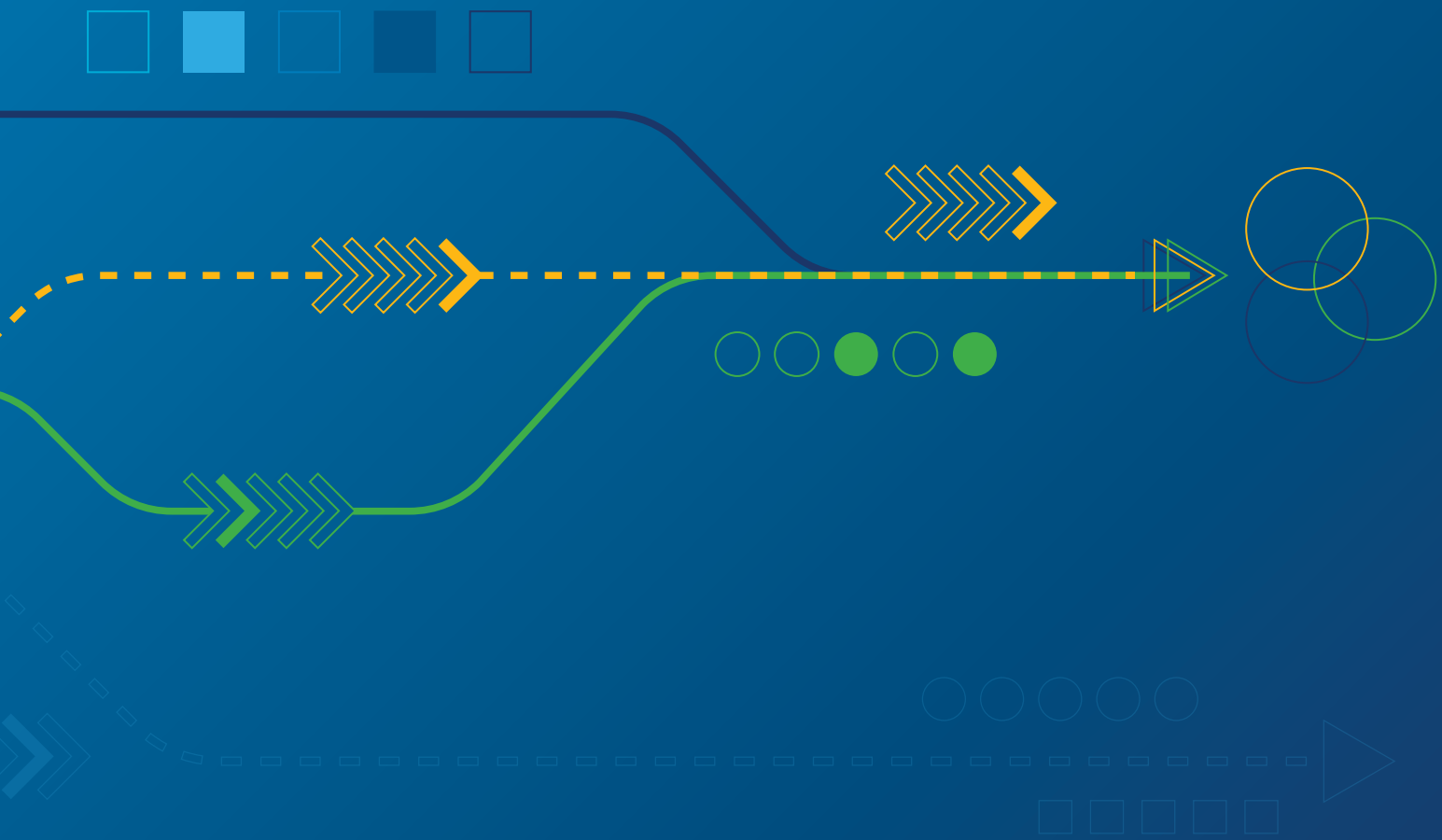
United Nations | UN ENERGY

UN-ENERGY POLICY BRIEF

Aligning Critical Raw Materials Development with sustainable development



ABOUT UN-ENERGY POLICY BRIEF

The drafting of this UN-Energy Policy Brief was led by the Economic Commission for Europe (UNECE), the Economic and Social Commission for Asia and the Pacific (UNESCAP), and the Economic and Social Commission for Western Asia (UNESCWA)) as members of UN-Energy. It builds on discussions at a UN-Energy meeting at technical level held on 10 May 2023 in New York, and on additional technical inputs from many other UN-Energy organisations.

This UN-Energy Policy Brief was prepared in support of the SDG7 review at the High-level Political Forum 2023 in line with the UN-Energy Plan of Action Towards 2025. The Plan outlines UN-Energy's contributions towards the implementation of the Global Action Plan for Accelerated SDG 7 Action presented by the UN Secretary-General as an outcome of the UN High-level Dialogue on Energy in 2021. The HLPF 2023 will inform the SDG Summit to be held during the UN General Assembly High-level Week in September 2023.

This work is a joint product of staff of various UN-Energy members and partners. The findings, interpretations, and conclusions expressed in this publication do not necessarily represent those of UN-Energy or any of its members or partners.

ABOUT UN-ENERGY

UN-Energy is the United Nations' mechanism for inter-agency collaboration in the field of energy established by the UN System Chief Executives Board for Coordination. It aims to promote coherence in the UN system´s multi-disciplinary response to achieve Sustainable Development Goal 7 (SDG 7) in support of the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change. The member organizations of UN-Energy are: FAO, IAEA, IFAD, UNCDF, UNCTAD, UN DESA, UNDP, UN ECA, UN ECE, UN ECLAC, UN ESCAP, UN ESCWA, UNESCO, UNEP, UNFCCC, UNFPA, UN-Habitat, UNICEF, UNIDO, UNITAR, UN-OHRLLS, UN Women, World Bank, WHO, WMO, and partner organizations IRENA and SEforAll.

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KEY MESSAGES

Climate change, ongoing geopolitical tensions and the COVID-19 pandemic have all highlighted the need for a more resilient and sustainable global economy. They have also highlighted the need for a global economy less reliant on fossil fuels and more reliant on renewable energy.

The transition to that clean energy future requires a significant increase in the supply of critical raw materials (CRMs), however. This presents a number of challenges.

In their extraction and trade, CRMs can face environmental and social difficulties. Indeed, poorly managed mineral development can have a range of negative impacts on the economy, environment, society and governance.

If these challenges are adequately addressed, however, the sector can become an engine of sustainable development.

Significant efforts are therefore needed to align the future development of CRMs with the goals of sustainable development. This policy brief aims to provide relevant advice to policymakers to support that development.

The key messages are as follows:

- **Policymakers should promote the diversification of sources of CRM supply.** They should do this while ensuring high environmental, social, and human rights standards in their trade agreements. Resource-consuming countries and regions should also respect the sovereignty and interests of resource-rich countries, especially in the global south, and avoid unfair practices or exploitation.

- **Policymakers should promote the recycling and recovery of CRMs.** This should be done in mining, processing and commercial waste to ensure reliable, secure and sustainable access. Countries should also set dedicated recycling targets for each CRM. These should be based on the available recycling technologies and the given CRM's concentration in the starting matrix. These targets should also be within a robust monitoring framework. Policymakers should also support the development of local recycling capacities and infrastructure in the global south.

- **Policymakers should promote investment in innovation to reduce demand for CRMs.** This would shift demand to more abundant materials with fewer negative environmental and social impacts. Policymakers should also support research and innovation in substituting CRMs with less critical or more abundant alternatives. They should also improve resource efficiency and circularity in producing and consuming products that use CRMs. Moreover, policymakers should support research and innovation that can identify sustainable solutions in the end-of-life management and recovery of CRMs. Developed countries should also facilitate the transfer of technology and know-how to the global south.

- **Policymakers should launch a global campaign to promote sustainable and responsible consumption of CRMs.** The campaign should use various media channels and platforms to discuss CRM sources, uses, benefits, risks and challenges. Additionally, the campaign should provide practical tips and tools to reduce consumption. It should also showcase best practices in sustainable and responsible consumption and highlight success stories.

Furthermore, the following are recommended to increase transparency along CRM supply chains:

- **Adopt a standardized and harmonized approach to public disclosure of the environmental, social and governance (ESG) performances of the mining companies.** Transparent and regular environmental reporting can safeguard a sustainable critical minerals sector. Extraction and trade of minerals should follow internationally applicable, United Nations Framework Classification (UNFC) and United Nations Resource Management System (UNRMS) standards to ensure security of supply and reasonable, sustainable utilization of critical minerals.

- **Encourage governments and extractive industries to work together to eradicate illegal financial flows.** This should be done by promoting multi-stakeholder financial transparency and anti-corruption initiatives. This would ensure transparency in critical mineral development licensing processes, mining agreements and company ownership. While global mining players generally report their financial figures transparently, some mining companies lack full financial transparency. This deficiency can enable corruption and illicit financial flows.

- **Enhance the transparency, efficiency and sustainability of resource use and allocation with modern information and communications technology (ICT)**. Remote sensing, blockchain, machine learning and artificial intelligence (AI) can all remove friction from multiparty transactions, accelerate transaction speeds, optimize queries, automate resource management and reduce costs and errors. They can also support the circular economy and the recovery of CRMs from waste streams.

In addition, in order to enhance global cooperation in enabling the secure and sustainable supply of CRMs, the following actions are recommended:

- **Coordinate global efforts to establish norms and arrangements that promote free markets for CRMs.** This could include exploring an international agreement to mitigate supply chain disruption. Such an agreement should also promote the sustainable use of scarce mineral resources using a Sustainable Development Goal (SDG) risk index for minerals, based on a global governance framework. This framework can lessen environmental and social impacts and ensure coordination in the security of supply.

- **Coordinate efforts to establish international standards on green finance.** This should be done in alignment with the UNFC and the UNRMS and based on an SDG risk index. An international framework for governing green finance can facilitate regulatory harmonization and standardization of market practices.

- **Develop a global risk assessment programme for CRMs and suppliers**. This should be supported by the United Nations regional economic commissions, the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP). Such a risk assessment programme could identify and prioritize CRMs, evaluate their potential impacts and the likelihood of disruption, assess social and environmental risks and suggest mitigation strategies. The programme should leverage data and analytics to provide a global dashboard accessible to policy and decision-makers. This will enable them to monitor supply chain performance, identify vulnerabilities and opportunities and take proactive steps to ensure the security and sustainability of CRMs.

- **Establish relevant regional institutions to facilitate regional coordination, dialogue, and capacity building.** Multilateral efforts to enhance capacity building and knowledge-sharing can address key resource gaps between countries. Building the capacity for resource management and governance in resource-rich developing countries via platforms such as forums and expert groups will help those countries and the global community jointly achieve the energy transition and the SDGs. Knowledge sharing should focus on policy design, legislation and regulation, environmental governance, revenue management and international cooperation. These efforts should promote a fair and transparent global governance system for CRMs.

OVERVIEW

Transitioning towards a clean energy future is a core element of global efforts to achieve the climate goals of the Paris Agreement. The technologies underpinning that transition to low-carbon energy systems – such as wind, solar photovoltaic (PV), electric motors and batteries – are more minerals-intensive than fossil fuel-based technologies, however. As a result, the energy transition implies a shift from fuel-intensive to material-intensive energy systems, creating significant demand for CRMs.

Although there is no single definition of a CRM,[1] the term typically refers to a mineral or metal essential to the contemporary economy and for the transition to a net-zero, circular economy. Many CRMs also face high supply disruption risks and have environmental and social impacts.

While developing CRMs creates significant economic opportunities, as with other extractive industry products,[2] the mining and trade of CRMs may lead to additional ESG challenges. These are faced by both producing/exporting and importing countries. They are also particularly significant for developing countries that do not have experience in managing substantial mining activities or are experiencing difficulties leveraging mining revenues to support sustainable development. There is therefore an urgent need to explore the challenges and opportunities faced by the CRM industries that support the energy transition.

Shortages in the supply of CRMs can hamper the deployment of renewable energy technologies, digitalization and electric mobility. These three are crucial in reducing greenhouse gas (GHG) emissions, enhancing access to energy and information and in creating decent jobs and economic opportunities.[3]

Assessments of CRM supply risks, however, will differ according to the possibilities for substitution, such as between aluminium and copper, or the development of new technologies, such as the sodium-ion battery. Nevertheless, CRM supply risks can undermine various SDGs by affecting poverty eradication, gender equality, access to clean water and energy, sustainable economic growth, resilient infrastructure, responsible production and consumption and climate action.

As a further example, shortages of CRMs can affect the health sector by limiting the availability and affordability of medical devices and equipment. This would include magnetic resonance imaging (MRI) scanners, pacemakers, ventilators and thermometers, all of which rely on materials such as rare earth elements, cobalt and platinum.

The extraction of CRMs can also have significant environmental and social impacts. These include land degradation, water pollution, biodiversity loss, human rights violations and conflict. Therefore, transforming extractive industries for sustainable development requires a comprehensive approach that addresses the sector's economic and ESG dimensions, as well as its interlinkages with other SDGs.

BACKGROUND

Implications of the energy transition for CRMs

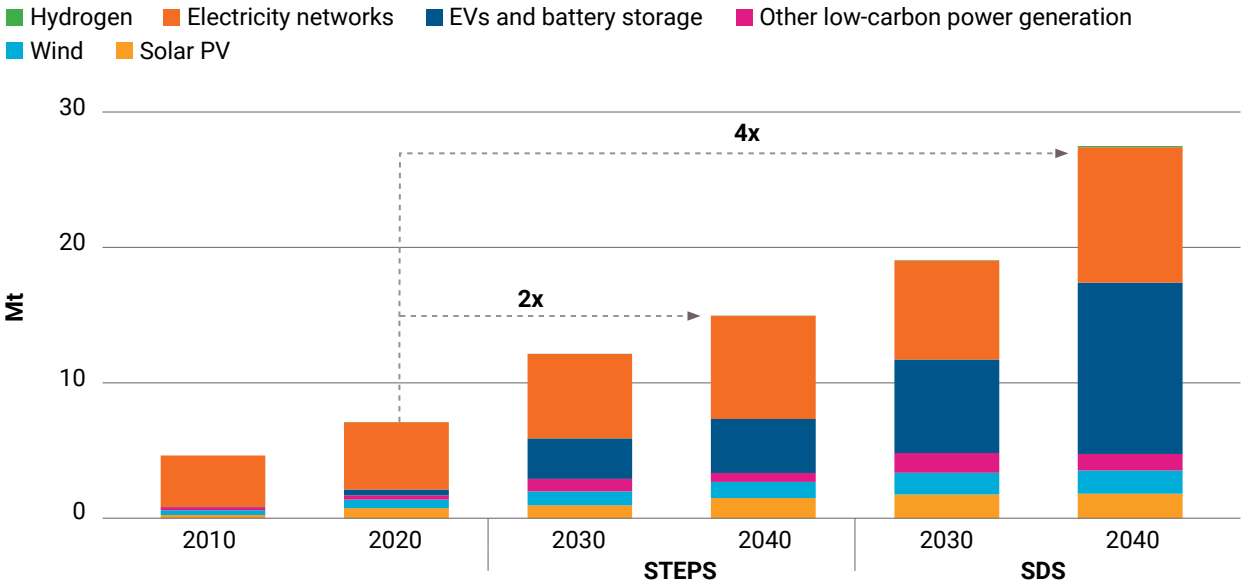
The mineral intensity of electricity generated from renewable energy technologies is much higher than from fossil fuels-based infrastructure. A typical electric vehicle (EV), for example, requires six times the quantity of certain minerals compared to a conventional vehicle. An onshore wind turbine requires nine times more mineral inputs than a gas power plant of the same capacity. Per unit, solar PV and wind power generation require up to 40 times more copper and 14 times more iron than fossil fuel generation on a life-cycle basis.[5]

Demand for critical minerals is expected to grow many times by mid-century, driven by clean energy investments (Figure 1). Demand growth is expected for all major CRMs, including graphite, lithium and cobalt, nickel, copper, chromium and rare earth elements.[6]

In the future, according to the IEA "World Energy Outlook 2020", the primary driver for increased CRM demand will be EVs and battery storage. By 2040, these will account for about half of total mineral demand growth from clean energy technologies. Mineral demand for EVs and battery storage will grow nearly tenfold under the outlook's stated policies scenario (STEPS), while under its sustainable development scenario (SDS), it will grow around 30 times (Figure 2). Also, under the SDS, copper demand by the power sector will double, while mineral demand will triple.[7]

FIGURE 1

Projected trends in mineral demand for clean energy technologies by scenarios



KEY: MT: million tons, **STEPS:** stated policies scenario, **SDS:** sustainable development scenario.
SOURCE: UNESCAP, 2023.

The extractive industries and sustainable development

The extractive industries are closely related to almost all the SDGs due to their wide-ranging connections to other industries, society and the economy.

As the energy transition proceeds, for example, increased mineral extraction to meet the growing demand for mineral resources will present opportunities for fostering economic growth, facilitating job creation – a target of SDG8. It will also promote infrastructure development and the creation of downstream industries – goals under SDG9. This is because extractive industries often benefit remote communities due to the development of substantial infrastructure needed to support the extraction and transport of products to market.

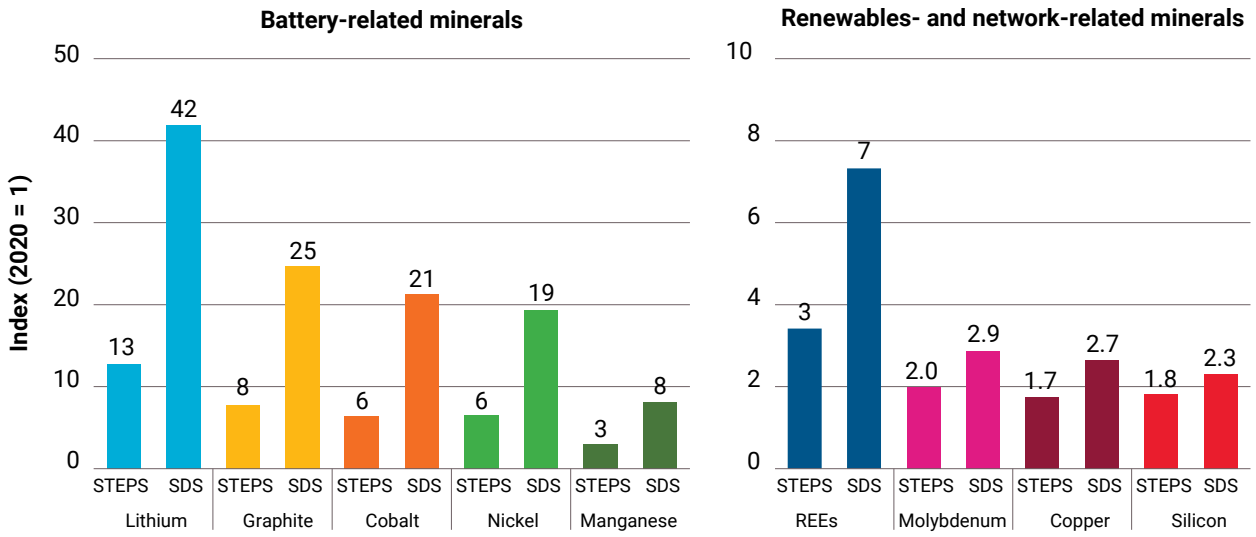
Significant revenue from increased mineral extraction could also create opportunities for countries to invest in a sustainable future and thus contribute to SDG1, the goal of no poverty, SDG2, the aim of zero hunger, SDG3, the target of good health, SDG4, that of quality education, SDG5, the goal of gender equality, SDG6, which aims for clean water and sanitation and SDG7, which targets access to affordable and clean energy.

Yet, the economic benefits arising from the extraction and production of energy and mineral resources have not always translated positively into sustainable socio-economic development – a phenomenon known as the 'resource curse'.[8] If poorly managed, mineral development can lead to many challenges related to the economy, environment, society and governance.

Replacing fossil fuels with clean energy sources, by extension, increases dependence on mineral resources. Moreover, every country is only partially self-sufficient across the entire spectrum of CRMs. Therefore, many countries are both exporters and importers of CRMs. India, for example, is a key exporter of chromium, graphite, manganese and titanium and a fast-growing importer of other CRMs.

FIGURE 2

Growth in demand for selected minerals from clean energy technologies in 2040, relative to 2020 levels



Source: IEA (2021), "The Role of Critical Minerals".

CHALLENGES TO THE SUSTAINABLE DEVELOPMENT OF CRITICAL MINERALS

Challenges to furthering the sustainable development of CRMs include, but are not necessarily limited to, insufficient investment, supply chain vulnerability and weak core technologies. They also include unmitigated emissions, inadequate recycling due to technological barriers and inappropriate e-waste disposal. There are also the challenges presented by the lack of social acceptance for mining and women's participation in the industry. Artisanal and small-scale mining also presents its own challenges, as do weak institutions and insufficient coordination, both nationally and internationally.

Increasing demand for CRMs will not only have profound and far-reaching implications for the extractive industries. It will also impact the socio-economic, environmental and governance spheres of resource-rich countries, posing both challenges and opportunities for their sustainable development.

Environmental risks and sustainability

Mining for critical minerals has many of the same potential economic, social and environmental consequences as other extractive industries, including fossil fuels.

To meet rising demand, the extraction of CRMs must, however, increase. This by itself has implications for climate change. The extractive industries are energy-intensive and currently produce large quantities of GHG emissions, which SDG13 seeks to reduce. These emissions come both from fossil fuel use in CRM production and from deforestation of mining areas.

On the production side, the extraction and processing of natural resources currently account for approximately half of global GHG emissions. Metals and non-metal minerals are responsible for about 20 per cent of this.[9]

Amongst other impacts, large-scale mining can also lead to environmental degradation, including water pollution and competition, the use of hazardous chemicals, loss of biodiversity and a change in land use. This degradation can further impact health, poverty, inequality and demographic imbalances.[10]

Declining mineral quality is another challenge to future CRM mining projects. As high-quality deposits tend to be exploited earlier, ore quality declines across commodities over time. Over the past 15 years, for example, Chile's average copper ore grade has decreased by 30 per cent.[11] Extracting low-quality ores requires more energy and produces more waste and tailings, resulting in higher production costs and increased emissions. Resource depletion could severely limit the availability and accessibility of CRMs, especially of those that have low recycling rates, increasing their extraction costs and environmental impact.

In addition, the potential for high and increasing revenue from CRM development poses challenges to countries with weak governance and revenue management capabilities.

Security of supply

As the energy transition progresses, energy security discussions have become increasingly focused on the availability and security of supply of CRMs. There are growing concerns that the supply chains of critical minerals are less transparent and more concentrated than fossil fuels.[12]

The extraction of CRMs is unevenly distributed, with production and processing operations highly concentrated in a few countries. This, combined with a lack of transparency, make CRMs more vulnerable than fossil fuels to physical disruption, trade restrictions and other developments in major producing countries.[13]

High market concentration and a lack of transparency also threaten the security of supply of CRMs. This is because in major producing countries CRM supplies are sometimes more vulnerable than fossil fuels to physical disruption, trade restrictions or other developments.

Threats include many factors, such as economic and market issues, environmental concerns, geopolitics and the ongoing impacts of the COVID-19 pandemic. Increased demand for CRMs has also intensified the competition for them in the world's major developed countries, which have successively designated critical minerals as key to their development strategies. This suggests that their economic security depends on the continuous and stable supply of CRMs.

Supply chain disruptions

The security of supply of CRMs can be disrupted by a number of factors. These include market volatility, with sharp price rises, trade distortions, export restrictions and supply shortages all potentially affecting the availability and affordability of key technologies and products that rely on CRMs.[14] Technological disruption can also risk the security and sustainability of CRM supply chains by creating new demand for specific materials, or by rendering existing ones obsolete. This requires rapid adaptation and innovation of products and processes and creates increasing uncertainty and competition in the global market.

Extreme weather events, such as floods, droughts, storms, wildfires, and heat waves, can also disrupt supply chains. They can do this in a variety of ways, from damaging infrastructure to reducing production capacity and from delaying transportation to affecting workers' health and safety. Water scarcity, which is expected to worsen with climate change, can affect CRM supply chains in particular by limiting the availability and quality of water for mining, processing and refining operations. This, in turn, may increase costs and heighten the environmental impact.

Land degradation and the loss of biodiversity driven by climate change and human activity can also affect CRM supply chains. They do this by reducing the availability and quality of land for mining and agriculture, increasing conflicts with local communities and indigenous peoples and exposing them to reputational and regulatory risks.

Social conflicts, triggered or exacerbated by climate change creating food insecurity, water scarcity, displacement and migration, can affect CRM supply chains, too. They can do this by disrupting operations, increasing security risks, damaging relationships with stakeholders and exposing them to legal and ethical risks.

Geopolitical instability can also affect the stability and security of critical raw materials supply chains, especially in regions prone to conflicts, sanctions, trade wars, or political transitions. It can also increase the risk of supply disruptions or price shocks.

Natural resource management

The rapid development of critical minerals is a particular challenge for many developing countries that have rich resources but weak governance. This challenge can be seen in areas such as environmental regulation, revenue management – including combatting corruption – and social development.

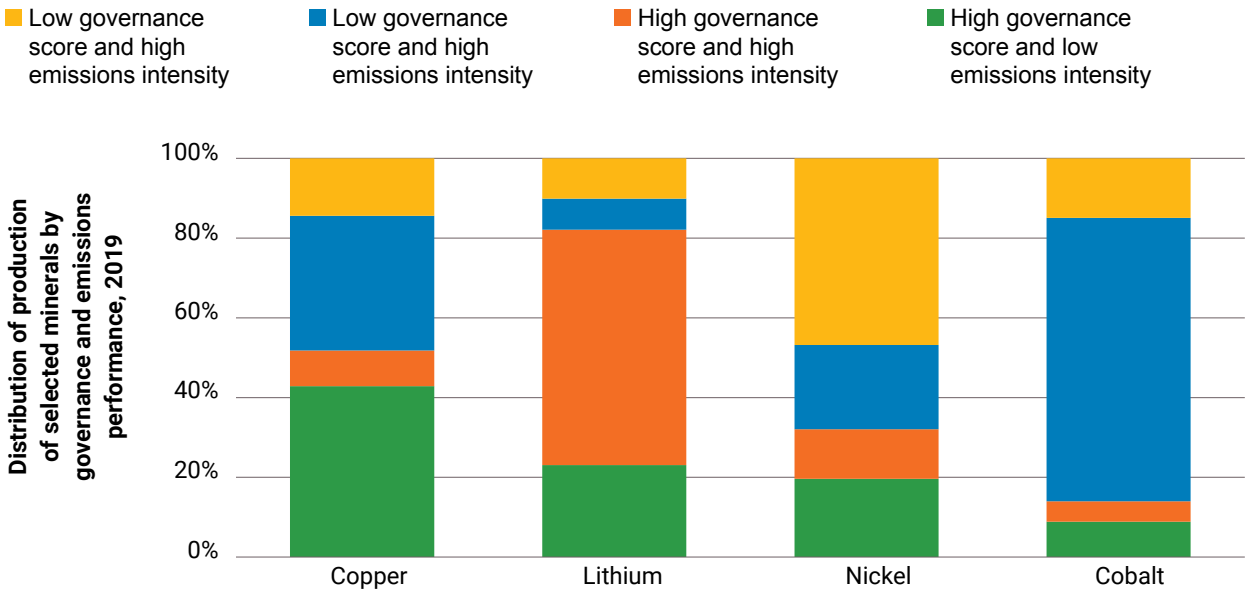
Many of the countries that have the most significant CRM resources and/or the greatest potential for their extraction, are emerging and developing economies. These often require stronger resource governance and have a limited capacity to mitigate the economic and environmental consequences of increased extractive activities.[15] A 2017 study found that more than one-quarter of known copper resources were in countries with unsatisfactory governance and it was therefore inevitable that some products would come from such countries.[16] As of 2019, around 10–15 per cent of the world's copper, lithium and cobalt production and almost half of its nickel production came from regions with low governance scores and high emissions intensities (Figure 3).

Weaknesses in the legal and judicial systems may undermine a host governments' capacity to detect and prevent corruption effectively, as well as its interest in doing so.

At the same time, although allegations of corruption in the mining industry occur frequently, governance and corruption are not high on the agenda of consumer countries when they consider CRM supply chains.[17] The illicit flow of funds can be a severe risk to CRM supply

FIGURE 5

Global annual grid capital expenditure (CAPEX) by region, 2022–2050 (US$ billions)



KEY: ETS: economic transition scenario, **NZS:** net-zero scenario
SOURCE: BloombergNEF.[13]

by enabling corruption, tax evasion, money laundering and other financial crimes that undermine the extractive sector's governance, transparency and accountability. It can also deprive developing countries of much-needed resources and revenue.[18]

Weak institutions that tend to encourage rent-seeking and patronage, leading to higher levels of corruption and reduced economic efficiencies, are also responsible for the adverse impact of resource development. This institutional weakness can, in turn, cause poor allocation of resources, loss of government revenue and increased income inequality.[19]

The potential for corruption is particularly problematic in an environment of rapidly rising demand. In CRMs, this is particularly so, given the opacity and immaturity of global markets, the dominance of a small number of commercial players and the concentration of resources in countries with potentially high levels of corruption.[20] For example, more than half of the world's cobalt is in the Democratic Republic of the Congo, which is considered to have high levels of both fragility and corruption.[21]

The severity of the social and environmental effects associated with mineral extraction could become even higher in jurisdictions where governments are unable or unwilling to safeguard against severe environmental and social impacts in mineral extraction. In contrast, mineral-producing countries with well-developed regulatory systems, vigorous enforcement and institutionalized transparency practices can produce sound environmental and social performances.[22]

RECOMMENDATIONS

International coordination and cooperation are increasingly important in a globalized world, as the proliferation of international initiatives increases the risk of duplication and inconsistency.[23] There needs to be an overarching international framework for critical minerals and coordinated policy action at the global level, leaving room for enhanced alignment and coordination.[24]

This policy brief therefore makes the following recommendations:

1. Achieve life cycle sustainable development

Various measures could be taken at different stages of the value chain to ensure the security and sustainability of CRM supply chains.

Examples of this include investment in resilient infrastructure, diversification of supply sources, increased inventory buffers and the implementation of emergency plans to cope with supply disruptions and market volatility.

To reduce their water footprint and mitigate water-related risks, CRM supply chains could also improve water efficiency and reuse and recycling. They could also adopt alternative technologies that use less or no water and hazardous chemicals and engage with local stakeholders to ensure sustainable water management.

To minimize the environmental impact and biodiversity loss, CRM supply chains could adopt responsible mining practices, restore degraded land, support conservation efforts and respect human rights and cultural values.

To address the social and governance challenges and prevent conflict and violence, CRM supply chains could conduct social risk assessments, engage in dialogue and collaboration with affected parties, support local development and peacebuilding initiatives and adhere to international standards and norms.

Industry leadership and standards must also be developed. For instance, global mining companies could lead by example.

Resource efficiency is vital to sustainable development and reducing the environmental and social impacts of CRM supply chains. Resource efficiency means using natural resources to minimize waste, maximize value, and optimize resource use throughout the life cycle of products and services. Resource efficiency can also enhance the security and resilience of CRM supply chains by reducing dependence on imports, diversifying sources and increasing recycling and reuse.

2. Promote green investment

The demand for critical minerals as inputs for low-carbon technologies requires more investment in their extraction and recycling. The IEA estimates that the expected supply from existing mines and projects under construction will be able to meet only 50 per cent of projected global lithium and cobalt requirements and 80 per cent of the world's copper needs by 2030.[25]

Given the scale and urgency of the challenge of financing sustainable development in CRMs, green finance has become more prominent in recent times, especially for developing countries with abundant critical materials.[26]

'Green finance' is financing by the public, private and not-for-profit sectors that provides environmental benefits. It can therefore help advance sustainable development projects that better manage environmental and social risks.[27]

Green finance is also growing fast. A range of financial instruments now exists, such as green bonds, green loans, sustainable bonds, sustainability-linked bonds and blue bonds, as well as green finance institutions, such as green banks and green funds. Green banks also play an important role in setting sustainable goals for the achievement of credit enhancement and loan programmes.[28]

Such higher standards, however., require global coordination to avoid a 'race to the bottom' in which financing entities that have lower standards undermine the efforts of those with higher ones. A more transparent enabling framework that promotes green finance should therefore be established to better align stakeholder expectations and practices. Information disclosure should be mandatory and fiscal policies must be adjusted accordingly. Such adjustments could include increasing subsidies for green products while eliminating those on fossil fuels.[29]

The COVID-19 pandemic has also underlined the urgent need to scale-up green finance and coordinate finance actions for global sustainable development. It did this by demonstrating the potential for advancing the energy transition[30] through economic recovery plans that can facilitate investment in producing and recycling the CRMs required for renewable energy development.[31] This can contribute to sustainable development by, for example, fostering growth and creating jobs.

The Financing for Development in the Era of COVID-19 and Beyond Initiative (FfDI) from the United Nations provides a valuable platform for mobilizing financial resources for the CRM sector.

At the same time, the proliferation of ESG standards and frameworks has created confusion and inconsistency in the green finance market, making it difficult for investors and stakeholders to compare and assess the sustainability performance of companies and countries.

This also increases the risk of 'greenwashing', in which entities make misleading or exaggerated claims about their ESG practices, exposing them to legal, reputational, and operational risks.[32]

To address this issue, there is a need to develop an SDG risk index that can link ESG performance to SDG outcomes and measure the contribution of entities to the 2030 Agenda for Sustainable Development. Such an index would provide a common language and a principles-based global framework applicable across sectors and regions.

UNFC and UNRMS could provide the framework for developing the SDG risk index for extractive industries. They offer a holistic and integrated approach to the assessment and management of resources based on their social, environmental and economic viability, technical feasibility and degree of confidence in resource estimates.

3. Promote the sustainable use of mining revenue

Gaps and discrepancies in internal corporate anti-corruption compliance and due diligence procedures weaken corruption detection and prevention efforts. In addition, shortcomings in the corporate integrity measures undertaken by governments that are both host and home to corporations – particularly regarding beneficial ownership disclosure – also provide opportunities for corruption to thrive.[33]

Regarding due diligence, for example, even though many companies already have policies on this, they still need further coordination to ensure consistency and increase uptake.[34]

Resource-consuming countries also have a significant role in preventing corruption in resource-producing countries. If consumer countries ignore mineral governance and corruption risks, they will not only lose secure, reliable supplies, but also reduce the potential for citizens of producer countries to benefit from the extraction of those minerals.[35]

There are a variety of existing facilities that can be used to identify and reduce the corruption risks of the critical minerals supply chain. These include the Extractive Industries Transparency Initiative (EITI), the OECD Equitable Framework and Finance

for Extractive-based Countries in Transition (OECD EFFECT), the Blue Dot Network, the Mining Awards Corruption Risk Assessment tool and the Infrastructure Anti-Corruption Toolbox. New tools can also be developed for this.

In addition, the International Labour Organization (ILO) has developed several useful tools for promoting participatory governance. These identify different types of participation, including, for example, a formal, institutionalized tripartite interaction between government representatives, labour unions and the industry on issues of common interests. They also identify more informal structures for dialogue among various stakeholders, mainly for the exchange of information.

Furthermore, the ILO also identifies several key pre-requisites for improving the effectiveness of participatory governance. These include the existence of sufficient technical capacity among labour and industry organizations, a strong political commitment by governments to engage in the dialogue and the provision of necessary institutional support.[36]

4. Secure social equality

As the extractive industries expand to meet rising demand for CRMs, minimizing their social and environmental impact becomes increasingly necessary – particularly in regard to indigenous peoples, islands and first nations communities.

In the past, international civil society groups have played an indispensable role in this minimization. In addition, local civil society groups in many resource-rich countries have also become increasingly involved in promoting public participation in mining development. Such international and local organizations can monitor the implementation of energy transitions and the SDGs, voice the concerns of under-represented segments of society, inform the public, facilitate multi-stakeholder partnerships and hold other stakeholders accountable.[37]

The mining industry still needs to work on attracting and retaining women at all employment levels, although there has been some improvement in recent years. The most common reasons given for the low level of women's employment in the industry are physical capacity and the complexities of accommodating women's workplace needs.[38] Evidence also shows that once employed, on-the-job challenges in mining activities lead to women leaving. These challenges include lower pay and fewer advancement opportunities, under-utilized advanced education and being side-lined for technical roles.[39] Despite the prominence given to efforts to tackle gender inequality by SDG5, the planning, implementation and closure of extraction sites often ignores women's needs and their relations to land and water, affecting their ability to provide food and clean water for the family.[40]

5. Protect global, transparent supply chains

While trade in CRMs at affordable prices is key to facilitating the energy transition, increased geopolitical tensions and other concerns can lead to trade decoupling. This creates potential uncertainty within the CRM market.

Enhancing supply chain transparency can help guard against this. A lack of transparency in the minerals market can increase risk, as mineral trading quotes change rapidly and buyers need to be aware of price movements to hedge against risk.[41] Governments could help address this issue by sharing geological and other relevant data and coordinating with neighbouring countries and trade partners to develop business and customs regulations.[42]

Global accreditation and transparent trading markets/rules could help to stop illegal trading and black markets, also helping to raise the sustainability standards of CRM extraction, production and recycling.

Emerging digital technologies, such as remote sensing, blockchain, machine learning (ML) and AI, can support the creation of transparent platforms for tracking and certifying CRMs. Information about the material's source, sustainability, journey from end to end and other details can be stored. The technology can also increase efficiency by streamlining supply chain processes via smart contracts, reducing the need for intermediaries.

Supply chain due diligence is critical for identifying, assessing and mitigating risks while increasing traceability and transparency. International frameworks for due diligence, with the support of organizations like the OECD, have developed standards for responsible and sustainable sourcing of minerals.[43]

6. Boost innovation to reduce dependence on CRMs

Members of the international community should work together to reduce dependence on CRMs by encouraging further research and innovation. This could take place in areas such as aluminium substitution, cobalt-free and sodium-ion batteries and recycling.

Regarding the first of these, substituting aluminium for copper in energy storage applications is one innovative solution.[44] While aluminium is more abundant and cheaper than copper, it requires about 25 per cent more material to achieve the same level of conductivity. Additionally, aluminium is more prone to corrosion than copper, impacting its durability and lifespan. Further research into aluminium substitution and investment in technological advances to enhance its conductivity and durability would therefore be beneficial for all countries engaged in the energy transition.

Another area for further research and innovation is in how to reduce the quantity of rare earth elements in magnets and/or in identifying alternative materials. Additionally, there is a need to identify viable commercial solutions for recycling end-of-life neodymium (NdFeB) permanent magnets and recovering the associated rare earth content.

Another technological innovation is the development of lithium-ion (Li-ion) battery chemistries that eliminate the need for cobalt. Cobalt is a CRM with a limited supply, making its substitution critical for the sustainability of battery production. While some Li-ion batteries without cobalt, such as iron-phosphate (LFP) batteries, have lower energy density than traditional cobalt-containing batteries, further research and development to improve their energy density will encourage the adoption of these cobalt-free batteries. Both LFP and sodium-ion batteries are also appropriate options for stationary applications.

Lastly, recycling initiatives focused on CRMs are gaining momentum. Glencore, for example, has announced plans to develop Europe's first 'closed loop' recycling facility for electric vehicle (EV) batteries.[45] However, further investment is needed in research and development to improve recycling processes and develop new technologies. Targeted policies to incentivize circular economy investments are also required to boost recycling activities and efficiencies, thus reducing demand for CRMs.

ENDNOTES

[1] CRMs include cobalt, copper, graphite, lithium, manganese, nickel, rare earth elements and others. See https://iea.blob.core.windows.net/assets/ffd2a83b-8c30-4e9d-980a-52b6d9a86fdc/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf, accessed 16 June 2023.

[2] Extractive industries, in this context, refers to the process of extracting raw materials from the earth. This includes fossil fuels – in particular, coal, gas and crude oil – minerals, such as rare earths, bauxite and gold and aggregates such as sand, gravel and clay.

[3] See, for example, www.oecd.org/newsroom/supply-of-critical-raw-materials-risks-jeopardising-the-green-transition.htm, accessed 16 June 2023.

[4] International Energy Authority (2021), "The Role of Critical Minerals in Clean Energy Transitions", IEA, Paris, https://iea.blob.core.windows.net/assets/ffd2a83b-8c30-4e9d-980a-52b6d9a86fdc/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf, accessed 16 June 2023.

[5] Edgar G. Hertwich and others (2015), "Integrated life-cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies", *Proceedings of the National Academy of Sciences,* 112(20), 6277–6282, National Academy of Sciences of the United States of America, Washington D.C., https://doi.org/10.1073/pnas.1312753111, accessed 16 June 2023.

[6] The estimation might be overstated if it has not taken into account substitutions. For example, aluminium, which is more widely available than copper, can replace copper for most energy uses while only requiring about 25 per cent more material to match the same conductivity as copper. Aluminium also weighs half as much and costs much less. See, for example, Auke Hoekstra (2023), "Copper scarcity will not materially slow down the energy transition", Neon Research, Eindhoven, https://neonresearch.nl/copper-scarcity-will-not-materially-slow-down-the-energy-transition/#:~:text=Although%20copper%20demand%20could%20increase,the%20transition%20to%20renewable%20energy, accessed 16 June 2023.

[7] IEA (2021), "The Role of Critical Minerals". www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[8] See, for example, Richard M. Auty (1993), *Sustaining Development in Mineral Economies: The Resource Curse Thesis,* Routledge, London and New York.

[9] UNEP (2019), "Global Resources Outlook 2019: Summary for Policymakers", UNEP, Nairobi, download from www.resourcepanel.org/reports/global-resources-outlook, accessed 17 June 2023.

[10] Éléonore Lèbre and others (2020), "The social and environmental complexities of extracting energy transition metals", *Nature Communications* 11, 48230, https://doi.org/10.1038/s41467-020-18661-9, accessed 17 June 2023.

[11] IEA (2021), "The Role of Critical Minerals".

[12] IEA (2021), "The Role of Critical Minerals".

[13] See, for example: Department of Industry, Science, Energy and Resources (2022), "2022 Critical Minerals Strategy", DISER, Commonwealth of Australia, Canberra, www.industry.gov.au/sites/default/files/2022-09/2022-critical-minerals-strategy_0.pdf, accessed 17 June 2023; IEA (2021).

[14] See, for example, Boston Consulting Group (2022), "Managing Raw-Material Volatility", BCG, Boston, www.bcg.com/publications/2022/managing-raw-material-supply-volatility, accessed 17 June 2023.

[15] See Saleem H. Ali and others (2017), "Mineral supply for sustainable development requires resource governance", Nature, Vol. 543, Issue 7645, pp. 367–372, Nature Publishing Group, London, https://doi.org/10.1038/nature21359, accessed 17 June 2023.

[16] Ibid.

[17] See Alexandra Gilles, Amir Shafaie, Patrick Heller (2021), "G7 Countries Cannot Secure Critical Minerals Without Tackling Governance and Corruption", Natural Resource Governance Institute (NRGI), Washington D.C., https://resourcegovernance.org/blog/g7-countries-cannot-secure-critical-minerals-without-tackling-governance-and-corruption, accessed 17 June 2023.

[18] See, for example, World Bank (2017), "Illicit Financial Flows (IFFs)", World Bank, Washington D.C., www.worldbank.org/en/topic/financialsector/brief/illicit-financial-flows-iffs, accessed 17 June 2023.

[19] See, for example: Angelos Angelopoulos and others (2021), "The distributional consequences of rent-seeking", Economic Inquiry, 59(4), 1616–1640, Western Economic Association International, Fountain Valley, California, https://doi.org/10.1111/ecin.13009, accessed 17 June 2023; Felipe B. Larraín and Oscar P. Perelló (2020), "Can mining countries take advantage of their mining rents? A question of abundance, concentration and institutions",

Oxford Development Studies, 48(2), 148–165, Taylor and Francis, Abingdon on Thames, https://doi.org/10.1080/13600818.2020.1732898, accessed 17 June 2023; Halvor Mehlum, Karl Moene and Ragnar Torvik, (2006), "Institutions and the Resource Curse", The Economic Journal, 116(508), 1–20, Oxford University Press, Oxford, https://doi.org/10.1111/j.1468-0297.2006.01045.x, accessed 17 June 2023.

[20] See Sebastian Sahla (2022), "Why critical minerals governance matters in the transition to 'net zero'", Extractive Industries Transparency Initiative (EITI), Oslo, https://eiti.org/blog-post/why-critical-minerals-governance-matters-transition-net-zero, accessed 17 June 2023.

[21] See David Manley, Patrick R. P. Heller, William Davis (2022), "No Time to Waste: Governing Cobalt Amid the Energy Transition", NRGI, Washington D.C., https://resourcegovernance.org/sites/default/files/documents/no_time_to_waste_governing_cobalt_amid_the_energy_transition.pdf accessed 17 June 2023.

[22] See, for example, ILO (2019), "Ending child labour, forced labour and human trafficking in global supply chains", International Labour Organization, Geneva, https://www.ilo.org/ipec/Informationresources/WCMS_716930/lang--en/index.htm, accessed 17 June 2023.

[23] UNEP (2020) Mineral resource governance in the 21st century gearing extractive industries towards sustainable development. https://www.resourcepanel.org/reports/mineral-resource-governance-21st-century

[24] IEA (2021), "The Role of Critical Minerals". www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[25] Ibid.

[26] See UNEP (2016), "Green Finance for Developing Countries," UNEP, Nairobi, https://wedocs.unep.org/bitstream/handle/20.500.11822/7673/-Green_finance_for_developing_countries_Needs,_concerns_and_innovations-2016Green_Finance_for_Developing_Countries.pdf.pdf?sequence=4&amp%3BisAllowed=y%2C%20Summary%7C%7Chttps%3A//wedocs.unep.org/bitstream/ha, accessed 17 June 2023.

[27] See Jung Wan Lee (2020), "Green Finance and Sustainable Development Goals: The Case of China", *Journal of Asian Finance,* 7(7), 577–586, Korea Distribution Science Association, Seongnam City, https://doi.org/10.13106/jafeb.2020.vol7.no7.577, accessed 17 June 2023.

[28] See, for example, Andrew Boettcher (2022), "What is Green Finance and Why it Matters", University of North Carolina Institute for the Environment, Chapel Hill, NC, https://ie.unc.edu/clean-tech-post/what-is-green-finance-and-why-it-matters/, accessed 17 June 2023.

[29] Lee, W.J. (2020). Green Finance and Sustainable Development Goals: The Case of China. Journal of Asian Finance, vol. 7, No. 7, pp. 577-586. Available at https://doi.org/10.13106/jafeb.2020.vol7.no7.577

[30] See Kai Li, Shaozhou Qi and Xunpeng Shi (2022), "The COVID-19 pandemic and energy transitions: Evidence from low-carbon power generation in China", *Journal of Cleaner Production,* 368, 132994, . https://doi.org/10.1016/J.JCLEPRO.2022.132994, accessed 18 June 2023.

[31] World Bank (2020), "Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition", Climate Smart Mining Initiative/The World Bank Group, Washington D.C., http://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf, accessed 18 June 2023.

[32] See, for example, Richard Mattison and others (2022), "Key trends that will drive the ESG agenda in 2022" S&P Global, New York, www.spglobal.com/esg/insights/featured/special-editorial/key-esg-trends-in-2022, accessed 18 June 2023.

[33] See, for example, OECD (2016), "Corruption in the extractive value chain: Typology of risks, mitigation measures and incentives," OECD, Paris, www.oecd.org/dev/Corruption-in-the-extractive-value-chain.pdf, accessed 18 June 2023.

[34] IEA (2021), "The Role of Critical Minerals". www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[35] Alexandra Gilles and others (2021), "G7 Countries Cannot Secure Critical Minerals".

[36] ILO (2022), "Social dialogue", ILO, Geneva, https://www.ilo.org/ifpdial/areas-of-work/social-dialogue/lang--en/index.htm)%20%20a, accessed 18 June 2023.

[37] See UNDP and others (2017), "Mapping the Oil and Gas Industry To the Sustainable Development Goals: An Atlas", UNDP, New York, www.undp.org/sites/g/files/zskgke326/files/publications/Mapping_OG_to_SDG_Atlas_Executive_Summary_2017.pdf , accessed on 18 June 2023.

[38] See, for example, Minerals Council South Africa (2020), "Women in mining: White paper", MCSA, Johannesburg, www.mineralscouncil.org.za/downloads/send/37-position-papers/1218-white-paper-women-in-mining, accessed 18 June 2023.

[39] See, for example, McKinsey & Company (2021), "Why women are leaving the mining industry and what mining companies can do about it", McKinsey & Company, New York, www.mckinsey.com/industries/metals-and-mining/our-insights/why-women-are-leaving-the-mining-industry-and-what-mining-companies-can-do-about-it, accessed on 18 June 2023.

[40] See, for example, UN Women (2016), "Promoting Women's Participation in the Extractive Industries Sector: Examples of Emerging Good Practices", United Nations Women, New York, https://www.unwomen.org/sites/default/files/Headquarters/Attachments/Sections/Library/Publications/2016/Promoting-Womens-Participation-in-Extractive-Industries.pdf, accessed 18 June 2023.

[41] IEA (2021), "The Role of Critical Minerals". https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[42] David Manley and others (2022), "No Time to Waste".

[43] OECD (2016), "OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas", OECD, Paris, https://www.oecd.org/corporate/mne/mining.htm, accessed 18 June 2013.

[44] Auke Hoekstra (2023), "Copper scarcity".

[45] See www.glencore.com/media-and-insights/news/glencore-and-li-cycle-announce-joint-study-to-develop-a-european-recycling-hub, accessed 18 June 2023.

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