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Summary report and recommendations on responsible investment opportunities

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Summary

The present report illustrates 100 recommendations and conceptual investment opportunities aimed at strengthening EU-Africa critical raw material value chain partnerships. The report builds on the content that has been developed within the EU-funded AfricaMaVal project and is addressed to the target audience of that project, comprising policy makers and public organisations in the EU and in Africa as well as the private sector, notably the minerals and metals sector, associated downstream industries and the financial sector. The report structure aligns with the mineral value chain segments as well as the mine and product life cycle, ranging from mineral exploration to value addition and recycling of critical raw materials. Each of the report chapters includes a general introduction, followed by specific recommendations and conceptual investment opportunities linked to that topic. The report is meant to provide a snapshot and broad overview to encourage discussions among target audience stakeholders in the spirit of EU-Africa strategic raw material partnerships, though it does not aspire to present a complete in-depth analysis of the identified topics. The report was written by the German Federal Institute for Geosciences and Natural Resources (BGR) as a contribution to AfricaMaVal Work Package 7 (Responsible Investment Opportunities), complementing other deliverables of that work package. While the report reflects the authors' views and ideas, it has been peer-reviewed by different AfricaMaVal project partners and builds on their contributions and AfricaMaVal deliverables as well.

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D7.3 – Summary Report and Recommendations on Responsible Investment Opportunities in Africa's Critical Raw Materials Sector

WP7 – Task 7.6

February 2025

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Abbreviations and Acronyms

Acronym	Description
3T/3TG	Tin, tantalum, tungsten (and gold)
AfCFTA	African Continental Free Trade Area
AfDB	African Development Bank
AfricaMaVal	EU-Africa Partnership on Raw Material Value Chains (Horizon Europe project)
AMEC	Association of Mining and Exploration Companies
AMREC	African Mineral and Energy Resources Classification and Management System
ASI	Aluminium Stewardship Initiative
ASM	Artisanal and small-scale mining
AUDA-NEPAD	African Union Development Agency
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
CAM	Cathode Active Material
CRMA	Critical Raw Materials Act
CSP	Concentrated Solar Power
DG INTPA	Directorate-General for International Partnerships (European Commission)
DRC	Democratic Republic of Congo
EBA	European Battery Alliance
EBRD	European Bank for Reconstruction and Development
ECRM	Extended critical raw materials as defined in the AfricaMaVal project (largely overlaps with critical and strategic raw materials as defined in the EU's most recent communication linked to the CRMA)
EDF	European Development Fund
EFSD+	European Fund for Sustainable Development Plus
EIB	European Investment Bank
EIT	European Institute of Innovation and Technology
EPA	Economic Partnership Agreements
EPR	Extended producer responsibility

ERMA	European Raw Materials Alliance
ESG	Environment, Social and Governance
EU	European Union
EV	Electric vehicle
GHG	Greenhouse gas
GIZ	Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
HPMSM	High purity manganese sulphate monohydrate
ICGLR	International Conference of the Great Lakes Region
IoT	Internet of Things
IRMA	Initiative for Responsible Mining Assurance
JOGMEC	Japan Organisation for Metals and Energy Security
JORC	Australian Joint Ore Reserves Committee
KCM	Konkola Copper Mines
LIB	Lithium-ion battery
MoU	Memorandum of Understanding
NI-43-101	National Instrument 43-101 Standards of Disclosure for Mineral Projects
OECD	Organisation for Economic Cooperation and Development
PARC	Pan-African Resource Reporting Code
pCAM	Precursor cathode active material
PDAC	Prospectors & Developers Association of Canada
PGII	Partnership for Global Infrastructure and Investment
PGM	Platinum group metals
PIDA	Programme for Infrastructure Development
PPP	Public-private partnerships
REE	Rare earth elements
RMAP	Responsible Minerals Assurance Process
RMI	Responsible Minerals Initiative
SDGs	Sustainable Development Goals
STL	Société pour le traitement du terril de Lubumbashi

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UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFC	United Nations Framework Classification for Resources
WP	Work package (within the AfricaMaVal project)

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Executive Summary

The present report illustrates 100 recommendations and conceptual investment opportunities aimed at strengthening EU-Africa critical raw material value chain partnerships. The report builds on the content that has been developed within the EU-funded AfricaMaVal project and is addressed to the target audience of that project, comprising policy makers and public organisations in the EU and in Africa as well as the private sector, notably the minerals and metals sector, associated downstream industries and the financial sector. The report structure aligns with the mineral value chain segments as well as the mine and product life cycle, ranging from mineral exploration to value addition and recycling of critical raw materials. Each of the report chapters includes a general introduction, followed by specific recommendations and conceptual investment opportunities linked to that topic. The report is meant to provide a snapshot and broad overview to encourage discussions among target audience stakeholders in the spirit of EU-Africa strategic raw material partnerships, though it does not aspire to present a complete in-depth analysis of the identified topics. The report was written by the German Federal Institute for Geosciences and Natural Resources (BGR) as a contribution to AfricaMaVal Work Package 7 (Responsible Investment Opportunities), complementing other deliverables of that work package. While the report reflects the authors' views and ideas, it has been peer-reviewed by different AfricaMaVal project partners and builds on their contributions and AfricaMaVal deliverables as well.

Keywords

Critical raw materials, mineral supply, value chains, Africa, investment, mining, artisanal and small-scale mining, mineral exploration, value addition, infrastructure, recycling

1 Introduction

The Horizon Europe-funded project "EU-Africa Partnership on Raw Material Value Chains" (AfricaMaVal) shall contribute to identifying potential investment opportunities and supporting value chain partnerships among African and European stakeholders. Running from 2022-2025, the AfricaMaVal project is embedded in a range of European Union (EU) policy initiatives in relation to strengthening European supply of critical and strategic raw materials termed 'extended critical raw materials' (ECRM) within the AfricaMaVal project. These EU initiatives include, in particular, the recently published Critical Raw Materials Act (CRMA) and the Union's bilateral strategic raw material partnerships with ECRM producer countries, including in Africa.

This report describes a total of 100 recommendations and conceptual investment opportunities that are meant to strengthen EU-Africa engagement and cooperation along ECRM value chains. These recommendations are grouped in different chapters reflecting value chain segments and the product lifecycle (exploration, mining, refining/value addition, recycling) as well as complementary lead topics (artisanal and small-scale mining, ASM, and infrastructure). Each chapter starts with a general introduction to the chapter topic and, if applicable, may contain methodological explanations, before presenting a range of recommendations. Environmental, social and governance (ESG) considerations were included in a cross-cutting sense in all chapters, rather than being presented in their own separate chapter, to ensure they seamlessly integrate with technical and financial aspects, all of which contribute to a sustainable investment case. Other AfricaMaVal deliverables specifically targeting ESG aspects comprise Awases et al. (2023), Ghezzi et al. (2024) and Falck et al. (2024).

The intended target audience of the report and its recommendations comprises the EU, including relevant directorates of the European Commission, country delegations, and Member state stakeholders – occasionally summarized as 'downstream government stakeholders' in this report – as well as their African counterparts, notably national ministries and agencies dealing with mining, industry development and investment promotion. The recent conception of ECRM-related national funds in some EU Member states (France, Germany, Italy) along with similar engagement by other governments worldwide points towards an increasing role of these policy makers. Beyond these, the report's target audience extends to downstream industry and financial sector stakeholders interested in securing or promoting ECRM supply through investment, financing or offtake agreements with partners in Africa. Notably, OEM manufacturers should be considered as an increasingly important stakeholder in this group for those ECRM that are of particular importance for their own supply chains.

The recommendations and conceptual investment opportunities presented in this report comprise two different kinds. On the one hand, the present report includes recommendations or

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conceptual investment opportunities of a general nature, not directly related to specific ECRM projects. These general recommendations might be helpful for EU and African policy makers, among others, to stimulate or deepen discussions related to strengthening EU-Africa partnerships along raw material value chains. On the other hand, certain report recommendations discuss and illustrate topics by making specific references to a number of ECRM projects in Africa, many of which – but not all – were presented as project factsheets in AfricaMaVal Deliverable 7.1 (Stoltnow et al. 2024); Figure 1 shows the location of all projects included in that deliverable. Readers may consult the two reports, D7.1 and the present report (D7.3), in conjunction. In the recommendations of the present report, we deliberately present a range of different ECRM projects for illustration, rather than only presenting single, pre-selected projects, since we seek to emphasize (1) the importance of diversification and engaging with multiple projects of interests to mitigate project and country risks, and (2) the need for downstream stakeholders, investors and policy makers to evaluate and conduct due diligence on projects of interest on their own terms.

This report was developed by the Federal Institute for Geosciences and Natural Resources (BGR). Besides BGR's own analysis, it integrates findings from other AfricaMaVal project partners as well, where these were available to the authors at the time of research. The report appendix includes a summary list of all recommendations and conceptual investment opportunities and illustrates links to AfricaMaVal partner contributions, where these could be directly identified. We encourage readers to consult additional AfricaMaVal deliverables available on the project website for topics of interest. In a general sense, the recommendations of the present report may be considered in conjunction with a value chain strategy developed in AfricaMaVal's work package 6 (e.g., Ufer et al. 2023).

The recommendations and conceptual investment opportunities presented in this report are based on the background experience of the authors and additionally reflect discussions and lessons learnt within the AfricaMaVal project. This includes, among others, partner presentations at a consultation workshop for consortium members, organized by the BGR in Cape Town in February 2024. Nonetheless, the BGR remains the sole party responsible for this report and the recommendations presented therein do not necessarily reflect the views of other AfricaMaVal project partners.

While aiming for a relatively broad coverage of different topics in the ECRM value chain, the content of this report should only be regarded as a snapshot or teaser for possible support actions and ideas. By no way do the authors presume to present 'the complete picture', nor do we assign any specific order of priorities to the presented recommendations or conceptual investment opportunities. We expect that different recommendations may be of varying relevance to different stakeholder groups.

In terms of the AfricaMaVal project's logical framework, this report is associated with AfricaMaVal work package 7, 'Responsible investment opportunities' (Task 7.6) and represents the last deliverable D7.3 of that work package. The report provides specific and general recommendations and conceptual investment opportunities that may support EU-Africa engagement along raw material value chains. In doing so, the report shall contribute to AfricaMaVal's KPI 3.1, 'Provide a list of 100 investment opportunities evaluated.' It is important to note that the recommendations and conceptual investment opportunities presented in this report do not represent the exclusive AfricaMaVal project output in this regard; additional project partners may provide additional relevant findings in their own deliverables.

Figure 1. ECRM projects presented as factsheets in Deliverable D7.1 (Stoltnow et al. 2024).

2 Mineral exploration

2.1 Background – Investment in mineral exploration

New mines opened in the 2020-2023 period had an average lead time of almost 18 years from discovery to first production. This implies that investing in mineral exploration, especially greenfield exploration, should not be expected to satisfy short-term mineral demand. Indeed, a selection of African ECRM projects, documented as factsheets for the AfricaMaVal project (Stoltnow et al. 2024), shows that out of 19 somewhat advanced exploration projects (defined at the scoping or pre-feasibility stage where at least a maiden resource estimate was available), the vast majority is unlikely to be brought into production by 2030, the reference year for the European CRMA. Nonetheless, exploration is of critical importance for the mid- to long-term mineral supply perspective, since any mined reserves need to be replaced to avoid depletion, and additional ECRM demand growth needs to be accounted for as well. As such, exploration is of fundamental strategic relevance from a mineral supply perspective, while it is equally important for mining countries in order to sustain their long-term economic growth. Considering that a major share of global exploration expenditure is typically spent on gold projects, it is of particular importance to support strategic investment in ECRM-related exploration.

Stakeholders invest in mineral exploration for different reasons. Two eminent investor groups in exploration comprise financial investors (e.g., funds) as well as major mining companies. The former group invests in public or private junior exploration companies – through the stock market or through private equity transactions – with the main objective of realizing capital gains on their investment in case of successful discoveries and favourable project/market developments, which may ultimately result in the project being sold to a third party. In contrast, the latter group invests in junior explorers or project joint ventures in return for an option for controlling exploration projects of interests, often through farm-in agreements. In this fashion, major mining companies may expand their own project pipeline, and thus their mineral resources and reserves at the corporate level, by outsourcing part of their exploration activities and part of the associated risk to junior explorers.

The investment recommendations in this chapter mainly target an additional stakeholder group that is currently less prominently engaged as investors in exploration. These stakeholders – downstream governments or industries – might regard investment in mineral exploration as part of a strategic approach to ensure long-term supply in ECRM. Certain downstream companies are already investing in existing or upcoming mining projects to ensure access to their future mineral supply requirements. For instance, Chinese companies in the battery value chain have undertaken significant investments in lithium mines in Australia or in copper-cobalt mines in the Democratic Republic of Congo (DRC) to secure supply or to enable vertical integration. It is less

common for downstream companies to invest in early-stage exploration projects, rather than in advanced projects that have already passed the feasibility stage. For reasons outlined in the following sections, it may be worthwhile for downstream governments and industries, to additionally consider investing in exploration in order to ensure well-diversified future mineral supply. Mitsubishi, Volkswagen and General Motors represent noteworthy examples for downstream engagement in this regard. Both Mitsubishi and Volkswagen have recently invested in relatively early-stage lithium hard rock projects in Canada, by means of project joint ventures or by taking an equity stake in the junior explorer managing the project, while General Motors invested in a somewhat more advanced lithium project joint venture in Nevada in the United States. These developments appear to be indicative of a growing willingness among OEMs to take active steps to ensure their ECRM supply by engaging in early-stage exploration and project development.

The typical exploration investment approach mentioned above consists of investing in individual or, for risk diversification, in a basket of different junior companies or project joint ventures. While this approach is feasible for downstream governments and industries, additional, more development-oriented forms of investment may help to improve the structural framework for mineral exploration in Africa and, as such, benefit exploration activities in general. For this reason, the following recommendations and conceptual investment opportunities put more emphasis on (but are not limited to) the latter type of investment, with the main objective of supporting long-term availability of ECRM, rather than short- to mid-term capital gains.

It is important to note that African government representatives frequently consider their countries as underexplored and therefore welcome investment in exploration. The Africa Mining Vision (African Union 2009) notes, though, that careful license governance is required to avoid disadvantages upon conversion of exploration to mining licenses. While these types of governance questions related to exploration and mining are beyond the scope of this report, increasing strategic engagement by downstream governments in mineral exploration in Africa opens the door for bilateral partnerships, improved transparency and equitable profit sharing by African states. Public-private partnerships (PPPs) may be a helpful means of cooperation to consider in this context, as recommended in the Africa Mining Vision. While the original PPP concept refers to a cooperation between the local or national government and project developers, one might consider expanding this concept to include downstream governments in the spirit of the strategic raw material partnerships and similar international initiatives.

2.2 Exploration dynamics in Africa

It is sometimes argued that some African countries receive comparatively low investment due to an unfavourable investment regime. The Fraser Institute recently found that the national

investment policy framework contributes 40 % to the investment decision of companies in mining and exploration. The complementary major factor conditioning investment decisions in exploration and mining is the mineral potential of a country. While the mineral potential of each country is fixed as far as ore deposit geology is concerned, public knowledge and perception of a country's actual mineral potential varies. If two countries theoretically had similar geological mineral endowment, the better-explored country that hosts successfully operationalized mines will likely be perceived as having a higher mineral potential than the less-explored country with limited precedents of successful mining ventures[1]. Attracting investment in exploration, potentially leading to successful discoveries further down the line, is thus of high importance for countries to improve public perception of their mineral potential. This, in turn, may attract further explorers, so that successful exploration may at some point generate a self-reinforcing trend – although this requires regularly re-investing mining income into exploration activities.

In mineral exploration, one may differentiate mine site, brownfield and greenfield exploration settings. Mine site exploration serves to adding reserves and resources to existing mines and in satellite ore bodies, thus expanding the life of mine and/or enabling potential expansion of plant throughput capacity to achieve a higher metal output. Regional exploration serves to discover new deposits, either close to existing mines in known metallogenic districts (brownfield exploration) or in underexplored areas with little known mineralisation (greenfield exploration). Continuous exploration efforts at all scales are required to sustain the future supply of critical and strategic raw materials. Exploration is a high-risk activity, which in most cases does not lead to a successful discovery and an economically viable ore deposit. Therefore, in order to sustain long-term mineral supply, it is important to progress a larger number of exploration projects in parallel.

Figure 2 shows an overview on currently active early-stage (from grassroots through pre-feasibility) ECRM exploration projects in Africa. A total of 231 of such projects were registered in the S&P Global (2024) database at the time of research (July 2024). Note that the map does not show projects that have already progressed to the feasibility or mining stage and, as such, does not cover mine-site exploration to expand resources. The majority of exploration projects are concentrated in southern Africa. Explorers target a broad range of ECRM, covering all major battery metals and other raw materials required for the global energy transition, digitalisation and other global economic trends. Approximately two thirds of all African exploration projects are managed by companies registered in Australia, Canada and the UK. African explorers account for 16 % of all projects, while companies from the EU, at 3 %, play a negligible role. EU-based investors may be shareholders in foreign exploration companies, which may be a sensible arrangement, given the available technical expertise and experience by companies from major

[1] The latter may be due to either a lack of exploration or a lack of demonstrated successes in mining involving international operators, for instance due to a national investment climate perceived as unfriendly.

exploration jurisdictions such as Australia and Canada. While China has an increasing footprint in African mining, Chinese companies show less prominent engagement at the exploration stage, covering only 6 % of all African ECRM exploration projects registered in S&P Global (2024). Chinese companies apparently prefer investing in late-stage ECRM projects or active mines in Africa. They buy inactive mines to bring them back into production or re-process tailings, and prominently engage in the ASM sector to purchase ECRM or to run small-scale mining operations. It is possible, though, that Chinese mineral exploration activity in Africa are more pronounced than suggested by Figure 2 since S&P Global (2024) cannot display data unless they become publicly available at some point.

A number of ECRM ore deposits in Africa were discovered and associated mines have been in intermittent production since colonial times. Some of these mines were re-opened in recent years, combined with a re-evaluation of their reserves and resources to expand life of mine while more prominently accounting for additional ECRM that have become of increasing economic interest, such as cobalt as a by-product of copper projects in the Central African Copperbelt. For example, in 1998, the DRC's historic Kamoto mine reserves and resources comprised 250,000 tons of cobalt and 2.2 million tons of copper; in 2017, the project operator increased these historical figures eightfold, to 2.2 million tons of cobalt and 16.6 million tons of copper (data sourced from S&P Global 2024). Similarly, some African pegmatites in countries such as Namibia (Uis), Zimbabwe (Kamativi) or the Democratic Republic of Congo (Manono) were uneconomic or only marginally profitable tin mines for several years, sometimes even decades. More recently, these old mines received renewed exploration interest due to their potential for lithium mineralisation, a commodity that used to be economically less important in the past. In such cases, tin and possibly tantalum would represent the by-products of a primary lithium mining operation, targeting either the in-situ ore body and/or historical mine tailings.

In response to changing market conditions, explorers successfully made new ECRM discoveries in Africa in recent times as well. Maiden resources for southern Africa's major graphite projects – mainly located in Mozambique, Madagascar, and Tanzania – were only defined over the past decade. Applying new means of data interpretation and employing updated geological deposit models allows for discovering new deposits even within well-known historical mining districts. The emerging Mingomba copper deposit in Zambia is a prominent example for the latter. Discoveries such as Kamoa-Kakula and Western Foreland in the DRC point to Africa's potential to host major copper deposits of global significance. Africa's major potential for platinum group metals (PGMs) was reinforced as well with the discovery of the deeper-seated Platreef mineralisation in the northern Bushveld Complex, South Africa. These examples underline Africa's mineral potential, even within the constraints of receiving overall rather low exploration expenditure as discussed below.

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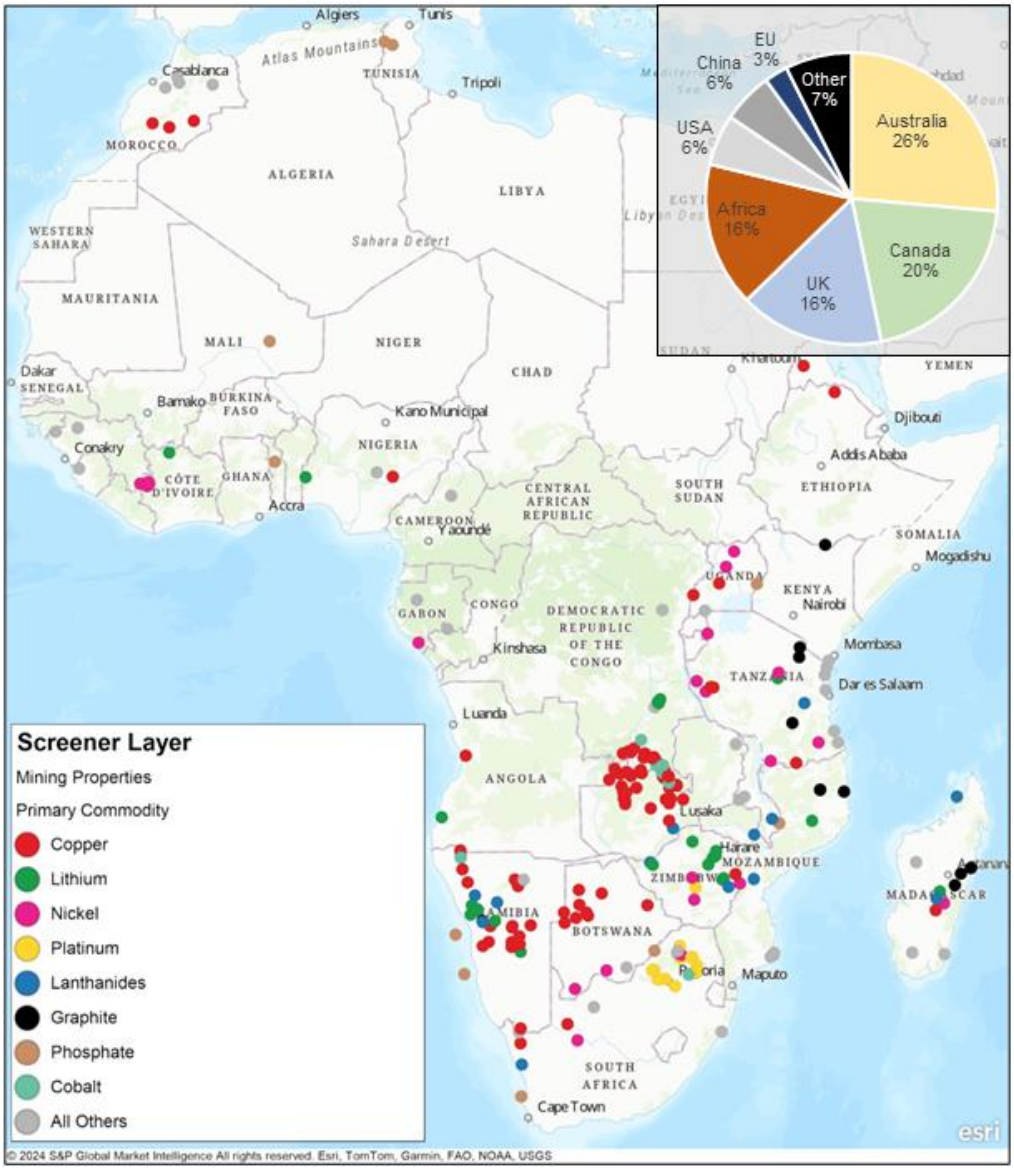

Figure 2. Location of early-stage (grassroots through pre-feasibility) ECRM exploration projects in Africa and origin of project operators (inset). Based on authors' evaluation of S&P Global (2024) data.

Recognizing the importance of stimulating exploration, particularly in greenfield areas, some African countries undertook efforts to make their geological potential better known to investors. For example, a little more than a decade ago, the Rwandan government defined national priority target areas for exploration and, to this end, facilitated interpretation of regional geophysical data while also financing surface-based ECRM exploration activities by independent expert consulting houses in selected areas. More recently, the DRC defined a national strategic exploration plan and selected priority zones to encourage exploration in areas beyond the well-known Copperbelt and covering a broader range of ECRM (as well as precious metals and

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diamonds). Similar to Rwanda, the government then signed a contract with a specialized consulting service provider, in this case to conduct geophysical and geological mapping in some of these areas. Supplementing such efforts, the government also entered into a cooperation agreement with Japan's Organisation for Metals and Energy Security (JOGMEC) to support exploration in the DRC. In South Africa, the national geological survey, the Council for Geoscience, started an ambitious mapping program of the whole country along with developing a streamlined, digitally interactive geological map to help identifying new deposits.

Notwithstanding these efforts and successful discoveries, compared to other continents, Africa tends to be underexplored as far as ECRM are concerned. This is not a new development – the fact that African countries attract lower exploration expenditure than others was already observed 30 years ago (e.g., Watts, Griffis and McOuat Ltd. 1991). Figure 3 shows that Africa's share in global exploration expenditure is around or below 10 % for rare earth elements (REE), lithium, copper and nickel. Only in cases where it hosts a major share of global reserves and production – which is the case for PGMs and cobalt – does Africa attract a somewhat higher relative share in exploration expenditure.

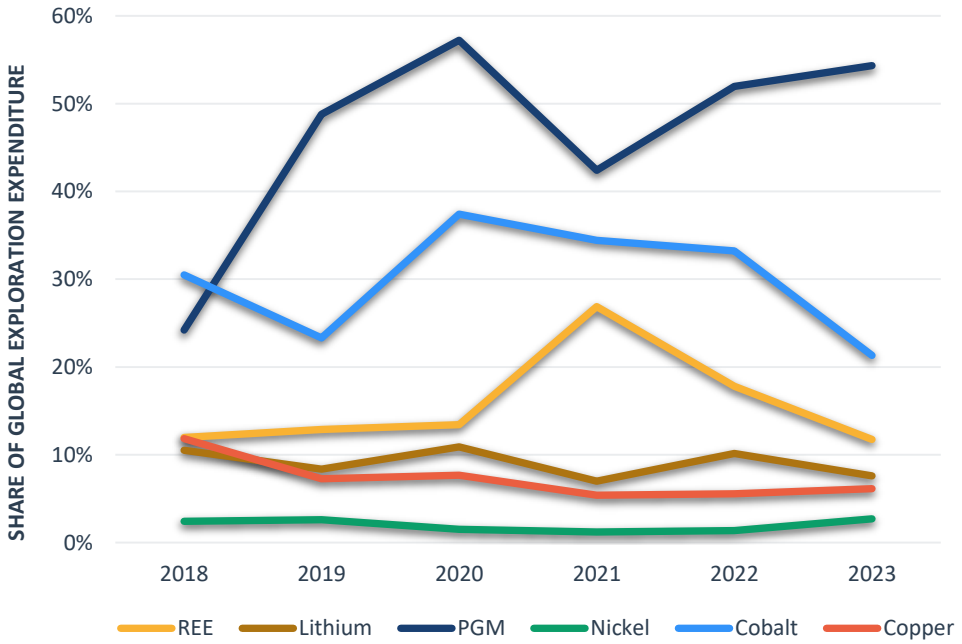

Figure 3. Africa's share in global exploration expenditure for selected critical raw materials, based on authors' evaluation of S&P Global (2024) data.

In absolute terms, exploration expenditure on ECRM in Africa is low as well, even though an increase can be observed in recent years (Figure 4), reflecting partly attractive raw material price development at that time. Copper attracts the highest exploration spending in Africa (lastly approaching around $200m/year) while other ECRM account for individual expenditure in the

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range of $20m - $70m per year. High-calibre campaigns such as Ivanhoe's exploration program at the Western Foreland copper project in the DRC – spending up to $90m – are exceptional and not the rule in Africa. The company's initiative demonstrates that it is possible to successfully raise stock market capital for such activities in sub-Saharan Africa. Overall, though, compared to the value of minerals extracted, investment in exploration in Africa is very low. In the case of copper, exploration expenditure amounts to only 0.6 % of the value of African copper mined in 2022 (authors' analysis based on S&P Global 2024 and data in the BGR raw materials database). Even when considering that exploration expenditure as provided by S&P Global (2024) might not capture spending by some companies (for instance, from China), this share of exploration expenditure is far from the typically recommended share of re-investing 5-10 % of mined production value in a given year. Moreover, while raising exploration funding for major commodities such as gold or copper is straightforward, relatively speaking, it is harder to do so for 'exotic,' that is, lesser known and illiquid ECRM with smaller markets.

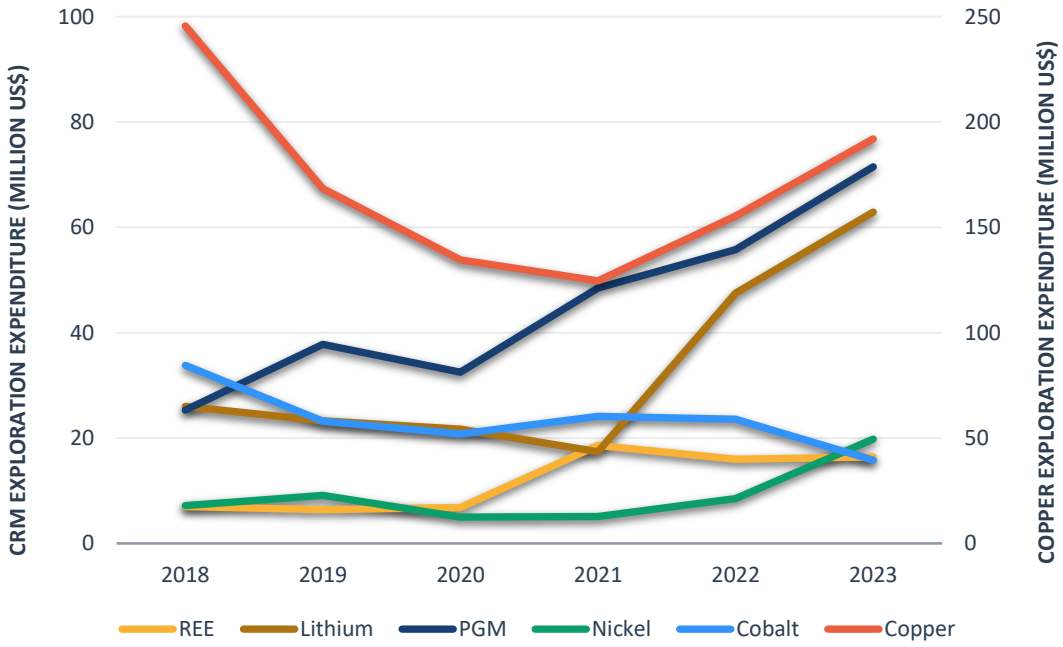

Figure 4. Exploration expenditure for selected critical raw materials in Africa, based on authors' evaluation of S&P Global (2024) data.

2.3 Recommendations and investment opportunities

The following recommendations and investment opportunities are meant to address some of the challenges identified above, but by no means claim to provide 'the solution' – if the latter was easy to grasp, it would already have been identified. The findings below represent the authors' own observations and experience, and are, as such, subjective in nature and not representative.

While there is no dedicated deliverable related to mineral exploration planned within the AfricaMaVal project, discussions with several partners in the AfricaMaVal project consortium and at workshops the BGR organised in Africa stimulated our thinking as presented below. As far as funding questions are concerned, readers may also consult Nederveen et al. (2023) and upcoming deliverables in AfricaMaVal's Work Package (WP) 3 for complementary information. Of particular interest is WP3's stakeholder mapping of financial institutions and funding bodies in connection with ECRM (Albery et al. 2024).

The recommendations and conceptual investment opportunities presented below are mostly of a general nature, targeting supportive measures by policy makers (both downstream and in producer countries) and others that might help raising public and investor awareness on mineral exploration, Africa's mineral potential and attracting the necessary capital while also considering ESG aspects. The order of the following recommendations does not represent any particular ranking in terms of priorities. The main target group for these recommendations are policy makers and, to a lesser extent, the industry in European downstream countries who, in partnership with their African counterparts, might pursue joint interests in creating a supportive framework for stimulating mineral exploration on the African continent. Some of the recommendations also refer to the academic sector. General recommendations are meant to provide initial ideas that should then be discussed among relevant stakeholders and adjusted to the national or bilateral context.

Recommendation 2.1: Create strategic investment partnerships to raise exploration funding in Africa throughout raw material market cycles.

As established above, exploration expenditure in Africa needs increase in order to discover new ECRM ore deposits and expand the reserves and resources of primary commodities and by-products in established and historical mining districts. While major companies with active production may re-invest part of their profits into exploration and generally have improved access to financing, funding of junior explorers often relies on the stock market and is particularly sensitive to raw material prices. Ideally, though, strategic investors should partner with exploration companies independently from commodity price market cycles, to enable continuous activities at promising exploration projects. This may take place through the stock market or as private equity transaction and might involve government-related funding agencies as well. A positive example in this regard is JOGMEC's investment in Namibia Critical Metals' Lofdal REE project. From 2020-2024, in return for the option to acquire a certain share in the project, Japan's JOGMEC approved a total investment of C$11.8 million to facilitate drilling, metallurgical test work and related studies at Lofdal. These steps are meant to take the project to the (pre-) feasibility stage. Over this time period, the project's resources were expanded four- to

tenfold, depending on the specific REE (S&P Global 2024). Ultimately, JOGMEC might chose to acquire a controlling stake in the project to contribute to Japan's REE supply security. Besides junior explorers, parastatal mining companies in Africa might benefit from similar international partnerships to facilitate exploration since they often hold large concession areas. In each case, though, potential partners and investors are advised to perform their own due diligence to understand the associated risks and uncertainties, especially for early-stage exploration.

Recommendation 2.2: Support exploration financing and project de-risking through downstream involvement.

Access to capital is a fundamental constraint for exploration activities in Africa. Moreover, from a strategic ECRM supply perspective, it is preferable if exploration funds are not concentrated among relatively few companies and projects but instead cover a larger number of sites, actors and jurisdictions – this serves to diversify project risk, corporate management risk, and country risk. For this reason, it is worthwhile to evaluate setting up mechanisms to support access to capital for African exploration projects in general. These mechanisms would not only serve to provide direct financing but create further leverage by allowing junior explorers to de-risk their projects or project portfolios to an extent that helps them raising continuous financing to ensure their liquidity, including during periods of weak raw material prices.

Downstream stakeholders (government or industry) might partner with local and regional development finance institutions (e.g., AfDB) to set up mechanisms such as national or regional support funding or guarantee programs, open to applications by junior explorers working in Africa. Development finance institution might usually not focus on supporting mineral exploration, for a variety of reasons, for instance considering their overall mandate or (lack of) potential multiplier effects. But overcoming the structural challenges for ECRM exploration in Africa, combined with the strategic opportunities it may offer in the long term, might be cause for reconsidering this approach, especially if combined African and European funding could be made accessible. Downstream stakeholders already have certain programs and instruments in place which may in principle support financing of ECRM projects. Many of these initiatives currently have limited applicability for exploration projects in Africa. This may be due to geographic factors (e.g., the African footprint of the European Bank for Reconstruction and Development, EBRD, is currently focused on northern Africa, though this is expected to change soon) or in relation to project stage (e.g., Germany's UFK guarantees require offtake agreements being signed by the project developer with a German company, but early-stage exploration projects may not be sufficiently advanced nor study work sufficiently advanced to allow negotiating such contracts). Similarly, support initiatives associated with the CRMA tend to focus on strategic projects with the potential to deliver ECRM to the EU by the year 2030, the

benchmark year of the CRMA, while many exploration projects likely have longer lead times. Therefore, modifying or setting up targeted funding initiatives allowing the inclusion of early-stage exploration projects may play an important role in ensuring long-term ECRM supply.

Besides government-led programs and instruments (or potentially investment capital pooled by downstream industry), one may additionally envisage supporting access to capital and supporting the public presentation of the business case by encouraging multiple listings of exploration companies, in addition to their international main listings (typically in Toronto, Sydney, London), for instance at African and European stock exchanges. While such listings might not lead to major capital raising for the affected companies – and may indeed have reporting and associated cost implications – it has a political and symbolic value that should be considered as well. African governments may further consider initiatives supporting exploration investments through, for instance, exploration-related tax credit schemes such as the flow-through share approach employed by the Canadian government. The latter allows investors in exploration, rather than the junior companies performing the actual exploration activities, to directly benefit from tax deductions plus additional tax credits in relation to their investments and the incurred exploration expenditure. Explorers may also seek financing through private equity, institutional investment funds or metal streaming companies, though these investors and lenders tend to enter at the feasibility stage or later, rather than in early-stage exploration projects.

Recommendation 2.3: Provide seed funding or competitive grants for African junior explorers.

As shown in Figure 2, African companies manage 16 % of all ECRM exploration projects (based on available public data) on the continent. While this is a respectable share, there is still room to grow. The AfDB (2022a) noted that the relative scarcity of African-based exploration (and mining) companies may create further dependencies for African countries. Starting an exploration company requires geological and management skills as well as access to funding. Skill development for African entrepreneurs looking to get into the mineral exploration business may be supported at the local university level or through training courses open to trainees that are already in employment. Access to funding for African explorers might be supported by creating a basket fund for exploration start-ups, supported by international development partners and/or the downstream industry. Funding could possibly be associated with a competitive grant system that is accessible to local geologists or other entrepreneurs for starting African junior companies and implementing initial activities for exploration target generation. Naturally, the available grant amount would have to be limited and might cover part of the budget for regional and limited site exploration, without coverage of extensive diamond drilling campaigns or similarly expensive items, while also requiring regular monitoring to ensure proper spending. Essentially, the grant would serve as a business incubator for new African exploration companies. Such a grant system

might be combined with funding to support travel for start-up explorers to attend key industry events such as the Investing in African Mining Indaba (Cape Town) or the Prospectors and Developers Association of Canada (PDAC; Toronto) for promoting their company, learning, and networking with potential investors. Moreover, an overarching support program might include complementary components such as facilitating the sharing or leasing of modern exploration equipment to participants, for instance hand-held portable X-ray fluorescence devices.

Recommendation 2.4: Consider investing in African ECRM exploration projects based on the continent's demonstrated potential to host significant deposits of metals associated with the energy transition.

AfricaMaVal Deliverable D7.1 (Stoltnow et al. 2024) presented factsheets on 59 African ECRM projects including 19 exploration projects, that, at the time of research, met certain selection criteria. Several of these projects were also discussed within the Minerals Security Partnership initiative. Potential investors interested in exploration are encouraged to perform further due diligence on these projects. The following section provides global context for some of these and other African exploration projects. Rankings in terms of resource endowment represent analysis performed by the authors based on the data currently available through S&P Global (2024). The context information below is provided to give an illustration of Africa's ECRM-related mineral potential. It does not imply that exploration-related investment should only target comparatively large projects, since the exploration process itself is meant to discover and add new resources while the economic viability of mining projects depends on many factors besides deposit size.

Nickel and cobalt: The cobalt potential for projects within the Central African Copperbelt (DRC, and to a lesser extent Zambia) is obvious. But while most of Africa's current cobalt production comes from the Copperbelt, the continent has additional cobalt potential as a by-product in nickel deposits such as Lubalisi (Tanzania) and Musongati[2] (Burundi); these deposits additionally show minor PGM mineralisation. In terms of cobalt endowment, both projects rank in the global top-25 of undeveloped deposits and contain significant nickel resources as well. Besides these two projects that are included in D7.1 reporting, African exploration projects with significant cobalt endowment outside of the Central African Copperbelt comprise Biankouma-Sipilou in Côte d'Ivoire and Gogota in Guinea (both nickel-cobalt projects) as well as Opuwo in Namibia (copper-cobalt). A D7.1 factsheet is available for the Zebediala deposit (South Africa) which has significant nickel resources, along with PGM, though only minor cobalt.

[2] Note that Musongati has already seen significant resource drilling and a so-called feasibility study was completed in 2011, but the project remains undeveloped due to challenging project economics and the feasibility study results have a high uncertainty that is more akin to a pre-feasibility study (at best). Due to these uncertainties, we do not refer to Musongati as a mining project.

Copper: In terms of large copper projects, a D7.1 factsheet was created for Western Foreland in the DRC. On a global scale, it currently ranks as the 34th largest copper exploration project and is located directly to the west of the giant Kamoa-Kakula copper mine. Since exploration at Western Foreland is still at a relatively early stage – with a maiden resource estimate published in late 2023 – copper resources may be expected to grow further. It should be noted that, due to geological factors, both Kamoa-Kakula and Western Foreland do not contain cobalt mineralisation, unlike most other copper projects in the DRC's Lualaba province.

Graphite: Africa's graphite potential is well known and a number of projects were brought into (or close to) production in recent years. Besides these well-established graphite projects, the continent hosts a number of exploration projects, for instance in Mozambique (Dombeya, Balam, Nipacue), Namibia (Okanjande/Okorusu) and Tanzania (Merelani-Arusha). By far the largest undeveloped project is Kasiya in Malawi, where a pre-feasibility study was completed in September 2023 and a D7.1 factsheet is available. Kasiya represents the world's largest undeveloped natural rutile project and the second largest flake graphite project.

REE: The Mrima Hill project (Kenya) shows significant REE as well as niobium resources, but is associated with high thorium grades as well, which might give rise to problems due to radioactivity. The D7.1 exploration stage-related reporting includes a factsheet on Monte Muambe in Mozambique, which globally ranks on 26th position in terms of reported REE resources.

Lithium: Africa hosts the world's largest undeveloped lithium deposit, Manono in the DRC. The project has already passed the feasibility stage, so it is not strictly speaking an exploration project, but legal and logistical factors represent challenges for mine development. Lithium exploration projects of note in Africa comprise Kamativi (Zimbabwe) and Bitterwasser (Namibia), for example.

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Recommendation 2.5: Support exploration project-related due diligence for prospective investors.

European investors are often not familiar with the mineral exploration business so that it may be difficult for them to evaluate the associated risks appropriately. This is all the more relevant for exploration in Africa, since European investors might regard the African continent as a high-risk environment where challenges still outweigh the opportunities. This is why it will be critical to involve independent, competent service providers to help prospective investors with project- or company-related due diligence. Such service providers need to have technical expertise on the matter at hand (that is, on the relevant ore deposit types, the associated market environment, and suitable exploration procedures), on financial and legal questions, and, importantly, regional experience in those regions of Africa where projects of interest are located. Similar to the way standard and certification initiatives point out accredited audit companies, the EU (at the Commission or member state level) or their African counterparts might research and publish lists of independent service providers to support prospective investors in engaging in exploration in Africa.

Recommendation 2.6: Support development of the local service sector for mineral exploration.

Mineral exploration benefits from a dedicated local service infrastructure. Supporting the development of such infrastructure additionally serves the objective of capturing more local value in a given country. International partners may work with national partners to support such developments. Reliable geochemical laboratories are of particular importance. Africa already hosts a number of commercial laboratories as well as university-affiliated laboratories, but in countries such as the DRC, the accuracy of in-country laboratory results is sometimes called into question. To produce acceptable results for mineral exploration, these laboratories need to offer sample preparation and analytical methods suitable for the ECRM commodities targeted in exploration, employ international QA/QC (quality assurance/quality control) standards and optionally obtain ISO 17025 (or ISO 9000) quality management certification. Running such laboratories will require a reliable supply of consumables, typically chemical products such as high-purity acids. Besides laboratories, there are other relevant exploration-related service providers in the scope of local sourcing, such as drilling contractors or expert consultants on geological, environmental and other questions. Careful market analysis is advisable to ensure that supply and demand of such services are balanced. Regional cooperation among African states may be an advantage in some sectors, as demonstrated, for example, by the multi-member state African Minerals and Geosciences Centre in Tanzania. Regional cooperation is not only beneficial in terms of market evaluation but might also be helpful in terms of skill development.

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Recommendation 2.7: Raise awareness on accreditation of Competent / Qualified Persons for reporting mineral resources and reserves.

Africa aims setting up its own mineral resource classification system, the African Mineral and Energy Resources Classification and Management System (AMREC), which is based on the United Nations Framework Classification for Resources (UNFC) framework (UNECA 2017) and shall include a Pan-African Resource Reporting Code (PARC). The UNFC framework – classifying reserves and resources established under certain reporting standards – is relevant for project developers seeking to have their project recognized as 'strategic project' in the framework of the European CRMA (although the latter focuses on mining and refining rather than exploration projects). While these developments are important, the Canadian and Australian stock exchanges are the global leaders for listing exploration companies and, thus, for attracting exploration capital. Also, the UNFC approach partly builds on these standards. The Australian and Canadian stock exchanges (or related entities) set quality standards to ensure credible reporting of exploration results, namely the Australian Joint Ore Reserves Committee's (JORC)-compliant reserves and resources or the similar National Instrument 43-101 Standards of Disclosure for Mineral Projects (NI-43-101) reporting (Canada). Such reporting requires exploration companies to enlist the services of Qualified (Canada) or Competent (Australia) Persons, typically geologists or mining engineers that demonstrate a specific level of professional experience (relevant for the exploration procedures and ore deposit type in question) and are members of a recognized professional association. Increasing knowledge among African geologists regarding the requirements for accreditation as Competent /Qualified and the associated career opportunities may support stock exchange-compliant reserves and resources reporting, even for companies that are not listed at these stock exchanges, such as African parastatal mining companies. This, in turn, might increase the international recognition of Africa's mineral potential. Ideally, this process would also take into account outreach on recent initiatives to support AMREC and PARC development as well as UNFC application.

Recommendation 2.8: Support regional greenfield exploration and baseline data generation in Africa.

Since the 1960s, UN organisations such as United Nations Development Programme have provided funding to spearhead regional exploration programs (typically stream sediment sampling) in many countries worldwide. These activities led to the identification of geochemical anomalies of key metals or pathfinder elements indicative of possible ore deposits. Other international donors (often through their geological surveys) or the producer countries themselves have intermittently supported regional geological mapping, geochemical and geophysical exploration activities. French activities in francophone Africa are a prominent

example in this regard, and other countries have implemented similar activities. Some efforts benefited from the pooled expertise of international consortia of geological surveys and specialized service providers, for instance the World Bank-funded mapping campaigns in Madagascar in 2005. Donor support for such regional exploration activities, targeting in particular the ECRM (rather than gold), is still worthwhile to pursue as these may lead to the discovery of ore deposits (at least if they show mineralisation close to the surface) or, nowadays perhaps more importantly, provide relevant baseline data for subsequent private sector exploration and target generation for deeper-seated ECRM mineralisation. This type of early-stage greenfield exploration activities should not be expected to result in the development of mines over a short-term planning horizon (up to 10-15 years) but is valuable for sustaining and diversifying mineral supply in downstream jurisdictions and economic growth perspectives in producer countries in the long term.

Recommendation 2.9: Improve accessibility to geological, geochemical, geophysical data at geological survey level.

Geoscientific data relevant for exploration comprise maps and other geological information, as well as processed geochemical and geophysical data, among others. African geological surveys often have historical data in their archives and maintain more recent data as well. A country's mineral potential may only benefit national economic development if such data are used by exploration companies to discover ore deposits. Governments in mineral producer countries may therefore maximize the potential for mining sector development if they provide easy, ideally online access to curated geoscientific data, free of charge or for a minor fee. To this end, countries may embark on initiatives to review, digitalize and manage all relevant geoscientific data, a process that might possibly be supported by international development partners. Nigeria's new Mineral Resources Decision Support System, recently launched with technical support by a German geo-consulting company, is a good example in this regard. Other African geological surveys such as the Geological Survey of Namibia have already started working on this subject as well. Cooperation projects such as the EU-supported PanAfGeo+ initiative might potentially be leveraged to provide guidance on this process, showcase how European geological survey address this question, and offer capacity development for African project participants. European geological surveys or international organisations might also make historical data available, so that African geological surveys may provide centralized access to all relevant data.

Recommendation 2.10: Support capacity development for African geological surveys to process exploration reports in a fast and reliable manner.

Frequently, mineral exploration concessions cover vast areas of prospective ground. Sometimes, concession owners hold on to exploration licenses for speculative reasons, aiming for profit by eventually selling the license off to other parties, for instance in case an ore deposit is discovered on a neighbouring concession. In order to hold on to the license without incurring substantial costs, these companies implement scaled-down token exploration activities (or avoid these altogether) to minimize their exploration expenditure. This situation is not desirable, since it promotes land grabbing and blocks access to the area for other exploration companies. Rather, holders of exploration licenses should invest in credible exploration activities as set out by national laws and regulations. National authorities in producer countries charged with supervising exploration progress, typically geological surveys, therefore need to efficiently process exploration reports submitted by license owners. This requires sufficient capacities in the geological survey to continuously review any submitted reports and react according to the country's regulatory procedures (in coordination with the mining cadastre) in case the license owner did not meet the requested requirements. International development partners may support capacity development in this regard, as efficient supervision of exploration progress ultimately benefits downstream ECRM access while avoiding land grabbing may also mitigate certain socio-economic problems in the producer country. While various European geological surveys, on behalf of bilateral or EU-funded development cooperation initiatives, already support capacity development among their African counterparts, the topic of processing exploration reports submitted by companies would merit more attention than it is currently receiving. It is important to note that for this approach to be successful requires full support by African geological surveys and related mining authorities. The latter may consider cooperation on exploration project-specific data processing a sensitive task due to the aforementioned links to permitting, which might be a political and governance issue in some countries. It is therefore more common for European and African geological surveys to cooperate on national- or regional-scale exploration data capture and processing, for instance with regard to airborne geophysical surveys (see, for example, GTK's recent support in Zambia).

Recommendation 2.11: Support local governments to build a globally competitive digital and transparent mining cadastre system.

One of the major obstacles, especially for junior explorers and miners, is the permitting process, as in the case of South Africa's ineffective SAMRAD system, which was criticised for years by investors as a bottleneck and hindrance to attracting investment. The first component of the exploration and mining value chain is the issuing of prospecting and mining licences, without

which exploration and mining companies are unable to conduct any exploration. An efficient mineral right cadastre system also enhances investor confidence in the mining sector by ensuring transparency around the security of land tenure. While progress has been made, there are still many countries in Africa that require hard copy applications, do not have an online mining cadastre system or apparently have inactive or outdated public web portals.

Recommendation 2.12: Raise awareness on ESG impacts and the role of artisanal miners in mineral exploration.

In a greenfield exploration setting, exploration geologists are often the first point of contact with local communities. The way exploration company staff conduct themselves and manage communication will have a major impact on subsequent corporate relationships with local communities. Furthermore, in central Africa, exploration concessions in key mineralized regions such as the Copperbelt (copper-cobalt) or in the Kibara pegmatite belt (tin, tantalum, tungsten) have a high chance of hosting artisanal and small-scale mining activities. In fact, exploration companies sometimes infer the presence of sizeable ore deposits from the observation of artisanal mining activities; conversely, artisanal miners may also get attracted to concession areas due to active corporate exploration activities.

Therefore, even in early stages of exploration, adequate knowledge of relevant ESG questions, communication management and engagement with local communities as well as with artisanal miners are important factors for responsible exploration and, later on, mining. While standards and certification schemes in mining are widely known, guidance is nowadays also available to help addressing ESG questions in exploration, such as the PDAC eplus principles (PDAC 2014), the Association of Mining and Exploration Companies (AMEC; 2023) Guide for mineral explorers on ESG, or the Initiative for Responsible Mining Assurance (IRMA; 2023) draft standard for responsible mining and mineral processing 2.0, which includes exploration in its scope. An update of Australia's JORC code, currently under review, will also draw more attention to ESG factors than before. It is recommended to promote the awareness on such guidance documents among local exploration company staff as well as among employees of the geological survey and similar government departments. Local government staff may play a particularly important role as mediators in situations where artisanal miners are present on the concession and the exploration company seeks ways for tolerating their presence and supporting setting up legal artisanal supply chains, subject to meeting certain conditions and in compliance with the national regulatory framework.

Recommendation 2.13: Support exploration activities to help formalizing the artisanal mining sector.

At least 19 African countries host ASM activities that produce a range of different ECRM (Vasters & Schütte 2023). Almost everywhere, these activities are informal or illegal (Sewpershad & Tufo 2024). The Mining Code of the DRC, representing Africa's most significant artisanal ECRM producer, contains the provision of establishing artisanal mining areas for hosting legal ASM operations. Establishing these artisanal mining areas requires exploration efforts to demonstrate the existence of an ore deposit suitable for ASM exploitation while, at the same time, the deposit should not be suitable for large-scale industrial mining. In the absence of geologically and logistically viable artisanal mining areas, artisanal miners illegally work on industrial concessions instead. This legally problematic situation is one of the reasons why ECRM produced by artisanal miners are frequently not accepted by European buyers. Supporting sector formalisation through exploration and designation of artisanal mining areas may therefore contribute to strengthening responsible artisanal supply chains and EU market access for thus produced ECRM. This approach is currently tested by the BGR and its partners in the DRC ministry of mines within the German-Congolese development cooperation framework (Ducellier et al. 2024), but a significant expansion of such activities would be required to make a mark on the country's large ASM sector.

Recommendation 2.14: Reinforce the role of mineral exploration in local university curricula and provide support to students to gain practical experience.

It has become a common benchmark in mining to maximize local employment. In mineral exploration teams, experience with relevant ore deposits and a successful track record of discoveries are key ingredients to achieve success. As future members of such exploration teams, geology students enrolled in African universities may benefit from courses tailored to relevant exploration questions. Beyond basic skills such as mapping and geochemistry, this refers to information on the particular ore deposits hosting ECRM (since these may have to compete with gold deposits for exploration expenditure) as well as new exploration techniques enabled through digitalisation, such as the increasing use of drones or data interpretation based on 'big data' and machine-learning approaches. Moreover, practical experience is of special value when training geologists. This can be achieved through academic cooperation with the mineral industry, for instance by inviting guest lecturers or facilitating short courses. It is also highly important to facilitate field visits to ore deposits, facilitated by experts familiar with mineralisation and rock alteration features. Local exploration and mining companies may already offer – or otherwise may be encouraged to offer – summer jobs for students to gather initial practical experience. Such activities may be more straightforward to implement in well-known historical mining countries, such as South Africa and the DRC. In countries with lesser exposure

to mining and exploration, international geological societies (e.g., the Society of Economic Geologists, the Society of Exploration Geophysicists or the Society of Geology Applied to Mineral Deposits) might help bridging the gap, along with funders such as the United Nations Educational, Scientific and Cultural Organisation (UNESCO) – they may be approached by local universities to provide access to experts as guest lecturers, conferences and associated short courses, and field trips for students to gain practical experience.

Recommendation 2.15: Fund research and postgraduate projects focusing on ECRMs in Africa.

Geological surveys in Africa typically conduct mapping on a broad, regional scale, and the detail of their work often depends on available budget and staffing resources. The available geological data is frequently outdated and includes generalisations that exploration companies only become aware of once they are on site. Research and postgraduate projects conducted by universities may involve more detailed geological mapping in smaller areas. By funding research and postgraduate projects that focus on specific ECRMs, not only can we support capacity building and encourage research work on ECRMs, but we might also enhance the precision and quality of geological data. The data produced from these detailed studies – such as mapping data, geochronological or geochemical studies, or structural geological work – are often made publicly available, which is invaluable for exploration companies and investors. This detailed and accessible information allows exploration companies to make more informed decisions about potential new deposits.

Recommendation 2.16: Support African-European cooperation in ore deposit research.

A number of European geological surveys is implementing research activities to better understand the potential of certain ore deposits to host specific ECRM that do not necessarily represent primary commodities but might be of interest to be recovered as by-product in mining and refining, or through re-processing of historical tailings and waste dumps. ECRM that might be of interest in this context are, for example, REE, yttrium, niobium, tantalum, indium, germanium, antimony, nickel, PGM, and cobalt. Beyond geological studies, research efforts may also include research on developing and improving economically and environmentally suitable processing methods to recover such ECRM. Implementing these activities in close cooperation between European and African partner geological surveys might represent an advantage for both sides in terms of access to samples, research capacities, and marketing of results. In the longer run, advances in ECRM-related ore deposit research with respect to Africa will benefit exploration activities in that they allow testing new targets or analysing metals typically not covered in standard exploration campaigns. This may further stimulate re-evaluating historic tailings and

mine waste dumps. Re-processing such secondary deposits has the added advantage of allowing the introduction of improved environmental management at such historical sites, which were not applied at the time of initial mining activities.

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3 Industrial mining

3.1 Current ECRM mining and market dynamics in Africa

Africa is endowed with many of the key minerals used in electrification, renewable energy generation, battery electric vehicles (EV) and new forms of energy storage, which are critical to the expanding low and zero carbon industries. The African Natural Resources Management and Investment Centre within the African Development Bank (AfDB) and its partners have initiated the development of an African Green Minerals Strategy to proactively engage with the new conditions arising from the global energy transition (AfDB 2022a). Individual African countries are in the process of developing strategies as well, for example Zambia, which released a national critical minerals strategy in 2024 (MMMD 2024). In order to meet the policy goal of increasing local value addition, some mineral-producing countries have turned to introducing export restrictions for ores and concentrates. For example, Namibia and Zimbabwe banned exports of un-processed lithium ore in 2023 (Reuters 2023a, Reuters 2023b) while the DRC's Article 108 of its Mining Law (2018) restricts the export of unprocessed minerals in general, though allowing for exceptions related to energy and/or smelting capacity bottlenecks.

Figure 5 shows an overview on mining in Africa with ECRM production data registered in S&P Global (2024). At the time of research (August 2024), this database showed a total of 91 of such projects for the following primary ECRM commodities: Bauxite, chromite, cobalt, copper, graphite, ilmenite, lithium, manganese, nickel, platinum, tin and vanadium. Similar to the distribution of exploration projects (Figure 2), the majority of mining projects are concentrated in southern Africa. Traditionally, southern Africa has strong copper-cobalt (i.e., DRC and Zambia) and PGM sectors (i.e., South Africa and Zimbabwe). The continent hosts a broad range of additional mining projects, however, for instance on battery metals such as graphite (Mozambique and Madagascar), nickel (Botswana and Madagascar) and lithium (Zimbabwe) (see Stoltnow et al. 2024, Ramsaroop et al. 2024a; Appendix Table 4).

Forecasts describe strong global growth in critical minerals demand, with the combined market value of copper, lithium, nickel, cobalt, graphite and rare earths more than doubling by 2040, reaching a projected value of US$ 770 billion by 2040. The impacts of this market expansion are expected to spread out across different regions, especially for mining. In the base case scenario, considering production from existing facilities and those under construction, Africa may see a 65 % increase in the market value of its mineral production by 2030 (starting from US$ 45 billion in 2023), mainly attributed to the rapid expansion of copper production on the continent (IEA 2024a).

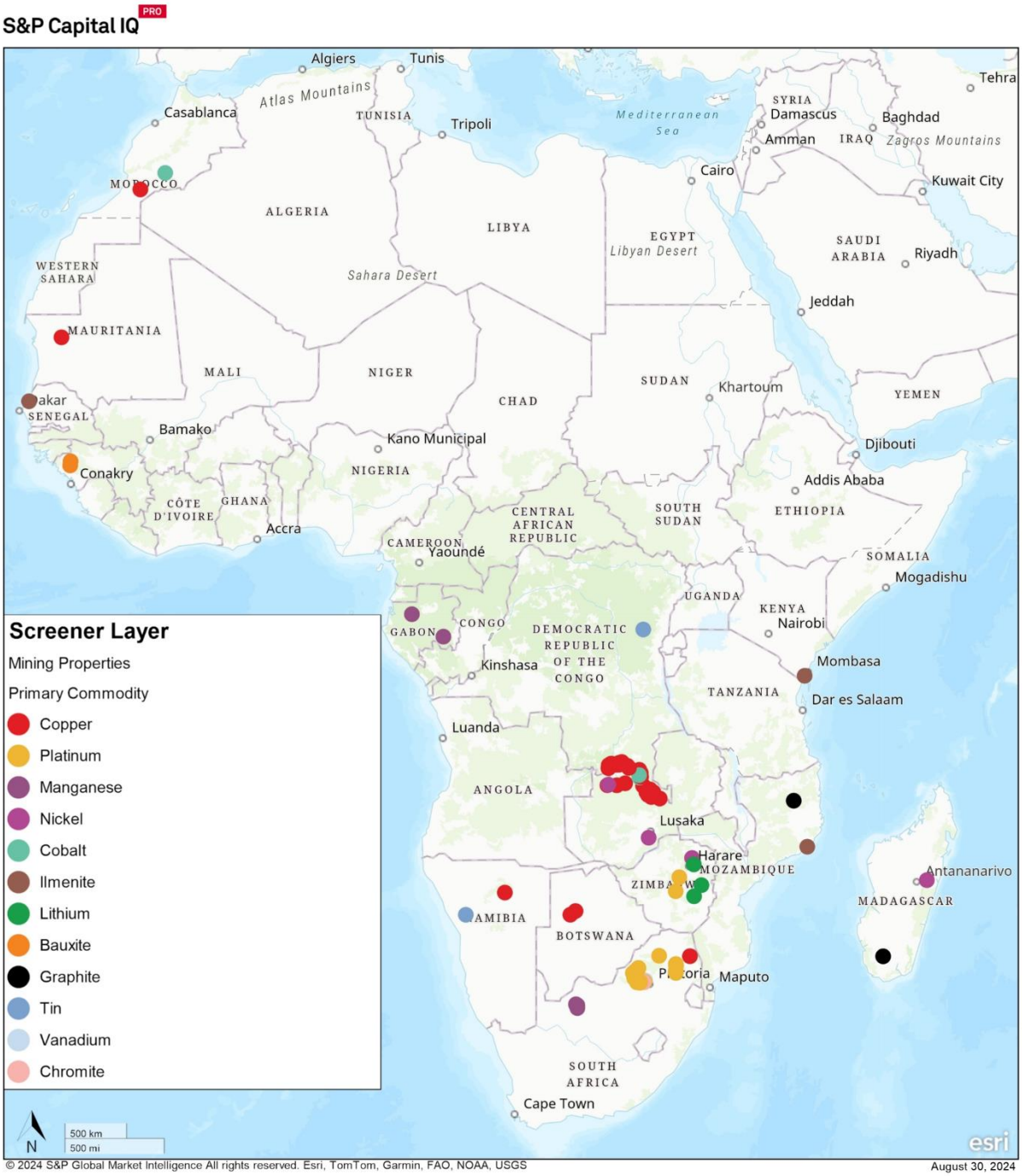

Figure 5. Location of currently active ECRM mining projects[3] in Africa, based on authors' evaluation of S&P Global (2024) data.

Economically speaking, **copper** may be regarded as Africa's most important ECRM mining commodity. Major and/or historic copper mining has taken place across the continent, with a

[3] Discriminating screening parameter in the S&P Global database: commodity production greater than 0 in 2023.

focus on southern Africa. Outside of the Andes region, the central African Copperbelt in the DRC and Zambia represents the world's most important copper mining district. Africa also hosts other copper provinces, such as the Kalahari Copperbelt in Botswana (extending into Namibia) or the historic base metal deposits of Congo Brazzaville. The Guelb Moghrein mine in Mauritania is an important copper producer, illustrating that northern Africa has copper potential as well, while artisanal and small-scale copper production is reported from countries such as Tanzania and Nigeria, in addition to the DRC and Zambia (Vasters & Schütte 2023). The global supply of mined copper reached ~22.4 Mt in 2023 (ICSG 2024), with Chile the world's largest copper producer accounting for 23.5 %, whereas the DRC and Zambia together share 13.6 % of the global mine production (ICSG 2024; Ministry of Mines 2024; S&P Global 2024). This reflects successful development and expansion of major copper mining projects in Africa over the past decade, such as Kamoa-Kakula in the DRC. In addition, at 4 %, Africa's copper supply disruption rate of originally planned production is slightly lower than the global average of 5 % (IEA 2024a).

Cobalt is a by-product of copper production in the DRC, which had a 74 % share in global cobalt mine production in 2023. There is currently an oversupply of cobalt, putting pressure on cobalt prices. Strong copper prices imply, though, that the DRC (and, to a lesser extent, Zambia) may continue to recover cobalt even at low metal prices, as it is a by-product of copper. Therefore, in absolute terms, cobalt production in the DRC may still continue to increase in the near future as copper mines such as Kisanfu and Kinsevere are ramping up or expanding production. Beyond Central Africa, Bou Azer in Morocco is a minor long-term primary cobalt producer while cobalt is also recovered as a by-product of nickel mining (Ambatovy in Madagascar) as well as in some of South Africa's PGM operations.

Medium-scale **lithium** mining in Zimbabwe has long been a relevant supplier of the glass and ceramics industry, but growing lithium demand from the lithium-ion battery (LIB) supply chain has spurred additional mine development and expansion, leading to production growth. In 2023, Zimbabwe produced about 7,700 t of lithium (41,000 t of LCE) in concentrates (in particular lepidolite, petalite). Further lithium mines are being planned or developed in Ethiopia, Mali, Ghana, Namibia and the DRC. Frequently, these mines used to be tin or tantalum mining operations where lithium has now become the primary commodity. At the moment, the lithium market is well supplied but requires continuous investment to develop projects to serve still rising long-term demand and meet supply diversification goals. At 2024 values, the current project pipeline requires US$ 0.65 billion for Zimbabwean lithium projects and another US$ 0.65-1.1 billion for other projects in Africa (IEA 2024a and references therein). There are risks that the current relatively low lithium price environment (though still reasonable in the historic perspective) may reduce appetite for investment in new lithium projects, including those with potentially good ESG performance or beyond core production regions, which would affect

medium- to long-term supply potential and the global concentration parameters of lithium hard rock mine production.

The mining of natural **graphite** is dominated by China, which accounts for 80 % of global production, but Africa has seen strong growth in recent years and hosts major graphite resources. Emerging producers are located in Madagascar, Mozambique and Tanzania. Care must be taken, though, to ensure mining activities are in line with the actual development of market demand, since several African graphite projects are very large. If these mines were run at full capacity, this might create market oversupply, especially in case demand for a given graphite specification turns out to be lower than predicted and/or anode manufacturers further expand their supply of synthetic at the cost of natural graphite. There is an economic risk for graphite mine operators and their investors if they cannot run their operations at full capacity or have challenges selling their products, as recently observed in Mozambique, for example.

Among the **REE**, neodymium and dysprosium are of particular interest for the energy transition due to their function in magnets for EVs or wind turbines. While neodymium is relatively common in many types of REE deposits (e.g., hard rock carbonatites or placer deposits), dysprosium and other heavy REE show enrichment (relative to light REE) in ion adsorption clay deposits. The Makuutu project in Uganda represents the latter type of deposit and has already passed the feasibility stage. Africa also hosts a moderate number of advanced-stage REE projects whose mineralisation is hosted in hard rock deposits such as carbonatites, for instance in Malawi (Kangankunde, Songwe Hill) and Angola (Longonjo). Once brought into production, these mines may be expected to annually produce concentrates or intermediate chemical products (mixed REE carbonate or sulphate) containing several 1,000 tons REE, to be further processed abroad. Other types of REE deposits occur as well and have already created international interest (e.g., Gakara in Burundi or Lofdahl in Namibia). Some REE deposits, for instance some of those found in South Africa and Kenya, are associated with elevated thorium content and, hence, high natural radioactivity, causing potential problems with shipping, processing/refining, and deposition of mining and processing residues, all of which may lower interest by international investors or buyers.

Besides the abovementioned commodities, several other ECRMs are extracted in Africa. Ambatovy in Madagascar is a significant producer of lateritic **nickel**, and additional potential for nickel mineralisation is associated with the East African nickel belt with Kabanga, Tanzania, currently representing the most advanced project. Nickel is also be recovered as a by-product of some PGM mining operations in South Africa and Zimbabwe, which represent the world's largest producers of **PGM**. South Africa is further a major **vanadium** producer and, together with Gabon, a major producer of **manganese**. Morocco is the world's second largest producer of **phosphate** rock and the world's third-ranked producer of **barite**.

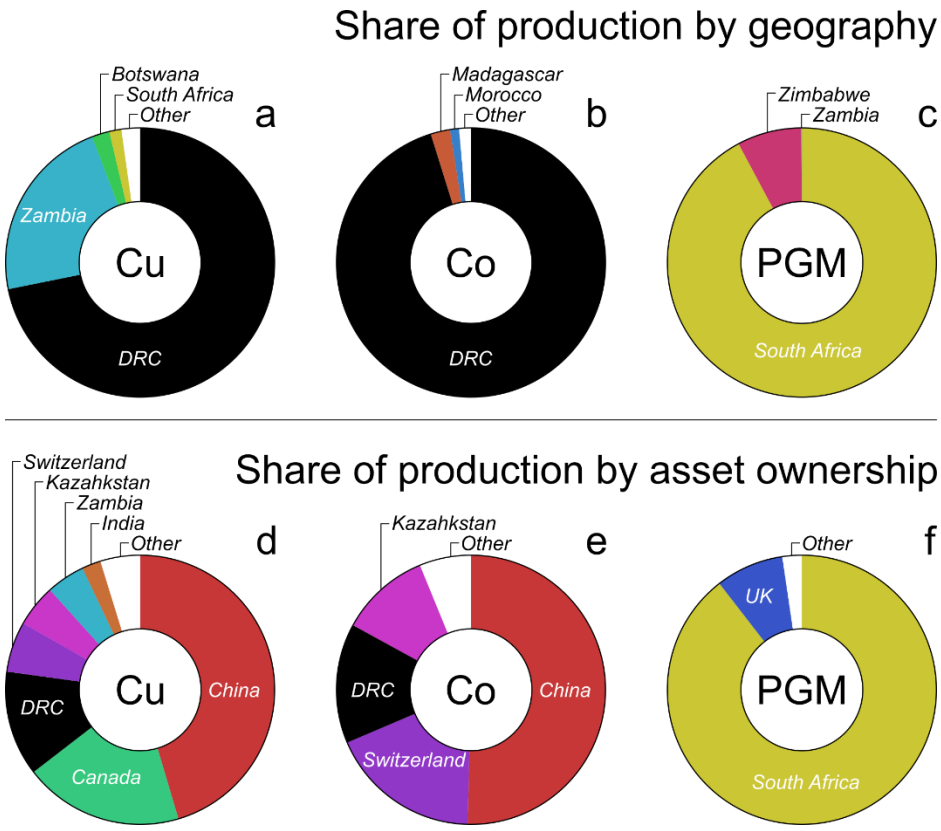

Figure 6. Share of production related to geography vs. asset ownership for copper, cobalt and PGMs (except osmium)[4].

In 2023, ~3.2 Mt of copper, ~175,000 t of cobalt and 229 t of PGMs (here simplified as platinum plus palladium) were mined in Africa. This corresponded to shares of 14 %, 74 % and 59 %, respectively, of global mine production (based on ICSG, 2024 and USGS, 2024). Assessing the attributable mine production by asset ownership (based on the owner's headquarter location) shows the influence of foreign shareholders in the African mining sector. As shown in Figure 5, African copper mine production is geographically concentrated in the DRC (72 %) and Zambia (22 %) and cobalt was mainly recovered in the DRC as by-product of copper mining (95 %). In terms of asset ownership, Chinese companies control major parts of African copper and cobalt mine output. Besides China, prominent investors in Africa's industrial copper-cobalt mining sector hail from Switzerland (Glencore), Canada (Barrick, Ivanhoe), Kazakhstan (ERG), and India (Vinmart Group, Chemaf/Shalina).

Regarding the African lithium-mining sector, out of the seven lithium assets that are expected to enter into production by 2027, five have at least 50 % equity ownership by Chinese companies. One of the most significant investments was the Arcadia project in Zimbabwe (by Zhejiang

[4] Source: Authors' analysis based on input data from S&P Global (2024), CRU (2024), Ministry of Mines (2024) and ICSG (2024).

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Huayou Cobalt; IEA 2024a, Meck et al. 2023). In general, China's investment in and acquisition of African mines has reached record levels of US$ 18.7 billion between 2019 and 2023 (AEI 2024). AfricaMaVal country case studies revealed the dominance of certain foreign direct investors in the respective ECRM mining sector including from:

- France and China in Gabon (Bailly et al. 2023);
- China, India/UAE, Kazakhstan, and Switzerland in the DRC (Stoltnow & Schütte 2024);
- Australia, Canada, Korea, India, Japan and the UK in Madagascar (Picault et al. 2023);
- Australia, Ireland and the UK in Mozambique (Represas et al. 2023);
- Australia, Canada, Oman, South Africa, the UK and the USA in Namibia (Drobe 2023);
- France, Switzerland, the UAE and the USA in Senegal (Pochon and Zammit 2023);
- Australia, Canada, China, Finland, Russia, Switzerland, the UK and the USA in South Africa (Cornelissen et al. 2023); as well as
- Australia, China, the UK and the USA in Tanzania (Ramsaroop et al. 2024b).

ESG is of major importance in the African mining sector, though European public attention tends to focus on ESG risks, rather than ESG opportunities. The DRC frequently takes centre stage in the European press with prominent mentioning of risks such as corruption, conflict financing, child labour, gross human rights violations and mineral smuggling. While many of these challenges especially apply in the ASM sector, there are overlaps with large-scale industrial mining in terms of location (e.g., ASM on industrial mining concessions) or along local supply chains. More detailed NGO reporting has additionally identified risks in industrial mining, such as governance challenges, forced evictions, inadequate community consultation, lack of grievance mechanisms, lack of free, prior and informed consent, and impact on the environment, to name but a few major discussion topics. Depending on their conduct, the actions of mining companies may variably cause ESG concerns or bring about positive ESG-related developments in the mine and surrounding communities. As seen in ESG-related assessments at the mine level, concerns on some ESG aspects and positive change in other areas do not have to be mutually exclusive.

Based on analysing ESG-related mining incidents and their relationship to project delays and supply disruptions, Kühnel et al. (2023) found that most ESG incidents in African mining are specifically associated with labour issues (strikes) as well as perceived livelihood limitations. Environment-related mining incidents, specifically pollution events, were observed as well, but to a lesser extent, and they did not cause as much local supply interruptions, project delays or regulatory reactions as social issues did. This is not to say that investors should not be wary of all ESG dimensions – they may have to consider them comprehensively anyway, based on applicable

financing standards such as the IFC performance criteria. But it is important to note that the impact on supply security or supply chain resilience may differ based on the ESG parameter in question. In addition, with increasing effects of climate change, environment-related supply interruptions might play a more prominent role in the future. A recent example for this is the El Nino-related drought in Zambia and Zimbabwe, causing a major decrease in hydropower generation at the Kariba Dam and dramatic energy deficits in both countries throughout the year 2024. On the other hand, the counterpart to the El Nino phenomenon – La Nina – may lead to widespread flooding, which may also impact on mining and transport logistics. In addition, negative environmental impacts from historic, rather than current mining operations, tend to generate harmful effects to the present day. This refers, for example, to long-term challenges of acid mine drainage in South Africa and its impact on local water quality, or past sulphur dioxide emissions in the Copperbelt, which caused acid rain and structural damage to buildings.

While all these ESG risks are highly pertinent in Africa's mining sector, the sector presents a number of ESG-related opportunities as well. Africa's strong potential for renewable energies, including the already existing hydropower capacities in certain regions of southern-central Africa, but also solar power, may reduce the carbon footprint of African mining operations. These effects may be leveraged further if grid stability was improved and if additional measures such as mine fleet electrification were introduced. As noted above, though, hydropower supply may be particularly vulnerable to the effects of climate change in some cases. Logistically, ECRM production in many African countries has a high potential for being associated with relatively short, direct supply chains to Europe, which is favourable both from a supply security as well as climate (emission) perspective. This effect will be more pronounced once certain infrastructure development initiatives, such as the refurbishing of the Lobito Corridor, are brought to fruition.

Mining is an important direct and indirect employer and source of state revenues in Africa, including in remote regions that might otherwise see little business and public infrastructure development. The continent's desire for increasing value addition in mining, as reflected in key policy documents such as the Africa Mining Vision, aligns well with Europe's ECRM supply needs, which do not necessarily require importing unprocessed raw materials. As such, mining may continue being an important contributor to economic development in Africa, especially if the continent's own market potential is considered, for instance regarding battery value chain development in connection with two and three-wheel EVs. Finally, while this report and the AfricaMaVal project as a whole focus on ECRM mineral commodities, it is important to point out Africa's potential for green and blue hydrogen production as a complementary factor. These are but a few examples that illustrate potential ESG-related discussion topics between Europe and Africa beyond the risk and compliance perspective.

3.2 Investment considerations at the mining stage

Profitable operating mines, without plans for expansion, do not necessarily seek investors, especially if the operator has recovered the initial investment and has no problems managing the mine's sustaining capital expenditure. Operators tend to refinance their debt at the start of mine operations once they have demonstrated their capacity to deliver and operate the project which should typically allow them to negotiate better terms. Operating mines, or projects nearing completion of construction, may seek external investors in some cases, though, without plans for an expansion. This may occur, for instance, if the operator is under financial duress due to low commodity prices and/or in case they need to manage their leverage ratio, that is, their relative debt load and its financial implications for the operator (see, for example, Chemaf's challenges at the Mutoshi Cu-Co project in the DRC). In some cases, operators may seek external investors for political reasons (e.g., to get into a stronger negotiation position with the local government) or to ensure supply chain viability as well. Mines are often planned in progressive expansion stages where the operator may use current cash flow from the on-going operation and the security it provides to raise funds for an expansion. At that time, the operator may also seek additional investors, for instance through public or private placements of new shares.

From a downstream supply perspective, investing in operating mining assets (project joint ventures) or in the mine operator itself may provide three main advantages, depending on the specific interest of the investor: (1) ECRM processors may consider mining investments to ensure availability of and access to sufficient ECRM feed under viable conditions; if processors bought a controlling share in an ECRM producer, this may effectively correspond to vertical supply chain integration, but holding a minor share may already contribute to securing supply, especially if the deal is combined with an offtake agreement; (2) large downstream clients may consider investment in mines (or, more likely, the mine operator) to ensure sufficient supply for their direct and indirect suppliers – for instance, Chinese companies in the LIB and EV value chain tend to invest in mining operations abroad and, recently, a few western OEMs have started undertaking similar moves; (3) compared to offtake agreements without accompanying investments, investing in mines and holding a board seat allows downstream clients to exert stronger influence on the mining operation, for instance in case they wish to bring about positive ESG developments.

While lead development times for new mining projects are quite long, usually well over a decade (and sometimes much longer) from the point of ore deposit discovery, expansions of operational mines are commonly feasible over a time span of just a few years and offer substantial boosts to ECRM output. For instance, Barrick foresees a time period of about 4 years to expand copper production at its Lumwana mine in Zambia by 70 %, adding another 100,000 t of copper output. Expansion of smaller mines may take place over a shorter time span still. Therefore, mine expansion planning may be a particularly suitable instrument to increase ECRM availability by the

CRMA benchmark year 2030. Mine expansion is beneficial from an economic and risk management point of view, since the operator will already have good knowledge of the ore body (metal grade distribution) and the metallogenic processes (recovery rates), the project will be generating cashflow from existing operations, the operator has operational and regulatory experience, and may create synergies from the infrastructure and mine workforce already in place. These are positive factors to lower project and country risks, capital expenditure and operational costs per unit of contained metal.

ESG topics require special attention for mine expansion. There may be positive impacts such as a well-structured community dialogue in place or reduced carbon emissions per ton of produced metal due to operational synergies. On the other hand, there needs to be careful monitoring whether an increased environmental footprint of the mine, for instance in terms of water withdrawal, can be reconciled with local ecosystem functions and human needs, for example for agriculture. Mine expansion may also necessitate expansion of tailings dams and waste dumps, which can impact on emission management and can be a general challenge in densely populated areas, for land use by communities, and amid neighbouring mining concessions held by other companies. This challenge is particularly pertinent for the copper-cobalt mines in the Kolwezi area, DRC (Schütte 2021).

Investments in mining projects at the feasibility stage may offer some advantages as well as trade-offs compared to expanding existing mines. At this stage, investors may still exert somewhat greater influence over project development decisions in some regards, for instance in terms of ESG management. If sufficient capital is available, plans may be adapted to allow new projects adopting industry best practice from the outset, including the latest technologies for greater efficiency, digitalisation as well as advanced practices to enhance their ESG profile (for instance, lowering carbon emissions). This approach is often easier to handle and less capital-extensive then retrofitting an existing operation later. The trade-off is a higher project risk compared to a well-established, longer running mining operation, that is, even after a feasibility study has been released, a project may still face significant delays in development, for instance in case of regulatory challenges or in case the underlying business case is no longer valid due to changing metal market conditions, lack of supporting infrastructure development etc. Up to the point of construction and commissioning, and even post-commissioning, budget overruns often make mining projects significantly more expensive than originally planned, especially during periods of high inflation, in case supply of necessary goods and services for mine construction is interrupted, or in case the mine's processing facilities do not perform as intended and require further upgrades. In such situations, an investor may face tough choices such as doubling down on their investment, adding further external investors (which may dilute their own share), or risk the project not being completed or (temporarily) suspended in the end.

3.3 Recommendations and investment opportunities

The following recommendations may be broadly divided into two groups. The first group consists of general recommendations related to supporting investment in ECRM mining activities in Africa as described above. The second group comprises recommendations that are linked to specific African ECRM projects, usually at the feasibility stage, in current production or under expansion. The links to these specific projects mostly reflect input received from other tasks and deliverables of the AfricaMaVal project. In particular, this refers to the 30 factsheets of ECRM projects classified as mining stage (that is feasibility, mining or expanding) in AfricaMaVal Deliverable D7.1 (Stoltnow et al. 2024). As further described in that report, these projects were pre-selected against certain criteria such as availability of part of their ECRM production to the EU industry. The factsheets include project-specific information on project economics, ESG impacts and, for selected projects, on infrastructure and may be consulted for further information. Additional AfricaMaVal-related ECRM project information is illustrated in Ghezzi et al. (2024) and Ramsaroop et al. (2024a), among others. The following chapter presents potential investment opportunities associated with this range of projects and, in few cases, of additional projects (without dedicated evaluation within AfricaMaVal), based on different parameters of interest. Unless noted otherwise in the text below, all projects mentioned in the following are referenced in the above publications.

Note that the chapter only refers to advanced ECRM projects already at the feasibility, mining or expansion stage. Early-stage projects (scoping and pre-feasibility stage), on the other hand, are classified as exploration projects for the purpose of this report; these as well as all value addition projects (e.g., refining) are discussed in separate report chapters. We treat ESG as a cross-cutting issue in mining. Therefore, the presented recommendations may either target (1) increasing African ECRM mine production in general and improving supply availability to Europe; and/or (2) improving ESG performance of African mines which serves to promote the interests of local communities and the government as well as those of responsible investors. In doing so, the produced ECRM commodities would have a higher chance of meeting the responsible mining standards or assurance expectations set in European or in global supply chain initiatives and regulations. As such, improving ESG performance in mining may increase opportunities for direct market access of African ECRM to different international markets, including the EU. A pragmatic and balanced approach is advisable, enabling progressive ESG improvement of the local situation through time rather than demanding highest standards right from the start (e.g., Ufer et al. 2023). Insisting on the highest ESG standards from a European downstream perspective right from the start, on the other hand, might set unrealistic targets and exclude promising mining projects. Furthermore, it may be viewed as post-colonial paternalism by African stakeholders, who were rarely consulted when international supply chain regulations and assurance schemes were developed.

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Recommendation 3.1: Consider potential investment opportunities aimed at maximising ECRM supply.

For most raw materials, high-production mining projects involve the extraction of large volumes of ore, offering economies of scale, which reduce the cost per unit of material mined and processed, making these projects economically more robust across volatile commodity market developments. In some cases, synergies in processing in large-scale operations are beneficial from the perspective of emissions per unit of produced metal. On the other hand, developing and managing large-scale projects requires higher capital expenditure and may cause substantial environmental impacts in absolute terms. They may face complex regulatory and operational challenges (e.g., Darling 2011). Cost overruns due to delays as well as liquidity management challenges in project development tend to scale with project size. Still, investing in large-scale mining projects may make sense if downstream ECRM demand is substantial and major downstream OEM seeking to secure sufficient ECRM supply may prefer investing in one or few large-scale projects, rather than in multiple smaller projects. Large-scale projects may also generate particularly strong synergies with the development of infrastructure corridors, such as the Lobito Corridor.

This report does not define a fixed ore throughput rate for the identification of large projects. Rather, we identify high-production projects based on their relative global position in terms of actual or projected ECRM production. If the produced commodity at a given project was among the global top 20 % of mining projects for that specific commodity, we include it in the group of “high-production projects”. The selection of the 20 % margin is based on the Pareto principle, which states that, for many outcomes, roughly 80 % of consequences come from 20 % of causes (the "vital few"; e.g., Juran 2019). Mining projects presented in the AfricaMaVal project (Ramsaroop et al. 2024a; Stoltnow et al. 2024; Appendix Table 4) include high-production projects (referring to the production year 2023; S&P Global 2024 and references therein) in the following commodities:

- Graphite: Balama, Syrah Resources (Mozambique), 94,000 t graphite;
- Nickel: Ambatovy, Ambatovy Minerals (Madagascar), 41,000 t nickel (with 4,076 t cobalt by-product);
- Copper: Lumwana, Barrick Gold (Zambia), 118,000 t copper (currently under expansion with 240,000 t copper targeted capacity);
- Bauxite: Sangaredi, Rio Tinto (Guinea), 14.28 Mt bauxite;

- Heavy mineral sands: Moma, Kenmare Resources (Mozambique); with ~1.0 Mt of ilmenite (328,000 t of titanium; and potential for rare earths) the world's largest ilmenite producer (currently in transition with unchanged target capacity).

In addition to the mining projects discussed in AfricaMaVal, other African high-production mining projects illustrate the importance of the African mining sector in a global comparison. It is important to note, though, that the following projects do not necessarily fulfil any screening criteria and, as such, their production is not necessarily available and investment not advisable for the EU industry. The projects are only shown to illustrate the ECRM mining potential of the African continent:

- Manganese: Moanda, Eramet (Gabon), with 7.4 Mt the world's largest manganese producer; Nchwaning/Gloria (South Africa), 4.3 Mt manganese;
- Copper: the DRC is the world's second-largest copper producer, hosting, amongst others, Kamoa-Kakula, 393,500 t (currently under expansion with 600,000 t copper targeted capacity);
- Cobalt: the DRC is the world's largest cobalt producer, hosting the top 6 cobalt projects producing between 31,000 t and 7,000 t, such as Kisanfu and Tenke Fungurume (CMOC) or Kamoto (Glencore), with additional major production from mine tailings (Metalkol/ERG);
- PGM: South Africa is the world's largest PGM producer. With respect to platinum, South Africa hosts at least the top 5 platinum projects producing between 23.5 t and 9.3 t, such as Marikana (Sebanye Stillwater), Impala (Impala Platinum Holdings) and Mogalakwena (Anglo American Platinum). South Africa is the EU's largest supplier of iridium (93 %), platinum (71 %), rhodium (81 %) and ruthenium (94 %). According to the CRMA, no more than 65 % of a commodity should come from a single third country, which is why imports of these commodities should be more diversified, but this is difficult in the case of PGM since they show strong global concentrations in few countries.

Recommendation 3.2: Consider potential mining investment opportunities with long mine life.

While mining projects are typically planned for a mine life of 10-30 years, some mining projects can draw on large reserves and resources, which may result in mineral extraction over multiple decades. From a financial investment perspective, a long life of mine may not appear to be extremely beneficial if a discounted cash flow analysis is applied where project revenues far into the future have little impact on the net present value of the project. Equipment maintenance costs may rise through time. Moreover, future commodity market development and, hence,

commodity prices may be difficult to predict in the long run. Therefore, short-term mining activities and associated revenues are preferable from a pure financial perspective. From a national and local sustainability perspective, a long mine life has a positive impact, though, as long as the mine operator employs adequate ESG management. It ensures tax revenues and employment, while making it likely that the project operator will support local infrastructure development/maintenance and implement CSR measures (such as health centres, education) over a longer time period. This may improve long-term community economic development perspectives, if sufficient attention is given to the topic of alternative livelihoods and economic diversification. Strategic investors seeking with a particular focus on ensuring long-term ECRM supply may find long mine-life projects attractive as well.

The AfricaMaVal project (e.g., Stoltnow et al. 2024; Appendix Table 4) identified and assessed several African ECRM mining projects with a long mine life, including:

- Balama graphite project (Mozambique); the operator Syrah Resources currently anticipates a mine life until 2073;
- Kangankunde REE project (Malawi); the operator Lindian Resources Ltd. currently anticipates a mine life until 2070;
- Makuutu REEs project (Uganda); the operator Ionic Rare Earths Ltd. currently anticipates a mine life until 2059;
- Moma ilmenite (titanium)/heavy mineral sand project (potential for rare earths; Mozambique); the operator Kenmare Resources plc. currently anticipates a mine life beyond 2100;
- Toliara ilmenite (titanium)/heavy mineral sand project (potential for rare earths; Madagascar); the operator Base Resources Ltd. currently anticipates a mine life until 2063;
- Waterberg PGM project (South Africa); the operator Platinum Group Metals Ltd. currently anticipates a mine life until 2069.

Recommendation 3.3: Support potential investment opportunities where mining operations recover multiple ECRM in parallel.

Mining projects may recover multiple raw materials from the same ore body. For instance, pegmatite ore deposits often contain lithium, tin, tantalum and niobium (and sometimes beryllium or other elements) in variable proportions. In case different raw materials have similar expected impact on mine economics they are termed co-products; in case additional raw

materials have only a minor impact, they are referred to as by-products. Recovering multiple raw materials together as co-products is economically useful for the operator to diversify their revenue stream, access multiple commodity markets and thus become financially more resilient. The additional recovery of by-products, rather than co-products, has less financial impact on the operator but still allows unlocking additional revenues and contributes to customer diversification. In addition, it may unlock new funding options for mine development in case the operator decides to (partly) sell the rights to a given co-/by-product to a metal streaming company in return for an advance cash payment. Even though most streaming deals focus on gold, silver, and PGM, a large streaming deal for cobalt by-production associated with a major Canadian nickel mine was signed in 2018. Recovering ECRM as co- or by-product may make a given mining operation more attractive from a downstream supply or policy maker perspective. Conversely, recovery of non-ECRM such as gold and silver (e.g., as by-product of copper mining) may be beneficial for ECRM supply as well since it likely makes the mining operation economically more robust and, hence, may contribute to continuous supply even during periods of ECRM price weakness. From an ESG perspective, by-product recovery is beneficial as well, since it implies more efficient use of the extracted ore, with relatively modest additional processing efforts.

The AfricaMaVal project (e.g., Stoltnow et al. 2024; Appendix Table 4) identified and assessed several African ECRM mining projects, which (anticipate to) recover multiple ECRM in parallel, including:

- The Balama project in Mozambique, where graphite is currently being mined, also contains globally significant vanadium resources. The operator, Syrah Resources, plans to advance metallurgical studies and prepare a preliminary feasibility study for the Balama vanadium project;
- The heavy mineral sand extracted from the Moma project in Mozambique contains 91% (titanium-bearing) ilmenite. However, the operator Kenmare Resources plc. also produces small amounts of rare earths in monazite as a by-product;
- The Uis mine in Namibia has been in operation, with a few interruptions, since 1953 for the extraction of tin as the only commodity. The current operator Andrada, however, considers for phase 2 a staged ramping up of the co-production of petalite concentrate (18,000 t of lithium annually).
- The Kanyika project in Malawi is operated by GlobeMM, which produces pyrochlore concentrate (niobium and tantalum) from an alkali granite. Although the reserve contains niobium at ~3,000 g/t and tantalum at ~140 g/t, the significantly higher price that can be realised for tantalum over niobium makes these two commodities co-products at Kanyika.

Recommendation 3.4: Consider lessons learnt from successful ECRM mine developments in Africa: The example of the Molo graphite project in Madagascar.

Discovered in 2010, the Molo graphite project was developed by the Canadian company NextSource Materials who published the first feasibility study in 2017 and an update study in 2019, accounting for more recent market developments. Molo is a source of 'SuperFlake' graphite shipped to different international customers. Molo's processing plant was developed flexibly, with a modular and scalable build solution. The plant was built and tested for factory acceptance off-site, then dismantled, shipped, and finally re-assembled at the mine location.

Construction took place in two phases to manage capital expenditure and cashflow. The operator, NextSource, signed offtake agreements with interested parties from Japan and Germany in 2018 and 2021, thus supporting project development and value chain integration. In addition, in 2021, a Chinese company agreed to enter into a three-way partnership with NextSource and the aforementioned Japanese trader. The Chinese partner is described as a leading processor of spherical and purified graphite and is highly regarded by OEM anode manufacturers. The partnership will provide NextSource with funding for a battery anode facility (in South Africa, Europe or North America) to be fully owned and operated at a later date. The Chinese partner will provide technical expertise and build the plant in return for a licence fee. Molo's financial situation was further strengthened by a US$ 29.5 million investment by Vision Blue in 2021. Finally, in mid-2024, the World Bank through the IFC agreed to provide a substantial US$ 91 million senior debt facility, which enables a major expansion of the project from 17 ktpa to 150 ktpa.

Molo project development emphasizes the importance of different success factors such as favourable geology, diligent planning and project execution through different production stages, engagement of different value chain partners and attracting credible financial partners. These factors may be kept in mind as lessons learnt when developing projects elsewhere.

Recommendation 3.5: Consider mining projects located in EU raw material partner countries in Africa.

The EU strives for closer cooperation with countries in Africa and elsewhere in the form of strategic raw materials partnerships. At the time of writing, four Memoranda of Understanding (MoUs) for strategic partnerships have been signed with African countries while three more MoUs or similar forms of cooperation are under discussion. As a contribution to a viable partnership, facilitating investment or otherwise engaging with ECRM mining projects in these countries may be of interest for the EU to demonstrate that they mean business while also directly benefiting from potentially supportive measures that are planned as part of a given

partnership. Mining projects in these countries presented in AfricaMaVal (Ramsaroop et al. 2024; Stoltnow et al. 2024) include. The following. Note that exploration or refining projects are listed elsewhere.

- Namibia: Karibib, Uis, Tsongoari, Otjozondu, Omitiomire;
- DRC: Bisie, Mutoshi;
- Zambia: Konkola, Lumwana, Mopani;
- Rwanda: Musha-Ntunga, Nyakabingo;
- Uganda: Makuutu;
- South Africa: Steelpoortdrift, Steenkampskraal, Waterberg;
- Tanzania: Kabanga, Mahenge, Epanko, Nachu, Grafica.

Recommendation 3.6: Engage in dialogue on regulatory requirements, ESG expectations, product quality standards and market trends to facilitate increasing market access for African mineral products.

Currently, many Africa-EU raw material value chains pass through third countries for processing, refining and downstream manufacturing. It may be in the interest of both parties to establish more direct value chains, which may entail higher value addition in Africa as well. The EU might contribute to facilitating improved market access and supporting African raw material producers to access European markets. Setting up Africa-EU dialogue fora on regulatory requirements (e.g., in terms of supply chain due diligence, responsible mining principles, as well as safety-related aspects associated with the EU's REACH regulation), product quality standards and market trends for mineral products may contribute to developing a mutual understanding and recognition of opportunities. This is a dialogue between two parties, though. Europe should not realistically expect that African countries and companies would comply with all European requirements, at least not from the start. It is a certain challenge that many international ESG / responsible sourcing standards and regulations have been developed with little input and consultation of African producer countries. It is therefore important to understand each side's concerns and priorities while demonstrating flexibility in interpreting and applying regulations on the base of mutual good faith efforts. Existing platforms on ESG include, for example, the MSP ESG forum that is already supported by the EU and could facilitate dialogue events in Africa, including at national mining events or in cooperation with national mining associations (or chamber of mines). The EU and EIB might as well leverage the technical assistance tool embedded in the ACP trust fund for application in the ECRM sector in order to support adopting appropriate

environmental and social management systems at African ECRM facilities that may ultimately benefit direct market access of raw materials mined and processed there.

Recommendation 3.7: Analyse and support the framework for ECRM offtake agreements in EU-Africa value chains.

The EU may support the framework for ECRM offtake agreements between African and European value chain partners by providing access to information on all support instruments that are available at the Member state or regional level, and by expanding the reach of such instruments. This refers to financing and securing credit, for instance via the untied loan guarantees and activities by export credit agencies, as well as insurance services associated with value chain logistics. A comprehensive overview on this topic is provided in AfricaMaVal's deliverable D3.2 (Albery et al. 2024). To advance the practical application of such instruments, the EU might analyse the factors contributing to successfully negotiated offtake agreements (e.g., cobalt supply from Managem's Bou Azer mine for BMW and Renault), evaluate the resilience of such measures, while also mapping the challenges that have precluded such agreements in other places. It is important to note that offtake agreements may include third parties in third countries, for instance in case downstream OEM manufacturers conclude such agreements on behalf of their own suppliers. The EU is currently discussing the launch of a Joint Purchasing Platform for critical raw materials. By pooling demand, such a platform offers the opportunity to have a larger purchasing volume and thus improve the negotiating position vis-à-vis suppliers, allowing prices and supply to be negotiated more favourably. However, industry interest (which products and up to which stage of the value chain) still needs to be ascertained, necessitating outreach to companies and analysis of their purchasing requirements.

Recommendation 3.8: Consider investing in projects or companies with existing offtake agreements with European companies.

Investing in African ECRM projects or companies that have already signed offtake agreements with EU partners may further strengthen the availability of raw materials for the EU, since the existence of such offtake agreements demonstrates that the involved project operators at that time fulfilled downstream expectations. Expanding these projects, developing similar projects by the same operator, improving the ESG performance of such projects (e.g., by developing renewable energy supply), or optimising supply chain logistics may all contribute to increasing long-term ECRM supply resilience. During potential periods of commodity price weakness, it may further be worthwhile to consider strategic financial support to the project operators to prevent

them from shutting down the mine (temporarily or permanently) and to maintain existing value chain partnerships, for instance by providing a credit line at preferential rates.

Within the AfricaMaVal project, the following companies were identified (and corresponding projects assessed) that operate mines or projects at the feasibility stage in Africa and have signed offtake agreements with the EU/European industry:

- Ecograf (Epanko project, Tanzania) has signed binding offtake agreements with the German commodity trader thyssenkrupp Materials Trading GmbH as well as with the German group Technografit for the production of high-grade graphite;
- Magnis Energy Technologies (Nachu project, Tanzania) has offtake agreements with the trading company Traxys (Luxembourg) for 600,000 t of graphite concentrate over a 6-year period;
- NextSource (Molo project, Madagascar) has signed a long-term agreement with the German commodity trader thyssenkrupp Materials Trading GmbH for the sale of NextSource's SuperFlake® graphite products;
- Greenwing Resources (Graphmada project, Madagascar) has sold a range of graphite concentrates to customers in Europe under an offtake agreement;

Apart from the examples already documented in AfricaMaVal-related deliverables, there are other ECRM offtake agreements between companies operating in Africa with Europe whose projects do not necessarily fulfil the AfricaMaVal screening criteria outlined in deliverable D7.1:

- In 2020, the Moroccan state-owned company Managem (Bou Azzer) signed a five-year cobalt supply deal with der German carmaker BMW. Additionally, from 2025 on, Managem is due to supply the French carmaker Renault with 5,000 t of cobalt sulphate;
- Marula Mining (Blesberg lithium-tantalum project, South Africa) has signed a long-term offtake agreement with UK-based base metals, minerals and energy commodities trading group Fujax, UK for spodumene ore and concentrate.

It is important to note that offtake agreements, especially if signed by downstream OEMs, imply that these offtakers may be held partially accountable in case of any actual or perceived adverse impacts of mining activities with regard to ESG. For example, the press, especially in Germany, publicly discussed BMW's responsibility in terms of supply chain risk monitoring when arsenic contamination at the Bou Azzer mine was made public in late 2023. Although this may cause reputational concerns, it is at the same time in the spirit of European (and, in this case, German) due diligence regulations that require downstream companies to engage with their whole supply chain in case of substantial concerns. The offtake agreement allowed BMW to follow up on the

mining-related allegations and discuss mitigation measures with the Moroccan mine operator. This transparent relationship is commonly viewed as favourable compared to a hypothetic situation where the downstream manufacturer argues that they do not know their indirect (n-tier) suppliers.

Recommendation 3.9: Encourage project operators/owners of ECRM mining projects in Africa to become members of the European Battery Alliance/the European Raw Materials Alliance.

In 2017 and 2020, the European Commission launched the European Battery Alliance (EBA; EBA 2024) and the European Raw Materials Alliance, respectively (ERMA; ERMA 2024). These initiatives are meant to increase Europe's global competitiveness in battery technology and production and support the diversification in the sourcing of raw materials from third countries to mitigate risks from international trade distortions. The EU or downstream stakeholders might therefore encourage project operators/owners of ECRM mining projects in Africa to become members of the EBA/ERMA. EBA/ERMA members are supported in networking and may profit from the following services provided by the EU:

- A One-Stop-Shop[5] to provide guidance in facilitating access to EU public finance. Members may gain knowledge on how EU financing programmes work and receive guidance in developing their investor material. They may benefit from an industry fitness check as well as technical and market intelligence supporting a high investment attractiveness. The One-Stop-Shop offers an assessment of a company's investor readiness for investor introductions potentially leading to a recommendation for investment opportunities to InnoEnergy in case of providing a stand- out business case;
- The Business Investment Platform for key stakeholders along the entire battery value chain with financial institutions – public and private – and several core industrial partners.

Recommendation 3.10: Stimulate cooperation, networking, business and skills development for European service providers in mining and processing technology in Africa.

African value chains face various bottlenecks (e.g., Ramsaroop et al. 2024). One particular challenge is a lack of key technologies and innovation centres in the African mining sector. In mining, digitalisation and automation are considered key enablers for cutting certain capital and operating expenditures through process optimisation and optimised equipment utilisation.

[5] Currently, the service is only available for start-ups or scale-ups with fewer than 249 employees on the payroll. As the service grows and adapts over time, the aim is to open it up to larger companies as well.

Examples include: (1) automated bucket-wheel excavators in open pits; (2) remote operation, where the machine operator is located in a safe environment (e.g., control room) that can be hundreds or thousands of kilometres away; (3) electric or battery-powered machine equipment to keep emissions within legally prescribed thresholds; (4) drone and robotic technologies for inspection and monitoring tasks in grade control or hazardous areas for human workforces (Clausen et al. 2020). However, the accelerated adoption of cloud, analytics and automation in the mining sector, as well as disruptive innovation to meet decarbonisation targets, is also making companies more vulnerable to fraudulent cyber activity.

The EU could encourage and provide support for European mining suppliers and service providers (including well-established companies as well as start-ups or academic research institutions) to facilitate the transfer of state-of-the-art mining, processing and monitoring equipment for use in the extraction of ECRM in Africa. This approach might seek to combine the business interests of European service providers with professional skill development for African partners. Besides all technical aspects of digitalisation in mining, cybersecurity and protection of patents could be considered as well. Importantly, European companies need to respect local content regulations established by African countries, so that they might be expected to enter into joint ventures or register for business in a given country, along with the associated requirements (for example, regarding the share of local partners in joint ventures).

The following examples of EU-based companies might consider activities in Africa in terms of ECRM-related business, research and development opportunities and are partly already operational on the continent:

- The mining supplier Epiroc is one of the world's leading providers of automation solutions, including for remote-controlled and fully autonomous drill rigs above and below ground as well as for remote-controlled and autonomous loaders and trucks above and below ground. The company is also supporting improved ESG performance in mining through battery-powered, emission-free equipment, including underground loaders, mine vehicles and drills for tunnelling, production drilling and rock stabilisation. The company established offices in Botswana, Burkina Faso, the DRC, Ghana, Kenya, Mali, Morocco, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe.
- Liebherr is a service organisation that has established several subsidiaries on the African continent to supply the mining sector with Liebherr machines and maintenance. So far the company established offices in Algeria, Ghana, Morocco, Mozambique, Nigeria, South Africa and Zambia.
- Indurad is a globally operating mining supplier specialising in the use of 1D, 2D and 3D radar technology in mine processing (mine feeding, bulk material in the plant, bulk

material volume), bulk material logistics (train logistics, stockyard management, ship loading) and underground mining (collision avoidance, production and automation, continuous mining). The company established an office in South Africa.

- Norsk Elektro Optikk is a privately owned research company within the field of electro optics. Amongst several fields of application, the company's HySpex (hyperspectral imaging) sensors can be used ground-based for product quality control, grading, close-to-face sorting, tailings monitoring and waste processing. Norsk Elektro Optikk's partner, Mapping Solutions Ltd. (UK), already serves the following African countries: Algeria, Egypt, Libya, Mauritania, Morocco, Sudan and Tunis.

Formal associations of companies are active in mining abroad, or consider becoming active there in the future. These formal associations may form a platform for information and the exchange of experience on the raw materials industry activities of their member companies abroad and represent the common interests of their members in their foreign activities vis-à-vis national and foreign institutions. For example, Euromines is the European Association of Mining Industries, Metal Ores & Industrial Minerals. The association is the recognised representative of the European metals and minerals mining industry and represents 14 national European associations and 17 companies as direct members from all over Europe.

Recommendation 3.11: Facilitate the interaction between EU and African researchers and students involved in the development of mining and processing technologies.

In addition to the aforementioned recommendation on technology-related networking, business development and training, it is worthwhile supporting interaction and cooperation among European and African research organisations and scientists on mining-related disciplines. Research initiatives in the mining sector tend to be fragmented and rather poorly coordinated, on both the European and African sides. This results in unrealized synergy opportunities. Research projects may run in parallel or in relative isolation, rather than supporting each other or pooling resources. European and African research institutions often have different research focuses. While European institutions tend to prioritize technological innovation and sustainability in mining, African researchers often focus on the immediate challenges of mining in their countries, such as environmental issues, working conditions, and corporate social responsibility. The EU research sector could (1) seek to increase access to innovative technologies and research findings in the mining sector that are not yet widely disseminated in African countries; (2) advocate for closer cooperation to give African institutions access to and ownership in research results that will contribute to the long-term strengthening of local capacities and research independence. Potential opportunities in this regard comprise, for example:

- SDG Graduate Schools is a programme of the German Academic Exchange Service that aims to contribute to the Sustainable Development Goals (SDG) of the United Nations. As part of the programme, partnerships are formed between higher education institutions in Germany and, among others, African countries to establish graduate schools in the latter. So far, graduate schools have been established in Cameroon, Ethiopia, Ghana/Nigeria and South Africa. Additional graduate schools that focus on sustainability in the mining sector could be launched over the next few years.
- EURAXESS and African Research Initiatives: The ARISE Programme, launched by the EU, funds African researchers working on scientific excellence, while partnerships with the European Research Council (ERC) enable non-European scientists to work in Europe. These programs provide funding and support for collaboration between European and African researchers in areas like natural resource management.
- The African Center of Excellence for Research and Innovation on Batteries (CAEB) is a joint initiative attached to the University of Lubumbashi in the DRC and involving partners from Zambia and Europe, and supported by UNECA. The initiative includes both the academic and the private sector.

There are also mining-specific societies, such as the Society for Mining, Metallurgy & Exploration (SME), the Southern African Institute of Mining and Metallurgy (SAIMM), the Minerals Council South Africa, or the Society of Mining Professors (SOMP) with members from all over the world representing industry, science and government organisations. The societies offer, amongst others, symposia for the regular exchange of knowledge, research and teaching co-operations, (funded) joint field trips, short courses or even publish scientific journals.

Recommendation 3.12: Explore support options for developing mining projects that have already passed the feasibility stage but whose completion has been suspended by the project developer due to financial bottlenecks or risk considerations.

In the development of mining projects, project operators may suffer financial bottlenecks due to budget overruns, overleveraged balance sheets or an inability to honour their debt obligations (e.g., due to market developments or implementation falling behind the schedule), which can then lead to the project being suspended. If the project is then put up for sale or simply abandoned once the initial investors walk away, there is a possibility that the project (or the associated company) will be available to third parties, possibly at a discounted price. In consultation with African partners, the EU could engage in supporting re-activating abandoned mining projects with significant geologic ECRM potential and/or initiate measures to minimise further risks in resumed project development. Examples to consider in this regard might include:

- The French mining company Eramet, through its subsidiary Comilog, developed an innovative hydrometallurgical process for the Maboumine rare earth-niobium-phosphate project in Gabon. This process includes five patents, a fluorine-free niobium/tantalum purification step, the production of ferroniobium by aluminothermic reduction as well as the recovery of the individual rare earth oxides. Nonetheless, in 2022, Eramet sold its shares in the Maboumine project for a symbolic price of one franc to the Gabonese government and walked away from the project, as the company was unable to find partners to mitigate the potential risks associated with further investment.
- Chemaf (Shalina), the operator of the Mutoshi (under construction) and Etoile (under expansion) copper-cobalt projects in the DRC, is seeking offers for a full takeover of the company due to debt totalling US$ 690 million and a further US$ 300 million required to complete the respective construction and expansion works. The respective mining lease falls under the authority of parastatal Gécamines. While a Chinese company offered to buy out Chemaf, Gécamines has so far objected to this transaction, leaving the future of completing the construction of Mutoshi hanging in the balance.

Recommendation 3.13: Support mining projects whose development will have synergistic effects with other local/regional industrial projects.

The development of mining projects that are located in the same region offers various opportunities to lower capital and operating expenditures. Depending on the distance between two or more projects, risks and costs might be shared, for example for the upgrade/construction of transport and energy infrastructure or water and waste management. It is also conceivable that a project already in operation could grant rights of use for infrastructure to a third party's project under development, for instance in return for ore/concentrate offtake agreements or through toll processing (e.g., to increase feed for existing processing plants or refineries). The EU, African partner countries as well as regional organisations (e.g., SADC, EAC) could provide both financial and diplomatic support, especially in cases where project synergies transcend country borders. In Africa, there are several (cross-country) metallogenic provinces, which host multiple existing and planned ECRM mining projects, thus offering potential project synergies.

Mining projects covered in AfricaMaVal-related reporting and located in these provinces comprise the following. Note that these provinces hold further ore deposits.

- Central African Copperbelt (DRC, Zambia): Konkola, Lumwana, Mopani, Mutoshi;
- Kalahari Copperbelt (Botswana, Namibia): Motheo, Tsongoari, Omitiomire;

- Mozambique-Usagara- (Graphite-) Belt (Mozambique, Tanzania); Balama, Balama North, Mahenge, Epanko, Nachu, Grafica;
- East African Nickel Belt (Burundi, Tanzania): Musongati; Kabanga;
- Bushveld Complex and Great Dyke PGM provinces (South Africa, Zimbabwe): Waterberg.

Recommendation 3.14: Support the development of mining projects located in countries whose government incentivises investments in the mining sector.

Foreign mining investors, including from Europe, might benefit from incentives offered by national governments to stimulate mining investment. These incentives can include financial incentives and tax breaks, improved infrastructure and subsidies, political and regulatory stability guarantees, local workforce and development incentives, easier access to export markets and a free foreign exchange regime. In the following, results from the 'Country profiles on the regulatory framework' (Deliverable 7.2 of the AfricaMaVal project; Sewpershad and Tufo 2024) and the 'Country case studies' (Deliverable 9.3 of the AfricaMaVal project) on investor incentives are shown:

DRC: Small and medium enterprises (SME) and small and medium industries (SMI) carrying out on an investment program receive a total exemption from duty and import taxes for machinery and equipment, second-hand machinery and spare parts for first allocation not exceeding 10 % of the CIF value of such equipment, as well as industrial inputs necessary to achieve the approved investment. SMEs and SMIs are also exempted from registration fees in the Trade Register and the acts of cooperatives or company (Stoltnow and Schütte 2023).

Gabon: Key provisions of the Gabonese Mining Code (2019) include progressive taxation based on project size and resource type, and tax incentives like 0 % tax during the research phase and a five-year corporate income tax exemption. (Bailly et al. 2023).

Madagascar: A special regime for large-scale investments in the Malagasy mining sector considers incentives for investments of more than MGA 50 billion, once certification has been granted by way of government decree. This regime mainly consists of a legal, financial and tax stability guarantee; the possibility to take advantage of any more favourable measures; and certain tax and financial exemptions, under certain conditions (Picault et al. 2023).

Morocco: Common investment incentives (not necessarily limited to mining projects) are granted with respect to (1) creation of stable employment (employment ratio between 1 and 1.5 = 5 % of eligible investment amount; between 1.5 and 3 = 7 %; >3 = 10 %); (2) gender ratio ≥30 % (3 % of eligible investment amount); (3) future-oriented sectors or upgrading of sectors (3 % of eligible investment amount); (4) sustainable investment projects (3 % of eligible investment amount); (5)

Local integration projects (3 % of eligible investment amount). In general, the government is keen to attract foreign investors and seeks to facilitate investments through favourable regulations, economic reforms and other incentives (Batista et al. 2023).

Mozambique: Mozambique's Special Economic Zone policy includes that within a geographically defined area of general economic activity, all goods entering, marketed, manufactured, processed or exported to the area are fully exempt from all customs duties, fiscal and parafiscal charges and fees. It also enjoys a free foreign exchange regime, appropriate tax, labour and immigration regimes established for the rapid access and efficient operation of companies and investors wishing to operate there and suitable for them to meet their commercial and financial obligations abroad. Companies operating under the special economic zone scheme will enjoy the tax and non-tax benefits, including: Tax exemption on import (including VAT) intended for carrying out the activities granted in the special economic zones; VAT exemption for domestic purchases; Exemption from corporate income tax for the first three tax periods and reduced corporate tax thereafter (e.g., Represas et al. 2023).

Namibia: There are no policy developments concerning ECRM investment incentives that can be reported on presently. However, the Namibia Investment Promotion Act (NIPA 2016) presents a legal development that is yet to come into force. Furthermore, Namibia's National Special Economic Zone Policy has made a provision for both fiscal and non-fiscal investment incentives for various investment categories including, among others, exporters and manufacturers. The identified incentives include but are not limited to the following: lower corporate income tax rates; reduced import duties/customs tariffs; capital deductions allowance; research and development allowance; establishment of one-stop shop to support the facilitation of incentives for investors in the SEZ; competitive utility tariffs; and supportive and directed approach to provision of visa for non-resident foreign investors (Drobe 2023).

Senegal: Regarding the fiscal, legislative and regulatory context, the Senegalese authorities have made a priority of improving the business climate. This has resulted in a number of reforms designed to facilitate business creation, the simplification and digitisation of customs procedures, the creation of organisations to support entrepreneurs, and the establishment of tax incentives and Special Economic Zones (Pochon & Zammit 2023).

South Africa: When a foreign company conducts business in South Africa it would need to register as an external company in terms of the Companies Act. There are numerous tax incentives enjoyed by foreign companies holding prospecting rights or mining rights, in terms of the Minerals and Petroleum Resources Development Act (2002) and specific tax laws. South Africa implements a system of exchange control in terms of which approval is required from the South African Reserve Bank to transfer sums of money to and from South Africa (Cornelissen et al. 2023).

Tanzania: An investor may benefit from incentives if the government has granted Special Mining or Special Export Licences. In case of the Nachu flake graphite project, the granted Special Export Zone licence allows Magnis to produce advanced graphite products as well as downstream products for lithium-ion batteries (Ramsaroop et al. 2024b).

Zimbabwe: Holders of a Special Mining Licence benefit from tax incentives, including 1) exemption from Corporate Income Tax for the first 5 years of operation. Thereafter, a corporate tax rate of 15 % applies; 2) Special Initial allowance on capital equipment to be allowed at the rate of 50 % of cost from year one and 25 % in the subsequent two years; 3) Specialised expatriate staff will be taxed at a flat rate of 15 %; 4) Exemption from Non-residents tax on Fees on services that are not locally available; 5) Exemption from Non-residents tax on Royalties; 6) Exemption from Non-residents tax on Dividends; 7) Exemption from Residents tax on Dividends; 8) Duty free importation of Capital equipment for Special Economic Zones; 9) Duty free importation of raw materials and intermediate products imported for use by companies set up in the Special Economic Zones (Meck et al. 2023).

Recommendation 3.15: Support EU raw material engagement with African regional economic communities.

African regional economic communities have differing members, history, roles and structures. Generally speaking, though, these economic communities aim to facilitate regional economic integration among members of the individual regions and through the wider African economic community. The African Union recognises eight regional economic communities, comprising 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 the Southern African Development Community (SADC). The EU (or its Member states) may engage with these economic communities in the spirit of fostering mining sector (and value addition) development and improving market access for African raw materials and intermediate products. These elements may be integrated in cooperation on elements such as regional mining visions, strengthened legislative frameworks, ESG provisions and links with the African Continental Free Trade Area (AfCFTA).

The International Climate Initiative's project 'Fostering environmentally and socially responsible, decarbonized, inclusive, and transformative value chains for energy transition minerals in the SADC region' is an example for a project that plans to involve working with six SADC countries. The project is scheduled to start in 2025 and run for eight years. The objective of this project is supporting that extraction and processing of energy transition minerals in the SADC region is

undertaken with low-carbon, environmentally, and socially responsible mining and manufacturing methods and serves the countries' global climate goals, and the region's ambition for a broad-based sustainable development and inclusive structural transformation.

Recommendation 3.16: Consider ECRM projects of interest for various EU industry sectors.

From an industry sector perspective (NACE Rev. 2 classification), the following ECRM projects, among others, may be of interest to develop or strengthen. Investing in or encouraging other forms of engagement with these projects and their operators may be beneficial from a general perspective for the respective value chains in a given industry sector. Linking specific industry (sub) sectors with the respective ECRM project operators may also be useful for the EU to initiate targeted discussions and outreach regarding potential investment or offtake needs and opportunities.

- Manufacturing of Wiring, Wiring Devices, and Electric Lighting Equipment (copper, aluminium, nickel, platinum): Ambatovy, Bisie, Kabanga, Konkola, Lumwana, Minim-Martap, Mopani, Motheo, Mutoshi, Nkamouna-Mada, Sangarédi, Waterberg, Tsongoari, Omitiomire;
- Manufacturing of Batteries and Accumulators (lithium, cobalt, graphite and nickel): Ambatovy, Balama, Balama North, Nkamouna-Mada, Ewoyaa, Kabanga, Karibib, Graphmada, Lumwana, Mahenge, Maniry, Molo, Mopani, Musha-Ntunga, Mutoshi, Epanko, Nachu, Uis, Waterberg, Zulu, Grafica, Sahamamy & Vatomina;
- Manufacturing of Computers, Electronics, and Optical Products (rare earths, tin, tantalum and tungsten): Longonjo, Ewoyaa, Bisie, Kangankunde, Kanyika, Makuutu, Moma, Musha-Ntunga, Songwe Hill, Nyakabingo, Toliara, Uis, Zulu, Steenkampskraal;
- Production of Renewable Energies (silicon metal, copper, nickel, and rare earths): Ambatovy, Longonjo, Nkamouna-Mada, Bisie, Kabanga, Kangankunde, Konkola, Lumwana, Makuutu, Momo, Mopani, Motheo, Mutoshi, Songwe Hill, Toliara, Waterberg, Steenkampskraal, Tsongoari, Omitiomire;
- Manufacturing of Air and Spacecraft and Related Machinery (titanium, aluminium, nickel, cobalt): Ambatovy, Nkamouna-Mada, Kabanga, Konkola, Lumwana, Minim-Martap, Moma, Mopani, Mutoshi, Sangarédi, Steelpoortdrift, Toliara, Waterberg.

Recommendation 3.17: Consider potential investment opportunities in EITI countries.

The Extractive Industries Transparency Initiative (EITI) provides a transparency framework to strengthen governance and accountability. In each country that joins the initiative, a multi-stakeholder group with representatives from government, industry, and civil society oversees implementation of the national EITI process. The process serves to increase transparent reporting by companies as well as reconciling reported tax payments with government use of mining-related income. Beyond transparency, the very existence of a national multi-stakeholder dialogue process in mining constitutes a benefit for natural resource governance. These purposes align well with the interest of responsible investors or offtakers concerned about ESG. Africa is relatively advanced in terms of EITI membership – a large number of countries across the continent have joined the initiative (Figure 7). The national EITI process in a given country is often already supported by international development partners, which may be an additional helpful factor to consider for responsible investors. In these cases, care must be taken to ensure alignment and cooperation among different development partners and set realistic targets in line with the capacities of the national EITI secretariat. In a donor-coordinating function, this process could be supported by the EU as well.

Mining projects presented in the AfricaMaVal project (see Appendix Table 4) operating under a national EITI framework comprise:

- Bisie tin project (DRC) operated by Alphamin Resources Corp. (Mauritius);
- Moma heavy mineral sands project (Mozambique) operated by Kenmare Resources plc. (Ireland);
- Sangarédi bauxite project (Guinea) operated by Compagnie des Bauxites de Guinée (Guinea);
- Toliara heavy mineral sands project (Madagascar) operated by Base Resources Ltd. (Australia);
- Ambatovy nickel project (Madagascar) operated by Ambatovy Minerals S.A. (Madagascar);
- Konkola copper project (Zambia) operated by Konkola Copper Mines Pls. (KCM; United Kingdom);
- Mopani copper project (Zambia) operated by Mopani Copper Mines Plc. (Zambia).

Funded by
the European Union

Figure 7. Map of Africa illustrating EITI member countries (as of 11/2024).

Recommendation 3.18: Consider ECRM projects promoting local stakeholder integration and dialogue.

Conflicts around mining projects are of increasing concern, in Africa and elsewhere. Not only should such conflicts be of concern to responsible investors but also they directly influence the ECRM supply perspective. This is because these conflicts may cause delays in project development, interrupt production and transport/supply logistics, or, in extreme cases, lead to the government suspending the mining license. Earning a strong Social Licence to Operate should be a main target for mining operators and their investors to increase resilience of ECRM supply. Early and meaningful stakeholder engagement on a regular basis is nowadays considered good international practice. Respecting the FPIC (free, prior and informed consent) principle and

involving local stakeholders in decision-making is advised for all stages of stakeholder engagement to increase acceptance (see for example OECD 2017, ICMM 2024). Stakeholder engagement affects multiple aspects of mining operations, such as water stewardship, local economic development and livelihood support, CSR efforts (e.g., health and community services), as well as structured regular dialogue and a grievance mechanism.

Mining projects presented in the AfricaMaVal project with an integrative stakeholder approach include, for example (for general guidelines on best practice see Ghezzi et al. 2024):

- Barrick Gold Corp. (Canada) operates the Lumwana copper mine (Zambia) and established Community Development Committees and grievance reporting at its project sites;
- Giyani Metals Corp. (Canada) operates the K.Hill manganese mine (Botswana); projects to be implemented as part of the community development plan are proposed and selected in cooperation with the local communities;
- Sandfire Resources Ltd. (Australia), operator of the Motheo copper mine (Botswana), initiated a Stakeholder Engagement Plan and Community Investment Plan to identify stakeholders and their use of natural resources and derive key community investment areas as well as the compensation framework for the Resettlement Action Plan. Engagement with the San people takes place through traditional decision-making forum.

Recommendation 3.19: Consider ECRM projects promoting mining community and local business development.

Corporate social responsibility (CSR) and support to local community development are important practices that European downstream companies commonly consider in their host countries. In the spirit of responsible value chains, such efforts should also be expected in mining areas in the upstream supply chain. Local economic development may in fact be encouraged or required by law, for instance through a certain mining revenue share that the state re-invests in local community infrastructure (e.g., in the DRC). As far as CSR is concerned, possibilities for supporting community development should be based on actual needs and local development plans, involving community stakeholders in the planning and decision-making process. Planning needs to consider the long-term perspective for any CSR-related process or facility to operate once the mining company is no longer active. This refers, for example, to sustainable solutions for covering operational or maintenance costs of such facilities as well as diversification of the local economy beyond mining-related services. The Mozambican legislation on mandatory community development agreements is seen as a good example on how to foster community development

(Ghezzi et al. 2024). Examples for local CSR and community development measures from among the range of projects described in AfricaMaVal include:

- Comilog (Gabon), operating the Moanda manganese mine (Gabon), and Grande Côte Opérations (Senegal), holding a large heavy mineral sand concession along the Atlantic coast of Senegal, are both subsidiaries of the French Eramet group. At both sites, the mine operator works in direct consultation with local communities on progressive rehabilitation measures of the mining area aiming at minimising environmental impacts and securing ecosystem service. Further investment are done in local water, education and transport infrastructure.
- Ambatovy Minerals S.A (Madagascar) operates the Ambatovy nickel mine (Madagascar), and is committed to support the national economy as one of few major business enterprises in Madagascar. By measures to maximise local procurement, Ambatovy became one of the largest consumers of goods and services in Madagascar. Measures comprises support of local enterprises to enhance competitiveness like a Supplier Audit Programme and a Supplier Database.
- Ivanhoe Mines (Canada) operates the Kamoa-Kakula copper mine (DRC) and is working on restarting operation at the Kipushi zinc-copper-germanium mine (DRC). Ivanhoe founded the Kamoa Centre of Excellence to educate local students for leading positions in the mining industry and invested in secure potable water supply and an adult literacy program in Kipushi.
- Syrah Resources (Australia) operates the Balama graphite mine (Mozambique), where a local development agreement was established including financing of local health care and school infrastructure, but also capacity building programs providing professional training for agricultural and livelihood development as well as special trainings for vulnerable people. The company was recognized by the provincial and district government of its CSR engagement and for strengthening of company-government relations;
- Greenwing Resources Ltd. (Australia) operates the Graphmada graphite mine (Madagascar) and runs the CSR program Graphmada Care, which was recognised as the leading programme of its kind in Madagascar in 2018;
- Barrick Gold Corp. (Canada) operates the Lumwana copper mine (Zambia) and besides funding of water supply and school buildings established a business accelerator program that aims on enabling local contractors to diversify their business and gain additional customers beyond the Lumwana mine. Moreover, 72% of the operators' spending for goods and services goes to Zambian suppliers. In 2017, the mine was acknowledged as best performer in social investments by Zambia's chamber of mines;

- Kenmare Resources plc. (Ireland) operates the Moma heavy mineral sands mine (Mozambique) and founded the Moma Development Agency as NGO, which is responsible for the implementation of community development measures (medical care, health awareness, schooling, conservation and agriculture, micro-credits for business development).

Recommendation 3.20: Consider ECRM projects associated with a high share of local workforce and local content policy implementation.

Many mineral-producing countries in Africa have by now established regulations or benchmarks concerning local recruitment of staff as well as local sourcing of goods and services. Local content policies exist, for example, in Tanzania and Ghana. National efforts are supported by regional organisations such as COMESA who have developed local content policy guidelines (COMESA 2018) while the African Mining Vision emphasized the importance of flexible local content milestones as early as 2009. Reporting on the preferred hiring of local employees is nowadays a common standard in mining. Often, >90 % of the mine workforce are represented by local or national staff. Filling higher management positions with local or national staff may be challenging but should be an important goal as well. The mining code of the DRC, for example, requires prioritising nationals with equal skills and setting up training programs for all qualification levels; reaching the quota for management level is set at ten years after commercial production.

Examples for good workforce policies of mine operators considered in the AfricaMaVal project include:

- Syrah Resources (Australia) operates the Balama graphite mine (Mozambique) where it established a Local Development Agreement that also includes capacity-building programs. Training programs in cooperation with a vocational school exists for different professional skillsets, targeting at least 30 % female participation. Until 2024 almost 400 trainees have graduated from the Balama Professional Training Centre;
- Kenmare Resources plc. (Ireland) operates the Moma heavy mineral sands mine (Mozambique) providing a skill development and training programs, including scholarships and internships, and reaching a 97 % quota of Mozambican employees;
- Base Resources Ltd. (Australia) operates the Toliara Ti-REE heavy mineral sands project (Madagascar,) initiating a skill development program in 2019 where 500 people were selected for traineeship from 7000 applicants.

Recommendation 3.21: Support mining skills development.

African countries with a long mining history, such as the DRC, Zambia, Ghana and South Africa, have well-established universities and mining schools that provide ample supply of technicians, mining engineers and other job functions. However, the skill set required in mining has begun to change. With the increasing level of digitalisation, the mining workforce will have to adapt and increasingly require software engineers and operational staff with high IT affinity (e.g., Clausen et al. 2020). Besides mining-related skill development, it is further important to consider skills for the mine service sector. In order to promote capacity building, cross-institutional cooperation, for example among universities, governmental agencies, labour unions, or professional associations, in Africa and Europe are possible options. Examples include:

- The EU-African PanAfGeo project (continued as PanAfGeo+) includes training program involving many European geological surveys with the aim to increase the professional skills of African geological surveys and geoscientists. To this purpose, African and European participants form expert groups for implementing capacity development measures; BRGM of France, who is coordinating the PanAfGeo process on behalf of the EU, is additionally offering ESG-related training courses for mining professionals as part of its national portfolio of services.
- The BGR is implementing development cooperation projects in mining on behalf of the German federal government, which often include elements of capacity development, for instance on regulatory and supervisory capacity of African mining authorities (e.g., in Mozambique or the DRC);
- The Namibia Institute for Mining and Technology (NIMT) is acting as a vocational training centre in Namibia offering professional training in mining-related disciplines to provide skilled labour for the mining industry (Drobe 2023).

Recommendation 3.22: Opportunities to support the role of women in African mining by encouraging networking and cooperation.

The global average share of women in the mining workforce is around 15 %. The share is low around the world, including for countries that are generally expected to have high ESG standards in mining (e.g., Canada and Australia: 16-17 % women in mining workforce). In South Africa, the figure is around 12 %, as noted in the Minerals Council's white paper on Women in Mining (Minerals Council 2020). Even in Rwanda, which is commonly considered to be an advanced country in terms of gender equality, women's share in the mining workforce is only 11 %, according to the national institute of statistics. There are no systematic data for all African mining

countries available. Indeed, International Women in Mining (Harris et al. 2024) highlight the challenge of a lack of gender-disaggregated data in the mining industry.

Common challenges for hiring women include cultural and societal norms, safety concerns, and lack of infrastructure to support female workers. In Africa, these challenges tend to be more pronounced while some jurisdictions elsewhere, such as Australia, have established policies and support measures to improve gender diversity in the mining workforce. However, awareness is rising. For instance, the DRC plans a survey on the female workforce in mining, and some similar efforts were observed in Mali and Burkina Faso.

In order to address these challenges, besides investing in mining projects with specific gender efforts and corporate policies, responsible investors may support general opportunities for women networking and cooperation in the mining sector. Examples include:

- Local networks to foster entrepreneurship of women which may help to increase women participation in local service companies and local content, such as the Délégation à l'Entreprenariat Rapide des Femmes et des Jeunes (DER/FJ), responsible for promoting entrepreneurship of young people and women in Senegal (Pochon and Zammit 2023);
- Promoting and supporting cooperation with universities that consider the potential of female students; for instance around 50 % of engineering students at the “Ecole Nationale Supérieure” des Mines de Rabat, Morocco, were female in 2020/2021 (Batista et al. 2023);
- The Women in Mining network is active across the world, including at the level of the African continent through the Association of Women in Mining in Africa (AWIMA) as well as through national Women in Mining (WiM) organisations. AWIMA is a direct project partner in the AfricaMaVal project and leading its Work Package on ESG (WP4), while national organisations of WiM may be supported by developments partners, for instance through WiM’s cooperation with the German BGR on outreach and training events in the Congolese mining sector.

Recommendation 3.23: Evaluate water risks and water management plans of mines considered as potential investment opportunities.

Alleged or actual water contamination or competition over water resources are often a major source of dispute between mining companies and communities. Responsible investors should therefore be aware of the water risks associated with a given mining operation. The location-specific water stress and riverine flooding risk levels, available online, may be employed as a first research step for risk evaluation. In cases where investors have access to more site information,

they may also apply assessment tools evaluating site water risks as well as corporate water management, for instance an adapted version of the Water Risk Filter (Gilsbach et al. 2019).

Many African ECRM mining projects are located in areas with low water stress, though it tends to be high in some regions of South Africa. Arid regions, widespread in Namibia, Botswana and South Africa, may appear to be under high water stress levels but as long as local water use is low, this does not necessarily represent a major obstacle. With many African ECRM projects being located close to the coastline, seawater desalination plants, for instance discussed for the Uis tin-lithium mine in Namibia, may represent a useful investment to ensure sustainable water supply. Water infrastructure elements – for mine water supply as well as for the generation of hydropower – may be scalable and benefit from cooperation and shared use among different operators, as well as from regional strategic environmental assessments of the whole watershed. Riverine flooding risks are considered as (extremely) high for many ECRM mine location in southern Africa, for instance in Madagascar, necessitating special attention to manage flooding and stormwater events and avoid associated contamination risks.

Recommendation 3.24: Evaluate proper mine waste management practices among potential investment opportunities.

Mining residues bear a high environmental risk potential and should be given special consideration while evaluating investment opportunities. As perpetual burdens of mining, proper handling of mining residues is imperative to prevent release pollutants associated with acid mine drainage, for example. For tailings storage facilities, the risk of dam failures exist, which may have catastrophic consequence. For example, the 2022 Jagersfontein dam failure in South Africa killed several people and displaced over a thousand. On the other hand, even if no catastrophic failure occurs mining residues may have lasting environmental impacts if not handled properly. This is, for example, the case in regions with long mining histories, like the DRC-Zambian Copperbelt with hundreds of millions of tons of tailings and waste dumps (Schütte 2021a).

Investors may therefore want to pay attention to alignment of operational practice with international standards such as the Global Industry Standard on Tailings Management (GTR 2020) or the Australian National Committee on Large Dams standards (ANCOLD 2019). African ECRM mine operators and associated projects reporting according to the Global Industry Standard on Tailings Management include, for example:

- Balama graphite project (Mozambique) operated by Syrah Resources (Australia);
- Longonjo REE project (Angola) operated by Pensana Plc (UK);
- Lumwana copper project (Zambia) operated by Barrick (Canada);

- Molo graphite project (Madagascar) operated by NextSource Materials (Canada).

Furthermore, robust mine closure and rehabilitation planning as well as sufficient financial provisions to cover associated costs are key considerations for responsible investment in line with the mine life cycle. Acquiring mining projects with limited life of mine requires particular due diligence on the associated liabilities and adequate financial provisions for closure.

Recommendation 3.25: Support sector-specific regulatory and policy implementation as well as institutional capacity development in African mining.

AfricaMaVal's deliverable D7.2 presents a high-level desktop review of 54 countries in Africa, evaluating these countries' national regulatory framework and good governance from an investor's perspective (Sewpershad & Tufo 2024). The review found that numerous countries have embarked on policy and regulatory reforms to foster private sector engagement, increase local value addition, improve mineral information systems, and attract new mining investment capital. As far as ESG is concerned, regional efforts have been initiated to amplify environmental management, benefits for mining communities, improve governance and transparency in licensing and management of mineral rights, and accountability in the management of mineral resources. Frequently, this is thought to be facilitated by joining initiatives such as EITI. Many African countries have also joined the International Governmental Forum on Metals and Mining (IGF), where they may exchange with other governments worldwide. As such, as far as the regulatory framework is concerned, many African countries appear to be on the right track. This is also exemplified by the high interest for Africa's mining sector, for instance at the African Mining Indaba event, where African countries regularly present their efforts in front of potential investors and their peers.

While further reforms and policy alignment may be desirable, it is pertinent to draw the attention on actual policy implementation, which is frequently still a challenge. While local or foreign investors may be presented with efficient one-stop offices or streamlined processes to start their business, good governance in the mining sector necessitates strengthening the capacity of mining sector authorities to fulfil their oversight functions. This requires sufficient national funding in the first place, and may further be supported through international development partners. The German BGR, for example, provided training for mining inspectors in the DRC, while the German Agency for International Cooperation (GIZ; with co-funding by the EU) supported mining sector supervision in West Africa. The IGF has provided training on mining governance aspects in multiple African countries over the past decade. Downstream stakeholders seeking to support policy reform and implementation in Africa may draw on the expertise of these and similar

organisations, since such topics commonly go beyond the influence that private downstream companies or investors can exert within their own supply chain.

Recommendation 3.26: Explore ways for cooperating with high-impact state-owned mining companies in Africa.

Fully or partly state-owned companies such as Gécamines in the DRC or Zambia Consolidated Copper Mines (ZCCM) in Zambia are important stakeholders in Africa's mining sector. Gécamines, for example, controls a large number of exploration or mining concessions that it either operates itself or sells / leases them to foreign investors. In addition, the company often holds a share of around 20-30 % in many major project joint ventures. Recently, Gécamines started marketing its attributable production share from major copper-cobalt mines such as Tenke Fungurume, Kamoto and Sicomines on its own, while it either directly or indirectly (through its subsidiary) sells zinc, copper, cobalt and germanium, the latter in a partnership with Umicore. In September 2024, the Zambian government presented a plan to establish a special purpose vehicle to control at least 30 % of critical minerals production through a production-sharing mechanism.

These initiatives increase the level of influence that parastatal companies, and hence the state itself, may exert on global ECRM value chains. Downstream industries, investors and governments may hence benefit from exploring possible cooperation agreements with these parastatal companies. France in this regard took a first step in 2023, when the French geological survey BRGM signed a partnership agreement with Gécamines, followed up by a B2B partnership deal between Umicore and Gécamines' subsidiary STL in 2024. At the same time, the role of some parastatal companies may partly be controversial, for instance in terms of risks for financial misconduct. Potential investors/partners may therefore wish to consider robust transparency and auditing requirements in any partnership agreements to avoid reputational or financial problems for themselves.

Recommendation 3.27: Consider cooperating with Western companies with a strong track record in Africa's mining sector.

One of the key factors for selecting which mining projects to invest in is the strength and experience displayed by the mine operator's management team, reflected in a successful track record. While only few European mining companies are prominently engaged in Africa, some Canadian companies have demonstrated a high capacity for successfully developing major ECRM mining projects on the continent, ideally on or ahead of schedule, on or below budget, and supported by the national government and local communities.

Two prominent examples in this regard are Ivanhoe Mines and Barrick (including former Randgold). While Barrick's focus is gold mining, it is also operating the major Lumwana copper mine in Zambia, whose expansion is expected in the near future. Ivanhoe's focus, so far, is in the DRC, where it operates major copper and zinc mines (Kamoa-Kakula and Kipushi, the latter's zinc ore contains germanium), and its Platreef PGM-nickel operation in South Africa. Both companies also implement exploration activities, for instance Ivanhoe announced such activities in Angola and Zambia, where they may benefit from their geological experience in the Copperbelt. For European investors or offtakers without significant operational experience in African mining, it may be worthwhile exploring cooperation options or investment partnerships with such companies for mutual benefit. If such initiatives were considered, it would be important to explore alignment on ESG expectations as well.

Recommendation 3.28: Consider ECRM projects associated with third-party assurance mechanisms.

Understanding mining project development and ESG impacts in mining is a challenging undertaking that requires high levels of experience and expertise. Engaging with sustainability initiatives that facilitate qualified third party assurance procedures may therefore be a useful approach for prospective investors or offtakers, especially for downstream small and medium-sized enterprises who may otherwise find it difficult to mobilise comprehensive ESG and mining experience in-house. In recent years, such sustainability initiatives have been implemented at a growing number of African mines producing different ECRM commodities.

Figure 8 shows an overview on ECRM-associated mines currently covered by different relevant initiatives. Responsible investors or offtakers may consider sourcing minerals from these projects to benefit from the information and assessments provided by these initiatives. It is important to note, though, that in a regulatory context of supply chain due diligence, offtakers may rely on support from such third-party initiatives but always retain ultimate responsibility for exercising due diligence in their own supply chain.

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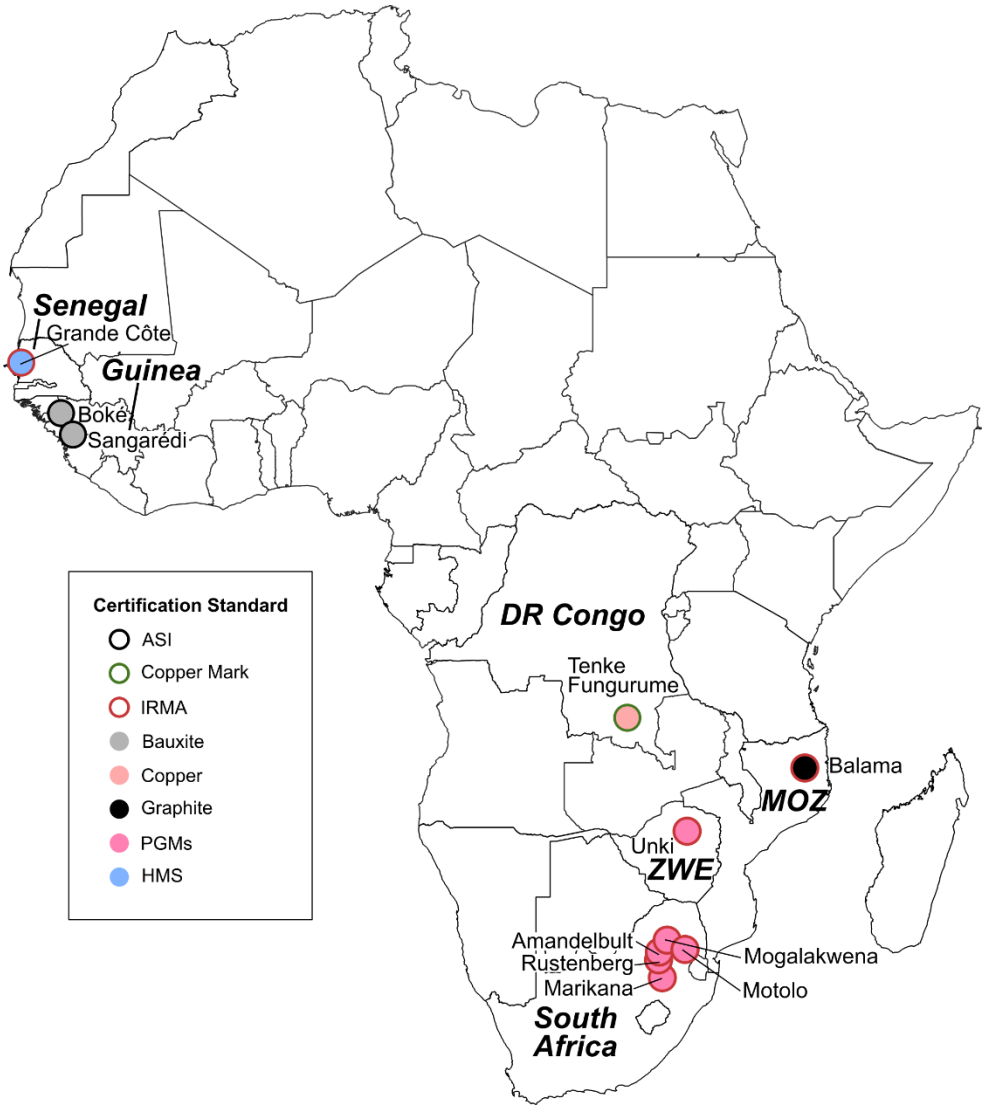

Figure 8. Geographic distribution of publicly known African ECRM mines currently covered by third-party assurance schemes (as of 12/2024)[6].

[6] Country abbreviations refer to ISO 3166-1 alpha-3 – three-letter country codes. IRMA = Initiative for Responsible Mining Assurance. ASI = Aluminium Stewardship Initiative. See Erdmann & Franken (2022) for more details on these initiatives.

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4 Artisanal and small-scale mining

4.1 Background – Investing in the ASM sector

The AfricaMaVal project has engaged with the ASM sector on multiple levels, comprising on the one hand research in WP1, WP3 and WP7 (Vasters and Schütte 2023, Albery et al. 2024, Sewpershad and Tufo 2024) and on the other hand outreach and training activities led by AfricaMaVal partners in WP2 and WP4, as well as in some of the AfricaMaVal country case studies of WP9. The following illustrations and recommendations were inspired by some of these activities and findings, but cannot cover their full scope. Interested readers are referred to the respective WPs and their deliverables to obtain more details.

Artisanal and small-scale mining is an important livelihood base for millions of people in Africa. At the same time, the sector faces many challenges due to health and safety concerns for workers and nearby communities, social and socio-economic problems (from child and forced labor to social tensions in communities), and negative environmental impacts (e.g., contamination, deforestation, poaching). While the socio-economic importance of the ASM sector is often recognized in Europe, the supply chain narrative among many European downstream stakeholders and the general public tends to focus on the risks and challenges of the ASM sector, rather than its ECRM supply opportunities. This has led to a situation where much of Africa's ECRM sourced from artisanal miners are sold to Chinese and other Asian customers for processing. Direct Africa-EU supply chains of ASM material are rare, with some notable exceptions especially in tantalum and tungsten supply chains.

Africa's is the world's largest ASM producer of ECRM. At least 20 African countries are currently producing ECRM in the ASM sector or have done so in the past (Figure 9). Current artisanal ECRM production comprises the '3T' minerals (hosting tin, tantalum, tungsten; note that tantalum, included in coltan, is typically associated with niobium, an additional ECRM), lithium, copper, cobalt, manganese, barite, fluorspar, graphite, PGMs, and REEs, with potential or historical production of beryllium, strontium and titanium (Vasters & Schütte 2023). Note that not all ECRM are recovered in considerable quantities. For instance, artisanal exploitation of 3T minerals is widespread across many African countries, whereas ASM-related production of PGMs or REEs was only observed in very few cases.

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Figure 9. African countries with current or historic ASM production of ECRM as mapped by Vasters & Schütte (2023)[7].

Due to its often informal nature and widespread capacity gaps, the ASM sector faces significant challenges of accessing formal financing (Albery et al. 2024; Sewpershad and Tufo 2024). Indeed, from a financial perspective, individual ASM mine sites must be considered a high-risk investment, given the lack of collateral such as mining title or proven mineral resources or reserves. Moreover, with some exceptions, the ECRM production output of a single ASM operation can be considered small to negligible and, from a supply perspective, will unlikely warrant attention by large European downstream OEM manufacturers. It may be of interest to specialized processors in certain commodity markets, and indeed it is there – for instance in tungsten and tantalum processing – where Africa-Europe ASM value chains occasionally already exist. It is mostly the cumulative production from dozens, sometimes hundreds of different ASM sites that accounts for the sector's general ECRM relevance though.

The following ASM-related recommendations and conceptual investment opportunities, targeting policy makers in the EU as well as downstream industries, therefore do not seek to identify individual ASM projects as investment targets. In some cases, interested parties may find information on individual ASM sites in other AfricaMaVal deliverables, for instance in some of the submitted country studies of WP9, accessible on the AfricaMaVal website. Moreover, a

[7] Country abbreviations refer to ISO 3166-1 alpha-3 – three-letter country codes.

planned AfricaMaVal business networking platform is, in principle, open to ASM operators to present their individual operations or products in order to generate downstream interest for investment and/or offtake. Given the capacity constraints faced by many ASM operators and their strong reliance on local traders and supply chain partners which link ASM sites to the mineral export stage, individual site operators might struggle accessing this type of platforms, though.

The following recommendations rather aim to improve investment conditions in the African ASM sector in a broader sense with a focus on increasing responsible artisanal ECRM supply potential which, importantly, should not only benefit downstream stakeholder interests but – directly or indirectly – contribute to local socio-economic development in ASM communities as well. From a technical perspective, this includes but is not limited to gathering and making good use of data on artisanal ore deposits, mining operations and local value chains, all of which are helpful to consider when seeking to improve ASM access to financing and expanding production. The recommendations further target the legal as well as reputational dimension of ASM activities, since their ultimate objective is to help establishing Africa-EU value chain partnerships, which implies the need for downstream industries and regulators to accept ASM material in formal supply chains. In the opinion of the authors, the following set of recommendations reflects a number of pertinent issues of practical relevance in this regard, but should certainly not be considered as an exhaustive list. Interested readers are further encouraged to consider the broad academic literature related to ASM governance, which may be considered as complementary to the current report's rather technical focus.

It is important to note that national governments in the producer countries represent the most influential stakeholder in the ASM sector. It is up to these governments to set and enforce enabling conditions for mining and trading of artisanal ECRM in their national legal framework. European governments are in a good position to support such efforts by leveraging bilateral cooperation projects meant to strengthen partner capacities in Africa. To a certain extent, downstream companies may also exert positive influence beyond their own supply chains, for instance through publicly stating their interest in purchasing ECRM from the ASM sector if certain compliance standards are met, or by participating in industry-wide initiatives or PPPs related to ASM, such as the EPRM. AfricaMaVal deliverable D7.2 (Sewpershad & Tufo 2024) illustrates a number of country-specific donor initiatives in African countries in this regard that readers may refer to for more information.

4.2 Recommendations and investment opportunities

Recommendation 4.1: Encourage and support ASM exploitation of high-grade portions of sub-economic large-scale mining projects.

Artisanal miners typically exploit mineral resources with higher metal grades compared to industrial large-scale mining. Exploitation of low-grade resources is frequently not economic with low degrees of mechanisation and/or without economies of scale, as often observed in Africa's ASM sector. Ore deposits targeted for large-scale industrial mining may contain higher-grade portions of mineralisation as well, though, through geological processes of secondary enrichment or due to the conditions of the original ore-forming process. Large ore bodies may also feature spatially associated satellite ore bodies of interest to ASM, and artisanal re-processing of historic industrial mine tailings is a frequent feature in central Africa. Some artisanal copper-cobalt mining activities in the DRC, for example, illegally target historical mine tailings or high-grade portions associated with ore deposits on industrial mining concessions.

If well planned and controlled, especially from a logistical as well as health and safety perspective, and if endorsed by national mining authorities, artisanal miners may be granted access to certain parts of industrial mining concessions to allow legal or, at least, tolerated ASM activities there. This may be increasingly difficult on small concessions hosting active industrial mining operation, which typically places high standards on health and safety, with strict control of working areas. It is however feasible to temporarily allow artisanal miners access to certain parts of the deposits while industrial operators are still in the earlier stages of project development, or if industrial exploration and mining concessions are very large. The ASM pilot project on Chemaf's Mutoshi concession in the DRC may serve as an example in this regard. There, artisanal miners mined copper-cobalt ore from 2018-2020, under the supervision of the government and the license holder, further aided by an NGO hired as technical partner. It could also be interesting to encourage ASM activities for projects that were found sub-economic for industrial mining operations. For example, in late 2023, French mining company Eramet stated that the Akonolinga rutile deposit in Cameroon did not meet their investment criteria and walked away from the project after several years of exploration. Cameroon has had historical ASM activities in alluvial rutile deposits until the 1950s (Vasters & Schütte 2023), so the government/concession holder could evaluate the feasibility for encouraging ASM activities in parts of the project area instead.

Recommendation 4.2: Evaluate opportunities for recovering ECRM as a by-product of ASM operations and encourage multi-metal recovery and valorisation by ASM.

Artisanal miners in Africa sometimes work on deposits that host multiple ECRM at the same time. These might be recovered as by- or co-products. When selling the ore, artisanal miners frequently

get paid for the main metal commodity only. Paying artisanal miners for all metals contained in their product instead may not only be considered as a question of fairness, but may additionally encourage them to increase recoveries of possible by-products, which, if left unpaid, may not be considered as valuable by artisanal miners. The most prominent example for this is the widespread artisanal exploitation of pegmatites all across Africa, which is typically associated with the potential to recover coltan (tantalum-niobium), tin, and lithium minerals as well as gemstones. In addition, in the DRC and partly in Zambia, copper and cobalt are closely associated in ore mined by artisanal miners. A geological assessment of the ASM deposits could reveal other potential by-products that are not currently being mined, as for instance there is the potential for PGM mineralisation to co-occur with some alluvial gold deposits being mined by artisanal miners in the DRC (Vasters & Schütte 2023). While the authors did not find a specific description of this for African ASM, it is geologically possible for gold ore to be associated with antimony mineralisation as well. Antimony is a critical metal that can be recovered as a by-product of industrial gold mining and smelting, in particular in Russia and China, and it is therefore currently of high supply concern for certain downstream industries.

For downstream parties seeking to pursue this recommendation, it would not be advisable to focus only on geological and metallurgical data collection, though. Rather, it would be a key step to engage all relevant stakeholders in the process, including artisanal miners, national mining authorities and, importantly, local mineral traders and processors. On the one hand, local traders or processors may oppose such initiatives in case they are already aware of valuable ASM by-products and increase their profit margin by valorising these but keeping this information confidential. In these cases, they would need to be convinced that it might still be in their business interest to clarify the full ECRM potential of ASM ore. On the other hand, traders or processors themselves might not be aware of the full ECRM potential of ASM ore, for instance due to limitations in their on-site analytical facilities, or they might not bother because they consider the associated processing steps to recover additional ECRM as too complex or expensive. In these cases, technical capacity development measures for local traders or processors might be worthwhile to consider.

Recommendation 4.3: Support establishing formal ASM mining zones.

In most African countries, the ASM sector has a fundamental challenge in terms of legalisation and formalisation. Even though ASM operations may partly be tolerated by local authorities, European downstream buyers tend to hesitate to engage due to their regulatory concerns. Legalizing ASM operations may therefore be considered an important step to increase the potential for Africa-Europe ASM value chain partnerships. The concept of ASM zones foresees that the state establishes production areas where artisanal miners, typically organized in

cooperatives, are allowed to operate legally. In different forms, such ASM zones have been introduced in several African countries such as Morocco (Centrale d'Achat et de Développement de la Région Minière du Tafilalt et de Figuig), the DRC (Zone d'Exploitation Artisanale), Mozambique (Áreas Designadas) and Zambia (Ndola Rural Emerald Restricted Area). As past experience indicates, different governance challenges may arise in the operation and supervision of these zones, and the viability of ASM activities in such zones is dependent on both logistical and geological factors. A fundamental challenge, though, is the creation of these zones in the first place because they require the state to invest in exploration for demonstrating the existence of viable deposits suitable for ASM (and potentially demonstrate that the site is unsuitable for large-scale industrial mining). The government authorities in charge of this process may face technical capacity challenges or they may not have a sufficient budget to fund significant exploration activities, which will be expensive if they involve shallow resource drilling and associated geochemical analysis in order to understand the extent of the ore body in three dimensions. International development partners and/or downstream industries may therefore consider setting up funding mechanisms and/or technical support facilities that help designating formal ASM zones on the base of a proper resource assessment while, later on, supporting the continuous management and supervision of such zones.

Recommendation 4.4: Encourage neighbouring countries' cooperation to understand their ASM ECRM potential and associated mineral trade.

Since its inception in the 1960s-1980s, Africa's ASM sector has very often been associated with informal mineral trade within national boundaries as well as cross-border mineral smuggling. While informal trade and smuggling may be performed deliberately to hide conflict financing or similar risks impacting on mineral market access, it more commonly reflects the general dynamics of artisanal mining and mineral trading. Traditionally, artisanal miners are often paid as subcontractors according to their daily production volume, so that regional price differences incentivize them to sell their production to the highest bidder, outside of formal channels. Moreover, liquidity is a central factor in ASM mineral trade where miners prefer traders offering immediate cash. Trade movements are further influenced by the local logistical situation. Informal cross-border mineral trade between the DRC and Rwanda has often been cited in the media and is prominently discussed in the regular reports by the UN Group of Experts on the DRC, but informal trade of artisanal 3T mineral concentrates is actually rather common in all pegmatite deposit-hosting countries of East and West Africa.

The informality of mineral trading represents a challenge from two perspectives. On the one hand, it becomes difficult to trace supply chains back to their origin in order to evaluate risks for human rights violations (as commonly expected for European buyers, based on applicable due

diligence regulations) and conformance with applicable tax and royalty regulations. On the other hand, informal cross-border trade and inaccurate export declarations make it more difficult to evaluate a given country's ASM production potential.

It is important to maintain realistic expectations on this matter. Stopping informal mineral trade in the ASM sector altogether should not be realistically expected from supply chain initiatives and similar actions whose main function is supporting supply chain due diligence measures. But international downstream stakeholders may encourage and support African partners as well as regional organisations (e.g., SADC, COMESA, EAC, ECOWAS, the International Conference of the Great Lakes Region; ICGLR) to coordinate on law enforcement, customs procedures and trade regulations in the minerals sector, share information on the relevant types and features of ASM mineral products (e.g., typical grade and expected unit value), and encourage harmonized reporting of exports (e.g., to accurately identify a common ware category in the UN Comtrade database).

Recommendation 4.5: Evaluate ECRM potential of historic ASM tailings and dumped ore.

Artisanal miners often apply techniques without continuous monitoring of processing efficiency, and without designing processing based on adequate metallurgical knowledge in the first place. This frequently leads to low metal recovery rates where artisanal miners dump processed ore that may still contain significant quantities of primary commodities as well as potential ECRM by-products. For example, Rwanda hosts a large volume of tailings generated from decades of ASM activities which may still contain valuable quantities of coltan (tantalum-niobium), tin and lithium (Heizmann & Liebetrau 2017, Schütte & Näher 2020). The situation is similar in neighbouring countries. Aside from the potential economic value of these tailings and dumps, artisanal mine waste also constitutes an environmental liability, since artisanal miners typically do not store tailings professionally or apply adequate backfilling in underground operations. Therefore, ASM-related tailings may be associated with elevated contamination risks for the environment. Evaluating and, ultimately, re-processing such tailings to recover contained metals may thus represent an opportunity to reduce environmental risks for the local population as well as ecosystems.

Recommendation 4.6: Explore legal and technical means for ASM to exploit deeper mineralisation.

Underground artisanal mining activities are typically limited by depth. Digging deeper makes it more challenging to bring mined ore back up to the surface while inflow of mine water

necessitates the increasing use of water pumps, which increases operational costs. Moreover, countries such as the DRC have established legal maximum limits for the depth of artisanal mining activities (e.g., 30 m). Notwithstanding these factors, artisanal miners partly do access deeper-seated mineralisation. For instance, artisanal copper-cobalt miners in the DRC construct shafts that may go as deep as 80 m. This naturally raises significant health and safety concerns. ASM operations exploiting barite veins in Morocco may reach a depth of 130 m by creating trench-like open voids. Introducing modern concepts of underground mine design could help these miners mining deeper-seated portions of the mineralisation while improving health and safety. This may necessitate support interventions by international partners both at the government and mine site level. At the government level, suitable regulations for legal underground ASM operations would have to be discussed. At the mine site level, this process may necessitate capacity building as well as support access to financing to invest in mine infrastructure. Certain forms of pre-financing are already applied in countries like the DRC, where artisanal miners may spend days or even weeks driving down new mine shafts without directly generating income from ore recovery. This demonstrates the capacity of the ASM sector to facilitate certain types of mine infrastructure development in anticipation of future cash flow.

Recommendation 4.7: Consider visibly engaging in ASM supply chains for the purpose of securing ECRM supply.

In their sustainability reporting, EU-based companies tend to make statements that they are aware of the livelihood significance of ASM but emphasize that they are not sourcing from the ASM sector themselves. This is usually due to regulatory, customer and investor concerns regarding human rights violation risks associated with the ASM sector and the question of legality of ASM operations. Companies seek reputational protection for their brands and avoid possible 'contamination' by ASM ores and concentrates in their supply chains. This practice has not led to any noticeable decrease in the intensity of ASM operations in Africa, nor on the risks for negative impacts potentially associated with some of these operations. Rather, it has resulted in a situation where many of the ECRM produced by artisanal miners in Africa – such as copper, cobalt and, recently, lithium – have been mainly processed in China.

Pilot projects targeting the DRC's artisanal cobalt sector in recent years exemplify this situation. Two pilot projects officially involved direct cobalt sourcing from ASM sites. These included the Kasulo artisanal mining area, involving a local subsidiary of Huayou Cobalt (China) as a partner and buyer, and the Mutoshi pilot project with Chemaf, a subsidiary of Shalina Resources (United Arab Emirates), as a partner and buyer of artisanal cobalt ore. In contrast, the pilot projects initiated around ASM mine sites in the DRC with funding support by downstream industries involving western companies, notably the Fair Cobalt Alliance and the Cobalt for Development

initiative, have so far made a point of presenting these initiatives as CSR measures without directly sourcing any cobalt ore from the associated ASM operations, mainly based on the argument that the material produced there would formally be considered as illegal.

Irrespective of the question of legality in specific pilot projects, the practice displayed by western downstream companies is economically viable as long as they have ECRM supply alternatives that meet their supplier standards. If, however, companies are starting to get concerned about the physical availability of sufficient ECRM supply at competitive prices for their supply chains, engaging in ASM sourcing might expand from being a CSR, responsible sourcing or compliance question to becoming a strategic supply question. In that case, directly engaging in pilot projects that do involve actual ECRM sourcing from artisanal miners may provide an important learning experience for these companies how to engage in the ASM sector. This corporate learning experience has two components: (1) establishing stakeholder networks with artisanal miners, local traders and local authorities to build mutual trust and understand the actual ASM-related business models of all local stakeholders; and (2) supporting and tracking progressive improvement of ASM operations through time in order to eventually qualify them as acceptable suppliers.

Such a strategic approach may go hand in hand with reframing the companies' ASM engagement in their supply chains and changing the public narrative. ASM sourcing is currently often evaluated from a corporate risk management perspective. But publicly reporting about ASM material in a company's supply chain may also be presented as an opportunity to support local livelihoods and community development while ensuring a company's ECRM supply. An example is the 'Solutions for Hope' initiative for tantalum sourcing from the Great Lakes region, launched by certain western companies (AVX, Motorola) in the wake of the conflict mineral regulation within the US Dodd Frank act in 2012. While the initiative recognized artisanal livelihoods and was meant to counter the effects of a temporary 'de facto embargo' against parts of the region at that time, it should be kept in mind that it also supported the business interests in terms of tantalum processing of the involved companies. While downstream companies generally have to satisfy regulatory supply chain due diligence expectations, it is important to note that engaging artisanal miners is encouraged by the OECD in the spirit of good faith efforts, and may be supported by ASM-related certification and support initiatives. The exact mode of engagement depends on the local situation and allows for different approaches, such as involving local traders or exporters of ASM ores and concentrates (instead of or in addition to ASM mine site operators), or seeking synergies with other private sector- or donor-supported initiatives active in a given country, notably those that go beyond supporting good mining practice and aim to increase ASM access to markets and formal financing as well. The ASM country profiles included in Sewpershad & Tufo (2024) may provide a few examples in this regard.

Recommendation 4.8: Support and incentivize artisanal mine site operators to comply with ESG standards suitable for ASM.

Several ESG-related standards and certification schemes have been established in the ASM sector. Certification schemes have already been applied at a growing number of artisanal gold mines, reflecting that this is the largest ASM subsector, both in Africa and worldwide. ECRM-related standards and certification schemes in the African ASM sector are less widespread. They mainly cover the 3T sector of the Great Lakes region, where ASM sites in Rwanda and in the DRC have been audited against ASM-related ESG standards such as the Certified Trading Chains (CTC) standard or, with a due diligence focus but still maintaining basic ESG elements, the ICGLR's Regional Certification Mechanism. Several standards have been developed for the DRC's artisanal copper-cobalt sector, including an internal ESG standard that was thought to be deployed by the Congolese parastatal Entreprise Générale de Cobalt (EGC) in cooperation with Trafigura, an ASM cobalt framework developed with support of the Responsible Minerals Initiative (RMI), as well as the aforementioned CTC standard which legally applies to both artisanal 3T and copper-cobalt mine sites in the DRC. Taken together, these standards, along with other standards on responsible ASM (usually applied in gold) such as Fairmined, Fairtrade or CRAFT, provide a comprehensive illustration of realistic ESG performance expectations in the African ASM sector. Companies and development partners therefore do not need to start from scratch but may use any of these standards as reference when engaging ASM operators, performing risk assessments, and discussing support opportunities.

It is important to note that ASM operators themselves need to fully understand a given standard and own its implementation at their sites, while external downstream partners may seek ways to incentivize and support this process, for instance through organisational capacity development. Incentives typically tested in ASM settings refer to increasing site productivity through improved access to (formal) financing, provision of equipment, and introduction of improved processing technology that increases metal recovery. Besides higher metal output (and, thus, ASM operator turnover), these approaches may have ESG side benefits, such as a lower environmental impact or safer work procedures. Setting up support projects without considering incentive structures might not lead to sustainable success if ASM operators cannot experience any immediate, visible benefits from applying responsible sourcing standards – unless these standards are enforced by local authorities with sufficient monitoring capacities. Considering the latter, it is also important to evaluate and consider which national legal requirements ASM operators have to fulfill, as these may sometimes deviate from the criteria covered in external standards or certification schemes.

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Recommendation 4.9: Support closure and rehabilitation of artisanal mine sites.

While the focus of this set of recommendations is on increasing ECRM supply from the ASM sector, it is important to employ a mine life thinking right from the start. All mineral resources are finite, even more so for the small mineral deposits that are the typical target of artisanal miners. For example, pegmatites – the host ore deposit type for tin, tantalum and lithium in Africa – are often thin ore bodies with limited tonnage and variable ore grades (Schütte & Näher 2020). This leads artisanal miners to abandon small mine sites once the attractive ore zones have been mined out (note that they may also abandon mine sites for other reasons).

The scale of abandoned artisanal mine sites is indirectly reflected in the data published by the iTSCi mineral traceability scheme in the central African artisanal 3T sector (iTSCi 2024). The scheme registers each artisanal mine site and, in their records, differentiates active from inactive, that is, abandoned sites. Collectively, after more than ten years of iTSCi implementation, there are records of hundreds of inactive ASM sites for the 3T minerals in the iTSCi core implementation countries (Rwanda, DRC and Burundi). Not all of the inactive sites are necessarily mined out but depletion of economic resources is an important factor for a site becoming inactive. The DRC's artisanal copper-cobalt sector is characterized by strong fluctuations of ASM intensity as well, which again leads to abandoned ASM sites.

Unlike industrial mining operators, ASM operators often do not have a mine closure and reclamation plan in place, and do not set aside the necessary funds to cover closure costs once a given site has stopped yielding regular profits. Downstream companies or governments interested in sourcing or supporting ECRM production by artisanal operators are therefore advised to obtain a realistic idea on the life of mine of a given ASM operation, understand the environmental as well as health and safety liabilities that artisanal mining may cause, and discuss with artisanal mining operators and local authorities how to manage and fund an adequate mine closure process, once attractive ore resources have been mined out. An additional challenge to consider is long-term metal price volatility which may incentivize artisanal to re-enter previously closed sites and potentially destroy reclamation efforts once metal prices rise.

The existing large environmental liabilities associated with historic ASM activities in Africa are beyond the scope of individual supply chain engagement by downstream companies. But development partners or even downstream companies or industry associations may consider supporting national mining or environmental authorities managing these historical liabilities, for instance with the help of basket funds to cover closure and rehabilitation costs. Cleaning up historic liabilities from past ASM activities would not only serve to protect the local population and ecosystems, but may also contribute to improving the overall reputation of the ASM sector, making it more acceptable as a source of ECRM supply among consumers in downstream countries.

Recommendation 4.10: Improve geological and economic data availability on ASM mine production.

The ASM sector is often portrayed as a 'swing producer', able to buffer ECRM demand spikes through short-term up- and downscaling of production. While this situation may appear beneficial from a downstream supply perspective, it does not represent a sustainable business model for artisanal miners themselves. From a long-term ASM business development perspective, one of the key challenges is that it is unclear how long artisanal miners can sustain ECRM production at a given mine site. The lack of defined resources implies a lack of collateral when trying to access financing. For example, artisanal mining in Africa has been the world's most important source for tantalum over the past decade but there are hardly any accurate quantitative tantalum resource estimates available.

Moreover, artisanal miners do not only lack geological information on the size and nature of their resources, but they also frequently do not have a business plan defining investment needs and mine development potential. Actual development of artisanal mine sites in Africa is largely limited to few formal or semi-formal operators (companies) that rely on ASM labour input, rather than ASM cooperatives. In order for artisanal miners to mine and process ore, the ore bodies need to be at an accessible depth, where increasing deposit depth correlates with increasing challenges, including navigating legal depth limits for ASM exploitation, controlling increasing water inflow into the mine (requiring the use of water pumps which are expensive to operate), or time-consuming manual ore hoisting. Additional economic factors impact on the operational costs of mineral processing or on the semi-mechanisation of mining activities. All these operational development factors and their cost impact need to be evaluated in a business plan, along with their capital needs, in order to understand whether an ASM site actually constitutes a viable business case.

Improving geological, metallurgical and economic knowledge of ASM ore deposits, along with complementary ASM capacity development on these topics (see following recommendation), is therefore an important contribution to facilitate responsible investment in the sector. Relevant activities range from performing regional baseline studies to advanced exploration activities (sampling, drilling), metallurgical or economic studies at a given site. This kind of activities may be supported by national governments, for instance through competitive grants. An example for the latter is Chile, where the state-owned company ENAMI regularly sponsors small mine development projects associated with ASM copper mining (ENAMI 2024). While national government carry the main responsibility to offer such services, for instance through their geological surveys, international development partners or, potentially through a suitable mechanism, the downstream industry can support the process. This might happen through pilot

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projects, as currently tested, for example, through the industry-funded Cobalt for Development project in the DRC's artisanal cobalt sector. An illustration of development partner engagement with regard to assessing ASM resources at artisanal mining areas is provided by cooperation project between the BGR and the DRC Ministry of Mines (e.g., Ducellier et al. 2024).

Recommendation 4.11: Support extension service provision in the ASM sector.

National governments may provide extension services to the ASM sector to address capacity gaps on different topics, such as health and safety, environmental management, legal compliance, planning and optimizing production and processing, and business development. Improving the ESG performance of ASM operations may be expected to generate a positive impact on their ability to potentially sell their products into European supply chains, as it would improve ASM supply from a downstream compliance perspective. Extension service programs have already been successfully implemented in Africa's ASM sector. For example, from 1986-88, the EU financed studies on geological evaluations, mining techniques, mineral processing, and socio-economic impact evaluation of ASM activities in Rwanda (Metcalf 2015). Based on this input, a national extension service, COPIMAR, was founded, taking inspiration from the structure of CADETAF in Morocco and providing training and support programs to ASM operators on site. COPIMAR operated from 1989 until the Rwandan genocide in 1994, and was revived afterwards, though had to stop activities due to lack of donor funding. Later on, COPIMAR was transformed into the Federation of Rwandan Mining Cooperatives (FECOMIRWA), which provided less training, but does offer mineral processing and export facilities for its members.

More recently, as part of the "MAGTAP" program to support ASM formalisation, an initiative on providing extension services in the ASM sector was implemented in Mozambique, partly drawing on experiences from other sectors, such as agriculture. Sewpershad & Tufo (2024) reflect on learning experiences from this program, noting the challenge of limited government resources to continuously deliver extension services may be mitigated by introducing a hybrid approach. The latter refers to the implementation level, with co-contributions by government authorities, civil society, educational institutions and the private sector, as well as to the funding level, where financing to operate the scheme may be sourced from the government, international partners, and from ASM operators themselves. Naturally, such a hybrid approach for extension services might create strong leverage for international downstream stakeholders seeking to stimulate responsible ECRM production in the ASM sector. As far as donor funding is concerned, it further emphasizes the importance of programming support and cooperation projects with long-term funding. The latter is sometimes a challenge in modern times, when the planning horizon for cooperation projects tends to be 3-4 years or even less.

Recommendation 4.12: Support ASM capacity development regarding access to financing.

In their mapping report on financing and investment instruments for raw material projects in Africa (Albery et al. 2024), as part of AfricaMaVal WP3, HCF identified several factors negatively affecting the availability of financing for ASM operators. These include (1) limited education and knowledge in general, (2) limited market knowledge to inform ASM sales strategies (or lack thereof), (3) limited business mindset in cases where ASM is performed as a subsistence activity, rather than targeting a profitable business, (4) and limited financial literacy, comprising knowledge of the financial sector, understanding of outcome-oriented decision making, and accounting knowledge. This may be combined with a general mistrust in the banking sector and preference for informal lending and cash management practices.

Notwithstanding these challenges, several sources of funding are or could be made available to ASM. Aside from general support and grants by governments or development partners, these may include village savings and loans associations, loans to cooperatives (as opposed to individuals), private sponsors (though these financings are informal and, as such, potentially exploitative), financial services by local banks, support by large-scale industrial miners hosting ASM operations on their concessions, mining equipment leasing (progressing in scale as the operation develops and with the option to ultimately own the equipment), and microfinance initiatives.

Support interventions could consider, in particular: (1) multi-stakeholder capacity development – for ASM operators as well as at the government and banking level, to understand mutual linkages and opportunities in the field of ASM-related financing; (2) helping ASM operators to establish collaterals, for instance through streamlined permitting, reduced permit costs, and establishing/expanding ASM resources through supporting prospection activities; (3) making equipment available to ASM operators through leases, streamlined import procedures and creation of equipment service centres; (4) improving ASM market access by establishing purchasing centres and the associated infrastructure, including communication; and (5) in progressively accessing financial services, establishing a credit history for ASM operators, which makes them more credit worthy in the long run. It is worth mentioning the example of the DRC where local banks have already made efforts to engage in the ASM sector. For example, Trust Merchant Bank sought to cooperate with international partners such as USAID and BGR to support providing financial services to ASM operators in the eastern DRC. Even though efforts by Trust Merchant Bank as well as similar efforts by Equity Bank may face challenges in terms of replication and upscaling (Sewpershad & Tufo 2024), they nonetheless demonstrate the feasibility for the formal financial sector to successfully engage ASM operators.

Recommendation 4.13: Improve transparency on value addition in the ASM supply chain.

Economic discussions on the ASM sector often discuss the livelihood of artisanal miners, but ASM supply chains comprise additional stakeholders, notably traders, processors and/or exporters, who play an important role. Based on the developments over the past decade, it would not be accurate to claim that artisanal ECRM products in Africa are generally exported as unprocessed raw materials – while this may apply to some, such as lithium ores and concentrates (see Vasters & Schütte 2023), the situation may be different for 3T minerals as well as copper and cobalt. Frequently, 3T mineral pre-concentrates recovered by artisanal minerals undergo at least one additional concentration step (gravimetric and/or magnetic) prior to export from central Africa, whereas artisanal copper ores and pre-concentrates in the DRC, Zambia and Tanzania may undergo hydro- or pyrometallurgical treatment and be ultimately exported as copper cathodes or anodes. Similarly, artisanally-sourced cobalt ore mined in the DRC and Zambia may undergo further in-country processing; in the DRC this is typically crude cobalt hydroxide. Even for lithium, where significant ASM exploitation in Africa only started in 2022, the Zimbabwean government already issued regulations prohibiting the unprocessed export of lithium ore, leading Chinese operators to install local processing facilities.

The stakeholders involved in local processing may capture significant shares of the export value of artisanal ECRM products. Accurately estimating this value share is not an easy task due to the general lack of transparency surrounding ASM mineral trade as well as technical factors, such as accounting for the value addition impact of processing and refining services provided along local ECRM supply chains from mining to export. In 2014, the BGR in partnership with Rwanda Natural Resources Authority contracted a study to evaluate mining revenue streams along 3T supply chains in Rwanda (Cook & Mitchell 2014). The study found that artisanal miners tend to capture a higher value share (around 60 %) of mineral export value for high-value tantalum (coltan) concentrate while the share was lower (around 40 %) for tungsten and tin concentrates, which command lower prices than tantalum concentrate. The remainder of the export value, that is 40-60 %, is shared among concession holders (mining companies or cooperatives) as well as exporters, both of which may perform variable processing and logistical services. A conceptual technical and business model for a leaching plant of artisanal copper ore in Tanzania (Stoltnow et al. 2024) suggests that plant operators could pay out a sizeable net smelter return to their artisanal suppliers of copper ore while still making a reasonable return on their invested capital (for instance, 56 % ROI in case they paid out a NSR of 77 %). Findings collected as part of a mapping exercise in the DRC's artisanal copper-cobalt sector (BGR 2021) indicate that local trading houses ('comptoirs') tend to offer much lower buying prices to artisanal miners, suggesting that their own profit margins are very high.

Comparing local ECRM prices and verifying the associated business models of supply chain stakeholders requires collecting and evaluating data along local ASM supply chains as illustrated in the above examples. This is not only important from an ESG perspective (price fairness and transparency, e.g., in the context of EITI) but may also be important for national governments (to design appropriate taxation models and verify the plausibility of tax data declared by companies) as well as for downstream industries open to ASM sourcing (to verify whether prices offered to artisanal miners are sustainable and robust to ensure the expected ECRM supply over a given time period).

Recommendation 4.14: Encourage cooperation between artisanal miners (cooperatives) and formal concession holders.

From a downstream compliance perspective, informal ASM production is sometimes regarded as a contamination risk for supposedly 'clean' supply chains linked to audited industrial mines. Irrespective of this downstream perspective, it is important to consider the legal situation in the upstream supply chain itself, though. The DRC, as Africa's largest artisanal ECRM producer, may serve as an example to illustrate the challenges as well as opportunities associated with ASM-LSM cooperation and the question of informality of ASM production. In the country's copper-cobalt sector, artisanal miners usually exploit ore deposits located within industrial exploration or mining concessions. While sometimes formally tolerated by provincial authorities to ensure social peace in the area, these operations are officially illegal, since ASM activities according to national mining law shall be conducted either by a registered cooperative within an artisanal mining zone (ZEA) or, if representing a more advanced organisational level, with a valid small-scale mining license (PEPM). Official concession holders seeking to endorse close-by ASM activities would have to cede parts of their concession, so that the area in question could be covered through an ASM-related license type. This has happened only on very few occasions so far (at Kasulo and, recently, with EGC) whereas large parts of the country's artisanal copper-cobalt production are considered as informal.

Stakeholders in the DRC's 3T sector, on the other hand, have demonstrated the feasibility for industrial concession holders to engage with artisanal miners on a goodwill base by establishing a cooperation contract with cooperatives on their concessions, supervising these ASM activities, and accepting the mined material into formal supply chains. Legally, this practice may be regarded as a grey area but, during repeated CTC audits commissioned in a cooperation project between BGR and the DRC Ministry of Mines, local mining authorities stated that this practice complied with the spirit of the mining law. Moreover, thus produced mineral concentrate has been formally accepted by smelters certified under international due diligence programs. It is important to note, of course, that in terms of mining infrastructure and operational complexity,

the situation in the 3T sector is not directly comparable to major large-scale copper mining operations in the DRC. But nonetheless, it demonstrates that ASM-LSM cooperation is possible and may help formalizing certain ASM operations if all relevant stakeholders, including artisanal cooperatives, concession holders and mining authorities work together towards a productive solution.

From a downstream perspective, beyond the ECRM space, ASM-LSM cooperation is gaining traction in the gold sector where the London Bullion Market Association (LBMA), as a major international gold market association, actively seeks to expand its coverage of artisanal gold, rather than focusing on industrial and recycling gold only. To this end, the LBMA held talks with ASM and LSM stakeholders in Ghana, where they see potential for successful cooperation. This approach of seeking to endorse responsible ASM supply in cooperation with LSM might be beneficial to consider in the ECRM sector as well.

Recommendation 4.15: Improve ASM access to mining rights and sector formalisation.

Studies undertaken within the AfricaMaVal project (Sewpershad & Tufo 2024) indicate that a few African countries still have rather old mining codes that do not account for ASM activities or that provide only a narrow, limited legal space for ASM. From among the African artisanal ECRM producer countries (Figure 9), many do have a legal framework for ASM in place, though. However, even there, the sector remains largely informal. ASM sector legalisation challenges are described in detail in the academic literature and a practical illustration of some of the implicit legal challenges in the DRC is presented in the above recommendation. It is frequently pointed out that the difficulty of access to a valid license for artisanal miners is one of the major challenges for the ASM sector, in Africa and worldwide. This concerns, for example, the associated license fees, the time scale required for registering a permit, the complexity of regulatory procedures, and the place and process for submitting permit applications. If any of these are too difficult or impractical to fulfil for applicants, artisanal miners will continue to operate in the informal or illegal space.

The lack of a valid license makes it less likely for ASM operators to gain access to formal financing (where the license may serve as a collateral) and directs ECRM supply chains away from European customers, since the latter are often concerned about compliance implications for themselves in case they were to source from mine sites considered as informal. For this reason, in the interest of stimulating viable Africa-EU partnerships along ECRM value chains, it is worthwhile for downstream investors and policy makers to consider supporting national action plans and similar initiatives on ASM formalisation in African ECRM producer countries. As pointed out by Sewpershad & Tufo (2024), development cooperation projects focusing on high-value ASM

commodities such as gold or diamonds might potentially be leveraged to expand their scope towards the artisanal ECRM subsector, which is often smaller than that of high-value ASM commodities.

When engaging national governments and development partners, it is important for downstream stakeholders to work towards a common understanding of 'ASM formalisation' in a given country or project, as the term is applied differently by different stakeholders. Legalisation of ASM operations, which may give miners access to licenses but also implies they might be expected to pay taxes, is a crucial part of ASM sector formalisation – but it does not have to end there. In fact, many of the recommendations presented in this chapter, dealing with professionalizing the sector with the help of extensional services, increasing data availability on ASM ore deposits and business parameters, or improving ASM access to finance, may be considered to form part of a discussion on ASM sector formalisation. For this reason, downstream stakeholders are encouraged to address several of the recommendations of this chapter (in parallel or progressively) while striving for efficient coordination of internal and external measures in a given country among the different implementation stakeholders, such as national mining authorities or international development partners.

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5 Refining and value addition

5.1 Background – Refining capacities in Africa

Critical raw material value chains for green technologies require a range of extraction, smelting, refining, and manufacturing steps across several related industries. For example, in battery value chains, essential raw materials including lithium, cobalt, nickel and manganese (in the case of NCM-type cathodes) or lithium, iron and phosphate (in the case of LFP-type cathodes) are extracted, processed to intermediate products and then refined to battery-grade chemicals (e.g., lithium hydroxide or lithium carbonate, and sulphates of cobalt, nickel and manganese). These materials are subsequently processed into Precursor Cathode Active Material (pCAM) blends and then shaped as Cathode Active Material (CAM). Battery cells are manufactured from CAM, anodes (graphite), electrolyte (lithium), separators, and current collectors (copper, aluminium) and integrated into battery packs fit for EVs or energy storage solutions (ESS). Components for solar power (cells and modules) and wind turbines (magnets) require high-purity silicon, aluminium, copper or REEs. It is worth pointing out that installing renewable energy capacity should ideally be accompanied by complementary ESS capacities, thus requiring further battery metals to ensure that clean energy is available whenever required. Electrolysers for hydrogen production use refined nickel and PGMs, with electro refining ensuring catalyst-grade purity. Each value chain step requires maintaining careful process control to meet the performance requirements necessary for full product functionality in sustainable energy applications.

The global ECRM smelting and refining capacities show a high level of concentration, with China commonly playing the leading role (Figure 10). Mining and refining are frequently geographically separated. For example, the DRC currently supplies about 70 % of global mine output, yet most of this cobalt is exported as crude hydroxide to be further refined abroad, with China dominating advanced refining capacities (Figure 10). Indeed, Chinese companies are the leading refiners and manufacturers in downstream battery supply chains, accounting for the refining of 60 % for global battery-grade lithium, 74 % for cobalt and 97 % for manganese, as well as 90 % for cathode and 98 % for anode materials, 85 % for battery cells as well as two thirds of global EV manufacturing (Figure 10; IEA 2024a). China also dominates global REE refining with a share exceeding 90 %. The geographic distribution between global mining and refining capacities for critical raw materials highlights the opportunities to increase ECRM local smelting and refining in Africa. The development of diversified smelting and refining capacities closer to the mines could help eliminating bottlenecks and reducing geopolitical and logistical risks associated with current supply chains, but it requires adequate supporting infrastructure development and, potentially, fiscal or other incentives to ensure the process is economic.

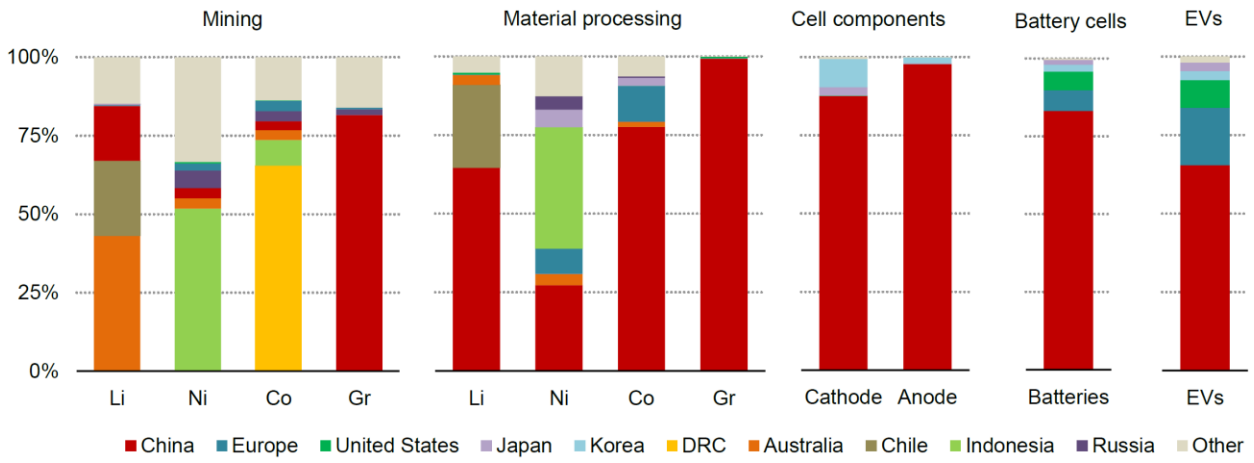

Figure 10 Geographical distribution of the global EV battery supply chain, 2023 (IEA 2024a).

African critical raw materials are partly processed to intermediate and refined products in the producer countries, and partly exported as ores and concentrates and then refined abroad. For example, copper mined in central Africa is typically smelted to anodes (Zambia) or refined to copper cathodes (DRC) prior to export. Cobalt mined in the DRC is typically recovered as crude cobalt hydroxide while nickel-cobalt ore in Madagascar is locally processed to intermediate products (nickel) or cobalt cathodes. Recently, a hydrometallurgical processing facility in Lubumbashi, DRC, has started recovering germanium hydroxide from zinc smelter slag. Elsewhere, Africa hosts advanced processing and refining operations as well, such as specialized refiners of PGM or manganese in South Africa. Morocco aims to develop its lithium-ion battery value chain further, with the country successfully attracting investors for battery plants and for recycling of European battery-related waste materials. These developments demonstrate the feasibility for setting up refining and further value addition operations in Africa. Within the AfricaMaval project, De Oliveira et al. (2023) published a database with a total of 215 entries, comprising 117 plants (general term for various industrial facilities), 45 refineries (for petroleum and chemicals) and 47 smelters in the African ECRM sector.

Nonetheless, African countries face several bottlenecks that make developing critical mineral refining and downstream manufacturing industries challenging (e.g., Ramsaroop et al. 2024a). Inadequate transportation infrastructure, including roads, railways, and ports, limits the efficient movement of raw materials, processing chemicals and processed materials. Remote mining sites or land-locked locations make it costly to transport raw and refined materials. Mineral beneficiation is energy-intensive, but many African countries suffer from unreliable power supplies, frequent outages (due to ageing energy infrastructure, increasing power needs and dwindling water levels partly due to the effects climate change), and high energy costs. The lack of reliable and affordable energy hinders the construction and expansion of smelter or refiner facilities that require a constant power supply to be cost-efficient. Hosting such facilities in

Special Economic Zones where, along with fiscal incentives for operators, these zones might benefit from preferential or subsidized access to electricity (as currently discussed in Tanzania, for example) might improve the business case for such value adding activities. The high energy intensity of mineral beneficiation and manufacturing plants can lead to significant carbon emissions for those countries reliant on coal or other fossil fuels, though, and thus impact on the carbon footprint of smelted and refined products. African countries implementing stricter environmental regulations may increase the required capital expenditure and operational costs for smelting and refining facilities.

Meeting higher environmental standards in refining often requires substantial additional investment in cleaner technology, which many companies may be reluctant to fund or find difficulties raising the required capital. Setting up refining and manufacturing plants requires substantial investment, often on the scale >US$ 100 million, which is challenging for many African countries to attract due to limited domestic capital funding pools, high borrowing costs and low credit ratings. International investors often find it too risky to fund large-scale projects in countries with perceived political or economic instability or taxation regimes unfavourable to investors. This situation might be changing slowly, though. Several African countries have been trying to encourage local refining and further manufacturing through establishing special economic zones that offer more attractive investment conditions. Also, new funding options may arise in the wake of initiatives such as the EU's strategic raw material partnerships in Africa, EU member state national raw material funds, or the Mineral Security Partnership, all of which may contribute to de-risking projects and making investment or financing more likely.

Beyond the question of access to financing, many African countries lack the necessary workforce skilled and experienced in refining and downstream manufacturing industries. With few exceptions, in particular South Africa, skills in advanced metallurgy and chemical engineering are in short supply, so that operators may resort to working with foreign expats, which can increase operational costs and might go against policy targets of African countries in terms of scaling up the local workforce, including at management level. Advanced mineral processing and refining requires modern technology, but many African countries lack the capacity to build, operate, and maintain these facilities. Indeed, much of the required processing expertise, especially in the lithium-ion battery value chain, is currently concentrated in China. Technology transfer or access to patents in sophisticated refining processes are limited, reducing opportunities for knowledge development within the continent. This challenge is known in Africa, leading some experts to launch initiatives such as the African Centre of Excellence for Research and Innovation on Batteries (CAEB) in the DRC and Zambia, which has already led to some success in terms initial capacity development efforts through cooperation with EU-based stakeholders.

5.2 Background – Value addition in Africa

Africa currently represents only 2 % of global manufacturing (futures ISS 2024). Many of the challenges identified above for refining apply similarly to downstream manufacturing. Moreover, the decision for installing local manufacturing facilities is a function of proximity to downstream markets. Africa's current demand for ECRM-related downstream products is relatively low. For example, electric vehicles account for less than 1 % of total car sales in Africa (IEA 2024b).

African downstream demand is growing at a moderate level. Recent forecasts predict that the share of the service sector in Africa will rise steadily from 50 % to 58 % and that of the manufacturing sector from 12 % to 22 % by 2043 (Current Path forecast 2019-2043; futures ISS 2024). Raji (2021) expects 50,000 to 300,000 Africa-wide new EV sales by 2030, and considers South Africa, Nigeria, Egypt, and Kenya to be the most important EV markets on the continent. Even though these predictions might have to be revised in the wake of global EV market weakness, recent developments nonetheless show encouraging efforts to increase the demand for renewable energy components in Africa. For example, BasiGo, Africa's largest electric bus company, has an order backlog of 350 electric buses and plans to sell a further 1000 in Kenya and 200 in Rwanda in the coming years.

Efforts are being made in battery swap technologies for two-wheelers. Ampersand, a Rwanda-based company, currently carries out 140,000 battery swaps per month for more than 1700 customers who collectively travel 1.4 million kilometres every week in Kigali and Nairobi. In general, two- and three-wheelers play a critical role in Africa for daily passenger and commercial transportation. Electrifying two- and three-wheelers is thus a promising lever for decarbonising mobility and improving urban air quality in Africa while stimulating local battery demand as well. Spiro, an African electric car start-up, has secured around US$ 60 million by 2023 to expand its electric car fleet and finance more than 1000 swap stations. The growth pattern in Africa-based downstream demand may help attracting further manufacturing on the continent. Indeed, organisations such as UNECA expect a substantial increase in African lithium-ion battery demand in the mid-term until the 2040s and encourage the development of special economic zones to support developing the associated value chains. The following table illustrates a few additional examples in terms of manufacturing in Africa.

Morocco	Strategically positioned to expanding its EV industry due to preferential access to European and US markets. Renault and Stellantis expanding their production of the Dacia Sandero as well as the Citroën Ami and Opel Rocks-e at the Kenitra plant. China is actively expanding its EV footprint in Morocco, primarily through major battery production investments with companies like Gotion High Tech (also in Kenitra) and CNGR Advanced Material having invested in gigafactories and battery component plants. It is noteworthy that Chinese companies might be technological

	or supply chain partners of European companies so that these activities might indirectly already affect the EU as well. For example, Gotion and Volkswagen have a technological partnership, with Volkswagen being Gotion's majority owner.
South Africa	Well-developed automotive industry exploring the possibility of switching to EV manufacturing which would support local demand for ECRM and stimulate value chain development. The South African Megamillion Energy Company, the continent's first large-scale producer of lithium-ion batteries, works toward a ~10 million lithium-ion cells-per-year capacity by 2028 based on nickel-manganese-cobalt (NMC) chemistry. Local manufacturing of solar cells (e.g., ARTsolar).
Kenya	Growing EV industry focused on electric motorcycles, which could eventually support demand for domestically processed battery minerals. Local Manufacturing of solar cells (e.g., Solinc East Africa). Semiconductor Technologies Limited, the country's first nanotechnology and semiconductor manufacturing plant, was launched in 2021 in a public-private partnership.
Rwanda	Volkswagen car assembly including Polo, Passat and Teramont. Locally assembled cars offered for ride hailing and corporate car sharing in Volkswagen's (and Siemens') mobility service Move. The e-Golf has also been part of the fleet since 2019. In 2019, the Dubai-based Mara Group started making its Mara Phone in Kigali. Mara's entire manufacturing process, from the motherboard all the way to the packaging of the phone is done in the Kigali factory.
DRC	Assembly and manufacturing of the Okapi Mobile smartphones, which have focussed on meeting the everyday needs of the Sub-Saharan African population.
Ghana	Solar Power Solutions (SPS) operates a solar factory in Ghana built in 2016 and produces all types of solar electronics.

Table 1. Examples for ECRM-related downstream manufacturing in Africa.

African policy makers have initiated several steps to support developing of manufacturing value chains and downstream markets on the continent. The AfCFTA was launched on 1 January 2021 to horizontally integrate intra-African production centres, value creation hubs, labour resources and a huge market (1.3 billion people). The aim is to increase intra-African trade and generate revenues totalling US$ 450 billion by 2035. The African Union and its member states have set specific goals in terms of critical mineral beneficiation, developing domestic downstream industries, expanding market capacity, and increasing domestic demand outlined in several key official documents on continental and national levels including, for example:

- Africa Mining Vision (2009)

- Agenda 2063 (2015)
- AfCFTA (2018)
- SADC Industrialisation Strategy and Roadmap 2015-2063
- South Africa's National Development Plan
- Botswana's Economic Diversification Drive and Vision 2036
- Zimbabwe's Agenda for Sustainable Socio-Economic Transformation and National Development Strategy 1
- Namibia's Growth at Home Strategy and Vision 2030
- Zambia's Vision 2030 and Seventh National Development Plan

These documents address the bottlenecks and list key goals including:

- Maximising the economic benefits of mineral resources by promoting domestic value creation through local processing, smelting and refining and supporting broader economic diversification;
- Generate employment opportunities and develop a skilled workforce to support beneficiation and downstream industries. Build local expertise, encourage technological innovation, and reduce reliance on foreign technology in mineral processing;
- Foster regional cooperation to create cross-border value chains and processing hubs;
- Ensure that beneficiation and mining practices align with environmental standards and support long-term sustainability;
- Create demand for processed mineral products within Africa to reduce dependency on exports and strengthen domestic markets;
- Develop the necessary infrastructure, including energy and transportation, to support large-scale beneficiation activities.

These aspects may thus be kept in mind in a cross-cutting sense, in addition to considering the specific topics addressed in the following subchapter.

5.3 Recommendations and Investment Opportunities

Recommendation 5.1: Support free trade agreements and encourage development of value-adding projects in African countries that have a free trade agreement with the EU in place.

Free trade agreements between the EU, its member states and African countries are laid down in so-called Association Agreements and Economic Partnership Agreements (EPA) (Figure 11). Table 2 illustrates the differences between the two agreements. These agreements remove or reduce trade barriers such as tariffs and import quotas to the EU. Potential ECRM value adding projects in countries falling under such agreements might thus benefit from more efficient trade conditions, while additional support might be unlocked if countries have both free trade agreements and strategic raw material partnerships with the EU in place. Beyond that, the EU might support increasing the number of free trade agreements with Africa, notably with strategic raw material partner countries, or with regional blocks where EPAs have not yet been implemented.

Table 2. Comparison of Association Agreements and Economic Partnership Agreements.

Feature	Association Agreements	Economic Partnership Agreements
Purpose	Broad cooperation (political, economic, social)	Trade and economic development
Legal basis	Article 217 TFEU	Cotonou Agreement
Market access	Reciprocal trade liberalisation, often extensive	Asymmetric liberalisation, gradual access for ACP countries
Development focus	Limited focus on direct development support	Strong “Aid for Trade” component
African partner countries	Algeria, Egypt, Morocco, Tunisia	Often through regional blocs; Central Africa (Cameroon), Eastern and Southern Africa (Comoros, Madagascar, Mauritius, Seychelles and Zimbabwe), East African Community (bilaterally implemented in the EU-Kenya EPA), Southern African Development Community (SADC; Botswana, Eswatini, Lesotho, Mozambique, Namibia, and South Africa), Economic Community of West African States (ECOWAS; Côte d'Ivoire and Ghana)

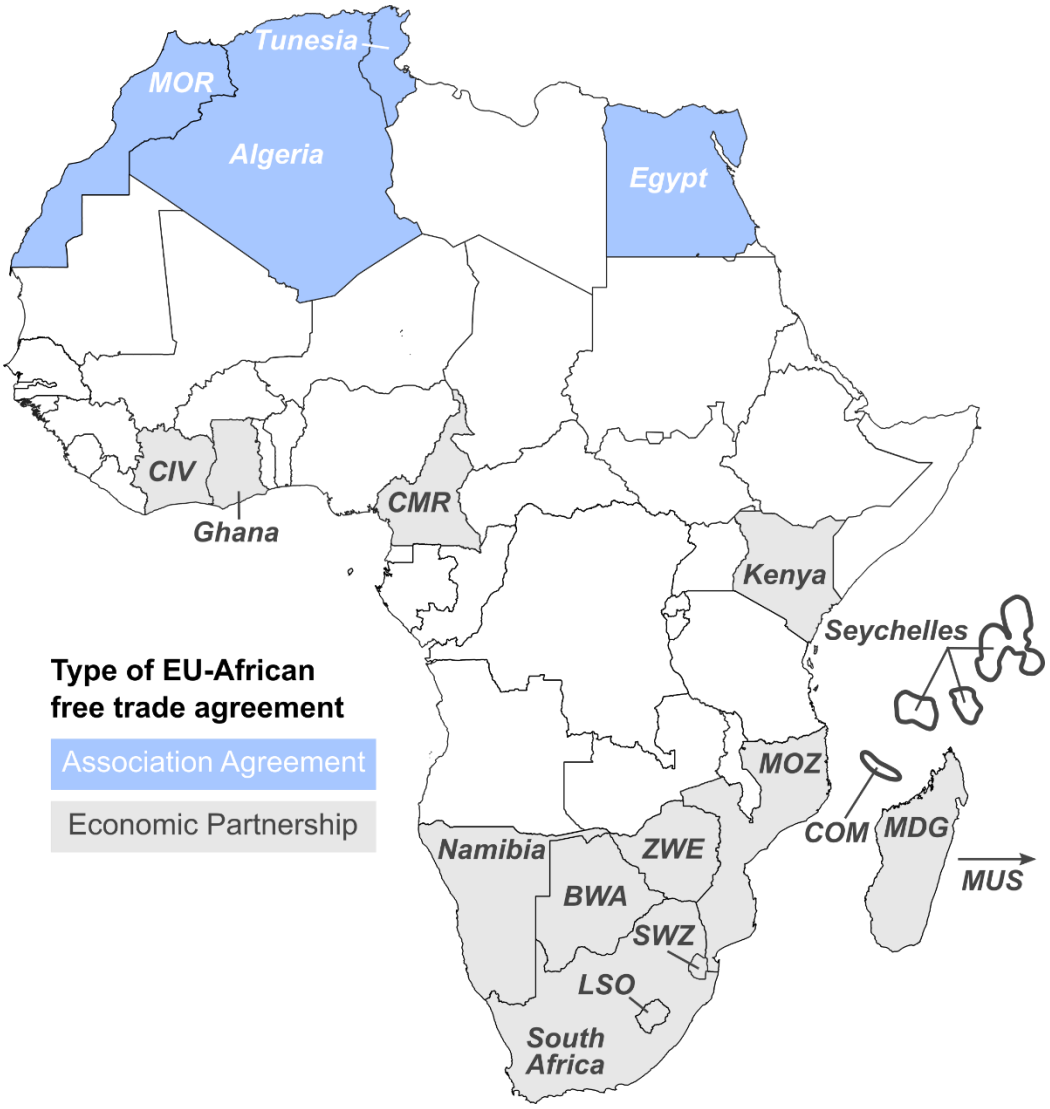

Figure 11. Countries in Africa that have a free trade agreement with the EU (European Commission 2025)[8].

Recommendation 5.2: Encourage Africa-based smelters and refiners to participate in certification or assurance programmes.

Metal smelters and refiners can participate in third party assurance/certification schemes to demonstrate their commitment to responsible sourcing, environmental sustainability, ethical labour practices, and quality standards (e.g., Erdmann & Franken 2022). Participating in these programs offers potential benefits in terms of downstream EU market access, as well as improved

[8] Country abbreviations refer to ISO 3166-1 alpha-3 – three-letter country codes

reputation and operational efficiency. Increasing the number of certified facilities in Africa is thus advantageous for both sides for strengthening EU-Africa value chains.

Relevant ECRM-related assurance schemes with public data on certified smelting/refining facilities in Africa at the time of research include:

- Aluminium Stewardship Initiative (ASI) certification applies to the aluminium industry and covers sustainable production and ethical sourcing of aluminium. ASI has standards for performance (focusing on environmental and social responsibility) and chain of custody (for tracking responsibly sourced aluminium through the supply chain). Smelters must undergo third-party audits to verify compliance.
- Copper Mark is a sustainability certification specific to the copper industry, ensuring that copper production adheres to high standards of environmental and social responsibility. Participating smelters and refiners need to align with the United Nations SDGs and pass a third-party assessment for sustainable and ethical practices in production.
- Responsible Minerals Assurance Process (RMAP), managed by the RMI, offers third-party assessments for smelters and refiners of different ECRM, historically starting with tin, tantalum, tungsten and in recent years expanding to additional ECRM, such as cobalt. It verifies that materials are sourced responsibly and meet due diligence requirements as defined by the OECD Due Diligence Guidance.

An overview on the certified CRM smelter or refiner facilities in Africa, at the time of research (December 2024) and based on data published on the websites of the Aluminium Stewardship Initiative, The Copper Mark, and the Responsible Minerals Initiative, is shown in Figure 12.

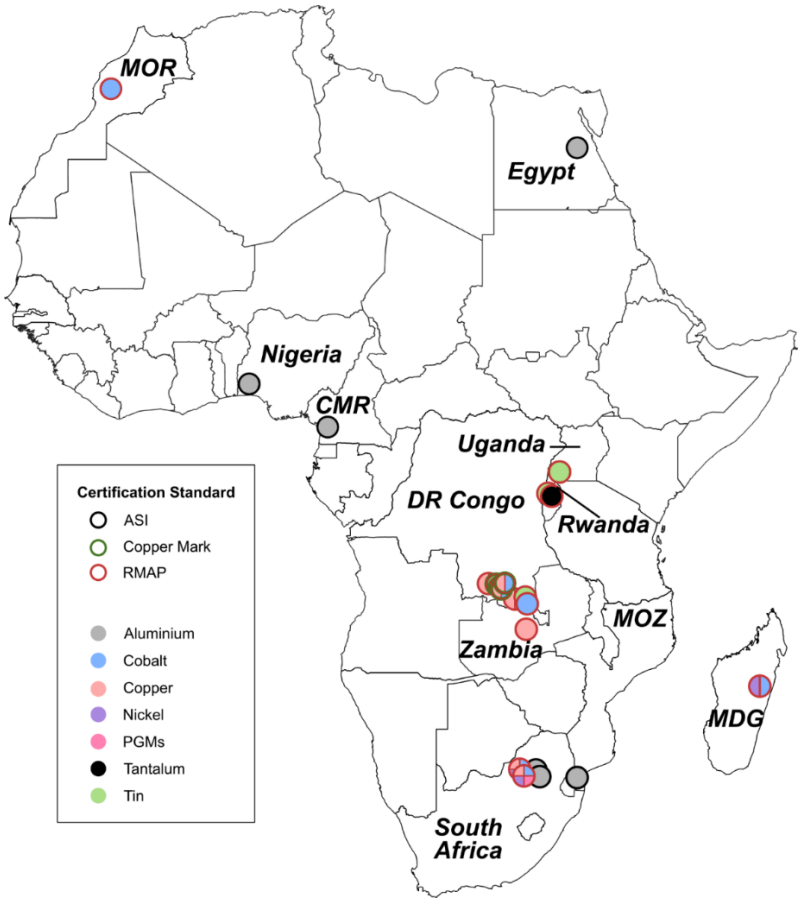

Figure 12. Location of smelter and refinery facilities with respect to the certification standards ASI, Copper Mark and RMAP (active and conformant; as of 12/2024)[9].

Recommendation 5.3: Consider the local enabling framework for investment in refining to ensure a sustainable business model.

For most of the ECRM, local mining capacities in Africa exceed local refining capacities but this does not imply that the investment case for refining is always clear-cut. African countries well-endowed with ECRM resources may lack the infrastructure, technology, or investment needed to refine these raw materials domestically. In addition, foreign investors may rely on a business case that builds on vertical integration where they mine locally but refine the raw materials in their own facilities abroad. It is further important to note that it is not realistic for each country to pursue local refining ambitions on its own. Rather, cooperation among neighbouring countries, for instance in terms of taxation and infrastructure development, as well as the international business case perspective can be important to ensure the economies of scale and sufficient long-term throughput to justify an investment decision for a given refining facility. Investors need to

[9] Country abbreviations refer to ISO 3166-1 alpha-3 – three-letter country codes.

consider this enabling framework but are rarely in a position to influence it individually. On a structural level, the EU might engage regional-international organisations (such as the AFDB or the World Bank) and African partner countries in order to address such issues. The following examples serve to illustrate these points for cobalt and aluminium but they generally apply to most ECRM mined in Africa.

The DRC produces more than 70 % of the world's cobalt. Most of the DRC's cobalt is exported as an intermediate product, cobalt hydroxide, and there is no in-country production of refined chemicals such as cobalt sulphate. Much of the refining instead takes place in China, where the refined cobalt chemicals serve as input materials for pCAM, partly by vertically integrated producers. A few operators in the DRC have expressed interest in installing local cobalt refining capacities, a process which the government aims to support by developing a Special Economic Zone, in cooperation with Zambia (see factsheet in AfricaMaVal Deliverable D7.1). Recently, cobalt refining plans were proposed in Zambia as well. It is noteworthy that a company active in both countries processed and refined DRC-mined copper-cobalt ore in Zambia until a few years ago, while this was still feasible from a taxation perspective. This underlines the importance for regional cooperation and bilateral agreements on mutual benefits sharing when it comes to refining operations.

Guinea is one of the world's biggest bauxite (aluminium ore) producers but to date only hosts limited alumina smelting and no aluminium refining capacities. Most of Guinea's bauxite is still exported as ore. While development of additional refining projects is currently underway (the Guinea Alumina Corporation facility in Boké and the Chalco refinery in Santou), unlocking the full refining capacities in countries such as Guinea will require major investment in supporting energy infrastructure. Mozambique demonstrates the feasibility for aluminium value addition in Africa. The country hosts an aluminium smelter that processes alumina imported from abroad. This reflects that Mozambique is ranked as having the highest energy potential in southern Africa (through the Southern African Power Pool) and emphasizes the close association of refining and infrastructure development.

Recommendation 5.4: Consider investments in countries that incentivise refining.

African governments are implementing policies that demonstrate their increasing commitment to supporting in-country mineral beneficiation and further processing as a tool for industrialisation, job creation and economic diversification to extract more value from their natural resources. This typically includes a combination of regulations encouraging in-country value addition combined with incentives to encourage such investment. Some examples include:

- South Africa: The country has a strong focus on mineral beneficiation, particularly for PGM. The Mineral and Petroleum Resources Development Act does require minerals to be processed domestically before being exported but there are also governmental incentives including tax incentives, infrastructure support, and funding for companies involved in beneficiation projects. There are also designated SEZs, such as the Platinum Valley SEZ, which offer reduced taxes and other benefits for firms engaged in value-added processes.
- Zimbabwe: In 2014, the government introduced a Mineral Beneficiation and Value Addition policy to promote in-country processing of minerals such as platinum. Ban on raw ore exports include the platinum, chrome and lithium sectors. Zimbabwe offers tax breaks and customs duty exemptions on imported machinery for companies setting up beneficiation plants. The government also provides other financial incentives, such as tax holidays for mineral beneficiation projects.
- Namibia: The country's Mining Charter includes provisions encouraging mineral beneficiation, with a focus on creating jobs in the diamonds, uranium, and base metals sectors. The government offers tax breaks, export allowances, and access to SEZs are available to companies investing in beneficiation activities.
- Ghana: The country has emphasised the need for local processing and value addition in its Minerals and Mining Policy. The government seeks to promoting domestic refining and other beneficiation activities, especially for manganese. The government provides tax incentives, such as exemptions on import duties for machinery used in beneficiation processes, and encourages partnerships between local and foreign companies for value addition.
- Tanzania: The country has introduced regulations that require mining companies to process certain raw materials, particularly in the gold (-copper) sector, domestically before export, notably through its Mineral Export Control measures. The government offers tax reductions, customs exemptions on imported equipment for processing, and access to SEZs for firms investing in beneficiation.
- Zambia: The government's Seventh National Development Plan includes mineral beneficiation as a key pillar to boost industrialisation and add value to the copper sector. The country offers tax incentives, such as import duty exemptions for beneficiation equipment, and reduced corporate tax rates for companies involved in beneficiation processes. The government also encourages foreign investment in copper smelting and refining through PPPs.

Recommendation 5.5: Support networking and cooperation on promoting horizontal and vertical linkages among raw material producers and associated value-adding industries.

Promoting horizontal and vertical linkages among raw material producers and corresponding value-adding industries might be an option for the EU to support fostering economic integration and industrialisation while reinforcing value chain links between Africa and Europe. As a first step, such a process may leverage platforms and networks already in place to initiate dialogue and support networking on this topic. Africa already hosts a major international mining event (the Mining Indaba) as well as multiple important national-level mining events. The EU equally has suitable communication events in place, such as the annual Raw Materials Week. The EU Member states have additional networking structures operational in Africa, such as the German or French chamber of commerce, as do African countries such as South Africa. Several EU-funded projects, including AfricaMaVal and the upcoming PanAfGeo+ Invest, also seek to support coordination and networking. Industry associations would also represent a relevant stakeholder to engage, as discussed in the following recommendation below.

Recommendation 5.6: Engage industry association on the topic of ECRM refining in Africa.

Industry associations bring together companies, governments, and stakeholders involved in the extraction, processing, and value addition of critical raw materials. By working together, members of an association can share technical knowledge and best practices. Associations can help standardise processes and products, ensuring, for example, that the quality of processed materials meets both local and international market and regulatory requirements. Similarly, associations may guide their members in implementing certain ESG standards. The EU could engage with African industry associations to discuss refining and further value addition, and identify potential synergies addressing typical refining-related bottlenecks (infrastructure, technical expertise, financing).

Examples for Africa-based industry associations include:

- Mining Industry Association of Southern Africa: This association advocates for local beneficiation and processing of minerals to boost industrialisation and ensure that local economies capture more value from their natural resources.
- African Battery Alliance: The African Battery Alliance is a Pan-African initiative aimed at supporting the development of battery manufacturing in Africa by utilizing the continent's critical minerals, particularly cobalt, lithium and nickel and promotes the local beneficiation of these materials into battery components, fostering the development of a domestic battery industry in Africa.

- Chamber of Mines of the DRC (Fédération des Entreprises du Congo): The Chamber of Mines advocates for investment in local beneficiation facilities to process cobalt, copper, and other minerals domestically, ensuring that more value is captured locally before export.
- South African Minerals Council: The council works closely with the government to promote local mineral beneficiation, particularly in refining platinum and manganese for use in industries such as renewable energy and automotive manufacturing.
- East African Chamber of Mines and Industry: This chamber advocates for policies that support local processing and value addition, encouraging governments to adopt legislation that promotes beneficiation as part of national industrial strategies.
- Zambia Chamber of Mines: The Zambia Chamber of Mines supports efforts to develop local refining capacity for copper and cobalt, ensuring that these minerals are processed domestically to capture more economic value from exports.
- Association of Tanzania Employers - Extractives Sector: The association works with the government and private sector to encourage local beneficiation initiatives and ensure that the mining sector contributes to Tanzania's industrialisation goals.
- Zimbabwe Chamber of Mines: The Chamber supports efforts to increase local processing of minerals, particularly platinum and lithium, and cooperates with the government to attract investment in processing facilities.

Recommendation 5.7: Promote the construction of refining facilities in regions where skilled personnel are more readily available.

Skilled engineers and other specialists in Africa can often be found in regions with a long-standing history of industrial activity, mining, and technical education. The following lists shows a couple of these regions:

- South Africa has one of the most advanced and diversified mining industries in Africa with a long history of mining and refining metals. Some of Africa's leading universities and technical schools focusing on mining and engineering are located in South Africa including the Universities of Pretoria, Witwatersrand and Stellenbosch.
- Zambia hosts educational institutions like the University of Zambia and the Copperbelt University which specialise in mining-related education.

- The DRC's Katanga region in particular has a number of educational institutions that have operated for multiple decades. Key educational institutions include the Universities of Lubumbashi and Kolwezi, as well as mining schools such as the Institut Supérieur des Techniques Appliquées, the Institut Supérieur des Mines, and the École Supérieure des Ingénieurs Industriels.
- Zimbabwe has a strong tradition of mining education, with institutions like the Zimbabwe School of Mines and Midlands State University.
- Morocco has expertise in mining and beneficiation related to phosphate processing, among others. The Office Chérifien des Phosphates is one of the largest phosphate companies globally, and its operations have helped develop skilled personnel in chemical engineering and mineral processing. Morocco has technical universities that provide specialised education in mining and engineering, producing a skilled workforce for its phosphate and broader mining sectors.

These regions present opportunities for investment from the EU (industry) in refining facilities, leveraging the existing pool of skilled labour for higher value-addition processes in combination with significant local raw material production to feed refining facilities.

Recommendation 5.8: Engage in targeted upskilling local talent for roles in smelting, refining, and manufacturing industries.

Upscaling skill development in Africa may be beneficial both at the university level as well as for community-based training of technicians. Relevant scientific disciplines include engineering and IT as well as non-technical disciplines covering legal and economic aspects. The latter are required not only for corporate purposes, but also at a public level to embed refining and manufacturing facilities in an adequate business environment, for instance through special economic zones. Multiple initiatives and stakeholders in Europe and Africa might be leveraged for supporting or delivering associated training activities in relation to refining and manufacturing. Some examples include:

- The European Institute of Innovation and Technology (EIT) and EIT Raw Materials;
- European industry stakeholders (individual companies such as Umicore or Aurubis, or industry associations), for instance to offer apprenticeships;
- The African Union Development Agency's (AUDA-NEPAD) programs support industrial skills development across the continent;

- African regional economic communities (e.g., SADC, ECOWAS) could facilitate cross-border training and exchange programs;
- Cooperation between African and European universities and research institutes, such as the collaboration between the Steinbeis Global Institute and the University of Lubumbashi.

Recommendation 5.9: Support vertical integration of Africa-EU value chains.

Some companies choose to control large segments of their upstream ECRM supply chains through vertical integration. While introducing operational complexity, this process secures a company's ECRM feed irrespective of the prevailing market situation or other impacts. Vertical integration may be of particular interest in case the price of raw materials has a strong impact on product manufacturing costs, for instance in the case of lithium-ion batteries in the battery metal value chain. Vertical integration is in alignment with EU policy targets, since the CRMA stipulates that the EU is required to cover 40 % of the EU's annual demand for processing with domestic capacities by 2030 (EC 2024a). ECRM refining or further manufacturing in the EU allows the operator to ensure that the final products meet specific standards required by customers in the EU market. Furthermore, with full oversight of the supply chain, the company can offer greater transparency, traceability and ensure that its operations comply with EU environmental and labour regulations.

At the same time, it is important to note that Africa aims to increase its share of value addition on the African continent itself, rather than having its raw materials processed abroad. While this may be feasible for large mining projects or clusters of mines (where the operators agree on shared processing), it is not always economically and logistically feasible to do so for small or medium-scale mining operations. In these cases, vertically integrated processing operations with the EU/Europe may be economically advantageous. In these and other cases, it may be worthwhile exploring options where stakeholders in mineral producer countries own a share in the associated processing operations abroad, and share benefits from them in other ways as well, for instance through dedicated capacity development/training on the processing techniques employed.

Examples for companies with ECRM mining projects in Africa targeting refining in Europe:

- Pensana Plc, which plans to refine the mixed rare earth double sulphate originating from its Longonjo REE project in Angola to a NdPrO product at its refinery in Saltend, United Kingdom;

- Mkango Resources plans to refine the mixed rare earth carbonate originating from its Songwe Hill REE project in Malawi together with the polish major chemical producer Grupa Azoty at its planned REE separation plant in Pulawy, Poland;
- The Evion Group plans to refine the graphite product originating from its Maniry graphite project in Madagascar to battery anode material (coated spheronised purified graphite) in Germany.

Recommendation 5.10: Support regional coordination and collaboration in African lithium-ion battery value chains.

The LIB supply chain builds on mining or recycling of so-called battery metals that are required to manufacture battery cathodes and anodes in different processing steps. Battery metals are most commonly defined to include nickel, cobalt, manganese, lithium and graphite, although this group of raw materials is associated with a specific type of battery cathodes (NCM, nickel-cobalt-manganese, in variable proportions) that has in the past had a large market share. There are other types of LIB cathodes, though, such as LFP (lithium-iron phosphate), that require different raw material input. Additional raw materials such as copper (for wiring) are required for manufacturing battery cells as well. The geological endowment by several African countries in some of these battery metals has prompted the desire to increase value addition in LIB value chains on the continent itself, rather than exporting the raw materials for processing in China and other countries. Specifically, different countries or investors have proposed plans for setting up manufacturing sites for pCAM, CAM, anode plants, battery cell production or battery assembly sites. It is also important to note that the input raw materials first need to undergo chemical refining before they may be processed to pCAM. To date, this refining step mostly happens abroad as well.

Prominent examples for investment plans in the LIB value chain include projects in Morocco, the DRC, Zambia, and South Africa. Among these countries, Morocco may be considered as the most advanced location from an investor perspective, benefiting from logistical and fiscal advantages with regard to European and US market access. South Africa has a well-established refining sector, for instance for manganese, and is engaging in LIB-related research and development activities. The DRC and Zambia seek to encourage investment based on designating special economic zones for the LIB value chain, which shall offer an advantageous regulatory and fiscal framework and may further have logistical benefits with the on-going international focus on developing the Lobito Corridor railway from Central Africa to the Atlantic coast. Both countries are also keen on developing their skill base for LIB-related manufacturing steps. LIB value chain development in Africa may serve different markets. Production facilities in Africa may help

supplying European or other EV value chains, although some limitations apply, for instance in terms of transport safety of certain intermediate products. In the medium to long term, African consumers themselves are expected to generate progressively increasing EV demand, especially for two- and three-wheelers.

EV markets such as China and, more recently, Europe have shown that demand for e-vehicles from end consumers fluctuates greatly and that they tend to favour EVs when the government subsidises the price. Once such subsidies stop, demand may slow, unless EV prices are competitive with vehicles relying on internal combustion engines. Moreover, technological progress in battery manufacturing leads to differences in LIB cathode composition and to the development of solid-state batteries, all of which will change demand parameters further. These and other market developments lead to consolidation processes in the LIB value chain, since not every facility and business operator turns out to be economically viable. This is a normal economic process that is not problematic per se, but African countries can observe and draw lessons from these business dynamics in other countries, including volatile demand patterns and technological and economic challenges.

Regional coordination or, potentially, collaboration may help African countries to increase the likelihood for setting up economically viable LIB value chain facilities. The DRC's and Zambia's initiative to set up a joint special economic zone for the LIB value chain illustrates the collaboration potential, even though both countries now appear to aim for two separate economic zones with a certain degree of collaboration in mutual raw material supply. The EU might support efforts for coordination and collaboration by participating in dialogue and technical exchange platforms on this subject in Africa, and by encouraging European downstream industries to engage in these discussions as well. Conferences and other events on this subject have already been organized in Africa, for instance by the UN Economic Commission for Africa as well as by private sector stakeholders, either as stand-alone events or as side events to larger conferences.

Recommendation 5.11: Encourage regional cooperation on smelting and processing of 3T (tin, tantalum, tungsten) minerals, for example in the Great Lakes region.

Several African countries host clusters of major mines that could economically justify setting up smelters or hydrometallurgical processing facilities. The copper mining sector in the DRC and Zambia or the PGM sector in South Africa serve as examples in this regard. The 3T sector, on the other hand, is different because the overall commodity market size is small in comparison, and production in the ASM sector is frequently dispersed, involving a large number of mine sites and traders, and is therefore difficult to capture. From among the 3Ts, tin has the largest market size

and tin smelting facilities have existed in Africa for many decades. Despite this background, most tin continues to be exported from the African continent in the form of ores and concentrates, rather than as metal ingots, and existing smelting facilities have often been decommissioned or seen only intermittent, low concentrate throughput through the years. This is due to technical challenges of setting up and operating tin smelters, in particular due to their power requirements, but also due to a lack of stable concentrate feed where old, existing or new, planned facilities tend to operate significantly below their throughput capacities, causing economic problems for the operator. With some notable exceptions, mainly in the DRC (the Bisie mine, Africa's largest tin producer) and Namibia (Uis), much of Africa's tin ore is mined in the ASM sector, which, due to its price-sensitive intensity of operations, may further complicate generating stable supply for a given smelter.

The challenge is even more pronounced in the tantalum sector, where tantalum ore is almost exclusively mined by artisanal miners and exported as coltan concentrate. Despite Africa representing the world's major source of tantalum over the past 15 years, hydrometallurgical processing takes place abroad (Schütte 2019). This includes the separation of niobium as a by-product recovered from tantalum processing. The hydrometallurgical processing of tantalum (coltan) concentrate is a complex metallurgical process, requiring sophisticated skills and equipment as well as chemicals supply (Schütte 2021b). Another main business impediment is the lack of long-term supply security and stable concentrate throughput rates for a potential local tantalum processor. This reflects the widespread risks for smuggling and informal trade of coltan concentrate all over Africa as well as the political tensions in the main production area, the Great Lakes region.

Regional economic cooperation on 3T mineral processing, in particular among the DRC, Rwanda, and Burundi, but also elsewhere in Western or Southern Africa, could unlock value addition opportunities for mutual benefit, and help attracting European investors and technology partners. Improved regional economic cooperation on 3T mineral processing might additionally create benefits for the implementation of cost-efficient supply chain due diligence measures. The means for the EU or other downstream stakeholders to support regional economic cooperation on this subject in Africa are limited, though, due to the complexity of the underlying political tensions. In the Great Lakes region, these are mainly associated with the conflict dynamics in the eastern DRC. Despite long-term international peace building efforts, the conflict continues to this day and, in recent years, conflict intensity and the number of human rights violations has sadly been increasing. However, presenting viable business and investment opportunities for the in-region processing of 3T minerals that are contingent on regional cooperation in terms of mineral sourcing might encourage productive political discussions. Africa's regional economic and political organisations, such as the EAC, SADC, ECOWAS, ICGLR or Economic Community of the Great Lakes Countries, might play a role in this process as well.

Recommendation 5.12: Engage African integrated mining, smelting and refining operations with lighthouse character in improving their ESG performance.

Large integrated mining, smelting and refining operations in Africa may have an important lighthouse character on the continent. In addition to ECRM output and profit considerations, it is thus important to ensure that these sites operate well in terms of environmental performance, community concerns and governance ethics. EU stakeholders might therefore support the operators of these sites through providing expertise or access to financing for ESG-related improvements, such as more efficient emission reduction and monitoring, wastewater management, access to renewable energy, employee health and safety, or community relationships. This may make the ECRM output of these projects more readily acceptable for the European downstream market but may also inspire policy makers, other operators and entrepreneurs in Africa to set up projects achieving a similar degree of ESG performance elsewhere. The Ambatovy and Mopani projects may serve as examples for some of the ESG challenges at integrated mining-refining complexes in Africa.

Ambatovy (Madagascar) is the largest lateritic nickel-cobalt mining and refining operation in Africa. Mined ore is processed into a slurry and then sent via pipeline to an off-site refining site. The European Investment Bank (EIB) has actually contributed a share of initial financing for the project. The slurry pipeline has been a cause of concern for local residents who suspected uncontrolled emissions detrimental to their health. The EIB investigated these concerns and found that there was no danger to the local population, but these incidents nonetheless outline the importance of transparent and credible emission monitoring as well as appropriate community engagement strategies. Carbon emissions associated with mining and the energy-intensive pipeline transport of the ore slurry may become of increasing concern as well.

The Mopani Copper Mines complex has been a major copper producer since the 1930s and has a mine life in excess of 25 years. The complex comprises different underground copper mines, multiple concentrators, and a smelter and a refinery. Since the end of 2023, the mine is run as a partnership between the Zambia's investment holding company ZCCM and an Emirati investor. The complex is situated next to the cities of Mufulira and Kitwe and residents have been complaining about respiratory problems in relation to the smelting activities as well as due to dust emissions from the large tailings facilities associated with decades of mining activities. The safety and environmental impact of tailings storage sites is also of major concern for current operations as well as for the future mine closure process. While EU stakeholders are currently not directly engaged as investors or offtakers in the project, but the EU could include the topic of ESG improvements at Mopani in its discussions and activities of the EU-Zambia strategic raw material partnership, with the objective of supporting responsible copper mining, smelting and

Funded by
the European Union

refining activities as well as to manage the accumulating mining legacies and eventual post-mining transition.

Recommendation 5.13: Support companies that create value in Africa and locally source raw materials.

Value-adding companies in Africa that process critical raw materials locally may face a variety of challenges. While the decision to rely on domestic resources aligns well with supporting local economies, enhancing resilience, and promoting sustainability, it also brings specific hurdles that these companies must address to succeed. One of the challenges includes the risk of supply chain disruption, for instance due to logistical challenges (seasonal variations, lack of maintenance, scalability of mining operations) or political or fiscal instability. Furthermore, initial costs for localising supply chains, including for upfront investment in infrastructure, technology, and workforce training, might be high.

For example, the South African Manganese Metal Company is a producer of high purity manganese metal for more than 50 years. It plans to refine high-grade manganese oxide ore procured from South32`s Hotazel Manganese Mines in South Africa. The company is currently aiming to commission a refining plant for high-purity manganese sulphate monohydrate (HPMSM) with a capacity of 5,000 tonnes per year in 2026. The company, which would become the only current non-Chinese battery-grade manganese sulphate producer, plans to export 100 % of the HPMSM product. If a battery value chain was established in South Africa, it is envisaged that the required quantity for local consumption would be supplied by the facility to increase local value addition. Although the various certifications and authorisations are already in place, the challenges of the project are of an infrastructural nature, such as regular disruptions or delays to rail services. Furthermore, the cash cost of producing HPMSM in South Africa might be higher than in China, for instance due to the level of energy and labour costs.

In order to support the development of locally sourcing value addition projects, the EU could provide access to project financing (possibly at preferential rates) and/or discuss with African governments, for instance as part of its strategic raw material partnerships, to incentivize development of such projects in terms of local content policies as well as the fiscal and permitting framework. The EU might also raise downstream awareness on these projects in Europe and encourage or facilitate offtake discussions.

Recommendation 5.14: Support EU-Africa partnerships to improve local technical expertise for refining processes.

The EU could support value chain development in Africa by facilitating capacity building and curriculum development in terms of state-of-the-art processing technology for recovering ECRM main commodities and by-products, processing efficiency and environmental impact. This might include, for example, establishing vocational training centres in partnership with African universities and technical institutes, or bringing about partnerships between private companies as well as public-private partnerships. A range of European companies have experience on such matters, for example:

- Outotec (Finland): Outotec has extensive expertise in mineral beneficiation technologies, particularly in flotation, hydrometallurgy, and smelting processes. Outotec's processing technologies can help improving metal recovery rates and meeting product quality targets. The company offers training and consulting services as well, and has already been engaged in Africa.
- FLSmidth (Denmark): FLSmidth provides a wide range of equipment and solutions for mineral processing, including flotation cells and filtration systems. FLSmidth focuses on "MissionZero," an initiative aimed at reducing carbon emissions by providing energy-efficient processing technology.
- Thyssenkrupp AG (Germany): Thyssenkrupp has experience in managing complex engineering projects, including plant construction and operational support.
- Eramet (France): Eramet has operational experience in the processing and refining of critical raw materials such as nickel, cobalt, and manganese.
- BASF (Germany): BASF is a global leader in chemical processing and catalyst technologies, which is useful for lithium-ion battery value chain, among others.
- Umicore (Belgium): Umicore is a global leader in critical metal refining and recycling, and has already active partnerships related to a DRC value chain for germanium recovery.
- Aurubis (Germany): Aurubis operates state-of-the-art copper smelting and refining facilities in Germany and elsewhere, including recovery of high-value by-products, and meeting high environmental standards.

Recommendation 5.15: Facilitate market research on ECRM refining perspectives in Africa.

While there is a broad view, supported by national policy developments, that refining and value addition in Africa's ECRM sector should be increased, the underlying business case for a given project strongly depends on the specific raw material and the national context. For example, Indonesia's regulations on mandatory in-country value addition in nickel mining may be considered as successful (WTO trade disputes notwithstanding) in that the country has managed to shift part of the upstream value addition from China to Indonesia. But this development cannot necessarily be replicated in other countries since Indonesia, as the world's largest nickel producer, benefited from economies of scale while the smelting operations are associated with high energy demand and often necessitate large coal power plants (a commodity in ample supply in Indonesia as well).

Moreover, the risk profile for refining projects differs from that of a mining project. In comparison to mining, the project risks tend to be lower at the refining level provided that sufficient raw material feed can be secured in the long term and provided that the project operator has sufficient technological expertise for the anticipated processing technologies. The latter two factors can be closely intertwined as the processing steps are strongly dependent on the characteristics of the feed material (e.g., average metal grades and presence of deleterious elements). The somewhat lower risk profile of refiners compared to early-stage mining projects may unlock additional financing options, for instance through commercial banks. At the same time, the refining business model is somewhat different from mining as it depends more on competition in the refining market segment, where global refining over-capacities are relatively common. While the raw material price may play a role, the treatment charges levied by refiners reflect these other factors as well. Refiners are sometimes owned by vertically integrated manufacturers which will again influence the overall business model.

Navigating the complex market background of refining projects is therefore not an easy task and it might not be realistic to expect refining projects to be set up all over Africa wherever ECRM are mined, irrespective of the specific business case, supply and demand situation, infrastructure prerequisites and other impact factors. Performing or commissioning professional market research on the refining situation and requirements for specific ECRM and outlining realistic implementation scenarios in Africa, both for main commodities and potential by-product recoveries, may therefore be beneficial for both the EU and African partners to inform policy discussions as well as planning of activities in relation to strategic raw material partnerships. Different specialized consulting services may be contracted to facilitate this kind of market research.

Recommendation 5.16: Map and summarize ESG, due diligence and reporting requirements for African ECRM products to directly access the European market.

In recent years, the EU has published various regulations or directives with ESG and due diligence elements that apply to specific ECRM value chains or to raw materials in general. Examples include the battery regulation, the conflict mineral regulation, as well as cross-cutting directives that apply to managing corporate due diligence risks and human rights practice. Some EU Member states have published additional regulations in this regard. Furthermore, the EU's REACH regulation, managed by the European Chemicals Agency, represents a comprehensive system for reporting and registering chemical substances and their impact on human health and the environment.

While these regulations and directives may directly apply to the EU-based importers or market participants, they indirectly affect the international upstream supply chain associated with a given ECRM product that enters the European market. Smelters or refiners occupy a special position in the value chain, as they form a chocking point where up- and downstream information meets. Refining entities may directly influence their associated supply chain all the way up to the mine level, whereas downstream industries would typically rely on exerting indirect influence through their associated supplier network, unless they own direct stakes in upstream suppliers.

For present or anticipated ECRM refining operations in Africa intending to establish direct supply chain links and access to the European market, it is thus important to be aware of their direct or indirect responsibilities under different EU regulations so that they may set up the required management systems and reporting tools. A centralized online platform summarizing and linking all relevant regulations as well as outlining potential overlap and synergies between different regulations might help both African project developers and European offtakers to ensure early on that newly established supply chains comply with the applicable EU regulations.

Recommendation 5.17: Provide centralized information on funding and financing support opportunities for developers of mining, refining and value addition projects in Africa.

Over the past two years or so, broadly linked to the CRMA and related EU policy initiatives, the EU and its Member states have set up a number of new or adapted funding structures, programs and other instruments that are meant to support increasing EU supply security and resilience in critical raw materials while meeting the twin transition (energy and digital) targets in a broader sense. Among others, these initiatives variably refer to exploration, mining, refining, manufacturing, infrastructure development, or a combination of these. They include, for example, the recognition of "strategic projects" under the CRMA as well as Member state ECRM-related support funds set up in Germany, France and Italy. Some Member states additionally have

financial support instruments such as untied loan guarantees in place, and are beginning to expand the scope of some of these instruments. Further financing opportunities may be available through the EIB (e.g., initiatives under Global Gateway and the EU-Africa Infrastructure Trust Fund), the EBRD (which considers expanding their geographic footprint in Africa), the European Development Fund (EDF), and the European Fund for Sustainable Development Plus (EFSD+).

As part of AfricaMaVal's WP3 on financial instruments, Albery et al. (2024) provide a high-level overview on some of these initiatives and explain the underlying rationale for financing and investment considerations. The landscape of EU- and Member state-related funding and financing instruments for ECRM project development and associated infrastructure development is complex and highly dynamic, though, implying a frequent need to update information[10]. Developing and maintaining an easy-to-use 'one-stop solution' platform for EU- and Member state-related financing opportunities in ECRM value chains might make it more efficient for project developers to access the right programs and instruments, verify their eligibility to participate (including options for SMEs), and understand the associated implementation schedule (calls for project applications etc.). Project developers (outside of the EU) who successfully applied for recognition as 'strategic project' in relation to the CRMA may receive some advice on these matters as part of the CRMA process but other project developers, who for whatever reason did not apply or were not successful with their application, might still play a positive role for EU-Africa value chain development and might hence benefit from receiving such information as well. In addition, the website could point to a (non-exhaustive) list of financial advisory firms who might support ECRM project developers in accessing grants, programs and other EU-linked instruments through the appropriate process, if needed. A web portal might potentially be set up in English, French and Portuguese to expand its scope and impact on the African continent.

[10] For example, in some jurisdictions, ECRM price volatility has given rise to discussions regarding the employment of price support mechanisms that allow mine operators (especially single-asset producers with only one main output commodity) to survive low-price periods, for instance through a contract-for-difference approach that could be considered in offtake agreements or at the policy maker level as well (e.g., discussions in the United States on a financial reserve to manage domestic ECRM supply).

6 Recycling

6.1 Background – Secondary resources potential

The global energy system is undergoing a significant shift toward renewable energy. Unlike traditional fossil fuel-based systems, which consume resources as they are used and require a constant supply to keep plants running, renewable energy systems rely on raw materials that can be recovered and recycled at the end of the product lifecycle. Materials like copper, lithium, nickel, cobalt, REE and other critical raw materials have the potential to be reintegrated into the energy supply chain through recycling and second use, marking a transformative move toward a circular economy for modern renewable energy technologies.

Notwithstanding this recycling potential, meeting the goals of the global energy transition requires significant input of certain ECRM which can only be achieved by a major increase in primary resource extraction. Recycling cannot replace the need for this additional primary resource extraction in the short- to mid-term for scaling up the global energy transition. But it can play an increasingly important role to sustain the resource economy in the longer term, once sufficient total ECRM inventory levels have been achieved and products or infrastructure approach the end of their service life. The progressive creation of secondary sources of supply may somewhat reduce the overall growth required in primary mine supply, implying environmental benefits such as a reduced GHG footprint and reduced waste generation. Recycling may also be beneficial in terms of more secure access to raw materials for countries and regions with high use of renewable energy technologies but limited natural resources (IEA 2024c).

In addition to product or infrastructure end of life recycling and re-use, the re-mining and processing of waste (or tailings) from primary mine production represents an important ECRM resource. Waste in old mining districts (e.g., tailings and smelter slag) may represent valuable resources if they contain raw materials that were not of economic interest (insufficient market demand) at the time of initial ore extraction, or if recovery was not economic at that time. Developments in modern processing technology alongside increasing market demand and hence commodity prices may support the economic and efficient recovery of residual ECRM resources contained in old mining and processing residues.

Business models and related recycling technologies are already well established for metals such as aluminium, steel and copper. This is not yet the case for many other ECRM and the development of appropriate collection and efficient recycling infrastructure is lagging behind due to the following challenges:

- Typically, critical raw materials are present in low concentrations in a variety of products, but in complex mixtures and alloys of metals. This poses challenges to develop efficient metal recycling technologies. This often also implies that recovery processes for ECRM are energy-intensive and demand for a complex use of co-processing chemical mixtures, diminishing the lower footprint advantage compared to mining primary raw materials.
- At comparably low ECRM prices (compared to high-value commodities such as gold) and insufficient incentives for the recycling industry through regulatory and normative requirements, investments for the recovery of ECRM from waste products are low and hence individual ECRM are currently not recovered or recovered at a very low rate.
- Although new and upcoming regulations, policies and standards address the need of ECRM recycling, they are so far not specific enough to spur sufficient economic incentives for the required investments in the recycling sector. There is a need for further financial and fiscal incentives, including the general promotion of using secondary ECRMs in new products and market platforms where demand for recycled components, materials, and ECRMs meets supply (Manoochehri et al. 2021).

Due to its high value, gold has by far the highest recycling rates globally but is not considered a critical raw material from a supply perspective. From among the ECRM, over the last ten years, aluminium has had the largest recycled input rate (metal produced from all secondary sources over total metal supply) at an average of about 35 % while copper had a rate of about 17 %. For energy transition minerals such as cobalt, lithium and nickel, it should be noted that batteries for EVs and accumulators containing them are still in the early phase of their introduction and have not yet reached the end of their service life, meaning that there is only limited recycling feedstock compared to established metals such as copper and aluminium. Amongst them, however, cobalt has had a relatively higher secondary share reaching 10 % in 2023, due to its more common use in consumer products and its relatively high value. Lithium and nickel, in contrast, have shown relatively low secondary shares of less than 5 % in 2023. With respect to the recycling rates, however, Figure 13 shows that there has been rapid increases of recycling from lithium-ion batteries, particularly for nickel and cobalt, with the recycling rate of nickel over 50 % and cobalt over 40 %. The lithium recycling rate has also been rising steadily, reaching 20 % in 2023 (IEA 2023c).

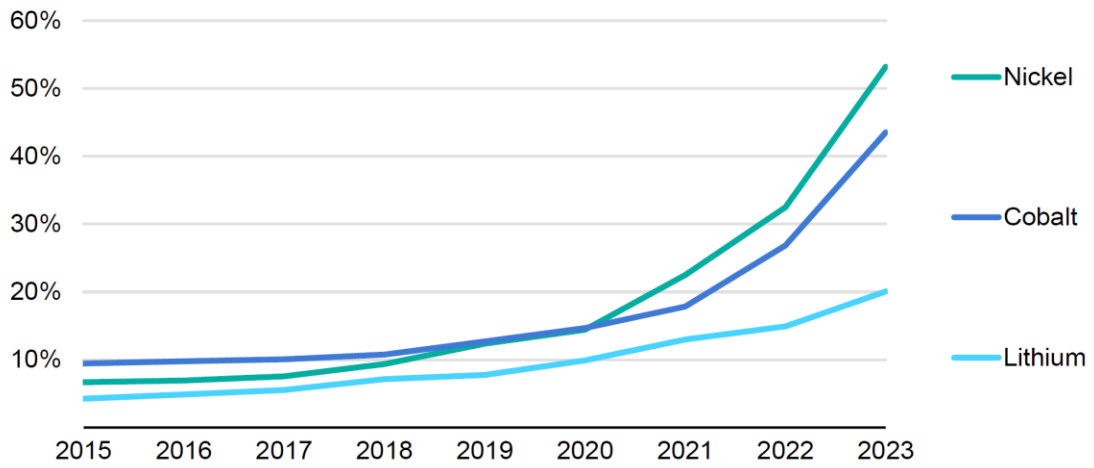

Figure 13. Global recycling rates of battery lithium, nickel and cobalt from available lithium-ion battery recycling feedstock[11] (IEA 2024c).

In terms of historic recycling, China, Europe and North America have the highest levels of secondary production and recycled input rate across all raw materials. The reason is that the input of secondary supply is higher in regions with a strong refining footprint. The sources of secondary raw materials can be found where a lot of material is already in economic use, hence typically in large and strong economic regions. For metals where end-of-life feedstock plays a significant role, international material trade will affect recycling input rates by influencing the availability of feedstock. Countries that import large volumes of products will have more feedstock available, while major exporters will have less. For raw materials with strongly increasing demand like cobalt and lithium, where end-of-life batteries are becoming a key source of feedstock, much of the current recycling capacity is concentrated in China. This trend is expected to persist in the near term, as China solidifies its leadership in recycling ECRM through initiatives such as the establishment of China Resources Recycling Group Ltd., a new state-owned enterprise focused on recycling and reusing end-of-life batteries, scrap steel, and electronic waste. For base metals, China is also the leading producer of secondary aluminium and copper (Figure 14), among other reasons, because of the high share of worldwide refining capacity of around 50 %.

[11] Comprises manufacturing scrap and end-of-life batteries from portable electronics, e-bikes, EVs, and maritime and storage applications.

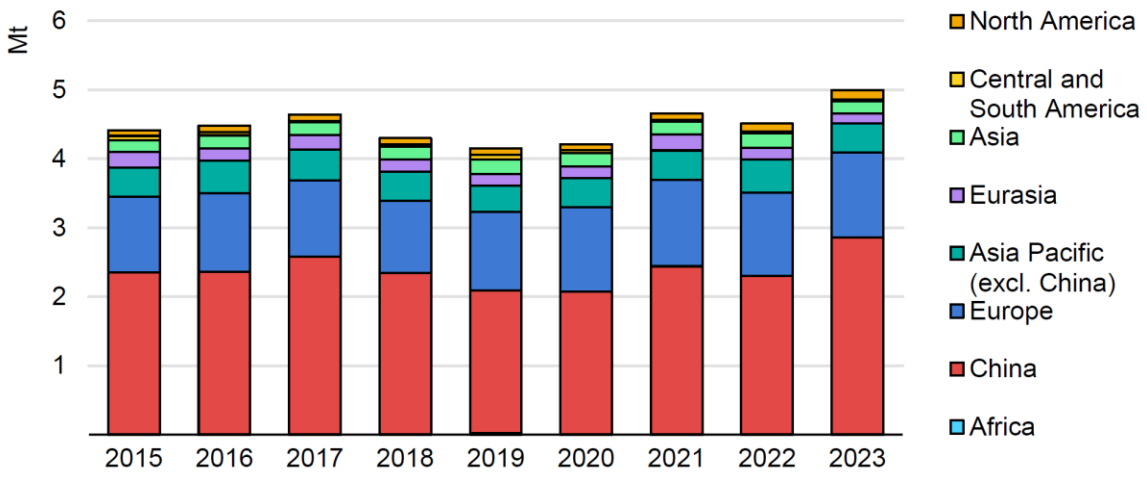

Figure 14. Historical secondary copper supply[12] by region (IEA 2024c).

At the absence of an established formal recycling infrastructure, overall formal recycling rates in Africa are below 1 %. Informal collection rates for scrap metals and e-waste can be quite high, providing enough economic incentives for waste pickers to provide a subsistence on day-by-day basis – somewhat akin to the situation of artisanal miners in primary resource extraction. Still, most of the collected and separated secondary metals (including copper wire and printed wiring boards) get sold and exported to international refineries, since smelters and refiners based in Africa mostly focus on processing feed from mine supply. Many waste fractions containing ECRM get disposed of illegally or on (semi-) official dumpsites without any recycling efforts.

Several countries, including many advanced economies, have announced high-level circular economy strategies and economy-wide targets for the sourcing of secondary materials. The EU CRMA, for example, aims to ensure that the EU's recycling capacity can produce at least 25 % of its annual consumption of strategic raw materials by 2030. This also includes provisions to promote the recycling and circular economy of critical raw materials in various sectors, including applications such as wind turbines. In Africa, Kenya's national e-waste management strategy lists high-level government policies for the recycling of waste electrical and electronic equipment (WEEE), including lithium-ion batteries. In addition to describing the development of infrastructure for WEEE, it also includes measures for public awareness, education, research and capacity building. South Africa’s Second-Hand Goods Act and extended producer responsibility regulations (EPR) require increasing recovery targets (pre-treatment and smelting) and minimum use of domestically recycled materials, including for base metals such as copper, aluminium, zinc, chrome, lead, nickel, tungsten and tin. Other African countries, such as Nigeria, Ghana, among

[12] Includes both refined and smelted copper; excludes direct use scrap.

others are following with more strengthened regulatory frameworks to address e-waste recycling and EPR mechanisms.

Many emerging and developing countries have imposed trade restrictions on used electrical and electronic equipment, because low-quality second-hand goods, containing hazardous materials are often received as waste and hence are illegally shipped into these countries. Many of those countries do not have sufficient recycling and waste management capacity to deal with such waste effectively and under safe conditions for workers and the environment. Nigeria's National Environmental (Electrical/Electronic Sector) Regulations prohibit the importation of waste electrical and electronic equipment and have strict regulations on the disposal of e-waste, though this may have little impact on illegal activities.

One of the most critical questions for a robust business case of ECRM recycling in Africa, aside from process technological considerations, is when the inventories of material to be recycled on the continent will increase. This is heavily dependent on how the African value-added sector and downstream markets develop, especially for electric vehicles (two- and three-wheelers) and for renewable energy facilities.

6.2 Recommendations and Investment Opportunities

Recommendation 6.1: Support the formalisation of the informal recycling sector.

The informal e-waste recycling sector plays a substantial role throughout Africa. A large informal workforce and small businesses makes a living by collecting, sorting, recycling, and selling valuable products, components, and materials recovered from waste. Collection rates in the informal sector go up to 90 % in some cases, underlining their relevance in the waste management sector in developing countries and their contribution to the circular economy. On the one hand, the informal sector contributes to poverty reduction in developing countries by providing employment, livelihoods, and income for workers and business owners. On the other hand, the poor working conditions created within the informal economy include unsound working conditions, child labour, lack of legal protection, numerous legal, health, and physical risks, often low social standing, and low and fluctuating incomes. Furthermore, the identified worst practices applied in informal waste management, such as open burning, chemical leaching, and uncontrolled depollution of wastes, among others, cause severe damage to the environment. Nevertheless, there is a consensus that the informal sector plays a key role in the collection of waste containing secondary raw materials and as such in accessing ECRM from waste streams such as e-waste in Africa.

Recommendations to preserve the livelihoods associated with the informal sector while improving the work and living conditions point towards investing into capacity building programs with the (informal) recyclers, addressing awareness creation about environmental and health risks, and trainings to improve the health, safety and legal situation of the recyclers. EU investment could entail to provide financial and technical support in order to create new formal businesses, e.g., for small and medium-sized enterprises (SMEs) or foster partnerships with local governments and businesses. This could help to increase the recycling rate, the health and environmental situation and to create income to the states by taxes of formal businesses. To facilitate the activities, NGOs and service providers working in the sector of informal e-waste recycling in African countries could be supported to have a better access to the recyclers. Examples are listed below:

- The International Alliance of Waste Pickers: Affiliates of this NGO can be found in several African countries, including Burkina Faso, the DRC, Ghana, Guinea, Kenya, Mali, Niger, Nigeria, Senegal and South Africa (International Alliance of Waste Pickers 2025);
- The youth-led program U-Recycle Initiative Africa promotes environmental education and circular economy practices in African schools and communities. Active in 11 countries, the initiative supports recycling projects, clean-ups, and youth fellowships;
- WEEE Centre (Kenya) is an e-waste management services provider specialised in managing e-waste through sustainable methods. The company collaborates with over 600 waste workers. The centre provides training in safe handling and works to integrate informal and formal recycling sectors.

Recommendation 6.2: Support collection and separation of waste streams in Africa.

When it comes to recycling, for some raw materials like printed circuit boards, it is crucial to have the know-how to properly recycle the various elements, which are often only present in very small amounts, but of high value. Additionally, other waste fractions might contain hazardous materials or produce hazardous by-products when heated or smelted.

Other raw materials like steel can be collected in relatively pure form as a metal. The difficulty might be that there are various types of steel with very different alloy types. Cast iron can be recycled relatively easily, but even car doors can have different alloy types, which might cause huge impurities when recycled together with relatively pure cast iron. This is even more important when it comes to recycling of stainless steel, which is strongly alloyed with chromium, nickel and other additives. When small portions of stainless steel are mixed with unalloyed steel, the raw materials like chromium or nickel are diluted and thus “lost”. As the amount of steel and

other metals per capita used in African countries are small compared to Europe, it is more cost-intensive per ton of recycled material to apply a proper collection system because scrap is less abundant locally.

There are several examples for companies running waste collection and processing facilities in different African countries (Ramsaroop et al. 2024a), for example:

- Electro Recycling Ghana (ERG) is active in collection, processing and remanufacturing of WEEE, printed circuit boards and batteries in Ghana;
- Desco Electronic Recyclers CC is active in collection and processing of WEEE, printed circuit boards and batteries in South Africa;
- SetTIC is active in collection and pre-processing of WEEE and batteries in Senegal with ongoing expansion to Mali and Guinea.

While these companies often operate at a regional scale at most, they might be taken as blueprint to establish and promote similar ventures in other parts of Africa. An important point is that existing informal collection structures should preferably be integrated rather than replaced by commercial ventures. By this, already existing networks can be used to build upon, rather than building up from the scratch. Furthermore, integrating already active workers by providing better and safer working conditions and higher income security will raise the acceptance of commercial venture and thereby prevent conflicts.

It could be beneficial for the collection and sorting as well if Africa-based recyclers had an informal exchange about the definition of scrap qualities and legal requirements for international trade and cooperation with European recycling companies.

Recommendation 6.3: Support African recycling capacities for high-value waste fractions.

The current practice to export the most valuable fractions of the waste stream, such as printed circuit boards (primarily recycled due to their gold content) or the black mass of lithium-ion batteries for recycling abroad bears the risk that recycling of the less valuable fraction remaining in Africa is not economically attractive and the resources are therefore lost for recycling. On the other hand, as waste streams in Africa might be too small to facilitate the establishment of African recycling plant capacities, it is recommended to support companies which have already started or are ready to establish such capacities. For example, companies such as Reclite SA, a South African company specialising in the recycling of electronic waste and hazardous components, receives support from various international collaborations and organisations. It is notably associated with the GIZ and the World Resource Forum (WRF). Increasing the value

addition in Africa might ease tensions and create trust, as the export of valuable waste streams to Europe is seen as post-colonial extortion in parts of the African population. If the collection of ECRM-containing waste and scrap becomes more efficient in the future, or if their production increases significantly in Africa, the construction of specialised recycling facilities would also be conceivable. Companies such as BASF and Umicore, which are currently active in the midstream battery value chain (e.g., cathodes), among others, are also positioning themselves as players in the battery recycling supply chain and could transfer technology, if not set up their own plants in Africa. Importantly, companies like Umicore have developed processes that do not only recycle high-value metals but may recover a broader basket of critical raw materials contained in e-waste and other recycling feed. Making this technology available in Africa might hence create broader benefits from a supply security and sustainability perspective.

Recommendation 6.4: Foster African national waste legislation and European extended producer responsibility.

A dedicated legislation for waste collection is a suitable tool to increase the collection rates. However, there are few examples for such legislation in African countries. Recent policy developments related to recycling of raw materials predominantly fall into four categories, including strategic plans (policy issued in Kenya and South Africa), financial incentives (not yet well implemented in Africa (IEA 2024c), extended producer responsibilities (EPR; policy issued in Ghana, Nigeria, South Africa) and cross-border trade (policy issued in Ghana, Nigeria, South Africa). The EU can help African governments to create regulatory and financial incentives as listed below:

- Financial incentives: Implementation of EPR based collection programmes that establish monetary incentives or remove the difficulty in returning end-of-life products and policies that leverage the environmental benefits of recycling. Provide financial incentives to encourage the implementation of recycling technology and expand their domestic capacity, including loans or guarantees aimed at fostering the growth of recycling infrastructure. Implement targeted support for the collection of emergent feedstocks such as batteries, recognising that processing capacity is valuable only when sufficient feedstock is available.
- EPR: Adopt regulations or requirements to mandate or encourage EPR, which holds manufacturers accountable for the collection and treatment of products at their end of life. EPR as a policy approach can raise revenue and set incentives for the collection and recovery of material at the post-consumer stage of a product's life cycle.

- Cross-border trade: Regulations under this category affect the transboundary trade of recyclable minerals. This can relate to the implementation of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention) or the OECD Council Decision on the Control of Transboundary Movements of Wastes Destined for Recovery Operations.
- As most of the waste collection happens in the informal sector without precise registration of waste streams and ensuring proper recycling, aforementioned approaches will require a formal collection and registration of waste streams to allocate fees properly.

Recommendation 6.5: Support recovery of ECRM from mine tailings.

Mining old tailings deposits or other forms of mine waste, such as smelter slag, has become an increasingly attractive option. Recovery of valuable minerals left behind in the original mining operations reflects the technological limitations or lower market prices/interest at the time of original extraction in the past. Reprocessing of these materials may lead to the improved recovery of contained primary metals and by-products and/or allow recovery of by-products not extracted before. Compared to mining of primary ore, reprocessing of tailings may often be performed at lower costs, if the material does not have to be milled again, which is an energy-intensive and hence expensive process. From an ESG perspective, reprocessing old tailings may create jobs and thus mitigate the social impact prior to mine closure. Moreover, historical tailings disposal may not have followed current international best practice. Re-processing these historical tailings allows storing them in a state-of-the-art facility with improved safety for local communities (e.g., geotechnical risks on tailings dam stability) and improved environmental management (e.g., to mitigate risks of acid mine drainage). Old tailings are sometimes targeted by artisanal miners, implying the need for operators and investors to consider an adequate socio-economic approach. This is particularly the case when a mine has already been close properly. In this case, ASM activities on the tailings can expose the material again, leading to erosion, stronger risk of acid mine drainage, instability of slopes, and other risks.

The re-mining of tailings in Africa focuses on several ECRMs (e.g., Stoltnow et al. 2024; Appendix Table 4), including:

- Copper: for example, KCM's Nchanga tailings leach plant in Chingola (Zambia);
- Lithium: for example, Kamativi Tailings Company's Kamativi tailings (Zimbabwe) and Tantalex' Manono tailings (DRC).
- In addition to the tailings mining projects discussed in AfricaMaVal, other African tailings mining projects illustrate the ECRM mining potential of the African continent. It is

important to note, though, that the following projects do not necessarily fulfil any screening criteria and, as such, their production is not necessarily available and investment not advisable for the EU industry:

- Cobalt: for example, ERG's Metalkol Roan Tailings Reclamation copper and cobalt project reprocessing copper and cobalt from previous mining operations around Kolwezi (DRC);
- PGMs: for example, UG2 tailings (chromite-containing) and Merensky Reef tailings (South Africa; e.g., Gibson et al. 2023);
- Chromium: for example, UG2 tailings (South Africa);
- REE: for example, Rainbow Rare Earths' Phalaborwa phosphogypsum tailings project.

The EU could support tailings project development, for example by facilitating knowledge and technology transfer. For instance, the EU-funded ReMine project focuses on utilising waste materials from mining (e.g., tailings, slag, and mine-influenced waters) to recover valuable renewable energy metals like cobalt, nickel and REEs. It emphasises the application of advanced methods like bioleaching and geochemical modelling to extract critical minerals while addressing potential health and environmental risks associated with re-mining operations. For African projects, advanced methodologies like mineral liberation analysis and sustainable processing technologies can be shared to optimise mineral recovery while minimising environmental risks. The Belgian materials technology and recycling company Umicore uses its refining and recycling expertise and assists, for example, the Congolese company STL in optimising its new hydrometallurgical facility to refine germanium (along with copper, cobalt and zinc) from slag.

Recommendation 6.6: Support the integration of aluminium scrap recycling in aluminium-producing African countries.

Several African countries have certified aluminium smelters, with South Africa and Mozambique being prominent players in the region, where the company South32 operates the Hillside and Mozal aluminium smelters, respectively. Aluminium recycling is, however, more prominent in South Africa compared to Mozambique, as South Africa has established systems for recovering and processing aluminium scrap supported, e.g., by the Aluminium Federation of South Africa. Recycling initiatives in the region aim to reduce environmental impacts and align with global decarbonisation goals. Aluminium recycling initiatives in the region could benefit significantly from the presence of a robust primary aluminium industry, as:

- The primary aluminium industry has established systems for processing and refining aluminium, which recycling initiatives can utilize. These include advanced smelting technologies, logistics networks and skilled labour;
- Companies operating in the primary aluminium sector can invest in recycling initiatives as part of their sustainability strategies, driving innovation and providing funding for advanced recycling technologies.

The EU could support these efforts by providing technical assistance and funding for recycling infrastructure development. Sharing best practices and advanced recycling technologies could help optimise operations. Moreover, trade agreements prioritizing recycled materials and incentives for green initiatives would strengthen the market for recycled aluminium in these countries, promoting sustainability and economic growth. European companies suitable for engaging in aforementioned aluminium recycling initiatives include Novelis (Germany), Hydro Aluminium Recycling (Germany) and Intals (Italy). In addition, the EU-funded project RecAl comprises 19 research and industrial partners focused on innovative recycling technologies and circular aluminium economy models. Their digital platform and expertise in sorting and alloying could offer technological and systemic support to African initiatives.

Recommendation 6.7: Promote closed-loop recycling through partnerships between African recycling companies and original equipment manufacturers.

For energy transition minerals, there is a greater emphasis on closed-loop and specialised merchant recycling models. For example, South Africa has significant potential for closed-loop recycling of catalysts, particularly those containing PGM essential for green hydrogen production. As the world's leading supplier of PGM, South Africa can leverage its natural resources to create a circular economy where spent catalysts are collected, refined, and reused locally. This approach would reduce dependence on raw material extraction, minimize environmental impacts, and, in the long term, enhance the economic value of a potential green hydrogen value chain. Recycling catalysts domestically also aligns with global decarbonisation goals by ensuring sustainable production processes for green hydrogen.

Another example is on the recycling of EV batteries. Although domestic capacities are being built, African countries importing end-of-life EVs could already be supported with collection activities and in the logistics to transport lithium-ion batteries to countries with recycling capacity. Partnerships with automotive or battery original equipment manufacturers (OEMs) and other industry stakeholders could ensure a steady supply of feedstock. While this does not necessary guarantee future supply of end-of-life batteries, such partnerships may contribute to a more reliable closed-loop ecosystem. These collaborations might also allow battery manufacturers or

OEMs to better track their collections and recovery targets that are mandated through policies such as EPR mechanisms. A noteworthy example in this regard is a joint project by Glencore and Managem to recycle cobalt and nickel from battery black mass from Europe at a processing and refining plant in Morocco.

The EU can support closed-loop recycling in cooperation with Africa by funding advanced recycling facilities, facilitating technology transfers from EU companies like BASF and Umicore, and fostering PPPs to build integrated recycling hubs. The EU and Africa can also collaborate on policy frameworks to incentivise sustainable practices, provide training to enhance local expertise, and ensure a stable market for recycled materials by integrating them into its EV or green hydrogen strategies. Finally, the need and opportunities for developing recycling systems and mobilizing associated funds could be illustrated through promotional campaigns in both Africa and Europe, especially for financial sector stakeholders as target group. For example, recycling-related business cases might be presented at the annual Mining Indaba conference and trade show in Cape Town.

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7 Infrastructure

7.1 Background – Transport and energy infrastructure in Africa

Increasing the production of ECRM at the mining and refining level necessitates parallel investment in infrastructure upgrades. Energy infrastructure is of particular importance, since energy constraints prevent the development of energy-intensive smelting operations, while a lack of reliable access to green energy implies a higher carbon footprint for the produced goods. Transport infrastructure is also of particular interest in the metals and mining sector, as mining products need to be shipped abroad and imported equipment and materials need to be transported to the mining and processing sites, which are often located in remote areas of the continent. The AfDB views the continent's infrastructure gap as both an untapped economic potential and a significant investment opportunity. As of early 2022, the AfDB (2022a) estimated that Africa faces an annual infrastructure-financing deficit exceeding US$ 100 billion. This deficit adversely affects the quality of life for Africans and hampers the continent's competitiveness on the global stage, including for mining and other industries. To fully realise the continent's potential in the critical minerals sector, significant infrastructure bottlenecks must be overcome.

In the context of the AfricaMaVal project, it is important to differentiate between local infrastructure development related to specific mining or refining projects and broader development of infrastructure corridors. The former serves the needs of that specific project and infrastructure development and the need to mobilize funding largely falls under the responsibility of the project investors and operators, although it may be incentivized or subsidized by the state. An example would be the construction of hydropower stations or solar plants for remote mine sites. Infrastructure corridor development, on the other hand, requires much larger funds and serves to increase economic development across whole regions. A typical example for this category would be the development of railway lines, highways and port infrastructure across hundreds or thousands of kilometres. The latter type of infrastructure development usually requires regional-international development organisations (such as the AfDB or the World Bank) or national government funding. The Chinese ‘belt and road’ initiative might also fall under this category. Transitions and synergies between both infrastructure development categories, project-specific and regional, are possible and should be encouraged. This chapter deals with both types of infrastructure development in Africa.

Ramsaroop et al. (2024a) evaluated infrastructure bottlenecks in Africa, some of which are presented in the following. Many mining regions, especially those rich in ECRM, are located in remote or landlocked areas, with limited road and rail connectivity to ports. Insufficient infrastructure thus (often) involves longer, less efficient routes to transport materials from mine to market. In 2019, nearly 74 % of Africa’s road network was unpaved, isolating the population

from basic education, healthcare services, transport corridors, trade hubs, and economic opportunities (Figure 15). The AfDB estimates that high transportation costs add 75 % to the price of African goods. Furthermore, poorly maintained roads and a lack of rail alternatives lead to extended supply chains that are heavily reliant on fuel-intensive trucking. Several African nations including Kenya, Ethiopia, Nigeria, and Tanzania, are investing in modernising their railway systems to improve logistics and reduce road congestion. For example, the Mombasa-Nairobi Standard Gauge Railway Project in Kenya connecting the port hub with the capital city (2017) unlocked a new and improved trade route. Similar efforts are being made to modernise ports and airports throughout the continent. Countries like Djibouti, Tanzania, and Nigeria are expanding their port facilities to improve the transport and storage capacities of bulk raw material.

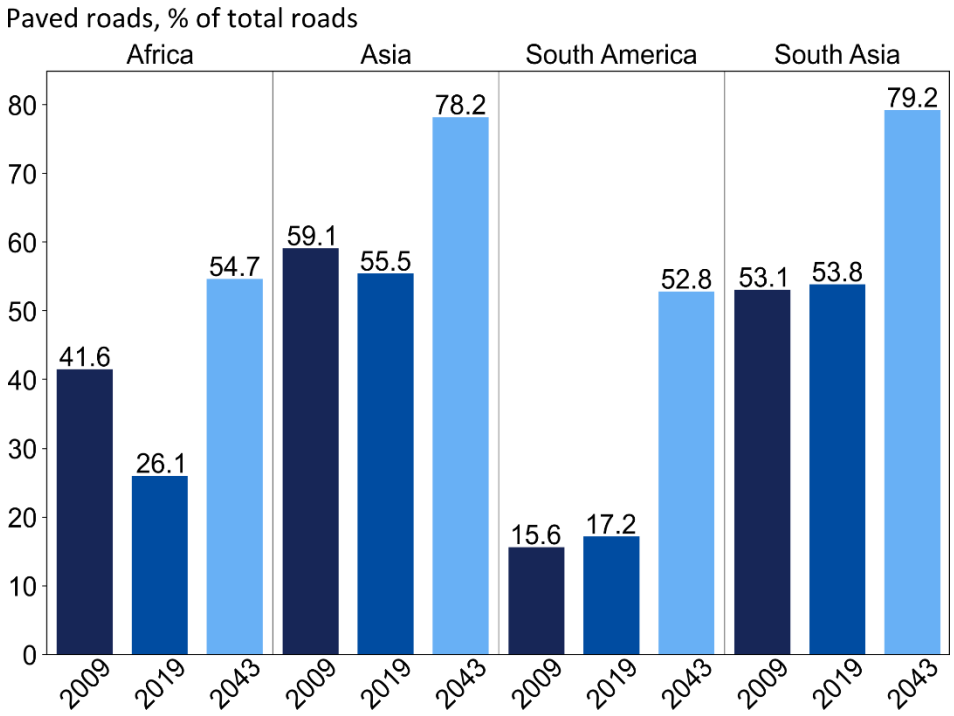

Figure 15. History and forecast of paved road share as proxy for infrastructure development by regions (Cilliers & Chipanda 2025).

At present, 600 million people, or 43 % of the total African population, lack access to electricity, most of them in sub-Saharan Africa (IEA 2022). Reliable (and affordable) energy is essential for the mining and beneficiation of raw materials, but many African countries struggle with energy shortages. In South Africa, for example, power shortages are suspected to have contributed to a 7 % decline in the mining sector in 2022 (Bird and Bird 2022).

Energy production in Africa is heavily reliant on, fossil-fuel-based energy sources. In 2019, the energy mix was dominated by natural gas, coal, peat, and oil (together 77.3 %), with renewable

energies making up the remainder. From the renewable energy sources, hydropower dominates with an overall contribution of 17.4 % to the total energy supply. While fossil fuels dominate the energy market in countries like South Africa, many African countries show major potential for renewable energy supply (Figure 16). This is particularly apparent for hydro and solar energy (IRENA and AfDB 2022). However, many countries suffer from energy deficits, necessitating the use of diesel-powered backup generators or energy imports during periods of undersupply. Moreover, hydropower is vulnerable to the effects of climate change, such as drought, as recently seen at the Kariba Dam in Zambia and Zimbabwe.

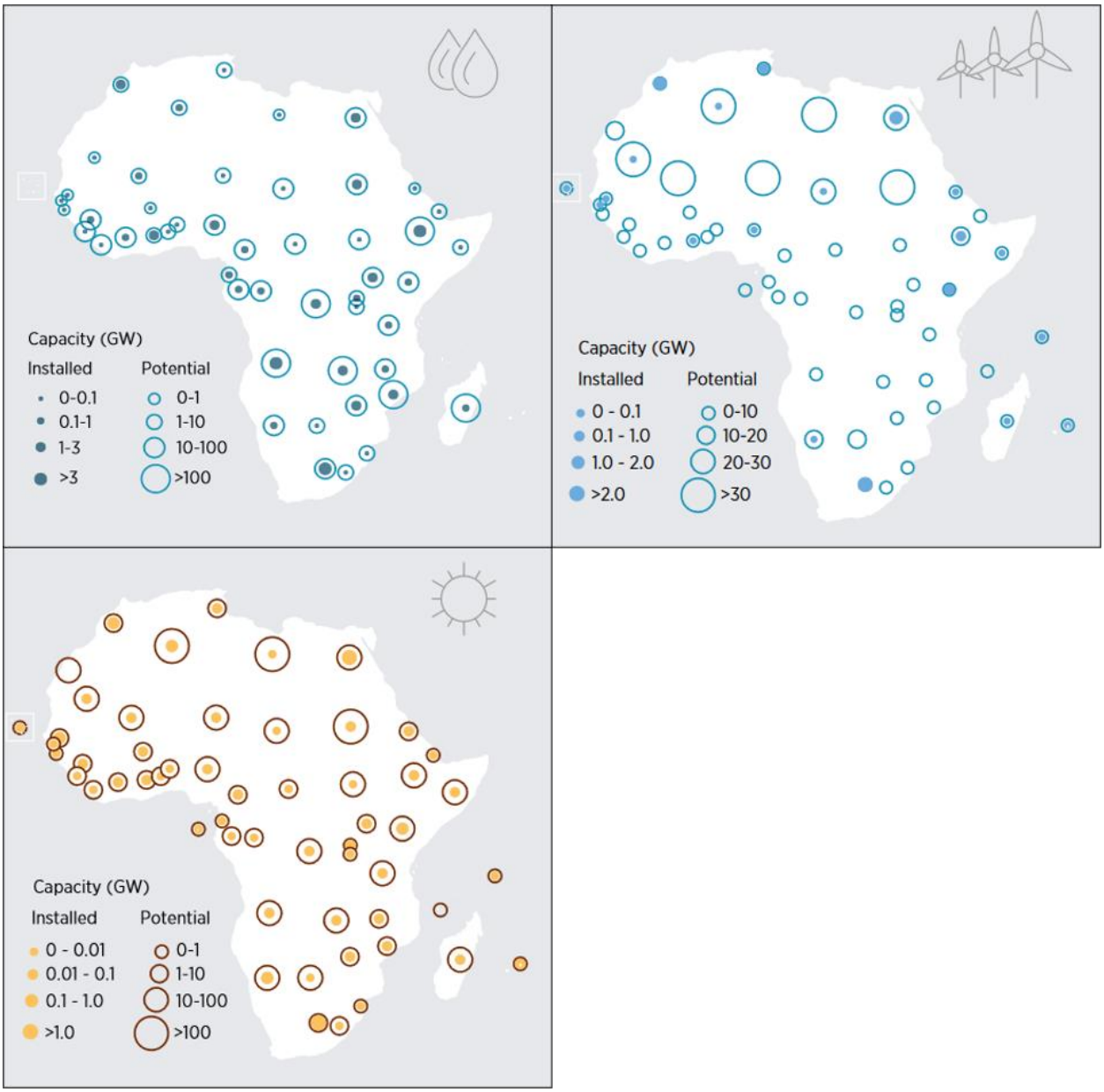

Figure 16. Africa's renewable energy installed capacity and potential for hydro (upper left), wind (upper right) and solar (lower left) power, as illustrated in IRENA and AfDB (2022).

Although sub-Saharan Africa has made substantial progress, especially in solar and wind projects, clean energy investments remain insufficient, representing only 2 % of global renewable energy investments over the past two decades (IRENA and AfDB 2022). Without reliable, affordable and clean energy infrastructure, the potential carbon savings from producing materials for green technologies are partially offset by carbon emissions from the mining and processing activities where these have to rely on fossil fuels. Mining projects in remote regions are well suited for the development of local renewable energy projects, since connection to the distant grid can be prohibitively expensive.

In line with their annual water balance, large-scale mining projects require a stable supply of industrial water and discharge options for surplus and used water. These projects should be integrated into regional and national water management planning to avoid conflicts with local communities, and may require investment in water supply and drainage for the mining project, including storage facilities. In order to counteract water scarcity in arid regions, industrial water has to be transported over long distances via pipelines.

Digital technologies are critical for modern mining operations, from geological surveying to fleet management to supply chain transparency. Modern large-scale mining projects produce large data sets that are processed and assessed in urban locations far away from the frequently isolated mine site. Furthermore, the adoption of more efficient, safe, and eco-friendly technologies, such as automated and sensor-based mining equipment, relies on broadband and telecommunications infrastructure. However, internet penetration is often limited in remote mining areas. Investments in fibre-optic cables, data centres and broadband networks are helpful for the development of industrial mining projects.

The African Union actively addresses Africa's infrastructure challenges through initiatives aimed at boosting connectivity, integration, and sustainable development. The Action Plan for the Accelerated Industrial Development of Africa identifies ‘infrastructure development’ as a priority, while the African Union's Agenda 2063 assumes that ‘world-class integrative infrastructure’ will increase intra-African trade to 50 % and Africa's share of global trade from 2 % to 12 % by 2045. AUDA-NEPAD’s Programme for Infrastructure Development (PIDA) in Africa provides the strategic framework for priority projects to transform Africa through the construction of modern infrastructure into an interconnected and integrated continent that is competitive domestically and in the global economy. The program has already facilitated hundreds of projects across the continent. At the national level, there are other initiatives focussing on infrastructure development, including South Africa's National Development Plan, Kenya's Vision 2030, Nigeria's National Integrated Infrastructure Master Plan and Rwanda's Vision 2050.

One of the main reasons for the infrastructure deficit in Africa particularly in the sub-Saharan African region, however, is the historical underinvestment in infrastructure by both governments

and the private sector. Many African countries have limited financial resources, which makes it difficult for them to finance the necessary infrastructure development. In 2020, US$ 80.9 billion were invested in African infrastructure development projects. Of these investments, only 41 % were financed by national governments, while 23 % came from the private sector, 22 % from members of the Infrastructure Consortium for Africa (including the African Union, Canada, France, Germany, Italy, Japan, Spain, the UK, the USA and Russia), 8 % from the Chinese public sector (decrease from US$ 25.7 billion in 2018 to US$ 6.5 billion in 2020) as well as 5 % from other public sectors (Figure 17).

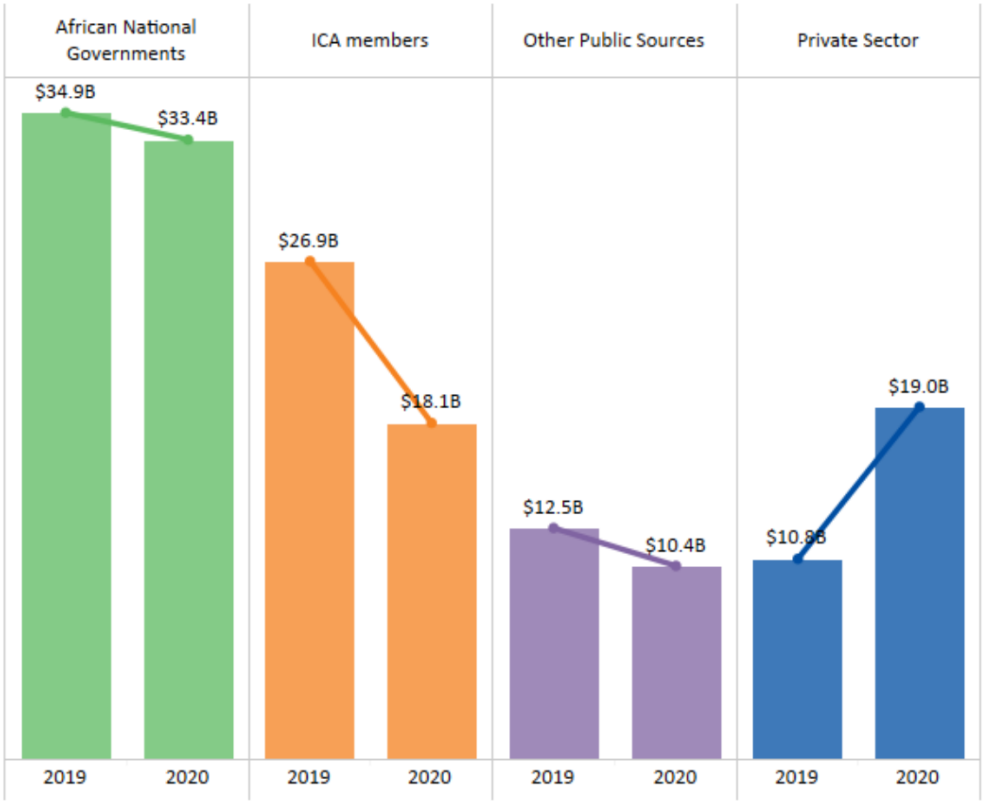

Figure 17. Contribution to infrastructure finance in Africa by source in US$ billion (Cilliers & Chipanda 2025).

China's involvement and (financial) support of large infrastructure projects in Africa is advantageous because it largely operates on a government-to-government basis (instead of private sector entities dealing with each other). One example is the Lamu Port in Kenya and Lamu-Southern Sudan-Ethiopia Transport Corridor, which is part of China's belt and road initiative aiming to revive ancient land and sea trade routes that link Asia with the rest of the world. From 2019 to 2023, Chinese financing totalled over US$ 11.5 billion in loans to African countries and organisations, according to Boston University's Chinese Loans to Africa Database (Global Development Policy Center 2025). In some cases, China's investments were part of deals with African leaders (i.e., to obtain bargaining rights for ECRMs). In hindsight, however, these deals

have not always turned out to be fair. In the DRC, for example, former President Kabila negotiated a 'mining for infrastructure' deal worth US$ 6 billion with Chinese partners. Chinese players were to invest in infrastructure and energy projects and receive mining rights in return, such as the 'Sicomines' company near Kolwezi. According to an IMF assessment, the Chinese partners invested almost US$ 3 billion and in return made profits totalling US$ 76 billion. The current president of the DRC, Felix Tshisekedi, has questioned the agreement and is calling for it to be renegotiated (Stoltnow and Schütte 2024).

In 2022, the G7 launched the Partnership for Global Infrastructure and Investment (PGII) at Elmau to counterbalance China's Belt and Road Initiative. The Partnership aims to mobilise US$ 700 billion by 2027, largely from the private sector, to finance global infrastructure projects. One of its flagship initiatives in Africa is the modernisation of the Lobito Corridor, a 1,300 km railway connecting the southeastern DRC (and potentially Zambia) to the port of Lobito in Angola, providing an alternative export route for copper and cobalt from the Copperbelt. The EU's Global Gateway strategy complements these efforts by prioritising sustainable and high-standard infrastructure development. Furthermore, the EU is engaged in the African energy sector, e.g., through the Africa-EU Energy Partnership. The EIB has been financing infrastructure projects across Africa, including renewable energy investments and grid expansions, such for the Noor Solar Complex (Morocco), one of the world's largest solar plants with a production capacity of 582 MW. In addition, the EDF has financed infrastructure that supports inclusive economic growth, with some projects directly or indirectly supporting Africa's mining and raw materials sectors. The fund has invested in transport corridors, energy infrastructure, and digital connectivity projects. The EU Joint Research Centre's and DG INTPA's project on 'Strategic Corridors and Urban Systems in Africa' is performing research on a limited number of strategic corridors in Africa that have the potential to facilitate intra-African and Africa-Europe trade to develop diversified and sustainable value chains in Africa that can benefit both African and European industries.

As this chapter outlines conceptual investment opportunities and recommendations, it will draw upon these existing EU engagements and seeks to illustrate how targeted investments – when aligned with regional infrastructure needs and supported by effective partnerships – might contribute to unlocking Africa's potential as a supplier of critical raw materials. By addressing these bottlenecks, African countries and their global partners can enhance the continent's role in the ECRM supply chain while fostering sustainable economic development for African communities. Critically, though, financial support to infrastructure development may foster economic development in Africa but it is not going to increase ECRM supply security in Europe unless it is directly accompanied by EU-related investment or offtake agreements in relevant ECRM mining or refining project that stand to benefit from these infrastructure upgrades. China's Sicomines "mining for infrastructure" deal in the DRC may be considered for illustration of this

point. Although the deal has been criticized by some and might be challenging from a governance perspectives, it nonetheless illustrates the importance of linking mining and infrastructure development objectives for mutual benefit. This observation applies in a cross-cutting sense to all recommendations listed below.

7.2 Recommendations and Investment Opportunities

Recommendation 7.1: Support the construction and modernisation of transport corridors between Africa's Great Lakes region and the Indian Ocean.

The Great Lakes region in central Africa – mainly encompassing Uganda, Rwanda, Burundi, the eastern DRC, Kenya and Tanzania[13] - relies heavily on corridors connecting to Indian Ocean ports for trade and access to global markets (Figure 18). The raw materials partnerships concluded between the EU and the DRC (2023), and Rwanda (2024) make these corridors important for the extraction and trade of the 3Ts as well as for other commodities found in the region. From an ECRM perspective, these countries host ore deposits, mining projects and ASM operations associated with 3T minerals (Burundi, eastern DRC, Ruanda, Tanzania, Uganda); lithium (DRC, Rwanda); graphite, nickel, copper, cobalt and phosphate (Tanzania, Burundi and to a small extent the eastern DRC and Uganda); manganese and titanium minerals (Kenya); and rare earth minerals (Tanzania, Uganda, Burundi, to a small extent eastern DRC).

The Northern Corridor is an important trade route that connects the landlocked countries of Uganda, Rwanda, Burundi, and eastern DRC (and South Sudan) with the Kenyan port of Mombasa. The transport routes comprise highways, railways (e.g., the Standard Gauge Railway from Mombasa to Nairobi), as well as pipelines. Upgrading this corridor would reduce transport costs significantly. So far, the EU has supported various road and rail infrastructure projects as well as projects to enhance trade logistics, including customs digitisation under the Northern Corridor Integration Projects initiative.

The Central Corridor connects the Tanzanian port of Dar es Salaam with Rwanda, Burundi, the DRC, and Uganda. The expansion of the corridor could be critical for the economic viability of potential future mining projects, e.g., the Musongati nickel project in Burundi (see Stoltnow et al. 2024 for project factsheet). The transport infrastructure includes road networks, railways (with modernisation projects like the Tanzania SGR), and inland waterways connected to Lake Victoria. The EU has already contributed to infrastructure upgrades on the Central Corridor, focusing on roads linking Tanzania to Rwanda, Burundi, Uganda and the eastern DRC. Initiatives like the EU-Africa Infrastructure Trust Fund (EU-AITF) have provided financial and technical

[13] The geographic Great Lakes region also extends to the south towards Zambia, Malawi and Mozambique, and to the north towards Ethiopia, but this recommendation only deals with its central African portion.

assistance for corridor development, i.e., the construction of bridges and rehabilitation of roads in Tanzania. The EU-AITF has furthermore contributed to port modernisation efforts at Dar es Salaam.

Both corridors require significant investment for infrastructure upgrades, modernisation, and extension to spur economic development and handle the increasing volume of trade. This refers to highways, logistical hubs and services, railways/dry ports, transport facilities across lakes (Victoria and Tanganyika), and ocean ports. Corridor extension for infrastructure development in the eastern DRC would be useful but work in some regions is currently challenging due to the on-going conflict dynamics.

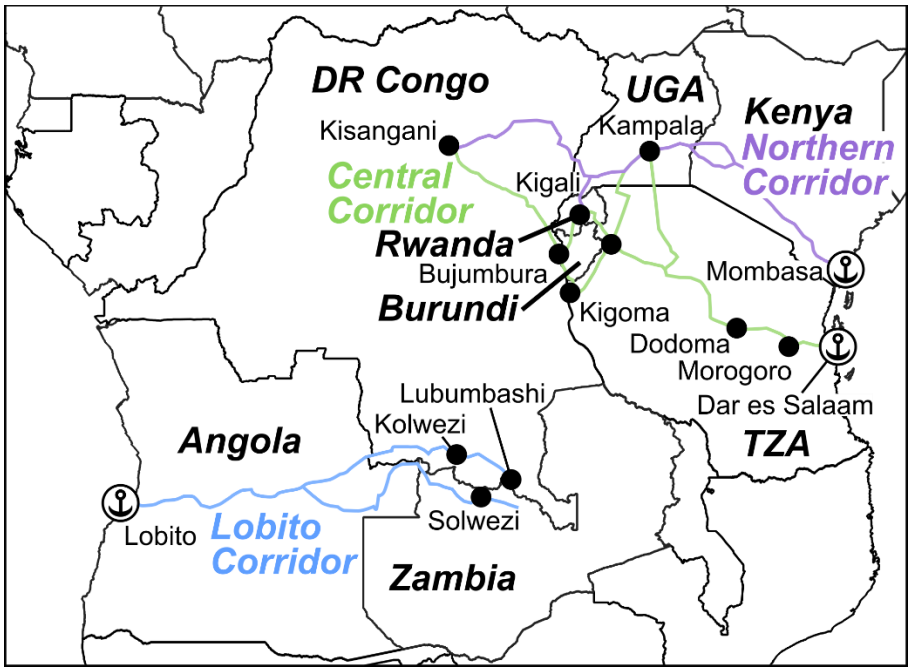

Figure 18. Selected transport infrastructure corridors in parts of southern Africa[14].

Recommendation 7.2: Support the modernisation and expansion of the Lobito Corridor to facilitate improved connection to the Central African Copperbelt.

The modernisation and expansion of the Lobito Corridor is already receiving financial support from the USA and the EU in order to facilitate the export of raw materials (Reuters 2024). The Copperbelt is one of Africa's most important mining regions for ECRM, particularly copper and cobalt. The DRC and Zambia are the two largest copper producers in Africa, and the DRC is by far

[14] Country abbreviations refer to ISO 3166-1 alpha-3 – three-letter country codes. Note that the figure focuses on transport corridors discussed in the text and excludes important existing road networks that connect the DRC/Zambia with the major southern African ports of Durban, Beira and Walvis Bay.

the largest producer of cobalt in the world. Currently, copper and cobalt are mainly trucked through southern Africa to ports in South Africa, Mozambique and Namibia, and part of the production is trucked to the railway stations along the Cape Gauge-Tanzania-Zambia Railway (TAZARA), from where it is shipped to the port of Dar es Salaam on the Indian Ocean. The Lobito Corridor is an alternative trade route, which connects the landlocked Copperbelt region with the port of Lobito on the Atlantic coast of Angola. The transport of raw materials via the Atlantic port favours exports to the EU and the USA compared to the established trade routes via the Indian Ocean (Figure 18). Importantly, the railway line would also be used for improved import of goods to supply the needs of the population as well as the mining sector.

The development of the Lobito Corridor is already supported by the EU's Global Gateway Initiative and the G7's PGII. The corridor was furthermore backed by the signing of an MoU (2023) between Angola, the DRC, Zambia, the EU, the USA, the AfDB and the Africa Finance Corporation (AFC) to promote sustainable development along the Lobito Corridor. Certain synergies may be expected in relation to the EU strategic raw material partnerships with the DRC and Zambia. The main line of the Lobito Corridor in Angola is the Cape Gauge-Benguela Railway, which connects Lobito with the eastern border town of Luau and the railway networks of southwestern DRC. The Benguela railway was severely damaged during the Angolan civil war but was rebuilt in 2013 and has been operational again since 2018. Part of the expansion of the Lobito corridor might include increasing the capacity of the existing route as well as extending the existing route from Kolwezi to Lubumbashi in the DRC and, potentially, to Solwezi in Zambia.

Recommendation 7.3: Support the construction and expansion of African deep-sea ports to relieve existing trade flows and increase the efficiency of emerging ECRM exports.

Africa's deep-sea port capacities are under strain due to increasing trade volumes and the rising demand for exports of ECRM. Many ports are operating near or above capacity, facing challenges such as outdated infrastructure, inefficient processes, and inadequate handling facilities for bulk and specialised cargo. Upgrading these ports presents significant opportunities to boost trade efficiency, reduce logistics costs, and facilitate the export of ECRMs critical for the green energy transition. The EU can support these efforts by providing funding, technical expertise, and promoting PPPs to modernise port infrastructure and integrate them with broader regional transport networks, while aligning with environmental standards. The following investment opportunities derive from DMT Kai Batla's contribution in AfricaMaVal deliverable D7.1 (Stoltnow et al. 2024):

- Côte d'Ivoire: Investments in San-Pédro can supplement Abidjan, this would leverage the country's strategic position with respect to its rich ECRM resources. Linking this with the

Harper (Liberia)–Yamoussoukro rail proposal would further enhance connectivity and establish a new port in Harper.

- The Gambia and Senegal: The Banjul-Barra Bridge, part of the Dakar-Lagos Corridor, could ease congestion at the Port of Dakar and improve access to northern trade flows.
- Morocco: The 2030 Port Strategy, with a planned US$ 7.5 billion investment, includes expansions to adapt to changing maritime demands. Supporting these efforts aligns with EU goals to enhance Mediterranean and Atlantic trade routes.
- Nigeria: Ongoing US$ 680 million upgrades to the Port of Cotonou and US$ 1.1 billion investments in Nigeria's port rehabilitation plan, including Apapa, offer opportunities to improve connectivity and trade throughput across West Africa.
- Namibia: The EU's US$ 1 billion commitment to the US$ 2.1 billion Port of Walvis Bay expansion underlines its strategic importance as a gateway for Southern Africa and an ECRM export hub.
- Angola: In line with the Lobito Corridor rail project, investments of approximately US$ 110 million will flow into upgrading and modernising the port of Lobito (see Recommendation 7.2 for further details).
- Tanzania: Although a US$ 61 million expansion of the Mtwara port was completed in 2020, further developments are being discussed to enable an export processing zone.
- Mozambique: Funding dredging (US$ 5.3 million) and improvements at Quelimane Port can enhance regional trade in Southern Africa.
- South Africa: The Durban Port deepening project and LNG infrastructure at Richards Bay are parts of the ZAR 154 billion (US$ 8.3 billion) KwaZulu-Natal (KZN) Ports Master Plan and present opportunities to collaborate in transforming these ports into global hubs. In addition, the state-owned company Transnet is planning a manganese export expansion at Port Ngqura. Within this expansion, a technology developed by Newlyn, together with the global OEMs Eurosilo and Bruks Siwertell, for a near-zero dust emissions mineral ore back-of-port export terminal is proposed to be integrated.

Recommendation 7.4: Support comprehensive due diligence for infrastructure projects linked to mining.

Just like mining projects, large infrastructure may be to the disadvantage of the local population and lead to protests and social unrest if planned poorly, without adequate consideration of ESG

aspects. To avoid this, investors and infrastructure developers need to conduct comprehensive due diligence assessments that do not only consider legal and financial but ESG perspectives as well. Due diligence generally requires an understanding of local environments and should align with global sustainability trends. The EU might therefore support due diligence on infrastructure projects linked to mining by facilitating evaluations that incorporate legal, environmental, social, financial, and operational considerations. This includes providing technical assistance for legal and regulatory compliance, ensuring alignment with local laws (e.g., land rights, permits, community consultation, and environmental impact assessments) and international standards like the IFC Performance Standards.

Additionally, the EU might provide expertise on the mitigation of (geo-)political risks by fostering transparent PPP agreements and improving governance practices. The EU could further assist in reviewing tax incentives, such as renewable energy credits in South Africa, to optimise infrastructure investments. Economic feasibility assessments, including cost analyses and ROI models, could be enhanced with access to EU-backed financing options through institutions like the EIB or partnerships with the AfDB. The EU can also promote environmental and social impact assessments, focusing on biodiversity, carbon reduction strategies, and community engagement to secure social licenses to operate. The resilience of local infrastructure planning, for instance on the background of climate change, might be evaluated as well. By ensuring supply chain robustness and incorporating climate resilience into infrastructure planning, the EU can help African mining projects becoming ESG-compliant, efficient, and globally competitive.

Recommendation 7.5: Promote and support the use of shared infrastructure in association with mining and refining project development.

The costs for infrastructure development in association with ECRM mining and refining projects often significantly exceeds the capital expenditure of the mine or plant itself, especially in remote locations. Subject to a positive result of the project's feasibility study, mining or refining companies already anticipate that they will have to finance and deliver the infrastructure they require and include these costs in their capital expenditure raising. There is thus an opportunity for governments to leverage mining- or refining-related infrastructure for regional economic development and public benefit.

Shared use agreements for infrastructure, either among different private sector stakeholders or between a company and the government may be particularly helpful in this regard, as they may narrow potential funding gaps, improve project economics through facilitating economies of scale, or provide other forms of incentives and benefits for the project developer. It is crucial that the parties involved explore the potential for shared use infrastructure in the early stages of

structuring project financing and execution, in line with national or regional development planning. The economies of scale and lower marginal costs derived from shared use infrastructure projects, particularly in the context of rail links and port terminal usage, means increased profit margins for project operators and investors as well as higher tax revenues for the government (potentially in the long term, in case tax holidays were provided as incentives to start up the project). If the EU plans to be involved in financing a given ECRM project or in the context of its general engagement through strategic raw material partnerships, it might work with African partners and project developers to explore options for shared infrastructure use. This could be of interest, for example, in Zambia, for instance to support the planned railway construction from Chingola to Kalumbila, or for the upgrading of transmission infrastructure and logistics around the Lumwana superpit extension (see factsheet in AfricaMaval Deliverable D7.1, Stoltnow et al. 2024).

Recommendation 7.6: Support access to green infrastructure development funds in Africa.

Green infrastructure projects, ranging from renewable energy generation to low-emission transportation as well as water conservation and recycling can play an important role for local economic development while supporting policy targets such as the EU's Green Deal or the African Union's Agenda 2063 as well. They are thus of particular importance on the background of developing mining, refining and value addition capacities for ECRM to enable the global energy transition. Investors can play a critical role in driving the development of green infrastructure projects which may be incentivised by government policies (e.g., tax benefits, subsidies and green bonds) and dedicated funding or support initiatives.

The EU and other international development partners are well-placed to incentivize investment and support activities through initiatives such as Global Gateway and through their development finance institutions. The list below indicates several funding initiatives that are already established to support green infrastructure development in Africa. Supporting stakeholders to access these initiatives while also ensuring overall coordination and synergy effects among different initiatives may be helpful to accelerate green infrastructure projects.

- The EU-Africa Infrastructure Trust Fund, i.e., the Sustainable Energy for All initiative focusses on energy, transport and water as well as information and communication technology infrastructure. The fund combines grants from the EU (EIB) and its member states with loans and expertise from European financial institutions.
- The Alliance for Green Infrastructure in Africa is an African execution-led solution that seeks to generate, finance, and execute projects with the private sector, to accelerate the Continent's transition to Net-Zero through a cohesive and inclusive approach to climate

finance. Led by the AfDB, African Union Commission and Africa50, the goal of the Alliance for Green Infrastructure in Africa is to raise US$ 500 million of early stage blended finance capital to catalyse up to US$ 10 billion green infrastructure opportunities for energy-efficient and climate-smart projects in mining and other sectors.

- The Sustainable Energy Fund for Africa is a multi-donor trust fund managed by the AFDB that aims to catalyse private sector investments in renewable energy and energy efficiency projects across Africa.
- The Africa Go Green Fund is a debt financing platform with the objective to encourage additional anthropogenic GHG reductions in Africa by providing debt and technical assistance to corporate and industrial entities, local financial institutions, and other partner institutions that develop and/or invest in eligible energy efficiency and renewable energy projects. Africa Go Green was initiated by the German KfW.

Recommendation 7.7: Support the development and implementation of Just Transition plans in Africa.

While Africa has a major renewable energy potential, many countries face power deficits and/or strongly rely on fossil fuels. Replacing fossil fuels with renewable energies is not only a question of carbon emissions but must also reflect social and economic issues, such as jobs and state revenues created in coal mining or in the petroleum industry. This necessitates the need for the Just Transition. Therefore, it may not be reasonable to expect that African nations will be in a rush to phase out certain fossil fuels as fast as possible unless this can be done in a fair and equitable way, safeguarding livelihoods and state interests. Some EU Member states, such as Germany, have faced similar challenges in the recent past. The political decision for phasing out coal mining in Germany, for example, was accompanied by a € 40 billion package to support structural change in affected lignite mining areas, considering ecological and economic perspectives in terms of post-mining development. This approach might be feasible for Germany, as a developed nation with a diversified economy, but, at least in the near- to mid-term, it will be significantly more challenging for less-developed African countries in case their economies substantially rely on fossil fuels. Therefore, at the COP26 climate summit in Glasgow, the international community decided to link global decarbonisation plans with the Just Transition and the concept of partnerships. Certain partnerships have been agreed, such as a partnership between South Africa, the EU, France, Germany, the UK and the United States on financing a just energy transition. Expanding these kinds of partnerships across Africa could not only benefit global efforts to combat climate change, but may direct or indirectly benefit ECRM value chains

in a cross-cutting sense, as it might lower the overall carbon emission footprint associated with mining and refining activities where these are not yet powered by renewable energy supply.

Recommendation 7.8: Support and coordinate with initiatives that aim to drive the decarbonisation of African energy production, and leverage these for development of the ECRM sector.

The EU may support and seek coordination with initiatives focused on advancing the decarbonisation of African energy production, access to clean energy, grid infrastructure improvements, and reducing the continent's reliance on fossil fuels, and seek to leverage these initiatives in order to create synergies with the development of ECRM-related mining, refining and value addition projects. Key initiatives include:

- The Africa Renewable Energy Initiative (AREI) was launched by the African Union and aims to achieve universal access to energy and the generation of 300 GW of renewable energy by 2030. The initiative, in partnership with the AfDB, various European countries, and the Green Climate Fund, supports large-scale renewable energy projects, focussing on solar, wind, hydro, and biomass energy sources.
- Power Africa is a U.S. government-led partnership (through the U.S. Agency for International Development) which involves private companies, governments, and financial institutions, aiming to add 30 GW of new energy generation capacity and 60 million new electricity connections. It supports renewable energy solutions and works to modernise grids, reduce energy losses, and encourage private investment. This initiative aims to increase access to reliable and sustainable power across sub-Saharan Africa.
- The Desert to Power Initiative, led by the AfDB collaboration with Sahel region countries and international climate funds, aims to install up to 10 GW of solar capacity across the Sahel region. The initiative targets to provide electricity to 250 million people by 2030 to reduce reliance on imported fossil fuels.
- The Global Energy Alliance for People and Planet (GEAPP) includes the Rockefeller Foundation, the IKEA Foundation, the Bezos Earth Fund, African governments, and local utilities to support decentralised renewable energy projects by providing capital, technical assistance, and innovative financing models. Globally, it aims to reduce emissions by 4 billion tons, expand energy access to a billion people, and create 150 million jobs by 2030, however, with a significant focus on Africa.
- The African Mini-Grid Program (AMP) is coordinated by the United Nations Development Programme and includes the Global Environment Facility, African countries, and private-

sector partners. The focus lies on the scale up of renewable-based (solar, wind, and small hydro) mini-grids to provide reliable and clean energy to off-grid rural communities.

- Scaling Solar is an initiative by the International Finance Corporation (IFC) in collaboration with the World Bank, African governments, and private-sector partners, which offers a one-stop-shop approach for governments to attract private-sector investment in solar projects. The initiative includes a standardised framework for bidding and financing, accelerating the construction of utility-scale solar plants.

- The Energy Transition Mechanism is a program, led by the Asian Development Bank and supported by African governments as well as global finance institutions, aiming to retire coal power plants early while scaling in renewable energy projects. The program uses financial innovations like concessional financing to make early retirement of coal plants feasible.

- The Global Energy Transfer Feed-in Tariff program promotes the development of small-scale renewable energy projects, aiming to increase clean energy generation capacity and improve the reliability of a country's power supply. Initially, the program was created by the Government of Uganda in collaboration with the German KfW, with significant financial support from various international donors, including the EU, Norway, Germany, and the United Kingdom. In addition to Uganda, the initiative is currently also active in Zambia, Mozambique, and Namibia.

- Mission 300 is an initiative launched by the AfDB and the World Bank to connect 300 million people to electricity in Sub-Saharan Africa by 2030. Efforts are also focused on investments in generation, transmission, distribution, regional interconnection, and sector reform to ensure quality, reliability, and affordability of power supply.

- The Renewable Energy for Electrification Program, funded by the EU and in collaboration with African governments, local energy providers, and private-sector investors, aims to electrify off-grid communities through solar home systems and mini-grids. It provides financial and technical assistance to local entrepreneurs and cooperatives working on clean energy solutions.

- The Africa-EU Green Energy Initiative within the Africa-EU Energy Partnership aims to deploy at least 50 GW of additional renewable energy capacity by 2030, providing electricity to over 100 million people, while promoting energy efficiency and supporting regulatory reforms to create a favourable environment for private investment. By fostering market integration, the initiative seeks to catalyse sustainable economic growth and improve the quality of life for millions. This is key initiative of the Global Gateway Africa-Europe Investment Package, which in turn falls under the Global Gateway Strategy.

- The African Single Electricity Market (AfSEM) was launched by the African Union in June 2021 aiming to harmonise regulatory frameworks and integrate generation, transmission, and distribution masterplans, with full operation anticipated to be reached by 2040. The AfSEM seeks to capitalise on the knowledge gained in Europe and apply it in Africa through the work of the EU Technical Assistance Facility for Sustainable Energy. The creation of the AfSEM (1.3 billion people to be covered) requires physical interconnection of Africa's continental energy infrastructure. This is why, in 2019, the AUDA-NEPAD was tasked to lead the development of this interconnection under a Continental Master Plan for electricity generation and transmission. The plan is designed to provide a strategic roadmap for connecting Africa's five power pools, namely (Central African PP, Maghreb Electricity Committee COMELEC, East African PP, Southern African PP, and West African PP) (Figure 19). In February 2024, the 37th Ordinary Session of the Assembly of the Heads of State and Government of the African Union elevated AfSEM and the continental master plan to Agenda 2063 flagship projects. Europe, through the Africa-EU Green Energy Initiative, supports the work to implement AfSEM and the Continental Master Plan to increase electricity production, improve energy access, and promote energy efficiency across Africa.
- The Just Energy Transition Investment Plans in Africa aim to support the transition from fossil fuels to renewable energy in a way that is socially inclusive and economically viable, addressing energy poverty while reducing emissions. Countries like South Africa, Senegal, and Egypt have launched these plans, supported by international partners, including the EU, which provides funding, technical expertise, and policy alignment. The EU's involvement includes commitments through mechanisms like the Global Gateway and partnerships under the Africa-EU Green Energy Initiative. However, for the plans to be successful, private sector investment must be mobilised, transparent management of funds ensured, and long-term capacity built for local institutions to effectively manage and support the transition.

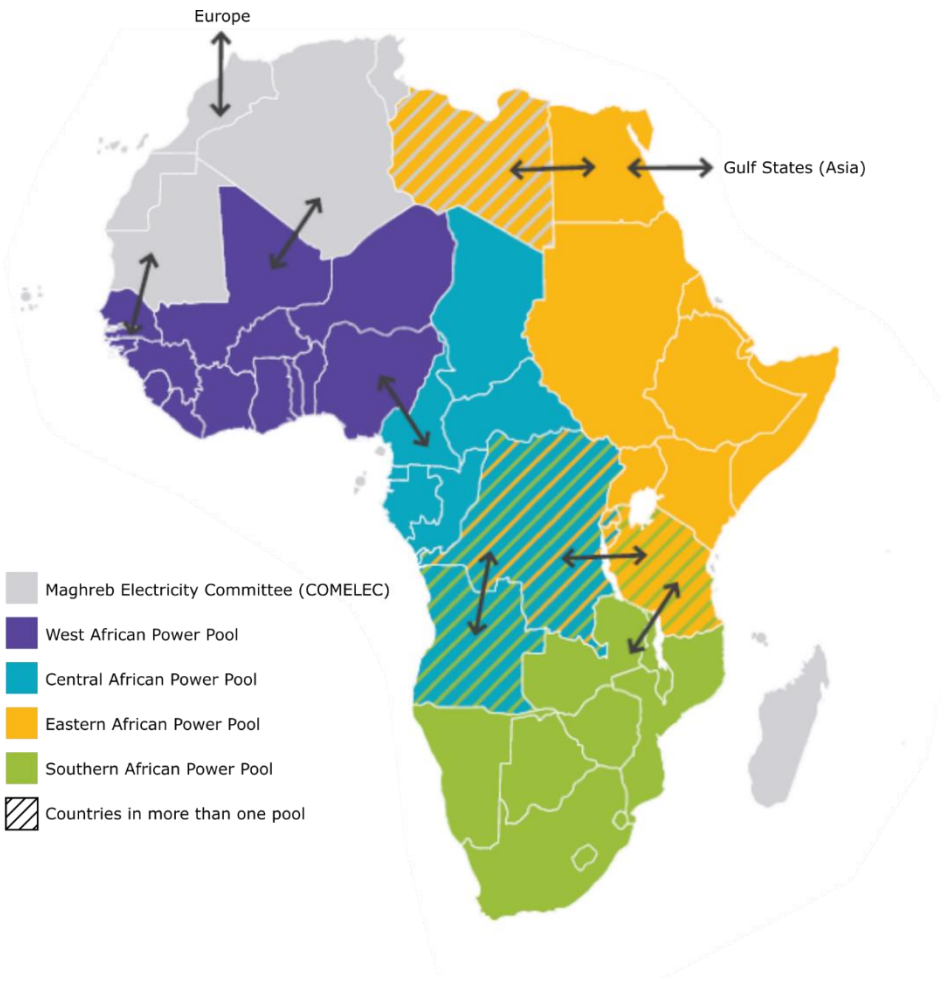

Figure 19. Strategy of the Continental Master Plan to interconnect Africa's five power pools (AUDA-NEPAD 2025).

Recommendation 7.9: Support capacity development and B2B exchange as well as policy advice on power grid improvements in Africa.

Integrating renewable energy into African power grids faces several bottlenecks. Limited grid infrastructure, including outdated transmission lines and insufficient grid capacity, hinders the large-scale integration of intermittent renewables like solar and wind. Many grids are not equipped with modern technologies, such as smart grids, to manage variations in renewable energy supply. Financing remains a significant challenge, with inadequate investment in grid expansion, stability and energy storage systems. Additionally, policy and regulatory frameworks tend to be underdeveloped, delaying projects and discouraging private sector involvement. Addressing these challenges requires targeted investment, international support, and regulatory reforms to enable a reliable and resilient power grid for renewables in Africa.

Successful integration of renewable energy into African power grids has been demonstrated through regional cooperation and innovative projects. For example, the East African Power Pool enhances cross-border energy trade and harmonises infrastructure, enabling countries to share surplus energy and mitigate shortages. Projects in countries like South Africa and Morocco show how robust policies, private investment, and local capacity building drive growth. For instance, Morocco's Noor solar projects and Kenya's wind and geothermal advancements are creating scalable models.

European companies such as Siemens Gamesa, Enel Green Power, and Vestas possess expertise in renewable energy deployment and grid integration. The EU could encourage and support these companies, for instance by facilitating B2B exchange, in collaborating with African partners to share best practices and develop capacities on novel grid management approaches, such as integrating artificial intelligence approaches in energy distribution to avoid grid losses. The EU or its Member states might also mobilise support for policy advise on regulatory reform to strengthen such efforts.

Recommendation 7.10: Lobby and incentivise ECRM mining and refining project operators to contribute to the stabilisation of national power grids.

Due to the high energy requirements of certain ECRM mining and refining projects and due to company-internal decarbonisation goals (seeking to minimise the use of backup diesel generators, also for economic reasons), mining and refining project operators plan or have already established plants for on-site renewable energy generation. These facilities might be connected to and support stabilising national power grids. Among others, grid stability requires installation of batteries to store energy, controllers to integrate energy generated on-site into the grid, and performance monitoring.

The EU and its Member states, in coordination with African partner countries, could lobby and incentivise project operators to contribute to national grid stability, for instance by facilitating access to financing at preferential rates, or through public-private partnerships. Examples for potential ECRM projects of interest (partly already successfully completed) in this regard include:

- Ivanhoe Mines and its joint venture partner Zijin Mining have launched a major public-private partnership project with the Congolese state energy company SNEL to modernise the Mwadingusha, Koni, and Nzilo 1 hydropower plants to supply their Kamoa-Kakula copper project (DRC). The German company ANDRITZ is supplying the electrical and hydro-mechanical equipment for Mwadingusha, while the Swiss consulting firm Stucky managed the project. Refurbishment of Mwadingusha was completed in 2021 and refurbishment of Turbine 5 at Inga II was expected to be completed in late 2024.

- AVZ and its project partner, Dathomir, plan to facilitate the rehabilitation of the Piana-Mwanga hydroelectric power station for the Manono lithium project (DRC), which is currently reliant on solar power and diesel generators.
- For the Karo PGM project (Zimbabwe) the integration of a 300 MW solar power plant is planned, whose surplus electricity will be supplied to the national grid.
- Black Rock Mining, for financing its Mahenge graphite project (Tanzania), have partnered with the Development Bank of Southern Africa to build, among others, a 220 kV powerline and associated switchyards at Mahenge town, which will supply power to the mine and contribute to general electrification in the region as well.

Recommendation 7.11: Support access to financing for ECRM mining and refining project operators seeking to establish green microgrid solutions.

The mining sector already accounts for around 50 % of electricity generation in sub-Saharan Africa (Bird and Bird 2022). Microgrid solutions are localised energy systems that operate independently or in conjunction with the main power grid. Microgrids are typically composed of distributed energy resources (such as solar panels, wind turbines, and batteries), control systems, and often backup generation like diesel or gas generators. They may be particularly useful for remote mine sites where connection to the national power grid would be prohibitively expensive, in cases where the national grid is unreliable, and they may also offer alternative sources of green energy in case the national grid strongly relies on fossil fuels.

Encouraging or supporting ECRM mining and refining project operators to seek establishing green microgrids may lead to a lower GHG footprint of the raw materials produced at these projects. The EU might therefore support preferential access to financing for these projects in Africa in case they have or plan to establish value chain links with Europe. AfricaMaVal deliverable 7.1 (Stoltnow et al. 2024) lists a number of ECRM projects that source or plan to source a considerably amount of energy from renewables including

- Balama graphite project (Mozambique) operated by Syrah Resources (Australia): Operating 11.25 MW PV; 8.5 MW/MWh BESS; average supply of 35 % power requirements;
- Maniry graphite project (Mozambique) operated by Evion Group NL (Australia): PV/BESS plant planned to initially supply 35 % of the overall 32 MWh/a power requirements; further increase of renewable energy share is anticipated;

- Molo graphite project (Madagascar) operated by NextSource Materials (Canada): Operating PV/BESS plant to supply 35 % of power requirements; the remainder coming from diesel generators, as there is no access to the national grid due to the remote location of the project;
- Motheo copper project (Botswana) operated by Sandfire Resources Ltd. (Australia): PV/BESS plant planned to supply ~1/3 of project energy needs; company-wide commitment to reach 50 % renewable energy by 2030 and net zero by 2050;
- Songwe Hill REE project (Malawi) operated by Mkango Resources Ltd. (Canada): planned to cover the energy demand of ~25 MW/h by three PV plants; supplemented by grid electricity (~75 % renewables, mainly bioenergy, 22 % oil, sufficient supply unclear) during the night and unfavourable conditions for photovoltaics.

Several other African ECRM projects have successfully adopted or plan off-grid energy solutions based on renewables, for example:

- Eramet Grande Côte in Senegal has implemented a hybrid solar and battery storage solution to supply its mineral sands operations. The project, developed in partnership with the German JUWI Renewable Energies company, consists of a 20 MW solar plant and an 11 MWh battery system, aiming to reduce dependence on heavy fuel oil and lower CO_2 emissions by 25,000 tons annually.
- Anglo American Platinum's Mogalakwena mine in South Africa is constructing a 100 MW solar photovoltaic (PV) plant. This project is expected to reduce reliance on the national grid and support the company's goal of carbon neutrality by 2040.
- Within the QIT Madagascar Minerals mineral sands mining and processing operation in Madagascar, Rio Tinto, the project operator, is developing a hybrid renewable energy project combining solar and wind power to supply energy to the site. This project is still in its early stages but represents Rio Tinto's commitment to achieve net-zero carbon emissions by 2050 while improving energy resilience at remote operations.
- Namibia Critical Metals is exploring renewable energy options, including solar PV and hybrid systems, to enhance the sustainability of rare earths production planned at Lofdal (Namibia).

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Recommendation 7.12: Promote and support African mining and refining projects as well as value chains providing ECRM useable for local energy infrastructure development.

Many ECRM have a direct use in energy infrastructure and energy storage components, for instance copper, aluminium, different steel additives, the battery metals, REE and PGM. From a sustainability perspective, it would seem appropriate that African raw materials are not only used for infrastructure development abroad, but serve to drive progress on the continent and in the country of production as well. Therefore, developing African ECRM projects and associated value chains that seek to establish direct links with local or regional infrastructure projects consuming some of these ECRM might be incentivized through appropriate mechanisms to be determined. The EU could engage with African partners to map such opportunities and discuss appropriate incentives, such as fiscal benefits or preferential financing rates.

South Africa's PGM sector may serve as an example in this regard. There is growing demand for hydrogen electrolysers and catalytic converters, essential for renewable energy and transport sectors. These materials can feed directly into infrastructure projects like hydrogen fuel stations and energy-efficient public transit. As part of the nuGen project, Anglo American and its partner First Mode (Seattle, USA) have developed a 2 MW hybrid battery/hydrogen fuel cell power plant to replace diesel engines in ultra-size haul trucks. Anglo plans to convert 40 diesel trucks in Mogalakwena to hydrogen trucks, committing to a partnership approach to South Africa's Just Energy Transition. Furthermore, South Africa's Hydrogen Valley Initiative leverages PGM for green hydrogen production, with applications in local energy systems and transportation. The local company, Hydrox Holdings, has developed advanced alkaline electrolysers that incorporate PGM in catalytic coatings and there are efforts to localise manufacturing components, including electrodes.

Recommendation 7.13: Support the development of large national renewable energy projects in Africa.

Developing certain energy mega-projects or project networks may generate sufficient power to satisfy national demand, including for prospective mining and refining projects, and in some cases even allow project-hosting countries to export energy at a large scale in the broader region. While some of these mega-projects are particularly challenging in terms of politics, engineering, financing and governance, they nonetheless hold the potential to accelerate and debottleneck economic development, including mining and refining projects, at a large scale. The EU, along with other African and international partners, could therefore intensify discussions on how to progress these large infrastructure projects, addressing all of the above factors, that is, politics,

engineering, financing and governance aspects. Prominent examples for African mega-projects or project networks for renewable energies include:

- Inga III hydropower project: Inga III is part of the larger Grand Inga Dam project in the DRC, which, if completed, could generate up to 11 GW of renewable energy, making it one of the largest hydroelectric projects in the world and allowing the DRC to satisfy national energy demand and export energy to South Africa. This might act as a catalyser for developing ECRM mining as well as smelting and refining projects in southern Africa. However, an estimated US$ 14 billion investment and a history of stalled agreements underscore the need for robust international and private sector collaboration to ensure Inga's viability.
- Geothermal projects, including Silali and Menengai, located in Kenya's Rift Valley, aim to generate more than 1 GW of renewable energy. While partially funded by the AFDB, the geothermal projects encountered delays due to insufficient financing and technical challenges. Additional funding is required for full development and potential scaling to increase Kenya's geothermal capacity. Besides Kenya, the African Union (and its partners, e.g., EU-Africa Infrastructure Trust Fund, KfW) provides grants for geothermal projects in 13 eligible East African countries via the Geothermal Risk Mitigation Facility for Eastern Africa.
- Ghana's Scaling Solar program, part of the World Bank's Scaling Solar initiative, aims to generate 200 MW of solar power to address the country's energy shortages. This program would reduce Ghana's reliance on imported fossil fuels and support industrial development.
- The TuNur solar project comprises developing a large-scale solar farm in the Tunisian desert with the goal of exporting renewable energy to Europe via undersea cables. If completed, TuNur could supply up to 4.5 GW of clean energy to Italy, Malta, and France. The project, which has received some interest from European investors, still requires substantial funding and regulatory support, both from Tunisia and potential European importers. Funding is in particular needed for undersea transmission infrastructure and local grid upgrades.

Recommendation 7.14: Support the expansion of national grids and the inter-connection of regional power pools.

Many African national grids suffer from aging assets, high transmission and distribution losses (averaging 20-30 % in some regions), and limited reach, with rural electrification rates below 50 %

in much of Sub-Saharan Africa. Despite these challenges, progress has been made in interconnecting regional power pools to enhance electricity trade and stability. For example, the Southern African Power Pool connects 12 member states and enables surplus energy from South Africa and other countries to be shared across the region, including with landlocked nations like Zimbabwe and Zambia. Similarly, the West African Power Pool has seen success in linking several countries, supported by infrastructure projects such as the 'CLSG' (Côte d'Ivoire, Liberia, Sierra Leone, and Guinea) interconnection.

The EU and other international partners are already supporting these developments, for instance through the Africa-EU Green Energy Initiative and through the Africa-EU Energy Partnership. Engaging in and further upscaling support and cooperation in these initiatives might be linked more directly with discussions on ECRM sourcing and ECRM project investment, both with African policy makers as well as with project developers, since grid expansion and connecting regional power pools would benefit the development of ECRM mining, refining and value addition projects in a cross-cutting sense.

Recommendation 7.15: Support the implementation and maintenance of concentrated solar power plants in South Africa.

Concentrated Solar Power (CSP) plants in South Africa have faced several challenges, primarily related to financial, operational, and grid infrastructure issues. These challenges have affected their ability to function at full capacity and deliver reliable power. CSP plants in South Africa's Northern Cape Province, such as the Kathu Solar Park, Xina Solar One, Ilanga CSP 1, as well as the Redstone solar thermal power project, are each designed to provide 100 MW of stable power, even after sunset through thermal energy storage. However, CSP is more expensive to build and operate than photovoltaic solar plants due to the complex thermal storage systems and higher maintenance costs.

All CSP projects in South Africa depend heavily on Eskom's ability to make timely payments for the power purchased. However, Eskom's financial challenges and its reliance on government bailouts have affected CSP projects' cash flows and their ability to remain operational. CSP has the potential to provide stable, dispatchable power, yet the current South African grid infrastructure struggles to handle renewable energy intermittency and peak demand. This grid instability and frequent load shedding reduce the benefits that CSP plants could provide by balancing supply during peak periods.

Through certain financial instruments mentioned throughout this report (see also AfricaMaVal deliverable 3.2, Albery et al. 2024), the EU might help lowering the cost of capital, thus making CSP projects more financially sustainable in the long term. Support from the EU could also extend

to develop South African capacity for CSP maintenance, potentially establishing local expertise and supply chains for critical parts. European companies that could be engaged as potential partners on this matter include Abengoa Solar, Engie, Sener, and Siemens Energy. Furthermore, the EU could work with the South African government to design policies that secure long-term stability for PPAs, perhaps introducing indexed payment schedules or price adjustments to safeguard CSP projects from Eskom's financial volatility. Such support could provide CSP operators with more predictable revenue streams, making CSP projects more attractive to investors.

Recommendation 7.16: Support the construction and upgrading of African water, sanitation and hygiene infrastructure.

Mining projects may require large quantities of water, especially for the processing of ore. Although high rates of water re-use or recycling are technically feasible and increasingly common, conflicts between mine operators and communities often centre on water availability and water quality for community needs and agricultural purposes (e.g., Kuehnel et al. 2023). The potential for conflict is likely to intensify in view of increasing droughts and the associated increased water stress caused by global climate change.

Mitigating potential water-related conflict risks in mining communities may be supported by assisting the community with groundwater wells, among others, though such measures are not necessarily sustainable in the long term. Reliable access to clean water, sanitation and hygiene (WaSH) is recognised as a human right, yet according to UN data, more than 2 billion people do not have access and many African countries face challenges in ensuring this access for their populations. Although progress has been made, forecasts show that even after 2040, a large proportion of the population will not have access to effective WaSH infrastructure due to a lack of funding, inadequate urban planning, and vastly unequal provisions in rural areas. Improving access to an effective local WaSH infrastructure may therefore be an indirect contribution to improving community acceptance of ECRM mining and refining projects. Potential support interventions in this regard include building and managing reservoir and water treatment facilities; providing technically simple and cost-effective sanitation facilities (e.g., composting toilets to reduce water contamination); and capacity development on water management, ranging from the broad aquifer level to the local level. Several development organisations acting on behalf of EU Member state governments are actively working on these questions in Africa.

Recommendation 7.17: Support the construction and upgrade of African digital infrastructure to address the growing digitalisation of the mining industry.

For Africa's mining industry to benefit from digitalisation and its advantages in terms of improved operational efficiency and safety necessitates robust digital infrastructure projects to support advanced technologies like the industrial internet of things, artificial intelligence and big data analytics. These projects face significant challenges, including connectivity gaps in remote areas, high (upfront) technology costs, limited technical expertise, fragmented regulations, and financial constraints. The EU could engage European, African and international partners from the public and private sectors to work collaboratively on these topics, benefiting, among others, from the expertise a number of mining digitalisation service providers have already developed in the EU. Discussion topics might include digital infrastructure financing, public-private partnerships, regulatory harmonisation, data privacy, data ownership, business models (e.g., software/data as a service) and cybersecurity. The Smart Africa Alliance, already in a partnership with the EU through Global Gateway, might be a natural starting point for such discussions.

The following examples underline both the potential and the challenges associated with digitalisation in Africa, which may influence mining and other sectors:

- National and regional broadband networks, such as the East Africa Submarine System (EASSy): The system provides fibre optic connectivity throughout Eastern and Southern Africa. Although capacity was recently doubled from 18 Tbps to 36 Tbps, the system recently experienced disruptions due to damages between Mozambique and South Africa, highlighting the vulnerabilities of the infrastructure and the need for sustained maintenance and digital innovation to complement the expanded capacity.
- Data centres and cloud services, such as Africa Data Centres (Cassava Technologies, Africa-wide) or Teraco’s data centres (South Africa), provide networks of data centres across Africa, including local hosting for data generated by smart mining equipment, which reduces latency and costs associated with remote operations and supports Artificial Intelligence-driven analytics, ensuring real-time processing of mining data.
- 5G Rollout by MTN and Vodacom to provide high-speed, low-latency connectivity, particularly in South Africa and Zambia. This technology which would benefit the facilitation of autonomous operations and remote-controlled equipment in mining.

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9 Appendix

Table 3. List of recommendations and conceptual investment opportunities and main authors

No.	Recommendation and conceptual investment opportunities	Authors	Linked deliverable
2.1	Create strategic investment partnerships to raise exploration funding in Africa throughout raw material market cycles.	P. Schütte (BGR)	
2.2	Support exploration financing and project de-risking through downstream involvement.	P. Schütte (BGR)	
2.3	Provide seed funding or competitive grants for African junior explorers.	P. Schütte (BGR)	
2.4	Consider investing in African ECRM exploration projects based on the continent's demonstrated potential to host significant deposits of metals associated with the energy transition.	P. Schütte (BGR)	
2.5	Support exploration-project related due diligence for prospective investors.	P. Schütte (BGR)	
2.6	Support development of the local service sector for mineral exploration.	P. Schütte (BGR)	
2.7	Raise awareness on accreditation of Competent / Qualified Persons for reporting mineral resources and reserves.	P. Schütte (BGR)	
2.8	Support regional greenfield exploration and baseline data generation in Africa.	P. Schütte (BGR)	
2.9	Improve accessibility to geological, geochemical, geophysical data at geological survey level.	P. Schütte (BGR)	
2.10	Support capacity development for African geological surveys to process exploration reports in a fast and reliable manner.	M. Drobe (BGR)	
2.11	Support local governments to build a globally competitive digital and transparent mining cadastre system.	S. Sewpershad (AHK)	
2.12	Raise awareness on ESG impacts and the role of artisanal miners in mineral exploration.	P. Schütte (BGR)	
2.13	Support exploration activities to help formalizing the artisanal mining sector.	P. Schütte (BGR)	
2.14	Reinforce the role of mineral exploration in local university curricula and provide support to students to gain practical experience.	P. Schütte (BGR)	
2.15	Fund research and postgraduate projects focusing on ECRMs in Africa.	S. Sewpershad (AHK)	

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No.	Recommendation and conceptual investment opportunities	Authors	Linked deliverable
2.16	Support African-European cooperation in ore deposit research.	P. Schütte (BGR)	
3.1	Consider potential investment opportunities aimed at maximizing ECRM supply.	M. Stoltnow (BGR)	D7.1
3.2	Consider potential mining investment opportunities with long mine life.	M. Stoltnow (BGR)	D7.1
3.3	Support potential investment opportunities where mining operations recover multiple ECRM in parallel.	M. Stoltnow (BGR)	D7.1
3.4	Consider lessons learnt from successful ECRM mine development in Africa: The example of the Molo graphite project in Madagascar.	P. Schütte (BGR)	
3.5	Consider mining projects located in EU raw material partner countries in Africa.	M. Stoltnow (BGR)	D2.3, D7.1
3.6	Engage in dialogue on regulatory requirements, ESG expectations, product quality standards and market trends to facilitate increasing market access for African mineral products.	P. Schütte (BGR)	
3.7	Analyse and support the framework for ECRM offtake agreements in EU-Africa value chains.	P. Schütte, M. Stoltnow (BGR)	D3.2
3.8	Consider investing in projects or companies with existing offtake agreements with European companies.	M. Stoltnow (BGR)	D2.3, D7.1
3.9	Encourage project operators/owners of ECRM mining projects in Africa to become members of the European Battery Alliance/the European Raw Materials Alliance.	M. Stoltnow (BGR)	D6.1, D6.2
3.10	Stimulate cooperation, networking, business and skills development for European service providers in mining and processing technology in Africa.	M. Stoltnow (BGR)	
3.11	Facilitate the interaction between EU and African researchers and students involved in the development of mining and processing technologies.	M. Stoltnow (BGR)	
3.12	Explore support options for developing mining projects that have already passed the feasibility stage but whose realisation has been suspended by the project developer due to financial bottlenecks or risk considerations.	M. Stoltnow (BGR)	D7.1
3.13	Support mining projects whose development will have synergy effects with other local/regional industrial projects.	M. Stoltnow (BGR)	D2.3, D7.1
3.14	Support the development of mining projects located in countries whose government incentivises investments in the mining sector.	M. Stoltnow, M. Drobe (BGR)	D7.2, D9.3
3.15	Support EU raw material engagement with African regional economic communities.	M. Stoltnow (BGR)	

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No.	Recommendation and conceptual investment opportunities	Authors	Linked deliverable
3.16	Consider ECRM projects of interest for various EU industry sectors.	M. Stoltnow (BGR)	D2.3, D7.1
3.17	Consider potential investment opportunities in EITI countries.	K. Kühnel, M. Stoltnow (BGR)	D2.3, D7.1
3.18	Consider ECRM projects promoting local stakeholder integration and dialogue.	K. Kühnel (BGR)	D7.1
3.19	Consider ECRM projects promoting mining community and local business development.	K. Kühnel (BGR)	D7.1
3.20	Consider ECRM projects associated with a high share of local workforce and local content policy implementation.	K. Kühnel (BGR)	D7.1
3.21	Support mining skills development.	K. Kühnel, M. Drobe (BGR)	
3.22	Opportunities to support the role of women in African mining by encouraging networking and cooperation.	V. Mawisa, P. Schütte (BGR)	D9.3
3.23	Evaluate water risks and water management plans of mines considered as potential investment opportunities.	K. Kühnel (BGR)	
3.24	Evaluate proper mine waste management practices among potential investment opportunities.	K. Kühnel (BGR)	D7.1
3.25	Support sector-specific regulatory and policy implementation as well as institutional capacity development in African mining.	P. Schütte, S. Sewpershad (BGR/AHK)	D7.2, D9.3
3.26	Explore ways for cooperating with high-impact state-owned mining companies in Africa.	M. Stoltnow, P. Schütte (BGR)	
3.27	Consider cooperating with Western companies with a strong track record in Africa's mining sector.	M. Stoltnow, P. Schütte (BGR)	
3.28	Consider ECRM projects associated with third-party assurance mechanisms.	P. Schütte, K. Kühnel (BGR)	
4.1	Encourage and support ASM exploitation of high-grade portions of sub-economic large-scale mining projects.	P. Schütte (BGR)	D1.4, D7.1
4.2	Evaluate opportunities for recovering ECRM as a by-product of ASM operations and encourage multi-metal recovery and valorisation by ASM.	P. Schütte (BGR)	D1.4
4.3	Support establishing formal ASM mining zones.	P. Schütte (BGR)	
4.4	Encourage neighbouring countries' cooperation to understand their ASM ECRM potential and associated mineral trade.	P. Schütte (BGR)	
4.5	Evaluate ECRM potential of historic ASM tailings and dumped ore.	P. Schütte (BGR)	
4.6	Explore legal and technical means for ASM to exploit deeper mineralisation.	P. Schütte (BGR)	

No.	Recommendation and conceptual investment opportunities	Authors	Linked deliverable
4.7	Consider visibly engaging in ASM supply chains for the purpose of securing ECRM supply.	P. Schütte (BGR)	
4.8	Support and incentivize artisanal mine site operators to comply with ESG standards suitable for ASM.	P. Schütte (BGR)	
4.9	Support closure and rehabilitation of artisanal mine sites.	P. Schütte (BGR)	
4.10	Improve geological and economic data availability on ASM mine production.	P. Schütte (BGR)	
4.11	Support extension service provision in the ASM sector.	P. Schütte, R. Tufo (BGR / Levin Sources)	D7.2
4.12	Support ASM capacity development regarding access to financing.	P. Schütte (BGR)	D3.2, D7.2
4.13	Improve transparency on value addition in the ASM supply chain.	P. Schütte (BGR)	D1.4, D7.1
4.14	Encourage cooperation between artisanal miners (cooperatives) and formal concession holders.	P. Schütte (BGR)	
4.15	Improve ASM access to mining rights and sector formalisation.	P. Schütte (BGR)	D7.2
5.1	Support free trade agreements and encourage development of value-adding projects in African countries that have a free trade agreement with the EU in place.	M. Stoltnow (BGR)	
5.2	Encourage Africa-based smelters and refiners to participate in certification or assurance programmes.	M. Stoltnow (BGR)	
5.3	Consider the local enabling framework for investment in refining, and encourage regional cooperation on this matter to ensure a sustainable business model.	P. Schütte, M. Stoltnow (BGR)	D7.1
5.4	Consider investments in countries that incentivise refining.	M. Stoltnow (BGR)	D7.2, D9.3
5.5	Support networking and cooperation on promoting horizontal and vertical linkages among raw material producers and associated value-adding industries.	M. Stoltnow (BGR)	
5.6	Engage industry association on the topic of ECRM refining in Africa.	M. Stoltnow (BGR)	
5.7	Promote the construction of refining facilities in regions where skilled personnel are more readily available.	M. Stoltnow (BGR)	D9.3
5.8	Engage in targeted upskilling local talent for roles in smelting, refining, and manufacturing industries.	M. Stoltnow (BGR)	
5.9	Support vertical integration of Africa-EU value chains.	M. Stoltnow, P. Schütte (BGR)	
5.10	Support regional coordination and collaboration in African lithium-ion battery value chains.	P. Schütte (BGR)	

No.	Recommendation and conceptual investment opportunities	Authors	Linked deliverable
5.11	Encourage regional cooperation on smelting and processing of 3T (tin, tantalum, tungsten) minerals, particularly in the Great Lakes region.	P. Schütte (BGR)	
5.12	Engage African integrated mining, smelting and refining operations with lighthouse character in improving their ESG performance.	P. Schütte, M. Stoltnow (BGR)	D7.1
5.13	Support companies that create value in Africa and locally source raw materials.	M. Stoltnow (BGR)	
5.14	Support EU-Africa partnerships to improve local technical expertise for refining processes.	M. Stoltnow (BGR)	
5.15	Facilitate market research on ECRM refining perspectives in Africa.	P. Schütte (BGR)	
5.16	Map and summarize ESG, due diligence and reporting requirements for African ECRM products to directly access the European market.	P. Schütte (BGR)	
5.17	Provide centralized information on funding and financing support opportunities for developers of mining, refining and value addition projects in Africa.	P. Schütte, M. Stoltnow (BGR)	D3.2
6.1	Support the formalisation of the informal recycling sector.	M. Stoltnow, M. Drobe (BGR)	
6.2	Support collection and separation of waste streams in Africa.	M. Drobe (BGR)	D2.3
6.3	Support African recycling capacities for high-value waste fractions.	K. Kühnel, M. Stoltnow (BGR)	
6.4	Foster African national waste legislation and European extended producer responsibility.	M. Stoltnow, K. Kühnel (BGR)	
6.5	Support recovery of ECRM from mine tailings.	M. Stoltnow (BGR)	D7.1
6.6	Support the integration of aluminium scrap recycling in aluminium-producing African countries.	M. Stoltnow (BGR)	
6.7	Promote closed-loop recycling through partnerships between African recycling companies and original equipment manufacturers.	M. Stoltnow (BGR)	
7.1	Support the construction and modernisation of African transport infrastructure corridors between the Great Lakes region and the Indian Ocean.	M. Stoltnow, A. Bachmann (BGR)	
7.2	Support the expansion of the Lobito Corridor to enable the trade of ECRMs, especially copper, cobalt (and germanium) across the Atlantic.	K. Kühnel, A. Bachmann (BGR)	
7.3	Support the construction and expansion of deep-sea ports to relieve existing trade flows and increase the efficiency of emerging ECRM exports.	M. Stoltnow (BGR)	D7.1

No.	Recommendation and conceptual investment opportunities	Authors	Linked deliverable
7.4	Support due diligence for infrastructure projects linked to mining.	J. Vasters (BGR)	
7.5	Promote and support the use of shared infrastructure in association with mining and refining project development.	M. Stoltnow, J. Vasters (BGR)	D7.1
7.6	Support access to green infrastructure development funds in Africa.	M. Stoltnow, J. Vasters (BGR)	
7.7	Support the development and implementation of Just Transition plans in Africa.	P. Schütte (BGR)	
7.8	Support and coordinate with initiatives that aim to drive the decarbonisation of African energy production, and leverage these for development of the ECRM sector.	M. Stoltnow (BGR)	
7.9	Support capacity development and B2B exchange as well as policy advice on power grid improvements in Africa.	M. Stoltnow (BGR)	
7.10	Lobby and incentivise ECRM mining and refining project operators to contribute to the stabilisation of national power grids.	M. Stoltnow (BGR)	
7.11	Support access to financing for ECRM mining and refining project operators seeking to establish green microgrid solutions.	M. Stoltnow, P. Schütte (BGR)	D7.1
7.12	Promote and support African mining and refining projects as well as value chains providing ECRM useable for local energy infrastructure development.	M. Stoltnow (BGR)	
7.13	Support the development of large national renewable energy projects in Africa.	M. Stoltnow (BGR)	D9.3
7.14	Support the expansion of national grids and the inter-connection of regional power pools.	M. Stoltnow (BGR)	
7.15	Support the implementation and maintenance of concentrated solar power plants in South Africa.	M. Stoltnow (BGR)	
7.16	Support the construction and upgrade of African water, sanitation and hygiene infrastructure.	K. Kühnel (BGR)	
7.17	Support the construction and upgrade of African digital infrastructure to address the growing digitalisation of the mining industry.	M. Stoltnow (BGR)	

Table 4. ECRM projects shown in AfricaMaVal deliverables D2.3 and D7.1

Project Name	Country	ECRM	Project stage as per D7.1 definition (at time of research)	Linked deliverable
Ambatovy	Madagascar	Nickel, cobalt	Mining, smelting, refining, expansion	D2.3, D7.1
Atlas Lion	Morocco	Vanadium	Pre-feasibility started	D2.3, D7.1
Aukam	Namibia	Graphite	Mining, expansion	D2.3
Balama	Mozambique	Graphite, vanadium	Mining, smelting, refining, expansion	D7.1
Balama North	Mozambique	Graphite, vanadium	Feasibility started	D2.3, D7.1
Bisie	DRC	Tin, copper	Mining, smelting, refining, expansion	D2.3, D7.1
Bitterwasser	Namibia	Lithium	Scoping & pre-feasibility started	D2.3
Desco Electronic Recyclers	South Africa		Operating, expansion	D2.3
Doornhoek	South Africa	Fluorite	Pre-feasibility started	D2.3, D7.1
Eisenberg	Namibia	REE	Scoping & pre-feasibility started	D2.3
Electro Recycling Ghana	Ghana		Operating, expansion	D2.3
Epanko	Tanzania	Graphite	Feasibility complete; construction	D7.1
Eureka	Namibia	REE	Pre-feasibility started	D2.3, D7.1
Ewoyaa	Ghana	Lithium, tin, tantalum	Feasibility complete	D2.3, D7.1
Farim	Guinea-Bissau	Phosphate rock	Feasibility complete	D2.3, D7.1
Grafica	Tanzania	Graphite	Feasibility complete; construction	D2.3
Graphmada	Madagascar	Graphite	Mining, smelting, refining, expansion	D2.3, D7.1
Green Giant	Madagascar	Vanadium, graphite	Scoping & pre-feasibility started	D2.3, D7.1
K.Hill	Botswana	Manganese	Feasibility complete	D2.3, D7.1
Kabanga	Tanzania	Nickel, cobalt, copper	Feasibility to be completed	D2.3, D7.1

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Project Name	Country	ECRM	Project stage as per D7.1 definition (at time of research)	Linked deliverable
Kamativi	Zimbabwe	Lithium, tin	Tailings reprocessing, scoping & pre-feasibility started	D2.3, D7.1
Kangankunde	Malawi	REE	Feasibility complete	D2.3, D7.1
Kanyika	Malawi	Niobium, tantalum	Feasibility complete	D2.3, D7.1
Karibib	Namibia	Lithium	Feasibility complete	D2.3, D7.1
Kasiya	Malawi	Rutile, graphite	Pre-feasibility complete	D2.3, D7.1
Kebemer	Senegal	Phosphoric acid	Feasibility started	D2.3
Konkola	Zambia	Copper, cobalt	Mining, smelting, refining, expansion	D2.3, D7.1
Kusini Resources Proprietary Limited	South Africa	Nickel, copper	Tailings reprocessing, scoping & pre-feasibility	D2.3
Leaching plant for artisanal Cu ore	Tanzania	Copper	Conceptual proposal without actual operator	D2.3, D7.1
Longonjo	Angola	REE	Feasibility started	D2.3, D7.1
Lubalisi	Tanzania	Nickel, cobalt, PGE	Scoping & pre-feasibility started	D2.3, D7.1
Lumwana	Zambia	Copper, cobalt	Mining, smelting, refining, expansion	D2.3, D7.1
Maboumine	Gabon	Niobium, REE, phosphate	Scoping & pre-feasibility started	D2.3, D7.1
Mahenge	Tanzania	Graphite	Feasibility complete; construction	D2.3, D7.1
Makuutu	Uganda	REE, scandium	Feasibility complete	D2.3, D7.1
Manganese Metal Company	South Africa	Manganese	Mining, smelting, refining, expansion	D2.3, D7.1
Maniry	Madagascar	Graphite	Feasibility complete	D2.3, D7.1
Manono tailings	DRC	Lithium, tin, tantalum	Tailings reprocessing, scoping & pre-feasibility started	D2.3, D7.1
Millie´s Reward	Madagascar	Lithium, tantalum, niobium	Scoping & pre-feasibility started	D2.3, D7.1
Minim-Martap	Cameroon	Aluminum / Bauxite	Feasibility complete	D2.3, D7.1

Project Name	Country	ECRM	Project stage as per D7.1 definition (at time of research)	Linked deliverable
Mokitso	South Africa	Manganese	Scoping & pre-feasibility started	D2.3, D7.1
Molo	Madagascar	Graphite	Mining, smelting, refining, expansion	D2.3, D7.1
Moma	Mozambique	Titanium, REE	Mining, smelting, refining, expansion	D2.3, D7.1
Monte Muambe	Mozambique	REE	Scoping & pre-feasibility started	D2.3, D7.1
Mopani	Zambia	Copper, cobalt	Mining, smelting, refining, expansion	D2.3, D7.1
Motheo	Botswana	Copper, PGE	Feasibility complete; construction	D2.3, D7.1
Musha-Ntunga	Rwanda	Tin, tantalum, lithium	Mining, smelting, refining, expansion	D2.3, D7.1
Musongati	Burundi	Nickel, cobalt, copper	Idle, outdated feasibility study	D2.3, D7.1
Mutoshi	DRC	Copper, cobalt	Feasibility complete; construction	D2.3, D7.1
Nachu	Tanzania	Graphite	Feasibility complete; construction	D2.3, D7.1
Nkamouna-Mada	Cameroon	Nickel, cobalt	Feasibility complete	D2.3, D7.1
Nyakabingo	Rwanda	Tungsten	Mining, smelting, refining, expansion	D2.3, D7.1
Omitiomire	Namibia	Copper	Feasibility complete; construction	D2.3
Otjozondu	Namibia	Manganese, silica, phosphorous, barite	Mining, expansion	D2.3
Panthera	South Africa	Manganese	Scoping & pre-feasibility started	D2.3
Phalaborwa	South Africa	REE	Tailings reprocessing, scoping & pre-feasibility	D2.3, D7.1
Pula	Tanzania	Graphite	Unclear, operator states production could start in 2025	D2.3
Reclite	South Africa	Battery black mass	Operating, expansion	D2.3
Sahamamy & Vatomina	Madagascar	Graphite	Mining, expansion	D2.3
Samapleu	Côte d'Ivoire	Nickel, copper, cobalt	Scoping & pre-feasibility started	D2.3, D7.1

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Project Name	Country	ECRM	Project stage as per D7.1 definition (at time of research)	Linked deliverable
Sangarédi	Guinea	Aluminum / Bauxite	Mining, smelting, refining, expansion	D2.3, D7.1
Selebi	Botswana	Nickel, copper, cobalt	Scoping & pre-feasibility started	D2.3, D7.1
SetTIC E-Waste	Senegal		Operating, expansion	D2.3, D7.1
Songwe Hill	Malawi	REE	Feasibility complete	D2.3, D7.1
Special economic zone on battery value chains	DRC	Cobalt, lithium	Scoping & pre-feasibility	D2.3, D7.1
Steelpoortdrift	South Africa	Vanadium, titanium	Feasibility complete	D2.3, D7.1
Steenkampskraal	South Africa	REE, phosphate	Planned revitalisation and expansion	D2.3
Steilrand	Namibia	Manganese, barite	Scoping & pre-feasibility started	D2.3
Swanson	Namibia	Tantalum, niobium, lithium	Feasibility complete	D2.3
Toliara	Madagascar	Titanium, REE	Feasibility complete	D2.3, D7.1
Tsongoari	Namibia	Copper, barite, manganese	Construction	D2.3
Tsumeb	Namibia	Germanium, gallium, copper	Mining, smelting, refining, expansion; exploring the extraction of Ge and Ga from slags	D2.3, D7.1
Uis	Namibia	Tin, lithium	Mining, smelting, refining, expansion	D2.3, D7.1
Waterberg	South Africa	PGE, copper, nickel	Feasibility complete and updated	D2.3, D7.1
Western Foreland	DRC	Copper	Scoping & pre-feasibility started	D2.3, D7.1
Yacob Dewar	Eritrea	Copper	Scoping & pre-feasibility started	D2.3, D7.1
Zandkopsdrift	South Africa	REE, manganese	Feasibility started	D2.3, D7.1
Zebediela	South Africa	Nickel, PGE, copper	Scoping & pre-feasibility started	D2.3, D7.1
Zulu	Zimbabwe	Lithium, tantalum	Construction	D2.3, D7.1

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Table 5. General task and topic responsibilities

Task /report chapter	Responsible
Work package 7 lead	P. Schütte
Task 7.6 lead	P. Schütte
Exploration	P. Schütte
Mining	M. Stoltnow. K. Kühnel
Artisanal and small-scale mining	P. Schütte
Refining	M. Stoltnow. P. Schütte
Recycling	K. Kühnel, M. Stoltnow
Infrastructure	M. Stoltnow, K. Kühnel

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