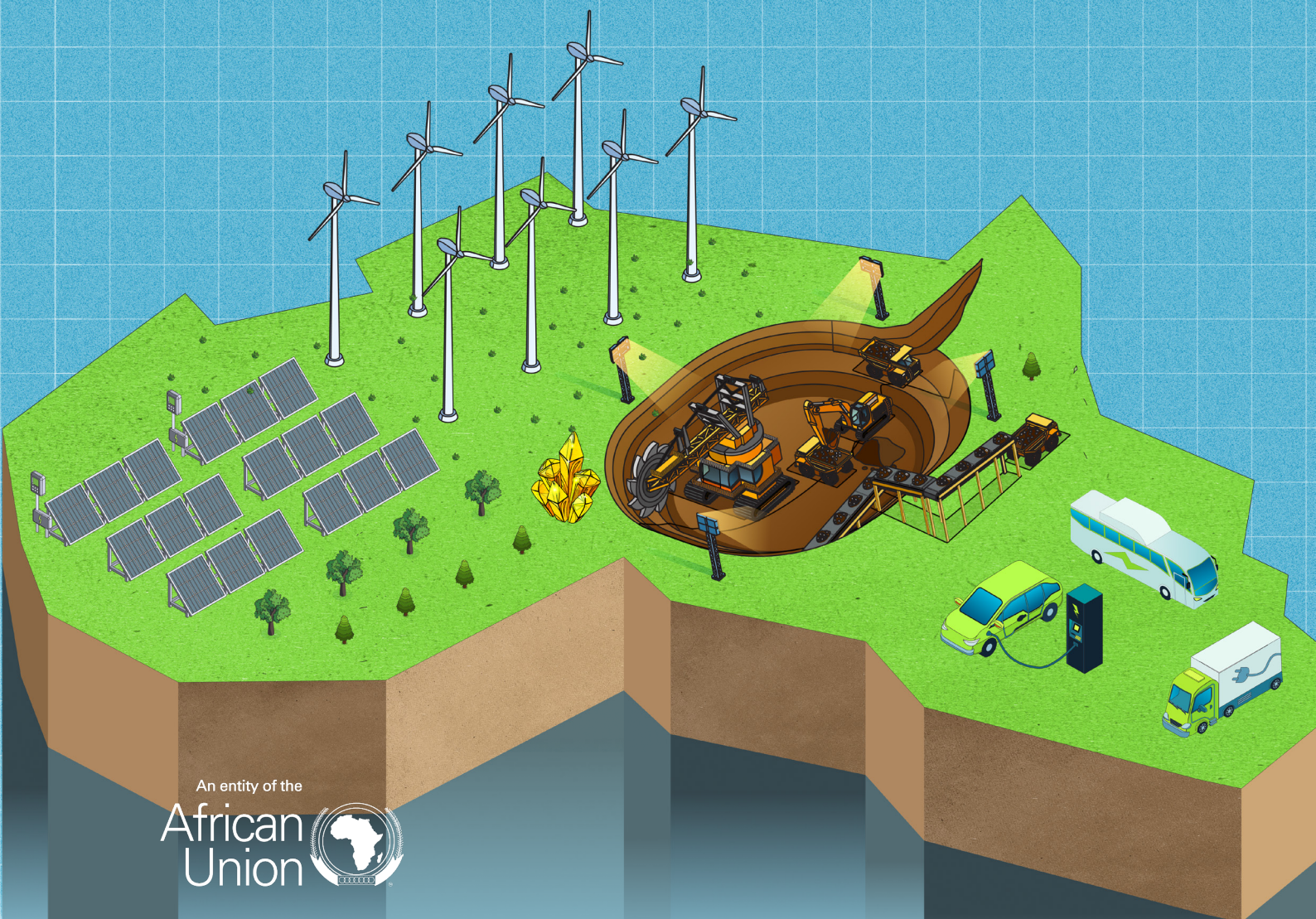




AMDC
African Minerals
Development Centre

AFRICA'S GREEN MINERALS STRATEGY



An entity of the
African Union





AFRICAN UNION'S MINERAL RESOURCES STRATEGY FOR THE JUST TRANSITION AND DECARBONISING FUTURE

December 2024

In partnership with



Preface

The African Green Minerals Strategy (AGMS) represents a defining moment in the continent's journey toward sustainable industrialization, energy security, and inclusive growth and sustainable development. With Africa holding a significant share of the world's green minerals, including lithium, cobalt, nickel, rare earth elements, and platinum group metals, the continent stands at the crossroads of the global energy transition and digital transformation. This strategy provides a roadmap for harnessing Africa's mineral wealth to drive value addition at source, regional industrialization, and climate resilience.

As the world accelerates toward net zero-carbon emission, demand for Africa's green minerals is set to soar. The AGMS recognizes that Africa must move beyond raw mineral exports and build strong, integrated value chains that foster local beneficiation, job creation, and economic diversification. The strategy aligns with the Africa Mining Vision (AMV) by advocating for equitable and sustainable mineral resource management, ensuring that mineral wealth translates into broad-based socio-economic development.

The AGMS is structured around four key pillars:

- i. Advancing Mineral Development, whose components are: Strengthening geological knowledge, exploration, and investment in mineral resource management;
- ii. Developing People & Technological Capabilities, whose components are: Building skills, research capacity, and technological expertise to maximize Africa's mineral potential;
- iii. Building Key Value Chains, whose components are: Ensuring industrialization through local beneficiation, green technology manufacturing, and mineral-based economic transformation; and
- iv. Mineral Stewardship, whose components are: Promoting responsible mining, environmental sustainability, and circular economy principles.

This strategy comes at a critical time. Africa must seize the moment to develop its battery industry, electric vehicle supply chains, and renewable energy infrastructure. The AGMS provides the framework for regional cooperation, investment mobilization, and policy harmonization to achieve this transformation.

As we embark on this journey, collaboration among African governments, private sector players and civil society will be essential in bringing this vision to life. By leveraging its vast mineral wealth strategically, Africa can contribute to the global shift toward a sustainable and green future.

We are grateful for the collaborative efforts of the African Union-African Minerals Development Centre, the African Development Bank, the African Legal Support Facility, and the United Nations Economic Commission for Africa in the development of this strategy. The task ahead is to effectively implement it.



Albert M. Muchanga
Commissioner for Economic Development, Trade, Tourism, Industry and Minerals

Acknowledgment

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Our gratitude extends to the United Nations Economic Commission for Africa (UNECA) for the insights and inputs provided, particularly to Mr. Antonio Pedro, Mr. Oliver Maponga, and Mr. John Sloan.

A special thanks goes to the team at the African Union's African Minerals Development Centre (AMDC) for their dedication, commitment and leadership in shaping this strategy and in pushing it forward for consultations and adoption by Member States. In particular, we acknowledge the leadership and guidance of Dr. Marit Y. Kitaw, Interim Director; the support of Mr. Arisekola Tunde, Senior Advisor on Geological and Mineral Information Systems; and the contributions of Mr. Mkhululi Ncube, Program Officer; Ms. Caroline Obure, Communications Consultant; Ms. Halima Goumandakoye, Policy Consultant; Mr. Theophilus Adoko, Policy Consultant; and Ms. Thuso Mogae, Administrative and Finance Assistant.

Furthermore, we extend our gratitude to Member States, Regional Economic Communities (RECs), and all other stakeholders such as civil society organizations, including women and youth, academia, the private sector, and Regional Mechanisms that provided invaluable inputs, comments and feedback during various consultations. Their contributions were instrumental in shaping discussions at the 4th Ordinary Session of the Specialized Technical Committee on Trade, Tourism, Industry, and Minerals, held in Malabo, Equatorial Guinea in May 2024, as well as the First Extra-Ordinary Session of the Specialized Technical Committee on Trade, Tourism, Industry, and Minerals held in Addis Ababa, Ethiopia in December 2024, which led to the adoption of the AGMS by the AU Executive Council in February 2025.

The collective efforts and commitment of all involved have been instrumental in developing the African Green Minerals Strategy (AGMS), with the aim of fostering a sustainable and inclusive approach to mineral resource development across the continent. By emphasizing on Industrializing and Lighting up Africa, the AGMS is poised to be the game changer towards minerals empowering Africa.

Executive summary

The world is in the early phase of a new industrial age: the age of clean energy technologies. Lower carbon emissions for the production and use of energy are essential aspects of the global commitment to achieve the Sustainable Development Agenda. In the age of clean energy technologies, greater quantities of “green” minerals are needed for the transition to Renewable Energy (RE) such as hydro, solar, wind, battery and electric vehicle industries than the fossil fuel-based ones they are replacing. Many of these minerals are sourced from Africa. Mineral supply chains are attracting greater attention. Access to raw materials is a matter of strategic importance, raising the profile of mineral producing regions and increasing their bargaining power and opportunities for Equitable Resource Based Industrialisation (ERBI). Further, Africa has exceptional resources of renewable energy, particularly hydro, solar and wind, only a fraction of which has been harnessed, but with increasing utilisation. These developments present Africa with a new set of development opportunities arising from the continent's mineral wealth and renewable energy potential. Alongside participating in global supply chains, new opportunities exist to channel minerals into industrialising clean energy industries for her own needs and ERBI.

Africa now has a chance to develop a strategy for minerals mined on the continent that are crucial in the age of clean energy technology. To highlight a few minerals used in these industries, Africa has cobalt, natural graphite, lithium, manganese, phosphorus and vanadium for batteries; bauxite (aluminium) and copper for electrical machinery and networks; chromium, nickel and zinc for wind farms, and concentrated solar power

plants and platinum group metals for hydrogen electrolyzers and fuel cells, rare earth elements for magnets in electric motors and generators, ceramics and energy efficient lights. Furthermore, Africa has iron, steel and alloys used throughout the economy, but also in renewable energy production and consumption. Grouped as “green minerals” to stimulate the development of green industries and broader industrialisation, a unified development approach called the African Green Minerals Strategy (AGMS) has been drafted. The strategy is aimed at achieving the Africa Mining Vision (AMV) goal of “a transparent, equitable and optimal exploitation of mineral resources to underpin broad-based sustainable growth and socio-economic development”. The AGMS supplements these mineral development frameworks with a specific focus on the opportunities and risks for Africa unfolding from the universal challenge of climate change and growth of new industries for a low carbon future while taking advantage of the digital economy. In respect of green minerals specifically, the draft strategic vision is:

“an Africa that harnesses green mineral value-chains for equitable resource-based industrialisation and electrification, creating green technologies and sustainable development to enhance the quality of life of its people”

4

pillars support the strategy to deliver this vision

1. **Advancing Mineral Development** by increasing geological knowledge, conducting feasibility studies to attract investment, building infrastructure for an enabling environment, establishing a Mineral Value Chain Investment Fund and aligning mineral resource management with the aspirations of the African Mining Vision.
2. **Developing People and Technological Capability** by identifying skills and technologies needed to capitalise on green minerals opportunities and the building the institutions to develop the skills and to anchor the required research, development and innovation
3. **Developing Mineral Value-Chains** to achieve equitable resource-based industrialisation (ERBI) through supply-chain development, beneficiation and value addition and access wider regional and continental markets through the African Continental Free Trade Area (AfCFTA).
4. **Mineral Stewardship** to responsibly guide the environmental, social and governance aspects of green minerals exploitation and utilisation together with material reuse and recycling.

Africa possesses six globally significant comparative advantages to realise the AGMS:

1. Africa's substantial known endowment and potential resources of green minerals.
2. Africa's huge mining inputs market (mining supply chain) which is common to all its minerals and mining-processing operations.
3. Africa's immense and diverse renewable energy potential, particularly hydro, solar, wind and bio-energy.
4. Africa's huge unrealised market for electrification of over 600 million unconnected citizens, a population of 1.4 billion people with a consequently constrained contribution to the continental economy but offering three-quarters of the global connection opportunity, particularly for local embedded clean energy.
5. Africa's youthful population as the workforce filling the growing number of occupations involved in building and servicing clean energy products and systems.
6. Africa's industrialisation potential, which is energy intensive, given the focus of member States and regional economic communities to pursue equitable resource-based industrialisation (ERBI) as the basis for modernisation and addressing of the continent's development and inequality challenges.

The growing importance mining and processing of green minerals gives Africa an opportunity to maximise the developmental impacts of extraction, as per the African Mining Vision, through the realisation of all the mineral linkages (fiscal, knowledge, spatial, backward, forward, et al) to underpin resource-based industrialisation and equitable development (ERBI). Surging demand for green minerals gives producers possibilities to move up value-chains through partnerships with importing countries looking to create secure supply chains. Producers need to act swiftly, however, to implement the AGM if they are to capitalise on this window of opportunity. Risks to avoid in the context of the geopolitical competition for critical minerals include being limited to the extractive stages of mineral value-chains, under-resourcing mineral governance institutions necessary to facilitate the development of African mining capital, neglecting the development of basic mineral feedstocks that are the bedrock of industrialisation (ERBI) and Africa's elites being compromised by foreign interests and agendas. To achieve a truly continental AGMS, unconstrained access to the African market by African manufacturers needs to become possible through deepening economic integration, moving forward with the AfCFTA and resolving lingering tariff and non-tariff barriers, plus reducing high intra-Africa logistics costs. Ideally for this Africa needs to move energetically towards Common External Tariffs (CETs) for the ERBI products (green mineral value-chain inputs and outputs). African states are at widely varying levels of development and all need to benefit from the AGMS, therefore instruments to manage "variable geometry" and "level the playing field" for weaker economies are called for. Several instruments are recommended:

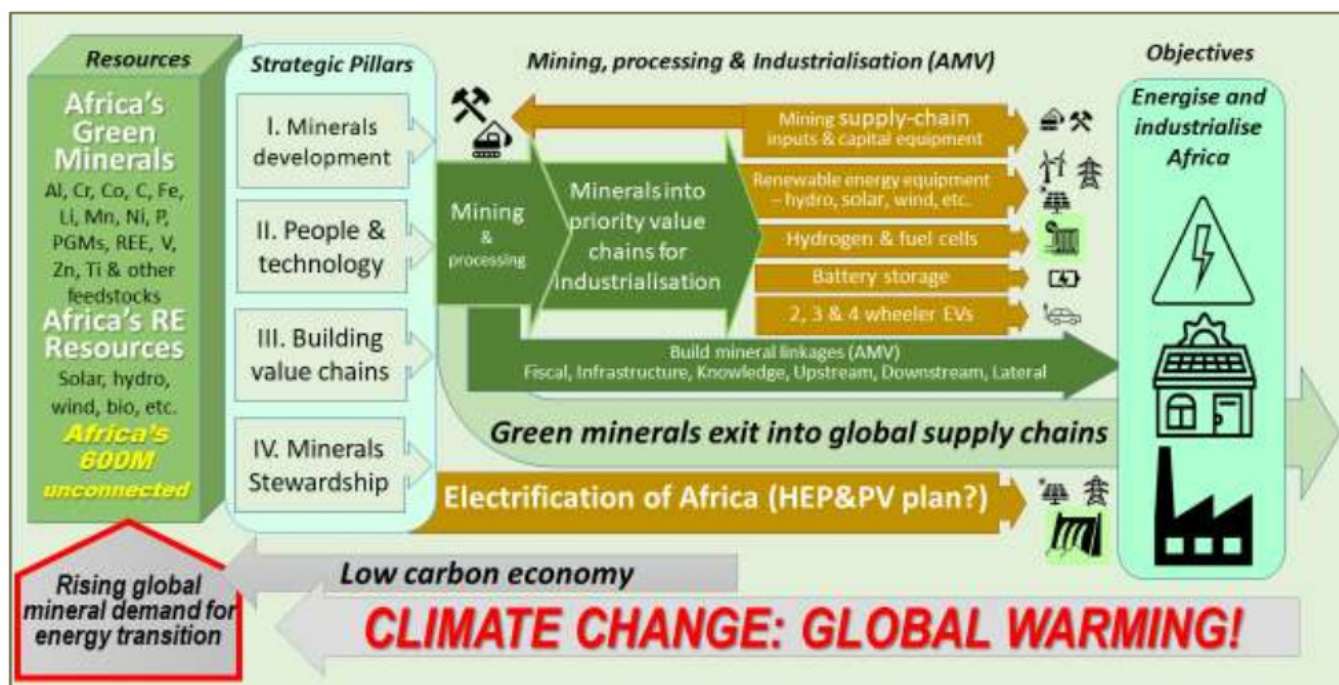
- i. Local-African Content (LAC) whereby all major African mining states introduce local content requirements for procurement of capital goods, consumables and services that recognise Africa-wide content as per the "cumulation" clause in the AfCFTA. Weighting recognition of LAC that is biased in favour of least developed member states (inversely proportional to GDP/capita is suggested) would increase the size of markets and the viability of supply-chain investment projects and stimulate regional trade.

- ii. African Green Mineral Value-chains Common External Tariff on designated Green Mineral Value-chain (MVC) products, of $\leq 10\%$ on imports of Green MVC products and exports of targeted unprocessed key green minerals.
- iii. Green MVC Investment Fund The cost of capital is so high in many African States that African firms will be unable to take up green transition investment opportunities. Establishing an African Green MVCs Investment Fund (VCF) is proposed, capitalised by foreign mining companies, development finance institutions, energy migration funds and others. Eligibility for funding could be biased in favour of least developed member states on the same lines as for LAC.
- iv. Critical skills and innovation funding on African Green MVCs by Member States harmonising their Green Minerals mining license regulations to require all investors to spend a minimum of **5%** of payroll on local STEM (science, technology, engineering and mathematics) skilling and **1%** of sales on local research & development and innovation (RDI) including data management. It is recommended this be done on a regional basis including support for Regional Green Mineral Related Centres of Excellence. Initiatives of this type have already begun.
- v. Infant Industry Protection to be considered for Member States falling below the African average GDP/capita, to impose infant industry import tariffs of up to **10%** for a maximum of **7 years**¹ within the AfCFTA to assist the establishment of new industries. In addition, if Africa manages to raise the capital to realise its huge hydro power potential, consideration could be given to supplying less developed states at a discount, possibly also linked to the inverse of their GDP/capita, as per the proposed LAC (above).

Alongside Africa's green mineral resources, the continent is endowed with enormous renewable energy resources. This combination opens economic development paths that address the linked goals to end energy poverty and industrialise Africa through ERBI. The strategy advanced in the AGMS links resources to achieving these goals through channelling minerals into priority value-chains for industrialisation (ERBI). Mining supply-chain inputs and capital equipment is itself a path to deepen manufacturing and services consumed by mining and processing of green minerals but also used to produce basic metals, construction minerals and chemicals needed for industrialisation. While green minerals will continue to be supplied into global supply chains, the AGMS elaborates manufacturing strategies for regional/continental markets for:

- Renewable energy equipment (solar panel manufacturing, panel assembly, mounting and tracking structures, hydropower turbines, wind towers, generators, electrical controls, et al);
- Hydrogen production and fuel cells (PEM electrolyzers, fuel cell stacks);
- Battery storage (lithium-ion battery precursors, cell manufacture and battery assembly, vanadium redox flow batteries, et al);
- 2 and 3 wheeler electric vehicles (electric motorcycles and tri-cycles and commuter busses).

African Green Minerals Strategy “on a page”



See Figure 44 on page 75

¹To cover the debt tenor portion of the capex invested, which disadvantages a new green-fields investor competing with established African industries.

Through pursuing the goal to electrify Africa, industrial opportunities are identified for the build out of electricity transmission networks and related electrical equipment (conductors, pylons, transformers, switchgear, control equipment, maintenance services). Brining electricity and modern energy services to the roughly 600 million African still without power requires the construction of new generation plants and a vastly expanded national and regional transmission networks to connect generators to load centres as well as to smooth and balance variable renewable generation on the network, mainly by hydropower or natural gas. African firms will not be able to scale up to competitively supply these markets without progress on established policies to deepening regional integration, reducing trade friction and above all improving intra-African logistics.

The following projects have been identified for prefeasibility studies in order to fast track investments into strategic green mineral value-chains:

- Production of nickel, manganese, cobalt precursor anode material.
- Production of lithium-ion ferrous phosphate precursors and manufacture of LFP batteries.
- Manufacturing of solar photovoltaic panels.
- Manufacturing of electric motorcycles (2 and 3 wheelers) and commuter busses.

To concretise implementation of the AGMS, an Action Plan accompanies the strategy recommendations. Action items for each of the four strategy pillars elaborate steps to take over the short and medium term accompanied by suggested roles to be played by the African Union Commission, the African Mineral Development Centre, the United Nations Economic Commission for Africa, the African Development Bank, AfreximBank, other partners and the private sector. Actions in the Green Mineral space at Member State level could potentially be made more impactful with information sharing and coordination between Member States through the indispensable role of Regional Economic Communities. The AGMS has been crafted to capitalise on opportunities from the attention given to

green minerals in the context of the energy transition to reinforce the message of the African Mining Vision, namely that to maximise the developmental impacts of extraction, all dimensions of mineral linkages – backwards, forwards, fiscal, knowledge et. al. need to be brought into play to underpin equitable resource-based industrialisation (ERBI). To illustrate, in 2023 Africa imported over 11 billion US\$ worth of select mining capital goods alone. This represents a huge opportunity for firms to enter the mining value-chain to deepen backward linkages. Instruments described above that should be put into practice under the AfCFTA are designed to assist firms realise these linkages. Importantly, these instruments propose ways to facilitate the participation of weaker economies in such opportunities to spread the benefits of economic development from minerals extraction.

Recommendations made in the AGMS on mineral development, skilling and enhancing technological capabilities as well as proper stewardship to protect people and the environment, cover familiar ground because making the most out of mineral development through ERBI, needs resolute effort. What is new are the opportunities flowing from the energy transition that foresee energising and industrialising Africa at a big picture level and that the AGMS endeavours to identify and concretise into projects.

Scaling up existing activities in the green minerals space and turning potential projects into reality will require the involvement of governments, investors and numerous stakeholders. Key among them will be the role that Development Finance Institutions are uniquely equipped to play. Here DFIs can assist Member State to refine regulatory frameworks for their green minerals, create the essential soft infrastructure of skills and knowledge for government officials and industry counterparts needed to implement green mineral initiatives effectively. Above all DFIs are needed to prepare investment projects for funding through feasibility studies, de-risking interventions and mobilising suitable funding instruments (debt and equity) to bring them to market.

ABBREVIATIONS AND ACRONYMS

4IR	4th Industrial Revolution
AfCFTA	African Continental Free Trade Area
AfDB	African Development Bank
AGHA	African Green Hydrogen Alliance
AGMS	African Green Minerals Strategy
ALBATTs	Alliance for Battery Technology Training and Skills
ALSF	African Legal Support Facility
AMGF	African Minerals Governance Framework
AMDC	African Minerals Development Centre
AMREC	Mineral and Energy Resources Classification and Management System
AMV	African Mining Vision
ANRC	African Natural Resources Management and Investment Centre
AU	Africa Union
AUC	Africa Union Commission
AUCS	Africa Union Commodity Strategy
BADEA	Arab Bank for Economic Development in Africa
CAEB	African Centre of Excellence for Advanced Battery Research
CBU	Copper Belt University
CET	Common External Tariff
COMESA	Common Market for Eastern and Southern Africa
CSP	Concentrated solar power
EAC	East African Community
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
ERBI	Equitable Resource-Based Industrialisation
EV	Electric vehicle
FCEVs	Fuel cell electric vehicles
FDI	Foreign Direct Investment
GHGs	Greenhouse Gases
Gt	Giga ton
GWh	Giga Watt hours
HRD	Human Resources Development
ICE	Internal Combustion Engine
IEA	International Energy Agency
IGAD	Intergovernmental Authority on Development

ABBREVIATIONS AND ACRONYMS

IPCC	Intergovernmental Panel on Climate Change
Kt	Kilo ton
LSF	Liquidity and Sustainability Facility
MVC	Mineral Value-chain
NDC	Nationally Determined Contributions
NTBs	Non-tariff barriers
NZE	Net zero emissions
Mt	Mega ton
OAGS	Organisation of African Geological Surveys
PARC	Pan African Resource Reporting Code
PFS	Pre-feasibility study
PV	Photovoltaic
RBI	Resource-Based Industrialisation
RDI	Research & Development and Innovation
REC	Regional Economic Community
REEs	Rare Earth Elements
RMCs	Regional Member Countries
RoO	Rules of Origin
SADC	Southern African Development Community
SDGs	Sustainable Development Goals
SDS	Sustainable Development Scenario
SEZ	Special Economic Zone
STEM	Science technology engineering and mathematics
STEPS	Stated Policies Scenario
TFTA	Tripartite Free Trade Area
UMA	Arab Maghreb Union
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNFCCC	United Nations Framework Convention on Climate Change
UNZA	University of Zambia
USGS	United States Geological Survey
VRE	Variable Renewable Energy
VRFB	Vanadium Redox Flow Batteries

Contents

	Executive summary	01
	Table of Figures	02
	Table of Tables	03
1.	1. The rising profile of strategic/critical mineral resources	01
	1.1. Impact of the energy transition on mineral demand	02
	1.2. Rise in demand for minerals arising from the energy transition	04
	1.3. Rationale for an African Green Minerals Strategy	06
2.	2. Analysis of current and future factors that could influence the AGMS	08
3.	3. Africa's Green Minerals Resources – Vision Goals and Objectives	12
	3.1. Defining Green Mineral Resources	12
	3.2. AGMS Vision and Goals	16
	3.3. AGMS Objectives	17
	3.4. Foundations for AGMS in Africa's mineral policy frameworks	18
	3.4.1. Equitable solutions to overcome uneven development	16
	3.4.2. Developing indigenous mining capital	21
	3.5. AGMS Goals to Energise	22
	3.6. Pillars supporting African Green Minerals Strategy	25
4.	4. Pillar I Advancing mineral development	26
	4.1.1. Governance of mineral resources	26
	4.1.2. Strengthening earth sciences institutions, undertaking geophysical mapping	27
	4.1.3. Infrastructure and finance to close production gaps	28
	4.1.4. Establishing a Green Mineral Value Chain Investment Fund	29
	4.1.5. Stimulating Exploration effort	30
5.	5. Pillar II develop people and technological capability	32
	5.1.1. Institutions to develop the required skills base	32
	5.1.2. Skills identification and skills development strategies	33
	5.1.3. Centre of Excellence for Batteries	34
6.	6. Pillar III building key value-chains	35
	6.1.1. Upstream linkages to optimise mining inputs opportunities	36
	6.1.2. Green mineral value-chains	40
	6.1.3. Priority value-chains to industrialise within larger African markets	57
	6.1.4. Manufacturing of Renewable Energy Equipment Value Chains	58
	6.1.5. Summary identification of opportunities along green mineral value-chains	74

Contents

7.	7. Pillar IV Mineral stewardship	76
	7.1.1. Economic and Social Contributions of Minerals to Sustainable Development	76
	7.1.2. Environmental, Social and Governance of Green Minerals	77
	7.1.3. Regional environmental management approaches	78
	7.1.4. Aiming for a circular economy	78
8.	8. Risk analysis and risk mitigation	79
9.	9. Conclusions & Recommendations	81
10.	10. Action Plan	87
11.	11. Bibliography	93
12.	12. Appendices	102
	12.1. Appendix I Illustration of African States recognition weights using inverse of GDP/capita	102
	12.2. Appendix II Shares of top 3 produces and reserve holders of critical minerals for 2019	104
	12.3. Appendix III Rise in demand for minerals arising from the energy transition	105
	12.4. Appendix IV Minerals Watch-list	109
	12.5. Appendix V African energy resources	110
	12.5.1. Renewable Energy Resources	110
	12.5.2. Fossil fuel resources: Natural gas as a bridge to clean energy for Africa	111
	12.5.3. New energy industries	112
	12.6. Appendix VI Skill Identification	113
	12.6.1. Mining skills	113
	12.6.2. Battery manufacturing skills	114
	12.6.3. Electric vehicle assembly	116

Table of Figures

Figure 1 Africa's share in global CO2 emissions for 2022	03
Figure 2 Mineral linkages for development and industrialisation (ERBI)	07
Figure 3 Energy mix in primary sources and final consumption, 2022	23
Figure 4 Exploration expenditure on Africa's green minerals 2011-2021	31
Figure 5 Key mineral value-chains for industrialisation (ERBI)	36
Figure 6 Africa imports of selected mining consumables by top 10 countries 2014-2023 (MUS\$)	37
Figure 7 Africa imports of selected groups of mining consumables 2014-2023 (MUS\$)	37
Figure 8 Imports of selected mining capital goods by top 10 countries 2014-2023 (MUS\$)	38
Figure 9 Africa imports of selected mining capital goods by type of equipment 2014-2023 (MUS\$)	39
Figure 10 Simplified aluminium value-chain	40
Figure 11 Top 10 exports of aluminium semis 2014-2023 (MUS\$) ..	41
Figure 12 Top 10 importers of aluminium semis 2014-2023 (MUS\$)	41
Figure 13 Simplified chromium value-chain	42
Figure 14 Simplified cobalt value-chain	43
Figure 15 Simplified copper value-chain	44
Figure 16 Top 10 importers of copper semis 2014-2023 (MUS\$)	45
Figure 17 Simplified graphite value-chain	45
Figure 18 Top 10 importers of graphite semis 2014-2023 (MUS\$)	46
Figure 19 Simplified iron and steel value-chain	46
Figure 20 Top 10 importers of ferrous metals, scrap and semis 2014-2023 (MUS\$)	48
Figure 21 Simplified lithium value-chain	49
Figure 22 Simplified manganese value-chain	49
Figure 23 Simplified nickel value-chain	50
Figure 24 Top exporters of nickel unwrought, matte and metal 2014-2023 (MUS\$)	51
Figure 25 Simplified A phosphate rock and B elemental phosphorus value-chain	52
Figure 26 Africa's NPK fertiliser imports 2014-2023 (MUS\$)	53
Figure 27 Simplified platinum group metals value-chain	53
Figure 28 Simplified rare earth elements value-chain	54
Figure 29 Simplified vanadium value-chain	55
Figure 30 Simplified zinc value-chain	55
Figure 31 Zinc metal and semis imports 2014-2023 (MUS\$)	56
Figure 32 Typical segments of renewable energy value-chain	58
Figure 33 Top 10 import countries of solar PV panels 2014-2023 (MUS\$)	59
Figure 34 Solar PV value-chain	61

Table of Figures

Figure 35 Concentrated solar power value-chain	62
Figure 36 Wind turbine imports 2014-2023 (MUS\$)	62
Figure 37 Onshore wind value-chain	63
Figure 38 Hydrogen energy value-chain	64
Figure 39 Imports of lithium-ion batteries by country 2019-2023 (MUS\$)	66
Figure 40 Battery feedstock value-chain	67
Figure 41: Feedstocks and fabrication processes for producing a VRFB	70
Figure 42: Top 20 import countries of motorcycles 2014-2023 (MUS\$)	72
Figure 43: Green minerals boom opportunities	81
Figure 44: African Green Minerals Strategy on a page	82
Figure 45: Possible African Green MVCs Development Strategy (AGMS) Interventions	85
Figure 46 Price of selected battery materials and lithium-ion batteries, 2015-2023	108
Figure 47 Large hydropower: installed capacity and potential	110
Figure 48 Utility scale solar PV: installed capacity and potential	110
Figure 49 Wind: installed capacity and potential	111
Figure 50 Hydrogen cost production potential in 2030 within 200 km of a serviceable coast	112
Figure 51 Main employing occupations in the mining sector	113
Figure 52 Battery Production and Maintenance – Academic Competences	114
Figure 53 Battery Production and Maintenance: Sector Specific skills	115
Figure 54 Battery Production and Maintenance: Cross Sector Specific Knowledge	116

Table

Table 1 SWOT analysis of Africa's Green minerals landscape	10
Table 2 Core minerals for the African Green Mineral Strategy	13
Table 3 Africa's share of Green Minerals in world production and reserves 2023 (estimate)	14
Table 4 Illustration of country recognition weights using inverse of GDP/capita for ECOWAS	20
Table 5 Global weighted average costs and GHG emissions by generation technology, 2022	24
Table 6 Ferrochrome exporter and importer countries 2014-2023 (MUS\$)	42
Table 7 Cobalt semis exporters 2014-2023 (MUS\$) .	43
Table 8 Top 10 copper semis exporters 2014-2023 (MUS\$)	44
Table 9 Apparent steel use 2019 to 2023 (million tons finished steel products)	47
Table 10 Apparent steel use per capita 2019 to 2023 (kilograms finished steel products)	48
Table 11 Export of manganese ores and concentrates 2014 to 2023 (MUS\$)	50
Table 13 Rock phosphate production volumes and shares 2022	52
Table 14 Export of PGM unwrought and semis 2014 to 2023 (MUS\$)	54
Table 14 Export of zinc ores and concentrates 2014 to 2023 (MUS\$)	56
Table 16 Value-chain opportunities and actions required	74
Table 17 Watch list minerals for the African Green Mineral Strategy	88

Chapter one

1 The rising profile of strategic/critical mineral resources

Africa has the resources and potential to reap the benefits of what is emerging as a new industrial age: the age of clean energy technologies. Lower carbon emissions for production and use of energy are essential aspects of the global commitment to achieve the Sustainable Development Agenda. In the age of clean energy technologies, greater quantities of minerals are needed for hydro, solar, wind, battery and electric vehicle industries than the fossil fuel-based ones they are replacing. Many of those minerals are sourced from Africa.

Mineral supply chains are attracting greater attention which provide Africa with a new set of development opportunities launched off the continent's mineral wealth. This report elaborates why the energy transition is so important for Africa and what is needed for the minerals industry to exploit opportunities and avoid risks arising from the broader context of climate change.

Imperatives to cut the greenhouse gas (GHG) emissions driving climate change is disrupting established industries. Targets are being set for the phase out of high emission sources and their low-carbon replacements are being introduced, albeit gradually. As these economic adjustments take place, a new energy and industrial security dynamic has been created between mineral producing regions and mineral consuming regions. Several developed economy countries have identified a set of minerals (and

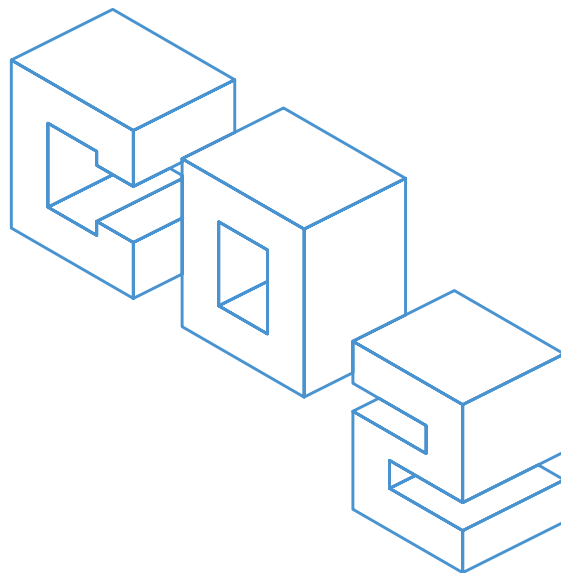
nonmineral raw materials for example natural rubber) that have limited sources of supply or vulnerable supply chains but are essential for clean energy equipment, high technology and defence industries as "critical minerals". Strategies to secure access to critical minerals by seeking diversified supply chains are also being developed. The previous mineral boom was largely driven by industrialisation and urbanisation of the Chinese economy, and arguably peaked in 2008, but the current focus is tied to decarbonisation.

For African commodity producers the rising profile of so-called "**critical mineral**" resources promises higher mineral receipts, but there is a far bigger opportunity to be won. Here is a window of opportunity to harness mineral wealth to underpin broad-based sustainable growth and socio-economic development, to channel mineral feedstocks into industries making products the continent needs and to break the pattern of mineral value-chains that terminate at the export of raw materials. Integrating mining more deeply into regional economies by increasing the local content of mining inputs, building mineral value-chains to manufacture renewable energy equipment that harvests the continent's vast renewable energy potential to provide clean energy to the more than 600 million African without modern energy services are achievable goals that capture these opportunities.

The continent has a development vision of green economic growth that is wholly inclusive, low-carbon intensive and uses digital technology to enhance productivity. Africa now has a chance to develop a strategy for minerals mined on the continent that are crucial in the age of clean energy technology: cobalt, natural graphite, lithium, manganese, phosphorus and vanadium for batteries; aluminium and copper for electrical networks; chromium, nickel and zinc for wind farms, concentrated solar power and fuel cells; platinum group metals for hydrogen electrolyzers and fuel cells, rare earth elements for magnets in electric motors and generators plus iron, steel and alloys used throughout the economy. These minerals are inputs into the basic sectors

of mining, agriculture, industry, construction, transport, water and power but they are also critical inputs for new green industries. They have been grouped under the collective term of “green minerals” with the aim of stimulating the development of green industries and broader industrialisation through a unified development approach called the African Green Minerals Strategy (AGMS). The rationale for the AGMS is to supplement the existing frameworks for mineral based development, such as the AMV and AMGF, with a specific focus on the opportunities and risks for Africa arising from the broader context of climate change, transitioning to a low carbon future and incorporating the digital economy.

1.1 Impact of the energy transition on mineral demand



The challenge of achieving net zero GHG emissions to avoid run-away climate change, sets the context for an examination of the impact of the energy transition on mineral demand to follow.

Global energy production, including that for transportation, makes up **74%** of the Greenhouse Gases (GHGs) which are driving anthropogenic climate change. Fossil-fuel use, together with deforestation and other human activities, has raised the atmospheric concentration of CO₂ from some 280 parts per million (ppm) at the start of the industrial revolution to above 400 ppm currently (NASA, 2023). As a result, the planet is now around 1.16 °C warmer. This is already damaging lives and livelihoods and poses an existential threat to people and the planet's ecosystems. In response, every UN member has adopted the 2015 Paris Agreement, committing to prevent the mean global temperature from rising by more than 2°C above pre-industrial levels and to make a concerted effort to keep it below 1.5°C. Though Nationally Determined Contributions (NDC), countries are bound to modify their GHG output. Striving for the 1.5 °C limit requires the combined effort of all countries to achieve net zero GHG emissions by 2050 (NZE) although many developed countries have set 2060 as the NEZ target date.

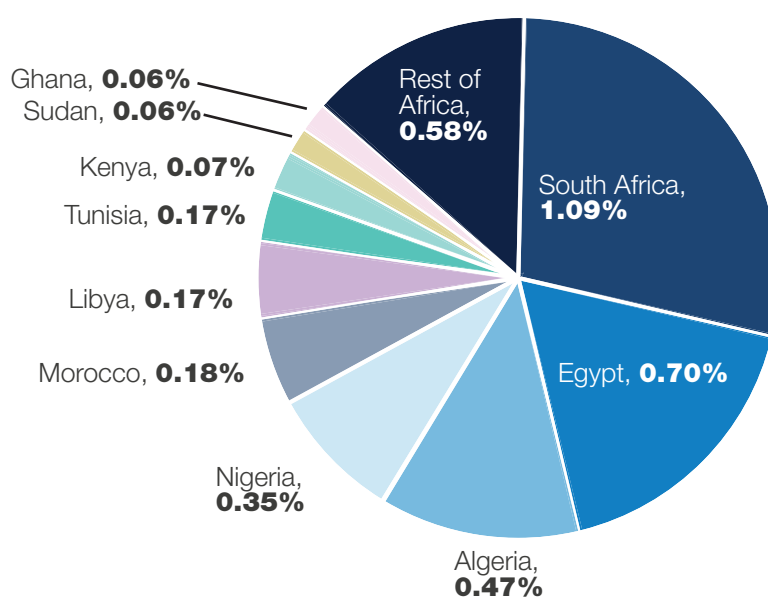
On the current GHG trajectory of NDCs, it is likely that global warming will exceed 1.5 °C during the 21st century. Without strengthening policies, currently rising GHG emissions, coupled with positive feedback loops that trigger more rapid warming (for example, the drying of rainforests which turns them from carbon sinks into carbon sources) projections point to a median global warming of 3.2°C by 2100 (medium confidence) (IPCC, 2022, pp. SPM-21). African countries are particularly vulnerable to the effects of climate change due, for example, to sea levels rising 2mm per year faster than the global average for some East African regions (WMO, 2020, p. 12) or deforestation occurring at a greater rate than the global average (ECA, 2018). While Africa has made the least contribution to global emissions, the burden of climate change on economies and livelihoods across the continent is disproportionately high, in short, a climate injustice.

There are some grounds for optimism, nevertheless. Various data points point to the energy transition unfolding faster than many

policymakers anticipated with regard to electric vehicle sales, rapid deployment of wind and solar energy generation and technology for sustainable buildings. These are signs that inflection points are being reached in important markets with major implications for investments by the fossil fuel industry, observes the IEA Executive Director (Biroi, 2023).

African countries are massively underrepresented in influential integrated assessment models, such as run by the IPCC, that often lump together African countries, or even 'Africa and the Middle East' — ignoring huge differences in socio-economic status and available resources. Net-zero plans often exclude Africa (Mutiso R. , 2022) and energy-transition plans leave out African data, models and expertise, excluding more than one billion people on the continent. Africa only contributed 3.182% to global CO₂ emissions for 2022. The majority of Sub Saharan African countries, except South Africa, have tiny baseline emissions and prioritise developing their energy infrastructure to power economic growth.

Figure 1 Africa's share in global CO₂ emissions for 2022



Source: (Richie, Roser, & Rosado, 2020).

Africa needs fair access to the global carbon budget. It is generally recognised that the real climate crisis in Africa is about adaptation (Mutiso & Auth, 2021). More than 1 billion people in sub-Saharan Africa are among the most vulnerable worldwide to climate impacts, and they urgently require more energy to adapt to those impacts, not less. The world's energy poor need every tool available to manage escalating adverse effects, including a diverse array of technologies to power energy-intensive solutions like desalination, cold storage, air conditioning, and to produce steel and concrete for resilient infrastructure.

Rich countries will generally be able to adapt to climate impacts. Few Africans will have that chance without significantly increased energy

supply. Energising Africa must be at the centre of developing minerals for green growth which is consistent with the overall energy transition given the availability of technological options to leapfrog the high carbon production processes of previous generations.

Africa must continue to campaign, alongside other member of the Global South, for a climate justice Grand-Bargain between the Global North and Global South to implement UNFCCC, Kyoto Protocol and the Paris Agreement commitments to extend technology transfer, financial support (concessional loans and grants) and loss and damage funding. Multilateral and international cooperation must underpin principled engagement to address global development challenges.

1.2 Rise in demand for minerals arising from the energy transition

Driven by the outsized contribution that energy production makes to climate change, a central focus for climate safety is given to the energy sector and the transition from fossil fuels to zero-carbon energy sources such as hydro, wind, solar, geothermal, ocean, biomass and nuclear, or fossil fuels with carbon capture and storage. Final energy consumption for households, industry and transport needs to be sourced from zero-carbon sources, preferably by directly electrifying them, for example by substituting internal combustion engine (ICE) vehicles with electric and switching to low carbon energy carriers like hydrogen or ammonia that can be combusted without releasing CO₂ into the atmosphere.

Transitioning energy systems from fossil fuels to clean energy sources involves replacing technologies fuelled by hydrocarbons with plant and equipment that require more materials to build than fossil fuel plants they replace. Building solar photovoltaic (PV) plants, wind farms and electric vehicles (EVs) generally require greater

amounts of metals and minerals their fossil fuel-based counterparts. The minerals critical to the energy transition are copper, lithium, nickel, manganese, cobalt, graphite, chromium, molybdenum, zinc, silicon, PGMs and rare earth elements plus steel and aluminium which are ubiquitous metals used throughout traditional and clean energy industries. The world is witnessing a shift from fuel-intensive to material-intensive energy systems states the IEA, observing that a typical electric car requires six times more of such mineral inputs than a conventional car by weight, and an onshore wind plant requires nine times more these critical minerals in kg per MW than a gas-fired power plant. Since 2010, the average amount of these minerals that are needed for a new unit of power generation capacity has increased by 50% as the share of renewables has risen according to the (IEA, May 2021, p. 5). More details of projected demand is given in Appendix III Rise in demand for minerals arising from the energy transition.

Demand for minerals used in the energy transition and green industries such as lighting, high efficiency heating and cooling and sustainable transport have major implications for

exploration, mining, processing, trading, use and recycling. Critical issues for the AGMS are the following.

1

A step change in demand. Modelling has been done by the IEA, build on earlier work by the (World Bank, 2020), on minerals most used for carbon power generation, electricity networks, electric vehicles, energy storage and hydrogen, adjusted for **mineral intensity improvements**. **The results suggest that mineral demand by 2040 is set to double** if governments implement their stated climate goals (STEPS scenario). Furthermore, if government take steps to **reach sustainable development goals mineral demand to 2040 will quadruple** (SDG scenario)

2

Clean energy demand is the main driver in higher consumption of certain minerals but traditional markets are still important. Attention is correctly focused on green minerals that are seeing the most dramatic surge in demand for clean energy applications, however, this should not obscure their importance in traditional markets for steel alloys, industrial and chemical markets that still make up the bulk of demand for many green minerals. Furthermore, the contribution that African producers make to foreign exchange earnings by supplying world markets remains an important role in their national economies. The share of clean energy technologies in total demand for certain minerals by 2040 under the SDS scenario is expected to rise from **30% to 90%** for lithium, from **30% to 70%** for cobalt and nickel, from **25% to 45%** for copper and from **15% to 40%** for neodymium (IEA, May 2021).

2

Green mineral demand is strongly influenced by changing technology choices. Materially different amounts of metals are used in different technologies, for example the amount of platinum used in a hydrogen electrolyser based on proton exchange versus alkaline

electrolysers. The swings between different lithium-ion battery chemistries underscore this point. Automotive lithium-ion battery demand increased by about **65%** to 550 GWh in 2022, from about 330 GWh in 2021, **90%** for EVs. In 2022, about **60%** of lithium, **30%** of cobalt and 10% of nickel demand was for EV batteries, while in 2017, these shares were around **15%, 10% and 2%**, respectively (IEA, 2023b). Currently lithium nickel manganese cobalt oxide (NMC) remained the dominant battery chemistry with a market share of **60%**, followed by lithium ironphosphate (LFP) with a share of just under **30%**, and nickel cobalt aluminium oxide (NCA) with a share of about **8%** in 2022. LFP, which uses lower cost iron and phosphorus rather than the nickel, manganese and cobalt found in NCA and NMC batteries which provides greater energy density. If manufacturers switch to greater use of LFP chemistries, projected demand for nickel and cobalt will fall significantly.

Mineral substitution and thrifting is actively pursued, particularly for minerals with highly concentrated sources such as cobalt. To illustrate this point sodium-ion battery chemistry is a candidate under intense focus in China and elsewhere as a technology that uses widely available minerals and dispenses with lithium, graphite and copper, although it has a lower energy density. CATL is testing hybrid lithium-sodium batteries (Bradsher, 2023). Nearly 30 Na- ion battery manufacturing plants currently operating, planned or under construction, for a combined capacity of over 100 GWh, almost all in China. For comparison, the current manufacturing capacity of Li-ion batteries is around 1 500 GWh (IEA, 2023b, p. 59). As battery technology develops it is likely that alternatives to lithium-ion will evolve alongside established chemistries to fill particular use-cases where they have superior characteristics or cost advantages.

Demand for green minerals is rising, already up and average by 30% over the period 2012-19 (Kowalski & Legendre, 2023) and the pace is accelerating. The speed and composition of change is uncertain, therefore a strategy for green minerals needs to account for factors likely to change namely:

- the extent to which climate policies, country commitments and actual adjustment take place that translate into different levels of metals demand;
- tipping points when minerals used in energy transition technologies overtake their use in other markets, such cobalt used in high

temperature steel alloys being overtaken by its use in batteries;

- variation in ratios of metals needed for different green technologies competing for leadership;
- price movements or disruptions to supply chains for green minerals that could increase the cost of adopting clean technology and slow the adoption of clean technologies; and
- China's dominant position as a producer and refiner of green minerals.

1.3 Rationale for an African Green Minerals Strategy

Africa's mineral wealth has long been seen as a springboard to modernisation expressed in the suit of policies that have been drafted over time. Relevant policies include, but are not limited to, the Africa Mining Vision (AMV) and Africa Union Commodity Strategy (AUCS). These policies are intended to guide national governments and multi-lateral organisations optimise the role that minerals and commodities should play in the continent's development and are discussed in more detail in section 3.4.

Although these strategies are fairly recent, they were adopted in 2009 and 2021 respectively and build upon a strong raft of policies on investment, industrialisation, trade, investing in human capital, environmental protection, global cooperation and sustainable development among others. Their development approach is to stimulate linkages between mining or other commodities and the rest of the economy. Yet neither anticipated the developing opportunities created by the energy transition, nor the implications of the fall in the cost of renewable energy for the minerals sector opening new possibilities to combine Africa's twin strength in minerals and renewable energy to launch industries that manufacture renewable energy equipment.

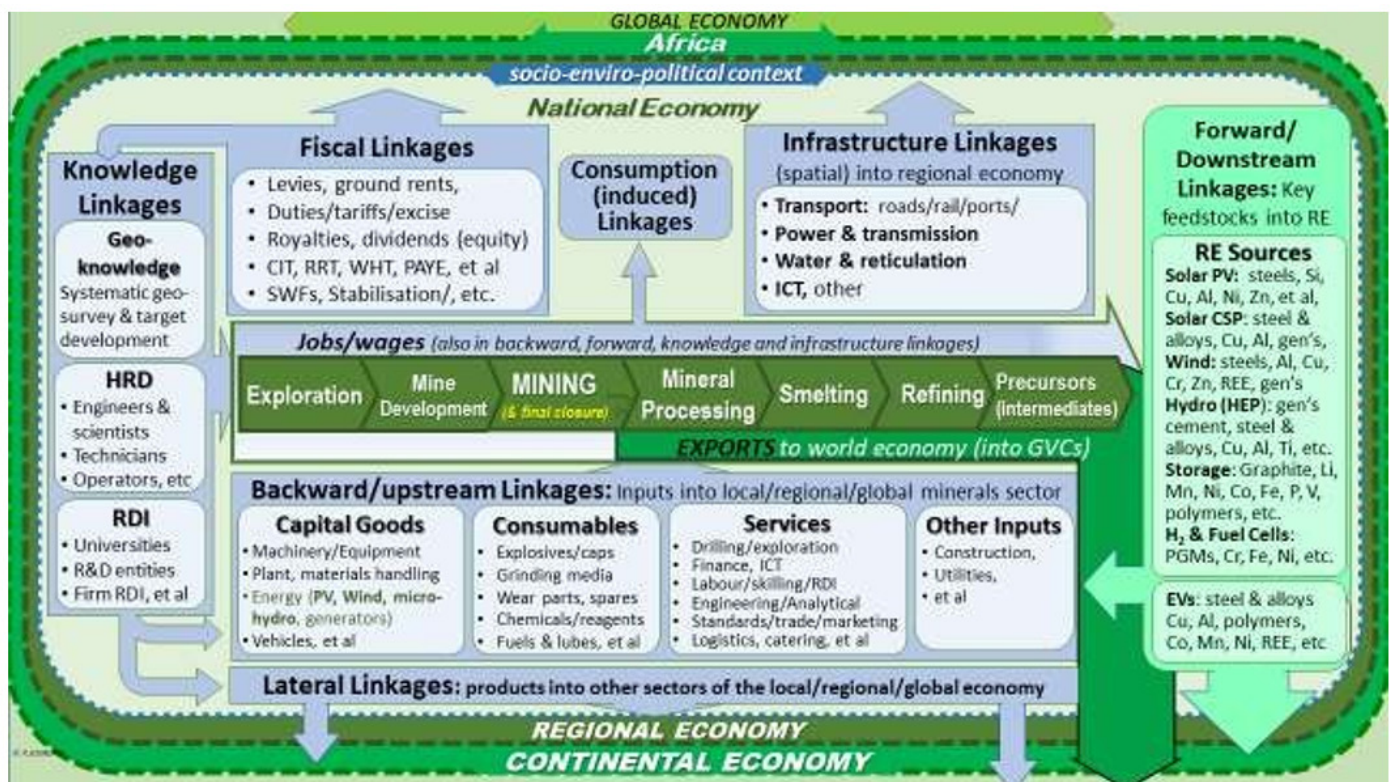
Africa has huge renewable energy resources, hereafter referred to as variable renewable energy (VRE) or simply renewable energy (RE). The continent has tapped only a fraction of its massive hydropower resources, vast solar energy Photo Voltaic (PV) and Concentrated Solar Power, (CSP) potential, significant on and off-shore wind power potential and enormous bio-energy potential (mainly in the well-watered regions between the tropics) and opportunities to enter new energy industries such as hydrogen using RE. Efforts should go into building equipment and services to tap these sources rather than simply importing them.

The rationale for the AGMS is to supplement the existing frameworks for mineral based development with a specific focus on the opportunities and risks for Africa arising from the broader context of climate change, transitioning to a low carbon future and incorporating the digital economy. To fully take advantage of industrial activities that respond to this new context, the AGMS needs to guide the development of mineral value-chains that are key to renewable energy and e-mobility (batteries and electric vehicles).

It is important to recognise that the share of base metals and minerals going into clean energy uses forms a very small share of the overall market for that mineral. Cobalt and lithium are exceptions where significant shares of production go into making batteries. Therefore, the AGMS, which focuses on a list of green minerals, is not divorced from the broader minerals industry. The methodology it uses is grounded in the AMV, namely to use mineral endowments to underpin sustainable growth, development, industrialisation and job creation by fully developing inter-sectoral linkages (ERBI). This strategy involves building the backward linkages (local mining supply-chains), the forward linkages (mineral feedstocks into regional

manufacturing, infrastructure, agriculture and other sectors) and the other requisite mineral linkages depicted in Figure 2. The aim is to build downstream/forward linkages to convert mineral feedstocks into renewable energy machinery, equipment and plant. In practice this will require a phased approach to grow competitive manufacturing industries at a regional level rather than trying to cover all sectors at once. The long-term aim is to develop these value-chains and all their associated linkages to leverage green mineral resources for green industries to serve regional markets and continental markets under the AfCFTA. In addition, the clean energy transition offers huge opportunities to close energy deficits and finally electrify Africa.

Figure 2 Mineral linkages for development and industrialisation (ERBI)



Source: adapted from (SADC, 2019). Note: GVCs: Global Value-chains, RDI: Research, development & innovation, ICT: Information & Communications Technologies, CIT: Corporate Income Tax, RRT: Resource Rent Taxes, WHT: With-holding Taxes (on dividends), PAYE: Pay as you earn (personal income tax), SWF: Sovereign Wealth Funds, Si: silicon, Cu: copper, Al: aluminium, Ni: nickel, Zn: zinc, Cr: chromium, REE: rare earth elements Li: lithium, Mn: manganese, Co: Cobalt, Fe: iron, P: phosphorus, V: vanadium, H: hydrogen, PGM: platinum group metals.

Chapter Two

② Analysis of current and future factors that could influence the AGMS

The AGMS will need to navigate numerous factors hindering and helping Africa chart its own course to use its green minerals for maximum benefit. Among them are the following



Access to critical minerals is becoming an energy and industrial security issue for importers of minerals hence the need to ring fence resources for domestic exploitation and processing;



Markets for minerals are taking on geopolitical dimensions as mineral importers seek to secure supply chains that serve their national interests;



Governments are turning to industrial policy tools as markets alone cannot respond adequately to economic transformation required to cope with climate change;



The number of trade restrictions on critical raw materials has grown over the last decade;



Latin American countries that produce lithium, yet host none of downstream industries, are changing their mineral policies to force more domestic value addition;



The current attention to critical minerals gives mineral producers a limited opportunity to use producer power to build value-chains by acting swiftly before mineral importers develop substitutes, mineral thrifting or alternative technologies.



Some African countries have commenced introducing policies that compel both foreign and domestic mining companies to value add to minerals before export, compelling producers to move up the value-chain so as to strengthen domestic linkages.

Of course, the AGMS is not immune from common challenges facing industrial development relating to weak institutions, policy miss-alignment, foreign agendas, lack of infrastructure or reliable energy to name a few. For countries manufacturing clean technology equipment and deploying larger amounts renewable sources in their energy mix, an increasing reliance on critical minerals is changing the traditional energy security paradigm, which focused on fossil fuel supply, and particularly oil. Hence their efforts to set up secure (to them) global supply chains for critical minerals and avoid energy security risks. Industrial policy, namely the state taking a hands-on approach to set up industries considered strategic or to direct investment into new sectors is making a comeback. State intervention was curtailed under the World Trade Organisation rules from the 1980s onwards as self-proclaimed economic orthodoxy ruled out active industrial policy pursuant to ERBI that interfered in **“free markets”**. The urgency of restructuring economies in response to climate change and the need for collective action and state coordination is driving recognition of the desirability, indeed necessity for state intervention. A revival of industrial policy gives governments far more policy space to direct their economic development paths and give muscle to policy goals with strategic incentives. Industrial policy is still contested yet there is a stronger recognition of the right of producer countries to have a greater share of the benefits of development. On industrial policy for the energy transition and referring to the potential of green hydrogen UNIDO's DG stated the key message is “value creation must be kept in the producing countries for investment in industrialization” (UNIDO, 2022). A rise in trade policy interventions for critical raw materials has included an increase in the global incidence of export restrictions, which has increased more than five-fold in the last decade, with several countries significantly intensifying use of these measures. Research has indicated that export restrictions may be playing a non-trivial role in international markets for critical raw materials, affecting availability and prices of these materials (Kowalski & Legendre, 2023). The impacts, while material, are product- and country-specific and the objectives for export restrictions are widely different, for example, fostering a circular economy (Kowalski & Legendre, 2023).

Geopolitical issues are gaining more attention in relations between mineral producer countries and mineral importing countries with the latter stressing the importance of secure supply chains for their national interests, whilst stating their support, at least formally if not in substance, for producer countries to move up the value-chain.

Governments of the countries that make up the so called **“lithium triangle”** - Argentina, Bolivia and Chile - are taking steps to move their lithium extraction sectors up the value-chain. In April 2023 Chile's President outlined his government's desire to hold a controlling interest in lithium projects in a public-private model by negotiating with private mining firms which extract lithium via long term concessions (Energy Storage News, 2023). In Bolivia, the State manages the production process through a public company but may partner with private companies for post extraction value addition. In Argentina provincial state-owned companies already hold most of the lithium exploration and mining exploitation rights with which newcomers, state owned or private, would need to partner. Mexico set up a new state-owned company in 2022 called LitoMx which will be responsible for managing the exploration, mining exploitation, and refining of lithium and controlling its economic value-chains (White & Case, 2022).

Technological change which alters demand for green minerals presents a significant risk to efforts aimed at building value-chains based on current feedstock and product assumptions. Alternatives to lithium-ion batteries, for example sodium-ion, are being closely watched. Alternative chemistries could severely disrupt the battery metals market. Noting these implications, the ANRC has observed that Africa now has a window of opportunity, possibly for the next decade, during which it must act rapidly to build value-chains (Ahadjie, 2023) or risk losing the chance to leveraged development of green minerals. For example, the rapidly developing critical mineral projects and value-addition initiatives being scaled-up, i.e., battery plants being established globally from 2022 and plans for the coming five years.

Possible weaknesses that could affect the AGMS will need to be overcome while mitigating risks, amplifying strengths and capitalising on opportunities are listed in the table below.

Table 1 SWOT analysis of Africa's Green minerals landscape

STRENGTHS	WEAKNESSES
• Significant resources of green minerals and underexplored geological potential; • Large continental market; • Massive renewable energy resource potential (hydro, solar, wind, bio, et al); • Demand from regional Power Pools (e.g. SAPP and WAPP); • Huge untapped demand (600M unconnected Africans) • Tertiary institutions teaching mining, metallurgy, earth sciences and engineering across the continent; • Significant existing mining industry with technology and skills in both green and nongreen minerals. • AMV and REC policies for integrated development of MVCs (mining linkages);	• Limited systematic geological mapping; • Limited mineral beneficiation; • Few strong national geoscience bodies; • Limited African based (owned) exploration and mining companies; • Dependency on imported technology due to limited STEM skills and R&D capability; • Limited capacity for advanced RDI; • Infrastructure gaps, especially in transport and power; • High intra-African logistics costs (especially NTBs). • Limited industrial demand for green mineral feedstocks; • Fiscal weakness limits public funding of industrial policy instruments (STEM HRD, RDI and investment incentives) for ERBI; • Low GDP per capita; • Weak governance • High cost of capital. • Limited data availability to support • decision making

OPPORTUNITIES	THREATS
• Under explored mineral terrains, therefore potential to significantly increase mineral resources; • Framework for resource-based industrialisation adopted by AU (AMV) and also domesticated in some RECs and member States; • REC and continental Free Trade Areas (FTAs) to overcome limited domestic markets; • Continental aspirations for closer economic integration progressing under AfCFTA; • Geopolitical advantage for Africa as an alternative source of green mineral supply; • Huge electrification opportunity (huge deficit for both consumptive and productive purposes) • Leveraging access to Africa's green minerals for investment in the production of precursors and RE sources (PVs, wind, turbines, et al.) and local content = access to minerals conditional on local processing and supply-chain development; • Huge clean energy export potential via hydrogen/ green ammonia • Leverage the building of Science, Technology and Innovation institutions financed from appropriate mineral sector levies (5% of payroll and 1% of turnover on RDI) • Decarbonising mining by replacing fossil fuels with RE resources; • Emerging, innovative green industries building batteries, manufacturing electric two- & three-wheelers, converting ICE to EVs • Industrial opportunities, amongst others: i) DRC-Zambia cooperation agreement on lithium-ion batteries - creation of cross border special economic zones; ii) Long duration Vanadium Redox Flow Batteries (VRFBs) using southern African vanadium; iii) Converting ICE vehicle assembly in Morocco and South Africa to EVs	• Geopolitical interests of Asian and Western producers to secure unprocessed raw materials; • Substitution of cobalt in the value-chain to weaken producer power and alleviate sourcing concerns; • National ambivalence to substantive economic integration, particularly to Common External Tariffs (CETs) and the elimination of all non-tariff barriers (NTBs); • Competition from current incumbents producing mining and RE equipment targeting African markets; • Delay in finalising AfCFTA Rules of Origin for motor vehicles; clean energy sources (PVs, windmills, batteries, et al.) and mining inputs; • Pervasive imports of used vehicles and dumping of obsolete ICE vehicles undermine potential African EV industry; • Failure to transition ICE vehicle assembly to EVs over longer term; • Climate change causing costly, damaging extreme events as well lower/higher rainfall; • Environmental impacts of the increased demand for minerals • Public health emergencies requiring development of new vaccinations.

The AGMS supports the work of the experts convened under the UN Secretary General's Panel on Critical Energy Transition Minerals and endorses its 7 principles and 5 actionable recommendations. These principles and actionable recommendations align with the principles of the AGMS. Members States are highly encouraged to use the UNSG Panel's guiding principles and actionable recommendations during extraction and use of critical minerals along the value chains.

Chapter Three

③ Africa's Green Minerals Resources – Vision Goals and Objectives

3.1 Defining Green Mineral Resources

Africa's Green Mineral Strategy is steered by the vision for green growth across the continent, namely:

“Green growth is a wholly inclusive economic growth and development path that is low-carbon, climate-resilient, resource-efficient, and maintains and enhances biodiversity and ecosystems.” (AfDB, 2021)

For low carbon energy generation, distribution and use in low carbon mobility, Africa needs to build upon the existing clean energy technologies deployed across the continent and scale them up. These principally involve the following:

-  Hydropower;
-  Battery storage (utility-scale and residential);
-  Concentrated solar power (CSP: parabolic troughs, central tower and PV hybrid);
-  Bioenergy for power or as fuel;
-  Electric vehicles (battery electric and plug-in hybrid electric vehicles);
-  Electricity networks (transmission, distribution, and transformer stations);
-  Geothermal resources;
-  Green hydrogen (electrolysers and fuel cells);
-  Solar photovoltaic (PV) (utility-scale and distributed);
-  Wind (onshore and offshore)

Industries that recover valuable metals through recycling and reduce waste also need to be encouraged.

Criteria for defining the scope for minerals to include in the AGMS are proposed as follows:

1. Minerals that are used in clean energy technologies and green industries.
2. Minerals that are feedstocks into mining supply chains and equitable industrialisation (ERBI).

Table 2 Core minerals for the African Green Mineral Strategy

Mineral	Hydro Power	Wind	Solar PV	CSP	Hydrogen and fuel cell	Energy Storage	Electric Vehicles
Aluminium	✓	✓	✓	✓		✓	✓
Chromium	✓	✓		✓	✓		
Cobalt						✓	✓
Copper	✓	✓	✓	✓		✓	✓
Graphite						✓	✓
Iron/steel & Alloys	✓	✓	✓		✓	✓	✓
Lithium						✓	
Manganese		✓				✓	✓
Nickel	✓	✓	✓	✓	✓	✓	✓
Phosphate						✓	✓
Platinum Group Metals					✓		
Rare earth elements		✓				✓	✓
Titanium						✓	
Vanadium						✓	
Zinc		✓	✓				

* neodymium, dysprosium, praseodymium for permanent magnets

Table 2 lists the proposed focus minerals which form the core ingredients of clean energy generation from wind, solar PV and hydrogen electrolyzers or fuel cells and the application of minerals into key industries namely battery energy storage and electric vehicles. Clean energy uses make up only a small part of the ubiquitous utilisation of aluminium from bauxite and steel from iron. These are included on this list nevertheless because they are core to industrial applications and the green mineral

mining supply chain (MSC). The minerals listed in Table 2 are frequently required in alloys such as stainless steel. Steel itself is a key metal across a range of technologies, indeed it is a fundamental requirement for industrialisation, particularly ERBI². Steel is critical to building the backward component of the green minerals value-chains (the African mining supply-chains) which also needs to migrate away from fossil fuels, particularly in trackless mining systems.

² ERBI: Equitable Resource-Based Industrialisation

The minerals proposed cover wind turbines and towers and generators using permanent magnets that require rare earth elements, particularly neodymium, dysprosium, praseodymium and terbium that are also used in permanent magnet electric motors for electric vehicles. Solar PV panels, frames and conducting stringers are covered as well as platinum and palladium catalysts for proton exchange electrolyzers for hydrogen production as well as hydrogen fuel cells. Lithium-ion batteries are manufactured using combinations of cobalt, lithium, graphite, copper, aluminium, nickel, manganese and phosphate. In short green minerals are feedstocks into

clean energy technologies, green industries and into mining supply chains and equitable industrialisation to serve Africa's needs. Other minerals for possible inclusion are listed in Appendix IV Minerals Watch-list. Production and reserve data for 2022 (estimates) for the main African producer countries of green minerals is shown in Table 3. Known deposits of minerals on the European Union critical minerals list, which has some overlap with the Green Minerals list are shown in Error! Reference source not found.. It should be noted that reserves are dependent on the prevailing price, as a higher price will decrease the mining cut-off grade and increase mineable reserves.

Table 3 Africa's share of Green Minerals in world production and reserves 2023 (estimate)

Mineral	World Production	World Reserve	Top African countries	Production (% of world)	Reserves (% of world)
Aluminium (saelter prod)	70 Mt		South Africa	720 kt (1%)	
			Mozambique	314 kt (0.5%)	
			Egypt	320 kt (0.5%)	
Alumina	140 Mt		Guinea	330 kt (0.3%)	
Bauxite	400 Mt	30Gt	Guinea	97 Mt (24.3%)	7.4 Gt (23.8%)
Chromium	41 Mt	560 Mt	South Africa	18 Mt (43.9%)	200Mt (35.7%)
			Zimbabwe	1.4 Mt (3.4%)	
Cobalt	230 Mt	11 Mt	DRC	170 kt (73.9%)	6 Mt (54%)
Copper mine production	22 Mt	1 Gt	DRC	2.5 Mt (11.3%)	80 Mt (8%)
			Zambia	760kt (3.4%)	21 Mt (2.1%)
Copper refinery	27 Mt		DRC	1.9 Mt (7%)	
			Zambia	380 kt (1.3%)	
Graphite - natural	1.6 Mt	280 Mt	Mozambique	96 kt (6%)	25 Mt (8.9%)
			Madagascar	100 kt (6.2%)	24 Mt (8.5%)
			Tanzania	6 kt (0.3%)	18 Mt (5.5%)
Iron & steel (raw steel)	1.9 Gt				
Iron ore (Fe cont.)	1.5 Gt	87 Gt	South Africa	39 Mt (2.6%)	600 Mt (0.6%)
			Mauritania	8.1 Mt (0.5%)	N/A
Lithium	180 Kt	28 Mt	Zimbabwe	3.4 kt (1.8%)	310 kt (1.1%)
Manganese	20 Mt	1.9 Gt	South Africa	7.2 Mt (36%)	600 Mt (31.5%)
			Gabon	4.6 Mt (23%)	61 Mt (3.2%)
			Ghana	840 kt (4.2%)	13 Mt (0.7%)

Source: (USGS, 2024) Note: Production and reserves for 2023 are up-to-date estimates by USGS

² ERBI: Equitable Resource-Based Industrialisation

Mineral	World Production	World Reserve	Top African countries	Production (% of world)	Reserves (% of world)
			Cote d'Ivoire	390 kt (1.9%)	N/A
Nickel	3.6 Mt	> 130 Mt			
Phosphate rock	220 Mt	74 Gt	Morocco	35 Mt (16%)	50 Gt (67%)
			Egypt	4.8 Mt (2.1%)	2.8 Gt (3.8%)
			Tunisia	3.6 Mt (1.6%)	2.5 Gt (3.4%)
			Senegal	2.5 Mt (1.1%)	50 Mt
			Algeria	1.5 Mt (1.1%)	2.2 Gt (3%)
			South Africa	1.6 Mt (0.7%)	30 Mt
			Togo	1.5 Mt (0.6%)	1.5 Gt (2%)
Platinum Group Metals (Pd +Pt)	390 t	1 Gt	South Africa	191 t (49%)	63 kt (90%)
			Zimbabwe	34 t (8.7%)	1.2 kt (1.7%)
Rare earths	350 kt	280 Mt	Mozambique	960 t (0.3%)	N/A
			Burundi		N/A
			Tanzania		890 kt (0.68%)
			South Africa		790 kt (0.6%)
Vanadium	100 kt	19 Mt	South Africa	9.1 kt (9.1%)	750 kt (3.9%)
Zinc	12 Mt	220 Mt	South Africa	230kt (1.9%)	6.2 Mt (2.8%)

Source: (USGS, 2024) Note: Production and reserves for 2023 are up-to-date estimates by USGS

Out of 20 critical minerals Africa is in the top three producer countries for chromium, cobalt, manganese, phosphates and titanium. See Appendix II Shares of top 3 produces and reserve holders of critical minerals for 2019 on page 13. It should be noted that Africa's relatively low level exploration would suggest that it should rise in reserve rankings when it attracts more exploration focus.

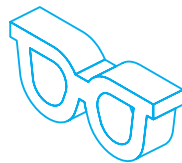
Critical minerals lists have been drawn up by several countries to guide national policy on minerals required for low carbon energy generation and important green industry technologies. While the United States has for many years maintained strategic stockpiles of "critical minerals" defined as a non-fuel minerals or mineral materials essential to the economic or national security of the U.S. and which has a supply-chain vulnerable to disruption, there's been a flurry of countries following suit. In the

United States the United States Geological Survey (USGS) released a new list of 50 critical mineral commodities (USGS, 2022) followed by tax credits for domestic production of minerals for EVs under the 2022 Inflation Reduction Act. India recently published a research paper assessing the criticality of 23 select minerals for India's manufacturing sector (Chadha & Sivamani, 2021). In March 2022 the Australian Department of industry, science energy and resources published a critical minerals strategy (Commonwealth of Australia, 2022). The latest iteration is a strategy with targets that run to 2030 (Commonwealth of Australia, 2023). In July 2022 the United Kingdom published a policy paper entitled resilience for the future: the U.K.'s critical minerals strategy (GOV.UK, 2022). Also in March 2023, the EU published Critical Raw Materials proposals to be passed into an Act by the EU Parliament.

There are obvious parallels between the proposed core list of minerals for the AGMS and critical minerals list, however, the latter are strongly influenced by an industrial-military paradigm which seeks security of supply by countries that are in most cases not major producers of the minerals. A critical minerals approach that is only concerned with security of supply and offtake from producer countries is contrary to Africa's development needs. International partnerships on supply chain development for critical minerals at a bilateral and multilateral level are proliferating. A recent example is the suggestion by the EU for a Critical Raw Materials Club open to consuming

and resource-rich that should, among other things, foster sustainable investment in producing countries and allowing them to move up the value-chain. Practically this could involve boosting exploration efforts, enhancing an environment for investment, driving innovation to unlock new supplies and collaborating on ESG and circular economy practices (EC COM 165, 2023). Member States need to take advantage of such bilateral and multilateral agreements, where feasible this could be handled at a regional level through RECs to be cognizant of wider development impacts, particularly where these could affect opportunities for value addition.

3.2 AGMS Vision and Goals



Vision Statement

An Africa that harnesses green mineral value chains for equitable industrialisation and electrification, creating green technologies and sustainable development to enhance the quality of life of its people.

The goal of the African Green Minerals Strategy is to steer mineral resource actors to boost local content for mining inputs and use the continent's green minerals as feedstocks to develop green industries that optimise opportunities created by climate change, the energy transition, the digital economy, and Africa's huge RE potential to energise the continent for productive and consumptive purposes.



3.3 AGMS Objectives

In line with the vision, the overall objective of the AGMS is to use green minerals to underpin Africa's industrialisation and electrification, whilst creating green technologies and sustainable development. The objective to achieve the AMGS goal call for mutually supportive actions from wide range of mineral industry stakeholders, notably but not limited to policy makers, government officials, training institutions, development partners, civil society, firms and investors. Key to achieving these objectives, will be actions that produce the following outputs:

- i. Increase in the local manufacture of inputs (capital goods, consumables) into mining and the processing of green minerals (ERBI) and provide more opportunities for local stakeholders to be part of the value-chains including through business and employment opportunities;
- ii. Channel an expanding portion of mineral feedstocks into manufacturing industries that add value to raw materials and to strengthen the value-chains and intra-industry linkages;
- iii. Grow the number of STEM graduates and technicians for green industries;
- iv. Increase in budgets for Research, Development and Innovation (RDI) applied to green minerals extraction and their use in green industries;
- v. Expand local manufacture of modules and components (Tier 2 & 3) for batteries, electric vehicles and renewable energy equipment and increasing local content over time;

- vi. Encourage support for a common African external tariffs (CET) on green mineral extraction inputs and mineral processing into manufactured products; and
- vii. Address the energy deficit and transport challenges by enhancing access to affordable and reliable energy and mobility.

Doing the above will create beneficial spillovers from up-stream, down-stream and lateral linkages in national and regional economies. The objective of the AGMS to achieve the following outcomes:

- viii. i. The Continent's mineral resources are harnessed to build a diverse industrial base.
- ix. Meeting a growing share of battery storage, e-mobility and renewable energy equipment demand from production on the continent.
- x. Increasing the quantum, range, quality and technological content of products and services in the green mineral supply chains by increasing volume sourced from Africa.
- xi. The emergence of internationally competitive green industry companies based in Africa using intellectual property and personnel sourced from continental institutions.
- xii. Effective stewardship of green mineral resources that protects people and the planet. Universal access to modern energy services by industry and all other stakeholders.



3.4 Foundations for AGMS in Africa's mineral policy frameworks

A core objective of the AGMS is to reorient Africa's suite of mineral policy frameworks with strategies to exploit the new opportunities for green minerals. Policies which view minerals as a finite resource that must be converted into capital to sustain economies into the future were laid down in the 2009 Africa Mining Vision (AMV) which calls for "Transparent, equitable and optimal exploitation of mineral resources to underpin broad-based sustainable growth and socio-economic development" (AU, 2009, p. v). Yet unfortunately mining's impact across the broader economy diminishes regarding more developmental indicators, with the sector visualized as an "inverted pyramid", accounting for an immense share of exports and foreign exchange, a large share of revenues, smaller share of growth and extremely small share of employment, due to the low employment elasticities of the sector. This is a situation that the AMV seeks to address. To turn the mineral sector into an engine for broad-based development, the AMV argues for integrating mining more extensively into the rest of the local economy (national, regional and continental) by increasing inter-sector exchanges in the form of goods, capital, knowledge, technology, know-how, market access, competitive pressure, skills, etc. Strengthening backwards or upstream linkages to sectors providing inputs and forwards or downstream linkages to industries to industrialise by converting minerals into fabricated products (ERBI) is central economic development strategy of the AMV.

To help countries domesticate the AMV into national policies, legal, regulatory and legislation a Country Mining Vision (CMV) was produced by UNECA (UNECA, 2014) that also advocated for ways to overcome limitations of small markets by acting at a regional level to achieve harmonised regulations and trade and investment conditions within Regional Economic Communities (RECs)

In 2013 UNECA produced a report titled "Making the most of Africa's commodities: industrialising for growth, jobs and economic transformation" (UNECA, 2013) that extended the argument for using minerals as a launch pad for industrialisation into a broader commodity-based industrialisation strategy. Similar themes of using Africa's comparative advantages in commodities coupled with strengthening linkages were carried through to the African Union Commodity Strategy (AU, 2021). Here four pillars namely "Commodity Markets & Pricing"; "Linkages & Diversification"; "Skills Development & RDI" and "Governance & Enabling Environment" support the commodity strategy to drive industrialisation and enhanced intra-Africa trade.

Increasing intra-Africa within a "single market for goods, services, facilitated by movement of persons in order to deepen the economic integration of the African continent" (AU, 2018, p. Part II Article 3 (a)) became closer to fruition when the Agreement Establishing the African Continental Free Trade Area (AfCFTA) came into force in 2019. For the AGMS the AfCFTA could underpin the development of a truly "African" green minerals strategy able to access the huge African markets for Green Mineral Value-chain products defined by comprehensive Rules of Origin (currently under discussion) to protect African value addition with a Common External Tariff.

In building upon existing mineral policy frameworks, the AGMS needs to overcome current challenges in the macroeconomic context of rising inflation, subdued growth, and increased debt vulnerabilities as well as structural obstacles in the way of building value-chains. These include infrastructure constraints, especially energy; downstream value addition constraints: trading rules, non-tariff barriers, subeconomic national markets and monopoly/oligopoly pricing of metals and intermediate feedstocks amongst others. Upstream constraints include skills and technology deficits and constrained access to finance amongst others. Other constraints arise from leakage of mineral rents due to weak governance, lack of regional alignment on conditionalities in licensing and national "self-sufficiency" doctrines that balkanises rather than opens regional economies. The AGMS is an opportunity to propose potential solutions to two recurring constraints to building regional value-chains.

3.4.1 Equitable solutions to overcome uneven development

First is the challenge of uneven development among and between the member states of the African Union regarding levels of economic development, quality of infrastructure assets and distance from major trade corridors. To overcome concerns that regionally stronger economies would gain the most from regional integration (a material factor behind the reticence for greater economic integration), it is proposed that a compensating mechanism be used that is biased in favour of weaker economies for weighting benefits to each country from regional economic cooperation. A simple proxy for the relative 'strength' of a country vis a vis its neighbours could be GDP per capita, the method proposed in the SADC Regional Mining Vision (SADC, 2019). Refinement and updating to reflect current economic conditions would of course be necessary for a system acceptable to member states, nevertheless the basic principles are as follows:



1. Weighting is calculated as the inverse of GDP per capita to favour low capacity economies;



2. The least GDP/capita sets the floor and the highest GDP/capita sets the ceiling of the spread for scoring;



3. Scores can be assigned for different development instruments or obligations attached to licences. For procurement this gives a scale for local content recognition. Purchases from



4. suppliers in country would count 100% towards local content targets, while purchases from regional suppliers would count 50-90%



5. A Venture Capital Fund (VCF) established to fund new enterprises or expansions could score applications for pre-feasibility study funding or debt funding on a scale of 10-90% or applications to the VCF for equity could qualify on a scale of 10-49%

Using local content requirements attached to mining licences as the instrument to build regional valuechains, the following example for ECOWAS illustrates how this could work in a REC. Table 4 below applies this weighting method for recognising regional content (Appendix 1 provides weights for all member states). Procurement by mining company in Ghana from Ghanaian suppliers (>50% Ghanaian value addition) would count 100% towards the Ghanaian minimum Local Content license obligation target; purchase from Sierra Leone 90% of the value, from Cote d'Ivoire 62%, from Nigeria 65%, from Cabo Verde 50%, from the rest of Africa 50% (ex-ECOWAS) and from suppliers outside Africa 0%. To meet local content targets, the mining company is incentivised to procure from local suppliers, then in declining order from poorer member states, richer member states and then from outside of Africa.

Table 4 Illustration of country recognition weights using inverse of GDP/capita for ECOWAS

ECOWAS Member state	GDP/capita 2021(Current USD)	Regional Local Content	Venture Capital Fund	
			Debt and PFS 10-90%	Equity 10-49%
Benin	1319	78%	66%	37%
Burkina faso	893	84%	78%	43%
Cabo Verde	3293	50%	10%	10%
Cote d'Ivoire	2549	61%	31%	20%
Gambia	772	86%	82%	45%
Ghana	2363	63%	36%	23%
Guinea	1189	80%	70%	39%
Guinea-Bissau	795	86%	81%	45%
Liberia	676	87%	84%	46%
Mali	874	84%	79%	44%
Niger	591	88%	87%	47%
Nigeria	2066	67%	45%	27%
Senegal	1637	74%	57%	33%
Sierra Leone	480	90%	90%	49%
Togo	973	83%	76%	42%

Source: (World Bank, 2023)

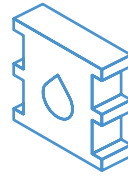
Developing economies must overcome numerous obstacles before their firms can participate in regional mineral value-chains. Access to capital is a major impediment to economic diversification where firms must overcome a lack of liquidity, high cost of capital and high investment hurdle rates to establish or expand businesses. A solution is to establish a minerals finance facility (Venture Capital Fund) structured to favour weaker member states by using the inverse of GDP/capita to weight the funding offered.

Options to capitalise such a fund would be improved by making it a regional economic community initiative so it could draw upon established regional financing protocols and mobilise funds from member state Development Finance Institutions along with regional DFIs. Capital contributions from the private sector (miners, refiners, suppliers) would be essential.

Other sources for capitalising the fund could come from multilateral DFIs and development partners.

The objective of the VCF would be to provide funding for project preparation and both debt and equity for bankable projects. For example, using the weighting system illustrated in Table 4, a project to supply mining inputs (e.g. personal protection equipment) being developed in Côte d'Ivoire could have 31% of the prefeasibility study funded. If an investment decision is reached for the project to proceed it could have 31% of the debt and 20% of the equity funded by the VCF. Refinement of the concept for a VCF will need to be made yet the important point is to lock in a financing mechanism that gives developing Member States possibilities to participate in regional value-chains.

3.4.2 Developing indigenous mining capital



Second is the weakness of domestic or indigenous mining capital compared to foreign owned firms in many countries. Foreign Direct Investment has brought capital and technology to successfully extract Africa's mineral wealth, yet this reliance on FDI can frustrate value-chain development in several ways: dividends flow to foreign shareholders, global mining companies tend to have centralised procurement rather than developing local suppliers, processing is also planned and global scale which can shut out local downstream opportunities, high level RDI tends to happen in the home country. As a result, fiscal, backward, forward and knowledge linkages do not work to the host countries advantage.

Developing local capital for the mining sector has several advantages, documented in the AMV, as it is generally more likely to make critical resource sector linkages into the local economy. Factors which are relevant for this linkage propensity include: better local knowledge of supply opportunities due to better networks, more reliant on local suppliers, a need to invest in local processing for value addition, a wider view of activities needed to develop the industry, taking initiative to develop skills and technology in-house and finally an inherent willingness to develop the local economy (AU, 2009).

Access to capital is a constraint faced by indigenous mining entrepreneurs. The exploration phase is high risk and therefore generally funded entirely by equity. Given the scarcity of capital, public institutions attempting to set up a standalone funding facility directed at indigenous mining entrepreneurs would pose an unacceptable risk of loss of capital. A possible solution would be to shift the risk for funding and running a venture capital fund for indigenous mining entrepreneurs onto the incumbent, foreign-owned, mining companies. If foreign mineral rights holders were induced to use their access to cheaper capital to expose a

small portion of their balance sheets (3-5%) to guarantee a venture capital fund as well as to manage it capital would be available to indigenous mining entrepreneurs on better terms.

Another approach to achieve local participation in mining ownership would be to stipulate participation minima to be reached at set intervals over the term of the mining licence. For long licence terms running for 25 years, local participation could be stepped as 20% by year 10, 40% by year 20 and 50% +1 by year 25. For shorter licence terms the participation rates should be pro-rated. Stepped participation rates at the suggested intervals would still allow foreign investors to achieve their return on investment before their equity is diluted. In this regard, in encouraging indigenous mining capital, it will be worth mentioning the African Mineral and Energy Resources Classification and Management System (AMREC). AMREC is a system developed to ensure that resources estimation and classification are adequately harmonized across Africa. It will provide a game-changing unified stock exchange and financial reporting code, the PanAfrican Reporting Code (PARC) to attract responsible investments continentally, also along the mineral resource regional and global value-chains.

AMREC follows the entire resource lifecycle coherently and consistently, facilitating seamless management from in-ground resource exploration and classification to mining/recovery of resources, processing or value-addition, to trade and use, including reuse and recycling of tailings, residues and wastes. AMREC will help effective capital allocation and build resilience in the continuously threatened industry by market volatilities. Importantly, AMREC is designed to support capacity building to create an efficient and internationally recognized African professional workforce.

AMREC is designed and developed by African experts for the peculiar needs of Africa as set out in the AMV. It is aligned both with the African Union Vision Agenda 2063 and the United Nations Sustainable Development Goals (SDGs). AMREC implementation is being hosted and incubated by the African Mineral Development Centre (AMDC), which has included AMREC as one of its strategic workstreams. AMREC is from conception to execution, internationally acceptable through its alignment with the United Nations Framework Classification for Resources (UNFC). Using AMREC will facilitate negotiation and implementation of reciprocal arrangements with other regions that have aligned their initiatives with UNFC and, hence, promote the progressive global integration of mineral resource reporting.

A module within AMREC is the Pan African Resource Reporting Code (PARC), which will facilitate transparent financial reporting of mineral projects. PARC will be used continent-wide for the industrial financial reporting of the total resource base of Africa to facilitate access to finance and attract the required capital investments. PARC also addresses the procedures and implementation strategy for recognizing Competent Persons. Competent Persons certified under PARC will sign off the public reports made available for all potential investors in Africa, whether domestic or foreign. It is important to state at this point that, Africa Mineral and Energy Resources Classification and Management System (AMREC) and Pan African Resource Reporting Code (PARC), which have been adopted by African Union for continental use in Africa, since September, 2021 is currently ready for continental deployment.

3.5 AGMS Goals to Energise Africa

Goals of the AGMS align with the imperative to end energy poverty in Africa and power development that is cleaner, healthier, local and creates more economically diversified economies.

1. Rolling-out supply to the almost 600 million citizens, some 43% of the population, mostly in SubSaharan Africa, who lack access to electricity will require expanded transmission and distribution networks in tandem with local embedded RE (e.g. PV) generation (home, homestead, community). This will involve a step-change in the mining and processing of infrastructure minerals, above all steel, copper and aluminium (plus limestone for cement). It will also help to switch household cooking from polluting fuels to clean energy.
2. Increased energy use is synonymous with development. Africa needs to industrialise and raise economy-wide productivity with reliable energy which is necessary for other priorities like food and water security. New capacity must come from least cost generation options and provide energy security that translates into an energy mix with growing renewable sources, balanced with fossil fuels, especially natural gas, as an energy transition energy source.
3. Opportunities for manufacturing power equipment, battery storage, transmission equipment, components and assembly of electric vehicles and fuel cell electric vehicles will provide an expanded basis for industrialisation in green industries and jobs in 'sunrise' sectors.
4. Expanding production of green minerals could help to offset risks of declining revenue from fossil fuel exports.
5. Energising Africa, as just described, is the optimal and just path the energy transition should take for its people and the planet. None of these goals, however, will be met without coordinated action by member countries and developed economies fulfilling their obligations to fund the transition and build the African value-chains.

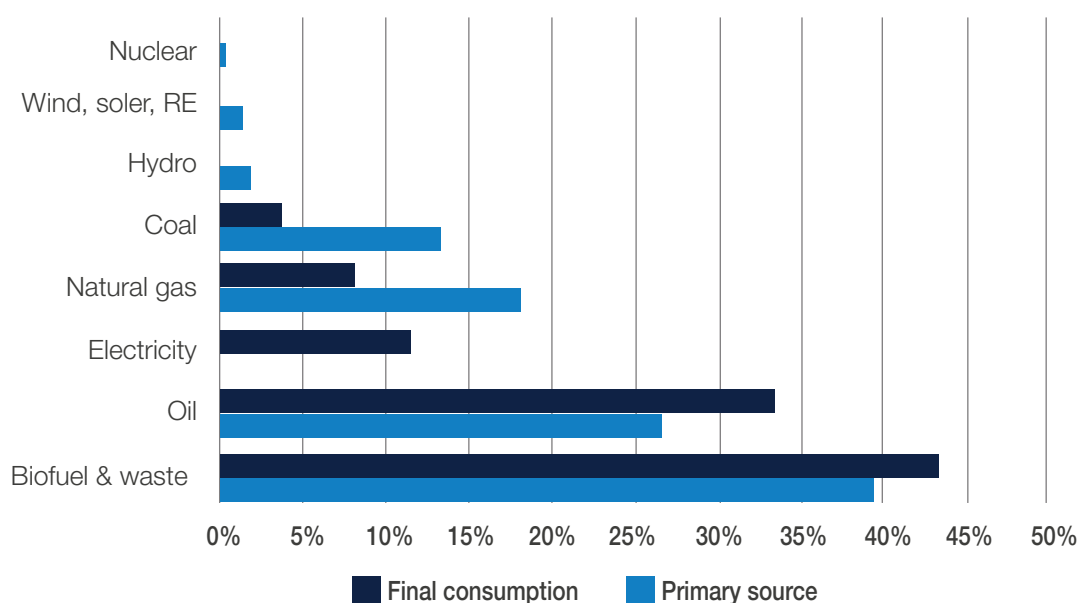
Frameworks setting energy goals already in place. At the apex level, the African Union developed the Green Recovery Action Plan 2021 – 2027 (Plan) to steer a recovery that is clean, resilient, and inclusive (AU, 2021). Supporting renewable energy, energy efficiency and national Just Transition programmes is one of the five priority areas in the Plan. The new energy economy is network intensive as it needs to connect solar during the day with the wind at night to storage such as batteries or pumped hydro, and on to load centres in cities, industries, or mines. Many African countries are faced with challenges to invest in both generation and transmission assets. This is such an important point that the plan argues that “the ‘just transition’ Programme should focus on ensuring that African countries invest in transmission grids” (AU, 2021, p. 14) and facilitate regional energy integration through, inter alia, regional power pools. As a long-term ambition, interconnection of Africa’s five regional power pools should be pursued, to provide the most cost-effective greener grid baseload to underpin local RE solutions.

Grid strengthening is vital. Without industrial demand to anchor investments, the inadequacy of the transmission and distribution network prevents the energy supply from reaching final demand which is one of the main causes of the low levels of energy access in the continent. To close this gap the AfDB’s New Deal on Energy for

Africa, amongst other things, supports regional projects and utility companies to extend national and regional grids (AfDB, 2016). Minerals needed to build transmission and distribution networks are galvanised steel (zinc coated), aluminium, copper, and grain-oriented steel (electrical steel) for transformers. This needs to happen in tandem with rolling out self-contained embedded RE (solar, wind, micro-hydro, et al) and storage for isolated homesteads and communities beyond viable grid connections. Self-contained RE systems also could enhance local community power and decision making.

Africa makes up only 5% of current global energy supply and 3% of current electricity generation. Biofuels and waste make up the largest share of the source and final consumption of energy. Significant differences in primary supply (see Figure 3), electricity access, household cooking fuel and sectoral composition of final energy consumption exist within and between African regions. Natural gas and oil dominate primary supply in North Africa while coal dominates in Southern Africa. Strategies to close energy deficits, substitute biofuels and waste and dirty fossil fuels with clean domestic energy, and reliably supply growing demand from mining, agriculture, industry and commerce will necessarily vary across regions.

Figure 3 Energy mix in primary sources and final consumption, 2022



Source: (IEA, 2022)

For the purposes of the AGMS three key advantages in Africa's energy landscape need to inform the strategy to energise the continent. There are three standout messages. Firstly, Africa possesses vast untapped renewable energy resources. At over 5500 exajoules per year, Africa is far and away the world's richest region for renewable energy potential, with 44.8 percent of the total technical potential of renewable energy (AfDB, 2022, p. 80). Specifically, the continent's major resources are as follows:

- i. Large hydropower unexploited potential of 584 GW and a technical potential of 1 753 GW (medium, small and micro hydropower)

- ii. Solar PV and CSP technical potential of 7 900 GW; and
- iii. Onshore wind power generation potential of 461 GW.

Bioenergy, offshore wind and geothermal resources further add to the continent's renewable energy richness. Details of Africa's energy resources are elaborated in Appendix V on page 18.

Table 5 Global weighted average costs and GHG emissions by generation technology, 2022

ECOWAS Member state	Installed cost USD/kW	Capacity factor %	Levelised cost USD/kWh	Life cycle emissions g CO ₂ e/kWh
Bioenergy	2162	72	0.061	52
Geothermal	3478	85	0.056	37
Hydropower 1	2881	46	0.061	21
Hydropower 2^a	2881	59	0.042	21
Solar PV	876	17	0.049	43
Concentrated Solar	4274	36	0.118	28
Onshore wind	1274	37	0.033	13
Offshore wind	3461	42	0.081	13

Sources: (IRENA, 2023, p. 15) * (NREL, 2021) Note a Authors estimate for high flow sites.

Large hydropower provides the cheapest and cleanest electricity from renewable resources and is concentrated in the tropics (Congo River Basin), see Table 5. As more renewable energy is integrated with the power network reserve capacity is required, both at short notice for smoothing the gaps due to intermittency and, on a scheduled basis, to balance the daily variable output from solar and wind plants and the seasonally variable output from run-of-river hydro plants. Large storage hydro plants with peaking capacity are ideally suited to provide smoothing

and balancing services and therefore anchor renewable energy generation. Africa's installed hydropower capacity at 38 GW, only 6.5% of the potential resource, with many undeveloped high value locations remaining. The series of rapids on the Congo River at Inga (Inga Falls) have an estimated hydropower potential of 40,000 MW yet the installed capacity is 1 800 MW (World Bank, 2014) with further massive resources along the length of the Congo river. Developing these resources warrants renewed attention from the AU and the AfDB.

Dryer and wetter weather patterns as a result of climate change are obviously going to affect hydropower operations. Currently available modelling by the IEA on likely impacts out to 2100 suggest that countries around the Congo and Zambezi basins are likely to experience a drop in hydropower capacity factors of approximately 3 percent while those in the Nile basin are projected to experience an increase (IEA, 2020).

Secondly, building new clean energy systems will require extensive planning and investment in transmission infrastructure. Fossil fuel development will be needed to reach reliable, balanced and sustainable clean energy systems. Proven natural gas reserves now stand at more than 17.56 trillion cubic meters. Gas to power will provide important grid balancing roles. Gas is also a feedstock for basic chemicals such as ammonia (for fertilisers, explosives, fuel cell hydrogen,

et al) and polymers (methanol route). The hydrocarbon sector will remain a key part of the energy industry up to net zero targets by 2060, producing transport fuel, and petrochemicals are still essential to produce polymers which will be needed in large quantities as economies industrialise.

Thirdly, Africa has huge potential to produce green hydrogen using its rich renewable energy resources by establishing entirely new energy export industries. Global declines in the cost of hydrogen production could allow Africa to deliver renewables-produced hydrogen to Northern Europe at internationally competitive price points by 2030. Hydrogen production at the scale needed for export would facilitate the gradual substitution of petroleum in domestic markets.

3.6 Pillars supporting African Green Minerals Strategy

Four complementary pillars support the AGMS, each addressing the policies and practices that need to function harmoniously to achieve the strategy's goals and realise the AMV vision, namely:

- i. Advancing mineral development
- ii. Developing people and technological capability
- iii. Building key value-chains
- iv. IV Mineral stewardship



Chapter Four

④ Pillar I: Advancing mineral development

4.1 Governance of mineral resources

To translate mining more effectively into mineral-based development to support equitable industrialisation (ERBI) requires rethinking the configuration of governance of the minerals sector. The key governance relationship that needs to be strengthened is that between ministries responsible for mining and ministries responsible for industry and trade. The administrative interface between these ministries should be analogous to links in a value-chain as mineral feedstocks flow into manufacturing. Effective governance of mineral resources involves a combination of specialist and complimentary functions carried out by the following “generic” entities, amongst others:

- A Minerals Development Board/ Promotion Entity
- A Geological Survey Department/Entity
- Department of Mines
- State revenue Authority
- Industry and Trade Department
- Environmental Regulatory Department
- Other industrial oversight departments

Appreciating how mineral value-chains stretch through different government functions makes the case for coupling the governance of mining with that of industry. The minerals value-chains go from mineral exploration through to the production of mineral-based feedstocks (intermediates) for downstream sectors such as manufacturing, construction and agriculture,

and includes inputs (backward linkages: supply-chain) into each stage. Consequently, in addition to the ministry responsible for mining, the governance of regional mineral value-chains requires the participation of numerous Ministries including, industry, environment, labour, health, education, and others. However, the Ministry of Industry is by far the most important as it governs the backward and forward mineral linkages. If the mineral linkages are fully realised, the Ministry of Industry will be governing a greater share of national economic value addition than the Ministry of Mines. Consequently, it is critical that for a successful strategy to build mineral value-chains the Ministries of Mines and Industries need to work together as one governance entity or, preferably combined into a single

Ministry, as is the case in several Nordic States³. Additionally, there is the need to harmonise the incentive regimes of the entities to avoid lacunas. Contemporary examples show that provision of incentives by the State facilitates rapid development of the mineral value-chains. Typical examples include the Inflation Reduction Act of the USA and China providing offtake arrangements for the production of EVs. Therefore, Africa needs to develop home-grown incentives to attract the requisite investment capital into development of the value-chains especially in the manufacturing sector.

³ Mining comes under the Ministry of Economic Affairs & Employment in Finland, of Enterprise & Innovation in Sweden and Trade & Industry in Norway.

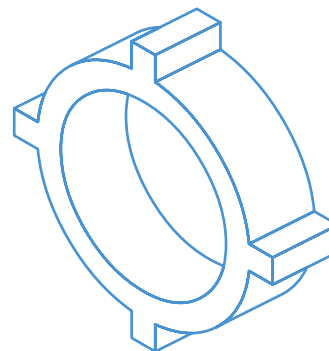
These can include subsidies, tax incentives for inputs to specific items to ensure localising processing and manufacturing on the continent. A comprehensive governance infrastructure of mineral resources requires availability of quality and timely statistical data to inform analysis, dialogue and decision making. Therefore, improvement in the quality of relevant statistics by produced by RMCs will significantly contribute to effectiveness in governance of minerals.

Energy policy is a second state function directly related to implementing the AGMS that also needs to be tightly coupled with the Ministry of Mines for the same reason, given the strategic aims of building value-chains for RE equipment.

An example is Egypt, which has reformed its Energy Ministry into the Ministry of Electricity and Renewable Energy to reflect the importance of developing new clean energy systems. Highly functioning administrative alignment that mirrors mineral value-chains also has the benefit of facilitating the cardinal natural resource taxation principle to diversify the economy to compensate for the depletion of minerals by using taxes from mining to invest in human and physical capital. It is essential that a portion of resources rents go into productive investments (creating and enabling environment for industry with infrastructure, skilled labour, industrial finance).

4.2 Strengthening earth sciences institutions, undertaking geophysical mapping

Public institutions conducting scientific surveys of geological provinces provide valuable public goods for government functions of planning, risk management and the identification of economic minerals resources. National geological surveys in many countries across the continent are poorly resourced and capacitated, therefore unable to perform these seminal functions. It is important to make the case for increasing geological knowledge of green minerals to governments, citing the high return on investment that well-functioning geoscience institutions return to their countries over the longer term. Three avenues for advancing geosciences and building geological survey institutional capacity should be pursued in parallel:



1. Budgets should be part-funded from mineral rents (royalties and taxes);
2. Inter-geoscience institution research collaboration, perhaps coordinated by the REC body. These should include specialist HRD programmes funded from technical development programmes with development partners;
3. More effort should go into multi-country surveys under the guidance of the Organisation of African Geological Surveys (OAGS) or REC strategies to create updated mapping using lowcost techniques such as the use of satellite imagery and the use of drones for geophysical mapping.

It is essential that Member States capitalise on the global focus on critical minerals to resource and upgrade their geoscience survey capabilities to underpin targeted minerals exploration and to be in a stronger position to set terms for their exploitation. Ideally, the mineral investment targets identified by state geo-survey entities should be developed for the compilation of a "Project Prospectus" to underpin the competitive auction of the mineral property against a) the state share of mineral rents, b) mineral value-chain development (local content and beneficiation; c) annual spend on STEM skilling and RDI; and d) the provision of public infrastructure (logistics, power, water). Rapidly evolving technologies, collectively referred to as the Fourth Industrial Revolution (4IR) that integrate digital technologies into all aspects of exploration, mining, and processing, alter the interface between humans and machines (Mutanga, et al., 2021). 4IR technologies are improving exploration techniques through, amongst other things big data analytics, and machine learning. Importantly for mining efficiency which allows lower grades to be mined

and safety, 4IR seems to offer the greatest benefits in core operations (PWC, 2021). Green mineral producer countries arguably have a limited window of opportunity to improve terms on which they enter global supply chains as developed countries scramble to secure access to critical minerals for their own needs. The United States has encouraged other G7 rich countries to join the Partnership for Global Infrastructure and Investment for the purpose of building clean energy supply chains along with the Minerals Security Partnership that focuses on supply and encouraging circularity. The European Commission has passed a Critical Raw Materials Act for the same purpose. Importers state a desire to work with producer countries to upgrade supply chains. These initiatives need to be leveraged for advancing geosciences and technical assistance for pre-feasibility studies for developing new resources and in-country value addition, accompanied by institutional capacity building of mineral governance institutions.

4.3 Infrastructure and finance to close production gaps

Power, transport and water infrastructure is essential for mineral extraction, processing and movement of intermediate forms of processed minerals (concentrates) to subsequent production stages. Low levels of infrastructure stock and poor maintenance of infrastructure assets is a serious impediment to the expansion of African firms. As products become more elaborately transformed, non-tariff barriers (NTBs) rise in importance in trade friction which effectively chokes intra-African trade. High trade costs are due to a mix of poor infrastructure and non-tariff barriers (OECD, 2017), which translate into transport costs that are more expensive by at least US\$13/ton than in economies of comparable incomes (Vilakazi, 2018).

2019 estimates by the African Development Bank suggest that the continent's infrastructure needs amount to \$130–170 billion a year, with a financing gap in the range \$68–\$108 billion (AfDB, 2019). These figures are dwarfed by the financing requirements for Africa to implement its climate action commitments and NDCs - between about \$1.3 trillion and \$1.6 trillion, averaging \$1.4 trillion (AfDB, 2022).

Infrastructure and services which are directly relevant to an enabling environment for green minerals include conformity with carbon disclosure and monitoring measures. This is especially so for internationally traded minerals and products. This requires access to clean energy supplies as well as carbon tracking and auditing services to be able to certify supply chains and products.

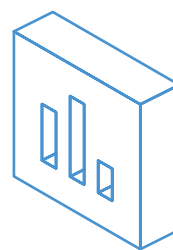
For African firms engaged in international trade, the medium and long-term carbon monitoring of supply chains is becoming increasingly important. As international companies are committing to Scope 3 net zero targets, African firms need to ensure low-carbon emissions along their value-chains. This implies that trading with African businesses in a country with high fossil fuel shares in their energy mix becomes more expensive and so less attractive. Several regions and countries, including the European Union, Japan, and Canada, are planning carbon border adjustment mechanisms intended to prevent carbon leakage and support their increased ambitions on climate mitigation (AfDB, 2022, p. 85).

Domestically originated capital market expansion has been boosted by the launch in 2021 of the Liquidity and Sustainability Facility (LSF) designed by UNECA in collaboration with Afreximbank. Created with the twin objectives of supporting the liquidity of African Sovereigns Eurobonds, and incentivizing SDG-related investments such as SDG and green bonds, the LSF is a domestically-owned base to complement the pledged commitments from development partners through Nationally Determined Contributions as per the Paris agreement, which are still outstanding.

Raising finance for mineral development and industrial finance for green industries also need to be seen in the context of the costs already carried by African economies arising from climate change induced damages.

In addition, the high cost of capital in Africa, where available, drives mineral development capital raising offshore in the form of FDI, with consequent loss of linkages development and industrialisation through ERBI. This needs to be tackled through the development of local and continental capital markets with instruments to ameliorate currency risk.

4.1 Establishing a Green Mineral Value Chain Investment Fund



Access to capital is a binding constraint for African firms seeking to realise the huge and dispersed economic opportunities for growth, employment and Equitable Resource-Based Industrialisation (ERBI) arising from mineral extraction. The cost of capital is so high in many African States that green transition investment opportunities will overwhelmingly be taken up by foreign

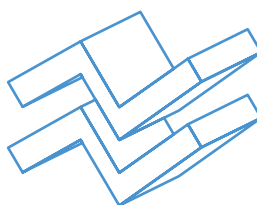
investors (FDI) with concomitant leakage of the benefits overseas unless measures are taken to provide access to capital for African investors. The AGMS can draw upon the AMV recommendations for establishing local venture capital funds and robust operating principles it suggested (AU, 2009) in the design of Green Mineral Value Chain Investment Fund.

Core principles for the design of a Green MVC investment fund could comprise the following:

1. Linking funding by foreign mining companies to proportional rights to mineral exports. To capitalise the fund, for example foreign miners would obtain the right to MVC-VCF projects' mineral exports at their share of MVC-VCF financing of the project, as well as their equity share in MVC-VCF financed projects.
2. Capitalisation of the fund could also come from AfDB, AfreximBank, DFIs (Brics NDB, IFC, etc.), Development Partners, Just Energy Transition Investment Funds, et al.
3. Weight financing eligibility in favour of least developed member countries adjusted for a suitable metric. The measure suggested is the inverse of countries GDP per capita. The fund would finance from **10% to 90%** of the project PFS, from **10% to 90%** of the project debt and from **10% to 49%** of the project equity.

Detailed design would be needed to ensure the Green Mineral Value Chain Investment Fund would be viable, responsive, risk tolerant and sustainable. The fund could initially be established under the AfDB or the AfreximBank.

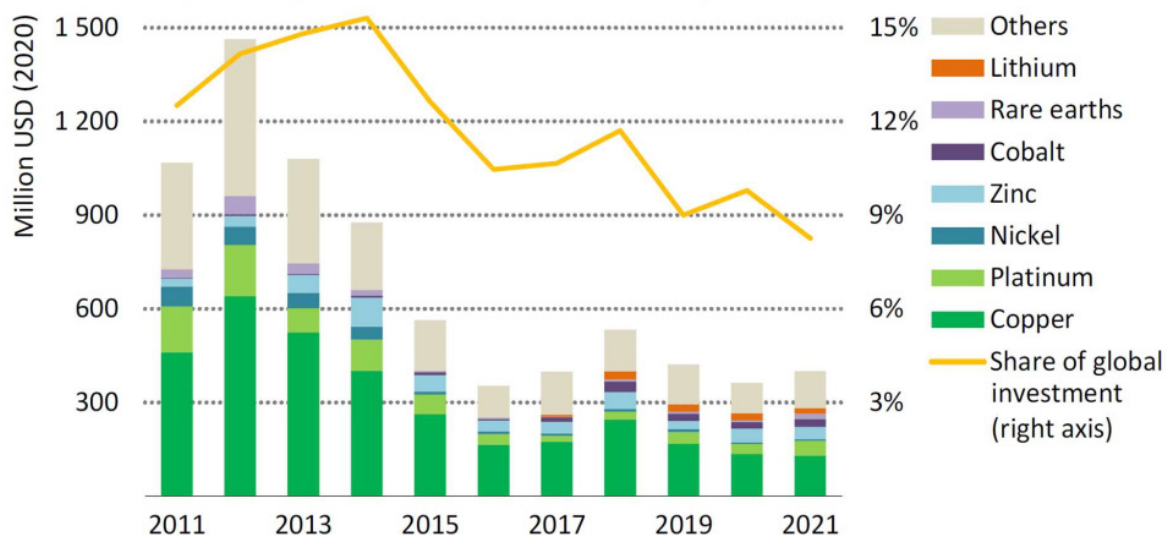
4.5 Stimulating Exploration effort



Using exploration expenditure as a measure of the attention being given to energy transition metals provides a reality check on the pace with which the mineral sector is adjusting. According to S&P data the global nonferrous exploration budget for 2021 reached 11.24 billion USD, up **35%** on pandemic affected 2021, but still only **50%** of the 2012 high. Gold was the most targeted commodity at **55%**, copper **21%**, nickel **4%** and **11%** on other commodities covering potash, phosphates, rare earth metals, molybdenum, lithium, cobalt and other minerals. Exploration budgets for lithium and cobalt increased **25%** and **27%**, respectively, in 2021 but were still below pre-pandemic levels despite sharp price rise in both metals at the end of 2021. Sustained demand for battery metals and project pipelines for the foreseeable future is consensus view but bigger shifts are emerging. "We are beginning to see a shift in exploration for lithium and cobalt, with more majors showing interest in what have historically been junior-dominated commodities. Major companies' share in cobalt exploration rose to **34%** in 2021 from **18%** in 2020 and **8%**

in 2018. For lithium, major companies' share increased to **24%** in 2021 from an average of 9% in 2017-20" (S&P, 2022, p. 12) Nonferrous exploration budgets for the Africa rose only **12%** over 2020 to 1.26 billion USD. Gold exploration posted the largest increase in Africa, although by only **18%**. Allocations for copper, diamonds, zinc-lead and lithium declined in the region. The DRC remained the top destination, despite a **7%** budget decline to \$130 million. Cote d'Ivoire was second in 2020 but slid to fifth in 2021 with an **18%** decrease to \$88 million. Exploration in Burkina Faso and Mali rose to \$126 million and \$129 million, respectively, **30%** of which targeted gold (S&P, 2022).

Over the period from 2011 to 2021 Africa's share of global exploration expenditure on green minerals has been on a downward trend, see Figure 4. To reverse this trend countries need to put effort into their earth sciences institutions to improve the quality of information on prospectivity.

Figure 4 Exploration expenditure on Africa's green minerals 2011-2021

Source: (IEA, 2022)

At a global level for the extraction of critical minerals, the IEA estimates that the gap between projected needs to reach NZE targets and expected supply in 2030 is above 25% for lithium and nickel, and nearly 20% for copper. The gap, at 35%, is largest in percentage terms for lithium, while the shortfall in supply in absolute terms, at 6 Mt, is largest for copper. For mineral

processing there is a 60% gap for nickel sulphate and 40% for cobalt (IEA, 2023a, p. 55). African governments can encourage expanding production from existing operations and prioritise exploration for green minerals especially lithium and copper by geological surveys undertaking mapping performing surveys.



Chapter Five

⑤ Pillar II: develop people and technological capability

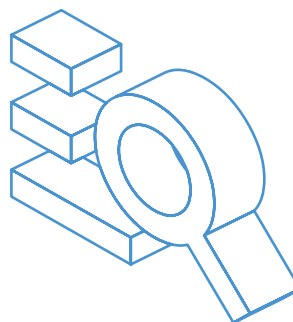
5.1 Institutions to develop the required skills base

Strategies for skills for mining, processing and manufacturing need to work with number of moving parts: differences between opencast and underground mining operations as well as hard or soft rock mining, the fit between training and education performed by education authorities and institutions of higher learning and the occupational requirements, the role played by in-service training, how shortages of skills are

handled, recruitment into employment and exit on retirement, policies on employment for local communities, the list goes on. For the purpose of the AGMS, the focus should be on a minimum mining right annual spend STEM skilling (around 5% of payroll) and on government policy makers to draw out key messages on skills relevant to establishing new value-chains.



5.2 Skills identification and skills development strategies



For the main occupations in the mining sector today average employment shares for surface mining are as follows: miners, drillers, drivers: **44%**, plant operators and technical staff: **25%**, engineering professions: **16%**, management and administration: 10%. There is now a broad consensus that technological advances will increase automation and reduce mining employment for physical jobs in highly structured and predictable roles, reducing overall mining employment and increasing the ratio of employees required with mechatronic skill sets. Policymakers and training institutions should work closely with the mining industry to stay up to date with changes to keep training relevant to industry needs at the same time as anticipate the need for more STEM skills with more resources for their creation. Lithium-ion battery manufacturing will take place in Africa if initiatives like the Republic of Zambia and DRC Battery Council come to fruition (see section 6.1.4.5). Anticipating the skills that would be needed is therefore important. Looking at new battery plants being built indicates that most desired academic competencies for battery production and maintenance are chemistry, mechanical engineering, and electrical engineering. It is noteworthy that in high technology plants with considerable automation

a wide range of categories skills are involved that include soft, academic, general transversal, crosssectoral specific and sector-specific competencies (Albatts, 2021).

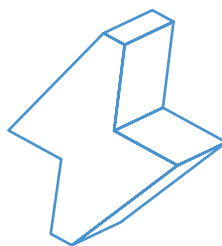
Assembling electric vehicles starting with two and three wheelers is a priority value-chain for the green minerals strategy. For electric motorcycles basic assembly line skills of fitting, fastening and testing are required. In time the established automobile assembly industry will need to switch to electric vehicles for increased roles for software, ICT, mechatronics and industrial automation occupations will need to be filled.

Skill requirements mining, battery manufacturing and electric vehicle assembly is examined in more detail in Appendix VI Skill Identification.

Funding skills development needs to be shared between the public and private sector. Guidance for funding is outlined in section 5.1.1 above. For manufacturing compulsory contributions to training funds should also be set as a percentage of payroll at **1%** or **2%** that will also incentivise firms to ensure that training stays relevant to the needs of industry.



5.3 Centre of Excellence for Batteries



Public higher education and research institutions are key enablers of economic growth by preparing graduates for careers in technical fields needed by industry. Shortages of critical skills are high among the factors that hamper African firms moving into higher value activities. Increasing the pool of skills that will be needed by clean energy industries is an important role that education institutions can play to implement the AGMS. Work underway at the African Centre of Excellence for Advanced Battery Research *Centre Africain d'Excellence pour les Batteries en R.D. Congo* (CAEB) at the University of Lubumbashi is model for investing in the human capital needed for an African battery industry. In November 2021, the DRC government in collaboration with its Partners (AfDB, ALSF, UNECA, AFC, AFREXIMBANK, BADEA and UN COMPACT) organized the DRC Africa Business Forum on Fostering the development of a battery, electric vehicle, and renewable energy industry value-chain and market in Africa. Among the deliberations, Skills for Battery Development in DRC were identified for action. Launched on 22 April 2022 CAEB includes cooperation with the University of Zambia (UNZA) and the Copper Belt University (CBU). The mandate of the centre is to create skills and competencies needed by the battery industry as well as to support the emergence of a competitive battery, electric car and renewable energy value-chain in Africa. The Centre is working on curriculum development for Masters and PhD programmes with the Ministry of Higher Education. CAEB is mandated to support

the cross-border Special Economic Zone that will be established under the bilateral Republic of Zambia DRC Battery Council, discussed in section 6.1.4.5, and is determined to ensure both countries benefit more from their green minerals industries by manufacturing products rather than exporting raw materials.

CAEB is seeking to collaborate with other African universities that have research programmes on energy as the longer-term ambition is to expand the focus from lithium-ion batteries to include renewable energy and the energy transition. Discussions have begun with amongst others the University of Pretoria, University of the Witwatersrand, University of Namibia, Mohammed VI Polytechnic University (where a battery materials laboratory has been built with support from the AMDC). Industrial partners such as De Beers, CSIR and Phillips have also expressed interest in collaborating (Kanda, Kasonde, & Tumba, 2023).

The principal researchers argue that Africa is starting late compared to the research work being done in China and the EU and needs to act quickly to catch up. Additionally, expertise is scattered among several institutions which makes collaboration and pooling efforts essential (Kanda, Kasonde, & Tumba, 2023). CAEB has the advantage of being a part of the Republic of Zambia DRC Battery Council which gives it official government backing.

Chapter Six

⑥ Pillar III: Building key value-chains

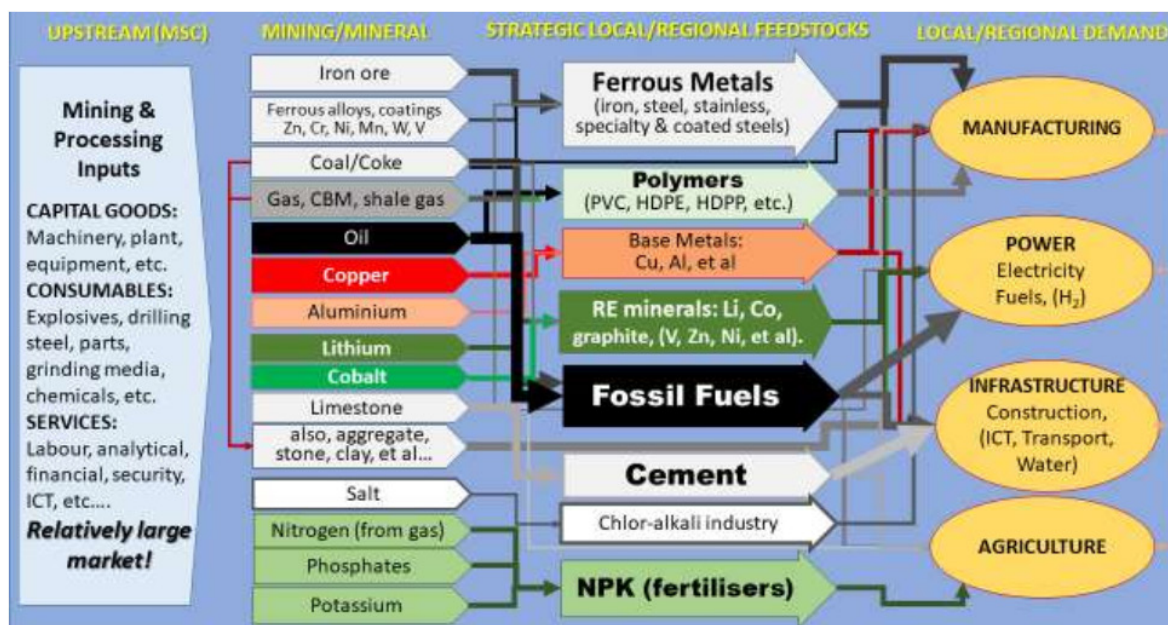
The AU Commodity Strategy sets a vision for commodity-led industrialisation, namely: “Commodities contributing to an integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the international arena” and is fully aligned with the AMV and an African ERBI strategy. It seeks, among other benefits, to enable African countries to, add greater value, extract higher rents from their commodities, integrate into African value-chains, and promote vertical and horizontal diversification and local content development that recognises inputs from the whole continent (AU, 2021, p. 10). By focusing on green minerals, the AGMS adds to the role charted for mineral commodities in the continent’s development frameworks, summarised in section 3.4, but cannot be separated from the necessary actions for advancing the minerals sector as a whole. Specific strategies are needed to guide the development path for establishing and growing green industries, especially in the renewable energy space elaborated below, nevertheless

the basic conditions needed for value addition, deepening inter-sectoral linkages and moving downstream, apply economy wide.

Creating jobs at the scale and pace needed to cater for Africa’s young and expanding workforce involves dramatically expanding the manufacturing sector. Currently, the key minerals and their roles for local/regional growth and equitable industrialisation (ERBI) are in fact limited. These minerals are iron/steel for manufacturing and infrastructure/construction, fossil fuels (but accelerating migration to RE sources) for power, metallurgy, petrochemicals/polymers, nitrogen/fertilisers, et al, copper and aluminium into manufacturing, construction, et al, limestone into cement/infrastructure, agriculture, et al and nitrogen, phosphate, potassium (NPK) fertilisers into agriculture. Figure 5 depicts the linkages and mineral flow along value-chains to downstream sectors. It also summarises the upstream linkages (inputs) component, which is generally common for the different value-chains.



Figure 5 Key mineral value-chains for industrialisation (ERBI)



Source: Adapted from (SADC/AMDC, 2015/6)

Green jobs to preserve, protect or restore the environment are expected to make up a bigger share of employment in time. However, to fully participate in high value green industries of the future Africa must grow its manufacturing base. The most important mineral-based inputs into manufacturing are steel/alloys, polymers, base metals and construction minerals. Globally, steel

and polymers are by far and away the most important mineral feedstocks into economic activity, excluding construction minerals and mineral fuels, at about 1840 Mt/y (WSA, 2024) and 390 Mt/y (Statista, 2023) respectively, compared to less than 300 Mtpy for all other metals combined (USGS, 2022).

6.1.1 Upstream linkages to optimise mining inputs opportunities

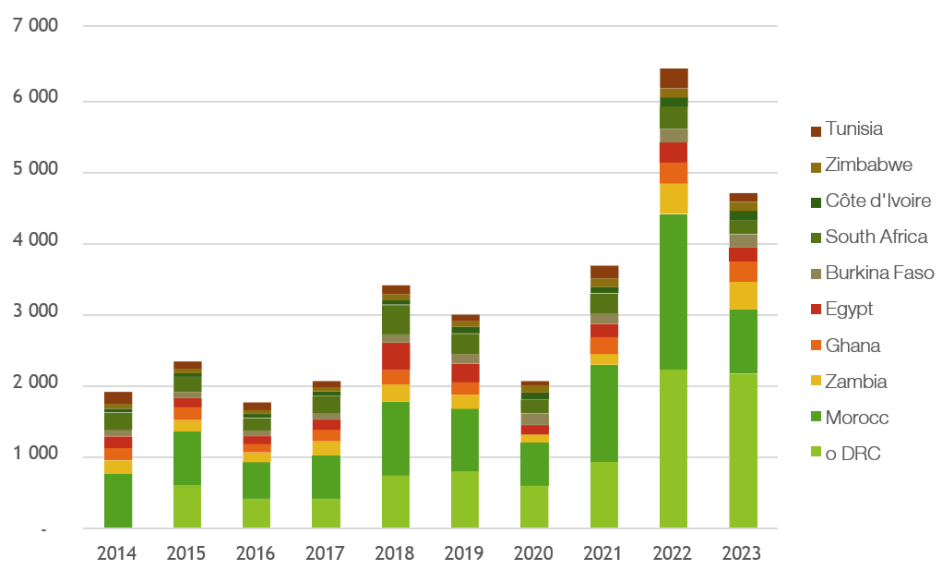
The mining and mineral processing supply chain (MSC: capital goods, consumables and services) is by and large common to all mineral value-chains. At the extraction stages the main distinction is between inputs into underground mining and open cast and whether the mining is hard or soft rock. This determines the equipment and methods to extract and transport the

mineral ores which might be similar for different ores, for example bauxite and rock phosphate. At the mineral processing stages many common methods for crushing, separating and purifying minerals are used even though a particular refinery process is mineral or deposit specific. Trade data provides a macro picture of the value goods traded under uniform definitions that is useful to identify the size of markets along mineral value-chains starting with ores, moving to intermediate products and onto finished articles. Trade data is analysed in this report from 2014 to 2023 for all African member states to track the value of mineral production over time and the value of minerals processed to intermediate stages where they serve as inputs or precursors to manufacturing products. MSC import replacement opportunities are also revealed through the analysis of trade data.

After the major inputs of fuel, lubricants and power, mines consume large volumes of chemicals, steel, explosives, fuses, grinding media, reagents and other inputs. Africa imported **5.7 billion US\$** worth of mining consumables in 2023, down from 7.9 billion

US\$ in the previous year as mining rebounded from the sharp contraction in 2020 due to the COVID-19 pandemic. The top 10 import countries, shown in Figure 6, absorbed **83%** of all African imports.

Figure 6 Africa imports of selected mining consumables by top 10 countries 2014-2023 (MUS\$)

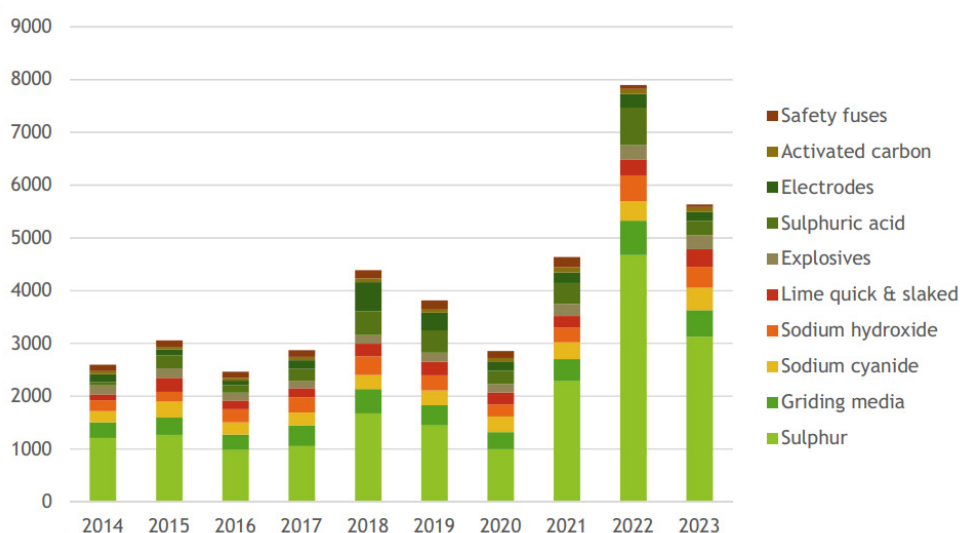


Source: (ITC Trade Map, 2024) Note: HS Codes: explosives 360200, detonators/fuses 360300, cyanide 2837, grinding media (forged 732611 and cast 732591), sulphur 250300 & sulphuric acid 280700, electrodes 854511, activated carbon 380210, hydrochloric acid 280610, chlorine 280110, sodium hydroxide 281511, lime (calcium oxide quicklime 25221 and calcium hydroxide slaked lime 252220).

DRC, Zambia, Ghana, Egypt and Burkina Faso are major importers of mining consumables. Morocco is a major sulphur importer which goes into the production of phosphatic fertilisers. Mining is not the only market for the consumables and other

user may be larger than mining (e.g. chlorine for water treatment, sodium hydroxide and lime into diverse sectors), but all importers nevertheless add to the viability of a potential local or regional plant.

Figure 7 Africa imports of selected groups of mining consumables 2014-2023 (MUS\$)

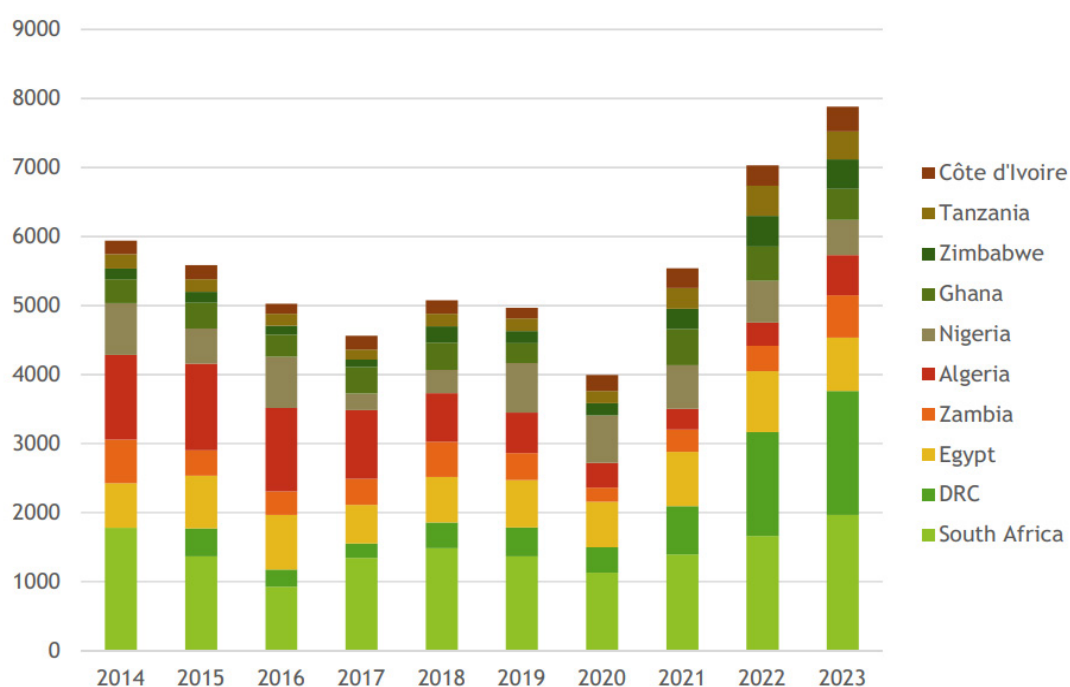


Source: (ITC Trade Map, 2024)

Significant import displacement opportunities based on market size alone are shown to exist for grinding media, safety fuses, explosives, cyanide. Basic chemical industries are also

shown to be lacking for the supply of chlorine, sodium hydroxide, hydrochloric and sulphuric acids, widely used in other sectors too.

Figure 8 Imports of selected mining capital goods by top 10 countries 2014-2023 (MUS\$)

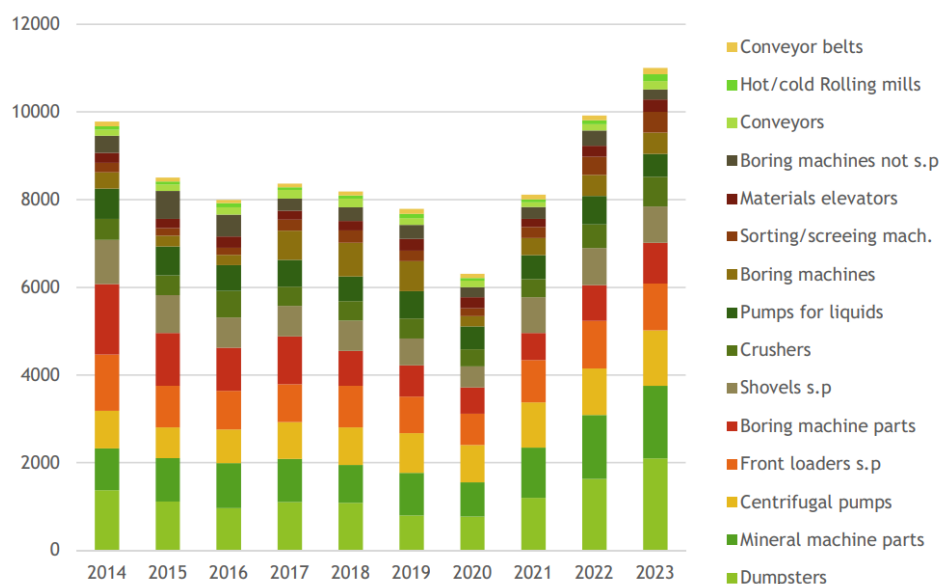


Source: (ITC Trade Map, 2024) Note HS codes 870410, 842951, 847490, 842959, 843041, 843143, 841370, 841381, 847420, 820713, 847410, 843031, 401012, 843141, 842839, 845530, 401019, 845521, 841790, 843049, 842833, 843050, 842820, 841710, 401011, 843061, 843039, 845522, 842831, 842320, 845510, 842520, 842850, 845940

Mining capital equipment comprises machinery, equipment and plant to extract, transport and separate minerals from the host rock. Much of the equipment used in opencast mining overlaps with the heavy construction sector (earth moving) and thus also captures demand in the heavy construction sector. Mining capital goods use of similar off-road vehicles such as articulated dump trucks, front-end loaders, excavators, bulldozers, shovels, et al, which enhances the market and the business case for a local or regional plant. Africa imported 2 billion

US\$ worth of selected mining capital equipment in 2023, back up to the previous nominal high of **12.5 billion US\$** in 2012 when exploration expenditure also peaked. The top 10 importing countries, shown in Figure 8, make up **65%** of total imports. The largest country shares for 2023 being as follows: South Africa 1967 MUS\$, DRC 1793 MUS\$, Egypt 775 MUS\$, Zambia 617 MUS\$, Algeria 578 MUS\$, Nigeria 508 MUS\$, Ghana 449 MUS\$, Zimbabwe 428 MUS\$, Tanzania 406 MUS\$ and Côte d'Ivoire 359 MUS\$ each.

Figure 9 Africa imports of selected mining capital goods by type of equipment 2014-2023 (MUS\$)



Source: (ITC Trade Map, 2024) Self-propelled s.p

Capital equipment embodies greater technology than consumables and their assembly/manufacture typically draw upon a hierarchy of sub assembly and component suppliers that may also involve licencing technology. National science systems to create STEM skills and the institutions for Research, Development and Innovation are prerequisites for advanced manufacturing capabilities needed for building specialised equipment. Realising knowledge linkages are critical to successfully developing backward linkages for mining inputs and capital equipment. Though technically demanding, the market opportunities are large in major categories of off-road vehicles, mining machinery, mechanical shovels, tunnelling, drilling, pumps, comminution, and conveyors shown in Figure 9.

The import displacement opportunities are numerous as scale economies are breached for almost all products at a continental level (Figure

9). Which is why an AGMS both best pursued at an African level through finalising the AfCFTA Rules of Origin (RoOs) and augmenting it with an Africa-wide Common External Tariff for select green minerals inputs (MSC) and outputs (RE equipment). Such a strategy could be further enhanced through Afreximbank developing special instruments to facilitate intraAfrican trade in the green mineral value-chain products selected for an Africa-wide external tariff (CET).

Local content targets included in mining licences is one of the policy instruments advocated by the AGMS, however, it is vital that the regulations for recognising local content be harmonised among REC member states. Overcoming the reluctance by member states adopt regional harmonisation for fear local businesses will be disadvantaged is the rationale for the weighted approach to recognise local content proposed in Equitable solutions to overcome uneven development set out in section 3.4.1.

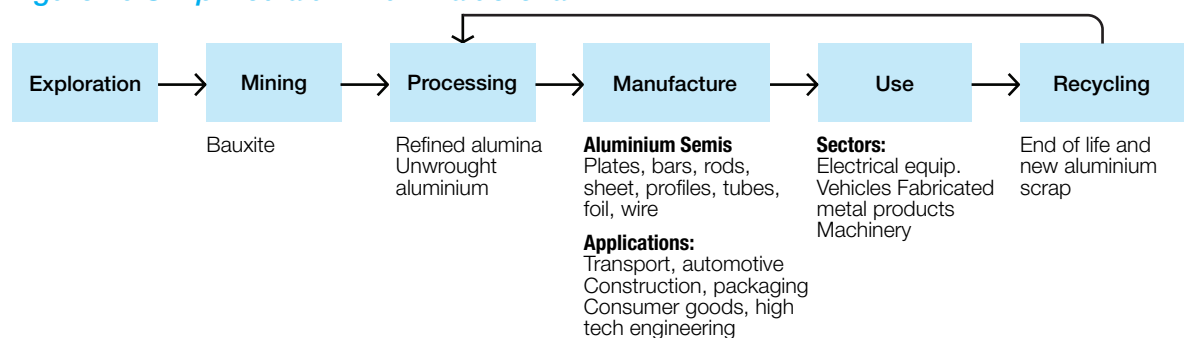
6.1.2 Green mineral value-chains

African Countries should prioritize green mineral value-chains for equitable industrialisation. Select green mineral value-chains are mapped to

obtain high level import displacement industrial opportunities. Each mineral is briefly described

6.1.2.1 Aluminium

Figure 10 Simplified aluminium value-chain

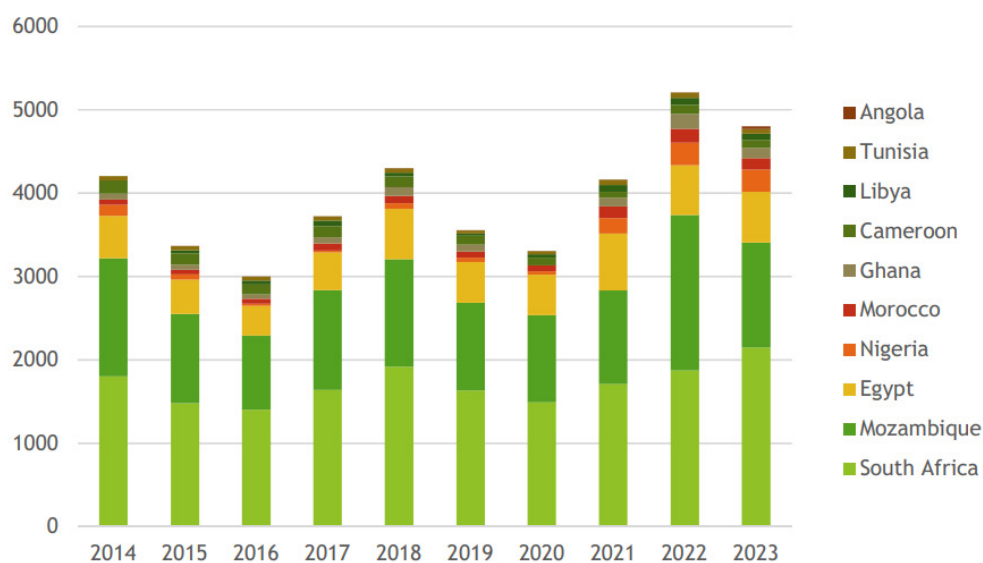


Source: adapted from (European Commission, 2020a)

Aluminium is a lightweight, silver-grey metal, and a good conductor of heat and electricity. Aluminium's superior malleability and low melting point of **660°C** makes it highly workable and easy to alloy with a high strength to weight ratio making it a very versatile metal. Aluminium is highly corrosion resistant as it develops a natural oxide layer, protecting it against corrosion. Aluminium is fully recyclable and reusable. The combination of these properties has made aluminium the second most widely used metal in modern society after steel (European Commission, 2020a, p. 37). Its green credentials come from its use in electrical systems, renewable energy equipment, vehicles, corrosion resistance and recyclability, but smelting is energy intensive making it currently a major contributor to global warming. Globally,

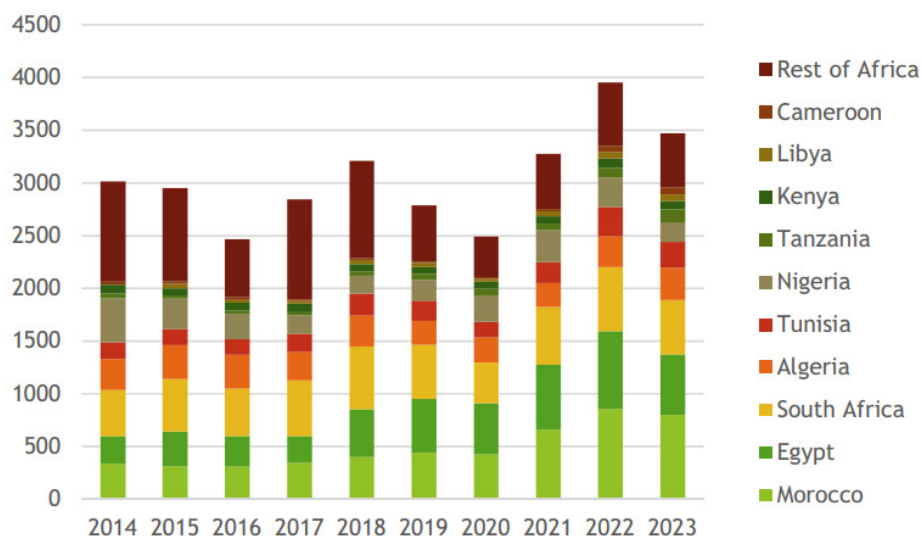
aluminium smelters need to migrate to RE sources, which could be an opportunity for Africa to attract dirty smelters to relocate close to its clean energy sources, particularly hydro and solar.

Africa's aluminium ore (bauxite) resources are concentrated in West Africa, the major producers being Guinea, Sierra Leone and Ghana. Guinea holds some **24%** of the world's bauxite reserves, producing an estimated 440 kt of alumina and 86 Mt of bauxite (**22.6%**) of world production in 2022 (USGS, 2024) and recording **3.9 billion US\$** in exports for 2021. The aluminium value-chain in West Africa is concentrated in the bauxite mining stages without a commensurate aluminium smelting capacity.

Figure 11 Top 10 exports of aluminium semis 2014-2023 (MUS\$)

Source: (ITC Trade Map, 2024). Note HS codes 7601-8 (Aluminium as unwrought metal, scrap, powder, wire, plates, foil, tubes)

South Africa, Mozambique and Egypt are the three major primary aluminium producers with minor production taking place in Nigeria, Morocco and Ghana (all based on imported alumina and dirty energy).

Figure 12 Top 10 importers of aluminium semis 2014-2023 (MUS\$)

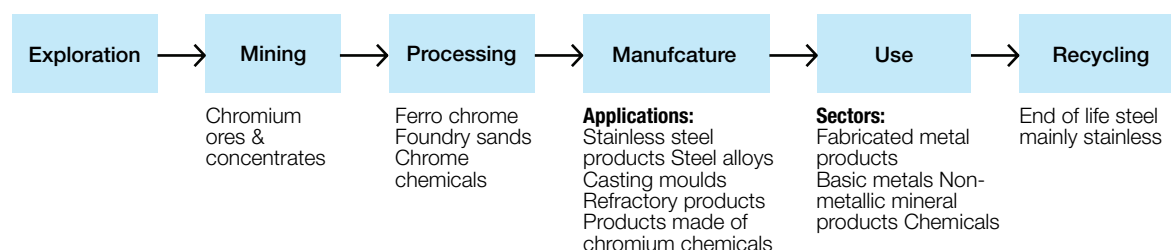
Source: (ITC Trade Map, 2024).

Africa imported **347 billion US\$** aluminium semis in 2023 but ran an overall positive trade balance of **1.48 billion US\$**. Top importers of aluminium semis are shown in Figure 12, which also shows an import displacement opportunity of about **US\$ 3bn** which could underpin the viability of several new smelters based close to RE generation and Africa's alumina deficit could be covered by Guinea's plans to dramatically

increase alumina production based on bauxite and caustic soda. Caustic soda could be produced from salt (solar evaporation) and RE and the by-product, chlorine, used in water treatment and polymers (PVC). Consequently, a AGMS for aluminium should include a CET for all the products in its value-chain, in addition to other instruments to facilitate investments.

6.1.2.2 Chromium

Figure 13 Simplified chromium value-chain



Source: adapted from (European Commission, 2020b)

Chromium is a lustrous, silvery-white, corrosion-resistant, hard metal. Mined as chromite ore it is mainly processed into ferrochrome, which is an essential component in the manufacturing of stainless steel, a key material in a variety of industries and end-uses. In general, chromium presence as an alloying element to steels and non-ferrous metals enhances strength, and resistance to corrosion, temperature, and wear. Its brightness, hardness, low coefficient of friction is used to good effect in chrome plating (European Commission, 2020b, p. 68). Its green credentials come from the durability it provides to steels used in harsh/ demanding environments of wind turbines, CSP, fuel cells and hydropower. However, ferro-chrome smelters are energy intensive and currently a significant source of GHGs and global warming and need to migrate to RE sources, which could play into Africa's huge RE potential where clean energy is used for energy intensive processes coupled with low emission technologies.

South Africa and Zimbabwe are Africa's leading producers of chrome. South Africa produced an estimated 18 Mt of chromium in 2023 (**43%** of world production) and holds 200 Mt of reserves (**36%** of world reserves) (USGS, 2024). While South Africa exports close to **2 billion US\$** of chrome ores and concentrates annually, both countries convert most of the chrome they produce into ferrochrome for export, using high emissions smelters based on coal. Madagascar exports small volumes of chrome ores. Intra-African ferrochrome trade is negligible, see Table 6. An AGMS for chromium would need to migrate all smelters and downstream stainless-steel plants to RE sources, which could also be opportunities to onshore foreign smelters and plants to take advantage of Africa's RE potential. The chromium value-chain needs to be part of an AGMS CET.

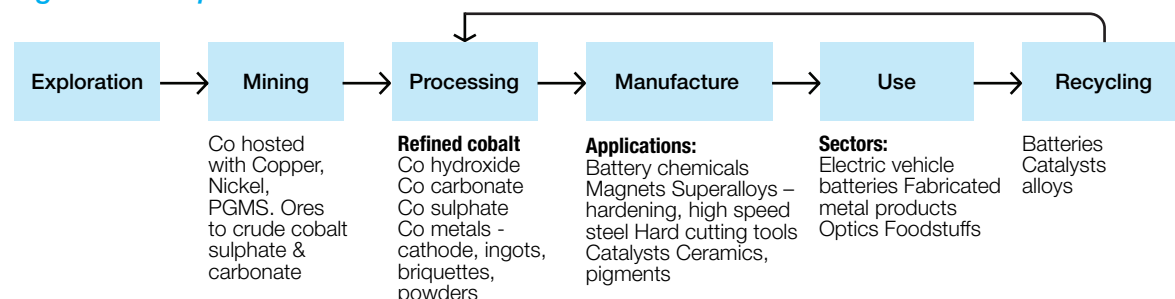
Table 6 Ferrochrome exporter and importer countries 2023-2014 (MUS\$)

Exporters	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
South Africa	3219	2904	3086	3172	3092	2690	2290	3660	3645	4247
Zimbabwe	271	158	120	279	244	219	139	296	363	384
Importers	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
South Africa	3	15	21	16	31	10	5	13	20	12
Egypt	4	5	3	1	4	3	3	4	5	4
Zambia	1	1	2	2	2	2	3	1	2	2
Tunisia	1	1	1	1	1	2	0	0	1	1

Source: (ITC Trade Map, 2024) Note HS code 720241-50

6.1.2.3 Cobalt

Figure 14 Simplified Cobalt value-chain



Source: adapted from (European Commission, 2020a)

Cobalt is a shiny, silver-grey metal with many diverse applications from steel to batteries. It is a hard metal retaining its strength at high temperatures, has a high melting point and keeps its magnetic properties at temperatures higher than any other metal. It is easy to alloy with other metals to give hightemperature strength and increased wear-resistance (European Commission, 2020a, p. 133). Cobalt increases energy density and ion movement in lithium-ion batteries which has overtaken alloys as the main use sector. Its green credentials come from its use in the manufacture of lithium-ion batteries. The DRC produced an estimated

130 kt of cobalt as a co-product of copper mining in 2022, **(68%** of world production) from reserves of 4 Mt (48% of world reserves) (USGS, 2024).

The DRC has been successful in forcing producers to process cobalt prior to export. Cobalt ores and concentrates exports which peaked at 493 MUS\$ in 2018 have been almost entirely replaced by cobalt hydroxide for export. Zambia's apparent cobalt exports have declined as imports of concentrate from the DRC for refining were curtailed.

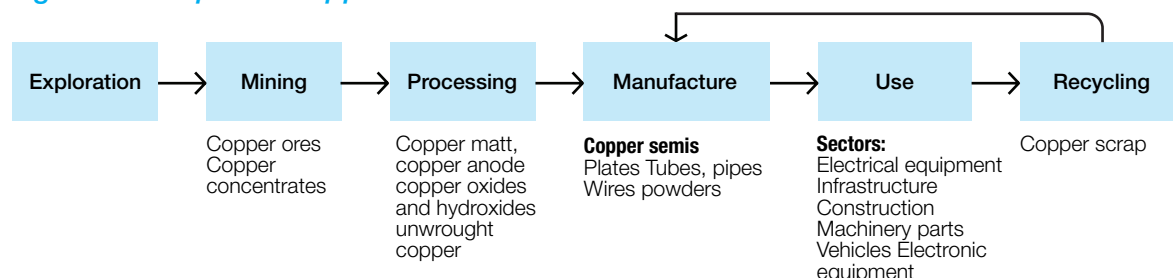
Table 7 Cobalt semis exporters 2014-2023 (MUS\$)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
DRC	0	2276	1742	4972	10346	3956	3311	5572	8265	4971
Madagascar	87	89	81	168	227	103	33	106	217	115
South Africa	21	12	23	36	67	24	311	20	167	90
Morocco	42	47	40	81	108	87	77	84	92	62
Zambia	126	85	108	273	120	46	11	5	83	48
Congo	0	0	0	0	0	0	0	0	0	19
Namibia	0	0	0	0	0	0	67	88	124	11

Source: (ITC Trade Map, 2024) Note HS code 2820, 810510-90 (Co hydroxide, matt, metal semis)

6.1.2.4 Copper

Figure 15 Simplified Copper value-chain



Source: adapted from (European Commission, 2020b)

Copper is a ductile, reddish metal, used since the early days of human history. Copper resists corrosion by oxidising to form a thin protective surface layer of copper oxide that prevents the bulk of the copper underneath from being oxidised. In most applications it is used for its very high thermal and electrical conductivity in combination with ductility and corrosion resistance. It is used as pure metal but often also in form of its two common alloys: brass and bronze (European Commission, 2020b, p. 100). Its green credentials come from its role as an electrical conductor that makes up a major share of the raw materials for renewable energy equipment, electric vehicles and electricity power networks. Clean energy makes use of far more electricity to do work than fossil fuels so copper producers are under pressure to increase output.

Copper production in the DRC reached an estimated 2.5 Mt (**11%** of world production) of reserves of 80 Mt (**8%** of world reserves) in 2023. Zambia produced 760 kt (**3.4%** of world production) reserves of 21 Mt (2.1% of world reserves) (USGS, 2024). Africa's exports of ores, concentrates and copper anode rose to 10.6 billion US\$ in 2023 led by Zambia **5.12 billion US\$**, DRC **3.67 billion US\$**, South Africa 615 MUS\$, Botswana 506 MUS\$, Tanzania 189 MUS\$, Eritrea 189 MUS\$, Morocco 158 MUS\$ and Mauritania 127 MUS\$ (ITC Trade Map, 2024). Exports of copper semis rose to **29.5 billion US\$** in 2023, led the DRC as new processing capacity has been commissioned. The major exporters of copper semis are shown in Table 8.

Table 8 Top 10 copper semis exporters 2014-2023 (MUS\$)

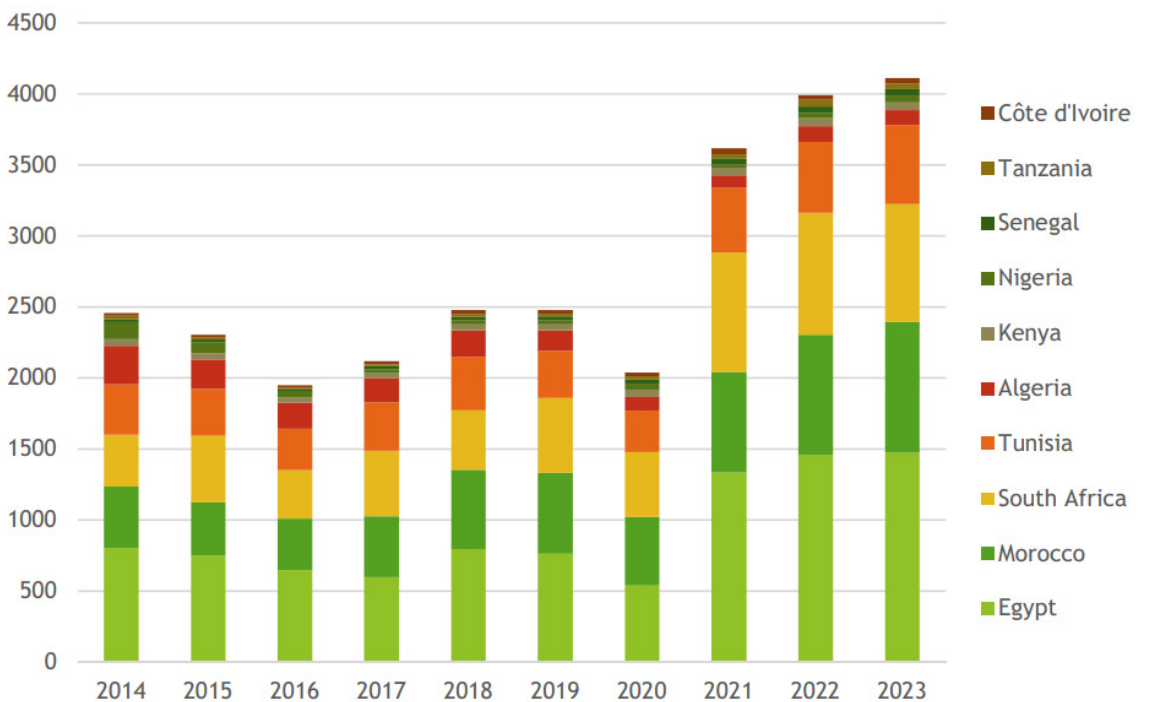
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
DRC	0	5187	4078	5227	6977	7470	9308	14520	16749	18976
Zambia	7197	5387	4514	6177	6816	5036	5919	8495	8123	6792
Congo	0	0	0	183	100	84	40	77	78	986
South Africa	438	569	486	596	681	540	537	859	898	940
Egypt	262	194	161	239	218	178	180	407	447	686
Namibia	322	635	388	408	1558	1637	1756	237	202	258
Morocco	154	136	98	135	135	125	107	218	200	197
Nigeria	49	15	2	2	12	35	17	73	149	179
Lybia	0	41	65	85	99	62	102	144	154	131
Tunisia	100	64	65	95	111	65	99	133	104	76
Rest of Africa	119	89	136	102	117	120	115	198	285	327

Source: (ITC Trade Map, 2024). HS Codes 7401-8

Copper’s role in infrastructure means that it is used by all member countries in various amounts, however five countries: Egypt, South Africa, Morocco, Tunisia and Algeria absorb

over 90% of the continent’s imports of copper semis to feed their domestic copper fabrication industries.

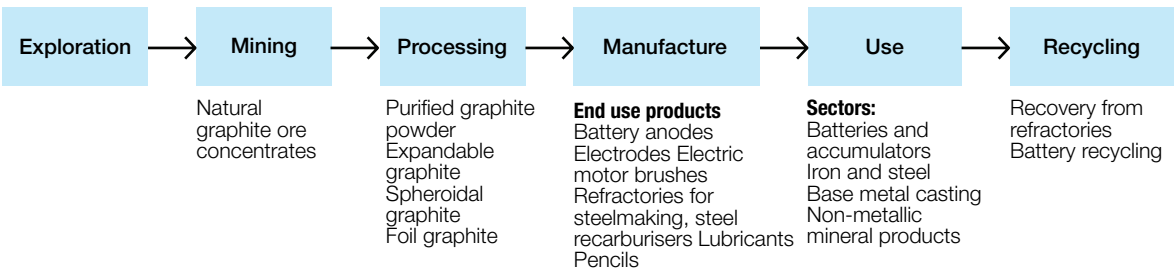
Figure 16 Top 10 importers of copper semis 2014-2023 (MUS\$)



Source: (ITC Trade Map, 2024). HS Codes 7401-8

6.1.2.5 Graphite

Figure 17 Simplified graphite value-chain



Source: adapted from (European Commission, 2020a)

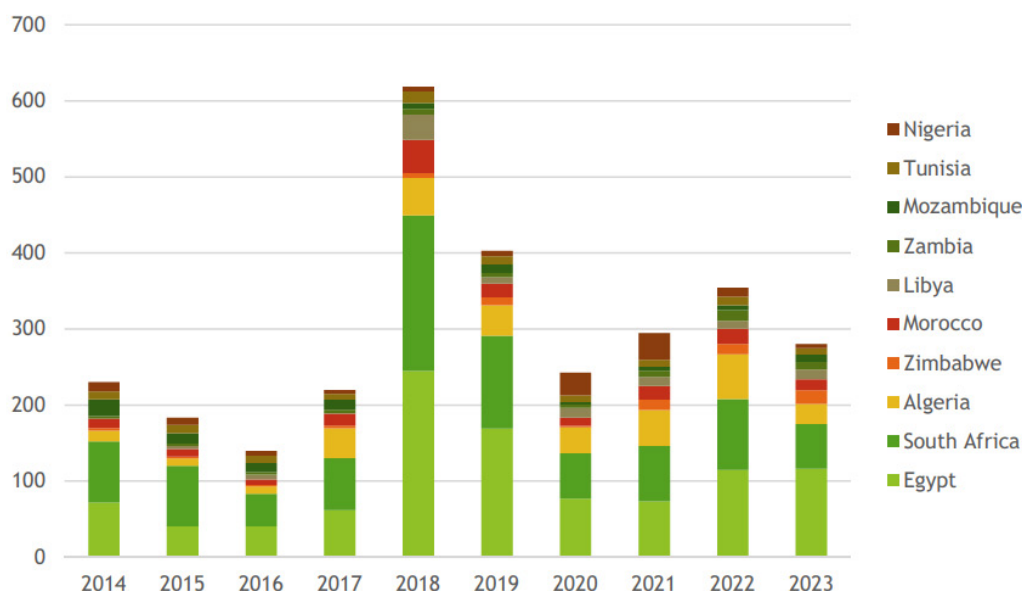
Natural graphite is a carbon allotrope which means it exists in different physical forms that have both metallic and non-metallic properties. It consists of planar sheets formed from three-coordinated carbon atoms. Free electrons between the layers allow graphite to conduct

electricity and heat. It is a good thermal and electrical conductor and has a high melting point (3,650 °C). Graphite is a raw material with a wide range of uses. Refractories for steelmaking are the leading consumer of natural graphite. It is also used in lubricants, batteries, brushes for

electrical motors, fire retardants, and pencils (European Commission, 2020a, p. 342). Graphite is used in lithium-ion batteries as an anode that is suited to intercalate lithium ions. Its green credentials come from its use in batteries and in fuel cells for decarbonising transport and power. It is also an important input for making steel and alloys as feedstocks going into agriculture, construction, mining, manufacturing. Natural graphite production estimates for 2023 and shares in world production for Mozambique, Madagascar and Tanzania were 96 kt (6%) 100 kt (6%) and 6 kt (0.3%) respectively.

Mozambique and Madagascar have reserves of 25 Mt each, some 8% of world reserves (USGS, 2024). Natural graphite exports have recovered from the COVID-19 disruptions. 2023 export values for Mozambique were 33.5 MUS\$, 28.6 MUS\$ for Madagascar and 5.3 MUS\$ for Tanzania. Inter-regional trade amounted to 3.2 MUS\$ Imports of graphite semis mainly in the form of electrodes for electric furnaces, furnace linings and carbon brushes for motors is shown in Figure 18 and indicate a possible case for intra-African trade and new investments to at least cover imports.

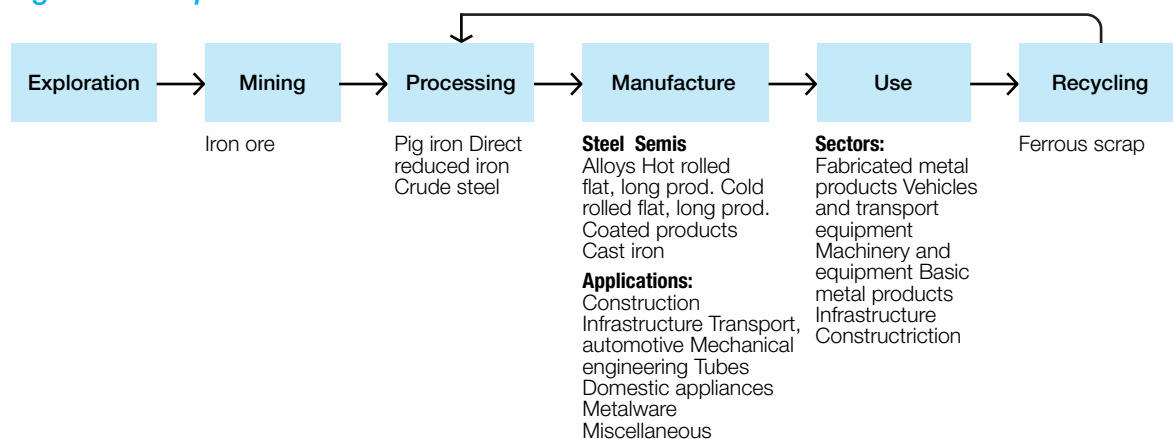
Figure 18 Top 10 importers of graphite semis 2014-2023 (MUS\$)



Source: (ITC Trade Map, 2024). Note HS Codes 854511, 854590, 380130, 854520, 380110, 380190, 854519, 380120.

6.1.2.6. Iron and steel

Figure 19 Simplified iron and steel value-chain



Source: adapted from (European Commission, 2020a)

Iron is a lustrous silver-grey metal with a melting point of 1,530°C. Iron ore consisting mostly of iron oxides, the primary forms of which are magnetite (Fe₃O₄) and hematite (Fe₂O₃) when smelted in a blast furnace in the presence of a reductant generally yields an alloy of iron and carbon (pig iron) which usually contains 3.5-4.5% carbon along with small amounts of other elements such as silicon, manganese and phosphorus. Direct reduction is an alternative process to reduce iron ore in its solid state using either natural gas or coal as reducing agents.

Steel is an alloy of iron and carbon and other elements covered in this section. Carbon is of fundamental importance for its properties; steel contains up to about **2%** of carbon but typically less than 1%. Numerous different types of steel are produced, each designed to provide the specific properties required for a great variety of applications. Its versatility, relatively low cost, is 100% recyclable and has a long useful life make steel the most widely used material in modern society (European Commission, 2020a, p. 230). Its green credentials come from steel's ubiquity in industrialisation, infrastructure and role in delivering modern energy services, but it is a major contributor to carbon emissions which has resulted in the development of new "green steel" technologies (still at pilot stage) using hydrogen as a reductant rather than carbon (coke), which could also be an opportunity for Africa to attract investment into green hydrogen plants, based on water and its RE sources, to underpin new green steel investments.

South Africa and Mauritania are the major iron ore producer countries, producing an estimated 61 Mt (**2.4%** of world production) and 13 Mt (0.5%) in 2023 respectively (USGS, 2024). Iron ore exports for South Africa earned **US\$ 6.5 billion** and **US\$ 1.4 billion** US\$ for Mauritania in 2023. Sierra Leone has seen output increase rapidly since 2021, earning 885 MUS\$ in 2023. West Africa's export position will be further strengthened when projects in Guinea come on stream. Egypt, Africa's leading steel producer, is the main iron-ore importer landing an average of 1.6 billion MUS\$ over the period 2021-2023. Over the same period Algeria and Libya average iron-ore imports were 900 MUS\$ and 240 MUS\$ respectively (ITC Trade Map, 2024). Africa's crude steel production for 2023 by country was Egypt: 10.4 Mt, South Africa 4.9 Mt, Algeria 3.5Mt, Morocco, 1.4 Mt, rest of Africa 4.1 Mt (WSA, 2024).

Africa's current position in world steel production and consumption is summed up in several key statistics from the World Steel Association 2024 report. World crude steel production reached 1892 Mt in 2023, down from the 1963 Mt recorded for 2021. Africa's share at 1.3% grew only 0.3% over the previous decade. Apparent steel use (finished products) stood at 1763 Mt in 2023 with Africa's share 2.0%. Africa has the lowest per capita steel use in the world, roughly three times less than other developing regions of Central and South America, India and South East Asia. Facilitating the development of competitive regional steel production is an important strategic goal of the AMV and AGMS.

Table 9 Apparent steel use 2019 to 2023 (million tons finished steel products)

	2019	2020	2021	2022	2023
Egypt	10.4	9.7	10.2	11.1	9.3
South Africa	4.8	3.8	5.0	4.3	4.5
Other Africa	26.0	23.2	24.0	20.2	21.2
Africa Total	41.1	36.7	39.2	35.6	35.0

Table 10 Apparent steel use per capita 2019 to 2023 (kilograms finished steel products)

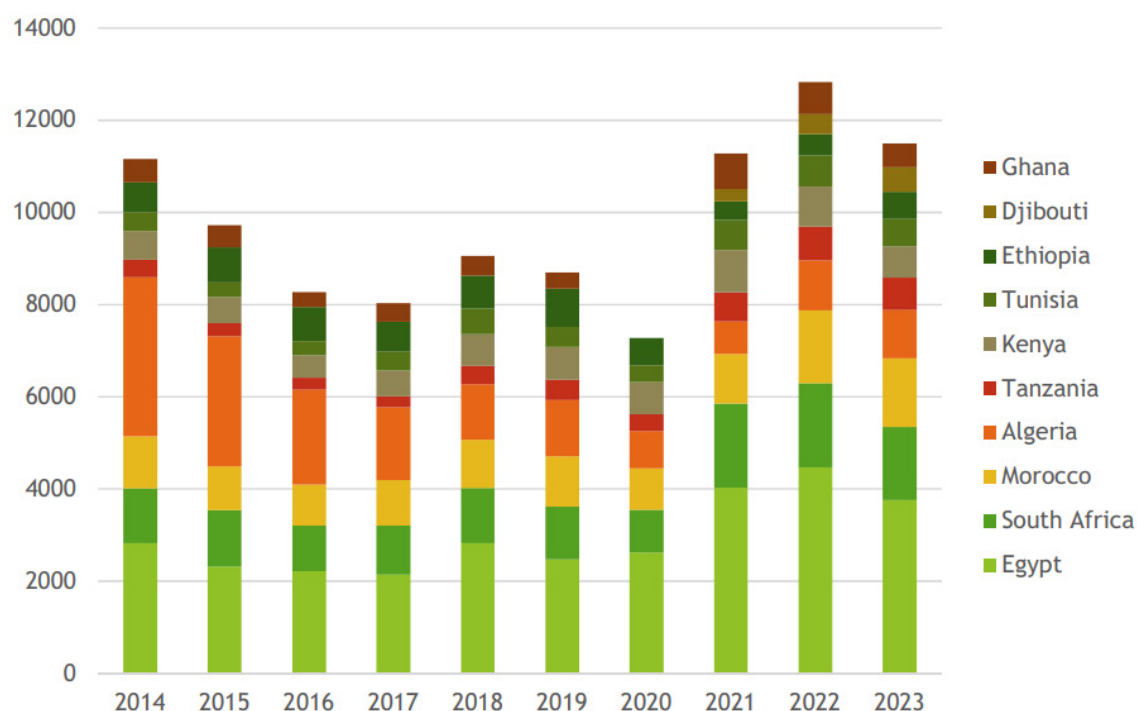
	2019	2020	2021	2022	2023
Egypt	98.0	90.2	93.4	100.3	82.6
South Africa	81.8	63.8	84	72.0	74.5
Other Africa	22.4	19.5	19.6	16.1	16.5
Africa Total	31.0	27.0	28.2	25.0	24.0
Comparative regions					
South America	3	4	106.2	94.2	93.5
India	2	2	75.5	82.0	93.4
South East Asia	1	1	81.6	79.6	78.7
World	2	2	233.2	223.7	219.3

Source: (WSA, 2024)

Imports of steel scrap, pig iron, ferroalloys, stainless steel, alloy steel and steel semis declined to 16.7 billion US\$ in 2023 after the strong rebound from 2020. Roughly half of all

ferrous scrap and semis are absorbed by five countries: Egypt, South Africa, Morocco, Algeria and Tanzania.

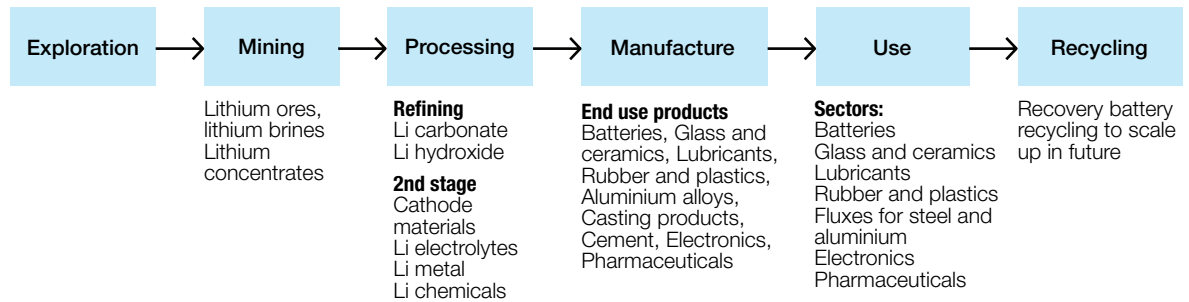
Figure 20 Top 10 importers of ferrous metals, scrap and semis 2014-2023 (MUS\$)



Source: (ITC Trade Map, 2024) Note HS codes Pig iron 7201/05, ferro-alloys 7202, DRI 7203, scrap 7204, steel 7206, Fe semis 7208-17, stainless steel 7218-23, alloy steel 7224-29

6.1.2.7 Lithium

Figure 21 Simplified lithium value-chain



Source: adapted from (European Commission, 2020a)

Lithium is a silver-white to grey metal belonging to the alkali metal group. Lithium is the lightest metal and the least dense solid element at room temperature. The element has excellent electrical conductivity and the highest electrochemical potential of all metals which is the reason it is used in batteries. Globally, batteries represent the application with the highest consumption. There are no substitutes foreseen in the short to mid-term that can replace the role of lithium in rechargeable batteries for electric vehicles and energy storage systems (European Commission, 2020a, p. 289). However, active research is underway to find cheaper more abundant

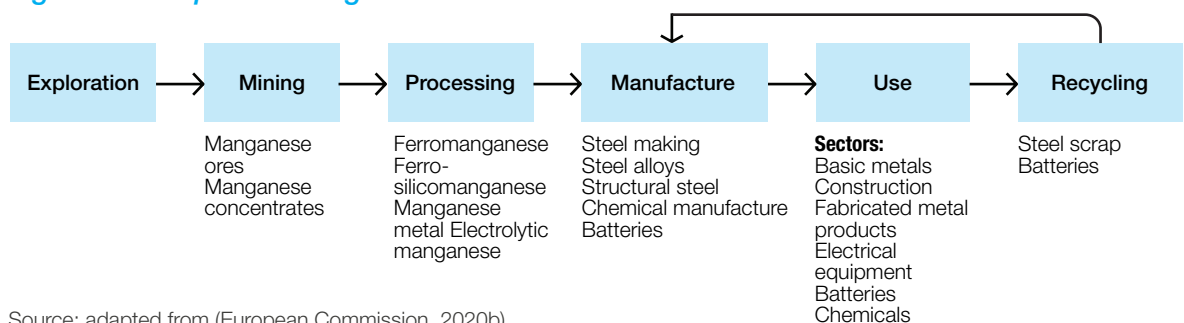
substitutes. Its green credentials come from its central role in rechargeable batteries, battery storage systems and electric vehicles.

Zimbabwe's production in 2022 was estimated at 800 t, (0.6% share of world production) and reserves given as 310 kt (1.2% of world reserves) (USGS, 2022).

New lithium resources are being developed in Zimbabwe, Mali, Namibia, Ghana and the DRC. Trade data in the ITC TradeMap database does not break out data for lithium ores for Africa.

6.1.2.6. Manganese

Figure 22 Simplified manganese value-chain



Source: adapted from (European Commission, 2020b)

Manganese is relatively hard, brittle metal with a high melting point of 1246 °C. The principal ore mineral of manganese is pyrolusite (MnO₂). Manganese is very efficient at fixing sulphur and acts as a powerful deoxidiser when it is used in the manufacture of steel. Ferromanganese is mostly used to improve the hardness and wear resistance of steel alloyed in various ratios of carbon. It is also used in the production of aluminium alloys, pigments, dry cell and

rechargeable batteries. (European Commission, 2020b, p. 323). Its green credentials come from its use in wind turbines and batteries for storage and electric vehicles, but the production of manganese alloys is energy intensive, currently based on electricity from fossil fuels. This could also be an opportunity for Africa to develop its RE sources to attract the manganese value-chain, particularly smelters.

Approximately 65% of world production for manganese originates in Africa. Estimated 2023 production and production share is as follows: South Africa 7.2 Mt (36%), Gabon 4.6 Mt (23%), Ghana 840 kt (4.2%) Côte d'Ivoire 390 kt (1.9%). South Africa's reserves stand at 600 Mt (32%), Gabon 61Mt (3.2%) and Ghana 13Mt (0.7%) (USGS, 2024). Mining company data, more up to date than the USGS, now places Gabon as the number one producer, with output of 7.4 Mt in 2023 and holding 25% of the world's manganese

reserves (Eramet, 2024). Most manganese is exported as ores and concentrates. South Africa was the dominant producer until 2022 and converts a portion of its mine output into ferromanganese and metal for export, however, volumes been on a long-term decline due to rising energy costs, falling 590 MUS\$ in 2014 to 105 MUS\$ in 2023 Countries with domestic steel production import small amounts of ferromanganese to produce alloys. Egypt imported 74 MUS\$ in 2023.

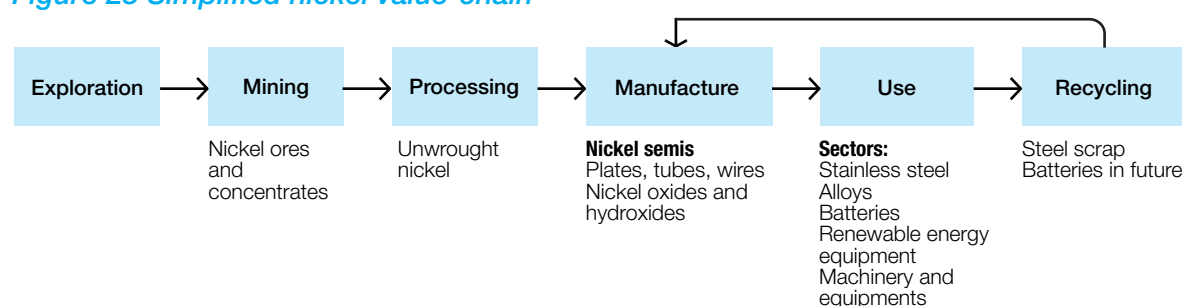
Table 11 Export of manganese ores and concentrates 2014 to 2023 (MUS\$)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Gabon	148	155	161	182	249	319	451	539	672	2955
South Africa	1644	1131	1397	2622	3627	3166	3166	2472	2908	2666
Ghana	94	75	101	155	288	360	0	234	22	314
Côte d'Ivoire	30	20	13	52	103	127	116	75	84	70
Morocco	13	13	21	17	21	15	25	25	25	21
Kenya	0	0	0	1	4	3	3	4	17	10
Namibia	14	2	1	2	2	2	3	1	13	5

Source: (ITC Trade Map, 2024) Note HS code 2602 Manganese ores and concentrate

6.1.2.6. Iron and steel

Figure 23 Simplified nickel value-chain



Source: adapted from (European Commission, 2020b)

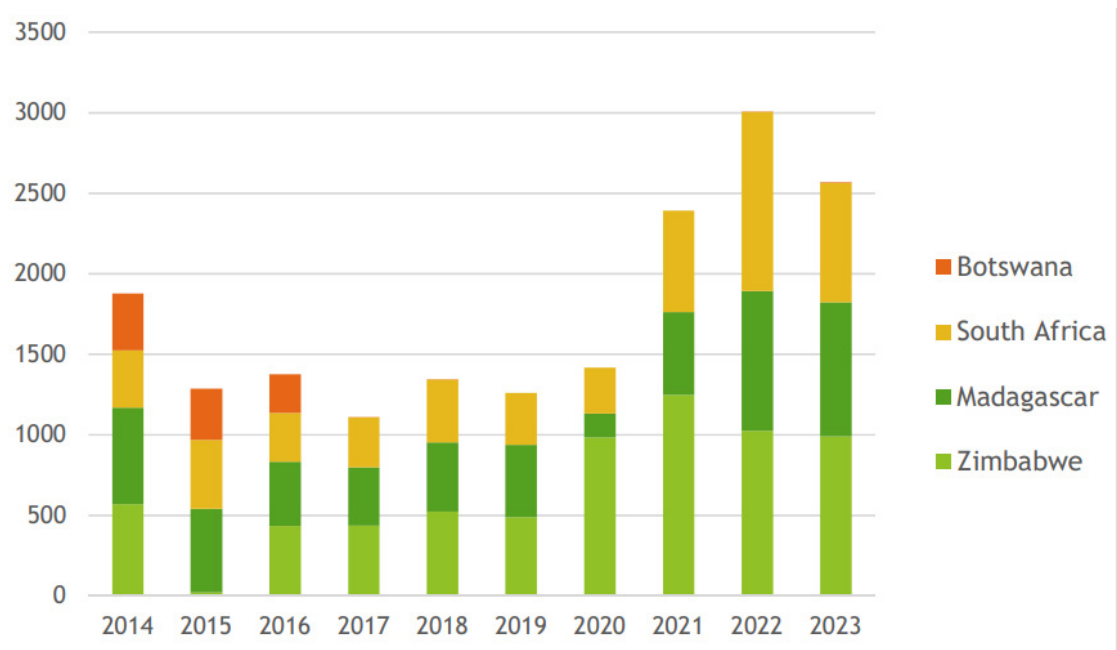
Nickel is a shiny white metal with relatively high melting point of 1,455°C. Nickel is malleable, ductile, and has superior strength and corrosion resistance so its main application is for alloy production (stainless steel accounts for about 65% of nickel first-use). This role as corrosion resistant alloy means it is widely used in steel for the manufacture of renewable energy equipment. Nickel is also used in batteries (European Commission, 2020b, p. 382). Its green credentials come from its use in batteries, renewable energy equipment and electric

vehicles, but its current value-chain (into stainless steel) is carbon intensive, though clean technologies applications are forecast to become dominant (see Section 5 on page 26). Zimbabwe is Africa's leading nickel producer, exporting both ores and nickel matte, followed by Madagascar. Zimbabwe's exports of nickel ore have grown from 357 MUS\$ in 2014 but have retreated from the high 1102 MUS\$ in 2022 to 647 MUS\$ in 2023, due to power shortages among other factors.

Zambia and Zimbabwe have suffered power shortages to low hydropower generation from a severe and ongoing drought which has severely choked their economies. In the last five years Zambia and Côte d’Ivoire have started exporting minor volumes: 134 and 85 MUS\$ in 2023 respectively. Africa imports nickel mainly in the form of stainless steel semis and products giving an overall nickel deficit. Significant reserves of nickel are also located in Tanzania and Burundi. Most nickel is exported in processed forms as

mattes, unwrought and alloyed metal from Zimbabwe, South Africa, Madagascar and Botswana (until nickel mining ceased in 2017). South Africa’s domestic nickel production and minor imports are absorbed by the stainless steel sector which has since 2012 produced an average of 440 kt/y of primary product rising 512 kt in 2017 then shrinking to 303 kt in 2020 and recovering to 340 kt in 2021. (SASSDA, 2022).

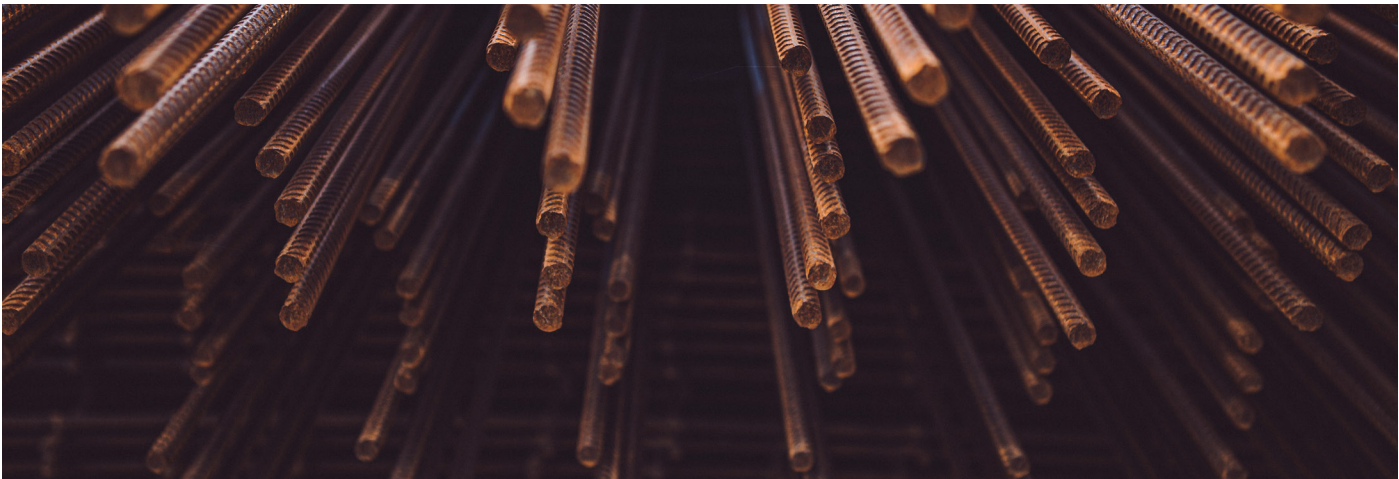
Figure 24 Top exporters of nickel unwrought, matte and metal 2014-2023 (MUS\$)



Source: (ITC Trade Map, 2024) Note HS codes 750210 (unwrought) 750220, 750300, 750110 (matte), 750120 (alloyed) 750400 (scrap)

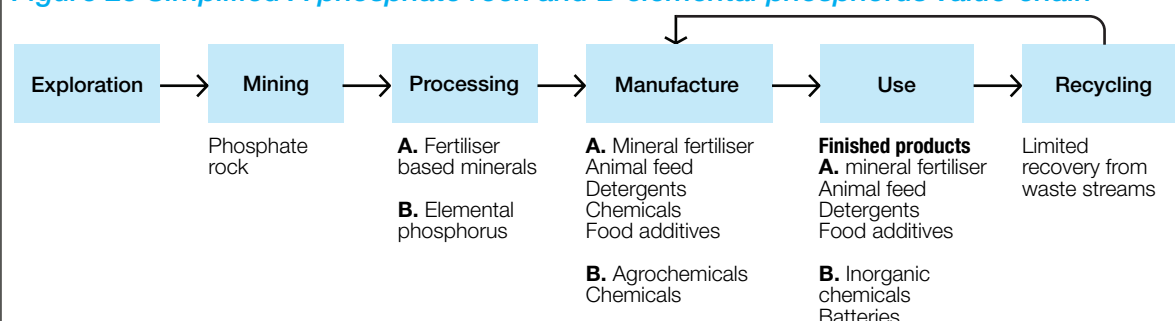
South Africa exports small quantities of nickel sulphate, which recorded an export value of

49 MUS\$ in 2023 due to the establishment of refiners targeting battery metals.



6.1.2.9. Phosphates

Figure 25 Simplified A phosphate rock and B elemental phosphorus value-chain



Source: adapted from (European Commission, 2020a)

Phosphate rock is the main source of phosphorus extracted from different phosphate minerals, in particular calcium phosphate. Phosphorus in different forms (mineral, organic) is used in agriculture and industry for fertiliser chemicals, organic fertilisers, manures, crop products, animal feed, pesticides, detergents, and plasticisers. Phosphorus is one of the six main elements vital for all life on the planet.

Battery grade phosphoric acid needs to be very pure. Its green credentials come from the fertilisers to raise agricultural output and use in lithium-ion-phosphate (LFP) batteries.

Rock phosphate is extracted in significant quantities in North, West and South Africa. Table 12 Rock phosphate production volumes and shares 2022

Table 12 Export of manganese ores and concentrates 2014 to 2023 (MUS\$)

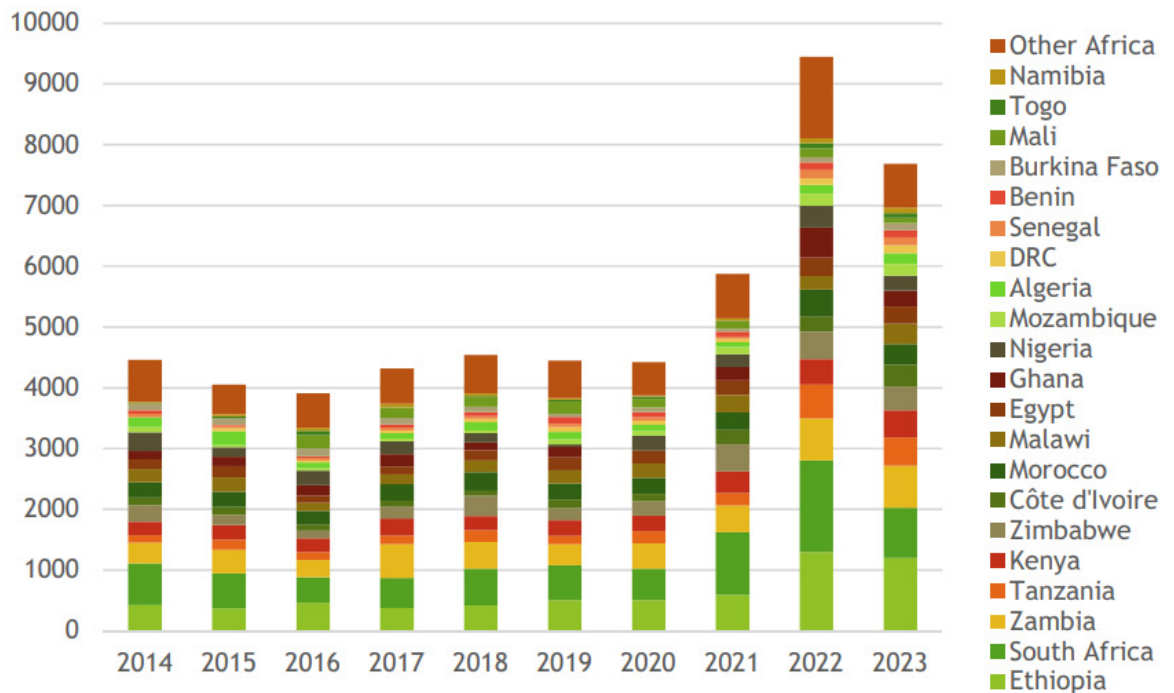
Country	Production 2023	Share of world production 2023	Reserves	Share of world reserves
Morocco	35 Mt	16%	50 Gt	67%
Egypt	4.8 Mt	2.1%	2.8 Gt	3.8%
Tunisia	3.6 Mt	1.6%	2.5 Gt	3.4%
Senegal	2.5 Mt	1.1%	50 Mt	>0.1%
South Africa	1.5 Mt	1.1%	2.2 Gt	3%
Togo	1.6 Mt	0.7%	1.5 Gt	2%
			30 Mt	>0.1%

Source: (USGS, 2024)

While these producer countries do export crude rock phosphate (HS 2510), generating export earnings averaging 1.45 billion MUS\$ 2014 – 2023, a far greater share is converted to nitrogen phosphorus potassium (NPK) fertiliser minerals for domestic and export markets. Africa's exports of fertiliser increased by 280% from 4.2 billion MUS\$ in 2014 to 11.9 billion MUS\$ in 2023 with Morocco

maintaining its share at close to 50% Egypt at over 30% and Algeria at over 12% over this period, (ITC Trade Map, 2024).

Increasing agricultural productivity of Africa's farmers requires affordable inputs key among them being fertiliser yet the application rates of fertilisers is low.

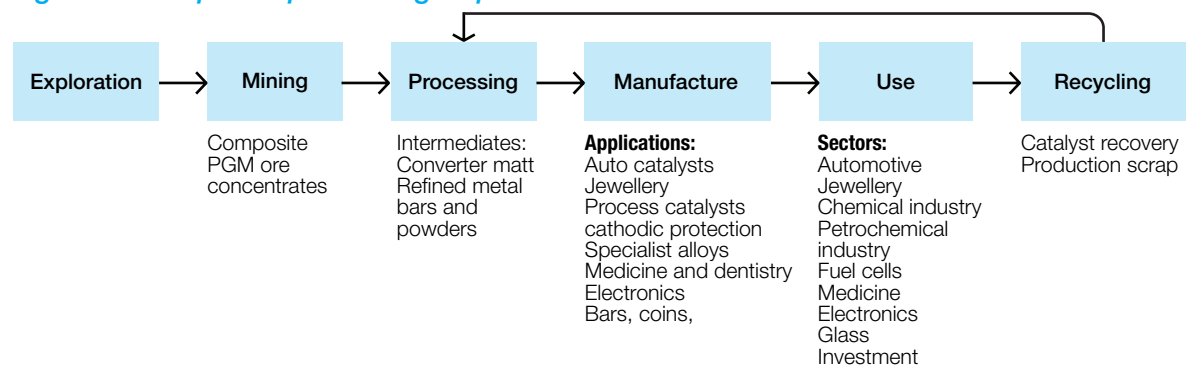
Figure 26 Africa's NPK fertiliser imports 2014-2023 (MUS\$)

Source: (ITC Trade Map, 2024). Note HS codes 3101, 3102, 3103, 3104, 3105

While Africa runs a positive trade balance in NPK fertiliser, except for North African countries and Nigeria, the rest of the continent are net importers. In 2023 imports of NPK fertilisers

amounted to 7.6 billion MUS\$ indicating a huge import displacement opportunity as a continental level (Figure 26).

6.1.2.10. Platinum Group Metals

Figure 27 Simplified platinum group metals value-chain

Source: adapted from (European Commission, 2020a)

Platinum is one of the six chemical elements comprising the platinum-group metals (PGM). In order of increasing atomic number PGMs comprise the elements ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir), and platinum (Pt). Platinum has exceptional

catalytic properties and is relatively soft and ductile, making it malleable enough to be worked into intricate shapes or stretched into fine wires that increase its contact with chemical substances. As it is extremely resistant to chemical corrosion and oxidation and has a

high melting point of about 1,770°C it can be used in many processes as a catalyst. In industrial applications platinum is mostly alloyed with other PGMs to achieve optimal properties. Its green credentials come from its role in emissions control for vehicles and use in fuel cells. Industrial applications and catalytic converters for internal combustion engines make up the biggest market segment for PGM's. Phasing out ICE vehicles would cut demand for platinum unless new markets such as for hydrogen and fuel cells

expand to take their place.

In 2023 South Africa produced an estimated 191 t platinum and palladium (49% of world production) and Zimbabwe 34 t (8.7%). South Africa has reserves of 63 kt (90% of world reserves) and Zimbabwe 1.2 kt (1.7%) (USGS, 2024). Lower prices for palladium and rhodium from 2021 onwards have reduced PGM export values by 40%, straining several producers at these lower prices.

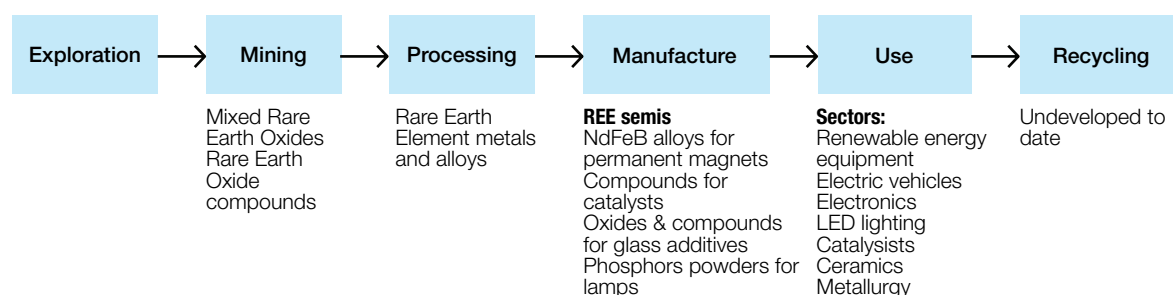
Table 13 Export of PGM unwrought and semis 2014 to 2023 (MUS\$)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
South Africa	6502	6849	6047	6586	7902	8284	10709	23160	16746	10727
Zimbabwe	137	36	54	46	44	60	134	205	182	121

Source: (ITC Trade Map, 2024). Note HS Code 711031, 711021, 711019, 711011, 711039, 711029, 711041, 711049.

6.1.2.11. Rare earth elements

Figure 28 Simplified rare earth elements value-chain



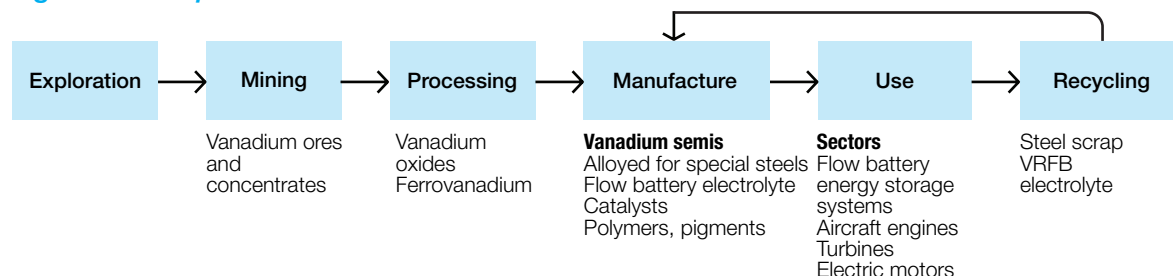
Source: adapted from (European Commission, 2020a)

The Rare Earth Elements (REE) are a group of metals comprising the 15 lanthanides (elements no. 57 - 71) so called because of their chemical similarity to lanthanum. Light REEs are lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm). Heavy REEs are europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb) and lutetium (Lu). Elements scandium (Sc) and yttrium (Y) in the same group are generally included in the REEs. Neodymium, praseodymium, dysprosium, samarium, gadolinium and cerium are used in permanent magnets for electricity generators and electric motors. REEs are used in other high-tech sectors for LED lights, catalysts, optics, glass, batteries, phosphors, ceramics. In 2019 it was estimated that magnet materials neodymium and praseodymium represent

75% of the total REE value and 20% of the volume; while lanthanum and cerium account for around 70% of the volume but only 8% of the value (European Commission, 2020a, p. 549). REE green credentials come from their role in renewable energy equipment and energy efficient technologies, particularly in strong magnets for electricity generators and motors. REEs are mined in Angola, Burundi, Madagascar, and South Africa. Madagascar was estimated to have produced 960 t in 2023 (USGS, 2024), however trade data does not pick up this output accurately by only recording exports of some 4.5 MUS\$ a year for South Africa over 2014 – 2023. (ITC Trade Map, 2024). There are REE projects in development in Malawi, South Africa, Tanzania, Madagascar, Morocco, and Mozambique and potential REE targets in central and west Africa.

6.1.2.12. Vanadium

Figure 29 Simplified vanadium value-chain



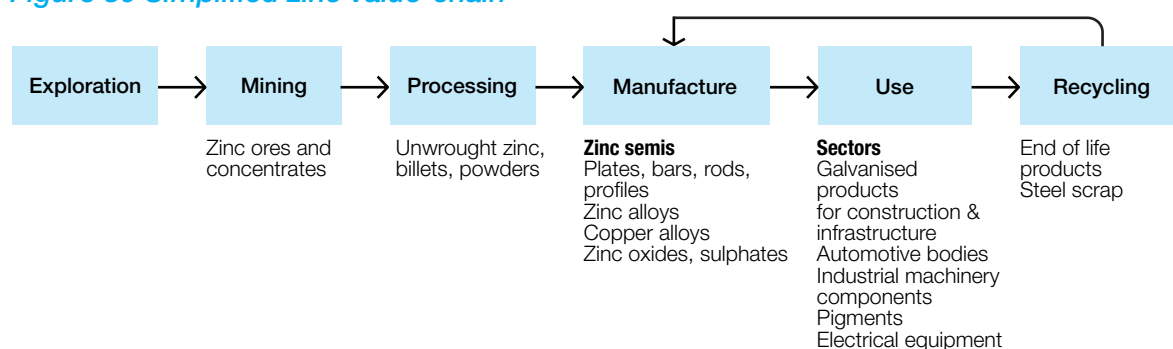
Source: adapted from (European Commission, 2020a)

Vanadium is a steel-grey, bluish, shimmering, and ductile metallic element with a melting point of 1,910 °C. In Africa it is mined from magnetite ores but elsewhere it is mainly obtained as a by-product from the production of steel. Its main application is as an additive in steel and titanium alloy steels to improve their strength and resistance to corrosion for critical component in jet engines, turbines, electric motors and nuclear reactors, as well as a catalyst for chemicals. Vanadium can exist in 4 common oxidation states so it can be reduced and oxidised easily and why it is the electrolyte for Vanadium Redox Flow Batteries (VRFB) for long duration energy

storage. Its green credentials come from its role in energy storage, electric motors and turbines. South Africa was estimated to have produced 9.1 kt of vanadium (9.1% of world production) off reserves of 750 kt (3.9% of world reserves) in 2023 (USGS, 2024) and exported some 110 MU\$ \$ worth of ferrovandium annually over the last decade. For trade classification vanadium ore is included in HS 261590 Niobium, tantalum or vanadium ores and concentrates. The main contributors to Africa's exports of 217 MU\$ in 2023 under this heading are from Rwanda, DRC and Congo, presumably mostly tantalum and niobium (ITC Trade Map, 2024).

6.1.2.12. Zinc

Figure 30 Simplified zinc value-chain



Source: adapted from (European Commission, 2020b)

Zinc is the fourth most used nonferrous metal, after iron, aluminium and copper. It alloys readily with other metals (low melting point of 419 °C) and is chemically active. Zinc is an essential element for the growth of living organisms. Its main application is steel galvanising to

protect steel from corrosion. Renewable energy technologies need zinc for the galvanisation of the steel used in wind turbines (particularly offshore), solar panel frames, power distribution poles, and hydro-electric plants. As a recyclable and durable metal, zinc contributes to the

construction of sustainable buildings (European Commission, 2020b, p. 564.). Batteries using zinc are being researched. Its green credential come from its role in making steel used in renewable energy equipment withstand

corrosion. Africa's main zinc producers are listed in Table 14 which shows the continent has raised output of zinc for export from 141 MUS\$ in 2014 to 737 MUS\$ in 2023.

Table 14 Export of zinc ores and concentrates 2014 to 2023 (MUS\$)

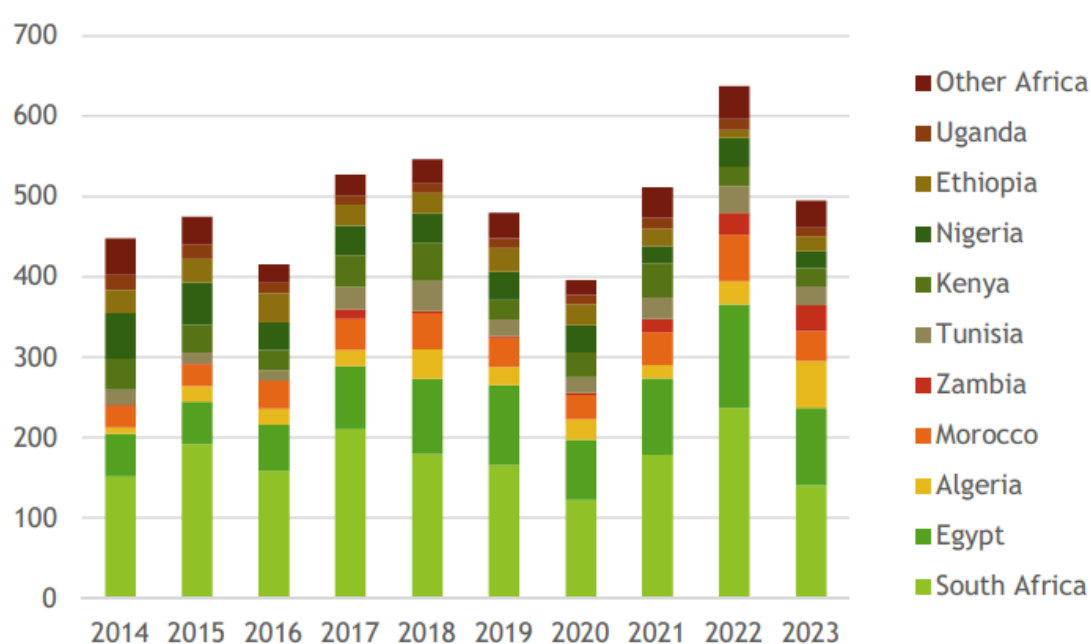
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
South Africa	37	35	38	70	48	108	205	462	532	315
Eritrea	0	0	42	221	267	217	178	280	353	230
Zambia	0	0	0	1	1	1	0	3	5	74
Morocco	44	46	56	83	83	56	43	64	64	51
Namibia	57	54	43	71	104	72	59	60	81	49
Congo	0	0	0	0	0	0	0	0	1	9
Nigeria	2	5	3	5	22	8	8	28	17	6

Source: (ITC Trade Map, 2024) Note HS 2608 Zinc ores and concentrates

Imports of zinc metal and semis, mainly for galvanising steel, follows demand for the construction and metal fabrication sectors.

Over the decade to 2023 imports have broadly tracked industrial activity (Figure 31).

Figure 31 Zinc metal and semis imports 2014-2023 (MUS\$)



Source: (ITC Trade Map, 2024). Note HS codes 3101, 3102, 3103, 3104, 3105

6.1.3 Priority value chains to industrialise within larger African markets

Mines, refineries and manufacturing plants are rooted in a local economy but the markets they serve, and compete within, extend regionally and internationally so it is essential to look at value-chain development from a regional perspective. Eight Regional Economic Communities are recognised by the Africa Union, the: Arab Maghreb Union (UMA), Common Market for Eastern and Southern Africa (COMESA), Community of Sahel-Saharan States (CEN-SAD), East African Community (EAC), Economic Community of Central African States (ECCAS), Economic Community of West African States (ECOWAS), Intergovernmental Authority on Development (IGAD), and Southern African Development Community (SADC).

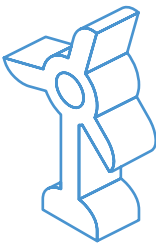
Regional Economic Communities that have formed FTAs are the effective legal instrument through which regional integration is implemented, though non-tariff barriers (NTBs) remain. The critical role played by RECs to give effect to the goals of the AfCFTA is explicit in Article 5 of the AfCFTA founding Agreement that states that the AfCFTA shall be governed by specific principles such as “driven by Member States of the African Union; RECs’ Free Trade Areas (FTAs) as building blocks for the AfCFTA.”

The high number of small national economy countries in Africa prevent firms being able to reach economies of scale and make regional markets essential. Regional economic integration is essential to increase demand to viable scales and for competition to discipline market participants. While RECs are formally committed to regional economic integration, in practice more than 60% of all intra-African trade in goods takes place among the Member States of one REC – the SADC. Greater trade facilitation and political backing of cross border trade is necessary for the AfCFTA to take off.

Inadequate transit, road, rail and maritime infrastructure are important impediments to trade but so too are Non-Tariff Barriers (NTBs) which hike the cost of Africa’s trade by an estimated 283 per cent (UNECA, 2017, p. 87). Empirical evidence suggests that NTBs in some instances can add as much as 15% to the price of goods, effectively reducing consumption of goods (UNCTAD, 2016). Fortunately, progress is being made to clear such obstacles. Trade dispute resolution mechanisms developed by the Tripartite Free Trade Area (TFTA) made up of EAC, COMESA and SADC have proved effective and being used as the model for the AfCFTA Non-Tariff Barriers Annex (TRALAC, 2018). More complex products involve greater cross-border flows of raw materials and intermediate inputs going into their manufacture. Trade facilitation measures are thus crucial for firms to become integrated into production networks and markets at a regional and global level (OECD, 2013). Regional approaches to trade facilitation make the greatest impact on reducing of the cost of doing business, facilitating intra-regional investment, and building of RVCs (ITC, 2017). Supporting DFIs in the form of the AfDB, Arab Bank for Economic Development in Africa (BADEA), Afreximbank are expanding their financing activities to enable private and state-owned enterprises to take advantage of the AfCFTA.

A critical requirement of the AGMS to meaningfully engage in regional and continental trade are simplified Rules of Origin (RoO) so firms can participate in regional value-chains at scale. Well-designed RoO would widen the range of intermediate goods sourced from within Africa and pave the way for more firms in Africa to participate as suppliers in regional and global value-chains and for countries to engage in manufacturing, technological upgrading, and economic and export diversification (UNCTAD, 2019). In January 2022 AfCFTA State Parties adopted rules that could cover 87.7 percent of goods on the tariff lines of member states. This paves the way for member states to gazette these legal instruments at the national level so that countries can apply these rules of origin for continental trade. Further negotiations on sensitive goods, including products in the automotive sector, have yet to be finalised.

6.1.4 Manufacturing of Renewable Energy Equipment Value Chains

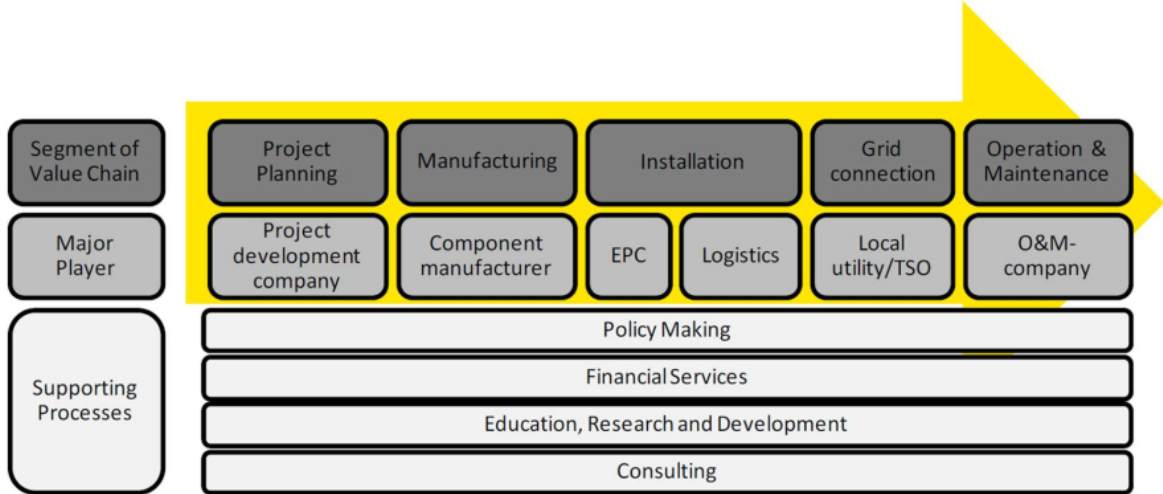


6.1.4.1. Generic features of clean energy value-chains

The AGMS aims to facilitate channelling minerals into manufacturing value-chains. While that is the focus of the strategy, all value-chains have many components that need to be taken into account, often called an ecosystem to capture the necessity of all the parts, that rely on critical roles to be played by government (policy-making, education, RDI, supportive frameworks) and private firms (consulting, financial services, mining, manufacturing, construction et cetera). Using renewable energy value-chains to illustrate generic features, the major players, depicted in Figure 32 perform the following roles. A project development company is responsible

for the coordination and quality assurance of all preliminary works, permits, pre-engineering and the different necessary environmental analysis. Component manufacturer fabricates and assembles different components drawn from different industrial sectors (steel, aluminium, polymers et cetera) and sub-assemblies (electronics, et cetera). An engineering procurement construction (EPC) company chooses components and ensures quality of the plant. Logistics and construction companies prepare the site, transport components and construct the plant. Grid connection is performed by the national company/utility/ transmission system operator (TSO). A company operates and maintains (O&M) the plant over its lifetime.

Figure 32 Typical segments of renewable energy value-chain



Source: (ITC Trade Map, 2024). Note HS codes 3101, 3102, 3103, 3104, 3105

Successful strategies to manufacture renewable energy equipment have to engage with the prevailing conditions in world markets:

- China is the leading global supplier of clean energy technologies today and a net exporter for many of them. China holds

at least 60% of the world’s manufacturing capacity for most massmanufactured technologies (e.g. solar PV, wind systems and batteries), and 40% of electrolyser manufacturing (IEA, 2023a).

- Research and patenting related to clean

energy is concentrated in a few countries (China, USA, Japan, Germany, South Korea, UK, France)

- Renewable energy technologies are developing rapidly therefore firms require the financial ability both invest in R&D as well as to quickly adapt production to remain competitive.
- Exports from production in West, Southern and East Africa will be challenging. Many countries have already established renewable energy manufacturing capability,

the majority with better access to large renewable energy markets (Asia, North America, and Europe), although North Africa is well positioned to supply Europe.

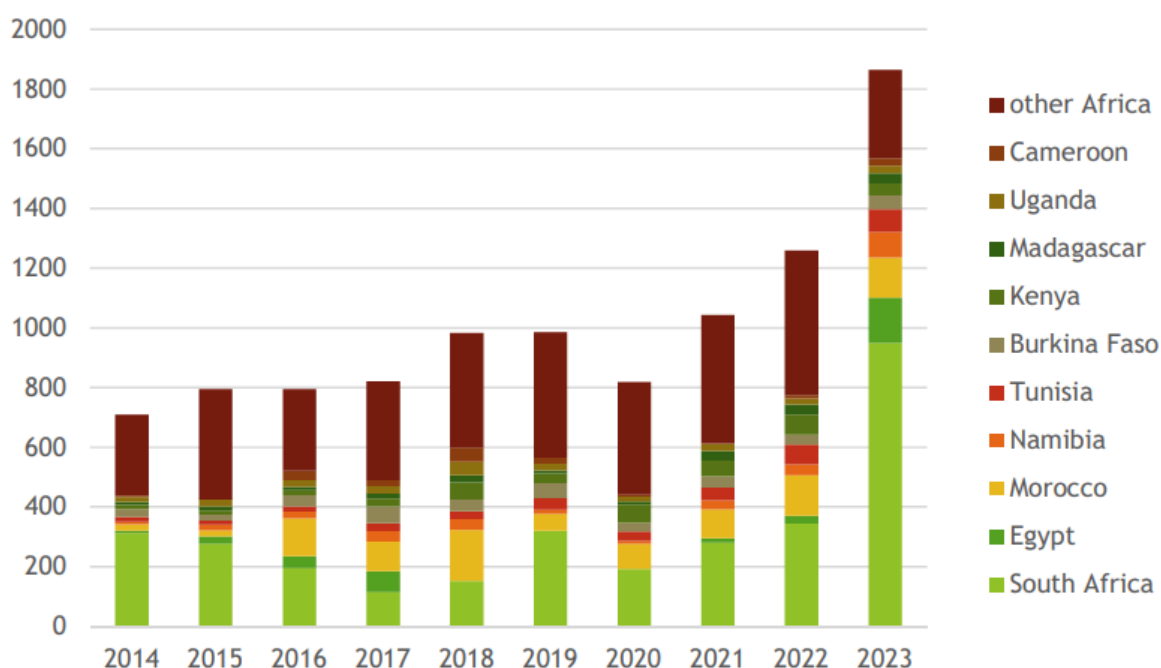
- The Africa and Middle East build could be 22GW a year of wind capacity and 27GW a year of solar PV capacity between 2030 and 2050 but, given current trends, the largest portion of this annual build is expected to be contributed by the Middle East and North Africa. The SubSaharan African utility scale market is largely at a project – rather than programme – level (SAREM, 2022, p. 22).

6.1.4.2. Solar photovoltaic and concentrated solar power value-chains

Africa imported over 1.8 billion US\$ worth of solar panels in 2023. This is a large import bill, but only 2.62% of world PV panel imports. As more PV plants are built and power users look for ways to manage costs and improve energy security, this import bill will escalate

without strong efforts to localise parts of the PV value-chain. From a trade and industrial policy perspective it should be noted that much of the electrical equipment used in RE power plants exceeds the value of PV panels alone.

Figure 33 Top 10 import countries of solar PV panels 2014-2023 (MUS\$)



Source: (ITC Trade Map, 2024)

Solar PV installations are broadly segmented into small-scale residential (less than 8 kWp), medium-scale commercial and industrial (10kWp– 1MWp) large and utility scale above 1MWp. Entry for manufacturing at the lower scale is easier because large-scale installations require tier 1 equipment standards with many years of operation at reference sites to obtain financing.

Feedstocks and equipment used in the solar PV value-chain are shown in Figure 34. Large quantity of the feedstocks for generic metal fabrication (steel, copper, aluminium) construction and electrical equipment going to PV installations. PV modules make up an average of 35% of the capital costs of a plant. Balance of plant components include inverters, transformers, switchgear, circuit breakers, busbars, control and instrumentation, system software and equipment housing. Assessments of localisation programs has shown most progress has been with balance of plant equipment, mounting structures and trackers (SAREM, 2022, p. 27).

Based on industry surveys (SAREM, 2022) reports sustained demand of at least 300MW per year is required to justify investment in module manufacturing and backward linkages (cells and other components). This excludes polysilicon and wafer production where a single plant in China has the capacity to meet global solar panel demand up to 2030. Crystalline silicon (c-Si) PV module manufacturing using imported wafers is considered the most viable and already takes place in several countries. Solar glass is not produced on the continent and likely continue to be imported from largescale

manufacturers in Asia (Fitzgeralds & Terblanche, 2020). Inverter supply is a highly competitive international market dominated by tier 1 suppliers who require extensive testing and certification from local producers to enter their value-chains. Opportunities to localise more production require improving the quality of local transformer manufacturing which requires high quality electrical steel and copper wire.

Mounting structures are more readily localised due to the high cost of transport but are relatively lower value components of a solar PV system. Addressing input material (i.e. steel and aluminium) costs could open the way for more local mounting structure manufacturing. Opportunities for localisation require competitive costs for steel fabrication, galvanising and aluminium extrusion.

Cables, already manufactured in several countries are a major candidate for localisation. Copper, aluminium, polymers for insulation and steel for armouring the main feedstocks.

Lessons need to be drawn from actual experience operating companies. Solinc East Africa Ltd, a Kenyan solar module manufacturer that has managed to remain in the market, despite intense competition from imports of low-cost solar panels of over 40 MUS/y. Firm strategy Solinc has used to its advantage includes: (i) initial access to knowledge and material inputs from upstream linkages; (ii) downstream integration and partnerships with key distributors and customers; (iii) close proximity to customers; and (iv) provision of complementary and increasingly high value-added services (Davy, 2023).

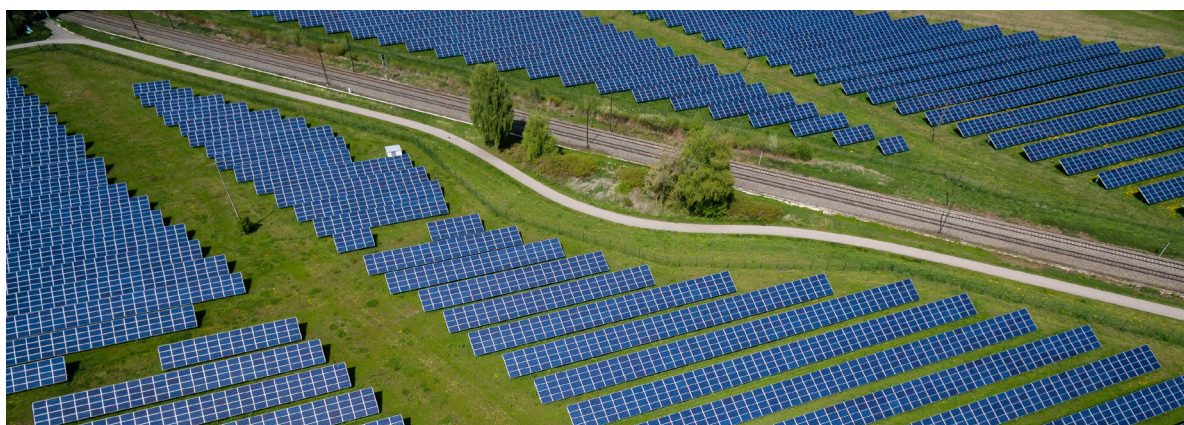
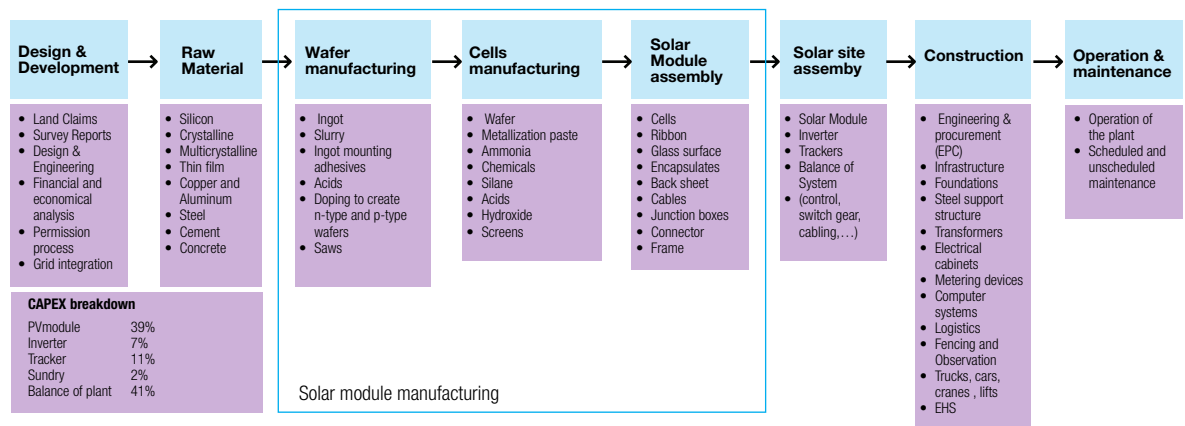


Figure 34 Solar PV value-chain



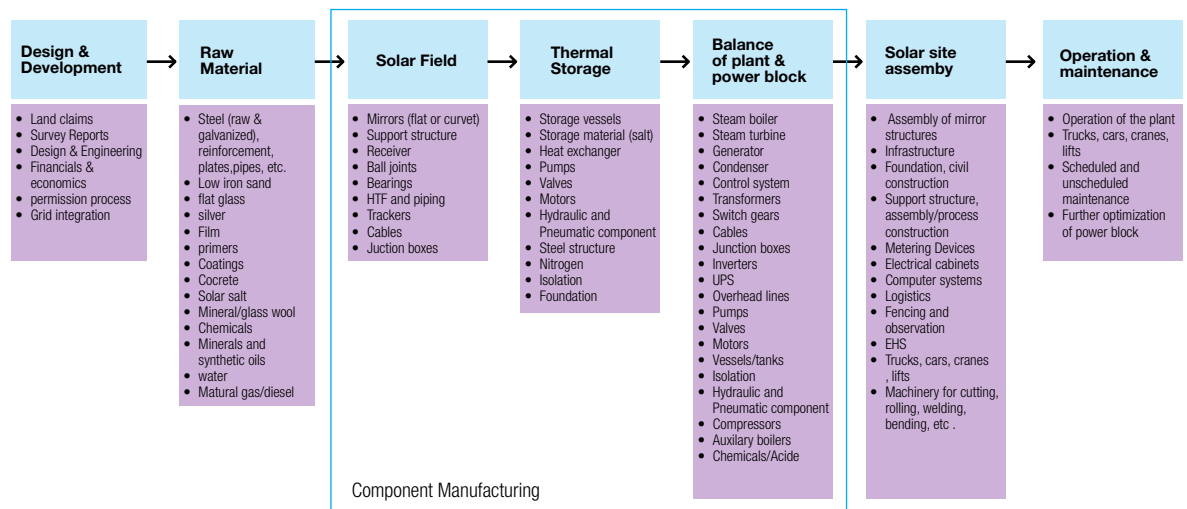
Source: adapted from (EIB and IRENA, 2015) and (SAREM, 2022)

Concentrated solar power (CSP), a mature technology, has a much smaller share of the global clean energy market due to a higher cost than solar PV. When coupled with thermal storage CSP offers the advantage of dispatchable power over a longer time. The value to a great of dispatchable power is rising as fossil fuel generation is retired. New designs for CSP plants that make them modular, more compact and combine PV and thermal generation may increase the attractiveness of this technology in the future (ABC News, 2023).

Feedstocks, materials and equipment used in CSP plants is shown in Figure 35. Construction of the power block of a CSP plant is similar to manufacturing and tier processes for conventional thermal generation carried out by heavy engineering industries that involve boilers and steam generators.

Part of Egypt's plans for RE is to increase local content. The Ministry of Electricity and Renewable Energy succeeded in reaching 30 percent local content for wind farms in 2018 rising to 70 percent by the end of 2020 and to reach 50 percent for CSP projects by the end of 2020 (ITA, 2022). The Suez Canal Economic Zone is aiming to cluster firms for solar panels, electric turbines, and maintenance to localise green industrial technology. ReNew Power of India has announced plans to build green plant for 20,000 t/yr of hydrogen and 1.1mn t/yr of ammonia in the zone (African Leadership, 2022). At the end of 2022 RE projects under development totalled 3570 MW with FDI of 3.5 billion US\$ (Egypt Today, 2022).



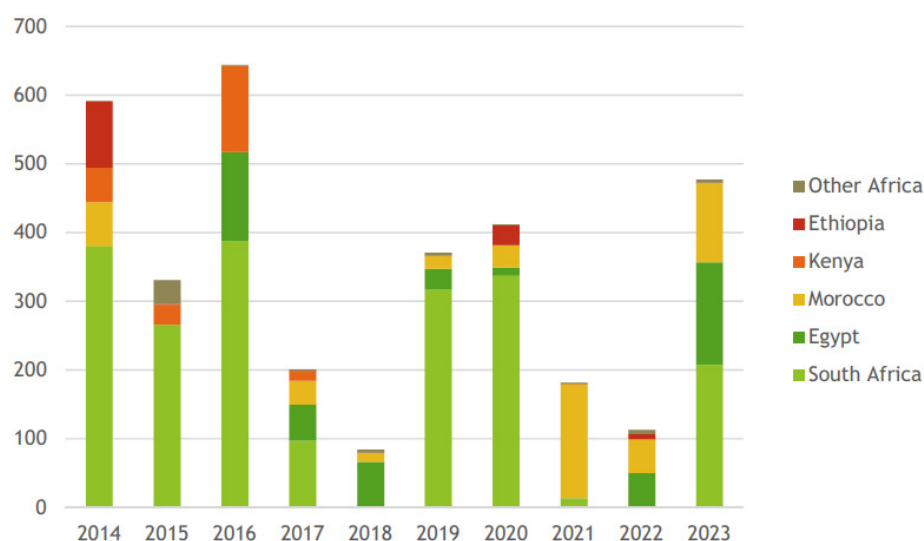
Figure 35 Concentrated solar power value-chain

Source: (EIB and IRENA, 2015)

6.1.4.3. Wind

Wind power projects are lumpy investments, as can be seen in the fluctuating import values for wind turbines in Figure 36. Imports reach close to 600 MUS\$ in 2014 all but collapsed in 2018. Large projects in South Africa, Egypt and Morocco boosted imports in 2023 to 470 MUS\$. The stop-start nature of wind projects seen in South Africa, Egypt and Morocco is a major obstacle to industrialising the wind power value-chain. In the case of South Africa firms that entered the wind industry early in the public renewable energy procurement programme were forced to close due to the stop start nature of the programme in practice. The failure to ensure continuity and predictability of South

Africa's power procurement process within energy policy cascaded down the wind energy chain impacting negatively on industrial policy attempts to localise domestic and foreign enterprises (Morris, Robbins, Hansen, & Nyard, 2022). Countries with good wind resources and an industrial base will face similar challenges unless big markets with sustained demand are created. Development strategies for green minerals into renewable energy equipment need to ensure markets are predictable over the medium-term to give firms the confidence needed to invest in capacity for localising value-chains.

Figure 36 Wind turbine imports 2014-2023 (MUS\$)

Source: (ITC Trade Map, 2024) HS 850231 generating sets, wind powered

Onshore wind turbines are typically geared while offshore ones are direct drive and used permanent magnet-based generators that require less maintenance. Wind power in Africa has been onshore to date which is the technology discussed below.

Analysis by (SAREM, 2022) indicates between 64-85% of the value of an onshore wind project until operation is in the supply of the wind turbine, including installation. Of the capital cost, towers and blades combined represent about half the cost, and the nacelle and all its sub-components make up the other. Feedstocks and capabilities to localise onshore wind value-chain involve the following.

A total market demand of 1,000MW per year would enable local nacelle assembly, starting with imported components, along with local manufacturing of generators and invertors viable.

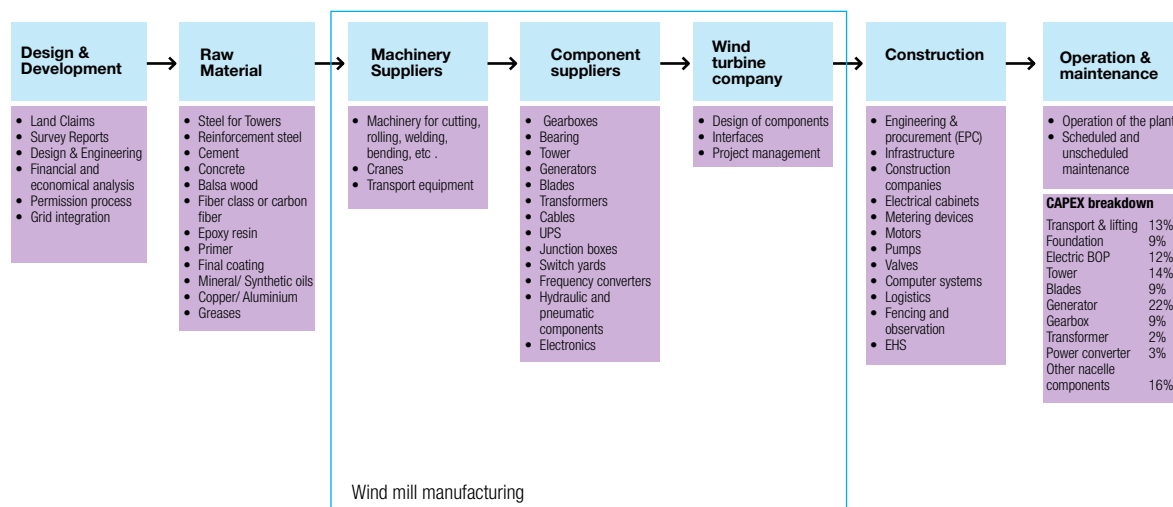
Capabilities in low, medium, and high voltage electrical engineering and electromechanical manufacturing are required.

OEMs indicate that a demand of 400MW per year per facility for a minimum of five years is required to make the local manufacture of blades from carbon fibre and fibreglass potentially viable.

Wind towers manufacturing requires steel, cement and tooling which makes it the first entry point for localisation.

Civil engineering, construction and logistics and electrical engineering which serve mining and infrastructure sectors are most easily able to expand into providing balance of plant manufacturing and services for the wind industry.

Figure 37 Onshore wind value-chain



Source: adapted from (EIB and IRENA, 2015) and (SAREM, 2022)

6.1.4.4. Hydrogen and fuel cells

Hydrogen is a secondary source of energy. It stores and transports energy produced from other resources (fossil fuels, biomass or by splitting water molecules) therefore it is called an energy carrier. It is a clean-burning fuel, and when combined with oxygen in a fuel cell, hydrogen produces heat and electricity with only water vapour as a by-product. Currently hydrogen made from fossil fuels, which is extremely emissions intensive, is used in

petrochemicals (e.g. desulphurisation) and industry (e.g. to make ammonia) generally collocated with its application. A new role for hydrogen is decarbonise hard-to-abate sectors such as iron and steel production, chemicals, as well as heavy duty transport, provided that it is made without emissions. To achieve that goal an entirely new energy value-chain using clean energy must be built from scratch to make, transport, store and use hydrogen.

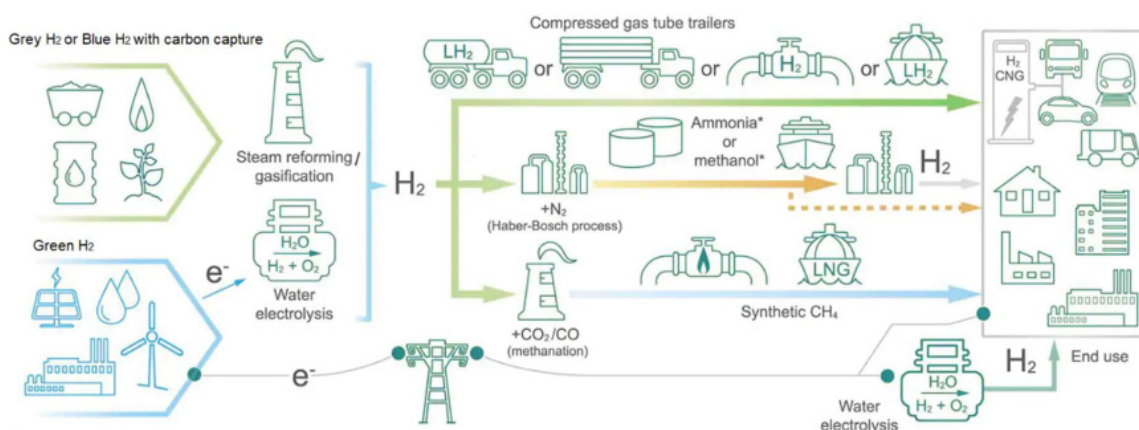
Expectations for the role that hydrogen can play in decarbonisation very high. According to McKinsey, it is estimated that as much as 25% of global emissions could be reduced using hydrogen by 2050 (World Bank, 2022, p. 15) while IRENA envisages it contributing 12% to total final energy consumption by then. Developed economies are hoping to substitute the use of oil and gas with new hydrogen industries and developing economies with good renewable energy resources are hoping to launch hydrogen production and exports for these new markets.

Hydrogen demand reached 94 Mt in 2021, 40 Mt in oil refining, the rest in industry and only 40 kt in new applications or transport. The IEA projects demand to rise to 115 Mt by 2030, although less than 2 Mt would come from new

uses. Current demand met almost entirely by hydrogen production from unabated fossil fuels. Low-emission hydrogen production was less than 1 Mt in 2021, coming from plants using fossil fuels with carbon capture, utilisation and storage (CCUS) (IEA, 2022).

There are currently 534 large-scale projects and investment value of 240 billion US\$ in the pipeline 6 of which are in Africa (World Bank, 2022). These announced projects could add 16-24 Mt per year of low emission hydrogen by 2030, however, while many projects are at advanced planning stages, just a few (4%) are under construction or have reached final investment decision. Among the key reasons are uncertainties about demand, lack of regulatory frameworks and of available infrastructure to deliver hydrogen to end users (IEA, 2022, p. 6).

Figure 38 Hydrogen energy value-chain



Source: adapted from (IHS Markit, 2019) Note N2 nitrogen gas, LH2 liquid hydrogen, CH4 methane

For the AGMS an evolving hydrogen industry has two main implications: first, the boost to renewable energy production to create clean energy sources to make green hydrogen, second the minerals that will be used in the hydrogen value-chain and the technologies choice for electrolyzers and fuel cells. There is considerable uncertainty over how rapidly these drivers will begin to directly impact the minerals industry.

A World Bank (World Bank, 2022) study on sufficiency, sustainability, and circularity of critical materials for clean hydrogen highlight that the largest source of material demand from the parts of the hydrogen sector modelled are likely to

come from the renewable electricity generating capacity needed for renewable hydrogen deployment. This basket of materials includes aluminium, copper, nickel, and zinc – though the actual scale and composition is highly dependent on the type (and sub-types) of renewable electricity used to power electrolyzers. Higher use of solar PV could increase the demand for aluminium, whilst more use of wind could increase the need for zinc, or even dysprosium and neodymium if wind turbines with permanent magnets are used. Stainless steel, nickel and titanium are widely used in hydrogen-related technologies compared to smaller volumes of platinum, iridium, cerium, cobalt and graphite.

Water electrolysis uses electricity to split water into hydrogen and oxygen. Technology choices for electrolyzers impact on the demand for green minerals. Currently 70% of the installed capacity uses alkaline electrolysis in which zinc, copper, iron, nickel and cobalt alloys are used. Proton exchange membrane (PEM) using platinum and iridium catalysts make up the remainder. Other emerging technologies are solid oxide electrolysis cells and anion exchange membranes electrolysis. Electrolyser capacity, which stood at 510 MW in 2021 could rise to 134 GW by 2030 with half of those expected to be PEM (IEA, 2022, p. 76). PGM use for hydrogen production will undoubtedly increase and offset some of the contraction in demand arising from auto catalysts used by ICE vehicles, however, it is unrealistic to assume that future hydrogen production will all be based on PEM electrolyzers.

Fuel cells effectively work as electrolyzers in reverse, converting fuel (usually hydrogen) into electricity and heat. There are various designs and use cases for transport or stationary power supply. Protonexchange membrane fuel cell (PEMFC) are emerging as the most useful for transportation as they can operate at relatively low temperatures and quickly vary their output. Key material needs are platinum, ruthenium and cerium and corrosion resistant steel alloys.

Greater availability of hydrogen in future will spur the wider use of fuel cell powered vehicles. Toyota and Honda are amongst the tier 1 auto makers promoting this technology. Fuel cells have a growing share of the zero-emission medium and heavy truck market, led by China IEA REF p40. In May 2022 Anglo-American began trials of a 1.2 MWh battery and 800 kW fuel cell hybrid heavy haul mine truck capable of carrying a 290-tonne payload fed by renewable energy and green hydrogen. A year later work has begun on a second-generation heavy haul truck. The company plans to replace its current fleet of diesel-powered trucks with this zero-emission haulage system, fuelled with green hydrogen (Anglo American, 2022). Reducing diesel use and building renewable energy systems to power operations is a major focus of mining companies in their efforts to reduce carbon emissions over time.

Under the umbrella of the African Green

Hydrogen Alliance (AGHA) Egypt, Kenya, Mauritania, Morocco, Namibia and South Africa are collaborating to create an enabling environment for projects by brining the public and private sectors together to address regulatory policy, certification, financing and capacity building needs (Green Hydrogen Organisation, 2022). Africa's exceptional renewable energy resources, discussed in section 3.4.1 is driving a strong pipeline of projects to produce green hydrogen (Energy Capital & Power, 2023). As at quarter one 2023 the following projects were underway.

Djibouti

- a 10 GW green hydrogen hub by CWP Global

Egypt

Egypt has a pipeline of 21 green energy projects many of which are to be built in the Suez Canal Economic Zone

- 3 Mtpa green ammonia facility; a 4 GW electrolyser plant at the Suez Canal Economic Zone
- (SCZONE) developed by Masdar and Hassan Allam Holding Group;
- 3.6 GW electrolyser project developed by Globeleq;
- 400,000 tpa ACME green ammonia project;
- 300,000 tpa Fortescue-Egypt-gH2 project; and the
- 200,000 tpa ReNew Power project

Mauritania

- 1.7 Mtpa Aman project, developed by renewable project developer CWP Global at a cost of \$40 billion with a 15 GW electrolyser and powered by 30 GW of solar and wind.
- 1.2 Mtpa Nour Electrolyzer project and the 1.36 Mtpa Masdar-Infinity-Conjuncta green hydrogen project, with a potential to reach up to 10 GW of electrolysis each.

Morocco

- 900,000 tpa Amun project, developed by CWP Global
- 710,000 tpa Guelmim-Oued Nour green hydrogen project by Total Eren
- 31,000 tpa Hevo Ammonia Morocco project; the
- 8,400 tpa Masen Green Hydrogen project;

Namibia

- 300,000 tpa 3 GW Tsau Khaeb project at cost of \$9.4 billion
- 2.5 GW Tumoneni project and 42 MW Daures Green Hydrogen Village 50 MW Swakopmund project.
- Three hydrogen valleys for Kharas, Walvis Bay port and Kunene

South Africa

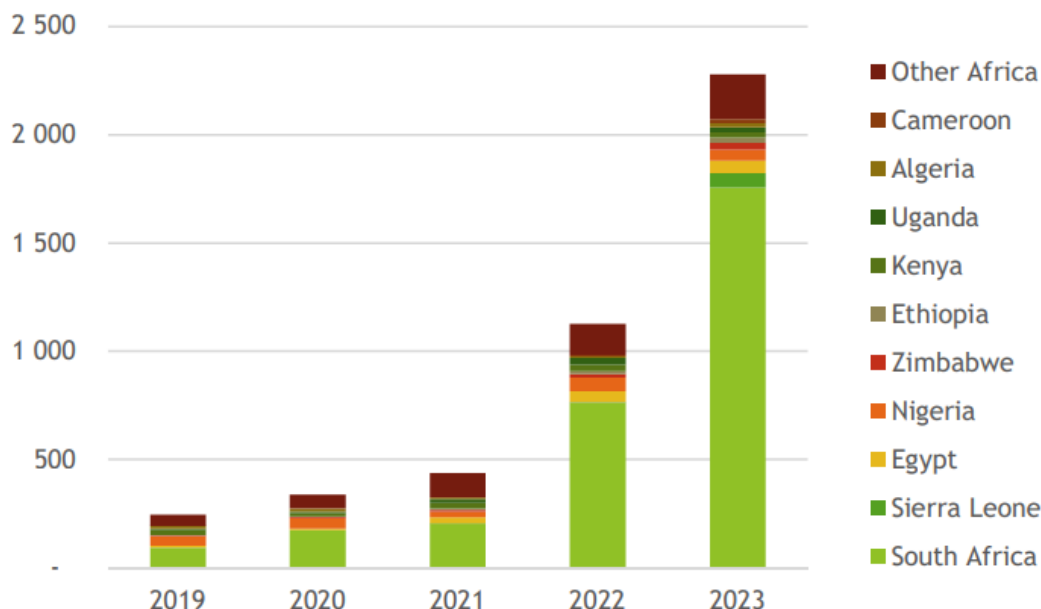
- 780,000 tpa Green Ammonia Plant developed by Hive Hydrogen with 4 GW of wind and solar
- at a cost of \$4.6 billion at the Coega Special Economic Zone to replace heavy fuel oil and diesel in the maritime industry.
- The Boegoebaai Green Hydrogen Development Project on the Atlantic coast

6.1.4.5. Batteries

Hydrogen is a secondary source of energy. It stores and transports energy produced from other resources (fossil fuels, biomass or by splitting water molecules) therefore it is called an energy carrier. It is a clean-burning fuel, and when combined with oxygen in a fuel cell, hydrogen produces heat and electricity with only water vapour as a by-product. Currently hydrogen made from fossil fuels, which is extremely emissions intensive, is used in

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Figure 39 Imports of lithium-ion batteries by country 2019-2023 (MUS\$)



Source: (ITC Trade Map, 2024) note HS 850760 Lithium-ion accumulators

Foundations for building a full battery value-chain have been laid in prior work supported by the mineral promotion bodies on the continent. Complementary work explored means to beneficiate REEs to develop the full REE value-chain up to final products (ANRC, 2021).

In 2021 the African Natural Resources Management and Investment Centre of the AfDB published the results of their investigation on harnessing the Lithium - Cobalt (Li-Co) Value-chain for Mineral Based Industrialisation in Africa (ANRC, 2021). The authors observed that all the

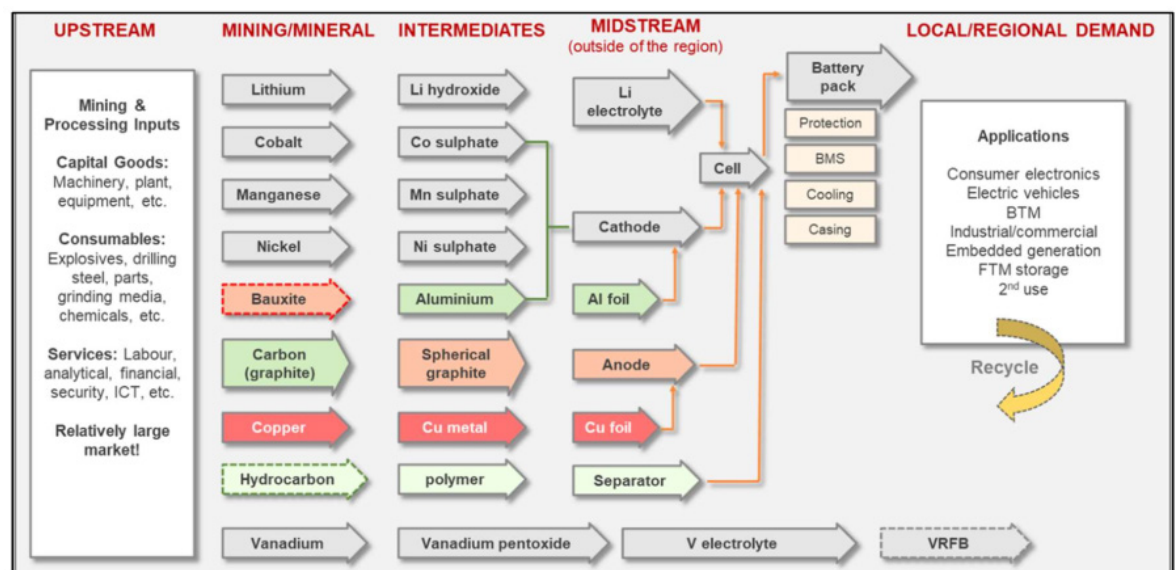
lithium-ion battery materials are mined in Africa which placed the continent on the first rung of the value-chain. The low level of beneficiation applied to battery materials, however, realises only 10% of the total end-to-end value of the supply chain, resulting in Africa losing out on opportunities to fully benefit from its mineral resources. The report made several recommendations to turn this situation around, namely: Conducting feasibility studies in order to identify the necessary investments for value addition;

- Promotion of linkages with other economic sectors for Li-Co development;
- Promotion of joint ventures with foreign companies to develop Li-Co deposits;
- Resourcing the African Minerals Development Centre to coordinate the development of strategy for critical minerals on the continent; and,
- Raising the profile of African interests in global associations.

In November 2021 the results of a study to determine the cost of producing lithium-ion battery precursors in the Democratic Republic of Congo benchmarks against the U.S.A., China and Poland were published (BloombergNEF, 2021). It was commissioned by the Africa Export-Import Bank, United Nations Economic

Commission for Africa, African Development Bank, Africa Finance Corporation, Arab Bank for Economic Development in Africa, and African Legal Support Facility. The report concluded that building a 10,000 metric-ton precursor facility in the DRC for NMC cathodes could cost \$39 million. This is three times less than what it would cost for a similar plant in the U.S. A similar project in China and Poland would cost \$112 million and \$65 million, respectively. Two critical caveats to this competitiveness finding must be noted. The capital cost in the DRC was cheaper than all three countries mainly due to the lower cost of land and construction compared to China and Poland. Second, the report concluded competitiveness is dependent on secure supply of cobalt on a long-term contract, because acquiring cobalt on a spot price basis would make the plant uncompetitive. DRC's hydropower-based electricity provides an additional advantage of lower energy costs and in reducing the carbon footprint of the precursor material. Macroeconomic projections made by the DRC Ministry of Finance of a larger scale plant with an annual production of 100 000 tons of NMC622 anode active material, estimated to cost USD 301 million to build at full production would gross USD 3.2 billion – a major step to towards transforming the DRC economy and improving its fiscal stability (Min Finance, 2021)

Figure 40 Battery feedstock value-chain



Source: Authors

The current state of the battery value-chain broadly is depicted in Figure 40 which highlights battery minerals are distributed amongst Southern African states, consequently only a regional strategy to aggregate feedstocks would be viable. The midstream stages that involve cell production, mainly in Asia, is the missing part that needs to be filled. This remains the most challenging part of the valuechain to complete due to the massive gigawatt scale at which battery factories on the cutting-edge of technology being constructed in North America Europe and Asia. Existing markets for applications in Africa include electric vehicles (mainly two and three wheelers and vehicle conversions currently) batteries for electricity storage at sites behind the meter that still draw power from the grid, industrial and commercial applications particularly for telecommunications equipment, batteries attached to embedded generation typically off grid solar installations, battery storage forming part of generation assets at utility scale referred to as front of meter storage and second usage batteries, when electric vehicle batteries reach the stage when they can only hold 80% of their rated capacity and are redeployed to stationary storage applications that are less demanding.

The battery material precursor study the DRC demonstrates the potential to close the missing midstream stages. In May 2022 DRC and Zambia signed a bilateral agreement establishing the "Republic of Zambia and DRC Battery Council" for the purposes of establishing electric vehicle battery manufacturing. The project will be implemented in two Special Economic Zone (SEZ) sites which is a unique cross border configuration. The DRC government has identified a 200 ha site in Katanga province 2.5 km from the Zambian border. The second SEZ will be close by in Ndola in Zambia's Copperbelt Province.

Morocco and South Africa have large automobile assembly industries producing ICE vehicles of which 80% and 50% respectively are exported to the EU. Both countries face major challenges in pivoting their auto industry to the production of electric vehicles in future given that EU policies to end the sale of ICE vehicles by 2035. Morocco is positioning itself to become a hub for electric vehicle manufacturing (MEI, 2022) and South Africa in the process of developing a new policy framework for EV's (RSA, 2021) but neither country has broken ground on EV battery manufacturing yet.

South Africa is already engaged in battery pack development and manufacture for industrial and stationary energy storage applications using imported cells (mainly LFP) that are assembled into final battery systems. Although the companies are still quite small, all have developed proprietary know-how in the form of pack designs, battery management systems and control software. Rapid growth of the market for LIBs in South Africa and elsewhere in Africa has led to a significant expansion of these manufacturing operations (Engineering News, 2023).

In a regional study on the identification and project viability scan of investment projects for the development of energy storage (batteries), copper and mining inputs regional value-chains completed for (SADC, 2022) research concluded that established LIB assemblers in South Africa will likely expand their output as the domestic market grows and strategies should aim to build a full battery value by establishing cell manufacturing over the medium-term.

Low barriers to entry for LIB assembly of battery packs for stationary storage make it feasible for these operations to be entry points for firms to supply local markets and build capabilities for moving up the value-chain. The (SADC, 2022) study identified Harare, Zimbabwe; Dar es Salaam, Tanzania; and Walvis Bay, Namibia as prospective locations to establish LIB assembly plants. Similar production factor and market conditions apply in Nigeria, Kenya, Algeria, Ghana and Egypt where battery assemblers whether for stationary storage or two wheelers are likely to concentrate on LFP batteries. This battery chemistry has advantages of lower material costs, safety and widely available production equipment for common battery sizes like 16650 or 32700 which can be assembled into packs for applications that are less demanding than for electric vehicles needing long ranges. LFP batteries fit well the AGMS objective of facilitating e-mobility discussed in section 6.1.4.6.

The distribution of mineral resources in southern Africa underpins the logic of a regional approach to creating a full LIB manufacturing value. The Zambia and DRC Battery Council has been established to lay the groundwork for those countries to launch battery and EV manufacturing industries.

It is recommended that the first phase start with manufacturing nickel manganese cobalt (MNC) precursor materials, initially for export and then supplying regional cell manufacture if the latter can be shown to be economically viable. Access to cobalt, nickel and manganese at refinery gate prices, or similar favourable terms would be essential to anchor the viability manufacturing battery precursor products.

Owing to the scale required to make battery manufacturing for EV's viable, an assessment by (World Bank, 2023, p. 104) argues that a full value-chain would have to be predicated on the local automotive industry pivoting into EV manufacture, as this is the key lever that could stimulate the establishment of local EV battery system components manufacture and assembly, including cells. Timing of the shift to EV's is uncertain, however, OEMs are looking at how they can localise components to pave the way for shifting from ICE to EV assembly in the next decade.

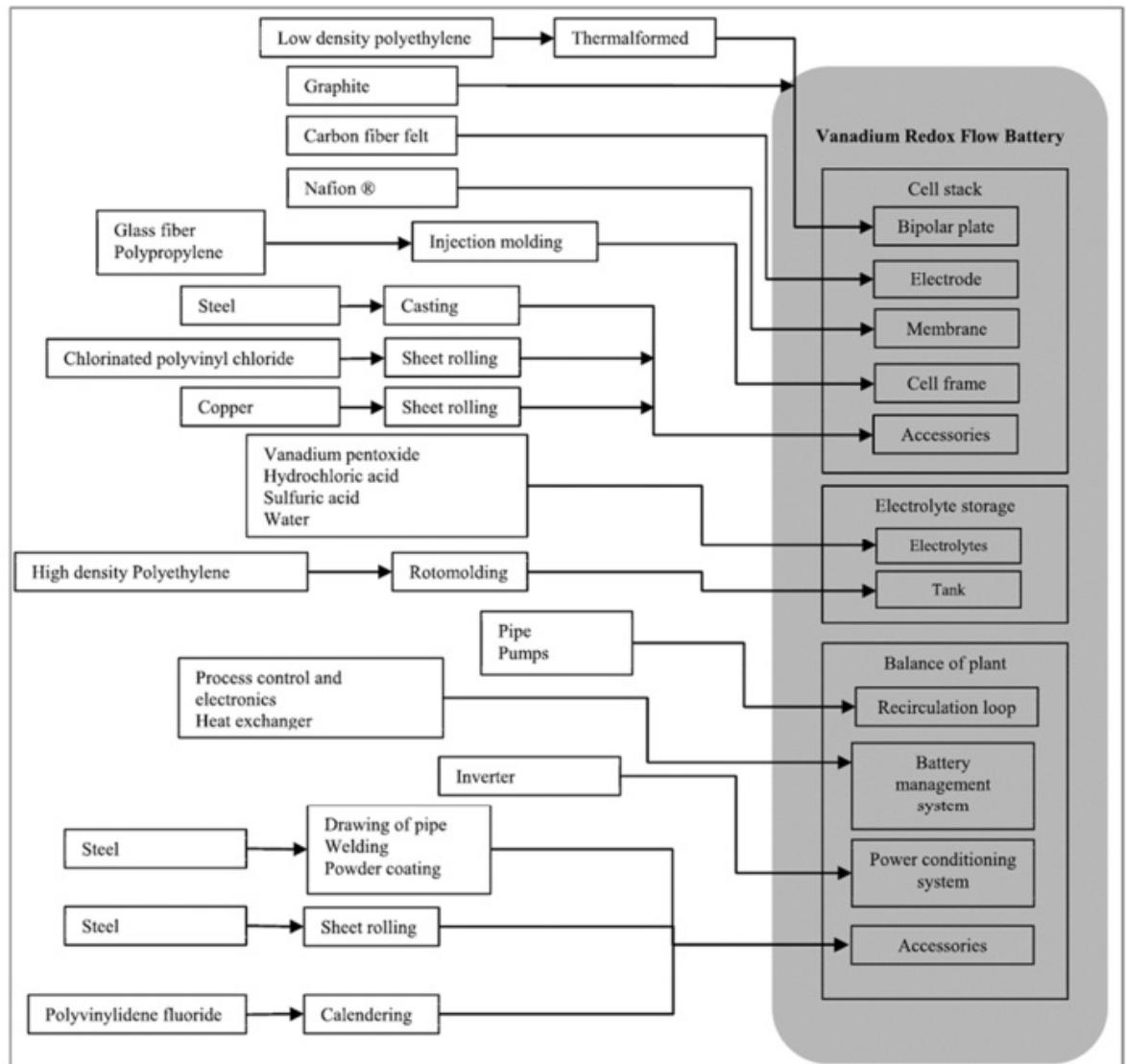
Non lithium based battery chemistries could provide opportunities for the continent. Sodium-ion batteries are starting to enter mass production in 2023, their market appeal based on the use of lower cost materials for cathodes (nitrogen, carbon, iron, sodium) replacing copper

foil with cheaper aluminium as a current collector and high intrinsic safety. Sodium-ion batteries have comparable energy densities to LFP batteries, at 2 kg/kWh yet with a metal cost of 4 US\$/kWh and 24 US\$/kWh respectively at 2022 metal prices (Wood Mckenzie, 2023). Africa's discovered lithium resources are small, relative to the major producers; however, it has extensive sodium resources at Sua Pan in Botswana. Lithium-ion chemistries are well established so will not be substituted in the medium term, it is more likely that other battery types will be developed to outcompete them in certain markets. Sodium-ion batteries for stationary storage could be a strong competitor in future. It is suggested they be kept on a technology watch-list.

Africa has the potential to build up a significant battery industry for large-scale stationary storage using vanadium flow batteries. Vanadium Redox Flow Batteries (VRFB) are gaining attention as suitable for modular, safe, scalable battery energy storage systems (BESS) in power grids where they become cost competitive with lithium-ion LFP at durations of 24 hours and above at all power capacity scales (PNNL, 2022). China is the world's leading vanadium producer is actively deploying large-scale VRFB projects.



Figure 41: Feedstocks and fabrication processes for producing a VRFB



Source: (He, et al., 2020).

The case for establishing VRFB manufacturing rests on three pillars. Firstly, the largest vanadium electrolyte production facility outside of China is being built in South Africa. Secondly, much of the fabrication and engineering capabilities required for their manufacture is common to mining equipment capital goods (tanks, pumps, instrumentation) that can draw established industrial clusters in Ghana, the

Copperbelt and South Africa. Thirdly coupling clean energy generation with storage becomes more important as the share of variable renewable energy in a power system increases. For Africa to make the best use of its exceptional clean energy resources, large scale storage will be required (including pumped hydro where land elevation is suitable) which has a role it can be formed by VRFB BESS.

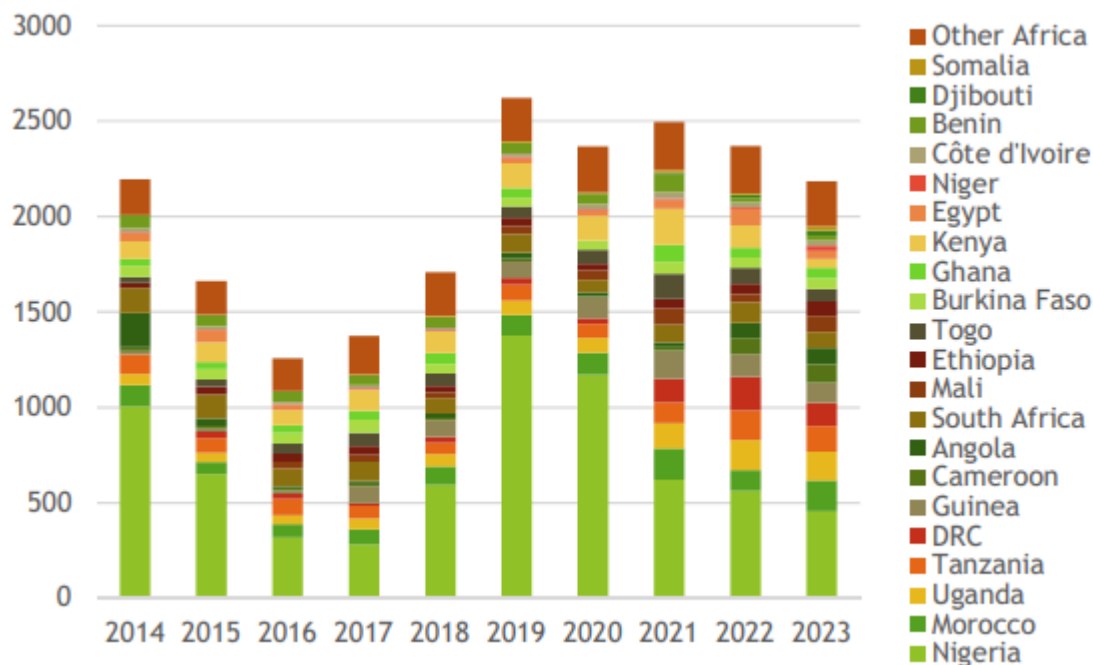
6.1.4.6. Assembling electric two wheeled vehicles and other niche markets

Electric vehicle market development in Africa faces several challenges. On the positive side the market for vehicles in Sub-Saharan Africa (SSA), though currently small, is growing very rapidly. It is currently met by imports, especially of used vehicles. SSA will become a significant global market over the next decade (Black & Makundi, 2017). Yet the key growth constraints to be overcome are weak manufacturing capabilities and the costs of trade diversion, which are particularly high given the large presence of low-priced, imported second-hand cars in most markets (Markowitz, 2019). Used vehicle imports are prohibited in Egypt, Morocco and South Africa, while Cote d'Ivoire, Kenya and Ghana ban imports older than 5, 8 and 10 years respectively. Even in those markets, the current lack of scale prevents many first-tier component suppliers establishing, however South Africa has some domestically owned first-tier suppliers. With the exception of the three countries referred to, most countries remain extremely reliant on second-hand imports and export very little. Most operations for new vehicles are small-scale and involve completely knocked down (CKD) assembly, with minimal to no local content (Barnes, Black, Markowitz, & Monaco, 2021). Over the longer-term Africa's automobile industry will have to pivot to the production of EVs, furthermore most countries have set policy objectives to decarbonise their transport sectors over time. Africa's automotive industry is expected to expand the production of Plug in hybrids (PHEVs) and Hybrid Electric Vehicles (HEVs) in their product mix due to the low density of charging infrastructure amongst other factors. This will continue to support demand for PGMs for emissions abatement.

The high purchase price of electric vehicles and need for simultaneous investments in charging infrastructure are significant barriers to EV growth in developing country markets (Mali, et al., 2022). Multi country studies report electric two- and three-wheelers are acceptable to consumers as they are affordable. In highly congested cities their low speed (less than 45 km per hour) and short range are not limiting factors. Recharging of two- and three-

wheelers uses domestic electrical supplies and requires no special fittings (Rajper & Albrecht, 2020). These findings suggest that in markets where policy support for EVs via consumer subsidies is both unaffordable and would worsen inequality, support should focus on public transport fleets for commuter services where the high utilisation rate of vehicles improves their financial viability and charging infrastructure is required only at bus depots. These findings support the AfDB policy brief which identified the two- and three-wheelers and E-buses as the segments most suitable for starting e-mobility adoption in Africa (AfDB, May 2022) and also have the greatest impact in terms of affordability for Africans.

Imports of motorcycles averaged 2.4 billion US\$ over the period 2019 to 2023. Africa accounts for some 6% of world motorcycle imports. The two-wheeler market was estimated to be valued at 3.65 billion US\$ in 2021 on imports of 2.5 billion US\$ taking into account services, overhead and mark-up on imports. Africa's two-wheeler market is expected to reach 5.07 billion US\$ by 2027 according to market research (Mondor Intelligence, 2022). Motorcycles have become a major segment of motorised transport across the continent for commuting, goods delivery and motorcycle taxis in the absence of dependable public transport. Motorcycles are favoured entry into motorised transport owing to their low cost of acquisition, low running costs, agility to handle poor roads and being quicker than cars in congested urban settings. The market is dominated by light models, over 80% have engine capacities between 50 and 250 cc. Demographics and urbanisation are structural drivers of the expanding motorcycle market helped along by some recent changes. The popularity of motorcycle taxis, known as Boda Boda in East and Okada in West Africa, popularity has skyrocketed in recent years providing transport services in urban and rural areas. Low-cost imports from Indian manufacturers, affordable vehicle financing and rising demand has turned motorcycle taxis into a significant employment sector.

Figure 42: Top 20 import countries of motorcycles 2023-2014 (MUS\$)

Source: (He, et alSource: (ITC Trade Map, 2024) HS codes 871110, 871120, 871130, 871140, 871150, 871160, 871190 2020).

Such a large motorcycle market has given rise to ubiquitous and vibrant ecosystem of service and repair businesses that can be found in almost every town and city. It is also driving new firms to enter the market with e-mobility products and services they aim to scale up and provide solutions adapted to local conditions. Studies by (FMO, 2022) of which mutually reinforcing conditions need to be present to achieve mature e-mobility ecosystems identify the following:

1. Inputs: Access to sufficient sources of high-quality raw, processed, and manufactured inputs (e.g. batteries, vehicles) to bolster the e-mobility value proposition;
2. Capital: Diverse funding ecosystem and sufficient flows of (concessional) growth and working capital to meet investee needs;
3. Energy: Reliable energy infrastructure (on- / off-grid) to power e-mobility solutions; minimal fossil fuel subsidies to encourage transition;
4. Market: An addressable consumer base large enough to support the transition of a market from being nascent to mature; and

5. Policy framework: A policy and business environment conducive to the provision of EVs and charging

The above conditions exist in several markets where a nascent African e-mobility sector built on two and three-wheeler vehicles is emerging. Experience to date has identified three main obstacles to growth: a reliance on electric motorcycles imported from China and India that are not suited to African conditions; poor and unreliable electricity supplies; and poor quality batteries. Examples from East Africa documented by (PREO, 2023) show how firms are overcoming these obstacles which should be replicated more widely. Designing and manufacturing electric motorcycles for local conditions is being undertaken by Roam (previously Opibus) in Kenya, a company that also converts ICE powered buses to electric. Electric motorcycle charging solutions using battery swapping and a pay for energy business model is being rolled out by Zembo based in Uganda. Charging networks have in some cases required building mini grids to ensure reliable electricity. Mobile power which has expanded from Kenya to

Sierra Leone, Liberia, DRC and Nigeria runs a battery charging business built on an intelligent battery management system ICT platform (PREO, 2023, p. 21).

For the AGMS to facilitate e-mobility, starting with two and three wheelers, action is required on each of the conditions listed above plus the flexibility to encourage firms to innovate business models that work for local conditions.

Finally, attention must be given to clean energy for heavy transport equipment on the continent. Full implementation of the AfCFTA with associated investments into transport infrastructure will create a boom for rail, shipping, air and road freight transport infrastructure and services. Projections for the stock of transport equipment required by 2030 is

material. For road freight, which carries the 70% of goods cargo on the continent, the size of the truck fleet should increase by 179 per cent for bulk cargo and 180 per cent for container units compared with the fleet in 2019 (ECA, 2022, p. 113). 1.42 million new heavy vehicles would need to be added to the existing stock of 794 000.

An opportunity of this size should be pursued to anchor strategies for decarbonising heavy vehicles where the right conditions exist support clean energy transport. New uses for hydrogen often refer to a 'hydrogen valley' from where the technology can grow. Hydrogen projects discussed above could similarly serve as anchor points for fuel cell powered transport to serve surrounding regions.

6.1.4.7. Conditions that are conducive to the development of green manufacturing value-chains

Strategies to foster the development of value-chains to manufacture renewable energy equipment, batteries and e-mobility products will require a combination of measures that are supportive of industrialisation in general and ones that are tailored to particular value-chains. Measures that are good for the economy overall need to use resources and current comparative advantages to the full by maximising inter-sector linkages while developing capabilities to enhance high value-addition and compete in high-skill tasks in global value-chains along with expanding enabling sectors such as infrastructure and finance.

It is not realistic for countries to compete across all parts of clean energy technology supply chains points out the IEA, stating international collaboration will be an essential element in industrial strategies [IEA tech perspective 23 p5]. Regional cooperation to achieve economies of scale is critical to an African development strategy. Drawing on observations about stimulating African renewables manufacturing from the Chinese renewables energy industry perspective (Sustainable Energy for All, 2022) and experience value-chain building in

developing countries (SAREM, 2022) priorities for valuechain building include the following.

Provide certainty over market size to meet investment thresholds for establishing manufacturing operations through providing policy certainty on government procurement to increase local (regional) market potential;

- support local manufacturing competitiveness via incentives and export promotion using appropriate instruments including trade and industrial policy instruments;
- develop local content regulations that encourage firms to specialise and increase their value add that will enhance competitiveness to serve continental and international markets;
- enhance production factors through education and skills development, strengthening reliability
- of utilities, especially electricity, and improving the quality of infrastructure (port, road, rail);

- improve local supply chains responsiveness and capacity to supply components and services (lateral linkages);
- increase system readiness to incorporate new capacity through planning and concurrent investment in transmission infrastructure;
- cluster industries along the value-chains in special economic zones;
- create training, skills development and knowledge exchange hubs;
- encourage international firms and their component suppliers to establish local operations and provide incentives for joint ventures or collaboration with local entrepreneurs;
- Support the establishment of renewable energy equipment sector organisations that convene government departments from participating countries, private sector and labour representatives from participating countries to solve problems and build a common development vision for the sector.

6.1.5 Summary identification of opportunities along green mineral value- chains

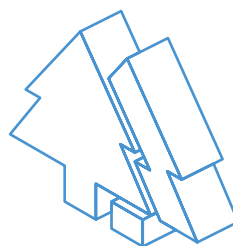


Table 15 Value-chain opportunities and actions required

OPPORTUNITIES	THREATS
Transmission and distribution grids Conductors Transformers Switchgear Pylons	Confirm network extension plans Review existing manufacturing capacity Industry desk of REC to set up a value-chain committee tasked with identifying feedstock availability and setting plans to fill gaps Promote opportunities to investors
Solar panel manufacturing Panel assembly Mounting and tracking structures	Confirm public sector market including concessional funds from climate mitigation finance Promote opportunities to investors including VCF funding
Wind energy equipment Towers Nacelle components (generators, gears, controls)	Confirm public sector market funded by climate mitigation finance Promote opportunities to investors including VCF funding

Table 15 Value-chain opportunities and actions required

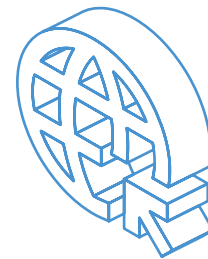
OPPORTUNITIES	THREATS
Hydrogen and fuel cells	Promote PGM use for PEM electrolyzers Support fuel cell applications in public sector, for example busses Set local content for wind and solar equipment to power green hydrogen plants
Batteries Precursor manufacture Assembly Cell manufacture	Facilitate the Zambia-DRC Battery Council SEZ to start precursor production Encourage battery assemblers to scale up for grid BESS opportunities linked to transmission plans
Vanadium Redox Flow Batteries	Develop the market for VRFB BESS in power grids and for RE balancing for hydrogen production
Two and three wheelers	Set minimum standards for battery performance to stimulate market for charging or battery-as-a-service enterprises



Chapter Seven

7 Pillar IV: Mineral stewardship

7.1.1. Economic and Social Contributions of Minerals to Sustainable Development



African Mineral producers face tight markets for the foreseeable future; indeed, they may struggle to keep up with demand. Past mistakes during mineral booms of government overreliance on mineral receipts for revenue and export earnings should be avoided. There are several reasons for optimism: better policy tools for maintaining macroeconomic balances, experience with stabilisation or sovereign wealth funds and, most important of all, more favourable conditions for economic diversification via manufacturing renewable energy equipment as the AGMS is implemented.

More attention is being given to preserving the ecology along with intangible social and cultural assets in the process of resource extraction. The AGMS is an opportunity to raise the profile of mineral stewardship to perform a developmental role in the allocation mineral rents between mineral producers, affected communities and the state. Using mineral rents sustainably involves converting natural capital from non-renewable resources into physical and human capital for sustainable development. Indeed, these principles are embedded in the

shared vision of the AMV which postulates “**A sustainable and well-governed mining sector that effectively garners and deploys resource rents and that is safe, healthy, gender & ethnically inclusive, environmentally friendly, socially responsible and appreciated by surrounding communities.**”

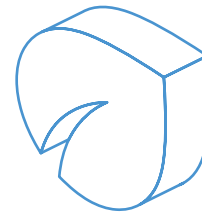
Effective governance of mineral revenues and fostering linkages along value-chains are important channels through which mineral resource extraction is converted into sustainable development. On both counts there are gaps between generally established practices contained in national mining laws compared against principles contained in policy adopted for the minerals industry at the AU level. Progress has been made to increase transparency of revenues and protecting human rights through initiatives such as the Extractive Industries Transparency Initiative, Equator Principles and Kimberley Process, for example. In the context of the higher profile being given to green minerals the timing is right for a review of mining policies, legal and regulatory frameworks among member states.

First, to encourage harmonising national laws to bring them into alignment with the African Mineral Governance Framework, especially the pillars addressing legal and institutional frameworks for contracts and licensing and fiscal regimes and revenue management as regards contracts, transparency and financial flows including illicit financial flows (AMDC, 2017). Existing tools such as the African Legal Support Facility's African Mining Legislation Atlas (AMLA) and its Guiding Template can support the legislative reforms and harmonisation required to ensure alignment with the AMV and AGMS.

Second, making the developmental conditions for building value-chains and simulating linkages mandatory through stipulation in mining licences. Exercising rights through ownership of national mineral assets, generic development conditions should cover the following:

- Mineral value addition requirements as a percentage of value-add above metal/alloy/base state;
- Minimum corporate expenditure on Human Resource Development (5% of payroll) plus Research, Development and Innovation (e.g., 1% of sales);
- Minimum local-regional content for labour, goods and services;
- Developmental pricing for local/regional downstream industries;
- State rights to a reasonable portion of production of strategic feedstocks at equitable prices;
- Contributing to capitalising a fund for development of indigenous mining capital.

7.1.2. Environmental, Social and Governance of Green Minerals



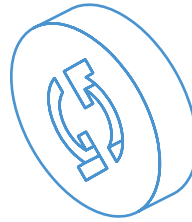
Environmental Social and Governance (ESG including health & safety) standards are a core component of the AGMS to protect Africa's environment and people and to set exemplary standards for good governance and management of environmental and social impacts of mining, mineral processing, manufacturing and recycling or safe disposal at end of life.

A risk based framework for identifying and managing the impacts of projects is documented in the AfDB Integrated Safeguards System (AfDB, 2013) as well as updated climate safeguards decision making tools for screening (and modifying) project to reduce vulnerability (AfDB, n.d.). These provide rigorous readymade tools for Green Mineral project evaluation and guidance for enhancing robustness. As the AGMS is explicitly aiming to accelerate sustainable industrialisation on the continent, which will inevitably have major environmental implications, integrated safeguards ought to be applied from the outset of project development.

Mineral stewardship that gives agency to local communities and affected stakeholders is one that aims to achieve normative agreements between affected stakeholders and mines that can hold parties to the agreement to account for collectively upholding a 'sustainable development licence to operate' (Pedro, et al., 2017). This is an application of holistic governance the AGMS supports.

Scrutiny over battery supply chains as well as their assembly into products should be turned to the advantage of African producers by upholding high ESG standards together with the required verification systems. Monitoring of the EU strategic action plan on battery supply chains (European Commission, 2019, p. 12) should be undertaken to ensure that they do not become non-tariff barriers to the detriment of African exporters. For practical purposes this should be led at a continental level, for example by the AMDC or devolved to the RECs. Civil society organisations may also have a role to play to reinforce transparency from the public and private sector and assist affected communities to have a voice in decisions that affect them.

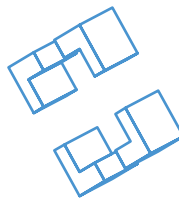
7.1.2. Regional environmental management approaches



Components of mineral stewardship can benefit from a regional approach that pools expertise and creates effective knowledge hubs for spreading best practice. One example from the SADC region illustrates this approach. Starting in 2007, a handbook on environmental assessment legislation SADC region was published by the southern African Institute for Environmental Assessment with backing by the Development Bank of Southern Africa (DBSA). Subsequent

editions have been produced to keep pace changing environmental and social regulations. The fourth edition now covers 26 Sub-Saharan countries includes recent revisions to national regulations that include climate change considerations environmental development goals taking their rightful place alongside (and as an integral part of) commitments to gender, labour, social and cultural heritage matters (Walmsley & Hussleman, 2020).

7.1.3. Aiming for a circular economy



A circular economy is an aspirational goal that embraces a combination of reduce, reuse and recycle activities. No universal definition of circular economy exists, save for agreement on the aim to eliminate the concept of waste, that exists in the current linear economy, and minimise the dependence on virgin materials. Circularity must consider materials, process and product simultaneously. For manufactured goods companies should design in strategies related to circularity that include materials reduction, durability, disassembly, refurbishment, recycling from the start. Material efficiency is also important and one where the mining industry can make a significant impact to reduce water and energy requirements through better metallurgical plant design to recover heat and re-use process water.

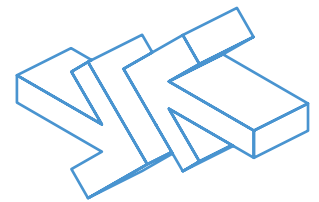
The AGMS can contribute to responsible use of mineral resources by advocating circularity for green minerals and sustainable use of raw materials more broadly. Material recycling is well established for aluminium, copper, and steel scrap, similarly for high value green metals like

cobalt and PGM's. Recycling of battery metals will also become feasible in the medium to future as the stock of lithium-ion batteries that have reached the end of their life grows so recovering valuable metals will become an additional source of feedstocks for battery manufacturing. A recent techno-economic analysis suggested that recycling becomes economical at a feed rate of around 500 tons annually for lithium-ion batteries with high metal values (Gericke, Nyanjowa, & Robertson, 2021). Currently lithium-ion batteries are being exported for recycling in Asia.

The AGMS should encourage the second use of products such as electric vehicle batteries and solar panels. As the stock of renewable energy equipment expands and ages now markets for a wider range of equipment repurposing and recycling will become economically viable. Solar panels that are retired from utility installations after 20 years but still retain about 85% of their original performance are being channelled for second use at low cost is one example of product reuse.

Chapter Eight

8 Risk analysis and risk mitigation



The AGMS has highlighted the opportunities presented by the energy transition for Africa's mineral resources and their potential to give a significant boost to equitable resource-based industrialisation (ERBI), focusing on clean energy equipment. At the same time there are risks associated with the surge in demand for green minerals. These opportunities are unfolding against a backdrop of intense competition from developed countries to rapidly build their own battery, EV and renewable energy industries at scale. These developments are spawning a new form of geopolitics around access to critical minerals in spheres of influence potentially creating cleavages between supply chains that are oriented to the People's Republic of China on the one hand and supply chains to North America and Europe that are seeking to lessen dependency on Asian suppliers. Potential risks and proposed mitigations to be addressed by the strategy include the following:

1. Technological change that disrupts demand for Africa's green minerals and closes the window of opportunity to take advantage of currently favourable conditions for mineral based development.
2. Possible lock-in of long-term offtake agreements: In the struggle for strategic advantage by firms, backed by their governments, to secure access to critical minerals African mineral producers may get locked into long-term offtake agreements. Such contracts can benefit miners by giving them access to low-cost capital for expansion, but the consequences of

such lock-in could reduce the availability of feedstocks for processing and downstream manufacturing or worse still perpetuate the position of Africa as a producer of raw materials and not of valueadded products.

3. China's control in metals refining: China has built up a large refining capacity which relies on imported minerals, therefore its interests are served by continuing to import mineral concentrates to feed domestic refineries rather than seeing them processed where they are mined. Following this reasoning, Chinese owned mining operations on the continent may be disinclined to support initiatives to increase processing and downstream value addition.
4. Foreign Constrained Supply Chains: China and the OECD countries are developing green mining machinery and equipment (such as trackless mining EVs) which they intend to export to Africa. Thus, these countries may not be interested in supporting the development of green African mining supply-chains.
5. Potential of new battery technologies avoiding use of cobalt: cobalt use in lithium-ion batteries and the producer power this confers on the DRC is at risk from switching to low or cobalt free battery chemistries, partly due to the perception of "blood cobalt" from some operations in the DRC, particularly ASM (artisanal and small-scale mining).

6. Lack of exploration capital in Africa: Lithium and class I nickel are the two battery materials that currently face the greatest supply constraints. This could shift attention in the main battery and EV markets towards Latin America, Australia and Indonesia with the result that Africa receives less mineral exploration and green minerals attention.
 7. Rapid technology advancement in battery production: Rapid technological advances in battery production create risks of technological obsolescence for particularly for firms entering the battery manufacturing industry that rely on licensing technology.
 8. The capture of African elites by well-resourced foreign governments and corporations to provide unprocessed minerals (with minimal local content) for their value-chains is an everpresent danger and, unfortunately, commonplace. The EU has gone further by stipulating that 40% of its critical minerals supply must be processed in the EU⁴, to underpin European jobs and industries.
- Strategies to mitigate possible risks include the following.**
1. Motivate for rapid implementation of the AGMS at a continental and regional level to make the most of favourable conditions.
 2. Provision in new mining licences that tie extraction to local processing.
 3. Encouragement of local processing and increased value addition among existing mining operations by improving the environment for beneficiation through supportive policies and measures to improve infrastructure and stimulate off-take industries.
 4. Provisions in mining licences to ensure that mineral feedstocks are available to regional consumers at export parity prices to improve their competitiveness and to ensure the development of the local/regional supply-chain (local-regional content).
 5. Make full use of bilateral and multilateral agreements on critical mineral supply chains to fund and build capacity for Africa's Green Minerals development to ensure that producer countries move up the value-chain.
 6. Review and seek to renegotiate terms of existing Bilateral Investment Treaties that prejudice Member States from pursuing strategies for mineral resource value addition.
 7. Promote the work of the Fair Cobalt Alliance and the Cobalt Action Partnership to document responsible cobalt sourcing, to ameliorate the "blood cobalt" perceptions and uphold accountability instruments to combat use of minerals to fund conflicts and worsen state fragility.
 8. Encourage mineral exploration through effective earth sciences institutions (geological survey, education of earth scientists) and incentives such as tax deductions for exploration expenditures.
 9. Increase financing for clean energy and SDG targets on clean energy and industry, innovation and infrastructure, including capitalising the proposed VCF, through the Liquidity and Sustainability Facility and similar instruments.
 10. Develop competitive strategies as nimble technological followers rather than competing head on at the technological frontier (leading edge rather than bleeding edge). Such strategies are better suited to the African market and where resources for innovation could be directed to product development for local conditions.

⁴ <https://eur-lex.europa.eu/eli/reg/2024/1252/oj/p21>.

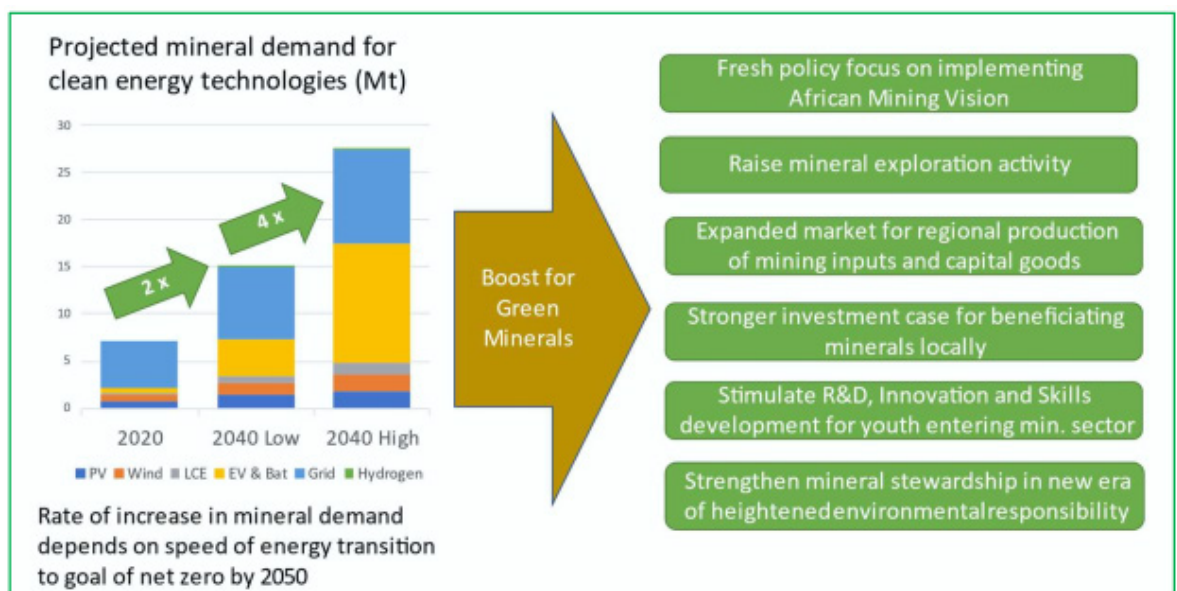
Chapter Nine

9 Conclusions & Recommendations: Towards an African Green Minerals Strategy (AGMS)

The African Green Minerals Strategy is driven by the spectre of global climate change and global warming and our existential need to rapidly and dramatically reduce carbon emissions and other

greenhouse gases, which has caused increased mineral demand for green minerals for the global energy transition.

Figure 43: Green minerals boom opportunities



The strategy is largely based on the continent's comparative advantages in (a) a substantial green minerals endowment and prospectivity

and (b) its huge renewable energy potential, particularly in solar, but also other RE sources, see Figure 43 above.

The AGMS is built on its four pillars of:



I. Minerals Development,



II. People and technology;



III. Building value-chains;

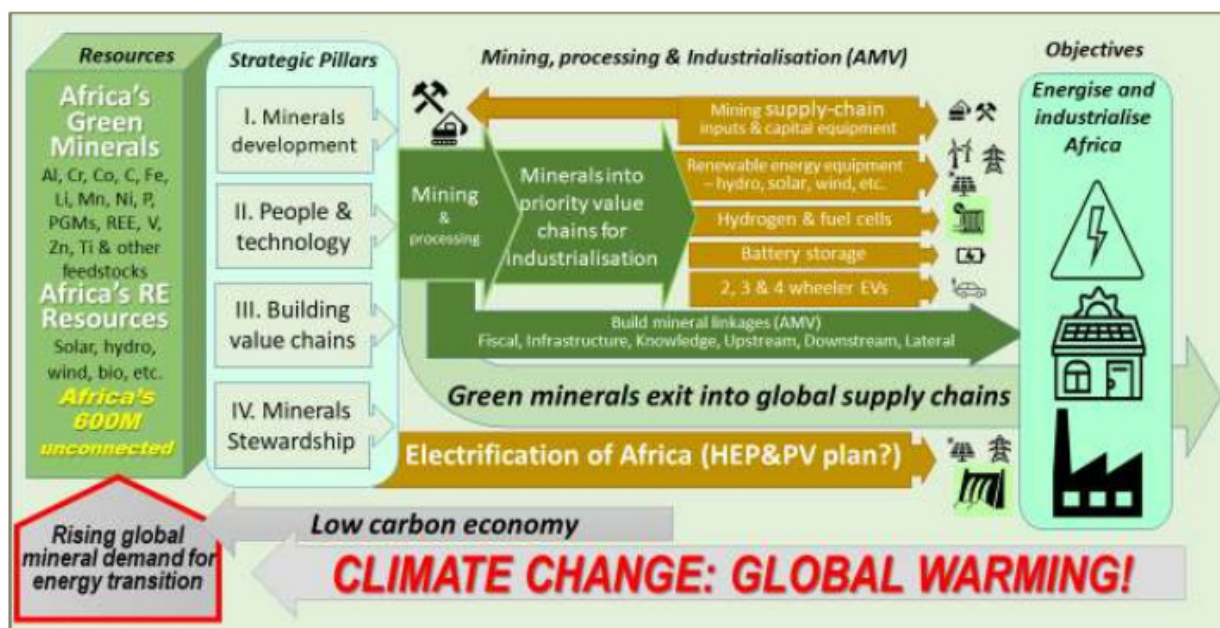


IV. Minerals Stewardship

Figure 44 attempts to distil and capture the strategy in a page (below). The mining and processing of green minerals feeds into our key minerals for priority value-chains for Africa's equitable industrialisation, which gives investment opportunities in: the mining supply chains (capital goods, consumables, services);

- the production of renewable energy machinery, equipment and plant;
- the production of hydrogen fuel (from RE) and fuel cells;
- the manufacture of energy storage systems;
- manufacturing of light electric vehicles (2 & 3 wheelers);
- other solutions for the transition from fossil fuels.

Figure 44: African Green Minerals Strategy on a page



The new investments into the mining and processing of green minerals gives Africa an opportunity to maximise the developmental impacts of extraction, as per the AMV, through the realisation of all the mineral linkages (fiscal, knowledge, spatial, backward, forward, et al) to underpin equitable resourcebased industrialisation (ERBI) and sustainable development.

Africa's huge solar, hydro, wind and bio resources and the substantial decline in the cost of RE sources, have added to the possible realisation of its vision of "energising" the continent by giving every citizen access to affordable electricity, whilst at the same time offering opportunities to industrialise through the local production of the RE systems and products (Figure 43).

However, this opportunity and vision are dramatically constrained by economies of scale (small markets) caused by the incoherent balkanisation of Africa by the European Empires in the nineteenth century, as noted out by numerous African leaders and thinkers. ***"By far the greatest wrong which the departing colonialists inflicted on us, and which we now continue to inflict on ourselves in our present state of disunity, was to leave us divided into economically unviable States which bear no possibility of real development"***. Kwame Nkrumah: African Visionary and Ghana's First Prime Minister.

Nevertheless, there is an increasing realisation, at all levels, across the continent that Africa needs to integrate economically, both at a regional (REC) level and at the continental levels. Some notable recent developments have been the advent of the AfCFTA and the establishment of the Afrexim Bank to facilitate intra-African trade. These two developments support the configuration of a truly continental AGMS based on the continental mineral and RE resources to industrialise based on unfettered access to the continental market. Unconstrained access to the African market by African manufacturers is unfortunately still a vision or objective, due

to lingering tariff barriers and NTBs and high intra-African logistics costs (poor transport infrastructure) which often make imports from developed countries into our ports cheaper than purchasing from other African states. This needs to be tackled through deepening economic integration by moving towards a customs union for Green minerals value-chain (MVC) products, through a common external tariff (CET) for the selected green MVC products. Further integration (CET) on a subset of products (green MVC products) could be a manageable pilot to chart the way for deeper integration across all products leading to an African Customs Union. The choice of a subset of green MVC products for a pilot is based on its greater chance of success due to:

1. Africa's substantial green mineral resources and its prospectivity for further green mineral resources, which has an element of producer power and has led to offshore customers offering unprecedented up and downstream investments (e.g. into battery mineral precursors) requiring scale economies;
2. Africa's huge endowment of RE sources makes for a cost competitive migration from fossil fuels and opens up opportunities for the bulk manufacture of RE equipment, such as PV solar panels, if scale economies can be realised behind a CET. It also opens up opportunities for the production and export of clean fuels such as hydrogen, manufactured from RE sources;
3. Africa's green mineral supply-chains are shared with its overall mineral supply chains which represent a globally significant market for MSC products (see Figure 6 and Figure 8) allowing for economies of scale plants to supply African mines behind a CET, provided that all Member States with significant mining include local content targets in their mining licences that recognise African content (albeit, possibly, discounted);
4. Africa's high proportion of citizens without access to electricity could be cost competitively connected to RE sources using African products manufactured at scale behind a common external tariff;

This AGMS would see the AfCFTA protocols expanded to include a pilot African CET for designated green MVC products. The AGMS Pilot CET would need regular review, assessments, monitoring and evaluation.

African states are at widely varying levels of development impacting profoundly on their ability to benefit from a continental green minerals strategy (AGMS) that realises the huge African market for key mineral inputs, feedstocks and manufactured products, all along the Green MVCs. Consequently, robust instruments need to be developed to manage “variable geometry” and “level the playing field” for weaker economies, less able to reap the benefits of a continental AGMS (based on the AMV), as discussed at a regional (REC) level under Section 3.4.1 on page 15.

Experience with the domestication of the African Mining Vision underscores the importance of adapting strategies for local condition and ensuring that government, the private sector and civil society work together to arrive at policies they are both committed to and capable of implementing. Political commitment is needed change established patterns of raw material extraction into sources of diversified growth but the threat of climate change justifies an instrumental approach from government to make their economies more resilient and diversified.

At a continental level some of the key interventions could be:

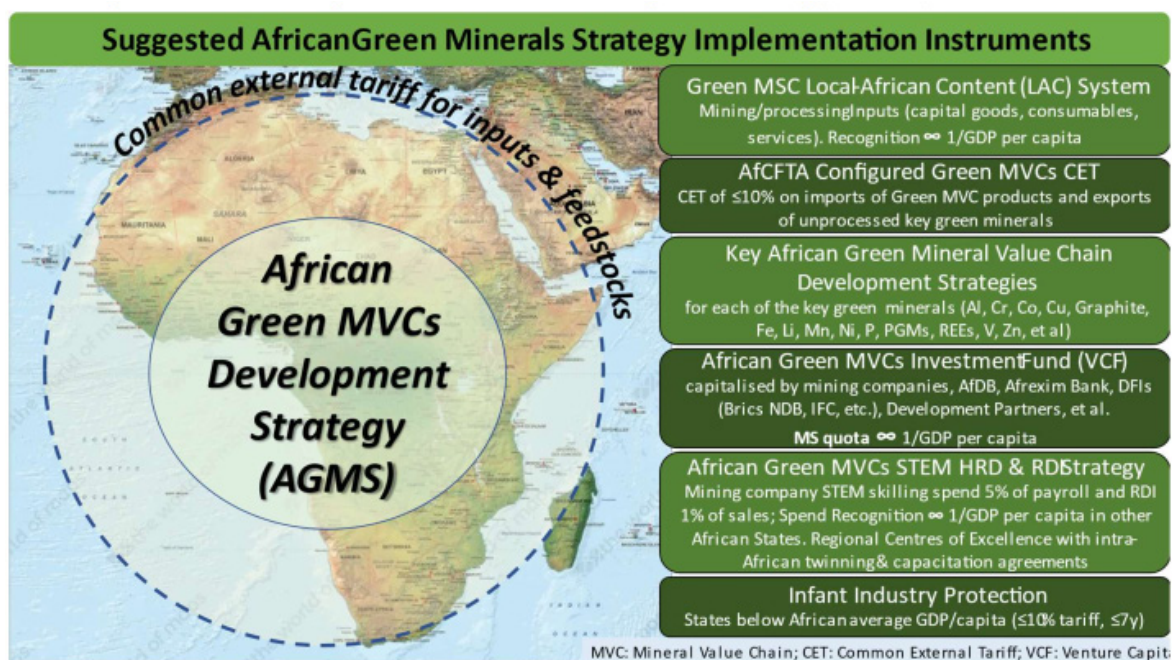
1. **Local-African Content (LAC):** An AU commitment for all major African mining states to introduce local content requirements that recognise Africa-wide content as per the “cumulation” clause in the AfCFTA. Such an MSC Local-African Content (LAC) System for mining & processing inputs (capital goods, consumables, services) could be

configured to recognise legitimate African products (using AfCFTA RoO Protocols) at a discounted rate inversely proportional to GDP/capita (Figure 45). Such a hypothetical system is presented in Appendix I Illustration of African States recognition weights using inverse of GDP/capita. In the example, designated green mineral value-chain products from the Seychelles (highest GDP/capita) would be recognised in any other AU member at 50% of their value, whilst products from Burundi (lowest GDP/cap) would be recognised at 90%, with products from all other Member States recognised pro-rata in-between (Appendix I, page 11).²⁾

2. **African Green MVCs CET:** The negotiation and configuration, under AfCFTA, of a Common External Tariff (CET), for designated Green Mineral Value-chain products, of $\leq 10\%$ on imports of Green MVC products and exports of targeted unprocessed key green minerals (ores, concentrates, metals, salts, etc.). Whilst this instrument may have WTO or other Trade Agreements constraints, given the absolute urgency of migrating to RE sources and Africa's dire need for industrialisation, equitable growth and poverty reduction, a waiver for Africa by WTO members may need to be negotiated by AfCFTA/AU. CET tariffs of $\leq 10\%$ are not distortionary, but could be critical to facilitate investments into the African Green MVCs (Figure 45). instrument may have WTO or other Trade Agreements constraints, given the absolute urgency of migrating to RE sources and Africa's dire need for industrialisation, equitable growth and poverty reduction, a waiver for Africa by WTO members may need to be negotiated by AfCFTA/AU. CET tariffs of $\leq 10\%$ are not distortionary, but could be critical to facilitate investments into the African Green MVCs (Figure 45).



Figure 45: Possible African Green MVCs Development Strategy (AGMS) Interventions



the green minerals (Al, Cr, Co, Cu, Graphite, Fe, Li, Mn, Ni, P, PGMs, REEs, V, Zn, et al), to unpack the detail for their value-chain development, to facilitate a quantum increase in investments all along these MVCs, not just in extraction. The formulation of these strategies by the AUC could be done by the AMDC with the ECA, AfDB, Afrexim Bank and other appropriate partners (Figure 45). 1)

1. Establishing a Green Mineral Value Chain Investment Fund

A priority for Pillar 1 Minerals Development is to overcome access to capital problems African firms face. Access to capital is a binding constraint for African firms seeking to realise the huge and dispersed economic opportunities for growth, employment and Equitable Resource-Based Industrialisation (ERBI) arising from mineral extraction. The cost of capital is so high in many African States that green transition investment opportunities will overwhelmingly be taken up by foreign investors (FDI) with concomitant leakage of the benefits overseas unless measures are taken to provide access to capital for African investors.

Core principles for the design of a Green MVC investment fund could comprise the following:

- I. Linking funding by foreign mining companies to proportional rights to mineral exports. To capitalise the fund, for example foreign

miners would obtain the right to MVC-VCF projects' mineral exports at their share of MVC-VCF financing of the project, as well as their equity share in MVC-VCF financed projects.

- II. Capitalisation of the fund could also come from AfDB, Afrexim Bank, DFIs (Brics NDB, IFC, etc.), Development Partners, Just Energy Transition Investment Funds, et al.
- III. Weight financing eligibility in favour of least developed member countries adjusted for a suitable metric. The measure suggested is the inverse of countries GDP per capita. The weighting method shown in (Appendix I, page 11) suggests a scenario where the Fund would finance 10% to 90% of the project PFS, 10% to 90% of the project debt and 10% to 49% of the project equity, and calculates the putative eligibility of all Member States, based on the inverse of their GDP per capita (Appendix I, page 11). Under this putative scenario, for example, a project in the DRC could receive funding of 89% of the cost of the PFS and, if the PFS indicates viability, financing of up to 48% of equity and up to 89% of debt, see Appendix I page 11.

Detailed design would be needed to ensure the Green Mineral Value Chain Investment Fund would be viable, responsive, risk tolerant and sustainable. The fund could initially be established under the AfDB or the Afrexim Bank.

2. African Green MVCs STEM HRD & RDI Strategy

Member States could consider harmonising their Green Minerals mining license regulations to require all investors to spend a minimum of 5% of payroll on local STEM skilling and 1% of sales on local RDI to uplift skills across the minerals industry. Spend in other Member States could possibly be recognised at the inverse of GDP per capita, similar to Local-African content recognition method shown in Appendix I on page 11, where, for example, corporate HRD or RDI spend could be recognised at 71% in Gabon and 83% in Ghana. Such a system could also recognise corporate spend on select "Regional Green Centres of Excellence" (skilling and RDI) that have intra-African twinning and capacitation agreements with weaker institutions in place (Figure 45). Enhancing data management and analysis skills will improve the quality of statistical data to inform decisions making and contribute towards transparency in the minerals sector.

2. Infant Industry Protection

New Green MVC investment projects in developing Member States suffer from debt financing costs as well as workforce training costs that are not incurred by established plants in more developed African States. Consequently, within the AfCFTA, consideration could be given to permitting Member States, below the African average GDP/capita, impose infant industry import tariffs of up to 10% for a maximum of 7 years (to cover capex financing costs), for example, until they become mature and competitive. Figure 45 depicts the implementation instruments involved.

Although the configuration and adoption of these instruments may seem overly ambitious, the current opportunity to develop the African Green MVCs at scale, may be missed if all Member States do not see any benefits, particularly the developing Member States. However, a subset of Member States could initially establish such a system that could then be expanded, once non-participating Member State see the benefits of economies of scale through reciprocal access and support to developing Member States.

Ideally the above suggested interventions should also privilege local capital (investors) all along the Green MVCs to build African businesses and to ensure maximum African retention of the benefits. As mentioned local capital is much more likely to develop the mineral linkages than foreign capital (FDI) (African Union, 2009).

Recommendations made in the AGMS on mineral development, skilling people and enhancing technological capabilities as well as proper stewardship to protect people and the environment cover familiar ground because making the most out of mineral development needs resolute effort. What is new are the opportunities flowing from the energy transition that foresees energising and industrialising Africa at a big picture level and that the AGMS endeavours to identify and concretise into projects.

Scaling up existing activities in the green minerals space and turning potential projects into reality will require the involvement of governments, investors and numerous stakeholders. Key among them will be the role that Development Finance Institutions are uniquely equipped to play. Here DFI can assist Member State to refine regulatory frameworks for their green minerals, create the essential soft infrastructure of skills and knowledge for government officials and industry counterparts needed to implement green mineral initiatives effectively. Above all DFIs are needed to prepare investment projects for funding through feasibility studies, de-risking interventions and mobilising suitable funding instruments to bring them to market.

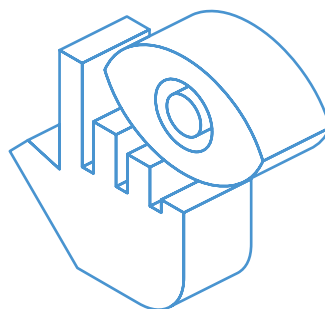
Finally, the AGMS needs to be attuned to the numerous developments unfolding in Member States, from infrastructure development to nurturing emerging manufacturers along Green MVCs because the Green Minerals space is broad, dynamic and developing rapidly. Actions in this space at Member State level could potentially be made more impactful with information sharing and coordination between Member States through the indispensable role of Regional Economic Communities.

Chapter Ten

10 Action Plan

Vision

mineral value-chains for equitable industrialisation and electrification, creating green technologies and sustainable development to enhance the quality of life of its people.



Defined outcomes of the AGMS:

The continent's mineral resources harnessed to build an industrial base (RBI).

- Meeting a growing share of demand for battery storage, e-mobility and renewable energy equipment from production on the continent.
- Increasing the quantum, range, quality and technological content of products and services in the green mineral supply chains by increasing content (value added) sourced from Africa.
- A growing number of internationally competitive green industry companies

based in Africa using intellectual property and skills sourced from continental institutions.

- Effective stewardship of green mineral resources that protects people and the planet.
- Ongoing fulfilment of the goals of the African Mining Vision.
- Universal access to modern energy services for households, business and social services.

Table 15 Value-chain opportunities and actions required

Pillar	Action Plan	Short term 1-2 years	Medium term 3-5 years	Responsibility (MS: Member State)
I Adopt African Green Minerals Strategy				
	Submit draft strategy to AUC for adoption by Heads of State	Submit draft AGMS to Council of Ministers Revise strategy, as necessary Submit to Heads of State for adoption		AMDC- ETTIM MSs (inputs)
II Advancing mineral development				
A	Convert the AGMS Action Plan into a REC Action Plan adapted for regional resources and comparative advantages. Integrate plan into programmes for mining, industry & trade, energy, education & science, and environment.	Appoint a regional AGMS Champion within 6 months of strategy adoption	Compile annual progress report of task team work.	AMDC- ETTIM RECs Development Partners (resourcing RECs) REC MSs
B	Foster integrated and shared green mineral development approaches between Ministries of Mines and Ministries of Industry at policy and technical levels by forming joint value-chain development committees / industrial policy task teams.	Within 9 months of adoption convene value-chain task teams under chairpersonship of AGMS Champion to address strategy implementation challenges and communicate same to Ministerial forums for solutions	Annual reporting to align with Monitoring & Evaluation of AGMS at AUC level	AMDC- ETTIM RECs: AGMS Champion MSs: Ministries of Mines and Ministries of Industry
C	Set targets for improving the capability of national Geological Surveys to conduct systematic surveys for green minerals. Include technical assistance programmes for African earth sciences in partnership agreements for critical minerals	Build intra-African support systems between the Geological Surveys at a REC and continental level.	Double funding for mapping from 2022 base line budgets by 2028	AMDC (high level) RECs MSs (double funding)
D	Maintain activism for wealthy countries to honour financial commitments to assist member states to implement their nationally determined contributions that include, inter alia, increasing infrastructure (logistics) resilience.	Include logistics in scope of African Group of Negotiators on Climate Change	>20% decline in intra-Africa logistics costs. Member states aim for national Logistics Performance Index score improvement of 2% per year	AU (AMDC-ETTİM) UNFCCC RECs (regional logistics) MSs: Ministries responsible for logistics (transport, customs, border control, etc.)
E	Reverse the decline in African exploration expenditure to build reserves of green minerals, particularly by African mining companies. Take advantage of bilateral and multilateral partnerships on crucial minerals	Offer incentives to (e.g. accelerated depreciation) to increase exploration	Increase Africa's share of global exploration spend from <10% to >15% by 2030	AMDC (high level) MSs Ministries of Mines and of Finance

Table 15 Value-chain opportunities and actions required

Pillar	Action Plan	Short term 1-2 years	Medium term 3-5 years	Responsibility (MS: Member State)
II Developing people and technological capability				
A	Move to harmonising Green Minerals mining license regulations among member states to require all investors to spend a minimum of 5% of payroll on local STEM skilling and 1% of sales on local RDI to resource training institutions and generated high levels skills for mining and manufacturing and data management	Secure agreement among REC member states on regulatory harmonisation. Encourage member states to adopt uniform legal terms and regulations	Complete national legislation harmonisation by 2027	AMDC (high level) RECs (regional level) MSs Ministries of Mines, of Skilling (education) and of Technology (RDI)
B	Ensure that skills training is kept relevant to building Africa's mineral value-chains	Establish training advisory boards with mining and manufacturing industry representation	Periodic (3y) audit of skills balance in Africa's mineral value-chains	AMDC (high level) MSs Ministries of Mines and of Industry, Mining and Manufacturing Industrial Associations
C	Scale up the DRC Centre of Excellence for Batteries (CAEB) to encompass more African institutions Double the enrolment for post-graduate degrees in electro-chemistry and associated fields at African universities for battery technology expertise	Encourage research institutions with complimentary capabilities across Africa to collaborate with CEAB. Encourage regional clustering of research effort to form the nucleus of a regional Centre of Excellence where there is sufficient scale to be viable	Minimum of one new Centre of Excellence for green technologies per REC by 2027 (shared target with II D)	AMDC (high level) RECs (regional centres) MSs, DRC, Zambia, et al MSs: Ministries of Mines, of Industry, of Skilling (education) and of Technology (RDI) Development Partners
D	Create research and innovation capacity in applied technologies to exploit the continent's vast comparative advantage in renewable energy, guided by resource advantages. i.e. East Africa: geothermal; Central Africa: hydropower; Southern Africa: wind; West and North Africa: solar Twin new COEs with centres in the main customers for Africa's clean minerals	Enlist support from the ALSF and national technology agencies to protect and optimise use of intellectual property developed by African researchers and institutions. 5 Private sector endowed renewable energy research chairs in each REC by 2025	Minimum of one new Centre of Excellence for green technologies per REC by 2027	AMDC (overall) AfDB-ALSF RECs MSs: Ministries of Mines, of Industry, of Skilling (education) and of Technology (RDI) Private sector (MVC firms) Development Partners
III Building key value-chains				
A	Secure AU support for mechanisms to address 'variable geometry' or equitable solutions to overcome uneven development that are biased in favour of least developed member states. This least developed bias applies to 1) weighting for local/regional/African content recognition; 2) eligibility for project funding for PFS, debt and minority equity. The method proposed is a weighting system inversely proportional to GDP/capita.	Consult member states to refine the weighting system and secure sufficient consensus to use a least developed bias system for reciprocal local-regional content recognition and investment project funding by 2025. (Possible AfDB or AMDC project)	By 2026 include a least developed bias system in instruments to build local-regional content and regional/continental value-chains as a key AGMS implementation instrument	AMDC (& AfDB) RECs MSs: Ministries of Mines and of Industry, Mining and Manufacturing Industry Associations

Table 15 Value-chain opportunities and actions required

Pillar	Action Plan	Short term 1-2 years	Medium term 3-5 years	Responsibility (MS: Member State)
II Developing people and technological capability				
B	Reform national local content regulations attached to mining licences to recognise Africa-wide content using the “cumulation” clause applied to AfCFTA rules of origin.	n parallel with III A, encourage member states to adopt uniform regulations on recognition of Africa-wide mining local content by 2026	All major mining states adopt harmonised content recognition regulations by 2027	AMDC (high level) RECs (regional level) MSs Ministries of Mines, of Skilling (education) and of Technology (RDI)
C	Formulate an investment and upgrade plan for each key Green Mineral Value-chain per commodity and related linkages for Al, Cr, Co, Cu, Graphite, Fe, Li, Mn, Ni, P, PGMs, REEs, V, Zn and others	High level coordination by the AUC, AMDC, AfDB, AfCFTA, Afrexim Bank and financial partners working with industrial policy counterparts at national and regional levels as per I B and others	Set time limits to end export of unprocessed ores matched to time frames to build processing capacity	AMDC & AfDB AfCFTA & Afrexim Bank RECs MSs: Ministries of Mines and of Industry, Mining and Manufacturing Industry Associations Development Partners
Ci	Sequence MVC upgrade plans to start with securing clean energy source for smelters, refineries and fabricators	Coordinate MVC upgrade plans with other industrial development instruments and policies such as building plants in Special Economic Zones	Encourage private sector power projects for MVC development that can be implemented rapidly while large scale multi-country projects (e.g. Inga 3) with long lead times are developed	AMDC & AfDB RECs MSs: Ministries of Mines and of Industry, Mining and Manufacturing Industry Associations Development Partners
Cii	Enhance inter-sectoral linkages	Stimulate clustering via industrial policy instruments		AMDC & AfDB MSs: Ministries of Mines and of Industry, Manufacturing Industry Associations, Development Partners
D	Create value-chain forums for: i. Transmission and distribution grids ii. Solar panel manufacturing iii. Wind energy equipment iv. Hydro-power equipment v. Hydrogen and fuel cells vi. Batteries vii. BESS (VRFB and others) viii. EVs (2,3 & 4 wheelers)	Coordinate at REC level linked to I B, II B, and III C Define increasing component manufacturing targets over time from OEM, sub-assembly and component suppliers (Tiers 1, 2 & 3)	Raise African content targets by 10% at three year intervals to 70% by 2036	AMDC (ETIM) AfDB, AfCFTA, Afrexim Bank RECs MSs: Ministries of Mines and of Industry, Manufacturing Industry Associations
Di	Initiate industrial development for high potential sectors	Conduct feasibility studies for NMC precursors LFP batteries Solar PV panels Electric motorcycles	Bring screened projects to market	AMDC AfDB, Afrexim Bank, DFIs MSs: Ministries of Mines and of Industry, Manufacturing Industry Associations Development Partners
E	Protect manufacturers of green mineral value-chain products and incentivise mineral producers to process green minerals before export by imposing a Common External Tariff up to 10% on imports of products and exports of unprocessed green minerals.	Launch negotiations under the AfCFTA for a CET, with support from AfDB and Afrexim Bank closely monitoring valuechain performance	Implement African CETs (under AfCFTA) for clean mineral value-chain products locally-regionally manufactured	ETIM, AMDC AfCFTA (with support from AfDB and Afrexim Bank) MSs: Ministries of Industry and of Finance

Table 15 Value-chain opportunities and actions required

Pillar	Action Plan	Short term 1-2 years	Medium term 3-5 years	Responsibility (MS: Member State)
II Developing people and technological capability				
F	To overcome the high cost of capital hurdle local investors face set up a African Green MVCs Investment Fund (VCF), capitalised by the mining companies, AfDB, Afrexim Bank, DFIs (Brics NDB, IFC, etc.), Development Partners, Just Energy Transition Investment Funds, et al.	Incorporate III A, above	Fund operational with possible support from mining companies, AfDB, NDB (BRICS) and other multi-lateral DFIs	AMDC – ETTIM AfDB, Afrexim Bank International DFIs MSs: Ministries of Mines, of Industry and of Finance Mining Industry Associations Development Partners
G	Establish a mechanism for infant industry protection restricted to member states below a threshold, for example less than the African average GDP/capita	Secure agreement to cap protection tariff rates and term at up to 10% for up to 7 years	Adhere to strict phase out terms to drive productivity improvements	AMDC AfCFTA, AfDB, Afrexim Bank MSs: Ministries of Industry and of Finance. Manufacturing Industry Associations
H	Take full advantage of international partnerships on critical minerals supply chains to expand processing and manufacturing	Proactively engage with partner countries to deepen the scope for supporting AGMS objectives	Channel partnership resources into upgrading value-chains as per III C	AMDC AfDB, RECs MSs: Ministries of Mines and of Industry. Manufacturing Industry Associations Development Partners (CRM consumers)
IV Mineral stewardship				
A	Publicise development obligations (including local content) of mining companies to increase transparency, accountability and societal awareness of state and mining sector actions to build value-chains	Encourage mines to publicise their legal reports and national EITI disclosures, if applicable, annually	Recommend Ministry of Mines produce a summary "Mineral Wealth Report to Citizens" annually	AMDC (AMGF) RECs, African CSOs MSs: Ministries of Mines and of Industry, local CSOs
B	Promote Strategic Environmental and Social Impact Assessments in respect of green minerals.	Add to the agenda of REC forums	Establish an Africa-wide reporting system by 2025	AMDC RECs, Environment NGOs MSs: Ministries of Mines
C	Configure green energy minerals assurance (verification) systems for battery supply chains	Engage importers, particularly the EU to pass the cost of assurance systems onto importers	Assurance systems in place and operational by 2025	AMDC AfDB, Afrexim Bank MSs: Ministries of Mines and of Industry Manufacturing Industry Asso'ns Development Partners (EU)
D	Use knowledge management tools to circulate environmental management good practice information among member states	Add to the agenda of REC forums	Establish an Africa-wide reporting system by 2025	AMDC RECs (forums) MSs: Ministries of Mines and of Environment Enviro NGOs (CSOs)

Table 15 Value-chain opportunities and actions required

Pillar	Action Plan	Short term 1-2 years	Medium term 3-5 years	Responsibility (MS: Member State)
D	Use knowledge management tools to circulate green minerals circularity good practice information among member states	Add to the agenda of REC forums and monitor the volume of material to reach viable recycling levels. Noting lithiumion batteries have a 5-8 year life, solar PV > 20 year life	Ensure regulations for trade in end-of-life / scrap products facilitates collection to establish recycling facilities on a regional basis	AMDC RECs (forums) MSs: Ministries of Mines, of Industry and Environment. Manufacturing Industry Asso'ns Development Partners
Strategy review, monitoring, and evaluation (M&E)				
A	Review scope of green minerals selection in consultation with Council of Ministers responsible for Industry to respond changes in technology, market conditions or other factors	Propose AMDC and Partners conduct review every 2 years. Secure funding for AMDC function	Implement ongoing biannual review of "green minerals" to be included	ETTIM – AMDC MSs: Ministries of Mines and of Industry Manufacturing Industry Associations Development Partners
B	AU to develop TOR for AGMS progress review (I to IV, above)	Build AGMS M&E capacity in AU with support from AfDB and Member States	Ongoing M&E of AGMS by AUC (DTI) supported by AfDB, Member States and Development Partners	ETTIM (AMDC - AMGF) AfDB MSs: Ministries of Mines and of Industry. Mining and Manufacturing Industry Associations Development Partners & CSOs

Chapter Eleven

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Chapter
Twelve

12 Appendices

12.1 Appendix I Illustration of
African States recognition
weights using inverse of
GDP/capita

Member State	GDP/cap 2021 (PPP \$)	Regional Local Content	Venture Capital Fund	
			Debt and PFS 10-90%	Equity 10-49%
		50-90%		
Algeria	12128	75%	61%	35%
Angola	6491	83%	75%	42%
Benin	3649	86%	83%	45%
Botswana	16304	80%	79%	46%
Burkina Faso	2395	88%	86%	47%
Burundi	775	89%	90%	49%
Cabo Verde	6717	80%	75%	41%
Cameroon	4065	86%	81%	45%
Central African	920	89%	88%	49%
Chad	1566	89%	88%	48%
Comoros	3547	86%	83%	45%
Congo Dem. Rep.	1179	89%	83%	48%
Congo Rep.	3553	86%	83%	45%
Côte d'Ivoire	5850	88%	83%	43%
Djibouti	5398	84%	78%	42%
Egypt	12706	75%	59%	34%
Equatorial Guinea	16080	70%	50%	30%
Eritrea				
Eswatini	9730	78%	67%	38%
Ethiopia	2548	86%	85%	47%

Member State	GDP/cap 2021 (PPP \$)	Regional Local Content	Venture Capital Fund	
			Debt and PFS 10-90%	Equity 10-49%
		50-90%		
Gabon	15176	71%	85%	41%
Gambia	2281	88%	86%	47%
Ghana	5971	83%	77%	42%
Guinea	2901	89%	87%	46%
Guinea-Bissau	2012	86%	87%	47%
Kenya	5211	84%	78%	42%
Lesotho	2522	89%	87%	47%
Liberia	1564	89%	88%	48%
Libya	24131	60%	50%	30%
Madagascar	1608	89%	88%	49%
Malawi	1638	89%	88%	48%
Mali	2330	87%	85%	46%
Mauritania	5831	83%	79%	42%
Mauritius	23035	72%	50%	29%
Morocco	8853	80%	69%	39%
Mozambique	1348	89%	89%	48%
Namibia	10039	78%	66%	37%
Niger	1348	89%	89%	48%
Nigeria	5408	85%	79%	42%
Rwanda	2460	89%	86%	47%
Sao Tome and Principe	4452 3840	85% 86%	80% 86%	44% 47%
Senegal	31596	50%	40%	20%
Seychelles	1744	89%	89%	48%
Sierra Leone	1249	89%	89%	48%
Somalia	14624	72%	60%	30%
South Africa	4066	86%	81%	45%
South Sudan				
Sudan	4066	86%	81%	45%
Tanzania	2836	87%	85%	46%
Togo	2334	82%	86%	47%
Tunisia	11282	76%	63%	36%
Uganda	2468	88%	86%	47%
Zambia	3556	86%	83%	45%
Zimbabwe	2324	88%	86%	47%

GDP per capita from (World Bank, 2023)

12.2 Appendix II Shares of top 3 produces and reserve holders of critical minerals for 2019

Metal	Production	Resources
Chromium	South Africa (41.1%) , Türkiye (18.7%) , Kazakhstan (15.1%)	Kazakhstan (41.1%) , South Africa (35.7%) , India (17.9%)
Cobalt	Democratic Republic of the Congo (68.7%), Russia (4.3%), Australia (3.9%)	Democratic Republic of the Congo (49.3%), Australia (17.4%), Cuba (7.2%)
Copper	Chile (28.1%), Peru (11.9%), China (8.2%)	Chile (20.5%), Australia (10.6%), Peru (10%)
Gold	China (11.2%), Australia (9.6%), Russia (9%)	Australia (18.1%), Russia (9.8%), United States (5.6%)
Natural graphite	China (61.7%), Brazil (8.5%), India (2.8%)	Türkiye (30%), China (24.3%), Brazil (24%)
Lead	China (41.6%), Australia (10.4%), United States (5.5%)	Australia (28.9%), China (21.7%), Peru (7.2%)
Lithium	Australia (81.4%), Chile (5.8%), China (2.9%)	Chile (57.1%), Australia (19.3%), Argentina (14.3%)
Magnesium	China (86.6%), Russia (6%), Israel (1.9%)	Democratic People's Republic of Korea (27.1%), Russia (27.1%), China (11.8%)
Manganese	South Africa (28.2%), China (15.8%), Australia (12.5%)	South Africa (32.1%), Brazil (13.6%), Australia (12.3%)
Molybdenum	China (41.5%), Chile (19.8%), United States (15.7%)	China (48.8%), United States (15.9%), Peru (14.1%)
Nickel	Indonesia (31.6%), Philippines (12%), Russia (8.3%)	Indonesia (23.6%), Australia (21.3%), Brazil (12.4%)
Other non-ferrous minor metals: germanium, vanadium, gallium, hafnium, indium, niobium, rhenium	China (54.1%), Korea (19.8%), Japan (6.1%)	Chile (54.2%), United States (16.7%), Russia (12.9%)
Phosphates	China (41.7%), Morocco (15.7%), United States (10.4%)	Morocco (71.4%), China (4.6%), Egypt (1.9%)
Pig iron	China (63.2%), Brazil (2%), Australia (0.3%)	Australia (28.2%), Brazil (18.8%), Russia (14.7%)
Rare-earth elements	China (60%), United States (12.7%), Myanmar (11.4%)	China (36.7%), Brazil (18.3%), Viet Nam (18.3%)

	Production	Resources
Selenium	China (36.2%) , Japan (23.3%) , Russia (10.9%)	China (26.3%) , Russia (20.2%) ,
Silver	Mexico (26.3%) , Peru (13.5%) , China (12.1%)	European Union (19.6%) , Peru (19.6%) , Australia (15.9%)
Tin	China (27.8%) , Indonesia (25.1%) , Myanmar (16.2%)	China (23.4%) , Indonesia (17%) , Australia (7.9%)
Titanium	China (43.9%) , Australia (13.1%) , Mozambique (9.3%)	Australia (28.4%) , China (26.1%) , India (9.7%)
Tin	China (32.9%) , Peru (11%) , Australia (10.4%)	Australia (27.8%) , China (19.1%) , Mexico (8.7%)

Source: (Kowalski & Legendre, 2023) Note: The calculated shares are based on gross weight of production. OECD calculations based on the United States Geological Survey data.

12.3 Appendix III Rise in demand for minerals arising from the energy transition

Driven by the outsized contribution that energy production makes to climate change, a central focus for climate safety is given to the energy sector and the transition from fossil fuels (coal, oil, and gas) to zero-carbon energy sources such as wind, solar, geothermal, hydro, ocean, biomass and nuclear, or fossil fuels with carbon capture and storage. Downstream energy use for transport and industry needs to be sourced from zero-carbon sources, preferably by directly electrifying them, for example by switching to battery electric vehicles or by using zero-carbon power to synthesise green fuels in the form of hydrogen or green ammonia which can provide mobile energy without releasing CO₂ into the atmosphere.

For the minerals industry climate change is encouraging mining companies to reduce their carbon footprint, however, the energy transition is altering which minerals are in greatest demand. An energy system powered by zero-carbon technologies differs profoundly

from one fuelled by traditional hydrocarbon resources. Building solar photovoltaic (PV) plants, wind farms and electric vehicles (EVs) generally requires more of the minerals linked to the energy transition than needed by their fossil fuelbased counterparts. The minerals critical to the energy transition are copper, lithium, nickel, manganese, cobalt, graphite, chromium, molybdenum, zinc, silicon, PGMs and rare earth elements. A typical electric car requires six times more of such mineral inputs than a conventional car by weight, and an onshore wind plant requires nine times more these critical minerals in kg per MW than a gas-fired power plant. Since 2010, the average amount of these minerals that are needed for a new unit of power generation capacity has increased by 50% as the share of renewables has risen according to the (IEA, May 2021, p. 5). Steel and aluminium are ubiquitous metals used throughout both traditional and energy transition industries.

Global production of critical raw materials has been gathering pace over the past decade. Production rose on average by **30%** in the period 2012-19 (22% if the period 2012-20 with the effects of the COVID-19 pandemic). Physical output of lithium, rare earth elements, chromium, arsenic, cobalt, titanium, selenium and magnesium grew faster than average demand for other minerals (Kowalski & Legendre, 2023).

The energy transition and development of green industries is giving rise to new industries and the scaling up of their demand for these minerals/metals by significant multiples. This is epitomised by the wider use of lithium-ion batteries which have migrated from consumer electronics to power electric vehicles which now makes up the largest market by value for such batteries. Owing to the tight coupling of battery manufacturing and electric car assembly these value-chains are intimately linked with final battery production usually close to vehicle assembly, even though the battery value-chain is global, and the bulk of the intermediate inputs are manufactured in Asia.

Manufacturing lithium-ion batteries will materially increase the demand for metals destined for energy storage, particularly copper, aluminium, phosphorus, iron, manganese, graphite, nickel, cobalt, and lithium. By 2030 batteries are forecast to require an average of 5.5 times more of these metals than consumed in 2021 (BloombergNEF, June 30, 2021).

Utility scale energy storage is also a growing application for lithium-ion batteries as they are gradually falling in cost to become viable for coupling with variable renewable energy (VRE) generation to ensure dispatchable electricity supply. Other battery energy storage technologies are in development, such as vanadium redox flow batteries (VRFB), zinc-air and sodium-ion, thus it is expected that a range of battery technologies will develop in future to compliment other forms of energy storage such as pumped-hydro, compressed air or gravity systems.

Estimates of demand for minerals used in the

energy transition made by the IEA, build on earlier work by the (World Bank, 2020). These estimates aggregate mineral demand from a wide range of clean energy technologies – low-carbon power generation (renewables and nuclear), electricity networks, electric vehicles, battery storage and hydrogen (electrolysers and fuel cells). Demand is derived from two main IEA scenarios: the Stated Policies Scenario (STEPS) and the Sustainable Development Scenario (SDS). Results have been adjusted to account for mineral intensity improvements. The following minerals are included in these aggregate estimates: chromium, copper, major battery metals (lithium, nickel, cobalt, manganese, and graphite), molybdenum, platinum group metals, zinc, REEs and others. Steel and aluminium, necessary inputs for all of the above technologies, have been excluded from these forecasts.

Total mineral demand from clean energy technologies by 2040 is set to double in the, more conservative, STEPS scenario and quadruple in the SDS scenario. According to the IEA, EVs and battery storage account for about half of the mineral demand growth from clean energy technologies over the next two decades, spurred by surging demand for battery materials. Mineral demand for use in EVs and battery storage grows nearly tenfold in the STEPS and around 30 times in the SDS over the period to 2040. By weight, mineral demand in 2040 is dominated by copper, graphite and nickel. Lithium sees the fastest growth rate, with demand growing by over 40 times in the SDS. The shift towards lower cobalt chemistries for batteries helps to limit growth in cobalt, displaced by growth in nickel.

For Africa, with particularly acute deficiencies in electricity transmission networks, it is important to note that electricity networks are another major driving force globally for copper (plus aluminium and steel). Electricity networks account for 70% of today's mineral demand from the energy technologies, but their contribution shrinks as EV and storage markets ramp up.

Mineral demand from low-carbon power generation grows rapidly, doubling in the STEPS and nearly tripling in the SDS over the period to 2040. Wind power plays a leading role in driving demand growth due to a combination of large-scale capacity additions and higher mineral intensity (especially with growing contributions from mineral intensive offshore wind). Solar PV follows closely, with its unmatched scale of capacity additions among the low-carbon power generation technologies. Growing interest in the hydrogen economy required to meet the SDS scenario underpins major growth in demand for nickel and zirconium for use in electrolyzers, and for copper and platinum group metals (PGMs) for use in fuel cell electric vehicles (FCEVs). Demand for REEs – primarily for EV motors and wind turbines – grows threefold in the STEPS and around sevenfold in the SDS by 2040. Hydropower, biomass and nuclear (Africa's second nuclear plant is planned for Egypt) make only minor contributions to clean energy minerals demand given their comparatively low requirements.

It is important to note that attention given to minerals in demand for the energy transition should not obscure their importance in traditional steel alloys, industrial and chemical markets. Furthermore, the contribution African producers supplying world markets make to foreign exchange earnings remains an important role in their national economies. Clean energy technologies become the fastest growing segment of demand for only certain minerals, and their share of total demand edges up to over 40% for copper and REEs, and the tipping point is when the energy transition is the main demand will be reached in the SDS at 60-70% for nickel and cobalt and almost 90% for lithium by 2040. A key implication for the AGMS said there is inevitably uncertainty about both the pace of clean technology deployment and the mix of materials they use, depending on the which technologies become dominant.

The demand for battery minerals is driving evolution in the global electric vehicle industry. This rapidly developing sector is dramatically disrupting a century old manufacturing industry built on internal combustion engine (ICE) technology. Investments, technology development, automobile and battery manufacturing company strategies, government

policies and EV supply chains centred in China, Europe and North America are having far-reaching impacts on Africa's mineral industry now and, over the longer term, it's automobile sector and electricity generation.

Electric car markets have grown exponentially. Sales exceeded 10 million in 2022 and are forecast to reach 14 million in 2023. China leads with 60% of EV sales, Europe 20% and US 8% India Thailand and Indonesia with the leading emerging EV markets. In Africa sales of SUVs were eight times more than small EV models leading to the observation: "The future of mass-market electrification in EMDEs relies on the development of smaller, more affordable electric cars, alongside two- and three-wheelers" (IEA, 2023b, p. 32).

China made up nearly 85% electric two-wheeler sales. India leads in sales of three wheelers (425 000 units in 2022) supported by supply-side incentives to reduce higher upfront costs plus demand incentives and innovative business models such as battery as a service and battery swapping. Rwandan electric motorbike company Ampersand uses a battery swapping model which it plans to scale up to shift East Africa's fleet of 5 million taxi bikes to electric mobility. Industrial opportunities are discussed in section 6.1.4.6.

Automotive lithium-ion battery demand increased by about 65% to 550 GWh in 2022, from about 330 GWh in 2021, 90% for EVs. In 2022, about 60% of lithium, 30% of cobalt and 10% of nickel demand was for EV batteries, while in 2017, these shares were around 15%, 10% and 2%, respectively (IEA, 2023b).

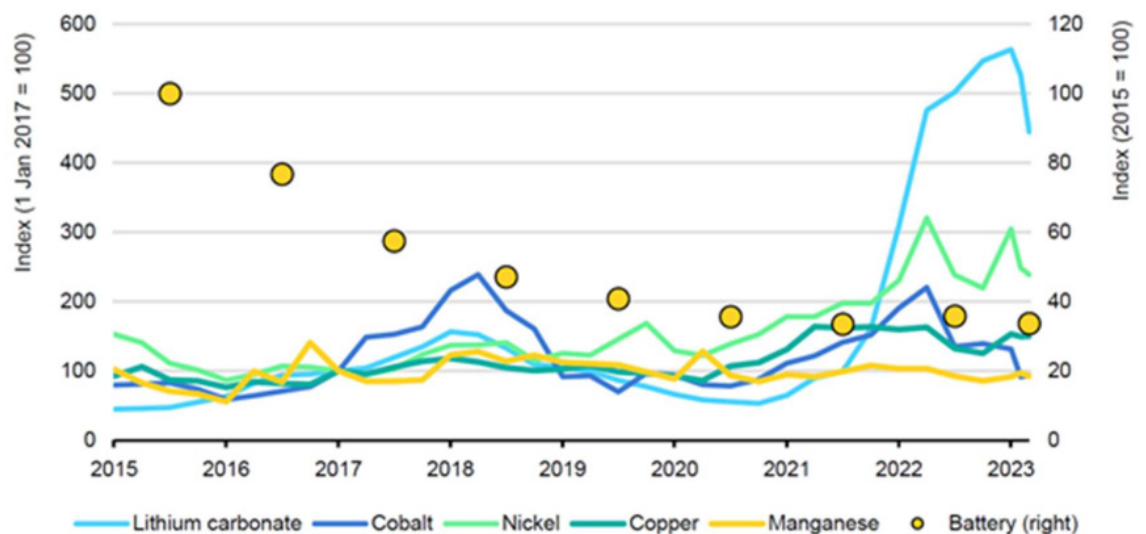
Lithium nickel manganese cobalt oxide (NMC) remained the dominant battery chemistry with a market share of 60%, followed by lithium iron phosphate (LFP) with a share of just under 30%, and nickel cobalt aluminium oxide (NCA) with a share of about 8% in 2022. LFP, which uses iron and phosphorus rather than the nickel, manganese and cobalt found in NCA and NMC batteries is expected to keep expanding its market share, especially in China owing to its lower cost although at the expense of the energy density of the nickel and cobalt rich NCA and NMC batteries. Greater use of silicon in anodes is occurring to both lighten and increase energy density of batteries.

Sodium-ion chemistry is a candidate under intense focus in China and elsewhere although it has a lower energy density. CATL is testing hybrid lithium-sodium batteries (Bradsher, 2023). Nearly 30 Na-ion battery manufacturing plants currently operating, planned or under construction, for a combined capacity of over 100 GWh, almost all in China. For comparison, the current manufacturing capacity of Li-ion batteries is around 1 500 GWh (IEA, 2023b, p. 59). As battery technology develops it is likely that alternatives to lithium-ion will evolve alongside established chemistries to fill particular use-cases where they have superior characteristics or cost advantages.

Finally, commodity price changes will of course influence upstream mineral exploration and development investment decisions as well

as downstream application markets. More significant for the energy transition and attaining the Paris climate goals, disruptions to supply chains or price spikes could show the transition increase the costs involved, a burden that will fall most heavily on less developed countries. As illustrated in Figure 46 between 2015 and 2020 battery prices have fallen over 60% but that price decline which has accelerated uptake has dramatically slowed. In 2022 the estimated average battery prices was 150 US\$ per kWh with cell pack manufacturing accounting for about 20% of total battery cost (IEA, 2023b, p. 61). In 2022 battery prices were pushed higher by raw material price spikes. Greater manufacturing efficiencies now make battery costs more sensitive to fluctuations in rawmaterial prices.

Figure 46 Price of selected battery materials and lithium-ion batteries, 2015-2023



Source:(IEA, 2023b)

12.4 Appendix IV Minerals Watch-list

The AGMS needs to maintain flexibility to adjust minerals for inclusion in the core list according to changes in technology, mineral discoveries on the continent and the establishment of new industries such as, for example, fabrication of high purity polysilicon for solar PV panels. In considering the scope for defining Green Minerals two additional criteria need consideration:

1. monitoring of a watch-list of minerals used

in clean energy, advanced manufacturing or novel technologies that address development priorities, for example water purification; and,

2. regular reviews of the core minerals for strategic focus to take into account technology developments that alter the importance of particular minerals for green technologies broadly.

Table 16 Watch list minerals for the African Green Mineral Strategy

Mineral	Main green technology uses
Arsenic	PV semi-conductor
Boron	EVs
Cadmium	PV semi-conductor
Gallium	PV semi-conductor
Germanium	PV semi-conductor
Indium	PV semi-conductor and
Iridium	Coating of anodes for electrochemical processes and as a chemical catalyst
Lead	Lead acid batteries and PVs
Magnesium	Steel alloys
Molybdenum	Steel alloys for geothermal plants
Niobium	Steel alloys
Selenium	PV semi-conductor
Silicon	PV, semi-conductor
Silver	PV semi-conductor
Tantalum	Steel alloys
Tellurium	PV semi-conductor
Tin	Protective coating
Titanium	Lithium-ion batteries
Tungsten	Wear resistant steel alloys
Zirconium	Hydrogen electrolyzers alkali process

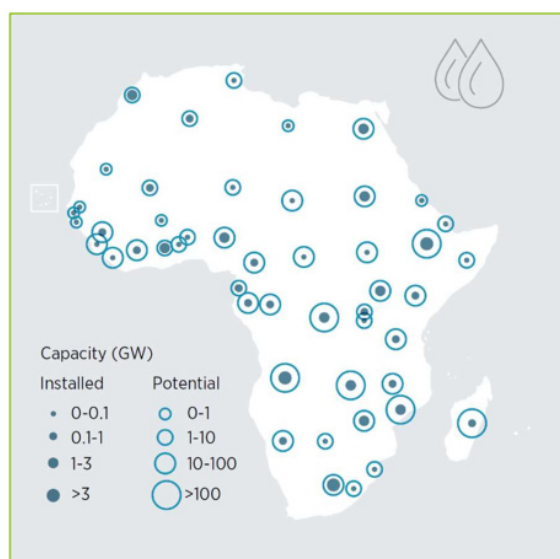
Source: adapted from (IEA, May 2021) and (USGS, 2022)

12.5 Appendix V African energy resources

12.5.1 Renewable Energy Resources

In 2021 Africa accounted for less than 3% of the world's installed renewables-based electricity generation capacity (IRENA, 2021). At 5500 exajoules per year, Africa is far and away the world's richest region for renewable energy potential, with 44.8 percent of the total technical potential of renewable energy (AfDB, 2022, p. 80). Here a brief overview of only three mature renewable energy generation technologies: hydropower, solar PV and wind underscores the point that closing energy deficits can simultaneously protect the planet. Large hydropower, the leading source of renewable energy on the continent, has an installed base of 38GW. A project pipeline of planned capacity additions for decades ahead amounts to 110GW, yet there is a further unexploited hydropower potential of 474GW (IHA, 2023, p. 18). The technical hydropower potential is estimated to be 1 753 GW, led by DRC, Angola, Ethiopia, Madagascar, Mozambique and Zambia (IRENA and AfDB, 2022, p. 39). Nigeria's hydropower potential is estimated at 25 GW.

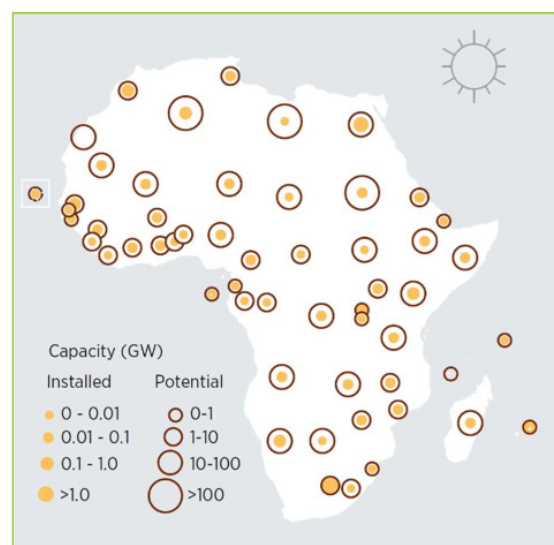
Figure 47 Large hydropower: installed capacity and potential



Source: (IRENA and AfDB, 2022)

Africa's landmass, except in Central Africa, receives some of the highest irradiation levels globally which give enormous potential for solar power generation. IRENA estimates the continent's solar technical potential at 7 900 GW (assuming a 1% land-utilisation factor). Unsurprisingly the most rapid capacity additions in the last decade have been solar plants standing at 10.4 GW by 2020 (9.4 GW solar photovoltaic; 1 GW concentrated solar power) (IRENA and AfDB, 2022, p. 41).

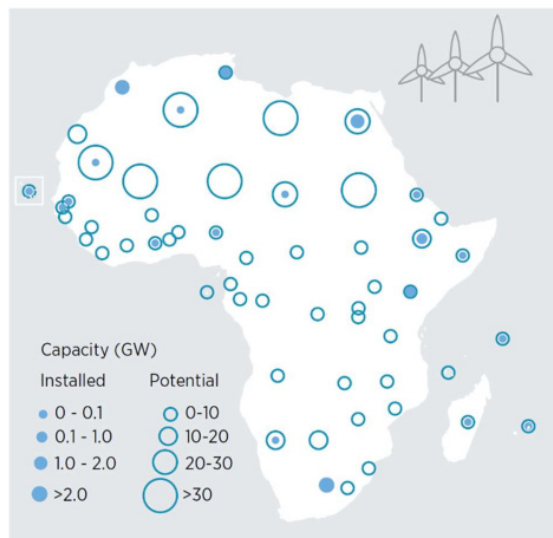
Figure 48 Utility scale solar PV: installed capacity and potential



Source: (IRENA and AfDB, 2022)

Wind power generation capacity stood at 6.5 GW in 2020, yet IRENA estimates the technical potential of wind power generation at some 461 GW (assuming a 1% land-utilisation factor), with Algeria, Ethiopia, Namibia and Mauritania possessing the greatest potential.

Figure 49 Wind: installed capacity and potential



Source: (IRENA and AfDB, 2022)

Harnessing large-scale renewable resources is a journey of many steps which African countries have begun to travel, supported by regional institutions and international bodies. Climate

commitments, appropriate policies, incentives, financing instruments and structural change to the energy sector will all need to be aligned. The role of the AGMS is to contribute to channelling opportunities in the energy transition into industrial development and job creation through adding value to mineral supply chains (MSCs) and through RE goods manufacturing, as well as facilitating regional cooperation to achieve economies of scale markets, technology and productive capacity.

Harnessing distributed renewables is also getting attention to close the energy access gaps. Planning, supportive policies and incentives have helped the deployment of mini grids. Solar home and homestead systems are proliferating aided by measures to lower upfront costs, such as pay-as-you-go financing. Distributed systems also playing an expanding role in mines' efforts to lower emissions. PGM producers in South Africa have a build programme to bring 295 MW of clean energy online for own use and supplying the grid by 2024. The role of the AGMS is to encourage such steps as an integral part of mineral industry stewardship.

12.5.1 Fossil fuel resources: Natural gas as a bridge to clean energy for Africa

Fifty four percent of Africa's primary energy is derived from fossil fuels (lowest region globally) with large regional differences reflecting resource endowments, Figure 3 on page 20. Over the last three decades the energy mix in developed economies has seen coal displaced by natural gas and renewables, even as per capita power (electricity) consumption has risen. Africa's energy mix is also changing as the share of gas increases, based on recent gas discoveries. Renewables are Africa's cheapest generation options. Large hydropower, utility-scale solar photovoltaic and onshore wind systems are now firmly established as the cheapest sources of electricity generation (AfDB, 2022, p. 74). Exploiting the continent's RE potential, however, requires many actions in parallel to create a reliable, balanced and sustainable energy system. Integrating renewable energy from various sources has to be supported by investment in non-variable sources (hydro, gas) to balance and transmission infrastructure to

evacuate power from sites of high RE resources. Grid balancing from flexible dispatchable generation provided by hydropower, natural gas or possibly battery storage is necessary to compensate for the variability of wind and solar power. Interconnection between regional energy markets enables trading between generators and load centres which contributes to optimising energy assets. Evolving power systems need to accommodate remote area power supplies (RAPS), mini grids and embedded generation (generation in the electricity distribution network). Limited industrial offtake and affordability thresholds for residential consumers makes tariff setting challenging. All these factors increase the complexity of planning, financing, constructing, operating and regulating energy systems.

Domestic and regional conditions will shape how energy systems develop, but in general natural gas should play a larger role in meeting Africa's energy needs over the medium term, as

CCGT produces only about one-third the GHG emissions of coal. Proven natural gas reserves, in Nigeria, Algeria, and Mozambique, with new reserves discovered in Senegal, Mauritania, and Tanzania now stand at more than 17.56 trillion cubic meters (620 trillion cubic feet) (Statista, 2022). Gas to power will provide important grid balancing roles. Gas is also a feedstock for basic chemicals such as ammonia (for fertilisers, explosives, Fuel Cell hydrogen, et al) and polymers (methanol route). The hydrocarbon sector will remain a key part of the energy industry up to 2040, producing transport fuel, and petrochemicals are still essential to produce polymers which will be needed in large quantities as economies industrialise.

Where competencies have been built in fossil fuel energy-based industries, it is important that countries begin to pivot to low carbon energy based industries and test opportunities around the production of green energy carriers, most notably green hydrogen and green ammonia,

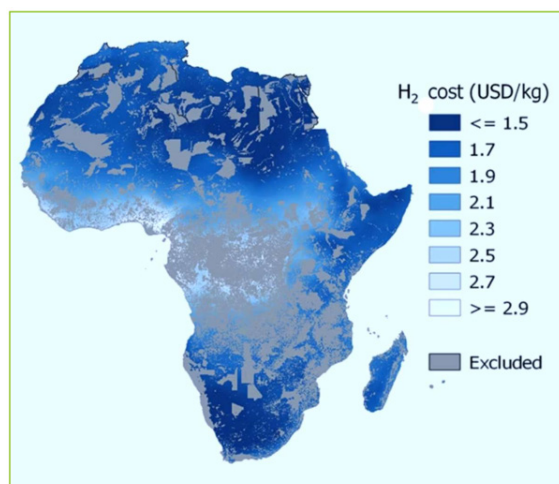
with assistance from the Global Warming perpetrators ("Just Transition"). Expertise in oil and gas producer countries must not be lost in the transition, but rather transition into new RE industries. At the continental level, it is important to observe that Africa's resource endowment in the new paradigms of green industries should increase its wealth, not reduce it due to the phasing down of fossil fuel exports, despite fossil fuels comprising over 40% of Africa's exports (AU, 2021). Projections for Africa made by the IEA indicate that revenues from copper and battery metals at the current market share will reach parity with fossil fuel earnings by 2050, or if the continent's market share were raised from the current 13% to 20% of the global market, revenue could more than quadruple by 2050 (IEA, 2022). However, if the MSC and RE manufacturing opportunities are realised, parity could be sooner through import displacement and value-added exports (intermediates & precursors).

12.5.3 New energy industries

Africa has huge potential to produce hydrogen using its rich renewable energy resources. A number of low-carbon hydrogen projects are underway or under discussion in Egypt, Mauritania, Morocco, Namibia and South Africa. These are focused primarily on using renewables-based power (mainly solar) to produce ammonia for fertiliser, which would strengthen Africa's food security, explosives into the MSC and, in the longer term, for fuel cells, green reduction of oxide ores (e.g. green steel, ferroalloys and silicon metal for PV cells) and direct combustion of hydrogen fuel.

Global declines in the cost of hydrogen production could allow Africa to deliver renewables-produced hydrogen to Northern Europe at internationally competitive price points by 2030. The size of the potential can be illustrated with a startling, but unrealistic, statistic: Africa has the potential to produce 5 Gigatons of hydrogen per year at less than USD 2 per kg—equivalent to global total energy supply today. What is realistic is to harness the exceptional natural resource advantage for clean energy for her people and world markets.

Figure 49 Wind: installed capacity and potential



Source: (IEA, 2022)

12.6 Appendix VI Skill Identification

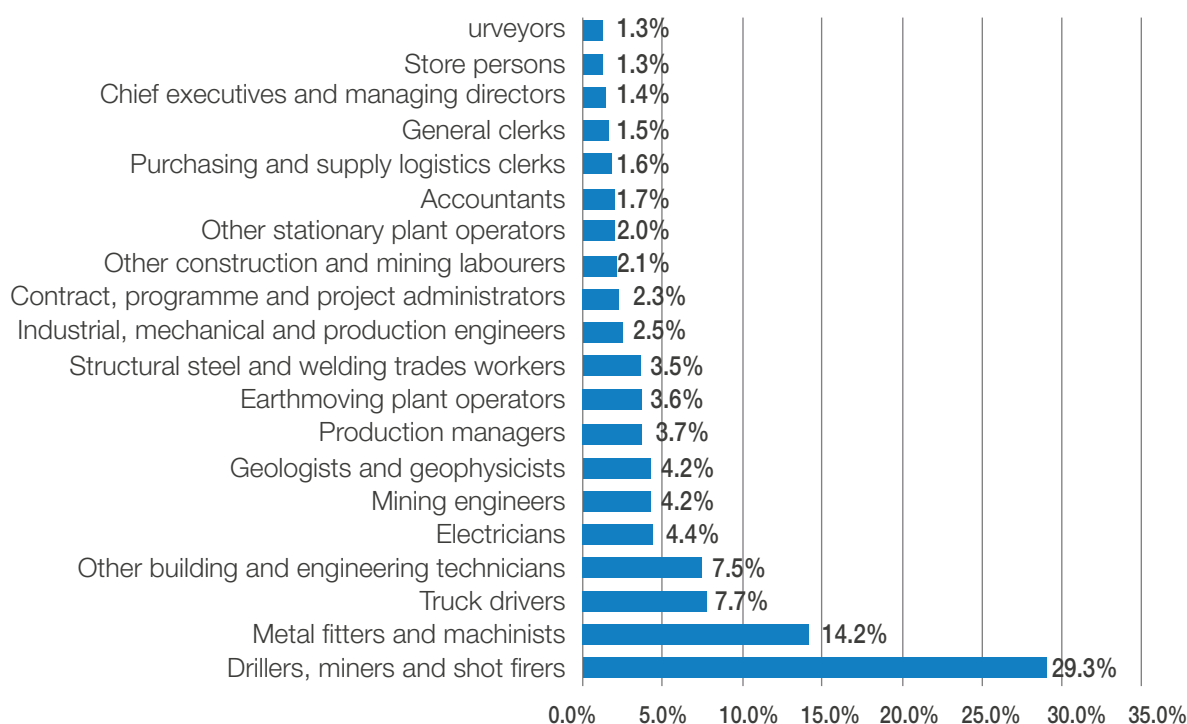
12.6.1 Mining skills

For the main occupations in the mining sector today, shown in Figure 51, there is broad consensus that technological advances will increase automation and reduce mining employment for physical jobs in highly structured and predictable roles, reducing overall mining employment and increasing the ratio of employees required with mechatronic skill sets. Employment of truck drivers, drillers, miners and shot firers will see the most reduction. Less certain is how automation trends applied in developing countries where science technology engineering and mathematics (STEM) skills are already in short supply. Policymakers and training institutions should work closely with the mining industry to stay up to date with changes to keep training relevant to industry needs at the same time as anticipate the need for more STEM skills with more resources for their creation. However, studies in South Africa and elsewhere

have indicated that the mechanisation of mining could approach job neutrality (Ashworth, MacNulty, & Adelzadeh, 2002) if the machinery, equipment, systems and services are locally manufactured and not imported. This would be difficult to achieve in any single African state due to limited demand, but attainable at a regional (REC) level, or better still, at a continental level (AfCFTA with a CET on mining inputs) which is the strategy recommended. Put simply, the idea is not to replace machines with people, but to gradually replace imported machinery with locally produced machinery through knowledge transfer (as against knowledge imports), technology transfer (as against technology imports) and innovations.

The localisation in Africa of green minerals mining and processing needs to go hand-in-hand with STEM skilling.

Figure 51 Main employing occupation in the mining sector



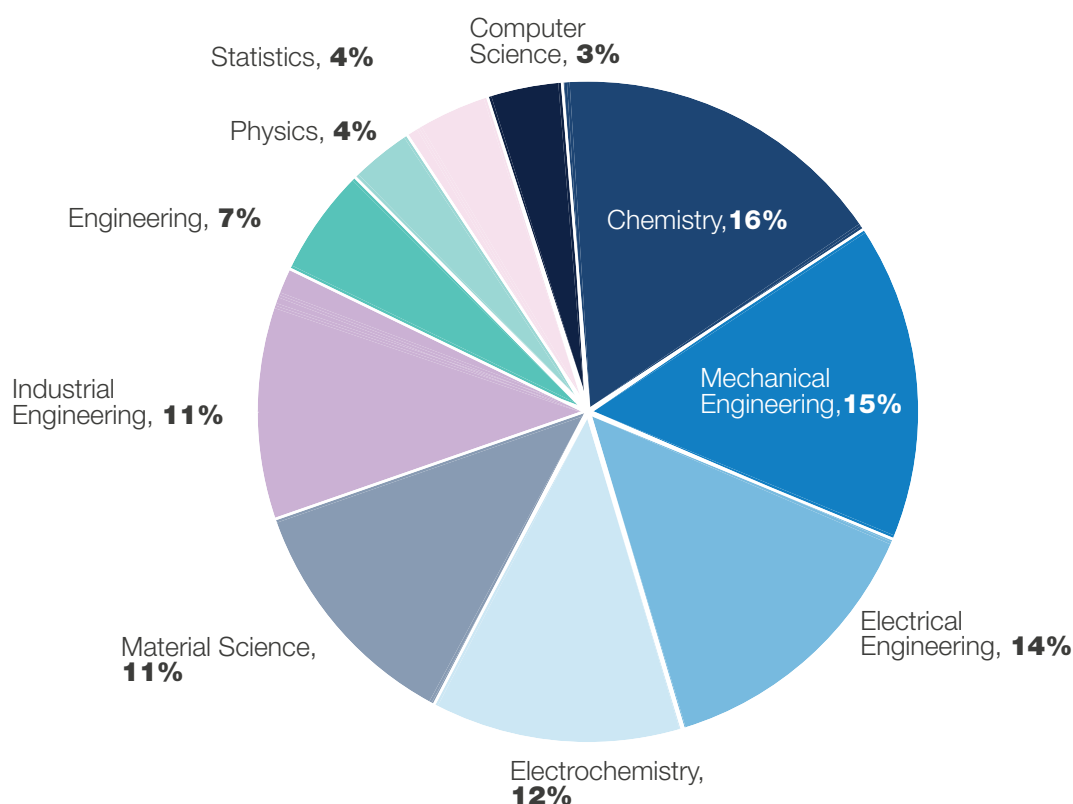
12.6.2 Battery manufacturing skills

Lithium-ion battery manufacturing will take place in Africa if initiatives like the Republic of Zambia and DRC Battery Council come to fruition (see section 6.1.4.5). Anticipating the skills that would be needed can be seen where battery industries have been established elsewhere.

As Europe has geared up for creating a battery manufacturing and electric vehicle sector the Alliance for Battery Technology Training and Skills (ALBATTs) funded by the EU has analysed what a largescale battery manufacturing plant

consists of in terms of departments and teams to determine who works there, and what kind of skills, competencies, and education are required. This is relevant as the research was undertaken precisely because a pool of battery/EV skills did not exist and therefore had to be created (Albatts, 2021). The most desired academic competencies for battery production and maintenance are chemistry, mechanical engineering, and electrical engineering ranked according to need, as seen in Figure 52.

Figure 52 Battery Production and Maintenance – Academic Competences

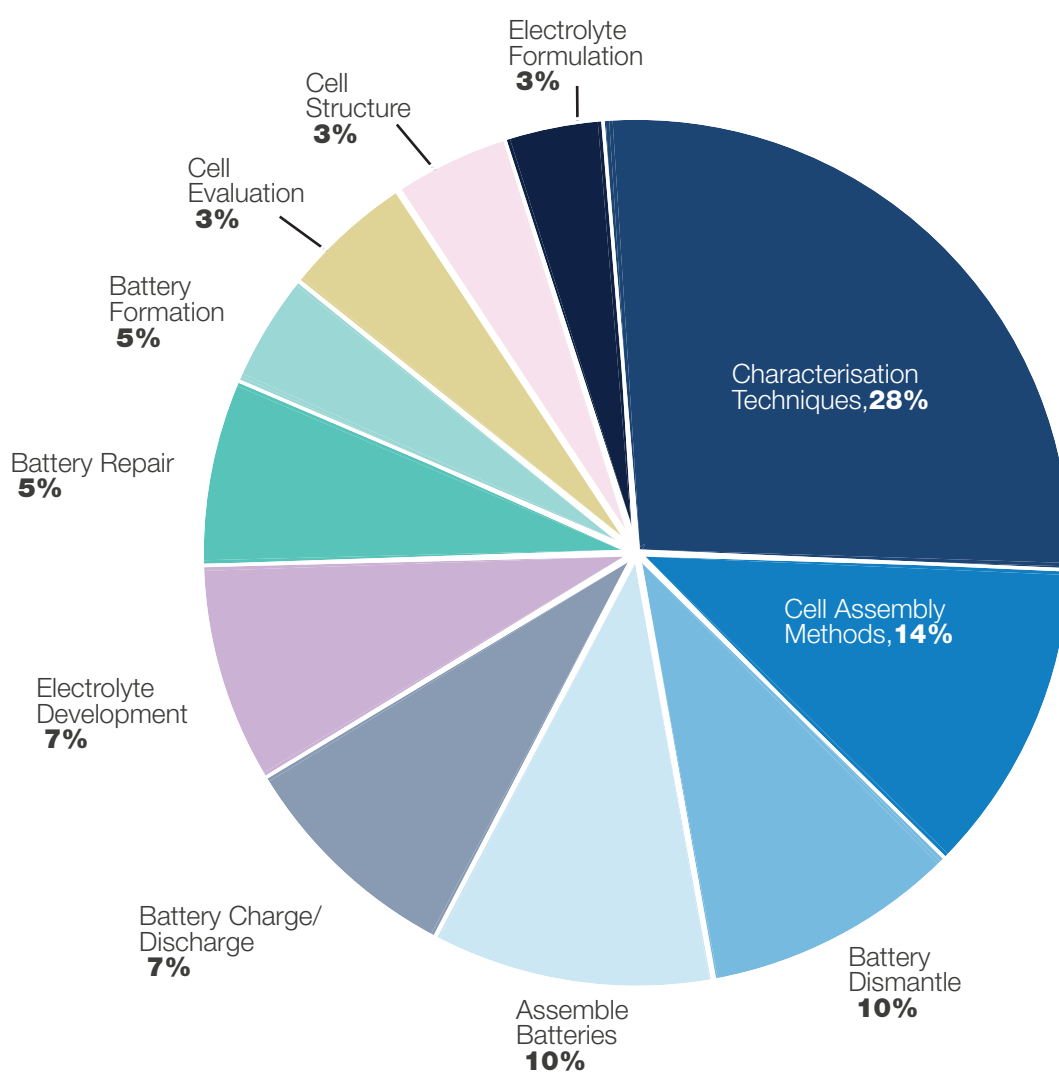


Source: data from (Albatts, 2021)

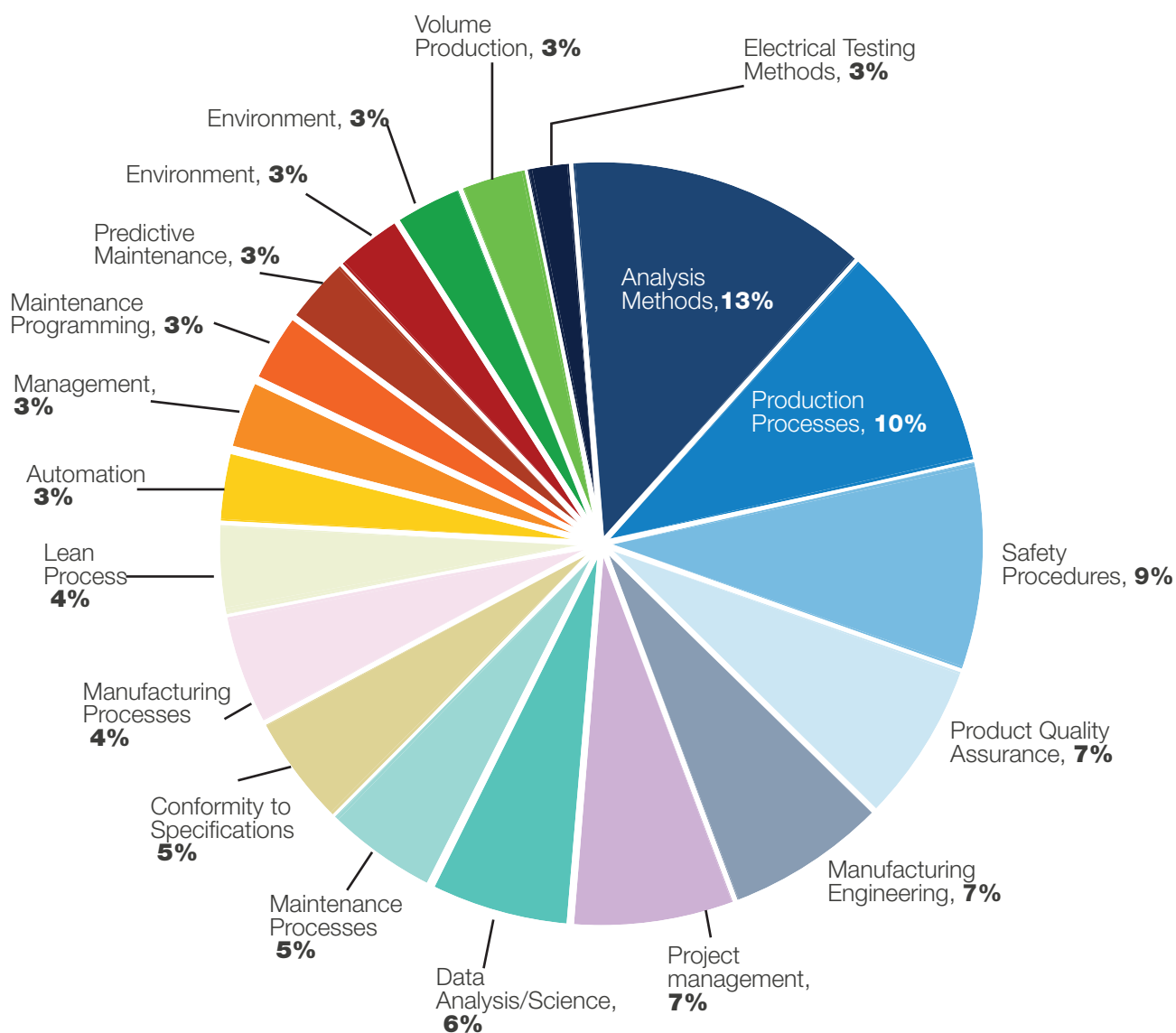
The ALBATTs research shows that a wide range of categories include soft, academic, general transversal, cross-sectoral specific and sector-specific competencies are required. In some instances, these do not exist in the labour force where a battery industry has not yet been set up and would need to be created by the investors themselves. Further details of sector specific

skills and specific knowledge needed for battery production is given in Section 5 on page 26. Battery production and maintenance employees the largest number of workers in a battery factory who need to be equipped with sector specific skills combined with sector specific knowledge shown in Figure 53 and Figure 54 respectively.

Figure 53 Battery Production and Maintenance: Sector Specific skills



Source: data from (Albatts, 2021)

Figure 52 Battery Production and Maintenance – Academic Competences

Source: data from (Albatts, 2021)

Several other important job functions are material handlers or planners and various purchasing roles and technicians for inventory, logistics, product testing/quality sampling and process improvement.

12.6.3 Electric vehicle assembly

Assembling electric vehicles starting with two and three wheelers is a priority value-chain for the green minerals strategy. In time Africa's conventional (internal combustion engine) automobile assembly industry with hubs in North, West and South Africa will have to transition to electric vehicles. Before this happens preparing for skills in the following occupational groups most aside associated with electric vehicle assembly will be a necessary step.

1. engineering professionals, in various fields: electrical, mechanical, sensor, mechatronics, optoelectronic, industrial, automation;
2. information and communications technology professionals: user interface developer, industrial mobile devices software developer and various types of ICT-related profiles which include ICT application developer, ICT system developer and ICT network engineer;
3. technicians and associate professionals such as robotics engineering technicians, industrial robot controllers and motor vehicle engine testers.

Analysis of skills for the Turkish automotive industry anticipating the shift towards electric vehicles finds that profiles such as electric and mechanical engineers, which have always been associated with the automotive industry, the introduction of new technologies will not diminish the need for those professions on which the sector has been historically dependent. New skills requirements driven by the introduction of new technologies, are user interface developers, sensor engineers, industrial mobile devices software developers (the latter is related to the growing importance of connected cars on the product side, and the internet of things on the process side) (European Training Foundation, 2021).

