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WORLD ECONOMIC FORUM

Securing Minerals for the Energy Transition: Unlocking the Value Chain through Policy, Investment and Innovation

WHITE PAPER

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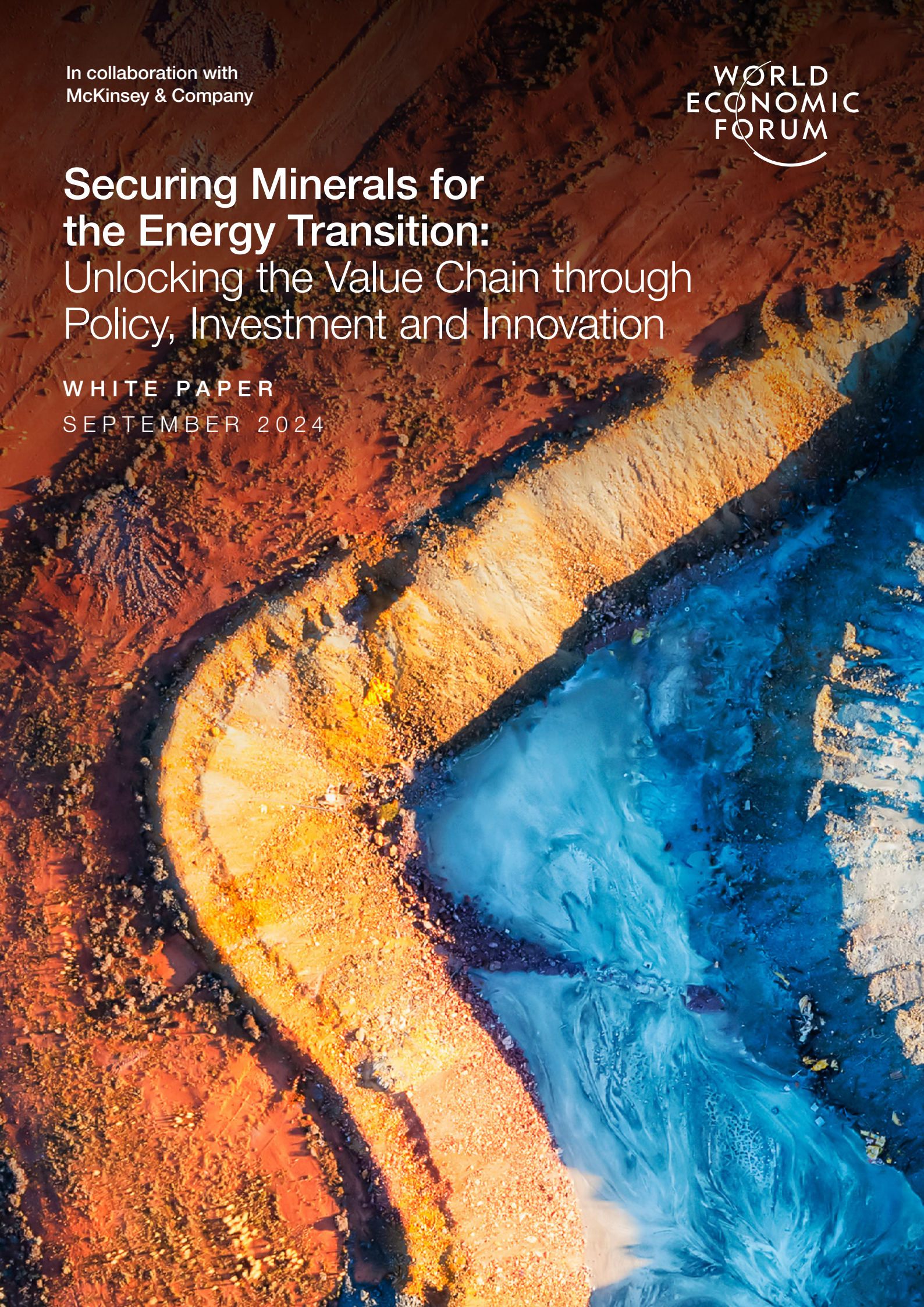

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Foreword

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Securing the critical materials needed to enable the net-zero transition is fundamental to achieving the goals of the Paris Agreement. The balance between the supply and demand of critical materials involves managing supply chain disruptions, long lead times between exploration and production, complex orebodies, surges in commercial needs and the concentration of supply in some geographies. Despite recent progress in boosting the production of certain materials, supply shortages are still anticipated for many of the critical minerals and metals necessary to produce the lower-carbon technologies that are key to the energy transition. This could mitigate nations' ability to decarbonize their economies.

Global leaders have acknowledged the need to secure the critical materials supply chain, as the consequences of inaction have the potential to extend beyond the low-carbon transition and mining ecosystem to encompass geopolitical, economic and environmental considerations. Consequently, several global and local initiatives have been established to provide technical assistance, promote industry standardization and share knowledge through research and analysis.

In 2023, the World Economic Forum's Securing Minerals for the Energy Transition (SMET) initiative was launched with the support of McKinsey & Company to raise awareness and encourage collaboration on innovative and enabling solutions that help close the critical materials supply-demand gap. In a previous paper, SMET discussed the risks of inaction along with collaborative risk management solutions.

This paper explores various approaches for unlocking critical materials supply. It identifies barriers to investment and innovation in critical materials and associated solutions for addressing them. It also highlights the need for global multistakeholder collaboration across the value chain and wider ecosystem to lower barriers and enable solutions.

We extend our appreciation to all SMET members, Forum leaders and experts from McKinsey & Company for their efforts and contributions to this paper. We hope it provides valuable insights and inspires concrete actions that lead to an available, affordable and sustainable critical materials supply and more predictable, balanced demand.

Executive summary

More collaboration and innovation are needed to ensure critical mineral supply meets clean energy demands.

For the energy transition to progress at the pace and scale required, it is crucial that the materials supply chain develops in parallel. Critical minerals and their derived products are necessary for clean energy technologies such as electric vehicles (EVs) and solar panels and therefore are a crucial part of the energy transition. This white paper follows the *Securing Minerals for the Energy Transition* published last year and its aim is to examine the barriers to enabling a just and orderly transition, and the solutions that could be applied to overcome these barriers.

Demand growth for critical minerals continues to increase. Supply has also increased but, despite recent progress, some minerals may still face a significant shortage.[1] Left unchecked, projected supply-demand imbalances of certain minerals could create acute risks ranging from energy transition delays to negative social and environmental consequences.[2] Public-private collaboration is essential to ensuring an available, affordable and sustainable global critical minerals supply-demand balance. Without these minerals, technologies for decarbonizing energy systems cannot be deployed at the scale needed to achieve the international targets outlined in the Paris Agreement.

Policy, investment and innovation can facilitate increases in primary and secondary supply, and promote decreases in demand without compromising equity in access to clean energy technologies and energy system decarbonization. Demand reduction through substitution may close some of the gap and reduce the risk of market imbalance. Current clean energy technology trends and scenarios indicate that, to achieve the Paris Agreement goals, it will be necessary to invest in developing new mines, expanding existing mines and supporting innovative technologies to enhance supply-side production. Targeted policy initiatives have the potential to facilitate these outcomes, help build resilient global supply chains and ensure that local communities benefit.

Barriers to investment and innovation in critical minerals can hinder progress in transitioning to clean energy systems:

- **Financial barriers** include high and uncertain capital expenditures for mining projects, insufficient business cases for scaling innovations and the financial risks of investing in early-stage innovation.
- **Barriers in the enabling environment** include lengthy permitting timelines, policy complexity, perceptions of the mining industry, lack of supporting infrastructure and skilled labour, and insufficient clarity in demand-side signals and prioritized innovation needs.
- **Cross-cutting barriers** include a lack of environmental, social and governance (ESG) standardization, risks related to an evolving external environment, the commercial risks of scaling and deploying innovations and a lack of transparency on minerals supply and demand data.

Solutions to help overcome these barriers (called **unlocks**) depend on aligning stakeholder incentives via targeted policy initiatives and stakeholder collaborations, such as:

- **Direct and indirect financial support** for new mining projects, innovation scale-up and early-stage innovation to improve the financing network.
- **Creating a favourable enabling environment** by streamlining permitting processes, reducing policy complexities (such as regulatory duplication), engaging with communities, provisioning supporting infrastructure, supporting mining education and communicating demand-side signals and innovation priorities.
- **Collaborative action** by a variety of actors to harmonize ESG standards, by countries to encourage trade and cooperation, by public- and private-sector players to reduce the commercial risks of scaling and deploying innovations and by critical minerals stakeholders to improve data transparency.

Potential next steps identified for consideration by critical minerals stakeholders highlight the importance of collaboration across the value chain and the wider network.

To enable investment and innovation, public sector players could engage with industry players and other public entities (for example, state-owned enterprises). International and multilateral organizations, meanwhile, could convene and develop solutions with stakeholders. For established incumbents, forming partnerships across the value chain could help to secure demand, increase supply, boost ESG outcomes and support innovation. Establishing partnerships could likewise allow less-established companies, including cleantech start-ups[3] and small mining companies, to grow and scale. Last but not least, financial actors working with peers and industry players could help to deploy the capital needed to achieve the aims outlined throughout this paper.

Introduction

A successful energy transition requires investment and innovation to unlock the supply chain.

Critical minerals are essential to the energy transition, but there is a risk that supply will fall short of the increasing demand for some minerals. Clean energy technologies rely on minerals, either directly or in processed form. Demand for these minerals may grow by 250% by 2030, according to the International Energy Agency's (IEA's) Net Zero Emissions by 2050 (NZE) scenario.[4] Despite recent progress in mining investments, the supply pipeline for many minerals may not meet this demand. There is also significant volatility in commodity prices (which reduces appetite for large multi-year capital investment programmes).[5]

Market tightness resulting from supply-demand imbalances could jeopardize the pace of the energy transition. Continued imbalance in supply and demand could cause a disorderly transition characterized by price volatility, geopolitical risks and environmental pressures that reduce investment appetite.[6] Concurrently, many of these same factors could make it more difficult to ensure critical minerals are globally available in an affordable and sustainable way.

Actual demand for each critical mineral will depend on the specific clean technologies that drive the energy transition and the unique supply-demand dynamic for each of them. For example, copper is expected to be in a deficit due to strong and rising demand and weak project pipelines while aluminum is expected to remain in balance. Palladium on the other hand, will have excess supply in the future unless new demand areas emerge.

Actions on three fronts, performed in parallel, could help to maintain supply-demand balance. Each entails additional investment and would benefit from innovation and strong support from public and private stakeholders.

- **Increase primary supply** by extracting virgin raw minerals. Industry regulation is paramount to building primary supply in a sustainable way. Companies that explore, mine and process minerals (including via innovative methods) could contribute to increasing primary supply with support from financial actors from the private and public sectors.
- **Increase secondary supply** by recovering minerals from waste and end-of-life products. Companies with mine tailings could explore innovative ways to reprocess them and create new value, while start-ups and government-funded research institutions could contribute to developing, improving and scaling recycling technologies. Consumer participation in technology recycling programmes could also help.
- **Reduce critical minerals demand** by minimizing or substituting the need for critical minerals in end-use applications. Companies manufacturing low-carbon energy technologies could change their products and production processes by making use of innovations developed in the public or private sector. As awareness of critical minerals challenges grows, market demand for technologies that rely less on critical minerals could potentially facilitate this solution.

Investment and innovation

Immediate investment is needed in primary supply to increase its capacity. McKinsey analysis indicates that investments of $300-400 billion in mining, refining and smelting would be needed per year through 2030 to meet growing demand,[7] including through secondary supply sources. However, investment in secondary supply capacity is insufficient to meet short-term demand due to limited availability in end-of-life feedstock for secondary facilities. The feedstock shortage is caused by increased demand and the use of materials in long-life equipment, which leads to extended lead times before these materials reach the end of their life cycle. It is, therefore, important to build a manufacturing network that will support secondary supply – especially for "newer" minerals such as lithium or rare earths – to ensure proper circularity in the medium to long term.

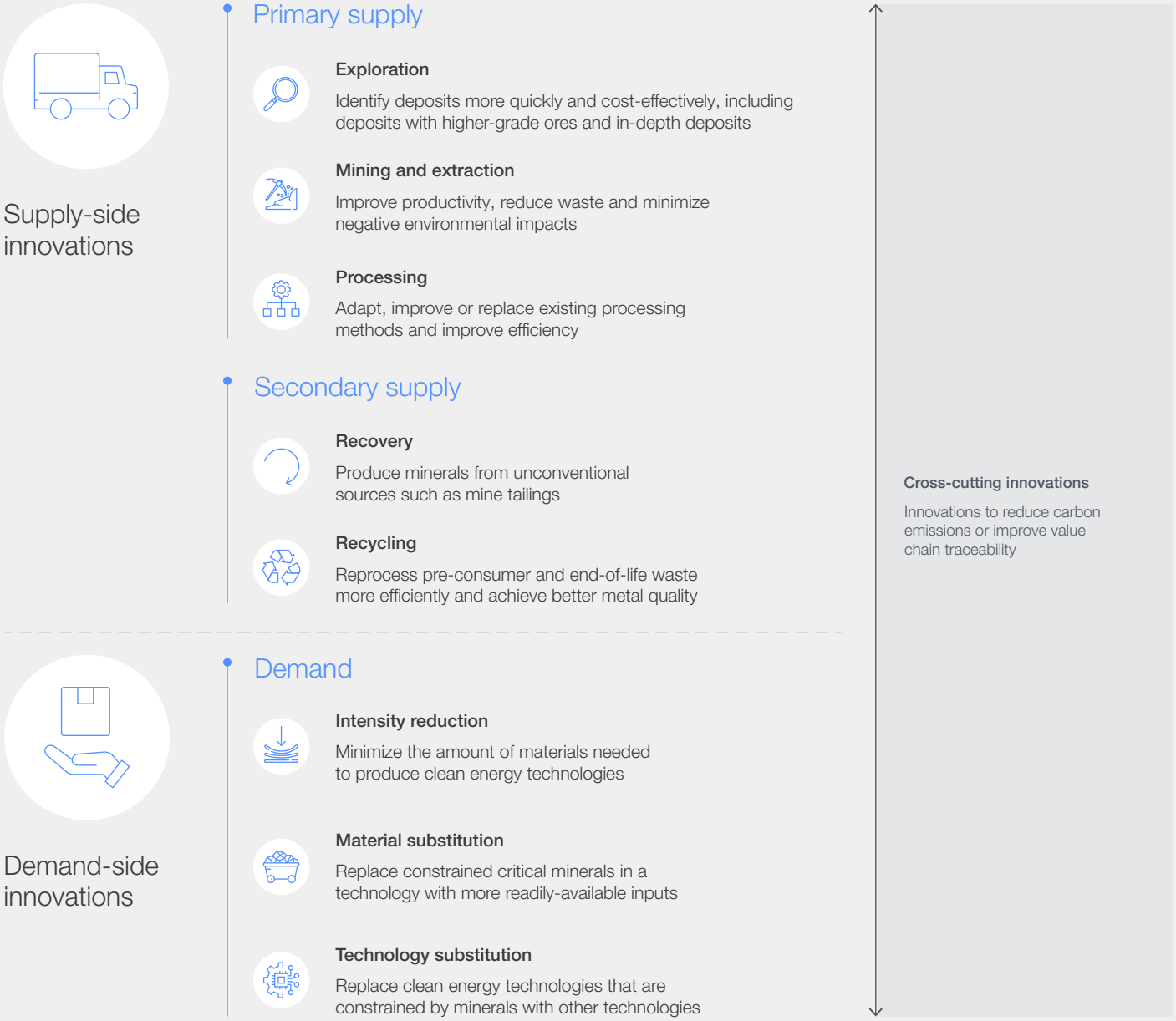
Further support for supply-demand balances depends on innovations that lower barriers to expanding the critical minerals pipeline. Developing new mines presents considerable challenges, including low ore quality and high production costs. While targeted policy initiatives and collaborative approaches could help to overcome some of these challenges, addressing others will likely necessitate innovation. Increased innovation applications require investment across early-stage research and development (R&D) funding to financially support innovation scale-up and deployment.

Necessary innovations include new and more efficient ways to produce and use critical minerals, which could help to make the energy system more secure, equitable and sustainable as it's decarbonized.[8] Throughout the value chain, innovations could contribute to a just transition by improving critical minerals' availability while reducing costs, increasing safety and minimizing environmental pressures (Figure 1).

Barriers and unlocks

While there are barriers to incentivizing industry players and other key stakeholders to invest and innovate, targeted policy initiatives and collaboration could help overcome these obstacles and unlock critical minerals. Barriers are paired with potential unlocks, illustrated with examples of specific policies and collaborative initiatives that have advanced progress to date (Figure 2).

FIGURE 1 **Innovation across the critical minerals value chain**



Note: Examples are not exhaustive.

Source: Derived from SMET insights and McKinsey analysis.

FIGURE 2 | **Barriers and unlocks for critical materials**

Financial barriers and risks	Direct and indirect financial support	Barriers in enabling environment	Creating a favourable environment	Cross-cutting barriers	Collaborative action
High and uncertain capital expenditures, especially for early-stage mining projects	Financial support for new mining projects and measures to reduce capital expenditures	Long permitting timelines for new mine development	Streamlined permitting to facilitate mine development	Lack of ESG standardization and enforcement across jurisdictions	Joint initiatives with public entities, value chain actors and other stakeholders to create harmonized ESG standards across jurisdictions and boost ESG capacity
Insufficient business case for rapidly scaling innovations	Financial support to improve the business case for innovation scale-up	Country-level policy complexity and lack of stability	Policy stability and engagement with the private sector to reduce policy complexity	Risks in the evolving external environment related to trade and the availability of specialized knowledge	International collaboration to address risks in the evolving external environment
Financial risks related to early-stage innovation	Financial support for R&D to de-risk early-stage innovation	Community considerations and perceptions of the mining industry	Information campaigns and inclusive stakeholder engagement procedures	Commercial risks associated with scaling and deploying innovations	Public-private partnerships and initiatives to reduce commercial risks in scaling and deploying innovations
		Lack of supporting infrastructure for minerals extraction	Provisioning supporting infrastructure in areas conducive to extraction	Low availability, transparency and traceability of data to aid understanding of mineral flows across the value chain and support production and innovation scale-up	Stakeholder collaboration to increase data availability, transparency and traceability across the value chain
		Lack of available skilled labour for the mining sector	Supporting mining education to boost available skilled labour		
		Insufficient clarity in demand-side signals to induce production and innovation in production	Communicating clear demand-side signals to induce production and innovation		
		Insufficient clarity on prioritized innovation needs throughout the value chain	Defining innovation priorities, including by establishing accelerator programmes		

Note: Different minerals may face specific challenges or be affected by these challenges in specific ways.

Source: Derived from SMET insights and McKinsey analysis.

BOX 1 | **Overview of the Securing Minerals for the Energy Transition initiative**

Securing Minerals for the Energy Transition (SMET) is a World Economic Forum initiative featuring McKinsey & Company as its knowledge partner.

To enable an orderly and timely energy transition, SMET acts as a global collaboration platform, convening a diverse group of stakeholders to work towards solutions to ensure the availability, affordability and sustainability of critical minerals.

1 Barriers to investment and innovation

Barriers inhibit investment in supply expansion and implementation of new technologies that maintain supply-demand balance.

Securing capital for mine development, as well as supporting the creation and deployment of novel technologies, can be challenging. Barriers to investment and innovation can complicate bringing new supply online. They can hinder improvements in critical minerals production and optimization of critical mineral consumption in end-use applications. These dynamics could exacerbate supply-demand imbalances as the energy transition accelerates.

1.1 Financial barriers and risks

- **High and uncertain capital expenditures, especially for early-stage mining projects**: Mining projects require significant investment before revenue-generating production can begin. Once exploration and initial scoping studies are complete, feasibility studies are conducted to estimate capital expenditure requirements and predict whether extraction is economically viable. During the initial stages of project development, the total amount of capital required is uncertain (though clarity increases between the initial scoping and pre-feasibility and feasibility stages). Most costs are incurred during a project's construction phase, when risks of budget overruns heighten uncertainty. Additionally, high interest rates increase overall project expenses.

- **Insufficient business cases to rapidly scale innovations**: Historically, the mining industry has been slow to adopt new technologies, and proven innovations are not being rolled out at scale with sufficient speed to meet predicted demands. For example, innovations that prompt positive environmental impacts (such as reduced carbon emissions during production and reduced water use through closed-loop processing systems) already exist. Using less water and emitting less carbon are positive environmental impacts that adopting these technologies elicit. Nonetheless, when companies cannot determine how their adoption fits into a business case for technology implementation – perceiving the costs to outweigh the immediate, tangible benefits – they may be discouraged from deploying innovations.

- **Financial risks related to early-stage innovation**: Due to a high risk of failure, R&D investment may not yield sufficient returns and may result in financial losses. Early-stage investments may not produce useful or commercially scalable innovations. There are risks associated with price volatility for both new projects and innovation in current operations. The required depth of knowledge on these risks may deter investors from entering.

- **Extended timeline from early-stage technology development to full commercialization**: Development timelines are often greater than venture capital (VC) investor return horizon expectations, thus limiting the innovation network. Long lead times also invite the risk of disruption to investments in innovation, consequently prompting a wait-and-see approach around innovation investment. Extended timelines necessitate continuous investment and adaptation and can deter stakeholders from investing in developing long-lead transformational innovations. This barrier is not exclusive to the critical minerals sector.

> Historically, the mining industry has been slow to adopt new technologies, and proven innovations are not being rolled out at scale with sufficient speed to meet predicted demands.

1.2 Barriers in the enabling environment

> Without an open dialogue between companies and communities, distrust could cause resistance that halts or hinders investment.

Long permitting timelines associated with mine development: Permitting procedures safeguard the interests of multiple stakeholders and ensure that investment in mine development is secured in a responsible way. The process of obtaining permits contributes to the average gap of 16 years between the discovery of a deposit and a mine's first production.[9] These long lead times can help ensure adequate time for stakeholder consultation and environmental assessments. At the same time, administrative or bureaucratic reasons for permitting delays (such as regulatory agencies' restricted capacity to process paperwork)[10] can unnecessarily impede bringing new mining projects online. Persistent permitting delays during exploration and development increase costs and may reduce the appeal of investment by inviting uncertainty regarding future returns.

Country-level policy complexity: A more complex policy environment can make investment less attractive by increasing the perceived burden associated with compliance and making non-compliance consequences less visible. Complexity could entail regulatory duplication or uncertainty regarding land claims. Significant or abrupt policy changes caused by a lack of long-term planning could also reduce investors' confidence in committing capital within a given jurisdiction.

Community considerations and perceptions of the mining industry: Community concerns about land rights, potential relocations or resettlement of communities and negative environmental or social impacts could cause community members to distrust mining projects and companies. Communities may perceive that mining companies are not adequately supporting strong environmental, social and governance (ESG) outcomes that balance the needs of communities with the mineral requirements of the energy transition. Without an open dialogue between companies and communities (along with clear efforts to address community concerns by adhering to stringent ESG standards), distrust could cause resistance that halts or hinders investment in mine development and critical mineral production. More broadly, unfavourable perceptions of the mining industry – some rooted in prior experiences where ESG expectations were breached – can reduce public appetite for targeted initiatives and funding supporting critical mineral production.

Lack of supporting infrastructure for minerals extraction: Lack of infrastructure can make investment less attractive and hinder exploration and mine-to-market transport. Without public sector provisioning, mining companies may need to undertake infrastructure development, which adds considerably to their production costs. For example, locations without railroads or roads may be difficult to access. Unreliable electricity supplies or freshwater shortages (such as those caused by a lack of desalination plants) may impact returns by restricting production. Even where miners can provide the investment for supporting infrastructure, delays in permitting for supporting infrastructure can reduce the viability of mines. Sustainability considerations may influence the type of infrastructure needed to encourage investment. For example, a mining or processing site with access to renewable energy could attract investment by supporting critical minerals companies' decarbonization objectives.

Lack of available skilled labour in the mining sector: The number of mining graduates is dropping, with labour shortages forecast for countries like Canada and Australia.[11] This could increase costs associated with finding and retaining talent to operate mines. More than 70% of mining leaders surveyed in 2022 indicated that talent shortages are impacting mine performance[12] – this could influence returns on investments in primary supply production. Required skillsets are also changing as approaches to mining evolve. For example, new skills are needed to support the sector's increasing focus on ESG standards.

> Stakeholders may underestimate the growth of clean energy technologies and future demand for critical minerals, leading to underinvestment.

Insufficient clarity in demand-side signals to induce production and innovation in production: During mine development, a lack of clarity on expected long-term demand could create risks by reducing certainty around future revenue, potentially impeding profitability and access to capital. This could motivate decisions to forgo investments in new deposits and processing facilities, thus curtailing future production capacity. Without clear indications of how countries' climate commitments will be reflected in their policies and translated into action in the near and long term, stakeholders may underestimate the growth of clean energy technologies and future demand for critical minerals, leading to underinvestment.

Price volatility influenced by shifting demand signals reducing investors' willingness to deploy capital: This price dynamic can also be caused by demand-side technology risks. For example, increased deployment of sodium-ion batteries in the market may decrease demand for lithium used in equivalent end-use technologies (lithium-ion batteries). This could reduce profitability and return on investment for lithium miners, even if policies send clear signals about demand for the electric vehicles (EVs) that depend on these batteries. Similar substitution may happen within commodity markets as well – for example, primary versus secondary metal.

Uncertainties in demand reducing the sense of urgency for innovation: A lack of certainty around demand can influence perceptions of projected supply-demand imbalances. Stakeholders who underestimate demand for primary and secondary supply may assume that returns on investment in supply-side innovations could be comparatively low. This can limit incentives to invest in R&D and innovation scale-up.

Insufficient clarity on prioritized innovation needs throughout the value chain: Innovations can be deployed across the value chain, but because some companies may not know where innovation is most needed, they may lack clarity on their priorities for investment in innovation. This could prevent innovators from allocating resources efficiently and making decisions about which innovations to scale. Furthermore, because mining is a deeply technical area, investors may not feel confident assessing an innovation's potential.[13]

1.3 Cross-cutting barriers

Lack of ESG standardization and enforcement across jurisdictions: ESG standards outline expectations regarding benefit creation for local communities and the implementation of measures to protect the environment. Differing ESG standards and the lack of transparent comparison between standards can reduce trust across the value chain, increase the burden of due diligence for responsible investors and lead to suboptimal community and environmental outcomes in jurisdictions where standards are insufficiently stringent. Consequently, investors may hesitate to put money into high-risk jurisdictions, regardless of safeguards implemented by individual projects. Furthermore, without well-enforced ESG standards, less-responsible companies may undercut more sustainable producers in a race to the bottom, creating undesirable social and environmental outcomes and negatively impacting perceptions of the mining industry.

Risks in the evolving external environment related to trade and the availability of specialized knowledge: Regional concentration of extraction and processing amplifies external risks that could disrupt the value chain with cascading effects. The International Monetary Fund (IMF) has found that disruption in critical minerals trade could hinder the energy transition, decreasing investment in renewable energy and EVs by up to 30% by 2030 compared to an unfragmented market.[14] Risks in the evolving external environment can influence trade policies. Export restrictions on critical raw materials (such as export taxes) saw a fivefold increase from 2009 to 2020.[15] Though often intended to support opportunities for investment in localized downstream value chains, such restrictions potentially impact upstream mine profitability and minerals trade. Constraints in knowledge sharing can also affect the investment environment, potentially hampering investments that would support the development of global capabilities related to downstream processing. More broadly, a global environment of volatility and uncertainty can disincentivize long-term investment.

Commercial risks associated with scaling and deploying innovations: Companies may hesitate to deploy innovations that have not yet been proven at scale, deterred by risks such as unexpected expenses during implementation, disruptions to production processes leading to revenue loss and failure of the innovation to deliver anticipated impacts. Established industry incumbents may likewise hesitate to partner with early-stage start-ups offering innovative technology to avoid the potential costly failures of unproven approaches.

Low availability, transparency and traceability of critical minerals data: Transparent, traceable and granular data is needed to aid understanding of mineral flows across the value chain and support production and innovation scale-up. A globally authoritative source for data on critical minerals supply and demand does not exist, which makes it difficult to assess the market and make investment decisions for responsibly mined materials. Granular data on critical minerals is not publicly available, and global figures do not always reflect reality. Notably, a lack of traceable sustainability data can make it difficult for capital to support production that minimizes negative environmental impacts and maximizes positive social outcomes. An opaque data environment can also make it more challenging to assess the revenue potential of innovative supply-side technologies and identify potential customers (which is necessary information when building a business case for innovation scale-up).

> Without well-enforced ESG standards, less-responsible companies may undercut more sustainable producers in a race to the bottom, creating undesirable social and environmental outcomes.

2 Unlocks for the supply-demand imbalance

Supportive policy and stakeholder collaboration can overcome barriers to channelling investment and implementing innovations.

Targeted policy initiatives and stakeholder cooperation between public- and private-sector actors could unlock investment and innovation by de-risking private investment and creating incentives. While each barrier is mapped to a solution in this chapter, the benefits of implementing one solution may spill over to help lower other barriers as well. As such, allocating efforts efficiently across solutions can maximize their impact. A network to support investors, innovators and early-stage ventures is needed as a potential solution. For systemic change to occur, all players need to act to move the needle. Etsablishing a network could help facilitate a clear understanding of the mix of investment ideas, people, organizations and markets.

2.1 Direct and indirect financial support

Financial support for mining projects and measures to reduce capital expenditure requirements: Financial support entails providing capital directly to stakeholders and crowding in additional capital by de-risking investment. Low-cost loans or direct equity can improve an upstream company's financial standing and make it more attractive to investors. For example, the US Department of Energy's Loan Program Office supports mining and extraction projects,[16] the International Finance Corporation (IFC) has given loans to multiple mining projects[17] and the UK's Infrastructure Bank has invested in a domestic lithium mine.[18] The European Union (EU) implemented the Critical Raw Materials Act (CRMA), under which strategic projects will be selected to expedite the mobilization of investment in the region, for example through the European Investment Bank. Public actors taking a stake in mining projects could provide a sense of security, making projects more attractive to private investors by bolstering their confidence.

Other measures are aimed at reducing capital expenditure requirements: Canada offers a tax credit for 30% of mine exploration costs,[19] while Sweden's credit guarantee for banks issuing loans associated with long-term offtake contracts aims to reduce risk and consequently unlock more favourable interest rates.[20] The US's plan to improve and publicize maps to support exploration is intended to reduce exploration costs,[21] and the Australian Northern Territory provides both free geoscience data and grants funding that supports exploration.[22] The EU Global Gateway, meanwhile, mobilizes investment for projects that include critical minerals. When applied in emerging markets, these measures could support the development of infrastructure needed for mining activities or facilitate the discovery of new deposits where geological potential is uncertain.

Financial support to improve the business case for innovation scale-up: Public sector measures could help reduce the financial risks associated with scaling up innovations. For example, the US has earmarked $800 million in tax credits for projects that undertake critical materials recycling, processing and refining.[23] The UK's A2D (accelerate-to-demonstrate) Facility provides £65.5 million in grant funding for pilot demonstrations of innovative clean energy technologies and business models in developing countries.[24] Although not targeted at critical minerals, Germany has launched a subsidy scheme to compensate companies for low-carbon production costs when using methods that are not yet cost-competitive.[25]

Financial support for R&D to de-risk early-stage innovation: Establishing innovation-friendly policies and maintaining a stable regulatory environment is essential for encouraging ongoing private investment, given the inherent risks and extended timelines associated with new technologies. Support for R&D could help develop breakthrough innovations in both the public and private sector. For example, Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), a government agency responsible for scientific research, has developed technology for reliable high-throughput ore sensing and sorting that can help improve production efficiency.[26] The US has invested $167 million in the construction of an Energy and Minerals Research Facility where public sector scientists and academics can conduct research together.[27] The UK's Circular Critical Minerals Supply Chains (CLIMATES) fund supports rare earths circularity and aims to unlock additional private capital, including by financing R&D.[28] Government support mechanisms remain critical in helping to lower the barriers associated with early-stage innovation (including unpredictable timelines for development and commercialization).

> Government support mechanisms remain critical to help lower the barriers associated with early-stage innovation.

2.2 Improvements to the enabling environment

Streamlined permitting to facilitate mine development: Eliminating unnecessary administrative delays and complexity in permitting processes across levels of government could help expedite mine development without compromising the ESG expectations that permitting is intended to uphold. Improvements could entail publishing timelines for governments to evaluate and respond to paperwork, clearly defining the roles of relevant agencies to help stakeholders navigate the process of obtaining approvals and improving coordination across government agencies.

Harmonizing requirements could also help reduce compliance costs while clarifying and shortening the timeline between development and revenue generation. This could, in turn, help to make mines more appealing to investors. For example, Canada's Critical Mineral Strategy aims to align federal and sub-federal approaches to permitting[29] and the EU's Critical Raw Minerals Act has set a timeframe of 24 months for extraction permits to facilitate timely mine development.[30]

Engagement with the private sector to reduce policy complexity: Governments could help stakeholders take a long-term view of the sector, thus reducing investment risk to enable efficient allocation of capital. Negative experiences in a particular country can leave lasting impressions on investors and mining players and discourage future investment. Such considerations highlight the importance of clear public-private sector communications – for example, regarding land tenure rights – and taking industry feedback on policy complexity into account. For instance, clear zoning laws could boost investor confidence by preventing competition between mine development and other land uses, and community resettlement or relocation caused by extraction projects.

Information campaigns and inclusive stakeholder engagement: Public- and private-sector-led campaigns could raise awareness of the mining sector's contributions to economic development, decarbonization and an equitable energy transition as well as highlight mutual benefits. At the project level, mining companies can meaningfully engage with community members to hear and proactively address their concerns by adhering to stringent ESG standards. For example, this could be achieved by supporting positive employment outcomes and safeguarding the environment. Additionally, clear zoning laws could help ensure land rights are respected. More broadly, equitably distributing dividends among stakeholders is

> In the absence of public sector provision, stakeholders can also explore opportunities for shared-use infrastructure development that distributes costs among participants.

crucial. This could entail, among other efforts, supporting the development of value-additive downstream activities to increase employment opportunities in resource-rich countries.

Provision of supporting infrastructure in areas conducive to extraction: Supporting infrastructure could lower mine development costs and the cost (and duration) of mine-to-market transport (especially in remote areas), while also boosting local communities' socioeconomic development. Public sector support could encourage the construction of new infrastructure, as in Canada, which allocated CAD 1.5 billion (Canadian dollars) for infrastructure development as part of the Canadian Critical Minerals Strategy.[31] Public entities could also establish partnerships for infrastructure development, such as China's commitment to the Democratic Republic of the Congo (DRC) to invest $7 billion in DRC infrastructure as part of the Sicomines joint venture,[32] or Angola's agreement with a consortium of actors to manage and invest in the Lobito railway.[33] In the absence of public sector provision, stakeholders can also explore opportunities for shared-use infrastructure development that distributes costs among participants.[34]

Support for mining education to boost the availability of skilled labour: Ensuring the availability of necessary skills could support mine development and reduce costs associated with sourcing talent. For example, the US Mining Schools Act would establish a grant programme for mining schools to support recruitment and education.[35] Albania's Regional Innovation Centre is aimed at building skills and promoting science, technology, engineering and mathematics (STEM) education in partnership with the EU's European Institute of Innovation & Technology (EIT) RawMaterials, which grants access to education to students from developing countries with high levels of mining activities.[36] Universities can work closely with the private sector to better understand skill gaps and develop programmes to fill them, while companies can invest in their employees by providing training. Digitization-related curricula (comprised of a mix of technical skills) could be implemented at universities. These skills could include mining and artificial intelligence (AI), internet of things (IoT) skills, automation and others. Intensifying focus on ESG standards – incorporating sustainable mining practices while balancing community and energy transition needs – could help raise the sector's profile among potential employees and bolster mining companies' efforts to recruit new mining talent. Re-skilling workers in the fossil fuel industry may also present an opportunity for companies in the critical minerals value chain to support a just energy transition by creating direct pathways to jobs in adjacent industries. Additionally, companies could participate in schools' "career days" to raise awareness about critical minerals career paths among young people.

Clear demand-side signals to induce production and innovation: More consistent demand-side signals could help boost investor confidence by mitigating volatility and giving a better sense of future revenue potential. Legislated objectives – such as the roadmap to ensuring zero-emission vehicles (ZEVs) comprise 100% of new car sales in California by 2035,[37] or funding for clean energy technologies such as the tax credits for EVs included in the US Inflation Reduction Act (IRA) – could inform such signals.[38] Governments could also help to stimulate demand by prioritizing clean energy technologies in their procurement policies (as seen in the US' goal to make most federal vehicle acquisitions ZEVs by 2035[39]), or by participating in offtake agreements directly. Similarly, policies such as the EU's regulation on batteries (which defines minimum levels of recycled content)[40] could create demand for secondary supply and related innovations in recycling. Explicit support for critical-metals-efficient technologies, such as fuel cell vehicles and hydrogen infrastructure, could further boost production of certain minerals, including PGMs.

Demand-focused policy could help signal the need for increased production as well as for innovations that strengthen production efficiencies to amplify availability. However, not all technology risks can be mitigated, as governments alone are unlikely to determine which technologies will prevail in the market or the associated demand implications for specific minerals.

Individual actors seeking additional certainty could create partnerships across the value chain to lock in demand needed for growth (for example, via volume-based offtake agreements between battery manufacturers and mining companies for specific minerals).

Definition of innovation priorities, including through the establishment of accelerator programmes: Public entities could express innovation priorities via targeted initiatives that allocate funding. Governments could implement innovation support schemes with a defined focus (similar to the EU's Innovation Fund),[41] or establish accelerator programmes to select and support high-value innovations from early stages and proof of concept to scale up. For example, Canada's Mining Innovation Commercialization Accelerator Network (MICA) aims to commercialize high-impact mining technologies related to four defined technical themes.[42] Accelerator programmes could also educate investors about available opportunities and help start-ups navigate the fundraising process. Private sector companies may also choose to define their own internal innovation priorities, based on their knowledge of bottlenecks and desired improvements within their businesses. Criticality assessments can be a first step to determining which innovation priorities to pursue.

2.3 Stakeholder collaboration

> Demonstration of new technologies can help increase the private sector's confidence in implementing innovations.

Joint initiatives with governments, value chain actors and other stakeholders could create harmonized ESG standards across jurisdictions and boost ESG priorities: Stronger ESG standards legitimized in law could help make mining more sustainable for local communities. They could also help increase access to green finance opportunities[43] and raise capital flows by reducing the risk of reputational damage for investors (especially in jurisdictions with poor ESG track records). Initiatives aimed at defining and committing to standards include the International Council on Mining and Metals (ICMM) members' pledges for nature-positive mining,[44] the Global Tailings Review's Global Industry Standard on Tailings Management,[45] and the investor-led Global Investor Commission on Mining 2030, which is working to define a vision for a responsible mining sector.[46] Other organizations such as the United Nations Resource Management System (UNRMS) are aimed at providing a common ESG standard. Stakeholder collaboration is also crucial for upholding ESG standards. Such collaboration could include capacity-building support for countries that may struggle to implement and enforce standards.

International collaboration to address risks in the evolving external environment: Diversification of the value chain of critical minerals could benefit the security of supply. Additionally, cooperation to increase technology transfer could be encouraged. International efforts to share knowledge and expertise could help kickstart value-additive local processing in areas where extraction takes place (for cobalt in the Democratic Republic of the Congo or nickel in Indonesia, for instance).[47] Trade policies could also have a positive impact on the value chain. Bilateral agreements and initiatives such as the Minerals Security Partnership (MSP), which focuses on collaboration between US allies to secure minerals,[48] are helpful, but an inclusive global focus may be needed to create truly diversified supply chains and an international environment conducive to long-term investment.

Public-private partnerships and initiatives to reduce commercial risks in scaling and deploying innovations: Demonstration of new technologies can help increase the private sector's confidence in implementing innovations. By further integrating advanced technologies from fields such as AI, robotics and renewable energy, the mining sector stands to achieve significant improvements in efficiency, safety and sustainability. Creating collaborative platforms and innovation consortia can help to promote integration, encourage knowledge sharing and accelerate the adoption of cutting-edge technologies in mining. Public sector support could involve launching industrial clusters such as the net-zero industrial park associated with the Indo-Pacific Net-zero Battery-materials Consortium (INBC).[49] Industry-academia partnerships could be further enhanced to accelerate the advancement of technology-readiness levels.

Stakeholder collaboration to increase data availability, transparency and traceability across the value chain: Reliable data supports information-oriented decision-making. A comprehensive data-sharing initiative for critical minerals could be comparable to the Joint Organizations Data Initiative on Oil and Gas (JODI) for fossil fuels. Such an initiative could combine information from national and regional databases in a harmonized way and allow data sharing, enabling all stakeholders to increase efficacy. Shared information could include geological data, production and demand data, trade data and data on inventories. The UK's Critical Minerals Intelligence Centre, which provides current data and analysis of market dynamics, is one example of such a database operating at a national level.

Next steps

Stakeholder collaboration is crucial for delivering a just and orderly energy transition. Working cooperatively can help to increase investment in the supply of critical minerals. Additionally, collaboration can prompt innovations that support the availability, affordability and sustainability of critical minerals and their derived products.

In its unique role as a global collaboration platform for critical minerals, SMET works to support these actions by bringing stakeholders together. SMET has identified high-impact strategic actions that could engage actors across the value chain and the wider networks. Stakeholders may consider undertaking such actions to help advance the critical minerals agenda.

High-impact strategic actions

Public entities and regulating bodies could:

- Engage with stakeholders across the value chain to understand their needs and behaviour, identify roadblocks to investment and innovation that could be addressed and tailor incentives to improve their efficacy.
- Collaborate with other public entities to improve resilience and information sharing (and potentially address trade barriers that may be contributing to supply chain bottlenecks), exchange best practices with other countries' bodies and prioritize consistency in policy and requirements. SMET and the United Nations (UN) Secretary-General's Panel on Critical Energy Transition Minerals are examples of such initiatives.
- Identify processes such as permitting that could be performed more quickly or efficiently to support industry and value chain development.

International and multilateral organizations could:

- Collaborate with peers and public sector actors to facilitate knowledge creation, for example, by collecting data on investment in critical minerals or identifying gaps in skills needed for mining sector jobs – e.g. the annual *International Energy Agency World Energy Investment Report* and the *International Renewable Energy Agency IRENA Renewable Energy and Jobs review*.
- Promote cooperation among countries and companies to share information and realize solutions, for example, by creating a comprehensive measure of performance and incentives for best practices in social and environmental responsibility at mine sites globally (e.g. the Initiative for Responsible Mining Assurance).

Large industry players and established incumbents could:

- Raise the bar on ESG. For upstream producers, engaging with local communities could boost positive social and economic impacts. For downstream manufacturers, working with suppliers could build capacity and improve traceability across the value chain.
- Create strategic partnerships up and down the value chain and beyond. This could include securing offtake agreements with downstream customers to lock in demand, collaborating with universities on R&D efforts for innovation, or acquiring stakes in innovative companies or companies in other parts of the value chain –for example, through corporate VC arms or mergers and acquisitions.
- Explore joint opportunities to de-risk deployment of upstream capital, such as joint investment in early-stage mine development, joint acquisition of mining companies or reservoirs, or joint supply agreements with advance payment (such as offtakes or streaming agreements).[50] Simultaneously, make use of support from the public sector where available (e.g. through Junior Exploration Assistance, which provides tax credits to junior mining companies whoare engaged in exploration).
- Connect with innovative peers to identify innovations and showcase their solutions to facilitate their successful deployment. Companies already implementing critical minerals innovations may wish to be recognized for their efforts (Box 2).

BOX 2 Critical minerals in the Global Lighthouse Network

The Global Lighthouse Network (GLN) is the leading industry movement that celebrates the world's top-performing production systems. Network members showcase proven impact and operational excellence through applications of technology, workforce and sustainability solutions. The GLN rewards measurable success, builds communities and inspires organizations to achieve new levels of productivity across the operations value chain. This year, the GLN is collaborating with SMET to highlight sites with innovative solutions to improve the sustainability, affordability and availability of critical minerals in support of the energy transition. For more information and to apply to become a Lighthouse, please refer to the "Become a Lighthouse" section of the GLN website.

Start-ups, less-established innovators and mining juniors could:

- Develop partnerships to support scaling and increase visibility. This could entail attending industry events to meet stakeholders, securing offtake agreements with downstream customers to increase certainty of demand and communicating with investors to secure funding.
- Use incubator and accelerator programmes, including those established by the public sector, to connect with peers and obtain expert support on how to scale. For example, this could be done by establishing the right organizational structure and deploying capital effectively. Align these programmes to the needs of the industry to secure testing and pilot activities for future deployment.

Financial actors could:

- Collaborate with peers and industry players to channel more capital into the mining sector by developing financial instruments that mitigate risk. Public financial actors such as multilateral development banks could engage with stakeholders to understand and address pain points for private sector investment in critical minerals.
- Work with early-stage companies at industry events to better understand their financing needs. This is especially relevant for financial actors that have historically had more limited exposure to critical minerals, such as VC and private equity firms.
- Raise the bar on ESG by communicating expectations to industry players and strengthening due diligence efforts, especially when investing in physical assets. This could be through initiatives that are driven by investor groups (e.g. the Climate Action 100+, which focuses on greenhouse gas emissions).

BOX 3 UpLink and Prospect Innovation – sustainable mining challenges

UpLink, the open innovation platform of the World Economic Forum, in partnership with Prospect Innovation, is working on a series of innovation challenges related to "sustainable mining".[51] These challenges aim to identify and scale start-ups capable of sustainably disrupting and transforming the mining and metals industry. A key aspect of these innovation challenges is building an integrated innovation ecosystem comprised of private companies, investors, venture capitalists, academia, civil society and others, that will support and engage with these start-ups to scale up. It is hoped this effort will help to bridge the current gap.

Contributors

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Endnotes

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