exploitation rights were in principle issued on a liberal first-come first-served basis. The Code sought to liberalize the copper sector and create a level playing field for investors. It envisaged a uniform tax regime and a transparent process to secure mining permits. In reality, Gécamines became the private gatekeeper to exploitation rights to the copper and cobalt mines, exploiting a clause in the Mining Code that allows state-owned mining companies to retain their mining permits and sell them to other companies. Gécamines is now largely a junior partner in over 20 joint ventures along with foreign companies and the production of copper and cobalt is currently undertaken by nearly 30 companies. Gold and diamonds are mined by both industrial and artisanal miners. A substantial proportion of their output is smuggled out of the country, and exact figures are currently unknown.

57. **The revised 2018 Mining Code has its merits and flaws.** The rates for royalties—except for strategic minerals—and the elimination of accelerated depreciation are in line with standard practice. Terminating bilateral mining agreements outside the Mining Code could have helped create a more level-playing field for investment and reduce the incentive for rent-seeking and corruption. On the other hand, the windfall profit tax appears ambiguous. It is not clear how windfall profit would be distinguished from normal profit. The discretionary power to classify minerals as “strategic,” which

carry the 10 percent royalty rate,²⁶ could increase the risk and potential cost of investing in mining activity in the DRC. The increase in the allocation of free shares to the state representing 5 percent of total shares each time a license is renewed would mean that over time, the state would hold a large percentage of free shares in private mining projects. This would be excessive relative to international norms, serving as a strong deterrent to investing or renewing mining licenses. Moreover, the requirement to repatriate all foreign currency earnings once the investment is amortized would hinder profit repatriation and thereby discourage investment. Lastly, the removal of the ten-year stability clause under the 2002 Mining Code raises legality and policy credibility issues. The main findings of the mining sector diagnostic of 2017 and the key elements of the revised Mining Code of 2018 are found in Annex 5 of Chapter 4.

58. As the code was introduced, mining companies threatened recourse to international litigation. Mining companies have been critical of the revised Mining Code, claiming that it would deter investment. They claim that they were not consulted during the revision process and that the code could reduce fiscal revenues from natural resources and threaten jobs, social programs, and infrastructure projects. They are also particularly concerned about the termination of the 10-year stability clause, which they perceive as a breach of a legally binding commitment. President Tshisekedi, inaugurated in January 2019, has endorsed the revised Mining Code, stating that his Government will continue to enforce the Code while remaining open to dialogue with mining companies to hear their concerns.

59. In 2021, mining companies were again concerned about instability with the investment environment as the country began reviewing the USD 6.2-billion Sicominex minerals-for-infrastructure copper-cobalt joint venture with China that has faced growing criticism since President Félix Tshisekedi came to power.²⁷ As a result, according to minutes from the meeting published on the website of the prime minister’s office, the Council of Ministers created a commission to investigate “major legal, technical and financial problems observed in the collaboration agreement” between the two countries.²⁸ More recently, the President has undertaken a visit to China to discuss these contracts in the interest of the DRC.

60. Improving mining regulations, transparency, and predictability can improve the DRC’s investment attractiveness. As one exploration company executive was quoted as saying in the 2020 Fraser Institute Survey of Mining Companies: “The lack of transparency in the renegotiation of mining

²⁶ **The 2018 Mining Code (Article 242) stipulates that shares of mining royalties (“redevances minières”) are to be paid directly by mining companies as follows:**

- 25 percent to the provincial authorities;
- 15 percent to the decentralized territorial entity that hosts the extractive project;
- 10 percent to the Mining Fund for future generations;
- 50 percent to the central government.

²⁷ Sinohydro Corp. Ltd. and China Railway Group Ltd. own a majority stake in the Sicominex copper and cobalt joint venture.

²⁸ The contract, signed in 2008 and renegotiated several times since, promised a USD 3.2-billion investment by China in a copper and cobalt mine and another USD 3 billion in infrastructure projects, all paid for by mining revenues. However, after more than a decade, less than a third of the infrastructure funding has been disbursed, and, according to the government, the Sicominex project has received only about three-quarters of the promised investment. While development of Sicominex has progressed—last year it produced 155,630 tons of copper and 886 tons of cobalt — the infrastructure part of the deal has lagged behind. According to the minutes of the Council of Ministers, only about USD 825 million in projects have been built thus far. Furthermore, a side deal concerning a USD 600-million hydropower plant known as Busanga, which will soon provide power for Sicominex, is also facing scrutiny, in part because of a “phantom” private company with a 15 percent stake in the project.

agreements hurts the DRC's mining competitiveness."²⁹ In addition to the Mining Code and Regulations, other legal and regulatory texts contain provisions relating to the mining sector, including the Tax Code and the Customs Code. The Ministry of Mines, which implements the mining policy of the government, has responsibility for granting or refusing to grant mining rights. Mining rights are granted by the Mining Cadastre (CAMI) in accordance with the Mining Code through either a tender process or by a request for rights. Extractive companies apply for special subsoil use permits, which are awarded through auction.³⁰

5. Climate Smart Mining: Net Zero Mining in the DRC³¹ and Climate Adaptation

This section discusses the mining sector through a climate lens. A more elaborate analysis is available in Annex 6 of this case study and will be detailed in the upcoming Country Climate Development Report (CCDR).

61. **Generally, the mining industry operating in the DRC uses hydropower for mining and processing activities, making its mining products among the greenest in the world.** There is limited literature available on measures companies are taking to mitigate their GHG emissions due to the sourcing of the main power demand from a clean energy source. However, there are a few examples available of what companies are doing in the country to mitigate their contributions to GHG emissions. Some large companies such as Glencore provide climate change reporting on company operations, but their data related to climate change are aggregated among all the projects they operate worldwide.

62. **Despite the primary sourcing of energy from hydroelectricity, the IEA predicts that fossil fuel use will rise in the DRC as oil use in industry increases significantly, with manufacturing and mining chiefly responsible for this growth.**³² Fossil fuel consumption is at a low level but growing and almost completely reliant on imports. Further industrial development depends on a large increase in imports. Electricity consumption is low today but is set to increase significantly as household incomes rise, access to electricity improves, and mining activities increase.

63. **The DRC intends to conditionally reduce its greenhouse gas (GHG) emissions by at least 21 percent by 2030.**³³ While the DRC has historically been a low emitter, the country's 2021-2023 National Sustainable Development Strategy includes plans to increase the use of renewables and improve energy access, partly through hydropower and solar electricity generation.¹⁰⁸

64. **Energy intensity for the mining and processing of copper and cobalt can be energy-intensive, particularly at the processing stage.** However, as shown in Figure 10, in terms of copper and cobalt, thanks to the shallow nature of the deposits, the metallurgical processes currently used, and the high grades, each unit of copper and cobalt produced is much less energy-intensive than in other copper

²⁹ <https://www.fraserinstitute.org/sites/default/files/annual-survey-of-mining-companies-2020.pdf>

³⁰ <https://eiti.org/countries/democratic-republic-congo>

³¹ A full analysis of the Climate Smart Mining Policy diagnostic and recommendations is found in Annex 6 of Chapter 4 and detailed in the upcoming Country Climate Development Report (CCDR).

³² Africa Energy Outlook, 2019.

³³ Government of the Democratic Republic of the Congo (October 2021), Contribution Déterminée à l'Échelle Nationale Révisée. Retrieved from:

<https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Democratic%20Republic%20of%20the%20Congo%20First/CDN%20Revis%C3%A9e%20de%20la%20RDC.pdf>

and cobalt producing regions. This is likely to change going forward as mining operations exhaust the oxide reserves and move into sulfide reserves, which will necessitate a change in metallurgical process from low-energy hydrometallurgy into high-energy pyrometallurgy such as the technology to be adopted at the Kamoa-Kakula operation in the future.

65. In turn, because of the high reliance on renewable hydropower, the DRC’s copper and cobalt production is among the least GHG intensive in the world. This creates the opportunity to position the DRC to be a potential supplier of choice as carbon border adjustment mechanisms are introduced globally and large commercial brands seek to minimize the GHG footprints of their products.

Figure 9 – Competitiveness of Global Copper Production, by Country, in terms of Emissions Intensity

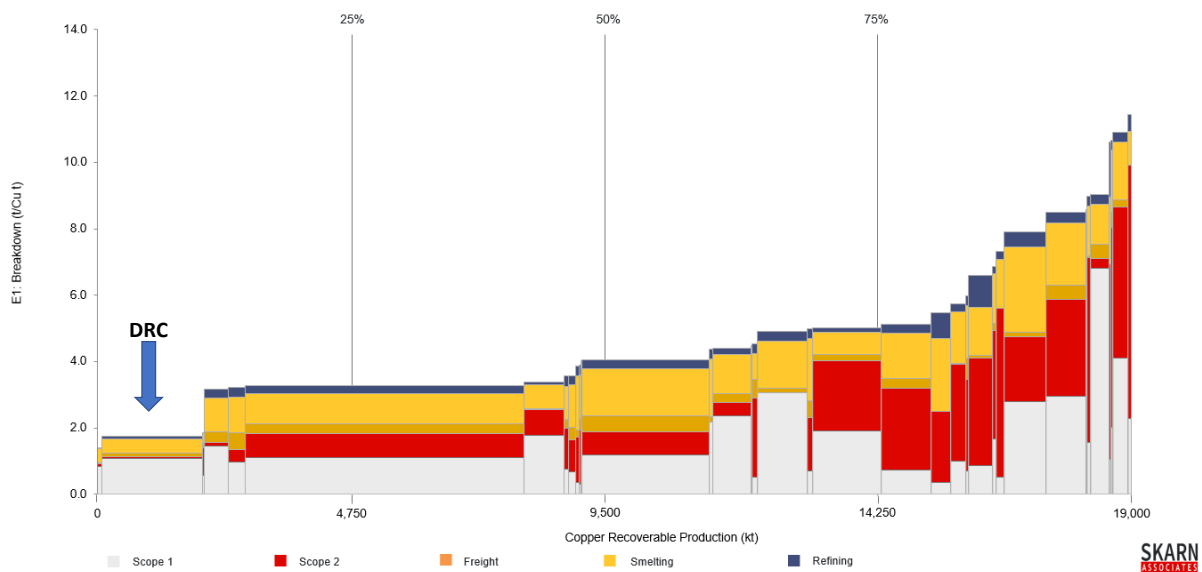
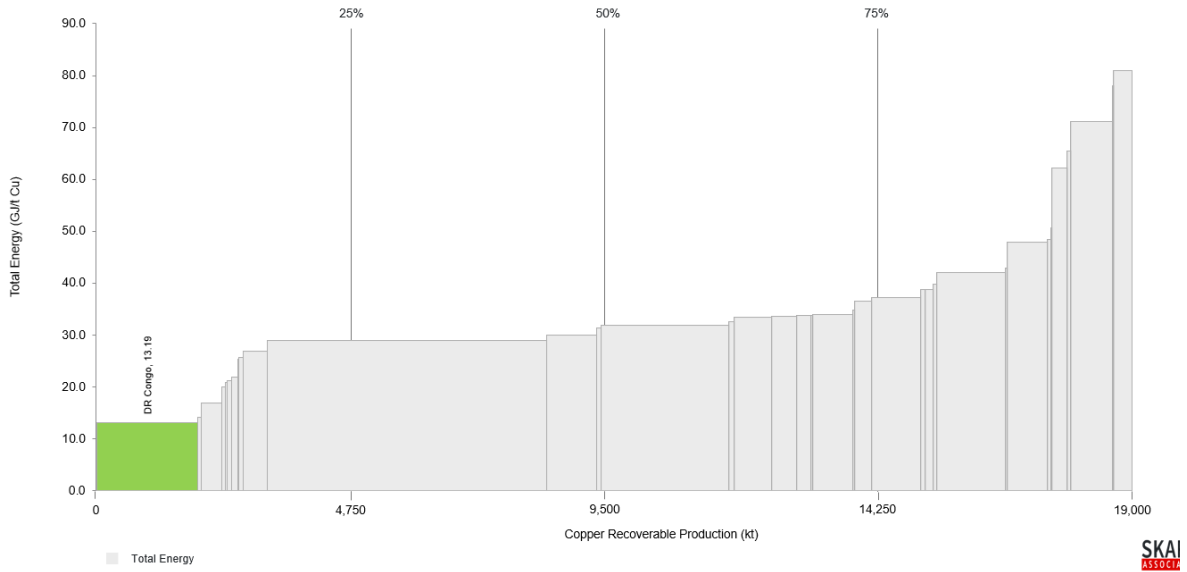
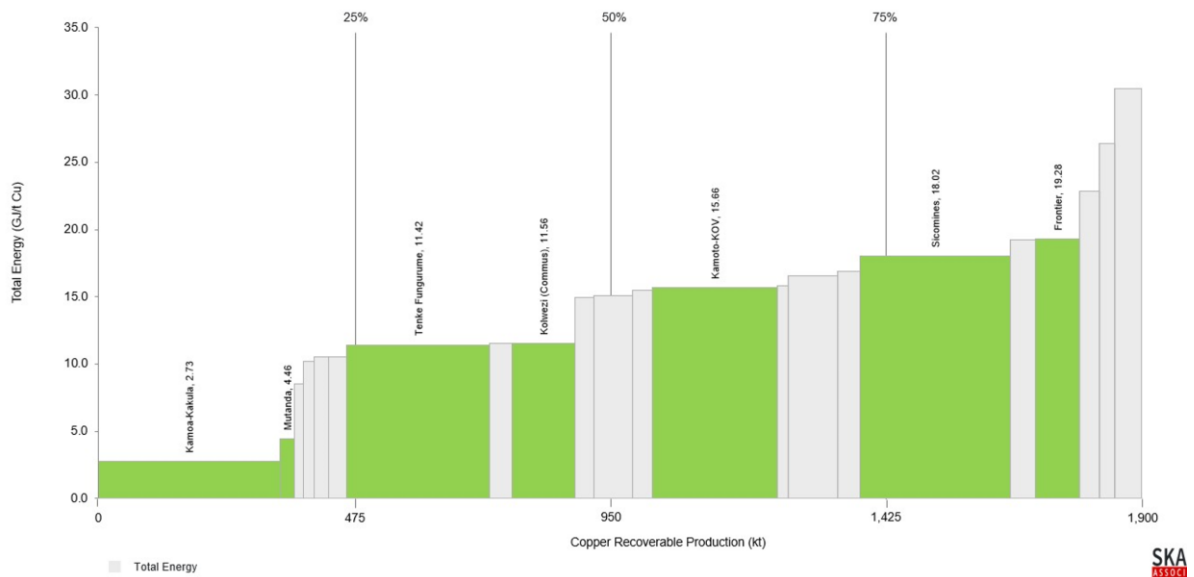


Figure 10 – 2022 Global Comparison of Copper Energy Intensity, by country

Panel a. The DRC’s copper and cobalt production is well positioned in terms of energy intensity



Panel b. Unsurprisingly, the highest grade deposits such as Kamoakakula require the least amount of energy for each ton of copper produced



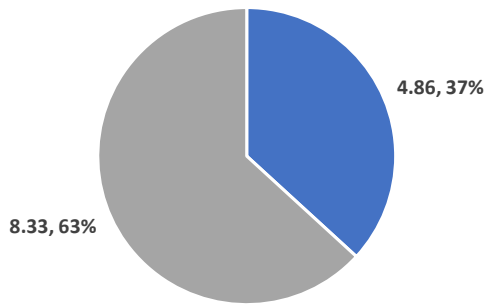
66. The use of diesel for back-up generators and fuel for transporting production to export infrastructure (land to ports) is the largest energy requirement for fossil fuels due to the availability of hydroelectric power that fuels mining and processing operations. Data obtained by Skarn Analytics shows energy usage and emissions intensity in the DRC (for copper and cobalt mining and processing). This can be seen in Figure 11, where energy intensity for direct energy use (a proxy for Scope 1 emissions) comprises 37 percent of total energy. However, because this is mostly for mobile mining equipment and on-site diesel generators, it makes up 61 percent of total emissions intensity. In comparison, Scope 2 emissions per ton of copper, which consists of mostly electrical energy, makes

up only 4 percent of total emissions intensity. The remainder (35 percent) comes from transport, smelting, and refining by third parties.

Figure 11 – DRC Copper Energy and Emissions Intensity³⁴

DRC copper production energy intensity

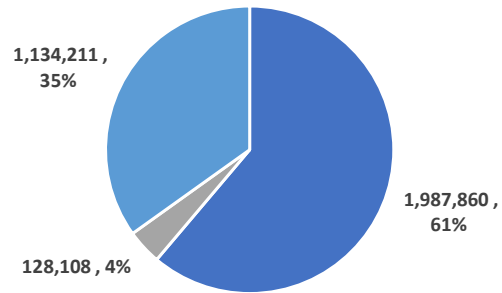
(GJ/t Cu)



■ Direct (~scope 1) ■ Indirect (~scope 2+3)

DRC copper production emissions intensity

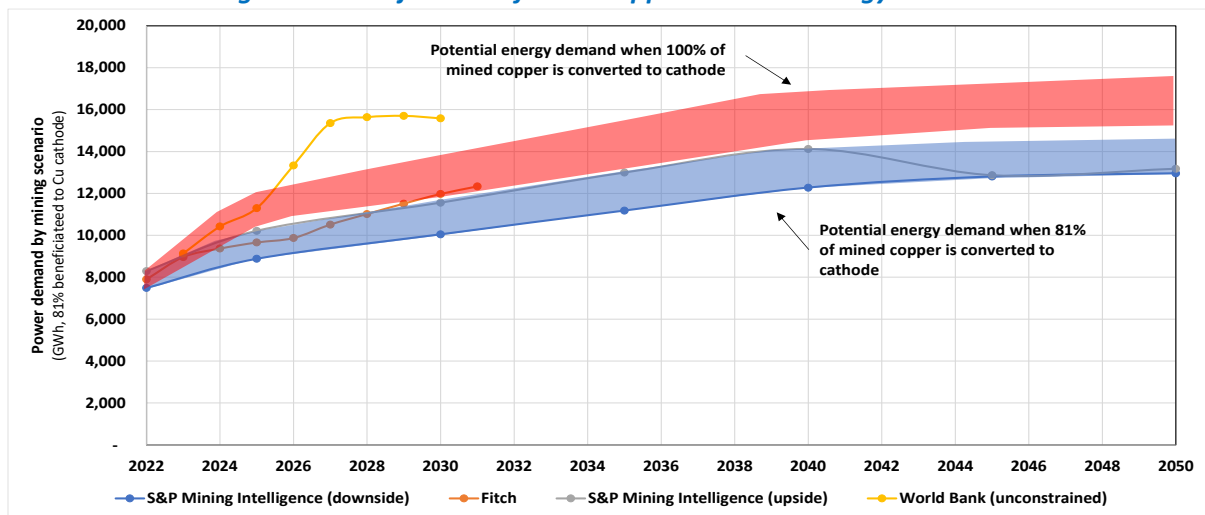
(tCo2eq/t Cu)



■ Scope 1 ■ Scope 2 ■ Transport, Smelting Refining

67. With an increase in copper and cobalt mining production expected over the next decade and beyond, energy requirements for copper extraction and processing will increase. When using the production profiles presented in Figures 4.7, 4.8, and 4.10) together with emissions intensity of operations, total copper production energy demand could increase from the current ~8 Gwh to between 12 and 15 Gwh (Figure 12). If we assume that 100 percent of copper production is converted to cathode within the DRC, demand for energy could increase to between ~15.5 and 17.5 Gwh.

Figure 12 – Projections of Total Copper & Cobalt Energy Demand



³⁴ Source: Derived from Skarn Associates 2023.

5.1. Industry Emissions Mitigation Actions

68. **The Kamo-Kakula copper mine will have one of the most favorable environmental footprints of any Tier 1 copper mine worldwide.** The mine will be powered by clean, renewable hydroelectricity and be among the world's lowest greenhouse gas emitters per unit of copper produced. Kamo-Kakula also will have a relatively small surface footprint as approximately 55 percent of the mine's tailings will be pumped back into underground workings. As confirmed in Panel b. of Figure 21, a 2020 independent audit of Kamo-Kakula's greenhouse gas intensity metrics performed by Hatch Ltd. of Mississauga, Canada confirmed that the project will be among the world's lowest greenhouse gas emitters per unit of copper produced. The mine has pledged to achieve net-zero operational greenhouse gas emissions (Scopes 1 and 2), though no specific date has been given. Ivanhoe, the operator of the mine, is also exploring for new copper discoveries under its Western Foreland exploration licenses in the DRC near the Kamo-Kakula project.³⁵

69. **Although potentially insignificant on a global scale, emissions from Kamo-Kakula will add to the current climate change issues being faced globally.** According to the EIA, the proposed Kamo copper project³⁶ will result in additional greenhouse gas (GHG) emissions arising from transportation, back-up diesel generators, general waste facilities, use of explosives, fugitive emissions, imported electricity, and oil and fuel use. In addition, site clearance for infrastructure will reduce the amount of vegetation and therefore its ability to capture carbon from the atmosphere. This impact will occur during the construction, operations, and decommissioning phases of the project. The proposed mitigation strategy is to: (i) implement a greenhouse gas program that will aim to enhance energy efficiency for the machines and equipment at the mine site; (ii) promote sustainable forms of agriculture and forestry designed to grow the carbon capture footprint; (iii) promote, develop, and increase use of renewable forms of energy such as solar power; and (iv) invest in clean technologies.

70. **Glencore has contributed to increasing hydroelectricity for their operations in the DRC as well as for the national grid.** In 2012, the company agreed with Société Nationale d'Électricité (SNEL), the DRC's national electricity utility, to contribute USD 375 million to a major electricity infrastructure refurbishment program, including the rehabilitation of two turbine generators at the Inga Hydroelectric Project along with transmission and distribution upgrades. This facilitated a progressive increase in power availability to 450 megawatts and allocated 50 megawatts of power for the use of the Kolwezi community. The project was completed in 2021.³⁷

71. **Glencore has pledged to reduce emissions on a sliding scale over the next 3-13 years.** The company has identified seven core pathways for meeting its short- and medium-term targets of a 15 and 50 percent reduction of total (Scopes 1, 2 and 3) emissions by 2026 and 2035, respectively, compared to 2019 emissions as well as its longer-term ambition of achieving net zero by 2050. Post

³⁵ Ivanhoe Mines (2021)_Kamo-Kakula Project.pdf. The Kamo-Kakula Copper Project is a joint venture between Ivanhoe Mines (39.6 percent), Zijin Mining Group (39.6 percent), Crystal River Global Limited (0.8 percent), and the Government of the Democratic Republic of the Congo (20 percent) and has been independently ranked as the world's largest undeveloped high-grade copper discovery. Kakula is projected to be the world's highest-grade major copper mine, with an initial mining rate of 3.8 Mtpa, ramping up to 7.6 Mtpa in Q3 2022. Phase 1 is expected to produce approximately 200,000 tons of copper per year, and Phases 1 and 2 combined are forecast to produce approximately 400,000 tons of copper per year.

³⁶ Kamo Copper EIA. June 2017 Report No. 1653699-314788-3 174.

³⁷ <https://www.glencore.com/.rest/api/v1/documents/12b9c4417f45c969007f6e09ebf2ca67/2021-Climate-Change-Report-+%282%29.pdf>

2035, Glencore's stated ambition is to achieve net zero total emissions by 2050 within a supportive policy environment.³⁸

5.2. Climate Adaptation

72. **There are clear indications that climate change is already a threat to the DRC's development and that the country faces the challenge of changing the current development model to create opportunities to improve resilience and to put itself on a stronger development trajectory.** Changes to the climate have already begun to affect the DRC. Over the last 30 years, the DRC has experienced temperature increases of 0.17°C per decade, while the warmest day of the year has increased by about 0.25°C per decade. Increased frequency of extreme weather events such as intense rainfall following prolonged dry spells have led to erosion and flash flooding. For the mining sector, changes to precipitation causing flooding can affect the stabilization of tailings dams and other mine infrastructure. Low levels of water mean that mining companies do not have enough water to mine or process minerals. High heat has negative impacts on personnel's health, resulting in lower productivity for the mine.

73. **The requirement for sufficient water for mining and processing is critical, particularly for the copper and cobalt industry.** Climate change can cause droughts or flooding depending upon the location of the mine. To strengthen the resilience of rivers, streams, and dredges with high flow rates, the National Action Plan on Climate Change recommends that they be further dredged and widened so that the excess water will flow freely.³⁹ River systems are expected to drain more water during peak flows. Thus the subsequent minimum flow periods will be longer. In areas at risk, river stabilization techniques can be used (e.g., development of river banks and construction of dikes, dams, spillways, etc.). For urban areas in the eastern DRC, increasing population density combined with erratic rainfall can in some cases lead to severe water scarcity. When the mining sector competes with communities for water, tensions can arise and mining delays can occur.

74. **International standards are increasingly being applied in tailings dam management globally, and greater attention is expected to be paid to these in the DRC.** The Global Industry Standards for Tailings Management (GISTM) have set a compliance deadline of August 2023 for all facilities with "extreme" and "very high" potential consequences of failure. According to SRK DRC, quite a few tailings dams in the DRC can be thus classified in terms of the potential environmental and social consequences of an incident. This means that mining companies in the DRC will come under pressure in coming months to finalize their compliance measures, while other tailings dams in lower categories will have to conform with the GISTM within two years.⁴⁰

75. **When addressing climate change and in particular adaptation, the National Action Plan (NAP) specifically states that it is important to recognize the crucial role the private sector plays in ensuring the livelihoods and security of a vast percentage of the population.** Just as it is the role of the Government of the DRC to establish guidelines for the country's climate change adaptation (CCA) through this NAP as well as subsequent ones, it is the role of the private sector motivated by corporate social responsibility to promulgate and finance any new policies emerging from the NAP that are relevant to their business practices. During a second phase of the NAP, the recommendations state that a public-private partnership as well as tools, methodologies, and approaches for the private

³⁸ <https://www.glencore.com/dam/jcr:ad341247-c81e-45b4-899d-a7f32a9d69a0/2021-Climate-Change-Report-.pdf>

³⁹ DRC NAP, 2021-2026: DRC-NAP_EN

⁴⁰ <https://www.miningweekly.com/article/drc-mining-on-the-up-but-with-hills-to-climb-2023-02-01>

sector should be developed and the sector should be encouraged to participate in consultations while preparing successive NAPs. This suggests a further role for the mining industry in leading climate change adaptation in the DRC as well as for its international development partners.

6. Value Addition beyond Midstream Smelting and Refining (copper and cobalt value chains)

This section provides a discussion on two key value chains in the mining sector: value addition from the copper value chain (wires) and from the cobalt needed for EV battery production.

76. **Despite various constraints, the DRC possesses a number of promising pathways for value addition in the cobalt and copper value chains.** Two opportunities merit further examination based on their prospective feasibility and benefits:

- **The first opportunity is to scale the manufacturing of copper products, including rods, wires, and cables.** Although nascent operations exist, this strategy will seek to scale up domestic manufacturing capacity and encourage long-term linkages to other types of manufacturing.
- **The second opportunity is to produce precursor material (often referred to as pCAM) for lithium-ion batteries.** Battery precursors are one of several intermediary steps between raw material production and fully assembled lithium-ion batteries.

77. **These industry expansions will set the blueprint for the development of other energy transition commodities that are plentiful in the DRC.** The country is abundant in other energy transition commodities, including lithium, tin, and zinc. Lithium, in particular, presents a significant opportunity for the country given its use in all types of lithium-ion batteries.

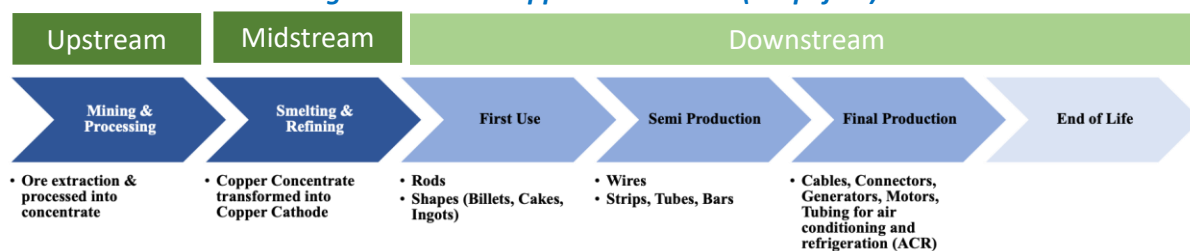
78. **Cobalt price volatility and supply chain security is the primary reason why researchers are seeking to develop zero cobalt and high nickel formulations for batteries.** The DRC would greatly benefit by making supply chains more transparent so as to meet the critical metals requirements set out by the United States and the European Union. This would also reduce the high price volatility seen in this commodity. Transparency will also present another significant employment opportunity for the country as proper supply chain management will be key.

6.1. Copper Value Chain (wiring)

79. **The first value addition option for the DRC would entail the development of copper-based manufacturing in the ex-Katanga region, with a focus on transforming the region into a manufacturing cluster with a local concentration of similar or complementary industries.**⁴¹ Under this option, the region would specialize in the production of electrical products, starting from copper wires, cables, and other semis and eventually move into products such as motors, transformers, and potentially copper foils used in EV battery cells. In addition to increasing the breadth of manufacturing capabilities by product, firms could also specialize in more complex and sophisticated products within a product category. For instance, firms could develop their manufacturing capabilities to move from low-voltage cable production to medium- and high-voltage cables. Firms could also develop cables optimized for signal transmission and other advanced industrial use cases.

⁴¹ Guidehouse. "Economic Clusters: Four Design Principles for Success."

Figure 13 – The Copper Value Chain (simplified)⁴²



80. **Wire rod is the most important copper product, accounting for more than 60 percent of copper usage.**⁴³ Some wire rod manufacturers are vertically integrated, with their own smelting and refining operations, while other manufacturers purchase copper cathode and scrap from the market. Copper rods are then used by cable companies to make wires and cables. Cable companies can be vertically integrated or operate independently. The production capacity of most cabling facilities is between 1,000 and 15,000 tons per year.⁹³

81. **Other key copper products include strips, tubes, and bars, which account for 30 percent of the copper market.** These products are also known as “semis” due to their semi-manufactured nature. While copper derived from scrap only accounts for a small percentage of inputs in wire rods, around 50 percent of the copper used in making semis is derived from scrap. There is wide variation within semis in geometry, alloy composition, and quality and hence little standardization, which is quite different from the wire rod market. Semis manufacturing also has a longer lead time.⁹³

82. **Copper wire can be segmented based on its application, such as its use in power transmission and distribution, telecommunications, and as building wire.** At its core, copper wire has two main uses: electrical power transmission, and signal transmission.

83. **As the transport industry becomes increasingly electric, vehicles are expected to contain more and more copper.** The battery packs used in EVs contain copper wiring and busbars, and the larger the battery, the higher amount of copper needed. Furthermore, the buildout of fast-charging networks and their integration into energy grids equates to more copper usage.

84. **Copper foil usage in battery cells could be a value-added product within the DRC’s existing capabilities and the battery value chain.** In lithium-ion batteries, copper current collectors are used on the anode side of the battery because this minimizes internal resistance and helps stabilize the system during charging and discharging. The choice of materials used for the electrodes for this role depends on the electronic conductivity of the material, and aluminum is typically used on the cathode side of the battery while copper is used on the anode side.⁴⁴ Conventional methods of copper foil production include rolling-annealing or electrodeposition process, and both methods can produce sheets in the 6µm to 10µm range.⁴⁵

85. **In comparison with smelting and refining, manufacturing copper products does not require as much energy.** Thus despite the DRC’s challenges with reliable and affordable electricity, it can

⁴² Source: Naveed and Vazir (2023), “Evaluating Strategic Opportunities for Value Addition in the Democratic Republic of Congo: Policy Analysis Exercise Prepared for the World Bank Energy and Extractives Global Practice.”

⁴³ Bernd E. Langer. “The Value Chain of Copper: From Mine to Application.”

⁴⁴ The graphite or a graphite/silicon combination typically used in the anode is coated onto nickel-plated copper foil that generally has a thickness of 9-10 µm.

⁴⁵ The higher the energy density, the lower the thickness of the copper foils required. NMC811 and NCA have thicknesses of 6-7µm compared to LFP, which requires thicknesses of 8µm to 10µm.

develop a robust manufacturing cluster for copper products without having to invest heavily in new electrical infrastructure. While precise figures for energy intensity differ based on location, facility, and copper product, relative to upstream and midstream energy consumption, manufacturing copper products entails energy usage that is lower by a factor of ten.⁴⁶

Figure 14 – Copper Value Chain Energy Intensity



1. Values for energy use in copper cathode production is from Chilean operations, whereas energy use value for wire drawing is based on data from US wire rod manufacturers

Source: Argonne National Laboratory's GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) Model • Created with Datawrapper

86. **As shown in Table 2, some copper value-addition activities are already economic in the DRC as it currently has a nascent copper product manufacturing industry with only two players.** One of those players, Proton, which is based in Kinshasa and is a family-owned business operating across different industries, has manufactured copper cables in DRC under the brand CABELEC since 2004.⁹⁶ Proton has an installed capacity of 3,000 tons per year and manufactures a range of low-voltage wires and cables.⁴⁷

Table 1 – Current Copper Value-addition Activities in the DRC

Company	Brand	Start-up date	Capacity	Products
Proton (Group Rawji)	CABELEC	2004	3,000 Tpa	Low-voltage wires and cables
Mining Engineering Services	Congo Cables	2023	4,200 Tpa	Now: Copper rods, low-voltage wires, and cables Future: High-voltage cables

87. **The other player, Mining Engineering Services (MES), is also a family-owned business based in Lubumbashi and operates primarily as an EPC contractor and solutions provider to the mining sector.**⁴⁸ MES also has various subsidiaries operating in mining and piping and launched a copper rod and cable manufacturing facility under the brand Congo Cables in January 2023. The facility is in the process of commencing operations, with an installed capacity of 4,200 tons of copper products per year. MES plans to supply the domestic market for copper wires, cables, and other semis, with longer-term ambitions for regional exports. It currently has the capability to manufacture low-voltage cables and intends to expand into medium- and high-voltage cables as its operations are scaled up.

88. **Both Proton and MES primarily use copper scrap as most virgin copper cathode supplies are locked in offtake agreements.** Furthermore, copper cathode suppliers are reluctant to service the

⁴⁶ Despite low energy intensity, intermittency can still hurt operating margins. Thus DRC operators would need to focus on ensuring stability of available supply.

⁴⁷ Source: Groupe Rawji, <https://www.grouperawji.com>

⁴⁸ Source: Mining Engineering Services, <http://www.messar.com/DownloadCenter.aspx>

small volumes currently required by these manufacturers. Given its manufacturing base in Kinshasa, another complicating factor for Proton is its distance from the ex-Katanga region, which is the main copper production belt in the DRC.⁴⁹ This limits the potential to competitively supply copper cathode from the ex-Katanga region to copper manufacturers in Kinshasa and Bas Congo, thus necessitating an ex-Katanga-based cluster approach.

89. The DRC’s existing operations show that it already has sufficient know-how supported by expatriate labor to produce copper products. Furthermore, as most of the DRC’s copper is already exported, converting this to wire for exports does not impose new logistical challenges. Existing transit networks for copper can be leveraged to support exports of copper products to neighboring markets. Thus producing and exporting copper products does not require the development of new road infrastructure or logistical capabilities. Furthermore, these existing transport networks already span Zambia, Botswana, Zimbabwe, Tanzania, and South Africa and local wire manufacturing could replace up to an estimated 236 million tons of gross copper wire imports in these countries.⁵⁰

90. Other constraints in terms of exports include quality assurance and product specifications. Due to the large range of product varieties, DRC producers will need to adjust production to meet the various demand specifications of target markets. Quality control will also need to be certified by international certifiers due to the DRC’s lack of domestic regulations.

91. The opportunity for new jobs and value capture through the copper value chain is real since the manufacturing of copper products involves a non-negligible degree of value addition during the process, with the Industry Value Added metric conveying the industry’s contribution to GDP. For example, on average, industry value added as a percentage of revenue for China, the US, the UK, and Australia averaged 22.4 percent over 2013 to 2022. Labor intensity is highest in China but averages 2,671 workers employed per USD 1 billion of production. With low barriers to entry, global operating margins are highly competitive and averaged only 5 percent. Assuming that the DRC is able to export USD 500 million of copper-based products per annum, this would result in USD 112 million of additional export earnings and value added and possibly 1,300-2,000 additional employment opportunities.⁵¹ This would account for a 0.5 percent increase in export earnings, and when assuming a 5 percent profit margin and 35 percent tax rate, exporting USD 500 million of copper-based products would add only USD 9m in annual taxable revenue.

92. Perhaps the single biggest challenge to a sustainable copper-value added sector in the DRC is access to finance. Although employment gains and value addition can be significant, operating margins are low and highly competitive, with an average global profit margin of only 5 percent. Access to competitive finance remains a constraint not only for value chain development but for all domestic investments in the DRC. The DRC’s lending rate, or the bank rate that typically meets short- and medium-term private sector financing needs, was 23 percent in 2021 (WB WDI), approximately double that of Kenya, three times that of South Africa, and eight times that of the United States. Consequently, investors need access to international financial markets to protect competitiveness,

⁴⁹ Kinshasa and the ex-Katanga province are commercially disconnected for freight transport purposes, with little road connectivity, inadequate rail infrastructure, and no river or seaborne transport.

⁵⁰ Source: *Atlas of Economic Complexity*.

⁵¹ Mining Engineering Services (MES), the Lubumbashi-based EPC contractor discussed earlier, currently plans to manufacture 4,200 tons of copper-based products at its facility with 60 employees. Source: Naveed and Vazir (2023), “Evaluating Strategic Opportunities for Value Addition in the Democratic Republic of Congo: Policy Analysis Exercise Prepared for the World Bank Energy and Extractives Global Practice.”

but even with this option, operating risk is high in the DRC, and international financiers will seek to be compensated for this risk through interest rates.

6.2. Cobalt Value Chain (EV batteries)

93. **The DRC is keen on actively promoting local battery precursor manufacturing in the Copperbelt, leveraging its comparative advantage as the world-leading cobalt exporter as well as its low-carbon hydropower electricity in mine production regions.** Despite significant reductions in cobalt content, cobalt accounts for 25-30 percent of battery costs. Going forward, the industry will likely introduce innovations as changes to the battery pack design that will contribute to cost reductions.⁵² Future cobalt demand is expected to remain bullish due to its importance in high-nickel cathode formulations and next generation battery technologies such as solid state.

94. **The growth of new BEV sales is expected to surpass 33 million vehicles in 2030 compared to the 7 million sold in 2022, and the percentage of those vehicles using high nickel chemistry with cobalt is expected to remain in the 55 to 59 percent range through to the end of the decade.** This translates to a 2.9 times increase in EV cobalt demand to 163Kt (or ~USD 8 billion) by 2030. Despite an increase in cobalt supply from Indonesia, the DRC is expected to maintain its market share through to the end of the decade.

95. **Developing an electric vehicle value chain in Southern Africa is an ambitious undertaking that requires a regional approach beyond Zambia.** Domestic demand for EV battery value chain components is an important factor. This is because as value is added to products along the value chain, manufacturers seek to source those components as close to their customers as possible, for two main reasons: (i) to reduce potential supply chain disruptions, which can affect the entire business model; and (ii) to optimize working capital. Although the penetration of EVs into the DRC is minimal to date, the DRC should think more regionally beyond Zambia when thinking about domestic demand and work to ensure that the necessary regional investments in transportation infrastructure are in place so as to minimize logistical disruptions.

96. **South Africa is the closest source of future demand for any EV battery value chain components manufactured in the DRC.** It is also the natural location for the assembly of electric vehicles since an export-driven automobile industry already exists, the workforce is trained and established, and marine ports provide the much needed logistical proximity to customers in North America and Europe. The final stages in the value chain, namely battery cell production, will most likely be established in South Africa as this part of the value chain needs to be produced close to EV car manufacturing sites. Furthermore, the country has an established battery producing industry.

97. **Another potential export market on the continent is Morocco.** While Morocco's EV manufacturing capabilities are still in the early stages of development, the country has shown a strong commitment to growing this industry and has attracted investment from major players in the automotive sector. The country has set a goal to produce 100,000 electric vehicles per year by 2025 and has been working to attract foreign investment to achieve this target. One of the major players in Morocco's EV manufacturing industry is the French automaker Renault, which has been producing electric vehicles at its Tangier plant since 2012. Renault announced plans to invest EUR 2 billion in

⁵² There has been a ~35 percent decrease in pack costs over the past two years due to design innovations as well as increasing energy density.

Morocco to expand its EV production capacity and develop a new electric platform which will produce its first vehicles in 2023.

98. **The existing availability of a skilled workforce, an important determinant of value chain projects being financed, can also be found in South Africa, and similar country experiences include Japan and the Republic of Korea (e.g., Panasonic and Samsung).** Recreating these successes in new regions and successfully persuading investors is not a simple copy-and-paste exercise (cf. CEPAL, 2021). Further, OEMs such as German car manufacturers are risk-averse about entering new production countries due to ESG concerns and reputational risks. That said, based on its current competitiveness and latent comparative advantages, a precursor plant in the DRC would fit neatly into a regional value chain.

99. **As one expert put it, manufacturing lithium-ion batteries is “mind-blowingly complex.”** In the short term, with its vast challenges and lack of competitive manufacturing capacity, it would be very difficult for the DRC to suddenly attempt to manufacture one of the world’s most complex products. Although the DRC has cobalt, this only amounts to limited cost reduction in marketing and transport, and compared to nickel and graphite, cobalt remains a small part of the battery manufacturing equation. For example, for an NMC 811 battery, a 10 percent change in cobalt price corresponds to only a 0.4 percent change in production cost. It is therefore illogical that the DRC should seek to spend its scarce resources trying to produce complete lithium-ion batteries simply because it possesses a cobalt advantage.

100. **Precursor production, on the other hand, is a necessary small step in a much longer and more complicated journey.** The jump from developing the capabilities to make precursors to developing the capabilities to manufacture batteries is wide. However, the production of precursors is a first and very important step toward this ambition, and although it may help generate a small cost advantage in the short term, it would set the stage for longer term production for other value chain products.

101. **Experts indicate that the know-how, infrastructure, and resources needed to produce precursors used to produce lithium-ion batteries are substantially different when it comes to refining products for industrial purposes.** Firstly, there is no single method for making battery grade materials, and end users have certain standards that must be met and must be certified to be of the necessary quality.⁵³ Furthermore, battery cell manufacturers and automakers have stringent qualification audit processes for pCAM and CAM suppliers. This ultimately means that precursor plants need to be able to adapt to meet these qualifications.

102. **Thus, we identify high potential segments of the EV battery value-chain with a focus on expanding copper production and providing cobalt precursor material to battery manufacturers of high nickel cathode chemistry.**⁵⁴ While other critical materials also warrant attention, we view these two goals as near term and more likely attainable.

103. **With the above in mind, the DRC should initially focus on two value chain segments within a regionally integrated electric vehicle value chain, namely: (i) Minerals Refining (upstream); and (ii) Battery Precursor Materials and Components Manufacturing (pCAM / CAM) (midstream).** Even if

⁵³ This is why the largest precursor producers such as GEM, Huayou Cobalt, and Umicore do not produce batteries but instead act as intermediaries between mining companies and battery cell manufacturers. Instead, these companies are focused on materials science, chemistry, and metallurgy.

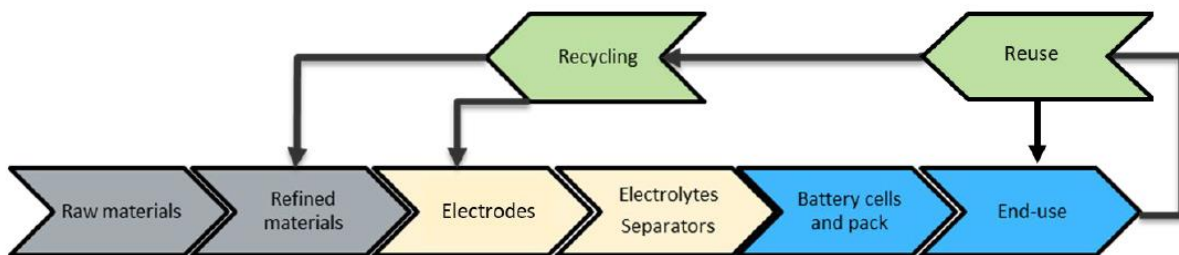
⁵⁴ These include NCA (Tesla), NMCA (GM) and NMC (other non-China automakers).

targeting only these two segments, an ecosystem approach is needed that must give consideration to the overall structure of the value chain and to the skills, infrastructure, and economic incentives necessary. These are expanded upon in the following sub-sections.

Overview of the Battery Value Chain

104. In general, battery supply chains encompass raw material procurement, refining, component manufacturing (electrodes, electrolytes, and separators), end-use products, and recycling. Figure 15 shows a typical battery system supply chain segmented into upstream components (raw and refined materials), midstream components (subcomponents such as electrodes and separators), downstream components (battery cells, packs, and end-use), and recycling, which recovers materials from the end use and sends them to upstream and midstream component steps.

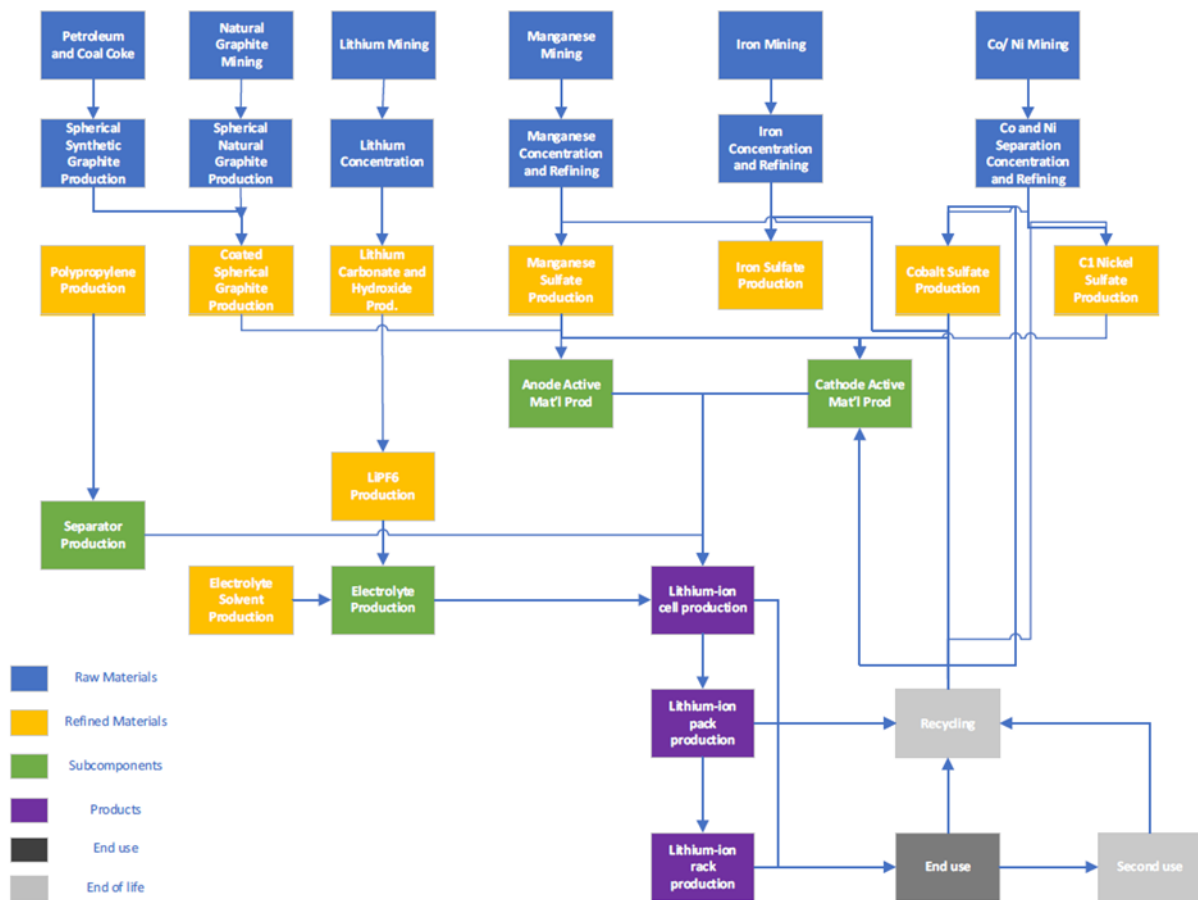
Figure 15 – Typical Battery Supply Chain Including Recycling and Reuse



105. The lithium-ion battery supply chain includes raw materials, refined materials, subcomponents, product, and end-use. Figure 16 presents a high-level view of the supply chain for most lithium-ion battery chemistries. The diagram is a simplification of the supply chain and only shows the main active cathode and anode materials and the major components of separators and electrolytes. Materials such as copper foil (anode), binders, and additives are not shown.

106. Each major sector of the supply chain, including the materials and processes, is described in Figure 16. A detailed description of each component of the lithium-ion battery supply chain and where it is extracted or produced is provided in Annex 7 of this Chapter.

Figure 16 – Lithium-ion battery Supply Chain Diagram

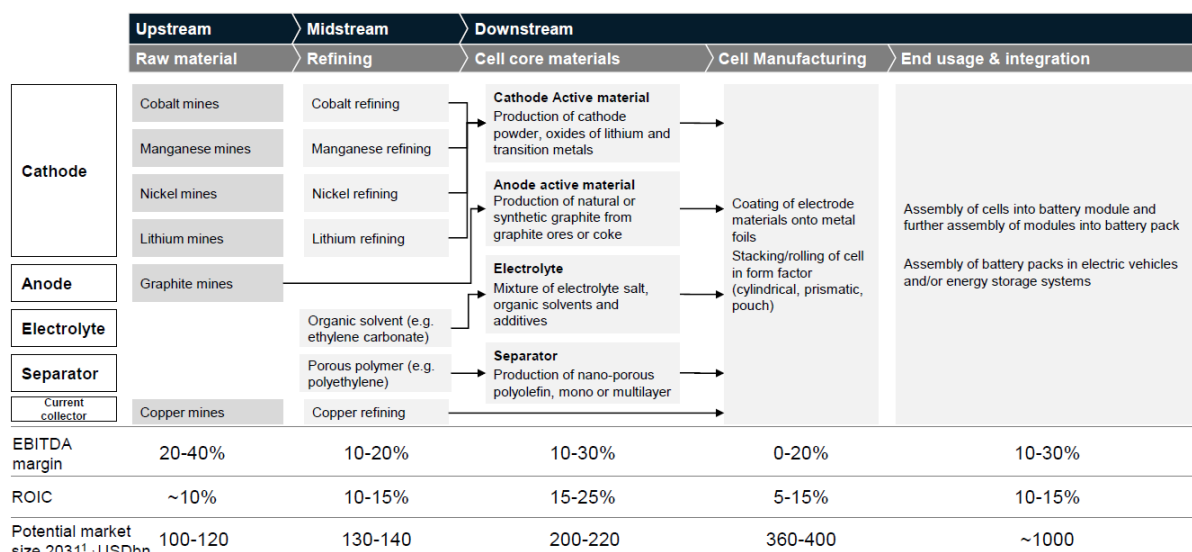


107. **EV battery value chain has the potential to quadruple the end value of battery minerals mined in Africa (see Figure 17).** Operating margins and capital costs tend to be the highest at the upstream (mining) stage of the value chain. In addition to the generation of foreign exchange and employment opportunities, the opportunity to generate revenues for the government are highest at this stage if tax policy and administration are of good quality.

108. **As we move to the midstream (smelting and refining), capital costs remain high and energy intensity tends to be very high, two factors that combine to necessitate a scale of operation necessary to justify investment in the facility and associated infrastructure.** In the case of the DRC, where grades of copper and cobalt deposits are very high and distances to the nearest ports are high, smelting and refining often takes place locally in order to limit the cost of transport. However, margins tend to be modest, thus limiting the opportunity for tax revenue.

109. **As we move further downstream and value is added, it is not surprising to note that the size of the market increases (see Figure 17).** At this stage, employment opportunities vary depending on the process but can be important. Activities are competitive globally, which caps profit margins; however these can range from 0 to 30 percent and thus can provide opportunities for generating government revenue depending on the specific facility. For the DRC, a large number of raw material inputs such as cobalt, lithium, and sulfuric acid can be sourced locally, and this provides a potential cost advantage over other countries, which need to import these raw materials.

Figure 17 – Opportunities in Value Addition in the EV Battery Value Chain⁵⁵



1. Africa expected to account for 1% of global EV sales in 2031

Access to Skilled Labor

110. **Employment is a strategic priority in the DRC given the country’s rapidly growing young population and struggle with unemployment, low wages, and informality of the labor market.** The DRC’s education system struggles with low coverage and quality, while unemployment and underemployment hinder productive growth. Labor productivity in the DRC is among the lowest in the world as the domestic workforce lacks a diverse range of skills and expertise, thus severely limiting the country’s ability to move into new industries.

111. **Paradoxically, the DRC is experiencing both extremely high unemployment and labor shortages.** Several sectors are experiencing shortages, particularly the construction and mining industries. Companies are often forced to take on foreign workers, for example in sheet metal work or to operate lifting equipment in mines. To perform these tasks, which require real expertise, workers are recruited not only from surrounding countries but also from New Zealand, Australia, and China.

112. **In order to address the skills gaps in the DRC and remove barriers to the sector’s growth (including value addition), a multi-pronged long-term strategy should be initiated, which would include:** (i) facilitating access to skilled foreign workers with commensurate requirements for skills transfer programs and obligations; and (ii) reinforcing the DRC’s own pipeline of skills, starting with STEM skills, with an inclusive focus on women, girls, and the disabled, to building vocational skills capabilities and finally improving the pipeline of quality graduates not only in engineering skills but also by developing social and environmental specialists so that growth can be achieved in a balanced, inclusive, and environmentally responsible manner.

Foreign Skills and Knowledge Transfer

113. **Given the highly complex processes involved in EV battery value chains, the DRC should consider pooling labor from regional neighbors and partner companies to fill any potential skills gaps.** South Africa, Namibia, and Botswana are the countries with the highest skilled labor in Southern and Central Africa (Global Competitiveness Index Skills > 50), with Zimbabwe and Zambia are not far

⁵⁵ Source: World Bank 2022

behind, scoring 49 and 48 respectively, whereas the DRC achieved scores in the range of 40 or below and thus has the lowest available skills base in the regional cluster.

114. **The cost of expatriate skills can sometimes act as an additional cost and negatively impact the economics of the sector and value chain activities.** However the DRC already has policies to mitigate this impact by offering tax benefits for companies operating in the SEZs. For example, companies receive a reduction in the tax rate from 25 to 15 percent.

Reinforce the Pipeline of Education and Skills

115. **The DRC's educational system is complex.** Despite efforts made over recent years, the training and education available throughout the nation is very uneven. In addition, the educational system is struggling to provide learners with the job skills they need since programs generally focus on theoretical knowledge or initial training through primary, secondary, and academic education. This training does not produce the professional skills required for immediate employment. Outdated school curricula left over from the colonial period also pose a problem, and additional challenges include a shortage of qualified teachers and inadequate infrastructure.

116. **The completion rate at the primary level remains low at 75 percent, and the quality of education is extremely poor.** An estimated 97 percent of 10-year-olds in the DRC are in "learning poverty," which means that they cannot read and understand simple text. In 2018, 7.6 million children aged 5 to 17 were still out of school, and half of all girls aged 5 to 17 were not in school (UNICEF). The pre-school enrolment rate for children aged 3 to 5 is only 5 percent. This level is considered very low given the benefits that pre-schooling can bring young children in terms of improving primary school entry and cognitive and social development from an early age. Furthermore, repetition and drop-out rates at primary level undoubtedly have an impact on secondary level (UNICEF).

117. **The various reforms initiated since the country gained its independence in 1960 have not succeeded in improving the quality of the system, which is hindered by deficiencies in several areas:**

- Strategic, legal, and institutional framework (governance)
- Content, methods, curricula, and follow-up and assessment
- Resources (human, material, and financial), and
- Training suited to employment requirements.

118. **Access to education has improved considerably over the past two decades, especially for girls and at earlier ages.** According to the World Bank, in 2021, the DRC had a total population of 95,894,118, with annual population growth of 3.2 percent. The adult literacy rate has increased from 61 percent in 2007 to 80 percent in 2016, a remarkable gain in such a short period of time. Between 2000 and 2017, primary net enrolment increased by 50 percent, from 52 to 78 percent. However, the quality of education is extremely poor. In terms of learning and achievement, the primary completion rate is only about 67 percent, and an estimated 86 percent of 10-year-olds in the DRC are in learning poverty, which means that they cannot read and understand simple text. Moreover, gender differences persist in the workforce in terms of pay and education gaps, and more so in rural than in urban areas.

119. **The overall education level in Haut Katanga is high by national standards.** This is especially the case for higher education, where Haut Katanga is on par with the capital Kinshasa. Technical and

vocational training per 100,000 is also above the national average. In terms of vocational training, state funding for Technical Vocational Education and Training (TVET) colleges is negligible and is not clearly allocated in the breakdown with other sub-sectors. Contributions from bilateral or multilateral cooperation together with certain development partners help make up the funding shortfall for TVET. However, these efforts are not sufficient to fill the funding gap for effective implementation of the various reforms.⁵⁶

120. **Yet substantial skilling and reskilling will be needed to appropriately equip the workforce for local battery manufacturing especially as this industry is not yet present in the DRC and is highly competitive internationally.** If efforts focus on the initial steps in the battery value chain such as battery precursor production, the skills necessary are metallurgical and chemistry, which are related to smelting and refining metal ores. Thus, upgrading the skills of related professions will likely constitute a feasible route to building the relevant skills the emerging industry will need.

Skills Base for Battery Value Chain Development

121. **In April 2022, the Centre of Excellence for Advanced Battery Research was launched in Lubumbashi as a partnership between Congolese and Zambian schools of mines and polytechnics.**⁵⁷ Though firm commitments have been signed, the country will have to overcome the obstacle of a qualified workforce. The creation of a vocational training school has been announced to train young people in areas such as mechanics, mining, and metallurgy, among others. The initiative is expected to create 2,000 jobs, including 500 direct jobs in the first year.⁵⁸

122. **Skills development is also in view at the African Center of Excellence for Batteries.** The Center's objectives are to provide education, research, innovation, and technological capacity to support a domestic battery industry. To develop senior staff skills, it is envisioned to integrate battery chemistry into the already established education of professional chemists in the Polytechnic Faculty of the University of Lubumbashi (UNILU). To provide vocational training, the Center has in view the establishment of a center of resources dedicated to skills building. It will have the objective of providing short-term training to qualify young people without university qualifications to take on jobs at the different steps of the battery and electric vehicles value chain.

123. **Looking forward to the short to medium term, battery industry value chain development in the DRC will have to rely on international expertise.** As precursor production is highly specific, it will likely require experienced international specialists who will likely expect substantial salaries with a two- to threefold expat rate for relocating to the DRC. The National Battery Council has also stated that it is willing to use the contribution of executives in the diaspora (based in Belgium, the US, and South Africa) to provide training and a Professional Master's degree program in battery chemistry. However, this will require substantial enrolments in undergraduate chemistry and chemical engineering to support this program. While this program could be financed by the mining companies, and Glencore is positioning itself to contribute to this endeavor, previous STEM education would be needed. As the program is still in its infancy, and it will take many years for new graduates to have the

⁵⁶ Four main employers' organizations play a role in TVET governance. They are the Federation of Enterprises of Congo (FEC), the National Association of State Portfolio Companies (ANEP), the National Federation of Small and Medium Enterprises of Congo (FENAPEC), and the Confederation of Small and Medium Enterprises of the Congo (COPEMECO). These organizations make requests for training of their workforce (qualification, sector, profile) to the bodies responsible, including the National Vocational Preparedness Institute (INPP).

⁵⁷ <https://uneca.org/stories/zambia-and-drc-sign-cooperation-agreement-to-manufacture-electric-batteries>

⁵⁸ <https://allafrica.com/stories/202112060311.html>

necessary practical experience. In the short to medium terms, the DRC will need to balance expatriate skills with a skills transfer program before fully staffing value-addition facilities with Congolese nationals. Experiences from other countries have shown that close collaboration between companies and educators helps ensure that the skills developed meet business needs.

Infrastructure

Transport Infrastructure

124. **The proximity of the Kinsevere SEZ to Lubumbashi is fortunate as the city is arguably one of the best-connected hubs in the country and the location is close to the production of the material inputs necessary (i.e. cobalt).** As a result, the location leverages the established trading and transporting routes of the mining sector and avoids the need to transport materials from the mining region to another location on the DRC's poor quality road network, which would add significantly to costs and erode the economics.

125. **Despite this, it can take up to two to four weeks to exit Kolwezi and cross the border into Zambia, with mining companies often considering eight days a good performance.** According to some estimates, it can take as long as 35 days to get from a mine in southern Congo to South Africa's ports. With copper production due to increase significantly, logistical bottlenecks will prove increasingly problematic unless investments in rail and roads are made.

126. **Transit costs are a major impediment for almost every exporter in the DRC.** For example, logistics charges for the Kamoia-Kakula mine in Kolwezi were USD 0.57 per pound of payable copper in Q3 2022. Shipping concentrate from Kolwezi to China therefore represented 39 percent of the company's USD 1.43 cash cost per pound of payable copper. However, this is only temporary though as the company intends to eventually build a smelter at the site.⁵⁹

127. **The cost of border and documentary compliance is also significantly higher for the DRC than for its regional peers.** One study estimates border compliance costs in the DRC to be higher than average costs in Sub-Saharan Africa by a factor of four and documentary compliance costs to be higher by almost a factor of three.⁶⁰ Tolls, for example, can amount to USD 900 for roundtrip exit and entry on the DRC-Zambia border.⁶¹

128. **More broadly, the location of building a precursor facility within the DRC constitutes a natural competitive advantage.** Precursor materials are less complex to transport over long distances compared to cathode active materials, so building a precursor facility in the DRC could be feasible if it can benefit from low material and manufacturing costs, which the SEZ is set out to provide.

Energy Infrastructure

129. **The DRC relies on hydroelectric power for almost all of its electricity generation.** The installed capacity of the public operator, SNEL, consists of 15 hydroelectric power plants with 2,581

⁵⁹ Worth noting is that due to the nature of the geology, the smelter will use pyrometallurgical processes to treat the sulfide ores. Kamoia-Kakula will capture the sulfur in the process to create sulfuric acid – a necessary ingredient to produce battery precursors such as cobalt-sulfate and an equally critical input to those copper mines in the Copperbelt that process ore using hydrometallurgical processes and have had to import sulfur from international destinations.

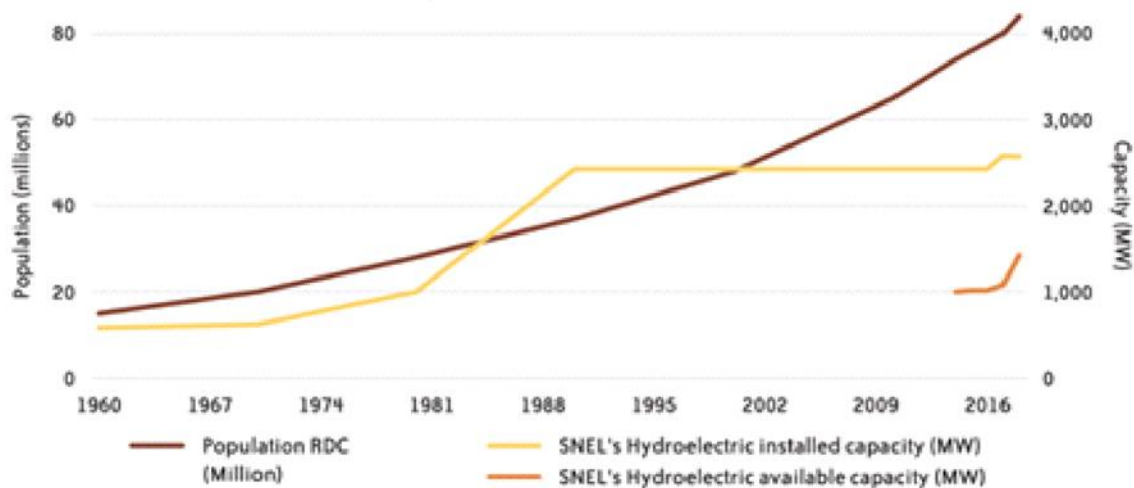
⁶⁰ COG.pdf (doingbusiness.org)

⁶¹ <https://www.bloomberg.com/news/features/2022-02-03/congo-s-kabila-family-made-millions-off-toll-road-built-by-china>

MW of installed capacity and 30 thermal units with an installed capacity of 28 MW. The Inga 1 and Inga 2 dams provide the bulk of this hydropower, although both currently operate at half capacity due to a severe lack of maintenance. Total available capacity is estimated at 1,444 MW, which is only 55 percent of the total installed capacity, while peak demand can reach 4,000 MW.

130. **Energy supply is a serious issue in the Kinsevere SEZ.** A gap of 1200 to 1300 MW is estimated, and a solution to this constraint will need to form part of the policy package or incentives offered to investors.

Figure 18 – SNEL's Hydropower Installed and Available capacity (RHS) against Population (LHS) (1990-2018)



131. **Société Nationale d'électricité (SNEL), the DRC's national utility company "has been unable to provide reliable power supply or improve stagnating access figures due to its poor financial health, operational inefficiencies, and governance issues."**⁶² The result is high rates of energy poverty and many shortfalls in zones with high amounts of hydro-electric power.

132. **The fact that the Kinsevere SEZ is still a greenfield at this stage and thus not yet connected to the grid highlights the fact that providing sufficient and reliable power could be challenging, especially as this has been a perennial challenge for the DRC.** Power shortages and intermittency force manufacturing firms to source half of their electricity through generators, with electricity costing up to USD 1 per kWh. Intermittency also disrupts manufacturing output and increases production costs. Studies suggest that manufacturing firms lose 11 percent of their annual sales due to intermittency.⁶³ Moreover, businesses that import diesel to fuel their generators are exposed to cost volatility and exogenous risk from regional diesel prices. One recent study summarizes these challenges by stating that 86 percent of surveyed businesses in the DRC agree that a lack of reliable electricity prevents their businesses from operating properly.⁶⁴

⁶² <https://documents1.worldbank.org/curated/en/231141609951093070/pdf/Concept-Project-Information-Document-PID-DRC-Electricity-Water-Access-and-Governance-Project-P173506.pdf>

⁶³ <https://www.ifc.org/wps/wcm/connect/277b2c5a-e92d-4c2e-9e6c-5b393a6eee4b/CPSP-Democratic-Republic-of-Congo-EN.pdf?MOD=AJPERES&CVID=nZWvJQj>

⁶⁴ <https://nextbillion.net/drc-energy-urban-development>

Finance

133. **Access to competitive finance remains a constraint not only for value chain development but for all domestic investments in the DRC.** The DRC's lending rate, the bank rate that typically meets short- and medium-term private sector financing needs, was 23 percent in 2021 (WB WDI), approximately double that of Kenya, three times that of South Africa, and eight times that of the US.

134. **Consequently, investors with international connections financing large projects often turn to foreign markets to raise capital.** While established companies can sometimes raise capital at 6-12 percent, it is more common for new projects to raise capital at 15-20 percent. This situation is made even more dire by the recent rise in global interest rates. As monetary tightening continues, the DRC's lending interest rate will continue to remain elevated. This will pose a barrier to downstream projects.

Economic Incentives

135. **To incentivize investments in strategic sectors, the DRC government defined the following six special economic zones in 2014 with the Law n°14/022:**

1. The Maluku area, comprising the City Province of Kinshasa; Kongo Central Province, and the former Bandundu Province
2. Kasai area, comprising the provinces of Kasai, Kasai Central, Eastern Kasai, Lomami, and Sankuru
3. Kinsevere, the former Katanga Province, where the mining center of Lubumbashi is located
4. Great Kivu
5. The former Eastern Province
6. The former Equateur Province

136. **The new SEZ legislation creates several tax holidays and administrative facilitations for developers and companies.** For developers, benefits are: (i) total exemption from property, movable, and professional taxes on profits for 10 years, renewable once after evaluation; (ii) reduction of 50 percent of the tax rate from the 21st year; and (iii) total exemption from import duties and taxes on machinery, tools and new or used equipment, and capital goods for 10 years. Meanwhile companies receive: (i) total exemption from property, movable, and professional taxes on profits for 5 years, renewable once after evaluation; (ii) reduction of 50 percent of the tax rate from the 11th year; (iii) application of accelerated depreciation; (iv) exemption from import duties and taxes on machinery, tools and new or used equipment, and capital goods for 10 years; (v) exemption from export duties and taxes on finished products for 10 years; (vi) reduction of 50 percent for all non-tax payments to the national and sub-national governments; (vii) unhindered access to foreign exchange – i.e. the right to repatriate profits, transfer funds, and make payments denominated in foreign currencies; and (viii) reduction in the tax rate on income from expatriate staff from 25 to 15 percent.

137. **The Maluku SEZ, close to Kinshasa, is by far the best developed to date.** The administration of SEZs in the DRC is the responsibility of a public entity, the Special Economic Zones Agency (AZES). It has a surface area of 885 ha, including 244 ha for the pilot zone. Sectors identified for this SEZ include: (i) agro-industry; (ii) construction materials; (iii) packaging; and (iv) metallurgical processing.

138. **The SEZ is not yet fully operational as the Decree granting exemptions to developers and companies that plan to set up in the SEZs was only signed on April 5, 2020.** Contracts have now already been concluded between the Congolese Government and the developer recruited for the

Maluku SEZ, and according to the National Investment Promotion Agency of the DRC, construction work for the necessary infrastructure has started.

139. **The Kinsevere SEZ, located in the south of the country in Haut Katanga (30 km north of Lubumbashi), will be dedicated to the battery industry.** This SEZ will be close to the African Center of Excellence for Batteries (CAEB) and the Zambian border. Some 2,000 ha of land were allocated by the government of the DRC and 1,000 ha by the government of Zambia to host this SEZ.

140. **The Kinsevere SEZ is currently a greenfield.** However, a protocol engaging Afreximbank, the DRC government, and the United Nations Economic Commission for Africa (UNECA) was signed with the company ARISE, a pan-African developer of industrial ecosystems that successfully implemented a SEZ in Gabon, to undertake a prefeasibility study for the establishment of the various Battery Value Chain segments in the Kinsevere SEZ. The protocol was signed on March 27, 2023. The study is financed by Afreximbank, and the completed pre-feasibility study is expected by August 2023.⁶⁵

Box 1 – US Initiatives to Accelerate Battery Industry Development

While there are plans in place to establish LFP battery cell manufacturing, high-nickel cathode formulations such as NMC (used by the majority of OEMs), NMCA (GM), and NCA (Tesla) will dominate US battery manufacturing over the next decade. The Inflation Reduction Act (IRA) aims to invest over USD 389 billion over the next 10 years in energy and climate programs on top of the Bipartisan Infrastructure Investment and Jobs Act, which includes USD 15 billion in subsidies to the industry, which the US Department of Energy (DOE) has begun to distribute. The IRA has also reinstated the USD 7,500 tax credit for Tesla and GM vehicles that were excluded after reaching the 200,000-vehicle cap. However, EVs will need to be assembled in North America to be eligible.

To qualify for the full USD 7,500 tax credit amount on a vehicle purchase, EV battery packs must contain: (i) at least 50 percent materials sourced in North America; and (ii) 40 percent of the value of critical minerals used must be extracted, processed, or recycled domestically or from one of the countries with a free trade agreement in place. If only one of these requirements is met, the tax credit is halved to USD 3,750, and these percentages are due to increase by 10 percent per year.

However, the IRA includes a loophole: If the vehicle is leased and not directly purchased, the credit still applies even if the content requirements are not met as the vehicle then qualifies as a commercial vehicle. The result is that the US is likely to see much more leasing of electric vehicles going forward.

On April 17, 2023, the US Treasury Department announced that only 10 vehicles, including Ford's F-150 Lightning, most of GM's vehicle line, and Tesla's Models 3 and Y, qualified for the full EV credit amount. Domestically-produced vehicles such as Ford's Mustang Mach E sports utility and the standard range version of Tesla's Model 3 will see the tax credit halved, and many vehicles manufactured by VW, BMW, Nissan, and Rivian are no longer eligible for the EV tax credit unless offered through a leasing arrangement.

⁶⁵ <https://copperbeltkatangamining.com/drc-signs-framework-for-pre-feasibility-study-of-economic-zone-for-batteries-and-evs>

6.3. Economic Analysis: Estimation of Costs and Rates of Returns

A. Economic Modeling: Assumptions and Costs

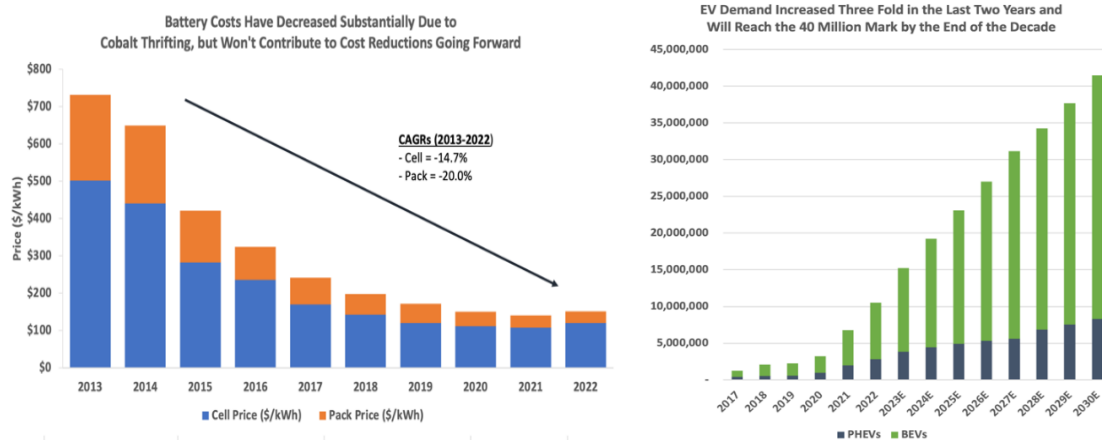
141. **Value chain analysis of the lithium-ion battery industry begins with forecasting the adoption of pure electric vehicles globally and forecasting key materials to be used in cathode chemistry.** Cobalt is tied to high-nickel cathode battery formulations used in battery electric vehicles (BEV), and global sales of these vehicles is expected to surpass 18 million by the end of 2025 and 33 million by the end of the decade. The industry uses a benchmark based on a cost per kWh basis, while cobalt thrifting and increased energy density have reduced average cell costs from USD 502/kWh in 2013 to USD 120/kWh in 2022.

142. **Cobalt is expected to remain a key ingredient in batteries through to 2030 and beyond.** Lithium-ion batteries operate by shuffling lithium ions back and forth during charging and discharging and are named after the chemical make-up of the cathode (e.g., NMC = nickel manganese cobalt). The cathode chemistry trend may continue to be the pursuit of high-nickel cathode chemistries such as NMC (most OEMs: NCA (Tesla) or NMCA (GM)) while thrifting cobalt content. However, production has been set up to use cobalt for the stabilization of nickel within the battery system during operation, and its use during cathode manufacturing makes it easier to produce. Even a zero-cobalt NMC formulation requires 2-5 percent cobalt.

143. **Increases in the uptake of LFP (lithium iron phosphate) battery chemistry outside China represents the nearest term risk to BEV cobalt demand.** Despite an increase in the market share of LFP cathodes in China, high-nickel formulations will be key to the North American market (9 percent of global EV market share) and European markets (45 percent of global EV market share) and will remain a popular cathode choice for higher-end vehicles in China (45 percent of global EV market share). This is because once the factories are built and supply chains secured, it is very difficult to change battery technology as the vehicle's auxiliary equipment (battery management systems, cooling, etc.) is tailored around the cathode chemistry. This means that even small changes to the chemistry and quality of raw materials can lead to higher development risks along the value chain and high reputational risk for automakers.

144. **Further reductions in battery costs will come from de-risking supply chains and achieving economies of scale and manufacturing efficiencies.** Prior to 2017, the NMC cathode formulation (NMC111) had 0.39kg/kWh while the current formulations of choice NMC622 and NMC811 have 0.2kg/kWh and 0.094kg/kWh, respectively. Thus although cobalt represents a smaller quantity on a per-cell basis, as EV adoption continues, cobalt demand from BEV growth will increase 2.9 times to an additional 181Kt by the end of the decade. Future declines in battery costs will come from de-risking supply chains, improving the stability of battery materials (e.g., coatings), pack design modifications, achieving economies of scale, and achieving the same manufacturing efficiencies that have been achieved by Tesla.

Figure 19 – Trends in EV Battery Costs and Forecast Demand⁶⁶



Source: World Bank Staff

145. We elaborate below the various key inputs to an economic model developed to assess the potential economics of a battery precursor plant in the DRC. The economic model is a spreadsheet-based discounted cash flow model developed by Argonne National Labs.⁶⁷ Critical inputs relate to capital costs as well as key operating cost components such as raw materials, labor, and energy. A set of high-level tax assumptions are included as a sensitivity analysis along with differing discount rates and IRR variation tables. The inputs are discussed in the following subsections.

1- Capital Costs

B. Processing Facility

146. As the feasibility study to construct a pCAM facility in the DRC is ongoing (having started at the end of April 2023) and many of the facilities in operation globally are owned by private companies in China, initial capital costs were estimated using international benchmarks. Based on the comparables listed below, an initial investment of USD 167 million for a 33,000-tons of cobalt sulfate per year plant was used as a benchmark, which could meet demand for approximately 470,000 electric vehicles per year.⁶⁸

- EVELution has proposed a **USD 200 million plant** in Arizona that will be using solar energy and produce 33,000 tons of cobalt sulfate per year.
- Electrek completed a feasibility study in 2020 to build a 20,000-ton cobalt sulfate plant in Canada and announced project economics that involves an initial investment of **USD 61.8 million** (inflation adjusted). This translates to a **USD 102 million investment** outlay for a 33,000 ton/pa cobalt sulfate plant.
- LG Chem and Huayou Cobalt have announced a **USD 920 million** (KRW 1.2 trillion) precursor project in South Korea that will produce 50,000 tons of NMC precursor materials by 2026. Since the

⁶⁶ BNEF, SFA Oxford, World Bank Group

⁶⁷ Kevin W. Knehr, Joseph J. Kubal, Paul A. Nelson, and Shabbir Ahmed, "Battery Performance and Cost Modeling for Electric-Drive Vehicles: A Manual for BatPaC v5.0", ANL/CSE-22/1, July 2022, <https://doi.org/10.2172/1877590>

⁶⁸ By comparison, just over 10 million electric vehicles during 2022. Source: <https://about.bnef.com/electric-vehicle-outlook>

process factors for nickel, manganese, and cobalt are similar, this translates to a **USD 200 million** investment outlay for a 33,000 ton/pa cobalt precursor plant.

147. **As the industry ramps up raw material processing to meet growing battery demand, a 33,000-ton plant is believed to be a suitable long-term goal.** We have used an initial capacity rate of 10 percent in 2025 ramping up to 100 percent capacity by 2028.

C. Associated Infrastructure (Transport and Energy)

148. **This analysis assumes that the associated transport and energy infrastructure would be established within the special economic zone that is being proposed in this report.** According to the update of the bill-of-materials in the GREET model by Argonne National Labs, the energy consumption for a ton of NMC532 cathode materials is 21.670mmBtu/ton.

149. **If additional capital investment is required by the investor to cover energy and transportation costs, this would significantly negatively affect the economic feasibility of the investment.**

2- Operating Costs

150. **There is little data available on the ongoing operating costs of pCAM and CAM production as producers are private companies or part of a larger cell manufacturing facility.** Furthermore, models on pCAM and CAM production are absent from peer reviewed research and battery cost models, such as the one used in this analysis by Wentker et. al., (2019) do not typically break out cost estimates by raw material and group them as ‘CAM materials’.⁶⁹

D. Raw materials

151. **Average material costs in Europe are USD 72.1/kWh while material costs in the US and China are USD 68.3 and 64.8/kWh, respectively.** The proximity of refining and precursor production to mine production in the DRC represents a competitive advantage. However, given the proximity to mine production, average material costs were reduced by 20 percent. Thus cobalt pCAM production in the DRC is estimated to be USD 4.7/kWh compared to an average of USD 5.9/kWh if produced in the other countries investigated and would be even cheaper than China’s at USD 5.5/kWh.

152. **Cobalt price volatility and supply chain security could be improved by the DRC by making supply chains more transparent.**⁷⁰ Cobalt prices are volatile and reached peaks of USD 91,250 in 2018 and USD 82,000/ton in 2022 compared to USD 29,525/ton today. The DRC represents 68 percent of global mine production and is expected to do so throughout our forecast period through to 2030. Spot prices should stabilize in the USD 30,000 and 45,000/T range over the next few years, and volatility should decrease substantially if the DRC implements the policies recommended in this report.

E. Labor

153. **Labor costs are not a key driver of the project’s economics.** Currently, China labor costs for the production of a full NMC811 cell are estimated to be USD 1.7/kWh, or 3 percent of the total cost of the cell, and this value was used as a proxy for the DRC. However, material costs are more labor-

⁶⁹ Wentker, M., Greenwood, M., and Leker, J. (2019). “A bottom-up approach to lithium-ion battery cost modeling with a focus on cathode active materials.” *Energies* 12(3): 504; <https://www.mdpi.com/1996-1073/12/3/504>

⁷⁰ However, as noted in section 3.3.2, due to the by-product nature of much of the cobalt production, cobalt supply is slow to respond to price changes, which will continue to contribute to price volatility in the future.

intensive (extraction to pCAM and CAM refining) in the DRC as China mostly imports raw material inputs for further refining and processing. Furthermore, China has a qualified workforce of battery chemists and established research facilities to support its domestic lithium-ion battery industry. Thus the percentage applied to determine labor material costs was increased to 5 percent of material costs, or USD 0.23/kWh for cobalt precursor production in the DRC compared to USD 0.11/kWh in China.

154. **In terms of expat salaries, we take the US State department daily per diem rates to get a reasonable sense of salary multipliers that could be applied.** The DRC notably has a very high price level, for example the daily per diem in Kinshasa is USD 392 while Lubumbashi it sits at USD 305 per day. Danger pay only applies in the Northeast (conflict affected regions around Goma in North Kivu, at roughly 15 percent of the base salary). The Zambian capital Lusaka on the other side of the border has a daily per diem of USD 355, and Cape Town in South Africa USD 292. This implies a slight, hence manageable wage premium of Lubumbashi over Cape Town of roughly 20 percent.

155. **The global pCAM industry is nascent, with few stand-alone companies in operation, and there is a labor shortage of qualified individuals outside of China.** Leading researchers have noted that pCAM and CAM production at the levels needed to support BEV demand is very complex as refined materials need to be consistent and processes need to be adaptable to meet client needs. Thus the DRC would need to engage consultants and bring in the expertise necessary at 2-to-3 times the global salary rates for the industry. Applying an additional 1-2 percent to material costs would translate to an additional USD 0.04 to 0.14/kWh for overall cobalt pCAM production costs.

F. Energy

156. **Given the high amount of hydro-electric power in the DRC, Norway's energy cost of USD 2.3/kWh was used as a proxy to calculate cell cost production.** Using USD 2.3/kWh as a proxy means that energy used in the DRC represents 2 percent of cell production costs, and when applied to energy costs to produce cobalt pCAM materials results in USD 0.09/kWh.

G. Transportation Costs

157. **Currently, 70 percent of battery grade cobalt sulfate is refined in China, with the remainder processed in Finland and Indonesia.** Therefore, the transportation costs of raw cobalt ore to China and Finland for processing conservatively include these costs in these estimates. Shorter distances between mine production and refining and processing locations decrease the costs and carbon footprints of a pCAM industry in the DRC, and raw material inputs will also be at lower cost.

158. **Shipping costs take into consideration road transport to the port of Dar es Salaam and then to the Shanghai SMM exchange.** Road transportation from Lubumbashi to the port of Dar es Salaam (1,837km) was estimated using a cost of USD 0.1/km per ton and marine transportation from Dar es Salaam to Shanghai (9,694km) was calculated using a cost of USD 0.004/km per ton.

3- Taxes and Other Fiscal Assumptions

159. **According to Trading Economics, the corporate tax rate in the DRC averaged 35.38 percent from 2010 to 2022, with an all-time high of 40 percent in 2011 and 30 percent in 2022.** While we assume that corporate tax breaks will be provided by the industry, we tested both a 30 percent and a 50 percent reduction, or 15 percent, a tax incentive implemented in Canada, another resource-rich country to build cleantech industries that will help meet the country's emissions goals.

160. **Discount rates used include 10 percent (low risk), 20 percent (medium risk), and 30 percent (high risk).** The DRC has a high long-term local and foreign currency sovereign rating even though

Moody’s Investors Service upgraded the country to B3 (high credit risk) from Caa1 (very high credit risk) in November 2022. The high-risk scenario or 30 percent incorporates this reality as well as the lack of ESG-related regulations in the DRC. Furthermore, companies already doing business in the country have a “high risk” ESG ranking, and the negative NPV and low IRR values show the need for improved transparency of the cobalt value chain.⁷¹ The medium-risk scenario assumes the establishment of more stringent regulations as well as traceability of supply chains from extraction to pCAM refining, and this has shown in positive NPV and improved IRR values. The low-risk discount rate assumes supply chain transparency and the implementation of the policies recommended in this report.

B. Economic Analysis

C. The economic analysis assumes an initial capital investment of USD 167 million for a 33,000 ton/pa plant and operating production costs of USD 4.7/kWh for cobalt pCAM production in the DRC.⁷² Production is estimated to begin in 2025 operating at 10 percent of nameplate capacity and is forecast to reach full capacity in 2028. These capacity rates are somewhat optimistic as it will take time to secure the necessary offtake agreements as battery cathode makers have different requirements and quality control methods. The initial capital investment depreciated over 5 years.

D. Variable and fixed costs were estimated using the assumptions described earlier on a kWh basis. Ongoing variable and fixed costs were calculated using estimates for NMC811 cell production costs on a kWh basis in the DRC and assuming a 43 percent industry estimate of pCAM material costs as a component to overall material costs. According to Argonne National Labs, cobalt has a process factor of 19.7 percent with NMC811, leading to an estimate of USD 6.7/kWh and USD 1.7/kWh for variable and fixed costs, respectively.

E. Discount rates of 30 percent (high risk), 20 percent (medium risk), and 10 percent (low risk) were applied. The medium to low-risk scenarios delivered positive economics overall, while the high-risk scenario produced negative NPV values on an after-tax basis (Table 3).

F. High internal rates of return (IRR) values were generated on both a pre-tax and an after-tax basis. For IRR calculations, pre-tax cash flows along with a 30 percent tax rate and a 15 percent tax rate were tested, with the latter based on possible tax incentives to foster industry investment.

Table 2 – Summary of Economic Analysis

Net Present Value (NPV, USD millions)	Discount rate		
	10%	20%	30%
Pre-tax NPV	542.73	243.02	87.36
After-tax NPV@15% tax rate	326.95	93.97	(23.11)
After-tax NPV@30% tax rate	237.79	44.80	(52.22)
Internal rate of return (IRR)			
Pre-tax IRR	30.6%		
After-tax IRR @15%	27.5%		
After-tax IRR @30%	23.8%		

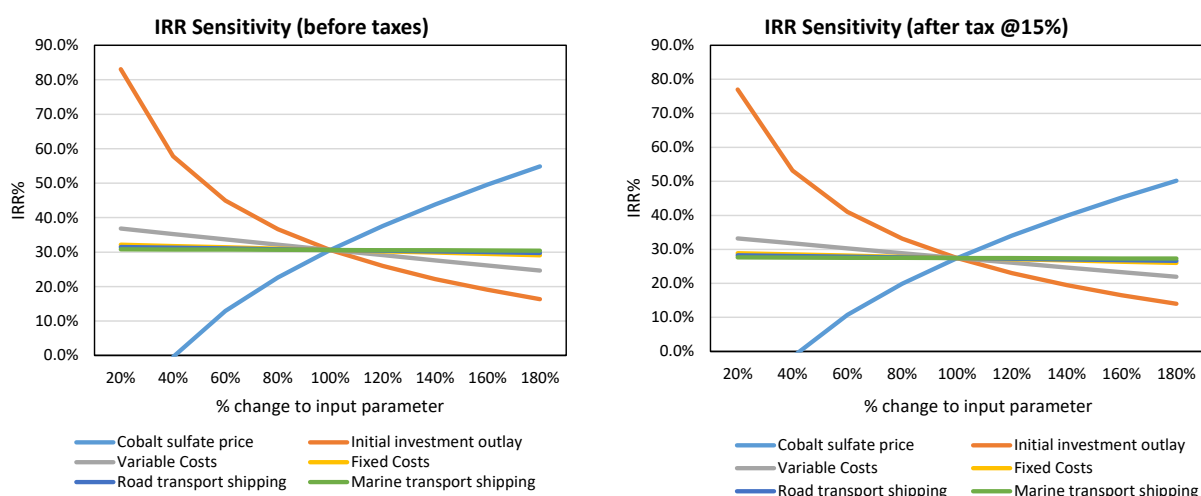
⁷¹ Our high-risk scenario was developed because more and more securities exchanges are proposing the inclusion of ESG metrics even though many companies have yet to achieve high ESG scores. While Sustainalytics currently ranks Glencore as high risk, the company is working to that end.

⁷²

G. **IRR sensitivities were tested that include cobalt sulfate prices, initial investment outlay, variable and fixed costs, road and shipping costs, and tax rates.** The results show that the IRR is highly sensitive to cobalt sulfate prices and initial investment outlay while less sensitive to variable costs.

H. **These results are important since they highlight some potentially important policy implications:** (i) given sensitivity to initial capital investment, this has the potential to render an investment sub-economic unless government is able to provide transportation and energy infrastructure; and (ii) given sensitivity to prices, governments wishing to diversify BEV value chains should explore incentivizing companies through offtake agreements that would provide price certainty (floor and ceiling prices).

Figure 20 – Sensitivity of Before and After-tax IRR to Changes in Input Parameters



I. **Annex 8 of this chapter elaborates a set of global case studies potential battery industry investors, and the DRC government may refer to while making policy decisions.** These case studies include analysis of the development and policies in the battery value chain in other countries. The countries referenced (Australia, Indonesia, India, Thailand, and Ethiopia) have already progressed or are planning to progress to increase their participation in the battery value chain.

7. Conclusions and Recommendations

7.1. Opportunities

Overall, climate change and the energy transition present diverse opportunities for the DRC. which are discussed below:

J. **Provide additional supply of energy transition minerals necessary to mitigate climate change.** Demand for various energy transition minerals is predicted to grow exponentially. Specifically, the future is more mineral-intensive than the past. Since 2010, the average amount of minerals needed for a new unit of power generation capacity has increased by 50 percent as the share of renewables has risen (IEA, 2021). Unlike previous commodity booms, this increase is structural and not transitory, and as a result, the time has come for the DRC to make long-term investments in its mineral supply opportunities. Doing so not only benefits the DRC but can lead to the creation of

transformational infrastructure investments in transportation and energy, both of which, if done correctly, could provide public goods and assist in diversifying the economy.

K. **Diversify global supply chains through local value addition.** Supply chains for the future global energy ecosystem are much more concentrated than the existing fossil fuel supply chains. This introduces risks to global energy security and raises geopolitical tensions. The more the supply chains for renewable energy technologies take place in the DRC, the greater the diversification of these supply chains while providing opportunities for increased local value capture, tax revenues, and employment opportunities. This will also improve the DRC's integration with the global economy.

L. **Contribute to two global public goods and create domestic public goods.** With the increased supply of energy transition minerals by the DRC and diversification of the supply chain, the DRC has the opportunity to contribute to two global public goods: (i) assisting with much-needed mineral supply to deploy technologies necessary to mitigate climate change; and (ii) diversifying renewable energy supply chains, which will improve the resiliency of those supply chains and reduce geopolitical tensions.

M. **Provide low-carbon inputs into global supply chains of renewable energy technologies.** The DRC is endowed with vast, low-cost green hydropower potential. This has already translated into extremely favorable carbon-competitiveness positioning for its copper and cobalt mining sector, and if it can be expanded to meet increased demand from an expanding copper sector, it could preserve this positioning and expand it into battery value chain industries. This will not only allow DRC products to avoid penalties under emerging global carbon adjustment trade mechanisms but will also position DRC producers as suppliers of choice. In turn, this could lead to price premiums realized by DRC enterprises.

N. **Make transformational investments in transport infrastructure and improve transport and logistics policies.** Mining is a catalyst for transport infrastructure development. The DRC's Copperbelt region is already constrained by transportation infrastructure, and this constraint will only worsen as production is forecast to significantly expand. Investment in strategic rail infrastructure is key for unlocking this untapped potential. Multiuse rail infrastructure will also reduce the carbon footprint and cost of all traded DRC products (imports and exports), create market access for other economic sectors such as agriculture, and support economic diversification.

O. **Energy infrastructure is a crucial enabler for the DRC's mining sector and value addition beyond mining, and— if done correctly, large investments could help alleviate energy poverty in the DRC.** The global increase in mineral demand also represents a new window of opportunity for the DRC to leverage its natural resource endowments sustainably and use mining as a catalyst for energy infrastructure development. A growing mining industry and its increasing energy demand can be an anchor load for national power system development and could provide an opportunity for policy makers and industry to work together to make a difference in tapping the enormous mineral wealth of DRC for the direct benefit of its population (including the poorest) and to improve rural access to electricity.

P. **Leverage sector growth and support for value addition to improve human capital formation, particularly skills.** The global mining sector is already suffering acutely from a lack of experienced professionals, not only university graduates but also experienced vocational skills. Unfortunately, there is no short term solution. Just as it can take 10-15 years for a new mineral deposit to become a producing asset, it takes approximately the same amount of time for a new graduate to have enough experience to be making decisions in these complex environments. Projected supply growth in the

DRC and across the value chain suggests a surge in demand for skilled personnel. Investment in the workforce of the future is necessary to ensure that the DRC has the workers (from university graduates to skilled tradespeople) to support its growing mining industry, capture the benefits from value addition, and take advantage of opportunities arising from new economic trade corridors development.

Challenges

Q. The opportunities identified above related to infrastructure (transport and energy) and skills also present challenges for the DRC. Transportation infrastructure together with already present significant constraints on the DRC's ability to increase its energy transition mineral supply and to add value. A shortage of qualified skills across various disciplines and even at the vocational level also represent a constraint on growth. However, as external shifts in demand and the need to diversify supply chains are long-term as opposed to cyclical trends, the DRC has the opportunity to make the necessary investments to grow and diversify its economy as well as to provide high-quality employment opportunities.

R. Cobalt is the most at risk commodity in the battery supply chain, and price volatility and concentration of resources in the DRC is the sole reason why researchers have been working to engineer it out of the battery value chain. However, engineering it out is not an option for producers as some large brands conscious of their ESG credentials (such as Apple) have sought to source responsible cobalt through recycling. Though the DRC has a number of initiatives to improve its cobalt transparency, they have not yet yielded results. If cobalt supply chains from the DRC became more predictable and transparent, research efforts would likely pivot toward making other chemistry improvements rather than myopically focusing on engineering cobalt out of the battery system. At the moment, this risk remains, but the authorities should work closely with industry to address this risk as it has the potential to not only lead to complete material substitution in the long term but also have a negative impact on those miners whose income depends on it.

S. Access to competitive finance remains a constraint not only for value chain development but also for all domestic investments in the DRC. The DRC's lending rate, the bank rate that typically meets short- and medium-term private sector financing needs, was 23 percent in 2021 (WB WDI), approximately double that of Kenya, three times that of South Africa, and eight times that of the US. Consequently, investors with international connections financing large projects often turn to foreign markets to raise capital. While established companies can sometimes raise capital at 6-12 percent, it is more common for new projects to raise capital at 15-20 percent. The situation is made even more dire by the recent rise in global interest rates. As monetary tightening continues, the DRC's lending interest rate will continue to remain elevated. This will pose a barrier to downstream projects.

7.2. Recommendations

T. The DRC stands to benefit greatly from the energy transition if it is supported in seizing the opportunity. Beyond the generation of foreign exchange, fiscal revenue, local procurement, value addition, and jobs, rising demand for critical minerals significantly increases potential benefits from the sector. Furthermore, investing in the DRC's ability to seize mineral value chain opportunities aligns with the Paris Agreement, supporting the global decarbonization agenda while leveraging a major development opportunity. Given its scale and multiple development agencies, the World Bank Group is uniquely positioned to support the following agenda for mining in the DRC:

I. Increase the DRC's supply response capabilities. Along with a stable and attractive investment environment, a better understanding of the DRC's geology is a necessary precondition for attracting

new and responsible mineral investments. A national perspective on geological data linked to the requirements of value addition to renewable energy technologies and supporting infrastructure needs would provide a good base on which other investments could be built. This would need to be complemented by sectoral governance reforms to strengthen public financial management together with International Finance Corporation (IFC) and Multilateral Investment Guarantee Agency (MIGA) support to catalyze private sector investments. In addition to critical minerals, IFC and MIGA support for private sector investments would extend to minerals that also offer development benefits, such as gold, which generates significant fiscal revenue for host countries.

II.Unlock long-term transformational development opportunities through strategic, resource-anchored transportation infrastructure investments. Infrastructure planning and investments need to be better coordinated with mineral potential. Poor infrastructure resulting in significant transportation delays from the DRC limits the potential for mining sector development but also for value addition, where “just-in-time” manufacturing practices are being adopted. The DRC should work regionally to support a shift from individual country to multi-country infrastructure planning, and a subregional integrated approach (when relevant) to decarbonized ancillary multiuser and multiuse infrastructure development will enable the operationalization of a significant number of known mineral deposits while having positive externalities for other economic sectors also constrained by insufficient infrastructure.

III.Support investments in renewable energy to decarbonize value chains, achieve countries’ NDCs, and alleviate rural energy poverty. The growth of an energy-intensive mining, smelting, refining, and value addition sector accompanied by renewable energy generation and storage investments in rural communities can achieve multiple development objectives, including freeing up existing generation and transmission capacity for other sectors of the economy. This agenda item combines governance and budgetary reforms with direct state and private sector investments in critical energy infrastructure.

IV.Support value addition beyond mining. Mining companies and manufacturers are increasingly moving vertically (up and down) along the value chain. This together with the global desire for increasingly diversified and resilient supply chains, creates opportunities in the DRC for increased economic diversification and the capture of more economic activity within its borders as well as on the continent. Improved trade infrastructure (hard and soft) would permit a regional approach in which an integrated value chain approach starting in the DRC but spanning many countries would allow for a variety of mineral products and intermediate manufactured products to combine into a final product.⁷³ More specific recommendations on this agenda item are included in the following subsection.

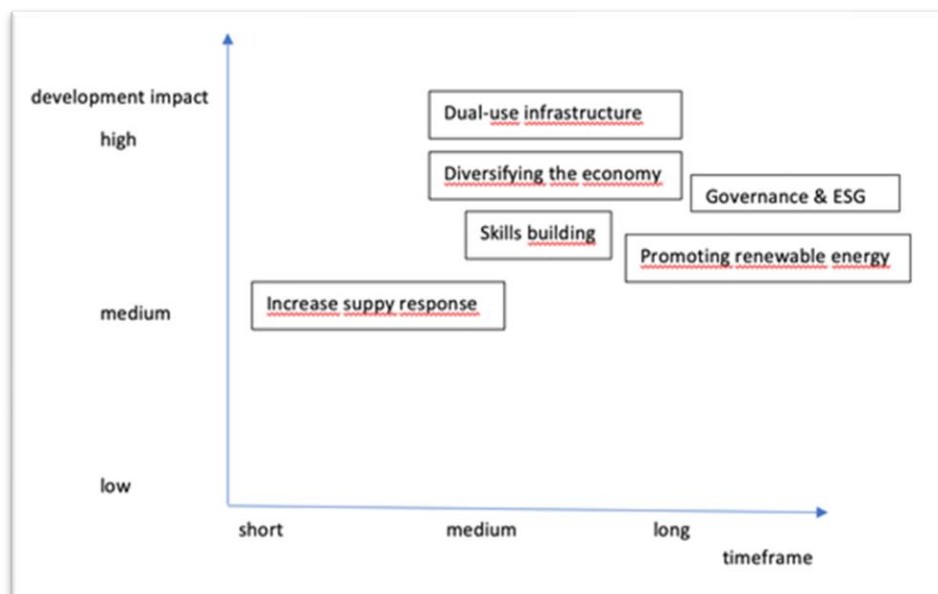
V.Invest heavily in human capital formation. Required supply growth across the value chain will create a surge in demand for skilled personnel. An investment in the workforce of the future is necessary now to ensure that the DRC has the workers (from university graduates to skilled tradespeople) to

⁷³ The lithium-ion battery value chain uses lithium, copper, manganese, cobalt, nickel, and titanium, all of which are abundant in Africa. It is foreseeable that the South African Development Community (SADC) countries could create a complete value chain that leverages existing manufacturing capacities while simultaneously developing and consolidating new capacities. Value addition opportunities exist for iron ore and aluminum in West Africa and for hydrogen in South Africa.

support its growing mining industry, capture the benefits of value addition, and take advantage of opportunities arising from new economic trade corridors identified in II above.

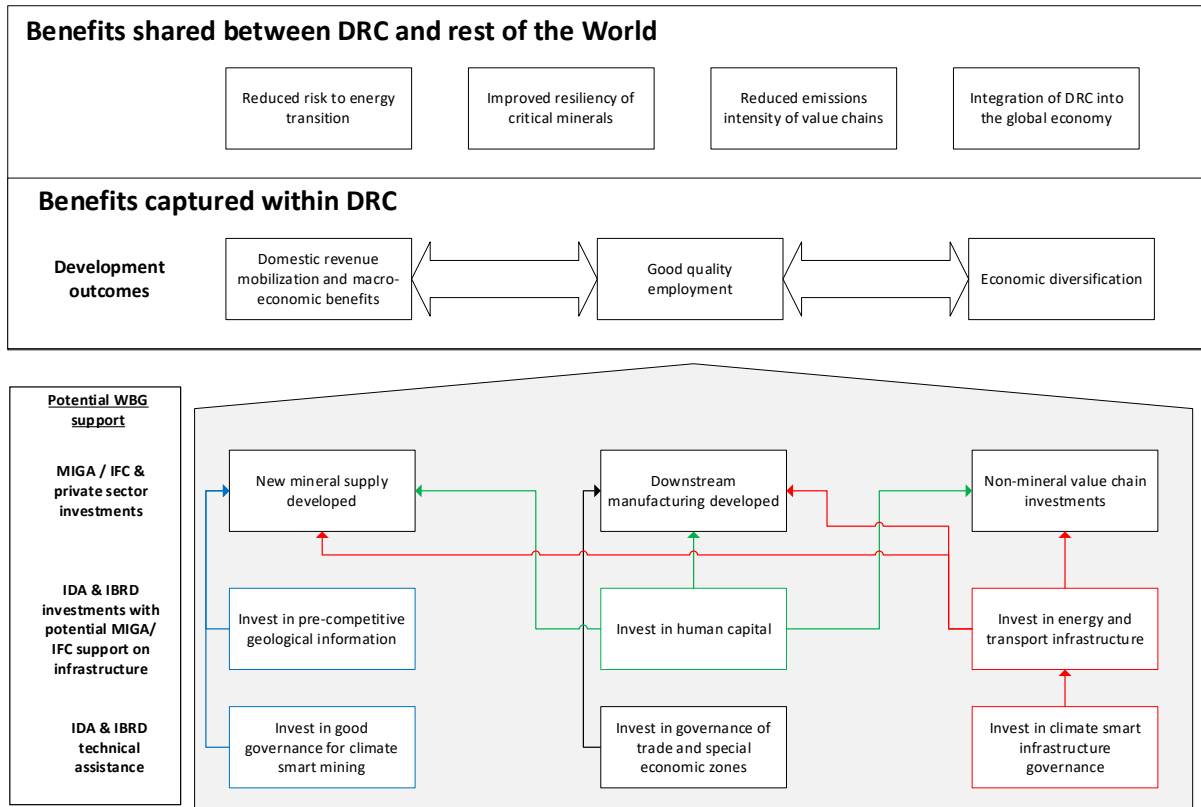
VI. Strengthen governance, mining-impacted communities, and environmental stewardship. Under the combined impact of decarbonization, geopolitical tensions, and increased stakeholder expectations, adherence to higher ESG standards has become a key feature of the mining industry. Mining companies are gradually building resilience in impacted communities, aiming to provide skills, jobs, access to water and power, and social and economic development. Automobile manufacturers such as Tesla, Mercedes Benz, and others are equally concerned about their ESG credentials and would need to find solutions to investment or purchase of products produced in the DRC. An inclusive approach through effective stakeholder engagement is essential so that costs and benefits from the development of the sector are evenly shared, gender imbalances are corrected, and the most vulnerable are not overly affected by adverse impacts. Improved governance, transparency, and environmental stewardship in both the private and public sectors will help ensure inclusive benefits sharing for resource-rich countries and their citizens within a context of sustainability.

Below is a table prioritizing the above six recommendations in terms of potential speed of realization and development impact:



U. As shown in Figure 21, adoption of the six-point agenda can yield multiple benefits for the DRC, some of which it will capture entirely itself, such as domestic revenue mobilization and macroeconomic benefits, good quality employment opportunities, and economic diversification. Others will have to be shared internationally as they generate global public goods, such as improved global ability to mitigate climate change, improve resilience of energy transition minerals, reduced emissions intensity of value chains, and improved integration into the global economy.

Figure 21 – Theory of change for 6-point agenda's application to the DRC



7.3. Recommendations for Enabling Value Addition in the Copper and Cobalt Value Chains

V. When looking through the various opportunities, constraints, and country case studies, several key recommendations emerge that would support the DRC in capturing more value addition in the copper and cobalt value chains. These are:

1. Improve Infrastructure and Logistics: Invest in infrastructure development, including transportation networks, power supply, and logistics, to facilitate the movement of raw materials and finished goods. This will reduce transportation costs, enhance supply chain efficiency, and attract investment in value-added industries. With respect to energy, consumer trends as well as those affecting large ESG-oriented enterprises is to ensure their products are responsible and have the lowest carbon emissions possible. Thus energy infrastructure development in the DRC should seek to leverage green resources and, where possible, link distribution to communities in order to alleviate rural energy poverty.

Country Examples

China: China has heavily invested in infrastructure development, including transportation networks and logistics, to support its manufacturing industry and facilitate efficient supply chains.

Vietnam: Vietnam has made significant investments in infrastructure development, including transportation networks and logistics, to support its manufacturing and export-oriented industries.

2. Accelerate the Development of the Kinsevere Special Economic Zones: Establish as quickly as possible the conditions necessary for the Kinsevere Special Economic Zone (SEZ) dedicated to copper and cobalt processing and manufacturing. Such zones should offer incentives such as tax breaks, streamlined regulations, and access to reliable utilities to attract both domestic and foreign investors. Where infrastructure gaps exist, policy makers should be speaking with the international community in order to align projects designed to support government objectives.

Country Examples

China: China has established several special economic zones (SEZs) such as Shenzhen, Shanghai, and Tianjin, offering tax incentives, streamlined regulations, and infrastructure support to attract foreign investment and promote value-added industries.

Ethiopia: Ethiopia has established industrial parks and special economic zones such as the Hawassa Industrial Park, offering incentives and infrastructure support to attract foreign investment and promote value-added industries.

Singapore: Singapore has actively fostered public-private partnerships in various sectors, including manufacturing and technology, to promote collaboration, attract investment, and drive innovation.

Mexico: Mexico has actively fostered public-private partnerships in sectors such as automotive manufacturing, attracting foreign investment, and promoting collaboration between industry and government.

3. Encourage Technology Transfer and Research and Forge Public-Private Partnerships: Promote technology transfer by partnering with international companies or institutions to facilitate knowledge exchange and enhance local capabilities in copper and cobalt processing. Invest in research and development to improve extraction techniques, metal refining processes, and product development for higher value-added applications. The leading European battery manufacturer Northvolt has expressed an interest to the World Bank to develop a relationship with the DRC government, and this could be an area of cooperation, with the skills development agenda discussed next.

W. Beyond technology transfer and research, the government should forge partnerships between the government, the private sector, and international organizations to foster collaboration, knowledge sharing, and investment in the copper and cobalt value chains. Engage with industry associations, research institutions, and foreign governments to leverage their expertise, networks, and funding opportunities.

Country Examples

South Korea: South Korea has focused on technology transfer and research collaboration with advanced economies such as the United States and Japan to develop its semiconductor and electronics industries, which has enabled value addition in these sectors.

India: India has actively promoted technology transfer and research collaboration through initiatives such as the Technology Acquisition and Development Fund (TADF) to enhance its manufacturing capabilities, including in sectors such as pharmaceuticals and information technology.

- 4. Enhance Skills and Workforce Development:** Invest in technical and vocational training programs to develop a skilled workforce capable of operating advanced machinery, managing production processes, and conducting research. Collaborate with educational institutions and industry experts to design training programs that align with the needs of the copper and cobalt value chains.

Country Examples

Germany: Germany has a robust vocational training system that combines classroom education with practical apprenticeships. This system has played a significant role in developing a skilled workforce, particularly in manufacturing industries.

Malaysia: Malaysia has implemented comprehensive skills development programs such as the National Dual Training System to provide vocational training and develop a skilled workforce in sectors such as manufacturing and electronics.

- 5. Support Access to Financing:** Facilitate access to financing for small and medium-sized enterprises (SMEs) involved in value addition activities. Establish specialized funds, grants, or loan programs to support entrepreneurs and businesses interested in establishing copper wire and foil production facilities or cobalt-based component manufacturing for electric vehicle (EV) industries.

Country Examples

Malaysia: Malaysia has established specialized funds such as the Malaysia Venture Capital Management (MAVCAP) to provide financing and support for technology-driven start-ups and SMEs involved in value-added industries.

Brazil: Brazil has established funding programs such as the National Bank for Economic and Social Development (BNDES) to provide financing and support for SMEs involved in value-added industries, including manufacturing and renewable energy.

- 6. Strengthen Environmental and Social Standards:** Implement and enforce stringent environmental and social standards to ensure responsible mining practices and sustainable value chains. This includes proper waste management, reduced carbon emissions, and adherence to human

rights and labor regulations. Complying with international sustainability standards will enhance the DRC's reputation and attract ethical investors. Operationalization of government plans for the formalization of cobalt mining together with traceability programs could feature as activities under this recommendation.

Country Examples

Norway: Norway has implemented strict environmental and social standards in its oil and gas industry, focusing on sustainable practices, reducing emissions, and promoting responsible extraction.

Costa Rica: Costa Rica has prioritized environmental sustainability and social responsibility in its tourism industry, implementing policies to protect natural resources, promote eco-friendly practices, and support local communities.

7. Promote Local Processing and Manufacturing: Beyond the law on special economic zones, the government should encourage local processing and manufacturing by providing incentives for companies to establish production facilities within the DRC. Implement policies that prioritize domestic procurement for copper wire, foils, and cobalt-based components to promote value addition and create employment opportunities for the local population.

Country Examples

Brazil: Brazil has implemented policies designed to promote local processing and manufacturing, particularly in the automotive industry, by imposing higher tariffs on imported vehicles and incentivizing domestic production.

Thailand: Thailand has implemented policies to promote local processing and manufacturing, particularly in the automotive industry, by providing incentives for domestic production and attracting multinational companies to set up manufacturing facilities.

8. Support Domestic Market Development and Work Regionally: Domestic market opportunities become increasingly important further down the value chain. Facilitate market development by actively promoting the DRC's value-added copper and cobalt products first regionally and then work collaboratively across the SADC region to support other country's value addition ambitions. Furthermore, leverage the forthcoming shift in South Africa's automobile manufacturing sector to secure continental demand for the DRC's future value-added products in the EV battery value chain. Explore opportunities for strategic partnerships with EV manufacturers and battery producers.

Country Examples

Germany: Germany actively promotes its high-value manufacturing and engineering products globally through participation in international trade fairs such as Hannover Messe, which showcases its capabilities and facilitates business connections.

Kenya: Kenya has actively promoted value-added products such as horticultural goods and textiles through participation in international trade fairs and by establishing export promotion agencies to access global markets.

9. Establish Clear Regulations and Policies: Develop clear and consistent regulations and policies that support value addition in the copper and cobalt value chains. Provide transparent, comprehensive, and easy to access guidelines on licensing, taxation, and export procedures to create an investor-friendly environment and foster long-term stability in the sector. Ensure that any contracts to be negotiated are standard in order to avoid unnecessary uncertainty and allow investments in the DRC.

Country Examples

United Kingdom: The United Kingdom has established clear regulations and policies to support value addition in sectors such as renewable energy and clean technologies, providing certainty for investors and encouraging industry growth.

South Africa: South Africa has established clear regulations and policies to promote value addition in sectors such as mining and renewable energy, providing a framework for investment and industry growth.

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Annexes

Annex 1. Table A1. List of minerals or metals by province

Province	Known Mineral Occurrences
Bandundu	Diamond, Oil, Kaolin, Clay
Bas-Congo	Bauxite, pyroschite, limestone, phosphate, vanadium, diamond, gold, copper, lead, zinc, manganese, marble, black and pink granite, rock-salt, iron, gypsum clay, talc, silica, kaolin, baryta, asphaltic schist
Equateur	Iron, copper and associated minerals, gold, diamond, limestone, kaolin, clay, granite, niobium, ochre
Orientale	Gold, Diamond, iron, silver, clay, copper, kaolin, niobium, ochre, asphaltic schist, talc
Kasai Oriental	Diamond, iron, silver, nickel, tin, clay, chromium, cobalt, copper, gold, kaolin, talc
Kas Occidental	Diamond, gold, manganese, chromium, nickel, clay, cobalt, platinum, copper, iron, kaolin, lead
Katanga	Copper and associated metals, cobalt, manganese, limestone, uranium, coal, niobium, gold, platinum, lithium, talk, tantalum, wolfram, zinc, clay, bismuth, cadmium, germanium, cassiterite, iron, granite, gypsum, kaolin, monazite, saltworks, beryl (emerald), sapphire
Nord-Kivu	Gold, niobium, tantalite, cassiterite, beryl, tungsten, manganite, clay, bastnaesite, coal, granite, monazite, niobium, platinum, wolfram, tantalum
Sud-Kivu	Gold, niobium, tantalite, cassiterite, sapphire, amblygonite, argent, argile, bastnaesite, beryl, bismuth, diamante, diatomite, monazite, wolfram, zinc, tantale
Maniema	Etain, diamond cassiterite, or amblygonite, lithium, clay, copper, iron, kaolin, manganese, columbium, lead, talc, tantalum, wolfram
Kinshasa	Clay, silica, kaolin, arkosic sandstone.

Annex 2. Demand for Specific Energy Transition Minerals

Energy Transition Mineral Demand

The transition towards a low carbon energy future will result in a dramatic increase in the intensity of metals and minerals use, especially for those keys for lithium-ion battery storage and expand the global metals and mining industry. According to the World Bank, the world is currently on track for a doubling of overall mineral requirements for clean energy technologies by 2040 and if a concerted effort was made to reach the goals of the Paris Agreement the mineral requirements for clean energy technologies would quadruple during that timeframe.³ The projected demand growth is particularly high for battery-related minerals such as lithium, cobalt, graphite, manganese, and nickel.

The transition to a low-carbon economy may put GHG-intense industries such as coal mining at risk; however, the demand for other mineral resources has risen considerably, particularly those needed for renewable energy generation and storage. These resources include aluminium (including its key constituent, bauxite), cobalt, copper, iron ore, lead, lithium, nickel, manganese, the platinum group metals, rare earth metals including cadmium, molybdenum, neodymium and indium – silver, steel, titanium and zinc.

As South Africa is known to have significant reserves of platinum group metals, manganese (the world's largest producer of manganese ore and chromite), titanium and other resources it is well placed to contribute to (and benefit from) this increased demand. South Africa is also home to significant deposits of rare earth elements that warrant commercial exploitation. Ilmenite (titanium ore) is being mined in Mozambique, Madagascar and South Africa. The total Southern African production equals about a quarter of global titanium ore mining (African Mining, 2020).

Copper supply is under enormous increasing demand to support the manufacturing of many products needed for the green economy. Due to its outstanding conductivity, copper is suitable for use in electronic products such as wiring and connectors, as well as renewable energy technologies and electric vehicles. As an alloy, copper is hard and resists both heat and corrosion. That's why it is perfectly suited for fresh water supply lines and plumbing fittings as well as cookware. Copper's antimicrobial properties can support infection control in hospitals and care environments. As a versatile and recyclable material, it makes an essential contribution to a low carbon future.⁷⁴

Mining and exploration opportunities are likely to open up for minerals used in large energy storage solutions – such as platinum, cobalt, vanadium, lithium and copper – as this technology evolves and gains ever-growing markets. Mines themselves are likely to make increasing use of renewable, off-grid energy as battery storage solutions become more effective and affordable. Demand, and hence price, is likely to remain volatile while new technologies are developed and optimised.

An energy system powered by clean energy technologies differs profoundly from one fuelled by traditional hydrocarbon resources. Building solar photovoltaic (PV) plants, wind farms and electric vehicles (EVs) generally requires more minerals than their fossil fuel-based counterparts. A typical electric car requires six times the mineral inputs of a conventional car, and an onshore wind plant requires nine times more mineral resources than a gas-fired power plant. (IEA, 2021).

Since 2010, the average amount of minerals needed for a new unit of power generation capacity has increased by 50% as the share of renewables has risen (IEA, 2021). The types of mineral resources used vary by technology. Lithium, nickel, cobalt, manganese, and graphite are crucial to battery performance, longevity, and energy density. Rare earth elements are essential for permanent magnets that are vital for wind turbines and EV motors. Electricity networks need a huge amount of copper and aluminium, with copper being a cornerstone for all electricity-related technologies.

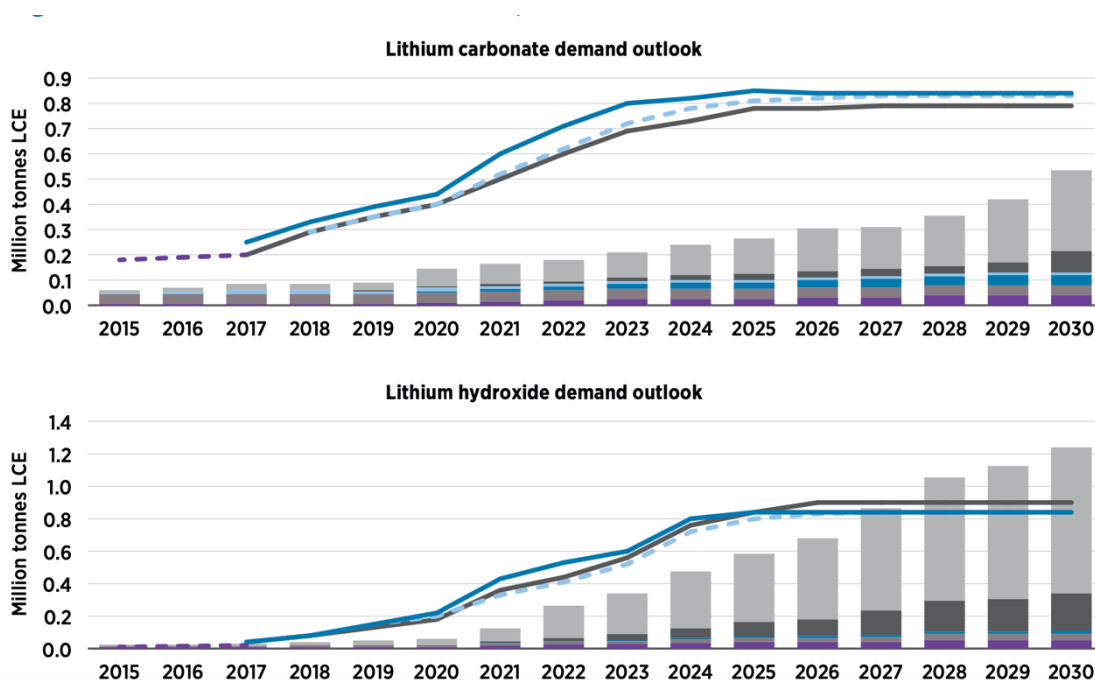
⁷⁴ Ibid.

A. Lithium

The global lithium market is estimated to grow significantly as factors driving the market are the accelerating demand for electric vehicles and increasing usage and demand for portable consumer electronics. However, rising concern over the demand-supply gap in the lithium market may hamper the market growth. Nevertheless, the growing adoption of smart grid electricity is likely to be a major opportunity in the global lithium market over the forecast period. Asia-Pacific dominates the market across the world, with the most substantial consumption from countries like China, South Korea, and Japan.⁷⁵

The global lithium compound market size is expected to grow from a volume of 299 640 tonnes in 2020 to 462 435 tonnes by 2026. The market is expected to grow at a compound annual growth rate (CAGR) of 7.5% between 2021 and 2026 (IRENA, 2022). Lithium carbonate is the most popular compound due to the huge demand for the product for the production of ceramics and glasses, battery cathodes and solid-state carbon dioxide detectors.

Figure A1 - Lithium demand projections



Source: IRENA, 2022

Global end-use markets for lithium include: batteries, 71%; ceramics and glass, 14%; lubricating greases, 4%; continuous casting mould flux powders, 2%; polymer production, 2%; air treatment, 1%; and other uses, 6% (USGS, 2021). Battery demand includes laptops, mobile phones and EVs. Today's battery demand is still dominated by laptops and mobile phones, but electric vehicles will drive overall lithium demand this decade. (IRENA, 2022).

A 2 000 GWh battery demand by 2030 (based on 40 million electric vehicles at 50 kWh/vehicle) would imply a four-fold increase in demand from 2020 levels. Some sources quote much higher growth, but such numbers refer to battery applications alone, while mining requirements also need to be considered from resource perspectives. Demand projections are uncertain due to the projected rapid growth of EV manufacturing and EV demand projections are rising quickly.

⁷⁵ <https://www.mordorintelligence.com/industry-reports/lithium-market>

Already between 2020 and 2024, total lithium demand may grow 2.5-fold. EV battery demand for lithium is expected to rise from a forecasted 47.3 kt in 2020 to 117.4 kt in 2024, at a 25.5% CAGR (Global Data, 2021). Lithium carbonate and lithium hydroxide depends on EV growth and battery technology assumptions, as high nickel cathode batteries require lithium hydroxide while lithium iron phosphate batteries require lithium carbonate. (IRENA, 2022).

As industry shifts to high nickel cathodes, there will be a corresponding shift from lithium carbonate to lithium hydroxide. In 2020, around 50% of cathodes required lithium carbonate, 20% lithium hydroxide and 30% could employ either. The expectation is for a market that shifts to more high nickel cathodes. (IEA, 2021).

B. Rare earth minerals (lanthanides)

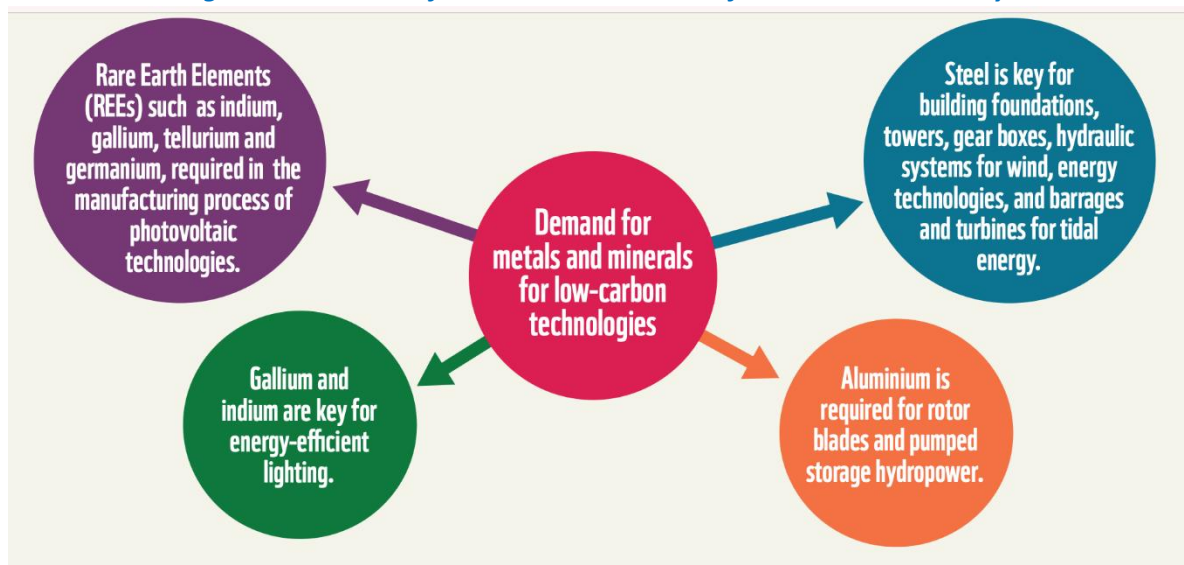
Rare earth minerals, including the subset of Lanthanides have particular value as catalysts, optical materials, magnets, batteries, lighting applications, amongst others. Rare earth elements (REEs) consist of a group of 17 chemical elements, 15 of which are the lanthanides. Certain REEs are critical for the production of permanent magnets used in electric vehicles (EVs) and for wind turbines. These constitute the key application from an energy transition perspective. Therefore, REEs and lanthanides are among the most critical materials for the energy transition. Neodymium, praseodymium, dysprosium and terbium are key elements for the production of permanent magnets. Neodymium is the most important one in volume terms. Yttrium is used for certain types of hydrogen electrolyzers, while europium, terbium and yttrium are used for energy-efficient fluorescent lighting.

In 2020 around 6-9 kilotons (kt) neodymium was used for EVs, out of 240 kt rare earth production (2-4%). In total 29-35% of all rare earth materials were used for permanent magnets. Less than 15% of these permanent magnets were used for EVs, also around 10% of all permanent magnets were used for wind turbines (notably offshore turbines and Chinese onshore turbines), around 4 kt neodymium (IRENA, 2021).

Going forward the volumes of magnet materials supply will need to increase substantially, largely driven by EV growth. EV and wind demand may increase fivefold between now and 2030 in a 1.5-degree pathway. These two demand categories together may double the demand for permanent magnet REEs. Because of the co-production, total REEs production needs to rise accordingly (IRENA, 2021).

The total global demand for rare earth oxides (REOs) is expected to increase from 208,250 metric tons in 2019 to a forecasted 304,678 metric tons by 2025. REOs are used for a variety of applications, including in permanent magnets, in batteries, in catalysts, and more. (Garside, 2021).

Figure A2 - Demand for Minerals and Metals for the Green Economy



Source: WWF 2018

C. Copper

Demand for copper is expected to continue increasing during the coming decades. Copper demand in 2050 is expected to be in the range of 50 – 70 Mt per year, on average doubling the current supply of 30 Mt seen in 2020. Copper is a vital resource for the energy transition, traditionally used in construction, engines, and electronic goods, most of the current copper demand originates from low-carbon technologies such as renewables and EVs. Copper is largely used in the infrastructure associated with solar energy and wind energy, as well as in end-use applications such as EVs. Due to its unique thermal and conductive qualities, copper is widely used in the cables that form the basis of the electricity network. (WB, 2022).

On average, a solar farm contains one ton of copper per megawatt of installed capacity (this value excludes copper use in grid expansions associated with solar PV projects), approximately five times larger than a conventional power plant. Although predominantly made of steel, iron and aluminium, the physical structure of wind turbines contains a considerable amount of copper. Copper use in wind farms is ample as it is also widely used in transmission cables connecting them to the electric substation, especially in offshore installations where substations are located further away. (WB, 2022).

D. Cobalt

Cobalt is used in many sectors from electronics, superalloys, hard materials/cutting tools and catalysts to healthcare and is an essential component of most lithium-ion batteries used for electric vehicles. In 2020, 20% of cobalt demand came from electric vehicles (JISEA, 2021). However recent development of new types of batteries that reduce or even eliminate cobalt use may change the picture going forward.

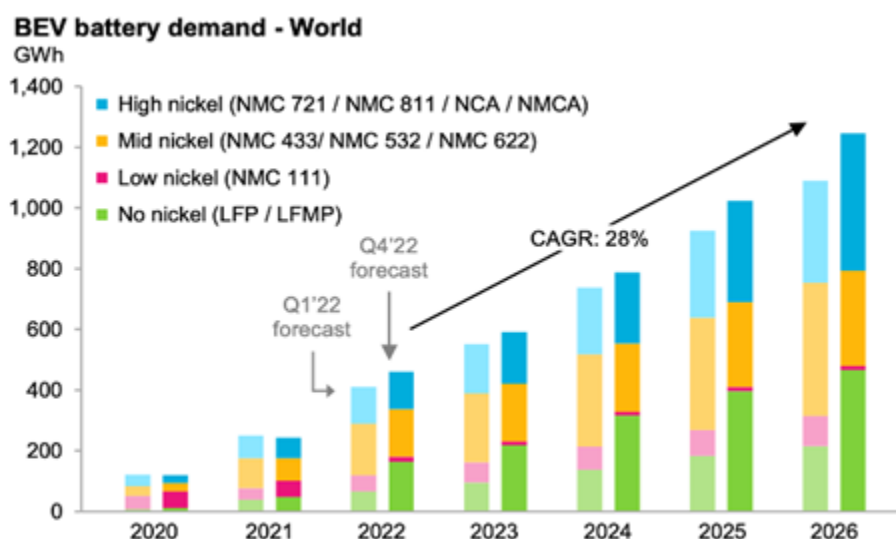
Cobalt occurs in a range of different deposits including sediment hosted, such as those across the Central African Copperbelt and magmatic sulphides such as those in South Africa. Cobalt is generally mined as a by-product of copper and nickel (Fu et al., 2020), with most of the production from copper-principal mines.

The cobalt market is highly concentrated, with more than 70% mined in the Democratic Republic of the Congo (USGS, 2022), and almost half of the cobalt refined in China (Brink et al, 2020). Africa as a whole accounts for almost 60% of the world's pre-mined resources and 55% of proven and probable reserves (Guj et al, 2022). Production in DRC generally comes from copper-principal mines with almost twenty large-scale mines producing the material (S&P, 2022). There are also twelve mines in Zambia producing cobalt as a co-product. Across both countries there is a large role for Chinese-ownership – with ownership accounting for over 40% of mines in DRC

and almost 30% in Zambia, compared to much lower roles for local-ownership, at just 13% and 15% respectively. 2017 numbers indicate that China is responsible for 58% of refined Co, 91% of which originates in the DRC (Fu et al., 2020).

The projected growth in demand for the mineral, due to booming EV production, has led to a large pipeline of pre-production projects across the southern Africa region, with over fifty potential mines at various stages of development. The majority of these are in DRC, with also a significant share in Indonesia, Zambia – and also new projects in Tanzania, Namibia and Botswana.⁷⁶

Figure A3 – Projected growth of batter electric vehicles (BEVs)



Source: SFA Oxford (Awaiting authorization to use)

Cobalt’s role in lithium batteries is solely tied to the growth of high-nickel cathode chemistries such as NMC (nickel, manganese and cobalt), NCA (nickel, cobalt and aluminum) and NMCA (nickel, cobalt, manganese and aluminum).⁷⁷ High nickel cathode types are expected to dominate light duty vehicles in North America and Europe as China will mostly use lithium iron phosphate or LFP in this segment and larger passenger vehicles and medium to heavy duty transport in all markets⁷⁸. Although many forecasts show an upward trend in cobalt demand, the continued use of specific NMC formulations such as NMC622, a stable chemistry that requires double the cobalt compared to NMC811, contributes to the variations seen in forecasts.⁷⁹ Furthermore, GM has chosen to go the NMCA route where cobalt is swapped out a bit for aluminum which has reduced cobalt content from 20% to 7-6%. According to BNEF, cobalt demand from EV batteries is expected to grow to 156kt in 2030 while SMM states that cobalt demand will be 223kt in 2023 and 236kt in supply.⁸⁰⁸¹

⁷⁶ The Cobalt Alliance has predicted that Indonesia’s share of cobalt is set to increase tenfold, from the current 5% to potentially 50%.

⁷⁷ Such as NMC (nickel, manganese and cobalt), NCA (nickel, cobalt and aluminum) and NMCA (nickel, cobalt, manganese and aluminum)

⁷⁸ China is instead most likely to use LFP (lithium, iron, phosphate) for this battery class.

⁷⁹ For one, chemistries such as NMC811 and NMC9,0.5,0.5 have yet to be scaled up to production level needed to meet growing demand despite being used in vehicles today.

⁸⁰ BNEF’s forecast can be considered “bearish” as it assumes a rapid uptake of high nickel cathode chemistries such as NMC811 and NMC9,0.5,0.5). These chemistries have yet to be scaled-up to the level needed to meet growing EV demand globally and the elimination of the use of NMC622 by 2030 seems unreasonable as this scale-up takes time. Furthermore, GM has chosen to go the NMCA route where cobalt is swapped out a bit for aluminum which has reduced cobalt content from 20% to 7-6%.

⁸¹ Although demand is expected to grow in the long term, SMM predict that cobalt will be in oversupply in 2023 with demand at 223kt and supply at 236kt.

Cobalt will continue to be an important part of the battery value chain despite efforts to reduce its content and dependency. It is important to note here that the removal of cobalt from nickel-based chemistries may not occur despite being an important research goal. It has been noted that if cobalt supply chains from the DRC became *more predictable and transparent* along with the value addition of precursor and CAM production on top of general mine production to export to Europe and the U.S., those research efforts would likely pivot towards other making other chemistry improvements rather than myopically focusing on engineering cobalt out of the battery system.

Cobalt and ASM

A significant share (approximately 20%) of DRC's production comes from artisanal and small-scale miners (ASM). ASM mining varies massively in scale and impact – from mechanized operations down to itinerant individuals working with rudimentary tools. The sector is one of the largest sources of non-farm rural income across sub-Saharan Africa providing income and employment to millions. However, ASM sourcing of cobalt has been criticized in the wider literature due to its potential to have negative health, social and environmental consequences (Faber et al, 2017, Cremer, 2019, Sovacool, 2021). This sector of the industry is associated with high degrees of informality and illegality, poor health and safety conditions, lack of regulation and use of child labor. Studies have placed estimates at between 40,000 – 150,000 child workers in the sector (Tsururkawa et al, 2011; Amnesty International 2016).

The reputational risks of sourcing cobalt from potentially illegal and ethically challenging environments is one of the reasons for a general movement away from cobalt in li-ion batteries. However, there could be benefits to an ASM sector in cobalt, should the positive benefits such as local employment and income generation and potentially more responsive increases in supply (Mancheri et al, 2018) be able to be realized without the negative impacts being dominant. Policies such as formalization, use of co-operatives, regulation and monitoring and incentives for improved uses of technology could help in this regard.

Cobalt is the most 'at risk' commodity of the battery supply chain and price volatility and concentration of resources in the DRC is the sole reason why researchers have been trying to engineer it out of the battery value chain. Depending on commodity prices, battery raw materials constitute 40-50% of the cost of NMC cathodes and the most "at risk" input according to several forecasting providers is cobalt.

Nickel demand is expected to grow substantially due to its widespread use in battery cathodes. Global nickel consumption amounted to about 2.4 Mt in 2019, with China and Indonesia leading the demand. Alternatives to nickel have been found in battery technologies, notably lithium-iron-phosphate cathodes, which could aid in lowering nickel demand. However, the technical performance of the alternative battery chemistries available is inferior.

Nickel has many applications and is typically used in stainless steel production which accounted for 70% of nickel demand in 2020. As previously mentioned, nickel demand has largely been driven by China, who positioned itself as the major stainless-steel manufacturer. However, this is expected to change in the following years where lithium-ion batteries may account for a quarter to a fifth of global nickel demand by 2025 (0.5-0.7 Mt/yr), bringing about changes in the geographical consumption share (WB, 2022).

Coltan

Coltan is one of the resources that is playing an important role in the technological revolution hosting tantalum and niobium minerals. Brazil, Canada and Australia are the leading producers of tantalum and niobium mineral concentrates. However, the DRC is the global leader in tantalum production by quite a large margin, followed by Brazil.

Niobium and tantalum are often found together but have very different properties and applications. As a report from the US Geological Survey notes, nearly 80 percent of the world's niobium is used in high-strength, low-alloy steels, while tantalum is key for the world's electronics industry. Roughly two-thirds of tantalum is used to manufacture electronic capacitors, a fundamental component of smartphones and other in-demand electronics. Tantalum is extremely ductile and can be drawn into a thin wire. Because it causes no immune

response in the human body, it is used to make surgical appliances, as a replacement for bone, as a connector of torn nerves and as a binding agent for muscles. Furthermore, tantalum has contributed hugely to the miniaturization of handheld electronic devices such as mobile phones as it allows an electrical charge to be stored in small capacitors.

Innovation and industrialisation will continue to increase demand for tantalum and niobium. Global demand for tantalum in 2021 was 1,887 tonnes and it is now forecast to grow to at least 2,440 tonnes by 2028, depending on the pace of innovation of new applications. In terms of niobium, the global market size was estimated at USD 1544.7 million in 2021 and is projected to reach USD 1979.63 million by 2028, exhibiting a compound annual growth rate of 3.61% during the forecast period.⁸²

⁸² <https://www.globenewswire.com/en/news-release/2023/03/28/2635831/0/en/Global-Niobium-Market-and-Hafnium-Market-are-Set-to-Surpass-Valuation-of-1-979-Million-and-114-47-Million-by-2028-Widening-Demand-Supply-Gap-to-Offer-More-Growth-Opportunities-for-.html>

Annex 3. DRC's Supply opportunity in other minerals:

A. Lithium

Continued progress at AVZ Mineral's \$554 million Manono project in the DRC, will add upside to the development of the domestic lithium sector in the coming years. Manono is well-positioned to be a leading lithium producer in Sub-Saharan Africa. In September 2021, AVZ Minerals received \$240 million in funding from a Chinese investment entity (Suzhou CATH Energy Technologies (CATH), a private equity firm jointly owned by Pei Zhenhua and Contemporary Amperex Technology (CATL), in exchange for an equity interest of 24%. (Fitch, 2022).

The Manono project may be the largest undeveloped lithium resource in the world - the mine estimates that there are four hundred million tons of lithium resource at 1.65%.⁸³ In the April 2020 feasibility study, Manono was estimated to produce up to 700ktpa (kilotons per annum) of lithium spodumene. In May 2022, AVZ announced that the mine had secured the permit necessary for construction. However, an ongoing legal dispute surrounding ownership between Australian firm AVZ and Mainland China's Zijin Mining may delay development. However, it is expected that legal disputes impeding its development will be resolved in 2023, with the first production estimated to be reached in 2027.⁸⁴

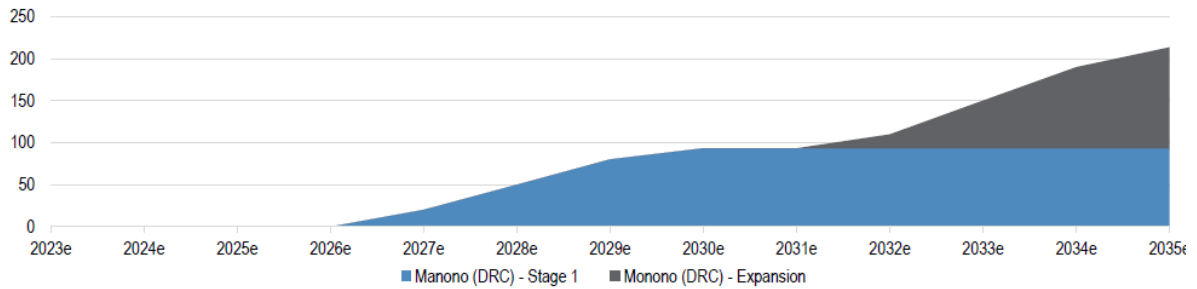
The project has not yet received a mining license, and there are still legal disputes over its ownership. JP Morgan (2023) assume legal issues will be resolved in 2023, followed by a 3yr build, with first production in 2027, before a 2yr ramp up to nameplate in 2029. 2030 is the first full year at nameplate. We then assume an expansion comes on in 2032, with a 2yr ramp up to name plate capacity.

⁸³ Africa News. [https://www.africanews.com/2022/02/25/drc-lithium-exploitation-may-replace-tin-in-the-city-of-manono//](https://www.africanews.com/2022/02/25/drc-lithium-exploitation-may-replace-tin-in-the-city-of-manono/)

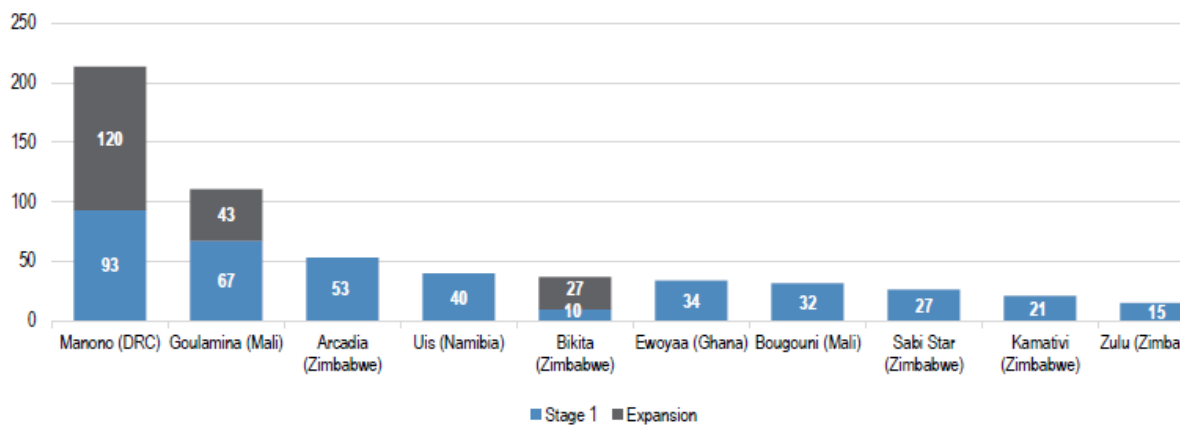
⁸⁴ JPM: Lithium, Africa Deep Dive, 2023

Figure A4 - Manono production forecasts⁸⁵

The Manono mine will be developed in two stages:



Peak production at Manono will far exceed other projects on the African continent making the DRC a significant producer of lithium.



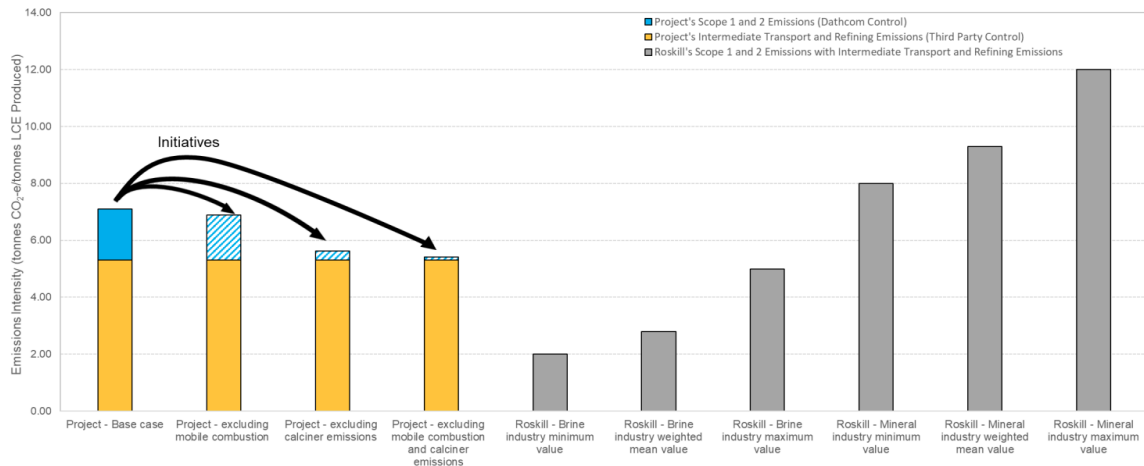
Transportation logistics are complex - transport costs are more than mining and processing combined, highlighting the complex logistics. Infrastructure in the area is also limited which will consume a large proportion of the project budget. Two main transport options have been proposed, one through Angola and another through Tanzania.⁸⁶

Manono’s emission intensity (i.e., total emissions per tonne of product produced) have been to published emission intensities for other lithium production facilities. As shown in Figure A5, a comparison of the Project’s emission intensity with other available intensities for SC6 production, suggests that the Project’s emissions intensity for LCE production is lower than the emission intensities for other mineral mines.

⁸⁵ Source: JP Morgan

⁸⁶ The combination of road, rail, and ferry to transport ore to the port of Lobito in Angola (2,486km) would account for (US\$229/t fob). Arriving to the Dar es Salaam port in Tanzania (3,137km) would cost around US\$319/t fob.

Figure A5 - African lithium reserves⁸⁷



Beyond Manono, Zijin is seeking to expand its presence in the DRC and is looking to explore for lithium in a joint venture called Katamba with state-owned La Congolaise d'Exploitation Minière. The JV has rights to two greenfield projects near Manono which offer some upside to the longer-term production forecasts if they move closer to development.

Within Sub-Saharan Africa, lithium reserves in the DRC are the largest, maybe the safest to mine and most cost effective to export. Compared to other jurisdictions such as Mali where political instability is a growing concern, the Congo is relatively more stable. When compared to Mali and even to Zimbabwe, the risk/reward potential of DRC is promising. Two main transport options have been proposed for the Manono product, one through Angola and another through Tanzania.

The DRC hosts the highest lithium reserves in sub-saharan Africa

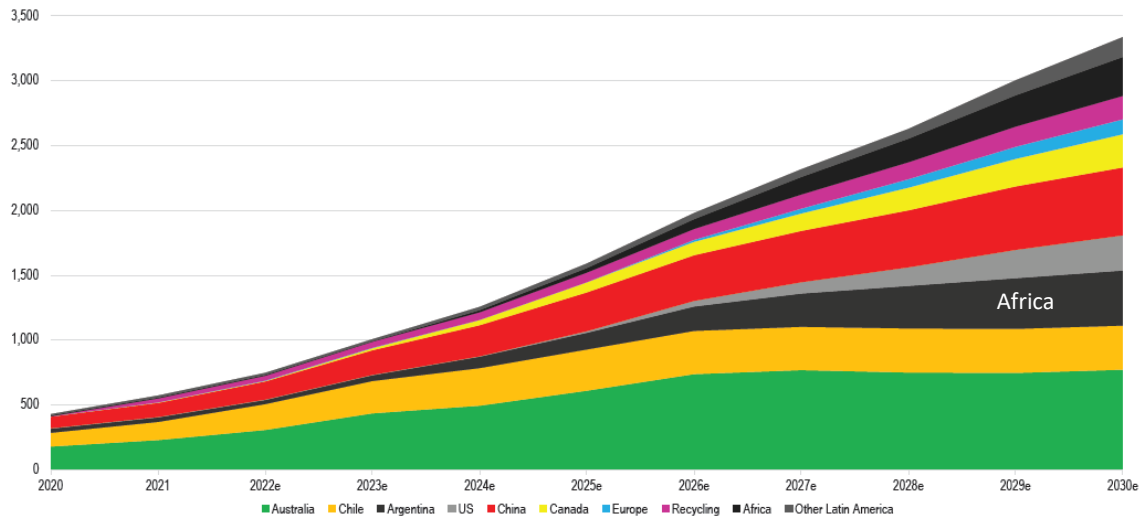
	Total Identified Lithium Reserves (mnt)	Share Of Global Reserves	Share Of African Reserves
DRC	3	3.5%	69.1%
Mali	0.7	0.8%	16.1%
Zimbabwe	0.5	0.6%	11.5%
Ghana	0.09	0.1%	2.1%
Namibia	0.05	0.1%	1.2%

As shown in Figure A6, African lithium production is set to play a significant role in total lithium supply from 2027. The DRC's share of global lithium production is set to grow from ~2026 to 2027 to 2030 and beyond.

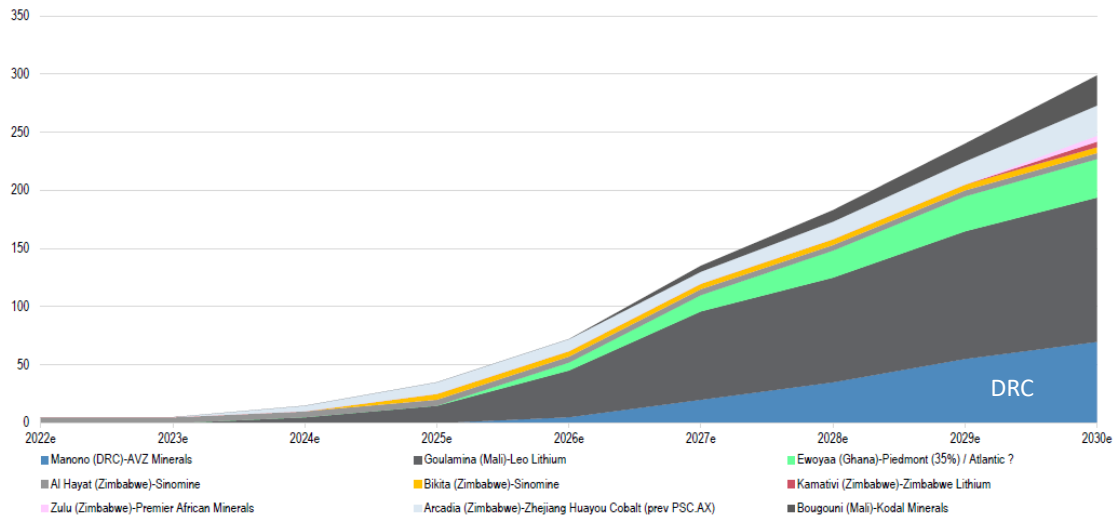
⁸⁷ Source: Fitch (2022)

Figure A6 - Global, African and DRC lithium supply forecasts⁸⁸

Global lithium supply by region (LCE, kt)



African portion of supply by country (LCE, kt)



B. Coltan

Coltan is one of the world’s most vital minerals, and 60% of reserves globally are found in the Democratic Republic of the Congo’s (DRC) Kivu province. In 2019, 40% of the global coltan supply was produced in the DRC. Coltan (short for columbite–tantallite) is a dull black metallic ore from which the elements niobium and tantalum are extracted.

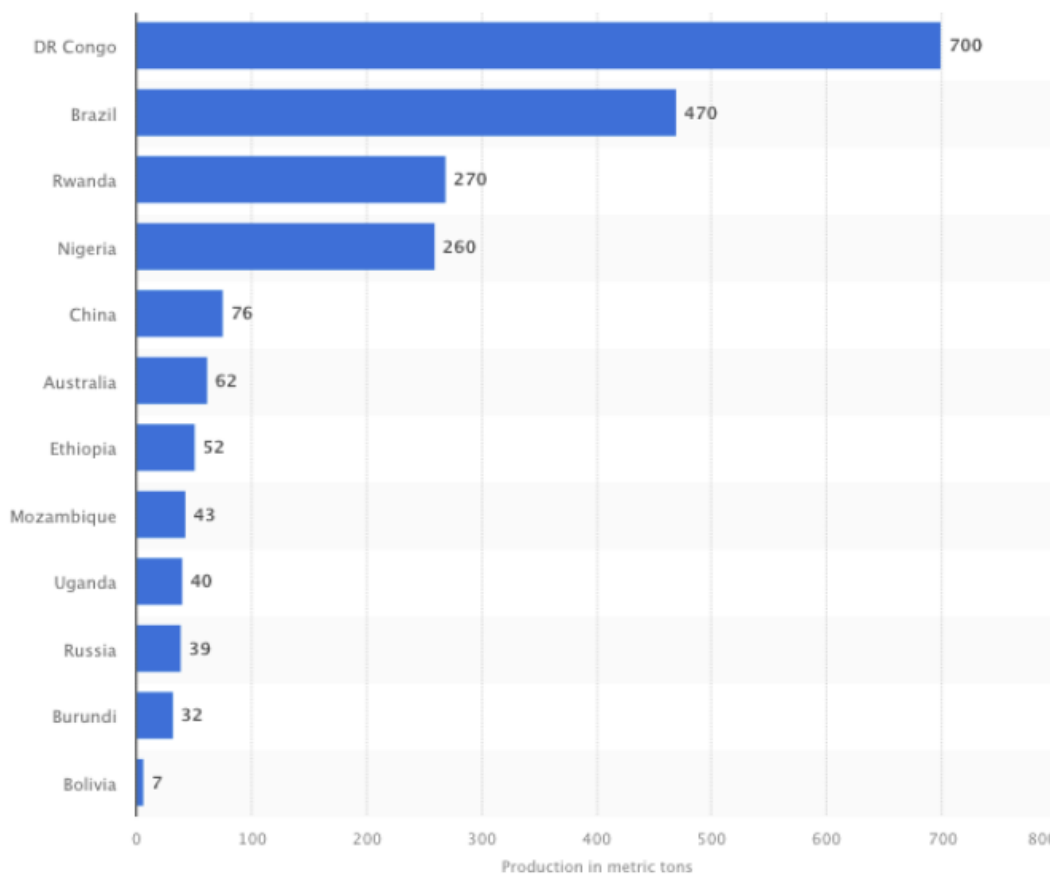
Tantalite was first discovered in the DRC in 1910. The country has substantial resources of tantalum-bearing ores, of which coltan is the most common. The main coltan deposits are located in the eastern part of the country, in particular in North and South Kivu provinces. The mineralized coltan containing deposits form dikes

⁸⁸ Source: JP Morgan

and sills of variable orientation and dip (often parallel to bedding or other structural control), thickness (up to several meters, rarely >10 m) and length (typically a few tens of meters to several hundred meters, rarely >2 km). The upper portion of these deposits are often weathered and soft and these are typically in easily mined alluvial or soft-rock deposits which makes them suitable for artisanal mining.

In 2021, the Democratic Republic of the Congo’s coltan production amounted to an estimated 700 tonnes, thus it was the world’s largest coltan producer by far. Production was mainly through artisanal mining methods. Geochemical analyses of pegmatite ore samples indicate that active ASM sites producing mixed coltan-cassiterite concentrates in the DRC feature typical run-of-mine ore grades in the range of 100–300 g/t tantalum, variably associated with 250–1200 g/t tin. These can reach up to somewhat higher tantalum grades (up to ~ 500 g/t tantalum). While it is often assumed that, compared to large-scale industrial mining, artisanal miners exploit high grade ore deposits, this is not necessarily the case at typical coltan mines in the Great Lakes region. Using the average grades to back-calculate the total amount of material mined indicates that approximately 1 million tonnes to 7.4 million tonnes of coltan bearing material is mined artisanal in the DRC every year by the DRC’s approximate 300,000 coltan miners.

Figure A7 - Global 2021 coltan production



Of these 300,000 miners, it is estimated that much of the country’s coltan is extracted using the labour of over 40,000 child and teenage miners.⁸⁹ Coming from remote villages and towns in Kivu, they either drop out of

⁸⁹ https://sites.unicef.org/csr/files/UNICEF_REPORT_ON_CHILD_RIGHTS_AND_THE_MINING_SECTOR_APRIL_27.pdf

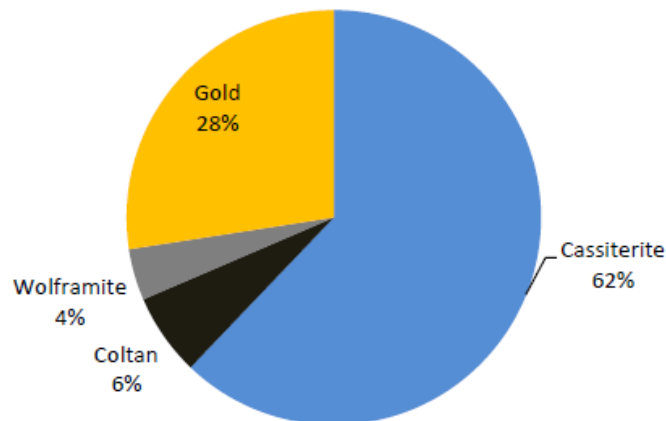
school or have never had the opportunity to attend. The informality of the extractive sector provides attractive job opportunities for vulnerable children, who serve as a pool of cheap labour.

Children work as washers and diggers in dangerous conditions. They also engage in petty smuggling, selling coltan for a pittance in towns along the borders with Burundi, Rwanda and Uganda. Doing adults' work in a hazardous environment, many child miners face harassment, abuse and ill health. Occupational hazards include daily exposure to radon, a radioactive substance associated with coltan, which has been linked to lung cancer. The coltan mined remains uncertified and untraceable; the illicitly extracted mineral is traded in the underground economy and funnelled into the global supply chain through smuggling, counterfeiting and collusion.

Rwanda is the preferred trade route for exporting coltan from eastern Congo for several reasons. Exports of tantalum concentrates are taxed by the DRC but are not taxed by Rwanda. Therefore, there is a clear economic incentive to smuggle coltan to Rwanda rather than export it legally from the DRC. Imported minerals can be declared as minerals produced in Rwanda if they undergo further processing that adds 30% to their value.⁹⁰ Rwanda also has the best transport connection with eastern Congo. As a result, a significant amount of coltan exported from Rwanda is likely to be of Congolese origin.⁹¹

Lastly, in the minds of many people the importance of coltan is mostly related to its contribution to devastating conflict in the DRC, where it often thought to have provided the motivation and means for numerous armed groups to engage in violence. This connection has made coltan almost a household name. It was listed as one of the DRC's conflict minerals along with tin, tungsten and gold. This reputation and link to armed conflict may be misleading though – a 2009 study found that trade in coltan only comprised a small amount of total trading profits from armed groups, with gold and cassiterite together comprising approximately 90% of profits.

Figure A8 – Distribution of armed groups' estimated profits from trade in four major commodities⁹²



⁹⁰ Bleischwitz, Raimund, Monika Dittrich, and Chiara Pierdicca. 'Coltan from Central Africa, International Trade and Implications for Any Certification.' Resources Policy 37, no. 1 (March 2012): 19–29.

⁹¹ Nest, Michael, Coltan, Polity Press, 2011, p.23

⁹² Enough Project, A comprehensive approach to Congo's conflict minerals, April 2009.

C. Gold

The DRC is known as the home to some of the purest gold mines in the world. These lucrative gold mines are controlled by powerful armed groups which commit human rights abuses and are involved in illicit trade of these golds, mostly in the eastern part of Congo. However, while the government has made progress in implementing transparency, significant challenges to monitoring, regulating and controlling gold trade need to be addressed.

Robust growth in the gold sector is expected in the short term, of 5.0% for 2022 and 2023, as high gold prices incentivise ramp-up of operations. In June 2022, the United Nations' annual report on the DRC highlighted heightened risks around violence connected to gold mining in the east of the DRC, particularly the Ituri province. In January 2022, Barrick Gold's Kibali gold mine confirmed that it had achieved its 2021 guidance with production of 812koz gold. In January 2022, Loncor Gold Inc announced that its open pit gold deposit confirmed production expectations of 303kozpa. In October 2021, Barrick announced that new reserves at Kibali would allow it to extend the mine life to 2040, an extension of 25 years. (Fitch 2022)

Elevated gold prices and a steady exploration pipeline will keep growth positive in the coming years. Gold prices recently hit almost \$2,000 (as of March 2023)⁹³ to hit a record yearly average of as geopolitical uncertainty remains amid the ongoing war in Ukraine and some forecasters are saying that gold could reach \$4000 by 2024.

Figure A9 - Forecast Gold Production in million ounces DRC⁹⁴

GOLD PRODUCTION FORECAST (DRC 2018-2031)														
Indicator	2018e	2019e	2020e	2021e	2022f	2023f	2024f	2025f	2026f	2027f	2028f	2029f	2030f	2031f
Gold Mine Production, moz	1.33	1.44	1.54	1.63	1.71	1.8	1.87	1.95	2.02	2.11	2.19	2.28	2.37	2.46
Gold Mine Production Volumes, % y-o-y	12	8	7	6	5	5	4	4	4	4	4	4	4	4
Gold mine production, moz, % of global	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.8

High continued gold prices will encourage foreign investment in the DRC. Continued gold exploration activities will further fuel growth. In June 2021, Loncor Gold filed a NI 43-101 Technical Report on its Imbo gold project which details a 38.0% increase in inferred mineral resources to 3.5moz of gold. The company began drilling at Imbo in October 2020. Earlier in April 2020, AJN Resources announced the historic mineral resources of 2.0moz (2.68g/tonne) and 4.0moz (1.04g/tonne) of gold at its respective Zani-Kodo and Giro Goldfields within the North Congolese Gold Project (NGCP), adding upside to the medium-term outlook. In January 2020, the firm signed a memorandum of understanding with the state-owned mining firm Société Minière de Kilo-Moto SA providing it the ability to acquire 30-35% free carried interest in the NGCP. In January 2021, Loncor and JV partner, Barrick Gold entered into two new agreements strengthening the firms' collaboration in the Ngayu gold belt. The agreements will add three exploration properties previously held exclusively by Barrick under the JV, bringing the total JV land ownership to 2,000sq km.

D. Diamonds

The Democratic Republic of the Congo had the world's fourth largest diamond reserves at the end of 2021 (after Russia and Botswana).⁹⁵ Artisanal and small-scale mining account for the majority of the country's rough diamond production and it is estimated that around one-third of the rough diamonds produced in the country are illegally moved out of the country to neighbouring nations every year. The DRC produced 14.1 million carats in 2022, making it fourth in the world in terms of production volume.⁹⁶

⁹³ Trading Economics: <https://tradingeconomics.com/commodity/gold>

⁹⁴ Fitch (2022)

⁹⁵ According to the USGS, the DRC had 150 million karats of diamond reserves.

<https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-diamond-industrial.pdf>

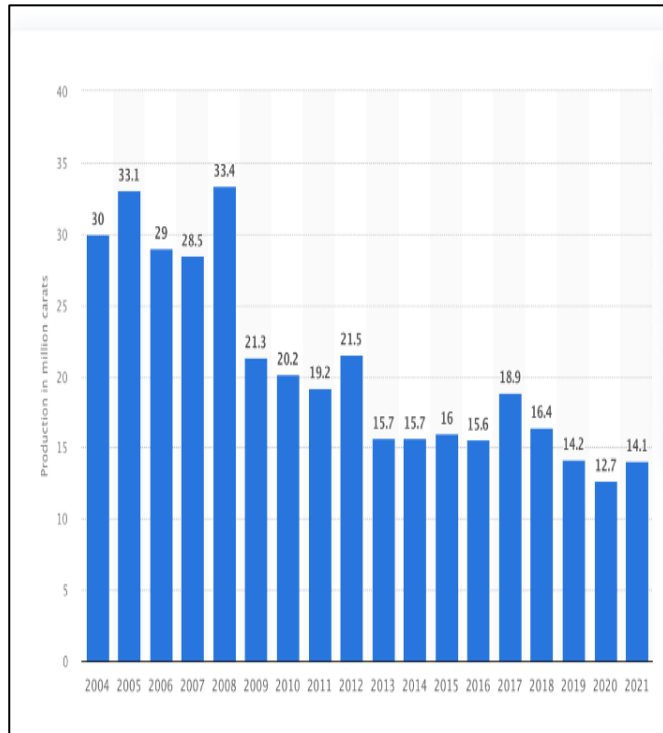
⁹⁶ <https://www.statista.com/statistics/964870/democratic-republic-congo-diamond-production-volume/>

Figure A10 - DRC diamond reserves and production⁹⁷

The DRC hosts the fourth largest diamond reserves in the world...

However, diamond production in the DRC has been in steady decline since 2008. (Diamond production, million carat)

COUNTRY/REGION	AGGREGATE DIAMONDS IN RESERVES & RESOURCES (CT)
Russia	1,111,549,000
Botswana	986,930,400
Canada	403,676,800
South Africa	338,864,631
DRC	150,000,000
Angola	132,172,840
Namibia	92,118,076
India	32,401,000
Lesotho	18,890,313
Sierra Leone	10,399,000
Australia	6,424,400



Substantial diamond reserves are located in Kasai Occidental and Kasai Oriental, most being alluvial and kimberlitic deposit types. Other potential diamond reserves remain little explored, including kimberlite pipes in north eastern parts of the country. The large-scale diamond mining industry is led by Mwana Africa Plc.

In the 1900's, the diamond industry was run by a state-owned mining company, MIBA -- the Bakwanga Mining Company. Set up in 1961, MIBA is 80 percent state-owned, while a Belgian company, Sibeka, has a 20-percent stake. Poor management, crumbling infrastructure, embezzlement and looting, especially during the two Great Congo Wars between 1997 and 2003, left MIBA crippled by debt and suffering from plummeting commodity prices. It shut down at the peak of the 2008 financial crisis, resuming operations in 2011, but remains a shadow of its former self. From an annual output averaging six million carats -- mainly of industrial diamonds -- in the early 2000s, production was no more than 500,000 carats in 2008 and half that in 2011. The situation in Mbuji-Mayi, the main diamond mining hub in the country, is far from what it used to be when some 40,000 workers and their families were supported by the company. Serious levels of poverty and unemployment have resulted from the downscaling of the mining operations. A government audit published in May 2020 revealed "serious dysfunction" in the management of the company.

President Felix Tshisekedi, who is from the Kasai region, announced the release \$5 million in August 2021 "to revive this company that was once the pride of the entire nation". The injection of cash has allowed MIBA to become operational.⁹⁸The first \$3 million went to "rehabilitating" a diamond processing plant at Disele and the purchase of a new one with an hourly capacity for 200 tonnes of ore. But the plant, manufactured in China, is still to be assembled at the Disele site, stored in containers or in the open air for now. As of 2021, operations have resumed in only one of the company's 13 zones. Current output is estimated at just 500,000 carats a year,

⁹⁷ Sources: S&P Mining Intelligence (2023) and USGS (2022)

⁹⁸ <https://www.rfi.fr/en/business-and-tech/20210607-dr-congo-diamond-mining-giant-struggles-to-revive-its-glory-days>

but the country's president Felix Tshisekedi hopes the modest investment - a fraction of the estimated \$100m needed - will help kickstart the operation and bring in much-needed foreign currency. MIBA has stated that it needs more investment to function properly.

Annex 4. DRC's Artisanal and small-scale mining sub-sector

Artisanal mining in the DRC remains of great economic importance. In the 1980s, artisanal miners primarily focused on diamonds, copper and gold but during the mid- 2000s, increases in demand for tantalum, tin and tungsten (3T) fueled further diversification of the sector. Today, artisanal mining has extended its activity further to cobalt. Whereas diamonds are mainly mined in Kasai Central and Oriental, copper and cobalt in Lualaba and Haut Katanga, gold and the 3T are mainly mined in Eastern DRC (Maniema, Tanganyika and the Kivus). It can be expected that continued economic attractiveness of the activity for rural households alongside strong international demand for minerals mined in DRC, will keep participation in this activity high.

In this sector we look at this sub-sector through economic, social and formalization lenses.

1. Economic dimensions

Artisanal mining is a major source of rural employment, especially for low-skilled labor in enclaved and isolated areas. The mining sector accounted for 10 percent of total employment in 2014. According to Delve, just over 2 million people labor directly in the artisanal sector of the DRC across the minerals cited above.¹¹ Women make up at least 40% of the laborers. A 2020 study by IPIS has mapped about 2,951 mines, employing 427,469 artisanal miners in eastern DRC alone. The World Bank estimates that for each miner directly involved in artisanal mining, four to five persons indirectly rely on the sector. Consequently, artisanal mining contributed to the livelihoods of 8 to 10 million people in 2008, representing up to 16% of the Congolese population.

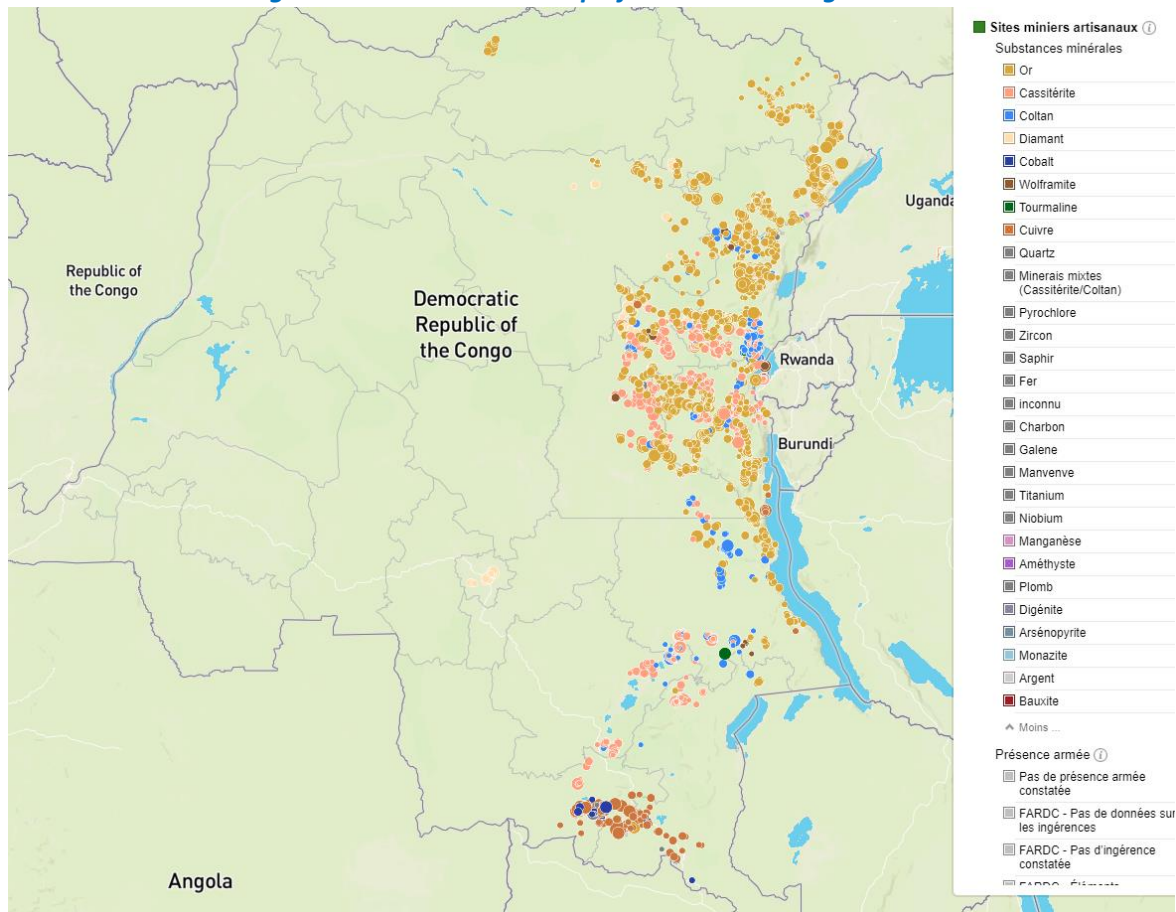
Engagement in artisanal mining can be on a full-time or seasonal basis and therefore plays a critical role in household income diversification. For many, artisanal mining has the advantage of presenting low entry barriers, enduring fragile situations such as conflicts and generating more revenues than the agriculture sector. A recent study estimated that 3T miners earn around USD 2.7 and USD 3.3 per day in eastern DRC whereas 76% of the population lived with less than USD 1.9 a day in 2012. Copper and cobalt miners have an average daily income of USD 7.65. Although 40% of the miners earn less than the Congolese legal daily minimum wage of USD 4.2, the daily rate may reach up to more than USD 50 a day.

International supply chain scrutiny on the conditions in which artisanal mining occurs has been steady since the 2000s, making on-going efforts to formalize the sector still crucial. The country has received significant attention from the international community in the forms of legislative action and due diligence programs seeking to support the sector's development as well as respond to the range of political, economic and social challenges in the DRC. Cobalt is a clear example where the country could capitalize on global demand but must demonstrate commitments to health, safety, and environmental standards. If the DRC wants to get the maximum benefit from the global interest in cobalt, significant improvements are needed on sector governance, including due diligence in supply chains and formalization of artisanal mining.

Security issues throughout the mineral supply chain have been the subject of a number of due diligence schemes and regulations. The German Government, through BGR, has been active in the area for more than a decade, working with the International Conference on the Great Lakes Region (ICGLR) and other donors to reduce illegal mining that fuels conflict in the region. The current phase of the project focuses on improving the Certified Trading Schemes (CTC) certification scheme for responsible artisanal and small-scale mining. The standard criteria have been updated and expanded to include direct references to the OECD Due Diligence Guidance as well as to the new DRC Mining Code of 2018. The mineral scope of the scheme is expanded beyond the 3Ts and gold and now includes copper-cobalt ore as well as galena and semi-precious stones exploited through artisanal and small-scale mining. A new governance structure is in the process of being established and operational procedures will be adjusted to facilitate sustainable long-term application of the CTC scheme. This project phase includes developing various technical solutions to support sustainable mineral supply chains in the DRC, including electronic traceability for gold, among others. BGR intends to continue its work in the DRC

beyond 2021 as the new project has a focus on both Artisanal and Small-Scale Mining (ASM) and Large Scale Mining (LSM) as part of sustainable economic development.⁹⁹

Figure A11 - Interactive Map of Artisanal Mining Areas¹⁰⁰



2. Social dimensions

ASM in the DRC is also accompanied by health and safety risks. Some risks are external to the mining context – including diseases such as malaria, tuberculosis or Ebola disease, and more recently Covid 19, while others are inherently associated to ASM. Some are more related to the mining activity itself, including acute and latent respiratory diseases due to dust hazards, noise induced hearing loss, or acute or latent poisoning linked to the use of mercury or cyanide. ASM is supposed to take place in artisanal exploitation zones (ZEA) and is legally limited in scope and equipment. Typically, artisanal miners must be Congolese nationals and join a cooperative in order to be eligible to mine.

Systemic violence against women and the use of child labor in artisanal mines cannot be ignored. In 2014, The World Bank and Harvard University conducted the largest quantitative survey on sexual and gender-based violence (SGBV) in the mines of eastern DRC. At that time, the results revealed a blurred line between sex work and sexual violence, with 58.5% of women having reported either trading sex for access to jobs or for protection in the mines. Research results led the World Bank to support the establishment of the National Women in Mining

⁹⁹https://www.bgr.bund.de/EN/Themen/Zusammenarbeit/TechnZusammenarb/Downloads/FS/Factsheet_RDC_20172135_6_en.pdf?__blob=publicationFile&v=1

¹⁰⁰Source : IPIS, <https://www.ipisresearch.be/mapping/webmapping/drcongo/v6/#-3.941374159962251/19.256159845844195/5.160058325614125/4/1/>

Network (Reseau National des Femmes dans les Mines) which has since 2015 worked to support women in the mining sector through a variety of outreach activities. Not until the Human Rights Watch report on child labor in the cobalt sector of the DRC did the issue of child labor come to international attention. It is still not possible to quantify child labor in the mines of DRC. It happens for a variety of reasons, and as the World Bank noted during the implementation of PROMINES, these reasons often have more to do with peer pressure, lack of afterschool activities or parental supervision, or school unavailability.

3. Formalization Efforts

International supply chain scrutiny on the conditions in which artisanal mining occurs has been steady since the 2000s, making on-going efforts to formalize the sector still crucial. The country has received significant attention from the international community in the forms of legislative action and due diligence programs seeking to support the sector's development as well as respond to the range of political, economic and social challenges in the DRC. Cobalt is a clear example where the country could capitalize on global demand but must demonstrate commitments to health, safety, and environmental standards. If the DRC wants to get the maximum benefit from the global interest in cobalt, significant improvements are needed on sector governance, including due diligence in supply chains and formalization of artisanal mining.

Formalization efforts do exist and can be enhanced. Formalization efforts have focused mainly on titling, registration and traceability. Key government institutions that oversee the sector include the Ministry of Mines, the Provincial Mining Divisions, and technical institutions such as SAEMAPE and CEEC. For example, in the cobalt sector, EGC is piloting an innovative collaboration with Trafigura and Pact. Through their contract, EGC will sell cobalt under a five-year deal with trading house Trafigura, which also will provide financing for EGC to help finance the creation and control of artisanal mining zones, the installation of ore purchasing stations and all other costs related to buying, transforming, and delivering of cobalt to end buyers. Pact, an international non-profit and consultancy with extensive experience in ASM, will form part of a Technical Committee (together with Trafigura and others) and will work to ensure ASM material is not only responsibly sourced but provides social and economic benefits to artisanal miners and nearby communities. Implementation of the pilot has been delayed as the parties have not yet identified a suitable pilot site. The World Bank, through its PROMINES project, also piloted several approaches to formalization in southern, eastern and central DRC which proved that with minimal investments considerable gains can be made in occupational health and safety. The *2020 State of the ASM Sector Report* (World Bank, 2021) provides a rich case book of global efforts to improve occupational health and safety mine site practices and could inspire new efforts in the DRC.

The World Bank, through its Promines project, financed several approaches to formalization in southern, eastern and central DRC which proved that with minimal investments considerable gains can be made in occupational health and safety. The 2020 State of the ASM Sector Report (World Bank, 2021) provides a rich case book of global efforts to improve occupational health and safety mine site practices and could inspire new efforts in the DRC. In the context of the Poverty and Resilience Assessment conducted in 2021, Government is putting forward a commitment to improve formalization of ASM through a range of activities including the creation of several artisanal mining areas (ZEAs) and cooperatives.

4. Climate change impacts on ASM

Climate change has a multifaceted impact on artisanal mining and the lives of artisanal miners, with changing rain patterns being one significant factor. One of the key ways in which climate change affects artisanal mining is through alterations in weather patterns. Increasingly unpredictable and extreme weather events, such as droughts, floods, and storms, disrupt mining activities and pose safety risks to miners. Heavy rainfall, for instance, can lead to landslides in mining areas, endangering the lives of miners and causing the collapse of mining tunnels. Droughts, on the other hand, reduce water availability, making it difficult for miners to wash ores and extract minerals. These weather-related disruptions can result in significant economic losses and even fatalities within the artisanal mining sector.

Another climate-related concern for artisanal miners is the extreme heat associated with climate change. Rising temperatures expose miners to health risks and safety hazards. Artisanal mining often takes place in remote and, if done through underground mining methods, in poorly ventilated locations, increasing the likelihood of heat-related illnesses such as heat exhaustion and heatstroke. These hazardous conditions further exacerbate the already challenging working conditions and negatively impact the well-being and safety of artisanal miners.

While climate change brings about numerous challenges for artisanal mining, there may also be certain opportunities arising from increased demand for minerals required for the energy transition. The global shift towards renewable energy technologies, such as solar panels and electric vehicle batteries, has created a surge in demand for minerals like lithium, cobalt, and rare earth elements. Artisanal miners, with their local knowledge and low-cost labor, may find new economic prospects in mining these minerals.

However, it is essential to ensure that artisanal mining practices are conducted responsibly, with adequate environmental and social safeguards in place to prevent further environmental degradation and protect the rights and well-being of the miners. Addressing these challenges and opportunities requires a comprehensive approach that considers the environmental, social, and economic aspects to ensure the sustainability and well-being of artisanal mining communities.

Annex 5. The 2017 Mining Sector Diagnostic and the revised 2018 Mining Code

A review of the governance of the mining sector was completed in 2017 using the 2002 mining code. A full dashboard of the diagnostic's findings is shown below.

Figure A12 - High level dashboard from the 2017 Mining Sector Diagnostic for the DRC.¹⁰¹

Thème	Chaîne de Valeur des Industries Extractives						
	Contrats, Licenses and Exploration	Opérations	Fiscalité et Participation de l'État	Répartition et Gestion des Revenus	Impact Local		
Politique, Législation et Réglementation	Règles pour l'Attribution des Licences et Collecte de Données Géologiques	Clarté et Harmonisation des Règles du Secteur	Politique fiscale, Instruments et Règles des Sociétés d'État	Règlement sur la Gestion des Finances Publiques, y compris le Partage des Revenus	Politiques Visant à Atténuer l'Impact Environnemental et Social		
Responsabilité et Inclusivité	Ouverture, la Transparence et l'Indépendance du Processus d'Octroi de Permis	Responsabilité des Processus, Indemnité, Réinstallation et Voix de la Mine Artisanal et à Petite Échelle	Fiscalité Minière et Gestion Financière des Sociétés d'État	Transparence et Responsabilité du Budget et Intégrité Publique	Droits de l'Homme, l'Équité de l'Impact Environnemental		
Capacités Institutionnelles et Efficacité	Cadastre, Géodonnées, Permis et Gestion Foncière	Gestion du Secteur et Coordination Inter-gouvernementale	Administration de la Fiscalité Minière et Gouvernance des Sociétés d'État	Mise En Œuvre du Budget et Efficacité de la Gestion Macrobudgétaire	Consultation Communautaire et Gestion de l'Impact Environnemental et Social		
Thèmes Transversaux							
Environnement Économique	Environnement des Affaires et des Investissements	Infrastructure Minière	Diversité et Stabilité Des Revenus Nationaux	Stabilité Macroéconomique	Croissance et Épargne Nationale	Disponibilité des Compétences et du Capital Humain	Santé Humaine
Environnement Politique	Risque d'Expropriation		Stabilité Politique		Politique Minière et Fiscale Prévisible		Lutte Contre la Corruption
Développement Durable	Planification du Développement		Développement des Fournisseurs Locaux		Promotion Des Investissements (Diversification)		Tirer Parti des Infrastructure

Performance Echelle de	< 10 - 1.32	> 1.32 - 5.20	> 5.20 - 3.32	> 3.32 - 4.0	NA
	Très Faible	Faible	Haute	Très Haute	Non classé

The main findings of the mining sector diagnostic were that:

- Across the extractive industries value chain there was good *de jure* performance of the mining code but limited capacities to apply it. The provisions of the 2002 mining code and regulations, such as the management of mining titles, appear to be effective. Conversely, the assessment of institutional capacity to implement policies, monitor or enforce the law remains low in quantitative evaluations.
- Energy deficiencies and mining infrastructure are an obstacle to the development and sustainability of the development of the mining sector in the DRC. The lack of rapid energy supply to manufacturers handicaps the sector. This weakness hinders the potential for mineral processing and the creation of new markets on Congolese soil. It also requires a policy of developing transport infrastructure that allows production to be exported at a lower cost and in a shorter time.
- The policy on local content is a major weakness and it should facilitate the transformation of the economy around the mining industrial activity zones.
- Decentralization and retrocession remain an important subject for the development of the new provinces and there is a need to provide the local level with the necessary means to ensure the development of institutional capacities for the application of laws and regulations.

¹⁰¹ This 2017 Mining Sector Diagnostic (then called MinGov) assessed policies against the 2002 mining code. Improvements to “de jure” performance (policies, laws, regulations) have been made through the 2018 mining code. It is not expected that many improvements have been made on “de facto” performance.

- Artisanal mining requires a national strategy to enforce the mining code and meet the challenges of the sector. The aim is to develop structures such as cooperatives and forms of grouping of cooperatives. In addition, it is necessary to develop the means made available to SAESSCAM to supervise the sector.¹⁰²

A revised mining code was introduced in June 2018, seeking to increase the benefits to the country. The following are the key elements of the revised code:

- Higher taxes and royalties: (i) Royalties on copper, cobalt, and gold increase from 2 to 3.5 percent; a new 10 percent royalty is imposed on “strategic minerals”. The designation of a mineral as “strategic” is arbitrarily determined by government decree, based on “economic context” and taking into account “critical” or “geostrategic” considerations. The base for computing royalty changed from net to gross revenue; (ii) The allocation of free shares to the state on new projects increases from 5 to 10 percent, with an additional 5 percent increase each time a license is renewed; (iii) Income tax remained unchanged at 30 percent; (iv) Elimination of the option for accelerated depreciation of 60 percent; and (v) A tax of 0.3 percent of business turnover is imposed as contribution to local development.
- A new 50 percent tax on so-called windfall profit was introduced. Windfall profits are defined as profits realized when the price of the mineral resource is more than 25 percent higher than envisaged in the feasibility study.
- The changes took immediate effect which breached and eliminated the stability clause under the 2002 Mining Code, which protected existing mining companies from any changes to the fiscal regime for the 10 subsequent years, a generous provision.
- Additional provisions to increase domestic content were introduced that include: (i) at least 10 percent of the equity of any project must belong to Congolese nationals; and (ii) subcontractors must be Congolese, unless no local subcontractor is in a position to provide the desired good or service.
- All export earnings in foreign currency should be repatriated to local banks once the investment is amortized (60 percent of earnings should be repatriated before the investment is amortized).
- Permit holders not to exceed a debt-to-equity ratio of 1.5.

The 2018 Mining Code (Article 242) stipulates that shares of mining royalties (“redevances minières”) are to be paid directly by mining companies as follows:

- 25% to the provincial authorities;
- 15% to the decentralized territorial entity which hosts the extractive project;
- 10% to the Mining Fund for future generations;
- 50% to the central government.¹⁰³

¹⁰² Service d'Assistance et d'Encadrement du Small Scale Mining ou Production Minière à Petite Echelle (SAESSCAM).

¹⁰³ Ibid.

Annex 6. Climate Dimension

Annex 6.A. DRC mining industry climate change mitigation commitments and adaptation measures

Industry mitigation commitments

Climate change mitigation action among companies operating in the DRC is mixed. The DRC's state-owned mining companies have not made any public commitments to decarbonize their operations (which they control, or have interest in), while many western-listed mining companies have commitments to achieve carbon neutrality by 2050 or sooner. Companies from other jurisdictions such as China operate under obligations to decarbonise "at home" but have not publicly announce corporate wide commitments for their overseas operations.

A significant proportion of the Congolese mining portfolio is under Chinese control, and so the industry is affected in a myriad of ways by China's policies on a range of issues, including climate change. As noted elsewhere in this report, Chinese investors such as Minerals and Metals Group (MMG) and China Molybdenum's Tenke Fugurume (CMOC) are prominent in the cobalt and copper rich Lualaba and Haut Katanga areas along with global traders like Trafigura and Glencore, and Canada's Ivanhoe Mines and Barrick Gold Corporation.¹⁰⁴

China has developed climate change policies that relate to mitigation of GHG emission effects on air quality within China but is silent on how these policies apply to overseas operations. For its overseas investment policy, China has developed financial and management policies; and corporate governance policies that include HR and Health Safety but have failed to include climate change in its articulation of how their companies will operate in other jurisdictions.¹⁰⁵

CMOC has developed an environmental policy that includes commitments to follow environmental regulations globally. The most germane elements of the policy relating to climate change include applying a risk management system based on sound science to:

- a) identify and evaluate environmental impacts;
- b) pursue where practicable energy efficiency, use of renewable energy sources and recycling of materials;
- c) conduct environmental audits of operations as part of a system of continuous improvement; and
- d) monitor and manage environmental aspects to proactively mitigate impacts to employees, communities and surrounding environment.

CMOC notes that some of their operations are located in developing economies, where environmental management programs not only comply with local, applicable law, but also refer to international best practice frameworks: such as those of the International Finance Corporation and the sustainable development principles of the International Council on Mining and Metals.¹⁰⁶

On the other hand, climate change commitments promised by "western" companies such as Glencore, Ivanhoe, Barrick and Anglo American, are more likely to make public statements of commitments toward net zero carbon emissions than their Asian counterparts. The table below includes companies mining in the DRC but is not an exhaustive list, given the lack of data on Chinese company climate change mitigation targets and initiatives.

¹⁰⁴ <https://icsin.org/blogs/2021/08/27/chinese-mining-in-the-drc-from-sicomines-to-global-cobalt-monopoly/>

¹⁰⁵ Chinese Overseas Investment Policy: Implications for Climate Change, 2021 The Authors. Global Policy published by Durham University and John Wiley & Sons Ltd. Global Policy (2021) 12:3 doi: 10.1111/1758-5899.12952

¹⁰⁶ CMOC Environmental Policy, 2020

Table A1 - GHG Reduction Targets of Base Metals and Diversified Miners¹⁰⁷

Company	Operating in DRC?	Large Copper Producer?	GHG Reduction Target?	Base Year	% Reduction	Target Year	Type	Scope	Description
Anglo American (AAL)	N	Y	ü	2016	30%	2030	Absolute	Scopes 1 and 2	AAL is also targeting carbon neutral operations by 2040. Management also discloses an ambition to reduce absolute Scope 3 emissions by 50% by 2040 against a 2020 baseline.
Antofagasta (ANTO)	N	Y	ü	2020	30%	2025	Absolute	Scopes 1 and 2	In addition to its 30% target, ANTO is committed to achieving carbon neutrality in line with Chile's long-term national target.
BHP	N	Y	ü	2020	30%	2030	Absolute	Scopes 1 and 2	BHP also has a long-term goal to achieve net-zero operational GHG emissions and net-zero Scope 3 emissions by 2050. Further, the company is targeting emission neutrality in shipping its product by the same year
First Quantum Minerals (FM)	N	Y	ü	2020	50%	2030	Absolute	Scopes 1 and 2	FM has also committed to interim target of 30% absolute GHG emissions reduction (Scopes 1 & 2) by 2025 as well as a 50% reduction in the GHG intensity of copper mined by 2030
Freeport McMoRan (FCX)	N	Y	ü	2018	50%, 35%	2030	Absolute	Scopes 1 and 2	FCX has four targets: reducing GHG intensity of Freeport Americas Copper by 15% and that of its Indonesia operations by 30% (intensity is measured as CO2e/metric ton cu). In September 2022 management announced two additional absolute targets: one for FCX's Atlantic Copper smelter/refinery in Spain (50% reduction by 2030 vs 2018) and one for primary molybdenum sites in Colorado (35% by 2030 vs 2018). Management has also announced a 2050 net zero aspiration.
Glencore (GLEN)	Y	Y	ü	2019	50%	2035	Absolute	Scopes 1, 2 and 3	GLEN has also set a short-term target (15% reduction in absolute Scope 1, 2 and 3 emissions by 2026). They also disclose an ambition to achieve net-zero by 2050.
Ivanhoe Mines (IVN)	Y	Y	û	ND	ND	ND	ND	ND	IVN has pledged to achieve net-zero operational GHG emissions (Scope 1 and 2) at the DRC Kamoanga-Kakula copper mine.
Rio Tinto (RIO)	N	Y	ü	2018	50%	2030	Absolute	Scopes 1 and 2	RIO also has a short-term target (15% reduction in absolute Scope 1 and 2 emissions by 2025). RIO discloses a commitment to reach net-zero emissions by 2050 and various goals related to Scope 3 emissions, including reducing its

¹⁰⁷ Source: BMO Capital Markets, 2022, "Beneath the Surface: Exploring ESG Trends and Progress in the Base Metal and Diversified Mining Industries"

Company	Operating in DRC?	Large Copper Producer?	GHG Reduction Target?	Base Year	% Reduction	Target Year	Type	Scope	Description
									shipping intensity by 40% by 2025 and progressing low-carbon steel making projects

State owned mining company, Gécamines, does not appear to have developed its own policy or initiatives related to climate change. Since privatisation of state-owned mining assets several decades ago, Gécamines has transferred responsibility for socio-economic and environmental impacts to the mining company with whom it has partnered. These companies are required to conduct environmental impact assessments as conditionality for mining rights. The requirement for an ESIA was first introduced in DRC through its mining code in July 2002, and the mining regulation that followed in March 2003.^{108,109}

Industry adaptation measures

For the mining sector, incorporating climate change risk into all phases of mining will assist companies in creating adaptation pathways that will be responsive to changing climatic conditions. Many mining and metals companies in the DRC have developed approaches, tools, data, resources and human resource capacity that will ensure that climate change risks are managed appropriately. A leading example is the agroforestry bee-keeping project we have implemented at our Kamoakakula Project to strengthen food security, alleviate poverty and combat deforestation.

Developing climate resilience is not unfamiliar to an industry that normally must deal with challenging climatic conditions. The International Council of Metals and Minerals has developed various tools to assist the global mining industry to adapt to climate change impacts. These include the new international standard on mine tailings management discussed previously, climate change policy principles; and provision of global mining industry examples on building operational resilience to climate change (ICMM, 2019).

In the DRC, climate change challenges relate primarily to water resources, especially during droughts, as well as to flooding during times of high precipitation; extreme heat; and human health implications of climate change. These additional climate change drivers are usually included within existing risk management and planning procedures. These internal processes are often reviewed regularly so that they remain relevant and periodic updates may provide opportune moments to consider greater integration of climate change considerations. (ICMM, 2019).

Glencore’s adaptation approach focuses on risk management in the areas of water, tailings storage facilities and biodiversity. Risks are reviewed on a quarterly basis as part of quarterly business reviews. These include a review of the Group Risk Register and the actions taken to manage these risks. Policies and standards have been developed to address the catastrophic hazards potentially caused by climate change that present a material risk to operations. The planning, design, construction, operation, maintenance and monitoring of surface and underground mines, water and tailings storage facilities, smelters, refineries and other infrastructure and equipment are carried out

¹⁰⁸ Netherlands Commission for Environmental Assessment Democratic Republic of Congo EIA. August 2019

¹⁰⁹ After only applying to the mining sector for several years, ESIA obligations were expanded to other fields with the enactment of the environmental law in 2011.

in a manner consistent with leading international standards and designed to prevent incidents and protect people, assets, communities, the environment and other stakeholders. A comprehensive process is in place for the independent assurance of catastrophic hazards across all operating sites. The company has implemented a comprehensive tailings management framework, with clear governance, accountabilities, systems, training, auditing and reporting on performance.¹¹⁰

Glencore has developed a Group Standard that requires industrial assets to identify and assess impacts and risks, including those related to climate where relevant, to develop appropriate responses, and to monitor and report on progress in order to manage those risks. Climate-related risks are prioritised, and materiality determinations are made, in line with the Group Risk Register process. For climate-related impacts and risks, responses may include relevant engineering works, optimisation of operational processes and review of asset infrastructure design and maintenance. Where relevant, such as in the case of water-related risks, its industrial assets are required to assess the risks to other stakeholders, and to incorporate stakeholder-related considerations in the response measures to assist with decision-making in relation to mitigating, transferring, accepting or controlling climate-related risks.¹¹¹

Ivanhoe has implemented emergency preparedness initiatives to alert communities should accidents occur due to climate change impacts. Kamo-a-Kakula has launched the Rochelle de Villiers Joint Operations Centre in 2022. This state-of-the-art security centre uses cutting edge security technology, such as drones, CCTV networks and radar tracking towers to ensure that responses to incidents on site are rapid and effective. This new facility was built to allow different departments and first responders to coordinate their responses to emergency events. A team of controllers works in shifts to provide around-the-clock coverage and provide a 24/7 dispatch facility, supporting the activities of firefighting, medical and other services.¹¹²

While water sources are abundant in the DRC and Ivanhoe's assessments to date indicate that there are multiple potential sources of water supply for the Kamo-a-Kakula and Kipushi projects, both projects must monitor a continual risk of flooding of the underground infrastructure. Risk management strategies include primary dewatering systems, as well as backup systems in case of failure and continual monitoring of the quality of all water being discharged. Furthermore, engineering designs and controls, primary and secondary pumping stations, diversion drains, dam walls and natural aquifers (such as wetlands) are put in place and continuously maintained to prevent, mitigate or reduce the impact of flooding. Although water quantities are currently high in the DRC regions, the risk of water scarcity has not been overlooked and is considered a medium risk by the company. This risk comes into play as a result of the impacts of climate change and the unpredictable variability thereof, which is continuously monitored in respect of impacts or changes to the water availability at Kamo-a-Kakula and Kipushi.¹¹³

Water governance

The Democratic Republic of the Congo (DRC) has an abundance of water resources. Over 50% of Africa's surface water reserves and approximately 25% of the continent's water resources are in DRC. The total volume of freshwater withdrawn by major economic sectors is 0.2 percent of the total resource endowment and total annual renewable water resources per person is 15,773 m³, far exceeding the Falkenmark Water Stress Index threshold for water stress.¹¹⁴ The vast resources of the Congo Basin contribute to year-round surface water flows. Approximately 30 % of water resources originate in neighboring countries.

¹¹⁰ Glencore Annual Report, 2022

¹¹¹ Glencore Climate Report, 2022

¹¹² Ivanhoe Annual Report, 2022

¹¹³ Ivanhoe Annual Report, 2022

¹¹⁴ Water Resources Profile Series, Democratic Republic of the Congo Water Resources Profile Overview, https://winrock.org/wp-content/uploads/2021/08/DRC_Country_Profile_Final.pdf.

The text that regulates water management, protection and development in DRC is Law No. 15/026 of December 31, 2015. The Congolese legislation regulating the mining sector is fairly developed and obliges companies to make sure that they do not pollute water resources as part of their operations. DRC has no national water quality monitoring programs. The lack of data limits regulatory capacity and enforcement and increases vulnerability to water-related environmental and public health safety risks.

Surface and groundwater pollution pose a risk to public health and biodiversity. Mining in the southern Copperbelt of Katanga has increased concentrations of trace metals and pollutants such as mercury, lead, cadmium, and copper in surface waters. Deforestation has led to sedimentation of surface waters, especially along the eastern border and near Kinshasa¹¹⁵.

Annex 6. B. - Climate Smart Mining Policy diagnostic

The following subsection examines the policy and governance framework to achieve climate smart mining in the DRC. This is a cursory diagnostic of the institutional and legal arrangements (de jure factors) together with their implementation (de facto factors). The diagnostic examines 7 key pillars through these lenses: (1) General Policies; (2) Climate Mitigation; (3) Climate Adaptation; (4) Market Opportunities; (5) Geological Information on Climate Action Minerals; (6) Human Capital; and (7) Value Added Opportunities.

An overall summary of performance along these dimensions is included in the table below. A set of recommendations following the same framework are included in Annex “A”.

Table A2 -Climate Smart Mining diagnostic summary table

General Policies	Climate Mitigation	Climate Adaptation	Market Opportunities	Geological Information on Climate Action Minerals	Human Capital	Value Added Opportunities
National Policies	Emissions Reporting and Reduction	Resilience Regulation and Planning	Strategic Planning	Tailings Geology Reporting Requirements	Sector-Specific Skills Development	Value Addition Strategy
Government Coordination, Capacity and Engagement	Energy Efficiency	Forest and Water Management	De-Risking Investment for Climate Action Minerals			
	Replacement of Fossil Electricity	Post-Closure and Land- Use Planning				
	Replacement of Liquid Fossil Fuels	Stability of Mine Tailings				
	Carbon Offsets and Capture					

Scoring Key	Very Low	Low	High	Very High
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¹¹⁵ USAID, Water Resources Profile Series, Democratic Republic of the Congo Water Resources Profile Overview, available on https://winrock.org/wp-content/uploads/2021/08/DRC_Country_Profile_Final.pdf

i. General climate change policy and background

The policy context that drives the DRC Government's adaptation response to climate change, is affected by the country's drive toward decentralization. The DRC is currently undergoing a decentralization process that should increase the competences and responsibilities of the provincial authorities in overall governance, including the prioritization, planning, budgeting, implementation, and monitoring of development processes. This decentralization is likely to bring the issues of climate change management to a more local level and affect local industries, including mining, more directly.

The decentralization process has important implications for many aspects of adaptation planning at the national level in the DRC. These decentralization initiatives will be followed by further improvements, including a move towards program-based budgeting and more participatory and consultative planning. In addition, administrative decentralization will be accompanied by fiscal decentralization policies. These initiatives create unique entry points for integrating CCA considerations into day-to-day governance processes, and the NAP process will guide this integration at the provincial level. It should be noted here that, as part of a GCF-funded NAP project, a guide for integrating CCA into provincial development plans (PDPs) was developed in 2019. The NAP process in the DRC fully adopts the principles of this guide. (NAP)

Currently, the Ministry of Environment, Nature Conservation, and Tourism is the responsible agency for climate change adaptation efforts (see chart on CC Governance). The DRC ratified the Paris Agreement in December 2017 and participates in the United Nations Reducing Emissions from Deforestation and forest Degradation plus (REDD+) program. The DRC is also a member of the Central African Forest Commission (COMIFAC), which aims to strengthen the preservation and management of forest ecosystems in the Congo Basin.

In 2021 the DRC updated their Nationally Determined Contribution (NDC) and identified the following priority sectors for climate action: agriculture, forestry, coastline protection, and energy/transportation. In addition, the DRC has recently published their National Adaptation Plan to Climate Change, which outlines the country's legal and institutional framework, historical and future projected climate data, and priority adaptation programs for the near-term.

As part of the plans negotiated at COP26 a landmark \$500 million agreement launched to protect the DRC's forests. President Félix Tshisekedi of the Democratic Republic of Congo (DRC) and Prime Minister Boris Johnson of the United Kingdom on behalf of the Central African Forest Initiative (CAFI) endorsed an ambitious 10-year agreement (2021-31) to protect the Congo Basin rainforest – the world's second largest. Through this new multi-year partnership, the DRC aims to first cap forest cover loss at its 2014-2018 average and ensure that deforestation continues to decline. The partnership will also promote the regeneration of 8 million hectares of degraded land and forests, and place 30% of national areas under a protection status, including areas where local communities undertake efforts to manage forests sustainably.¹¹⁶

However, in April 2022, a few months after COP 26, the government appeared to reverse course on its commitment to save the DRC's forests (that are important for carbon capturing). The DRC's seriousness about the multi-year agreement's forest saving intent, and whether it will ultimately prove compatible with the country's efforts to tackle chronic poverty and manage its resource wealth are in question. The Ministry of Hydrocarbons shocked observers when it announced the auction of 16 new oil exploration blocks, including three that overlap with the Cuvette Centrale peatlands, which holds one of the largest carbon deposits on the planet. The announcement follows the DRC's controversial decision to lift its moratorium on new logging concessions, which provoked an outcry from environmental NGOs.¹¹⁷

¹¹⁶ <https://www.un.org/africarenewal/magazine/december-2021/cop26-landmark-500-million-agreement> launched-protect-dr-congo's-forest

¹¹⁷ <https://news.mongabay.com/2022/06/in-the-drcs-forests-a-tug-of-war-between-oil-and-aid/>

The DRC does not have an accelerated depreciation policy for clean energy projects, but companies can negotiate on an individual basis. In terms of incentives, all economic activities related to the production, import and export of electrical energy are exempt from customs tax and, in certain cases, valued-added tax (VAT) for four years from the first day of importation. This applies to all energy sources. However, the VAT exemption is not transparent and is not continuously applied.¹¹⁸

New commitments at COP26 will boost the DRC's climate mitigation strategy, however the financing gap to achieve the country's NDC remains large. At COP26, the role of forests in capturing and storing carbon was high on the agenda, with \$19 billion in public and private funds pledged to the cause for the world. Leaders at COP26 also announced the Congo Basin Pledge, a promise of \$1.5 billion in financing between 2022–25 to support ambitious efforts and results in the region to protect and maintain the Congo Basin forests, peatlands and other critical global carbon stores. Likewise, the authorities signed a new landmark \$US500 million 10-year agreement with the Central African Forest Initiative (CAFI) to protect DRC's rainforest during 2021–2030.

The DRC released its updated NDC in 2021.¹¹⁹ The country increases its ambitions to cut its emissions from 17 percent to 21 percent by 2030. The updated NDC includes actions on both mitigation and adaptation, as well as their costs and financing gap. The financing needs to achieve this new NDC are estimated at \$US48 billion (87.5 percent of GDP in 2021) between 2022 and 2030, split between mitigation (\$US25 billion) and adaption (\$US23 billion).¹²⁰

ii. DRC's net zero goals

On February 3rd, 2023, the Minister of the Environment and Sustainable Development proposed an amendment to Environment Law No. 11/009 during a Council of Ministers meeting. The proposal, which was approved by the council, aims to bring the country's legislation in line with the Paris Climate Agreement and enhance domestic revenue collection. This includes the implementation of a carbon tax, a carbon market regulatory authority, and a national environmental contribution. The government had introduced a carbon tax of 50% in its 2020 budget but due to wide-spread opposition to the tax, it has been put on hold as the new proposal gains traction within the DRC Parliamentary and legal system.¹²¹

The Republic of Congo signed a landmark agreement with the World Bank's Forest Carbon Partnership Facility (FCPF) in 2021 that aims to unlock up to US\$41.8 million for reducing emissions from deforestation and forest degradation and increasing carbon sequestration—commonly known as REDD+. This Emission Reductions Payment Agreement (ERPA) will reward efforts to reduce 8.4 million tons of carbon emissions through 2025 under the Republic of Congo's ambitious emission reductions program.¹²²

The Republic of Congo's forests constitute carbon stock that is vital globally and are home to biodiversity of worldwide importance. The forest also plays an important role in national and household economies. The country has the third largest expanse of tropical rainforest in Africa, and 80 percent of it is not protected. The program will be implemented in the Sangha and Likouala Departments—a huge area covering over 12 million hectares of land and representing nearly 60 percent of the country's forests. While the national deforestation rate has been historically low, the rainforest risks becoming a future deforestation hotspot particularly due to increased activity among companies involved in logging, palm oil production, and mining. The World Bank fund will mitigate the impact of deforestation caused by the development of mining projects.

¹¹⁸ <https://www.global-climatescope.org/markets/cd/>

¹¹⁹ <https://climatepromise.undp.org/what-we-do/where-we-work/congo-democratic-republic#:~:text=The%20Democratic%20Republic%20of%20Congo%20submitted%20its%20revised%20NDC%20in%20December%202021.>

¹²⁰ <https://www.elibrary.imf.org/view/journals/002/2022/211/article-A001-en.xml>

¹²¹ <https://www.orbitax.com/news/archive.php/Democratic-Republic-of-the-Con-52011>

¹²² <https://www.worldbank.org/en/news/press-release/2021/05/03/world-bank-and-republic-of-congo-sign-agreement-to-reduce-carbon-emissions-and-preserve-forests>

iii. Climate change regulatory and institutional diagnostic

The DRC ratified the United Nations Framework Convention on Climate Change in 1997, the Kyoto Protocol in 2005, and the Paris Agreement in 2015. The DRC's Nationally Determined Contribution (NDC) is a commitment to a 21 percent reduction in emissions from 2021 to 2030, with 19 percent to be achieved with external support while 2 percent based on national efforts. The DRC's NDC budget is estimated at USD 48.68 billion, of which USD 25.60 billion is for the implementation of pledged mitigation initiatives and USD 23.08 billion for priority adaptation actions.¹²³

Legal frameworks and documents guiding climate action in DRC include the following¹²⁴: Nationally Determined Contribution (updated second version 2021); Law on the Protection of Nature (2014); Third National Communication to the UNFCCC (2015); Climate Change Profile (2018) and the National Adaptation Plan to Climate Change, 2022-2026 (2021).

Climate change issues have not yet been sufficiently included in the DRC's legal framework. However, there are several regulatory texts that address issues related to climate change and other decisions relating to United Nations Conventions, including the UNFCCC, the Kyoto Protocol, the Paris Agreement on climate, United Nations Convention to Combat Desertification (UNCCD) and the Convention on Biological Diversity, etc. Although numerous activities have been planned around these agreements, political and economic difficulties initially prevented the implementation of all of the proposed activities except for two (the agricultural/rural sector recovery program and the protected areas/national parks rehabilitation project).¹²⁵

Other relevant provisions on the fundamental principles on environmental protection, notably, the law on renewable energy, the Forestry Code and related laws and decrees, the law on water, the law on nature conservation, the law on sanitation, etc., are also considered in the regulatory framework. It should be noted that at the time of the plan's publication, a process was underway to consider the introduction of a special law on climate change. These line ministries contribute data used to calculate GHG emissions.¹²⁶

The Policy, Strategy, Action Plan for Climate Change (PSPA-CC) is the Congolese roadmap for all matters regarding climate change. As a reference framework on climate change, it aims to consolidate the various interventions in the areas of climate change, as identified in the DRC's NDC, on a five-year basis. The PSPA-CC (2016–2020) presents a list of priority adaptation interventions, estimated to cost around \$4.2 billion for the country, which focuses on four programs in eight provinces. The NDC specifies the following adaptation measures, by sector: Agriculture, fishing and livestock: Implementation of the adaptation component of the DRC's PNIA, integration of climate change resilience into development strategies and climate risk planning, investment in research and development, innovation, integration of early warning systems; Energy, water and transport: Improvement of access to drinking water, sanitation of wastewater, and sustainable waste management, improvement of infrastructure, and strengthening of institutional capacities; Forestry/silviculture; Coastal management: Erosion control, supporting income-generating activities, early warning systems and capacity building.

Climate Change governance is led by the Ministry of the Environment and Sustainable Development as presented in the chart below. Key line ministries that regulate aspects of the economy relevant to GHG emissions control, including Energy, Transportation and Agriculture are included and have working groups focusing on climate adaptation and mitigation, among others, reporting to them.

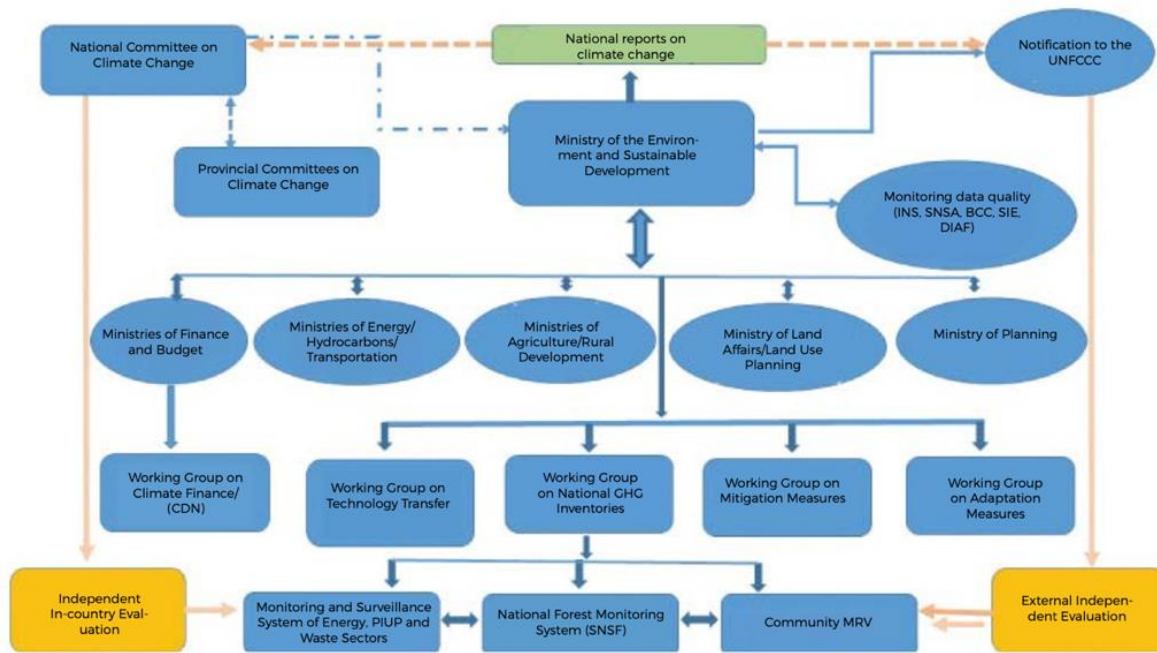
¹²³ https://www.usaid.gov/sites/default/files/2023-03/2022-USAID-DRC-Climate-Change-Country-Profile_0.pdf

¹²⁴ https://www.climatelinks.org/sites/default/files/asset/document/2023-02/BHA_Climate%20Risk%20Profile_DRC_2023_FINAL_508.pdf

¹²⁵ https://unfccc.int/sites/default/files/resource/DRC-NAP_EN.pdf

¹²⁶ <https://www.climatelinks.org/sites/default/files/asset/document/DRC%20GHG%20Emissions%20Factsheet%20Final.pdf>

Figure A13 - Institutional arrangements for monitoring the implementation of the DRC's NDCs



The NAP notes technical knowledge capacity gaps in the country’s ability to implement various aspects of its aspirational climate change policies. Global awareness of the impacts of climate on development and of ways to take them into account in development planning at the national, sectoral, and provincial levels is limited among key stakeholders, such as civil servants responsible for planning and budgeting. There is a lack of specialized technical capacities needed for planning and implementation, and of stand-alone capacity-building programs. Additional capacities and human resources are needed at the provincial level to provide support to communities in the form of technical knowledge to identify hazards and vulnerabilities.

The dispersed policies and strategies are limited in their integration of climate change into development planning, implementation, and monitoring. The adopted PSPA-CC still needs implementation support and to be significantly aligned with the main strategic national development priorities. Further, there is weak monitoring and evaluation at the national level of progress made in building resilience and adapting to climate change.

There is fragmentation and there are gaps in data records as well as observation and monitoring networks. The GEF-funded National Agency for Meteorology and Remote Sensing (MettelSat) project addresses some of these issues, but the limited climate knowledge base and information impede informed decision-making for adaptation priority setting.

Despite the above-noted weaknesses, the DRC has made efforts to mainstream climate change into its policy framework. Since 2009, the country has been involved in the reduction of emissions from deforestation and forest degradation (REDD+) process, a framework formed under the U.N. Framework Convention on Climate Change. Alongside that process, DRC has also been involved since 2009 in CIFOR’s Global Comparative Study on REDD+ (GCS-REDD+) that aims to support policy makers and practitioners with information, tools and analysis to design and implement effective, efficient, and equitable policies and REDD+ actions. GCS-REDD+ is currently in its fourth phase, which focuses on strengthening knowledge for action to protect tropical forests and increase climate finance. In 2015, the DRC became the first country worldwide to present its REDD+ Readiness-Package and release its first Nationally Determined Contribution (NDC). In its NDC, the country pledged to reduce GHG emissions by 17 percent and increased forest cover to 60 percent by 2030.

In addition, the DRC has taken further actions by integrating climate change in the National Strategic Development Plan (NSDP, 2019–23). Climate change considerations are included in the fifth pillar of the

National Strategic Development plan. This pillar focuses on activities that guarantee the sustainability of development, in particular those that contribute to mitigating and adapting to the effects of climate changes already present (floods, erosion, landslides, heat, drought). These activities include the promotion of i) sustainable management of resources in rural areas; ii) good governance of natural resources in the face of climate change and degradation caused by human activities; iii) climate monitoring and early warning system; (iv) livelihoods resilient to climate change; iv) climate change mitigation and adaptation actions (including REDD+).

Annex 6. C – Climate Smart Mining Diagnostic Recommendations

Competitive Mineral Sector			
Opportunity	Barrier	Enabler	Potential WB Engagement
<p>1. Acceleration in the development of the copper-cobalt sector depends to a large extent on the governance risk profile of the country that will likely affect levels of investment.</p>	<p>Weak Governance: The fast pace of dealmaking and pressure for companies and countries to gain secure sources of production, particularly in the cobalt sector carries high corruption risks.</p>	<p>Effective anti-corruption preventative measures and enforcement efforts must be delivered through stronger institutions and legal frameworks; these must be applied to all sizes of mining activity and throughout the entire supply chain.</p>	<p>Assessment of current anti-corruption institutions and legal frameworks to provide support to strengthen these to combat corruption and raise the country's investment risk profile.</p> <p>Support to EITI to include ASM and Provincial Governments would assist in improving transparency and accountability around license allocation decisions and tracking mineral supply throughout the chain of custody.</p> <p>Support the adoption of the latest transparency standards (the EITI Standard, in most cases), especially about disclosing license processes, applicants, recipients, and the full text of all licenses and contracts.</p>
<p>2. Mining Licensing Regulatory Efficiency: While the regulatory framework (outlined in the Minerals Act of 2018) is in line with modern mining regimes, in practice, there is significant discretion applied in the awarding of licenses¹²⁷</p>	<p>The standard practice in the DRC is for the state company Gécamines to be involved in the allocation of licenses. It will assign licenses to corporate entities and then sell shares of these entities to actual mining companies. This is despite the Mining Code requiring competitive tenders.¹²⁸</p>	<p>Reform regarding the role of Gécamines in the licensing allocation process would lessen the risk of corruption. Government should follow a transparent licensing regime that provides clear terms and conditions and that in practice, licenses are awarded on a merit system.</p>	<p>Support the existing oversight functions including EITI to limit discretionary licensing decisions and political influence, such as by using competitive tenders whenever appropriate; standardizing, automating and publicizing the licensing process; adopting robust and transparent qualification criteria; and involving oversight actors in the process.</p>

¹²⁷ NRGJ, 2022

¹²⁸The Carter Center has reported that while the Mining Registry controls all granting and withdrawal of mining licenses, Gécamines regularly usurps its power and is the de facto gatekeeper, making proper management of licenses difficult. Carter Center, A State Affair: Privatizing Congo's Copper Sector (2017), www.cartercenter.org/resources/pdfs/news/peace_publications/democracy/congo-report-carter-center-nov-2017.pdf

	<p>The bidding process for exploration and mining rights lends itself to irregular transactions.</p> <p>While the DRC has the basic elements in place for a “satisfactory” governance licensing process according to the latest Resource Governance Index, in practice significant problems exist. Licensing is not done openly, nor are contracts consistently disclosed. On the Worldwide Governance Indicators for “rule of law” and “control of corruption” the country scored respectively just five and six out of 100.</p>	<p>The current bidding process could be replaced by a “first come, first served” system that would increase transparency.</p>	<p>Encourage limited bidding processes and support the country’s move to a first-come, first-served open entry license allocation system.</p>
<p>3. Tax Stability and Attractiveness has become an issue in the DRC due to frequent changes in tax rates and conditions. The rise and fall in cobalt prices may have challenged some companies.</p>	<p>After the cobalt price rose between 2016 and 2017, the government increased the royalty rate from 2 percent to 3.5 percent and then to 10 percent as part of a major revision to the country’s Mining Code. Miners in the DRC then faced the highest royalty rate on cobalt in the world. The DRC had a high overall effective tax rate. The fact that royalties comprise such a large share of the DRC’s overall mining tax regime makes it highly regressive—the tax burden as a proportion of company profits rises when the price falls.</p>	<p>Governments, including in the DRC, might benefit from a middle way. Rather than change the royalty rate unpredictably, which investors have long said makes a country less attractive and is often delayed in response to the price rise, a sliding royalty might be better.¹²⁹</p>	<p>Reform of tax laws, especially the role and rates of royalties and how these are calculated.</p>
<p>4. Attraction of exploration investment is limited: While Southern Katanga has been extensively explored, with studies being conducted to advance the knowledge base on the geology and distribution of mineralization, the vast majority of concessions outside southern Katanga have remained underexplored.</p>	<p>Only 11 percent of the national territory is covered by mining activities with 3,053 different permits granted. Most of this area has yet to be discovered through geological and mining research.¹³⁰</p>	<p>There is a lack of sufficient numbers of highly skilled people with mining science backgrounds in the labour force, necessitating the import of these skills and raising costs.</p>	<p>Capacity building and training in the mining sciences at the tertiary level coupled with on-the-job apprentices and mentoring programmes should be supported (see HR section below).</p> <p>Up-grading of government laboratories to support exploration sampling analyses.</p>

¹²⁹ <https://www.fraserinstitute.org/studies/annual-survey-of-mining-companies-2020>

¹³⁰ NRG, 2022

		Lack of laboratories with sufficient technical capacity means that companies must send ore samples to Zambia and South Africa, increasing costs and creating delays. Most of the local laboratories offer only inspection analyses.	<p>Increased funding into geological database development, collection of data and security of data systems would increase private investment in exploration.</p> <p>Use of modern data interpretation techniques (artificial intelligence) could provide new insights into existing data for a limited cost.</p>
5. Positioning the DRC mining sector to take advantage of the increasing global demand for critical minerals.	Lack of Climate Action (critical) Minerals Strategy that helps to identify priority mineral development and prioritises problem areas requiring attention (i.e.caused by security issues or lack of transportation infrastructure)	Strategy for Climate Action (critical) Minerals: Develop a sector strategy for climate action minerals including mineral demand forecasting, assessments of main and by-product supply, retreatment of mine residues/tailings; coordination with the Chamber of Mines in the DRC.	<p>Assistance in development of Climate Action (critical) Minerals Strategy that would be consensus-based and involve mining industry, government and civil society in its development.</p> <p>Support for government in providing data for companies to reassess old geological surveys that may reveal previously overlooked resources. Governments should also be ready to license projects that were previously unviable.</p>
6. Energy Infrastructure development support for mining companies may be needed to address potential future shortfalls in energy supply.	There may be insufficient power availability to support the increase in mining from hydro-electric power; companies may have to source their own energy, adding significantly to cost and potentially adding GHG emissions to the country's inventory.	Support to develop clean energy availability in the DRC will add to investor confidence and will likely result in increased investment in the minerals sector, particularly for CRMs.	<p>WBG support for green energy projects, including the development of the Inga Dam project (in addition to what is currently being delivered by the WBG in terms of energy support)</p> <p>Rehabilitation of older hydro-power plants and construction of new ones</p> <p>Encourage government to provide industry incentives for them to switch to clean energy sources for mining vehicles, equipment, etc.</p>

<p>7. Other infrastructure support includes roads, railways, and ITC¹³¹</p>	<p>1. Road and transportation infrastructure: The DRC has vast landlocked regions, which can hamper the transport of mining inputs and goods.¹³²</p> <p>2. Water Infrastructure: The mining industry requires a significant amount of water for operations and is hampered by the lack of availability of this resource (that could be exacerbated by climate change).</p> <p>3. Telecommunication infrastructure is weak or lacking in many remote parts of the country, particularly where mining operations may be located.</p>	<p>1. Developing quality road networks and transportation infrastructure would enable easier transportation of inputs and products mined in the DRC.</p> <p>2. Investing in the development of the water infrastructure, such as treatment facilities to turn wastewater into potable water and the establishment of efficient pumping systems and water storage facilities, would ensure reliable supplies of clean water to mining companies and nearby communities.</p> <p>3. Investing in telecommunication infrastructure, such as fiber optic networks, would connect mining operations to global markets and</p>	<p>1. WBG Investments into the road and rail network, particularly after a needs analysis to determine linkages to priority mineral reserves¹³³</p> <p>2. Investments into water treatment facilities</p> <p>3. Investments into fibre optic networks</p>
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¹³¹ Roads: The copper/cobalt mining areas are often located in remote parts of the country, far from major cities and towns. As a result, the roads connecting the mining areas to other parts of the country are often poor quality and in need of repair. However, major roads such as the National Route 1 and the National Route 3 are used to transport copper/cobalt to other parts of the country for processing and export.

Railways: The DRC has a railway network that connects the mining areas in the southeast to the Atlantic port of Matadi. The mining companies use this railway to transport copper/cobalt concentrates to the port for export. The railway network is operated by the national rail company, Société Nationale des Chemins de Fer du Congo (SNCC).

River transportation: The DRC has several major rivers, including the Congo River, which is the second-largest river in the world. River transportation is used to transport copper/cobalt concentrates from the mining areas to the Atlantic port of Matadi, especially during the rainy season when road transport is difficult.

¹³² Another lithium potential project in the DRC is associated with the Bisie tin project, is located in the province of North Kivu, close to the border with Rwanda. The project is located in a remote area, and the nearest major road is the N2 highway, which runs approximately 200 km to the west of the project. The Bisie project site is also not located near any major rail lines. It is important to note that while there are some roads and rail lines near the lithium deposits in the DRC, the transport infrastructure in the country is generally poor, and many areas are difficult to access due to the challenging terrain and lack of infrastructure.

¹³³ The Manono Lithium Project comprises PR13359, which covers 188km². The Manono Project is located 500km due north of Lubumbashi in the south of the Democratic Republic of Congo (DRC) in central Africa. The project area can be accessed from Lubumbashi by a 1.5 hour flight or by road. Infrastructure in Manono and the surrounding areas is limited. Power is currently generated at the Manono township using diesel generators and a recently commissioned solar power system. Dathomir has agreed to facilitate the rehabilitation of Piana Mwanga hydroelectric power station and the road from Lubumbashi to Manono. The road is subject to a US\$285m upgrade presently being completed. There is an abundance of good water supply for both local consumption and any potential mining operation at Manono. Other consumables are bought locally and supplemented by goods brought in from Lubumbashi and Kalemie to the North. <https://www.nsenergybusiness.com/projects/bisie-tin-project/>

		<p>improve communication between regional mines in the DRC. This would enable the DRC to leverage the global markets for its mining exploitation.</p>	
<p>8.Human Capital Formation: Government and industry commitment is needed to meet demand for existing skills, and to develop new skills for mining in the energy transition.</p>	<p>Chronic Skills Shortages exist for all levels of mining-related occupations; this problem can delay mining project development, construction, operations, and management of mine closure. This problem can also limit the benefits sharing through a lack of employment opportunities as key roles are filled (even on a temporary basis) with skilled foreign workers.</p>	<p>Implementation of employment equity and training/educational measures to address skills shortages. These include:</p> <p>STEM @ secondary education level;</p> <p>Technical programs for skilled artisans (electricians, mechanics, etc.);</p> <p>Post-graduate engineering, social and environmental programs;</p> <p>Equal employment for women; and equal education opportunities for women and girls;</p> <p>Attraction and ease of permitting for temporary use of expatriate staff and expert international consultants</p> <p>Ensure opportunities for on-the-job training to transition to a fully domestic workforce.</p>	<p>Funding for Mining Sciences Training and Education at Tertiary Level (Universities and TVETs).</p> <p>Build the capacities of university laboratories and national institutions, including MEDD, INERA, MettelSat, MINAT, Ministry of Planning, Federation des Entreprises du Congo (FEC, Federation of Businesses of the Congo).</p>
Climate Change Mitigation			
Opportunity	Barrier	Enabler	Potential WB Engagement
<p>1. Application of legal, financial, and technological measures to manage carbon, discourage use of fossil fuels and reduce production of GHGs.</p>	<p>The DRC government had proposed a 50% carbon tax in a previous budget statement, causing strong negative reaction from domestic and international investors.</p>	<p>A new carbon tax and carbon market Regulatory Authority have been proposed that will bring the country's legislation in line with the Paris Climate</p>	<p>Assistance with implementation of Carbon Tax and setting up of the new Carbon Market Regulatory Authority.</p> <p>Encourage amendment of legislated exploration and mining rights requirements to include carbon pricing at the feasibility stage.</p>

		<p>Agreement and enhance domestic revenue collection.¹³⁴</p> <p>The country is also pushing forward the NDC implementation (as part of the same package as the new Carbon Tax)</p> <p>Companies should be required to include internal (shadow) prices for carbon on feasibility studies.</p>	<p>Support NDC implementation through financial contributions and technical support.</p>
<p>2. Energy Efficiency: Implement measures to decarbonise electricity and encourage private sector to adopt energy efficiency strategies and technology.</p>	<p>Without legal requirements, financial incentives or access to alternative energy companies may not transition from fossil fuel powered vehicles, machinery and equipment</p>	<p>Energy Efficiency: Require mining companies to report on energy consumption (all forms) in accordance with GHG Protocol.</p> <p>ESIA/ESMP: Projects for carbon credits/offsets, decarbonizing fossil electricity and liquid fossil fuels to go through mining project ESIA process.</p> <p>Replacement of Liquid Fossil Fuels:</p> <p>Facilitation of replacement and/or decarbonization of liquid fossil fuels (electrification, biofuels, hydrogen, EVs)</p>	<p>Support strengthening of legal framework and provision of financial incentives to encourage energy efficiency contributions of the mineral sector.</p>
<p>3. Climate mitigation strategies can be added to existing legal ESIA/ESMP requirements to provide an efficient mechanism for controlling climate change induced impacts and for monitoring implementation.</p>	<p>Current ESIA and ESMPs do not specifically include requirements related to estimating lifetime scope 1 and 2 emissions.</p> <p>Mine Closure requirements do not incorporate strategies for use of old mine infrastructure for climate change mitigation repurposing</p>	<p>ESIA / ESMP: Implementation of “Best Available Technologies” go through mining project ESIA/ESMP process.</p> <p>ESIA / ESMP: Require lifetime Scope 1 & 2 emissions estimation as part of ESIA/ESMP process (and to be amended throughout lifecycle of mine)</p> <p>Post-Closure and Land-Use planning: Government to develop a strategy for</p>	<p>Assistance with appropriate climate change mitigation revisions to environmental policies and/or legislation.</p>

¹³⁴ <https://www.orbitax.com/news/archive.php/Democratic-Republic-of-the-Con-52011hnology>

		repurposing and use of abandoned mines for climate mitigation outcomes.	
Climate Change Adaptation			
Opportunity	Barrier	Enabler	Potential WB Engagement
1. Opportunities to involve the private sector in the implementation of the next phase of the country's adaptation strategy included in the National Action Plan (NAP) which states, "When approaching climate change, in particular adaptation, it is important to recognize the crucial role that the private sector plays in ensuring the livelihoods and security of a vast percentage of the population."	Lack of private sector (mining) participation in the development of the adaptation component of the current NAP disengages the mining sector from the country's climate change goals. Mining companies are not required to include climate adaptation strategies in their social investment contributions.	Private-public sector partnerships to assist in the implementation of the adaptation strategy in the NAP. The sector should be encouraged to participate in the consultations while preparing successive NAPs According to the current NAP, the expectation is that it is the role of the private sector, through corporate social responsibility, to promulgate and finance any new policies emerging from the NAP that are relevant to their business practices.	Support for the stated objective to involve the private sector in the NAP: During a second phase of the NAP project, a public-private partnership, as well as tools, methodologies and approaches for the private sector should be developed. ¹³⁵
2. Increased Environmental Protection focus is needed due to higher critical mineral demand that could encourage further expansion of mines into environmentally sensitive areas. This could lead to more rapid deforestation and other negative impacts caused by mining in sensitive areas (biodiversity, etc)	Weak government capacity to monitor ESAs coupled with environmental degradation caused by illegal and/or unregulated ASM threatens environmental protection: loss of habitat and reduced biodiversity, soil erosion, river siltation, deforestation, air/water and soil pollution from increased use of chemicals for mineral processing are all environmental risks and may be accelerated if not managed well.	Stronger technical capacity and more financial resources would assist government to regulate environmental protection more effectively; formalisation of ASM would bring more mining activity under the regulatory framework.	Support for governments (both national and provincial): to apply the World Bank's forest-smart mining practices, to improve capacity for inspection and monitoring as well as licensing management; and to manage artisanal miners (formalisation) better, especially environmental impacts.
3. Water Management Strategies are needed for the mining sector to cope with various levels of water availability (droughts and floods)	Climate change is expected to increase the frequency and intensity of extreme weather events, such as floods and droughts, which will affect water availability and quality.	Taking the lead from relevant governmental strategies regarding water availability and use, the mining industry can implement water management strategies, such as efficient water use, wastewater treatment, and rainwater	Support the development and implementation of government's water management strategies through national development plans and water-specific planning processes.

¹³⁵ National DRC Adaptation Plan to Climate Change, 2022-2026. DRC-NAP_EN

	Competition of the water resource between users (communities, agriculture, forestry and farming) may become more frequent and acrimonious, creating conflict and threatening the “social license to mine.”	harvesting to reduce risks to operations and nearby communities.	
4. Climate Risk Assessments must be undertaken by the mining sector to plan for and mitigate climate change risks early on in the mining lifecycle to avoid problems caused by climate change (landslides, slope instability, etc.)	Climate change impacts must be taken into account during the mine’s design and development stage; otherwise, there are risks that tailings facilities may fail and cause spills if there is increased precipitation that affects the stability of the tailings pond.	Revisions to environmental legislation to include the planning for climate change risks in the early stages of mining through to mine closure planning will require companies to do advance planning and minimize the risk of spills and other accidents (related to other hazardous materials containment such as stored chemicals, oil in fuel barrels, etc.). Mining operations should develop emergency contingency plans to address potential disruptions caused by extreme weather events or other climate-related impacts. This will enable mining operations to respond quickly to emergencies and ensure that business continuity is maintained.	ESIAs (or other relevant legislation) should require the mining operator to conduct a climate risk assessment: Assessment of the risks that climate change poses to mining operations, communities, and supply chains in the region. This will help identify areas of vulnerability and inform decision-making for adaptation planning. Require the mining sector to adopt international standards in tailings dam management.

Resilient Mining Affected Communities

Opportunity	Barrier	Enabler	Potential WB Engagement
1. Opportunities presented by the energy transition to address long-standing access to energy issues for communities in the DRC could support new mining projects, radically transform the economy, and create economic growth.	Almost all rural communities lack access to energy, thereby impeding socio-economic development, access to education; cellphone communication, and SMME development; lack of energy negatively impacts women’s opportunities, in particular to participate in the formal job market (due to onerous family responsibilities created by lack of energy).	Sales of energy by mining companies to national energy facility SNEL: mining companies that are producing their own energy from alternative sources can fortify the national grid through direct sales, thereby assisting the country’s economic growth. Access to mobile energy facilities for communities that provide local supply to mining-affected areas would strengthen the local mining	Formalise public-private sector partnership arrangements and enabling frameworks for mining companies to sell energy to the national energy service provider, SNEL. Access to alternative, mobile energy programmes for mining communities should be prioritised to increase energy access. SMME (mine supplier capacity development) could focus on provision of energy

		supply chain (sourced from community businesses, etc.) Mine closure planning should be required to include climate change mitigation measures aimed at lessening these impacts on communities residing near mining projects (that may be affected by mine tailings containment failure, etc.)	related goods and services (solar lights, mini-generators, etc) Mine closure planning must be undertaken at the beginning of the mine development stage and include climate change mitigation and adaptation strategies
2. Gender-based support related to mining and climate change: women suffer more negative impacts of climate change in mining-affected communities	Women are often the single heads of households with family responsibilities – they suffer disproportionately the effects of droughts on farm land or access to water; women are often involved in dangerous and/or unhealthy (mercury) ASM operations as a response to poverty and lack the means or the training to pursue alternative means of livelihoods.	Programmes developed to address the impacts of climate change on women, particularly, as well as skills development could assist in increasing employment prospects and opportunities and gradually reduce the numbers of women engaged in dangerous ASM activities.	Support the development of a gender-based strategic plan to strengthen the resilience of indigenous women to the effects of climate change, particularly in mining-affected communities Support for a gender-mainstreaming plan focused on the National Action Plan for Climate Change and other relevant development plans Support for training and capacity building aimed at women in mining-affected communities to provide alternative sources of employment (particularly related to current participation in ASM)
3. Build Climate Change Resilient Communities through CSR	Current CSR requirements do not necessitate the inclusion of climate change mitigation and adaptation strategies throughout the mining lifecycle for affected communities.	Mining companies can build strong partnerships with local communities to better understand their needs and vulnerabilities to climate change. This will allow for more informed adaptation planning and ensure that the needs of communities are considered in decision-making.	Community-Mining Community Development Agreements should be revised to include a requirement for companies to address climate change impacts in these or similar instruments.

<p>4. Formalization of ASM (particularly gold, cobalt and copper mining) needs to be accelerated as the demand for these critical minerals increases. Artisanal and small-scale mining represents the primary source of income for many families, and a boycott would lead to further precarity.</p>	<p>ASM is a response to rural poverty and is difficult to eradicate. Roughly 2m people in the DRC are involved in the ASM sector; better management is needed as the rush for critical minerals will intensify in the coming years, potentially resulting in greater numbers of ASM illegal operations (fueling conflict and contributing to higher levels of crime, environmental degradation, child abuse and gender-based violence)</p>	<p>Reward demonstrated improvements in formalising artisanal mining: Conditions in artisanal and small-scale mining in the DRC are problematic, and it is highly improbable for them to reach international standards in the near future. In this case, it may be better for long term development to devise a series of midterm benchmarks which would allow artisanal miners to reach international standards progressively. Progress made toward formalising the sector should be rewarded over a set period of time. A first step could be to prevent children and pregnant women from working on the sites.</p>	<p>The DRC should receive support for the better management and control of official “artisanal mining zones” (ZEAs) in which cooperatives have the rights to mine. This would also reduce the potential for conflict between artisanal and large-scale miners.</p> <p>The WBG should provide capacity-building efforts to improve oversight and control and redouble its efforts to improve the conditions in upstream mining projects across the DRC.¹³⁶</p> <p>Support to the Enterprise Générale du Cobalt (EGC) established in 2019, which was set up to strengthen a responsible cobalt sourcing standard and buy ASM-produced cobalt.</p>
<p>5. Strengthening of the Mineral Supply Chain for ASM production of critical minerals is needed to curb illegal mining and the fueling of conflicts.</p>	<p>Human rights abuses attached to illegal ASM throughout the supply chain include poor worker conditions and wages, child labour and environmental degradation. These negative impacts caused by illegal mining may increase due to accelerated demand for critical minerals; Lack of integrated governance within the GLR impede progress of various due diligence schemes; lack of harmonised tax and customs regimes can lead to increased illegal mining and smuggling</p>	<p>Harmonisation of trade regulations across the GLR; increased support for industry due diligence schemes that stress compliance with various international regulatory requirements (EU Conflict Minerals Regulation and Dodd-Frank, OECD)</p>	<p>Support the Due diligence programs currently active in DRC. These include the abovementioned ITSCI and Better Mining programs. Certification programs include the Certified Trading Chains initiatives by the German government and the Congolese government Initiative for the Traceability of Artisanally Mined Gold (ITOA). There are also many responsible sourcing and community initiatives that target 3T (Madini kwa Amani na Maendeleo, Solutions for Hope, etc.) gold (Peace Gold project, Just Gold, Zahabu Safi, Women of Peace, etc) and cobalt (Her Security, Cobalt for Development, Mutoshi Pilot Project, etc.). Finally, there are a number of monitoring and reporting initiatives, such as Kufatilia and Matokeo.</p>

¹³⁶ <https://dgap.org/en/research/publications/climate-and-environmental-security-democratic-republic-congo#Equitable%20Energy>

Annex 7. Background on lithium-ion batteries and the need for cobalt

Lithium-ion batteries have been around for some time and was commercialized in 1991 with the introduction of the Sony Camcorder and has since evolved into a technology that can be used to propel a vehicle in a manner that can compete with gas powered ICE vehicles. The battery works by propelling lithium ions from the cathode to the anode during charging and discharging and the commercial cathodes include those described in the table below and the anode is typically graphite. Current collectors are aluminum on the cathode side and copper on the anode side. The design of the vehicle and the auxiliary equipment are tailored to the battery chemistry, and it is difficult to even tweak the chemistry, let alone change a component such as the cathode, during the design life of the vehicle. For one, the cost to build the infrastructure to support the EV industry is great and all work in a streamlined system that is difficult to modify. Therefore, cobalt is a part of many EV strategies from the auto sector and will continue to do so over the next decade.

Table A3 - With the exception of LFP all commercial cathodes used in EV battery packs contain cobalt

<p>LCO: Lithium Cobalt Oxide: (Electronics only)</p>	<ul style="list-style-type: none"> Used primarily in portable electronics (cell phones, laptops, cameras, etc.). Limiting factors such as low thermal stability (low safety) and high cost have made this cathode unappealing for the EV industry. However, further study of LCO as a reference cathode has provided researchers with more information about cobalt's properties within high nickel systems.
<p>LFP: Lithium Iron Phosphate: (Light duty EVs in China including Tesla vehicles built in Shanghai, electric busses and stationary energy storage)</p>	<ul style="list-style-type: none"> LFPs have the best thermal stability (high safety) of all the cathodes used today but have a low energy density (capacity) compared to high nickel cathode chemistries and therefore, were not pursued by the EV industry outside of China. Currently used in ~97% of electric buses and has become the staple cathode technology in stationary storage applications. LFP was the cathode chemistry of choice in China's first EV wave because of the availability of iron deposits within the country, however, as China's regulatory push that favored battery chemistries with increased energy density, NMC became the top choice of major EV manufacturer. Nonetheless, pack design improvements by CATL and BYD where the module of the battery pack has been removed have seen a resurgence in LFP and the U.S. DOE has set a goal of having the first LFP processing plant in the country by 2025.
<p>LMO: Lithium Manganese Oxide: (1st Generation EV)</p>	<ul style="list-style-type: none"> LMOs were essentially the first battery packs deployed in EVs, but since they have a much shorter lifespan as manganese deteriorates quite quickly especially in high temperatures, it was replaced by NMC.
<p>NMC: Lithium Nickel Manganese Cobalt Oxide (Prominent cathode chemistry outside of Tesla)</p>	<ul style="list-style-type: none"> Improving the NMC cathode continues to be the focus of battery designers and researchers. While the goal here is to reduce overall costs by reducing cobalt content, we are also seeing nickel-rich, no cobalt cathode technologies in the pipeline by introducing aluminum (NMCA). A major concern is that the higher the nickel content used, the better the energy density, but the <u>more unstable</u> the battery. Therefore, much of the current research on NMC is about understanding the behavior of nickel and finding out more about why cobalt is such a critical component.
<p>NCA: Lithium Nickel Cobalt Aluminum Oxide</p>	<ul style="list-style-type: none"> The NCA chemistry is most notably used in Tesla/Panasonic batteries, so NCA's potential is somewhat tied to Tesla's prospects. It is similar to the NMC chemistries that have increased nickel content in many ways but is more costly and has some safety issues that make it less attractive for more reasonably priced EVs as

(Tesla's chemistry choice for high end vehicles and its truck line)	considerable costs must be allocated to the battery management system. However, Tesla is moving quickly towards a non-cobalt NCA formulation.
NMC + NCA = NMCA (GMs new Ultium battery)	<ul style="list-style-type: none"> The combination of NMC and NCA is being pursued to increase energy density, reduce or eliminate cobalt and the addition of aluminum to enhance fast-charging capabilities. There is a reason why this is the GMs new chemistry of choice. Furthermore, zero-cobalt versions in development such as NMA (nickel, manganese, aluminum) and NFA (nickel, iron and aluminum) is in no doubt a product of this research.

Nickel's potential as a cathode material has been extensively studied over the last few decades. It has a higher specific capacity compared to other battery materials, performed better than the cobalt-only (LCO) and manganese-only (LMO) commercial cathodes that were used in many first generation EVs such as the Nissan Leaf and exhibited higher charge rate performance. Nickel-only cathodes (LNO) have high exothermic heat flows (33W/g) compared to other materials such as LFP (-6w/g) and this instability translates into a higher probability of thermal runaway that leads to battery fire. Therefore, a variety of metals have been assessed to improve this instability and today's commercial cathodes now contain various quantities of manganese, cobalt and aluminum and this substitution enabled the large-scale battery infrastructure and EV growth that we see today.[3] Cobalt in particular, stabilizes nickel in a unique way during vehicle operation and is needed to economically facilitate making these high nickel cathodes in the first place.

The main problems with high-nickel (Ni>80%) and nickel-only (LNO) cathodes are the following:

1. Layered high-nickel and LNO is hard to produce (off stoichiometry, Li/Ni mixing, etc.) and Ni²⁺ ions wreak havoc on the system and interfere with lithium intercalation.
2. The migration of nickel ions (interlayer mixing) cause irreversible creep, cracking and layer bending of the cathode leading to more rapid degradation of the overall battery pack.
3. Large structural phase changes occur when nickel content is above 80% that deteriorates the electrochemical properties of the cathode and causes microcracks loss of active material, rapid capacity degradation and side reactions with the electrolyte leading to thermal runaway and battery fire.
4. Poor thermal stability as high nickel layered oxides experience high exothermic energy release at a lower temperature leading to a higher probability of and coulombic efficiency

Elemental substitution of nickel with alternative dopants:

- A. Cobalt (NCA and NMC):
 - Reduces the interlayer mixing of lithium and nickel within the cathode structure as Co³⁺ does not have a magnetic moment and appears to stabilize the
 - Enhanced the intercalation and de-intercalation of reversible lithium in and out of the cathode
 - Reduces the impact of multiphase transition that occurs during charging and discharging
 - Improved cyclability and high-powered capabilities
- B. Manganese (NMC):
 - Cheap element compared to cobalt and nickel, but reduces specific capacity

- Improves structural stability by suppressing some of the phase changes that occurs when LNO is charged and discharged.
- Reduces the amount of oxygen released in the system compared to NCA chemistry

C. Aluminum (NCA):

- Increases lithium intercalation potential
- Prevents high nickel cells from overcharging.
- Suppressed all phase transitions when LNO is charges and discharged
- Can only be used below the 5% level due to the inertness of aluminum but has been able to improve cell performance and life cycle of NMC89 to produce NMCA with 89% nickel content compared to NCA90 and NMC90 (nickel content of 90%).
- Stabilizes the crystal structure for fast charging and increased vehicle range

Zero Cobalt High Nickel Formulations are in development but offer lower specific capacity. For example:

- **NFA:** Developed by Oak Ridge National Laboratory, NFA cathodes contain nickel, iron and aluminum at early research has yielded specific capacities of ≈ 200 mAh g⁻¹ and cycling stability with $\approx 80\%$ capacity retention after 100 charge/discharge cycles.
- **Complete:** NMA, LMN, DRS

Annex 8. Country case studies¹³⁷

This section of the report elaborates a set of global case studies that the Congolese and potential battery industry investors and the government may refer to while making policy decisions. These case studies include analysis of the development and policies in battery value chain in other countries. These countries have already progressed or are planning to progress to increase their participation in the battery value chain:

1. Western Australia: Future Battery Industry Strategy
2. Indonesia: Nickel Ore Ban and Consortium Creation for Smelting and Processing of Nickel Ore
3. Indonesia & Ethiopia: Engaging Global Companies for Localization of EV and Cell Manufacturing
4. India and Thailand: Cell Manufacturing Subsidy Programs
5. Global and Regional: EV and Charging Infrastructure Roadmap: Adoption Targets till 2030

These programs have several common elements, and generally focused on the following:

- Economic incentives for attracting investment
- Project Facilitation by making readily available land and supporting infrastructure
- Research and technology development (so that industries can remain competitive long term)
- Creation of domestic demand for adoption of battery technology
- Partnerships and skills development
- Regional collaboration (and across countries)

In the case of Indonesia, which had a favorable geographic position relative to target markets and access to cheap energy, export bans on unrefined products were used with mixed results, and pending trade disputed with the World Trade Organization.

Western Australia: Future battery industry strategy

Future Battery Industry Strategy developed by Western Australian Government in 2019 is an effort in this direction to make Western Australia a central player in the global battery manufacturing supply chain. To achieve this, a well-informed framework is prepared that builds on the existing expertise of mining and mineral processing.

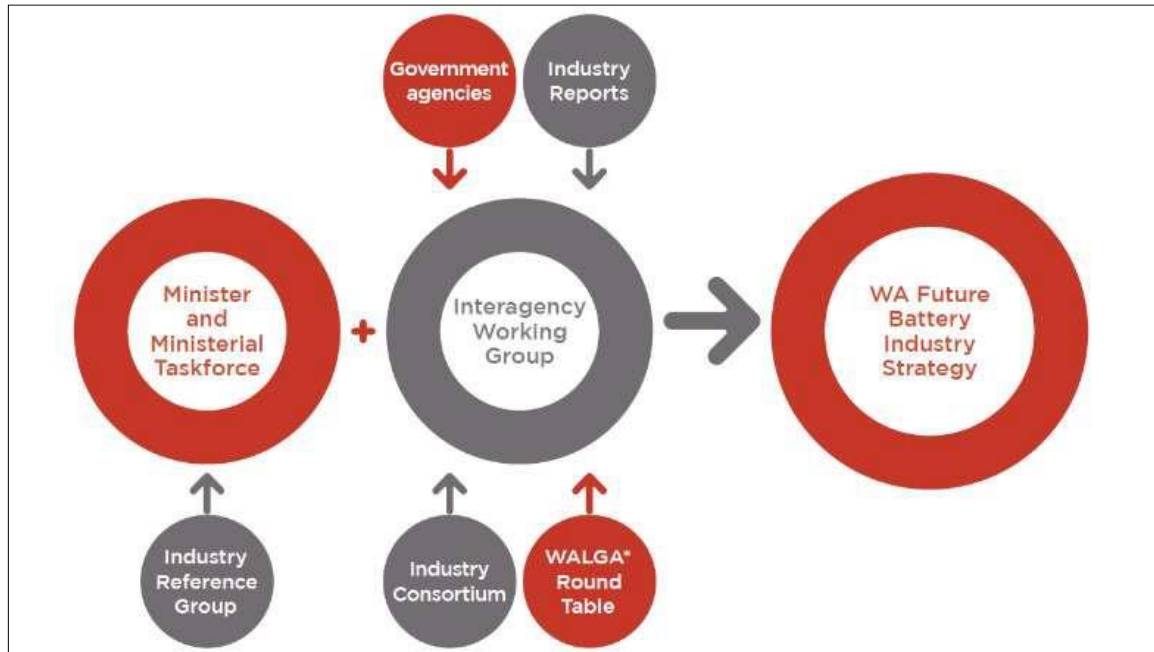
As mentioned in the Western Australia's Future Battery Industry Strategy document, battery related mineral export from WA (Western Australia) constitute one third of Australia's exports and 4% of total global supply, making it an important player in the upper stream of the battery supply chain. Ideal future pathway is increasing the local value addition in the further stages of supply chain. As an initial step, supply chain is divided into different stages and maximum possible local value addition is quantified for each stage to avoid misplaced focus. Multiple supply chain stages thus identified possesses different level of technological maturity and infrastructure in place requiring different types of supporting policies in varying quantum. An optimum distribution of projects across various stages taking note of differences in type and quantity of required support, four action themes are identified.

WA Government has formed a Ministerial taskforce with an industry reference group. This taskforce continuously guided the interagency working group formed out of industry consortium and various government

¹³⁷ These cases studies are drawn from the World Bank report entitled: "South Africa & Southern Africa Battery Market & Value Chain Assessment Report", 2023.

agencies. With an input from industry reports and round table discussion, WA future battery industry strategy was formulated.

Figure A16 - WA Taskforce and process for creation of Future Battery Value Chain Strategy



WA Government will deliver its vision by focusing on 5 objectives. Following are the objectives that have been documented in the strategy report:

- 1) Western Australia to be recognized as leading producer of battery minerals and materials, technology
- 2) Improve the competitiveness of WA’s future battery minerals and materials industry
- 3) Expand the range of the future battery minerals extracted and processed in WA
- 4) Increase the scale of processing, manufacturing and service activities across the breadth of the value chain in WA
- 5) Increase R&D focused on battery materials and minerals, associated technology

Each objective is achieved by 4 cross-cutting action themes identified for the purpose of optimum distribution of supportive policies and projects:

Attract Investment: WA Government to undertake various initiatives and activities to make WA an attractive destination for international investors looking for opportunities in battery manufacturing

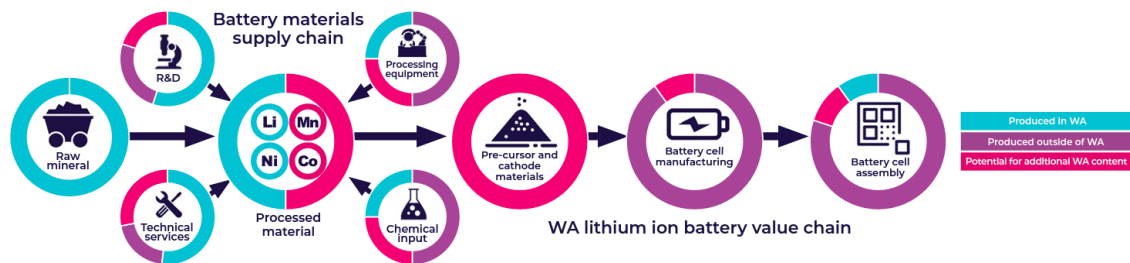
Project Facilitation: WA Government to facilitate projects by providing investment ready industrial land, reliable access to energy and water, single point entry and priority status for project approvals, export infrastructure and access to state funding

Research and technology sector development: WA Government will support research projects related to future battery manufacturing. For this purpose, research center called FBI-CRC had been established in 2019 with an initial funding of \$6 million from WA Government

Adoption of battery technology: WA Government plans to adopt battery technology for various applications to create a strong demand from domestic market that can act as a catalyst for growing battery mineral and material industry. Government envisages to achieve this by identifying innovative battery applications like grid connected battery storage in remote areas, Electric vehicles etc.

All these individual action themes, either individually or combined, will create different pathways to achieve the 5 identified objectives. With the five objectives as the guiding principles, and based on the existing mining expertise, WA Government had identified the level of opportunities available at different stages of battery supply chain.

Figure A17 – Battery materials supply chain



Raw mineral extraction involves the fullest value adding potential with Lithium and Nickel being extracted using the full potential for value addition. Manganese and Cobalt extraction have potential for more local value addition. WA Government identified manufacturing of pre-cursor and cathode materials as the stage that has highest potential for local value addition. It hopes raw material process to produce pre-cursor and cathode materials can act as a step towards further downstream value addition.

Other than Western Australia, other battery mineral mining countries like Argentina and Chile have not yet defined a clear battery value chain strategy.

Key takeaway:

To layout a national vision in the mineral beneficiation and battery raw material manufacturing plan can be the first logical step for the DRC. Only limitations of such strategy documentations are that they don't emphasize on plans of making processing more commercially viable in their particular geographies.

The DRC government, along with such a strategy documents can plan certain incentives, tailored beyond the existing SEZ regulations, to attract more companies. Incentives could be an investment in renewable energy for this sub-sector by the Government, financed by the WB. This can also be approached by restricting export of ores to an extent (though not without risks) or by providing export credits (if financially feasible).

Indonesia: Nickel ore ban and consortium for smelting & processing of nickel ore

Indonesia supplied around 30% of global nickel production for the year 2021. In line with the ever-increasing global demand for this battery material, the Indonesian Government plans to expand the capacity of its mining and minerals processing industry further. Additionally, the Indonesian Government introduced a ban on export of its nickel ore in 2019 and this ban became effective from 2020. This ban is expected to achieve the following goals: (i) preserve its nickel ore for rapidly growing domestic nickel smelting and nickel pig iron industry; and; (ii) boost the processing of low-grade nickel ore that can support the EV battery manufacturing and other nickel value added product industries.

In 2014, a similar ban on nickel ore export was imposed in Indonesia that resulted in a major Chinese stainless-steel manufacturer, Tsingshan, to invest locally in downstream nickel processing and nickel pig iron (NPI) manufacturing.¹³⁸ Indonesia's NPI production grew from zero in 2014 to 500,000 tons by 2020.

¹³⁸ NPI is a raw material used by steel industry.

This time the ban is expected to create investments opportunities in downstream activities linked to battery value chain. To process the ban induced nickel ore that is posed to accumulate in the domestic market, the Government plans to expand the capacity of its nickel smelting industry and a State holding company called Indonesia Battery Corporation (IBC) is kept in charge. IBC is formed out of four State Enterprises operating in oil exploration (PERTAMINA), mining (MIND ID), Nickel & Gold mining (ANTAM) and Electricity (PLN).

As of 2022, South Korean multi-national corporation LG had committed an investment of \$ 10 billion in activities spanning the entire supply chain from mining to precursor manufacturing in Indonesia. Smelting capacity is expected to increase with addition of eight projects with a combined capacity of 450,000 tons of Nickel and 150,000 tons of Cobalt. By 2028, Indonesia is expected to supply 60% of world's nickel compared to today's 30%.

While domestic processing requirements on nickel ore have obliged businesses to process or purify the raw materials in Indonesia prior to export, on 14 January 2021, the European Union requested the establishment of a panel of the WTO. The EU challenged: (a) a prohibition on the exportation of nickel ore and; (b) a domestic processing requirement for all nickel ore. On November 2022, the WTO panel found in favor of the EU and recommended that Indonesia bring its measures into conformity with its obligations under the GATT 1994. The issue remains unresolved as Indonesia has appealed the ruling.

Besides the potential, the Indonesian government needs to pay attention to a number of important issues that come with the export ban. The issues include: (a) state revenue loss & added value transfer, and; (b) employment.

State Revenue and added value transfer: The ban on nickel exports risks the diminution of state tax revenue from companies and export duties, and as a result, state revenues from downstream nickel industry must be able to replace the loss. Indonesia's local mining sector has to bear with the problems surrounding domestic nickel selling prices since the export ban has forced mining companies to sell their nickel ore to domestic smelters at lower prices compared to the higher international nickel price.

Employment: The ban on nickel ore exports is claimed to increase employment levels, especially in the smelting sector. However, smelting is a capital intensive, not labor-intensive activity, and data from Statistics Indonesia (BPS) show that the proportion of the Indonesian industry workforce over 2019-2022 in the basic metal and industrial metal goods industries have both decline. As a result, it is not clear if the net impact has been positive or negative on total employment in the sector.

Key takeaway:

The DRC can impose such restrictions on ore exports to boost local mineral beneficiation and processing.

To compete on this front with economies like China and India, through AfCTA, the DRC must look at the regional integration plan for battery value chains in order front to attract more investments. As such, local projects and manufacturing industries may allow processed battery materials coming from AfCTA region as part of the local content. There can be a single window facility created for clean tech investors to set up processing plants at suitable locations for mined material available in the neighboring countries.

In addition, also export and domestic processing restrictions are an option, as the case of Indonesia highlights, the policies are not without risk of violating the WTO rules. Expert legal advice should be taken to ensure measures are structured in a manner to be WTO compliant to mitigate any risk of any punitive measures.

Indonesia & Ethiopia: Engaging global companies for localization of EV and cell manufacturing

Like the DRC, Indonesia is blessed with abundant mineral resources for manufacturing of Li-ion batteries. Indonesia plans to build upon these advantages to develop an end-to-end supply chain presence. It envisages to do this by entering into joint partnerships with world renowned companies and benefit from the transfer of

technology and know-how. However, there are environmental concerns from downstream participants regarding ability of Indonesia to produce nickel without significant ecological impact. Hence, it will be important for mineral rich countries to address such issues while scaling up mining and processing operations.

As the total cost of ownership of electric vehicles in Indonesia is not competitive with respect to ICE technology, the export of EVs to foreign markets can be a short-term solution before EVs become competitive in the domestic market for Indonesia. Nonetheless, the Indonesian Government had recognized the convergence of electricity, transport, and mining sectors in the economy. In this context, Indonesia has also integrated the national electricity company PT PLN as one of the four members of the holding company IBC (Indonesia Battery Corporation) responsible for local battery value chain development.

On a smaller scale, the Nobel Peace Prize laureate, Abiy Ahmed Ali, the Prime Minister of Ethiopia, under his greening campaign has set manufacturing of electric vehicles as an important target in Ethiopia. His request to Hyundai Motors led to the company locally assembling its first EV in Ethiopia in 2020 through one of its dealerships. It is understood that the electric vehicle assembling plant set up by Marathon Motors (a Hyundai dealership) can ramp up to 10,000 cars per year with local and regional demand coming in place.

Key takeaways:



Entering the EV battery value chain is a complex activity and is new to the DRC. There are few companies globally that are present in this space and it will be important for the DRC to establish the right conditions to attract those investors, or form partnerships with them. At first this could mean less local employment opportunities for the Congolese, however over the medium to long term, the DRC must ensure if had the skills development programs in place, as well as regulations for local employee development to ensure the workforce can be eventually predominantly Congolese.

India and Thailand: Cell manufacturing subsidy programs

China, Europe, and the US are marching ahead compared to the rest of the world in terms of advanced battery manufacturing capacity, especially in Li-ion cell manufacturing capacity. It is estimated that between China, Europe, and the US, there would be close to 1000 GWh of cell manufacturing by 2025. The DRC can take inspiration from these countries for starting its own cell manufacturing program but practically it will be difficult for the DRC to attain the scale of expansion and their budget outlay around this sector.

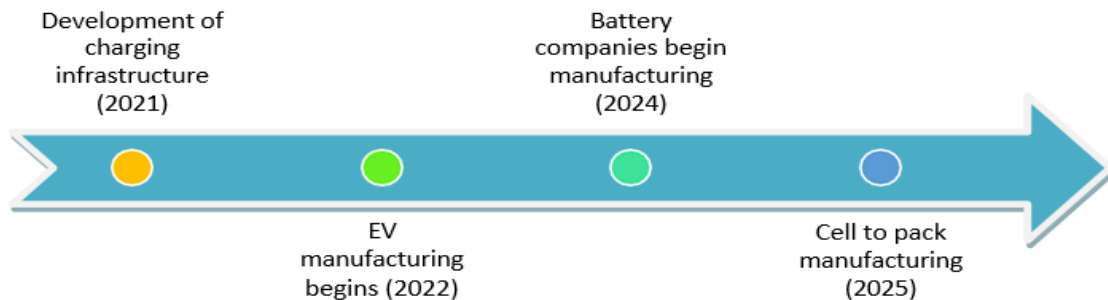
The cases of Thailand and India are studied in terms of schemes for supporting battery cell manufacturing indicating 50 GWh and 20 GWh respectively as shown in Error! Reference source not found.. ACC (Advanced Chemistry Cell) PLI (Production Linked Incentive) schemes of the Indian government is a good reference for the DRC as the scheme deals with subsidies in the form of a “production linked subsidy of up to 20% of cell price or \$30 per kWh”, whichever is lower. Under this scheme both local and international companies can bid for 5 to 20 GWh of capacities and they need to commit to 60% indigenous value addition in three years from production. Such schemes not only provide impetus for local cell manufacturing but also promotes creation of battery value chains in the country.

Figure A18 - Support programmes in India and Thailand for supporting battery manufacturing

	 India	 Thailand
Program	Advanced Chemistry Cell (ACC) Production Linked Incentive (PLI) Programme	Thailand Board of Investment (BOI) EV and components manufacturing package
Budget Outlay	\$ 2.5 Bn	\$ 1.1 Bn
Production Target	50 GWh by 2028	30% EV by 2030, estimated 20 GWh by 2025
Incentive Support	Sales linked subsidy of upto 20% of cell price for 5 years of production. Program requires local manufacturer to capture 60% of local value addition in first 5 years	3 years tax holiday, 8 years corporate tax exemption and 90% reduction in import duty on key raw materials to encourage cell and pack manufacturing The BOI approved the reinstatement of the International Procurement Office (IPO) category with the aim to strengthen Thailand's position as the regional business and investment hub.
Other Support	Apart from the ACC PLI, several state governments are also providing capital subsidy in tune of 10-25% and tax and duty exemptions on electricity tariffs/	IPO businesses will get import duty exemptions on machinery and raw materials for use in production for exports, as part of the policy to promote the development of the country's supply chain.

Indonesia, on the other hand, to cater to the expected increase in demand from the automobile industry, created Indonesia Battery Corporation (IBC) with mandate to sign partnerships with various international players for indigenous battery manufacturing. IBC is comprised of four state owned enterprises, each with a different mandate. One of the IBC shareholders, PT Pertamina, an Indonesian Oil & Natural gas company is tasked with construction and operations of precursor plants, cathode plants, battery cells & battery pack plants, and battery recycling plants. Inclusion of an oil & gas company to be in-charge of developing battery precursors, cathodes, and a battery manufacturing plant ensures avoidance of job losses in this sector. A strategy roadmap is created accordingly as shown in Figure A16.

Figure A19 - Strategy roadmap for creation of integrated battery value chain in Indonesia



As per the strategy roadmap, the Government of Indonesia has already signed MOUs with CATL and LG group. The government is optimistic about their domestic battery manufacturing capacity reaching 140 GWh and becoming a key supplier to the EU, the US, and the Asia Pacific.

Thailand is targeting 30% EV penetration by 2030. It aims to support the EV and component industry by extending tax rebates and holidays to cell manufacturing and other industries. Energy Absolute and GPSC are two Thai companies which have already announced ambitions to build Giga Factories in the country.

Key Takeaway:

Domestic demand for EV battery value chain components is an important factor. This is because as value is added to products along the value chain, manufacturers seek to source those components as close to home as possible for two main reasons: (i) to reduce potential supply chain disruptions which can affect the entire business model; and (ii) to optimise working capital. Although the penetration of EVs into the DRC is minimal to date, the DRC should think more “regionally” when considering domestic demand and work to ensure the necessary investments (regionally) in transportation infrastructure are in place to minimize logistical disruptions.

Global and Regional: EV and charging infrastructure roadmap: Adoption targets till 2030

South Africa has a large automobile manufacturing sector, though still produces only internal combustion engine vehicles (ICEs). The penetration of EVs in markets like Europe and China have crossed double digit percentages and it is very likely that the global EV sales trend, sooner or later, will impact the South African automobile market. The South Africa automobile market will need to soon pivot to producing EVs if it wishes to preserve its export market to the EU and others which have introduced bans on the sales of new ICEs beyond a certain date. By 2030 it is estimated that the demand for Li ion batteries in the South Africa would hit close to 8 GWh. Over 80% of this demand is likely to be generated by electric mobility demand. This demand in 2030 and beyond can potentially support Giga Factories. And these factories can drive local processing businesses alongside catering to the global demand.

Domestic African demand in South Africa provides the DRC has an opportunity to be part of a larger SADC regional EV battery value chain, which captures value along the entire value chain within the SADC region. SADC countries together contain all the material ingredients necessary to develop the full EV battery chain, yet current manufacturing capabilities vary but are strongest in South Africa. At first, the DRC could take steps to penetrate only the easiest parts of the value chain, but over time, it and other countries in the region could consolidate those skills and experiences and slowly build out to other steps in the value chain.

Key takeaway:

The DRC should leverage existing trade arrangements on the continent to meet emerging domestic (continental) demand for EV batteries. Within the SADC region, all the material ingredients and manufacturing capabilities exist to develop Africa’s first gigafactory.

A national strategy is first required, building towards a regional strategy. AfCFTA is being implemented in stages, while the SADC trade agreement is in place. The DRC should take advantage of these agreements to work regionally to ensure as many of the benefits stay on the African continent.



THE WORLD BANK



Democratic Republic of the Congo

Country Economic Memorandum

Case Study 1: Mining Value Chains