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WORLD ECONOMIC FORUM

Securing Minerals for the Energy Transition

WHITE PAPER

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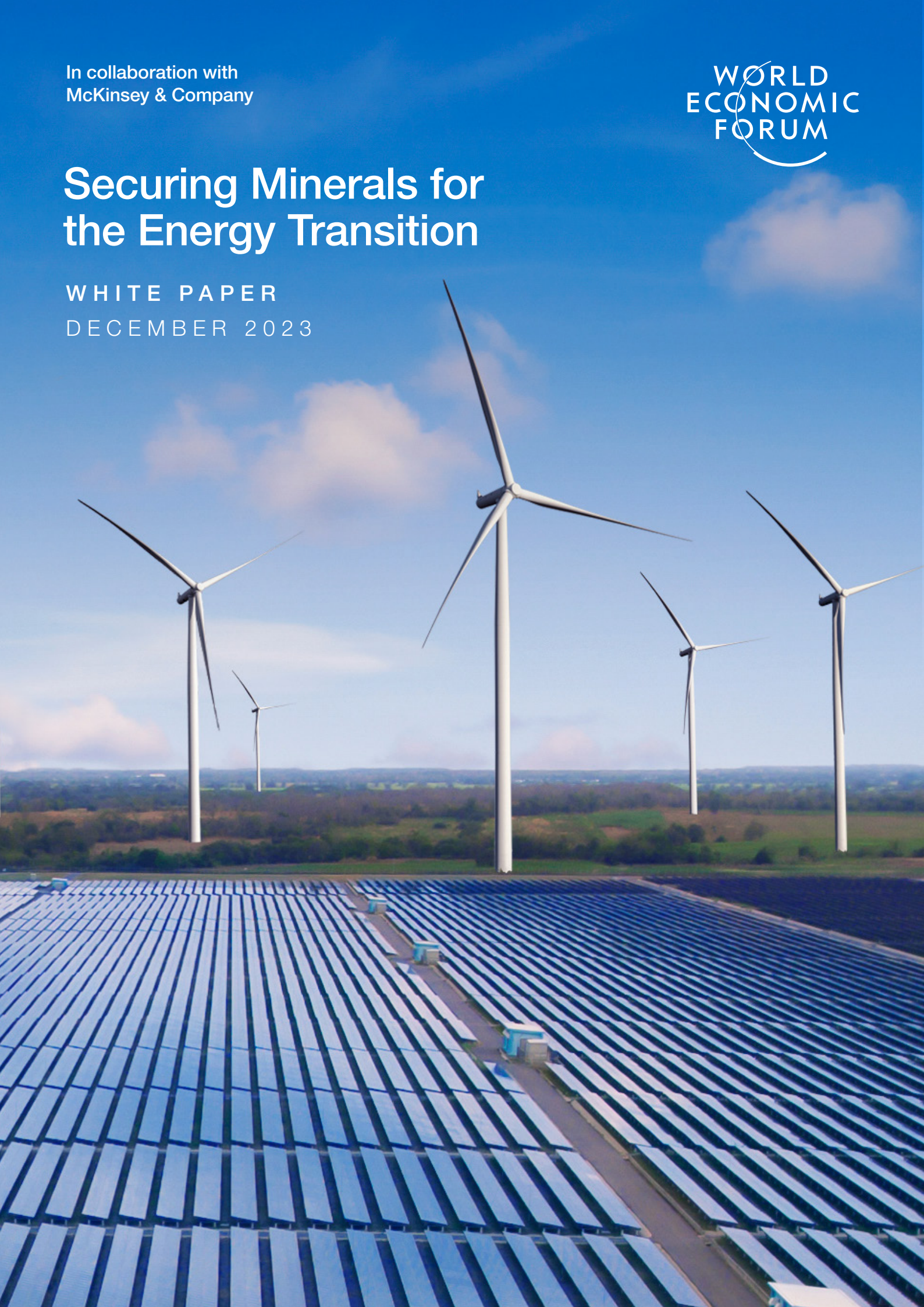

Images: Getty Images

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Executive summary

The world is on an ambitious path to decarbonize and achieve net-zero emissions. However, critical minerals essential for key emissions-reduction technologies may be in short supply by 2030.

Historical underinvestment in mining and exploration, as well as supply chain disruptions, are already creating demand-supply gaps. So are lengthy lead times between exploration and production, on top of the fact that often these minerals have complex orebodies, making them difficult and costly to extract. If current trends hold, many minerals' supply may fall short of demand by 2030, potentially jeopardizing short-term climate goals and driving further price volatility.

It is crucial to identify and understand key supply-chain risks to manage the minerals-related obstacles for the energy transition. Two types of risks are associated with the supply-demand gap of critical minerals: (i) risks associated with the *inability* to close the supply-demand gap and (ii) risks associated with the *efforts* to close the supply-demand gap. Both could significantly delay the energy transition. These risks threaten to disrupt the supply chain beyond the mining and metals industry, delay the energy transition, and have deleterious social and environmental outcomes.

This report identifies 10 high-priority risk management strategies for these key minerals. These strategies are designed to: reduce resource intensity; mobilize investment; leverage alternative financing; increase data transparency; address price uncertainty; increase value-add for local communities; encourage dialogue on policy design; accelerate innovation; address lack of consistency among mining-related environmental, social and governance (ESG) standards; and streamline mining projects' approval. They are essential for creating a more resilient and sustainable mining industry that can meet the growing demand for critical minerals in a responsible and equitable manner.

Effective risk management requires stakeholders to collectively reduce and adapt to supply-chain risks. Global collaboration can raise awareness and drive action to tackle the disparity in the supply and demand of critical minerals. On the contrary, isolated efforts by governments, the private sector and non-profit organizations are unlikely to address the energy transition challenge. Collaboration is necessary to unify efforts, mitigate regional imbalances and ensure sufficient and equitable supply of critical minerals.

The key themes for global collaboration include facilitating policy dialogue, supporting investment mobilization, accelerating innovation, evaluating gaps in existing ESG standards, and building capabilities across the value chain. This report dives into the critical role of three priority collaborative actions – facilitating policy dialogue, supporting investment mobilization and accelerating innovation.

Introduction

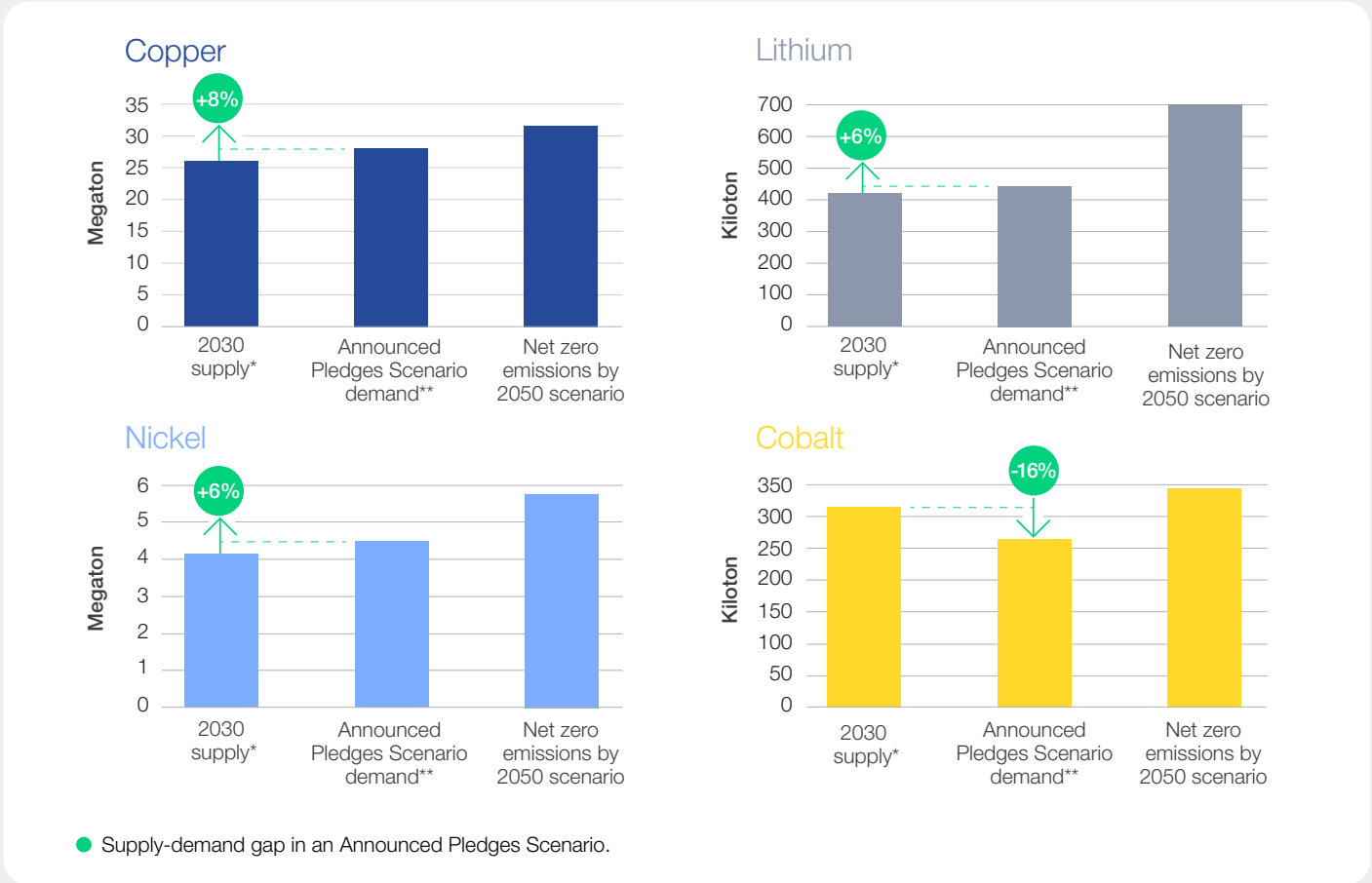
As climate ambition rises globally and the energy transition accelerates, the supply of critical minerals is expected to fall short of demand by 2030.

The world has embarked on an ambitious decarbonization journey towards net-zero emissions targets. This transition will require fundamental technology shifts across industries at an unprecedented speed. Each of the key low-carbon abatement technologies and energy solutions relies on minerals and metals, and the consumption of these raw materials is set to witness a significant increase over the next decade.

According to the International Energy Agency (IEA)'s Announced Pledges Scenario, demand for critical minerals for clean energy technologies will grow more than two-fold by 2030. Cleaner energy infrastructure, such as wind power and battery electric vehicles (BEVs) that use more critical mineral components than the legacy energy infrastructure, will depend on the supply of critical minerals.

Under current projections, the supply of critical commodities is expected to be insufficient to meet the rising demand. The consumption of minerals and metals comes in a historical context of underinvestment in mineral exploration and mining. In the last 10 years, the ratio of global capital expenditure to revenue decreased to less than 10% compared to 15% in the previous decade.[1] Moreover, the mining supply chain faced increasing challenges, such as complex orebodies, decreasing grades as well as disruptions. These challenges, as well as long lead times between exploration and mineral production that cannot easily be compressed, make it difficult to speed up development. Without further action, the supply of commodities such as copper, nickel, lithium, cobalt and rare earth elements (REEs) may not be sufficient to meet the 2030 demand (Figure 1).[2]

FIGURE 1 **Anticipated supply-demand gap under the IEA's Announced Pledges Scenario**



Note: * Expected supply by 2030 at current pace of production; ** Expected demand in 2030 under Announced Pledges Scenario.
Source: IEA, Critical Minerals Market Review 2023.

Shortages would lead to significant price spikes and volatility across minerals, which in turn would make the key technologies more expensive.

In the coming decades, it will be crucial to secure a reliable supply of energy-transition minerals to support the three dimensions of the energy triangle:

- **Security**: A reliable, uninterrupted and evolving energy system that can withstand and respond to supply-demand dynamics and recover rapidly from disruptions.
- **Equity**: An energy system in which energy is fairly distributed, accessible and affordable; a system in which sustainability initiatives (and benefits) are shared to enable inclusive, equitable economic growth and improved standards of living.
- **Sustainability**: An energy system that is consumption-conscious and decarbonized, supporting the ambition of a cleaner and less polluted earth for current and future generations.

The World Economic Forum's Securing Minerals for the Energy Transition (SMET) initiative has been working on identifying the risks that will emerge if critical minerals' supply lags demand, and formulating priority risk management strategies (Box 1). The initiative has also been focused on building collaboration and connections between relevant stakeholders to swiftly mobilize action and raise awareness to address the supply-demand imbalance.

BOX 1

Objectives of the SMET initiative

The Securing Minerals for the Energy Transition (SMET) initiative has two objectives:

1. Identify and characterize strategies for the collective management of risks from the supply-demand gap in critical minerals needed in the energy transition.
2. Convene global stakeholders in a common effort to support a secure, equitable and sustainable supply of minerals essential for the energy transition.

SMET is an initiative of the World Economic Forum in partnership with McKinsey & Company as the knowledge partner, and a diverse group of international and private sector organizations.

1 Risk characterization

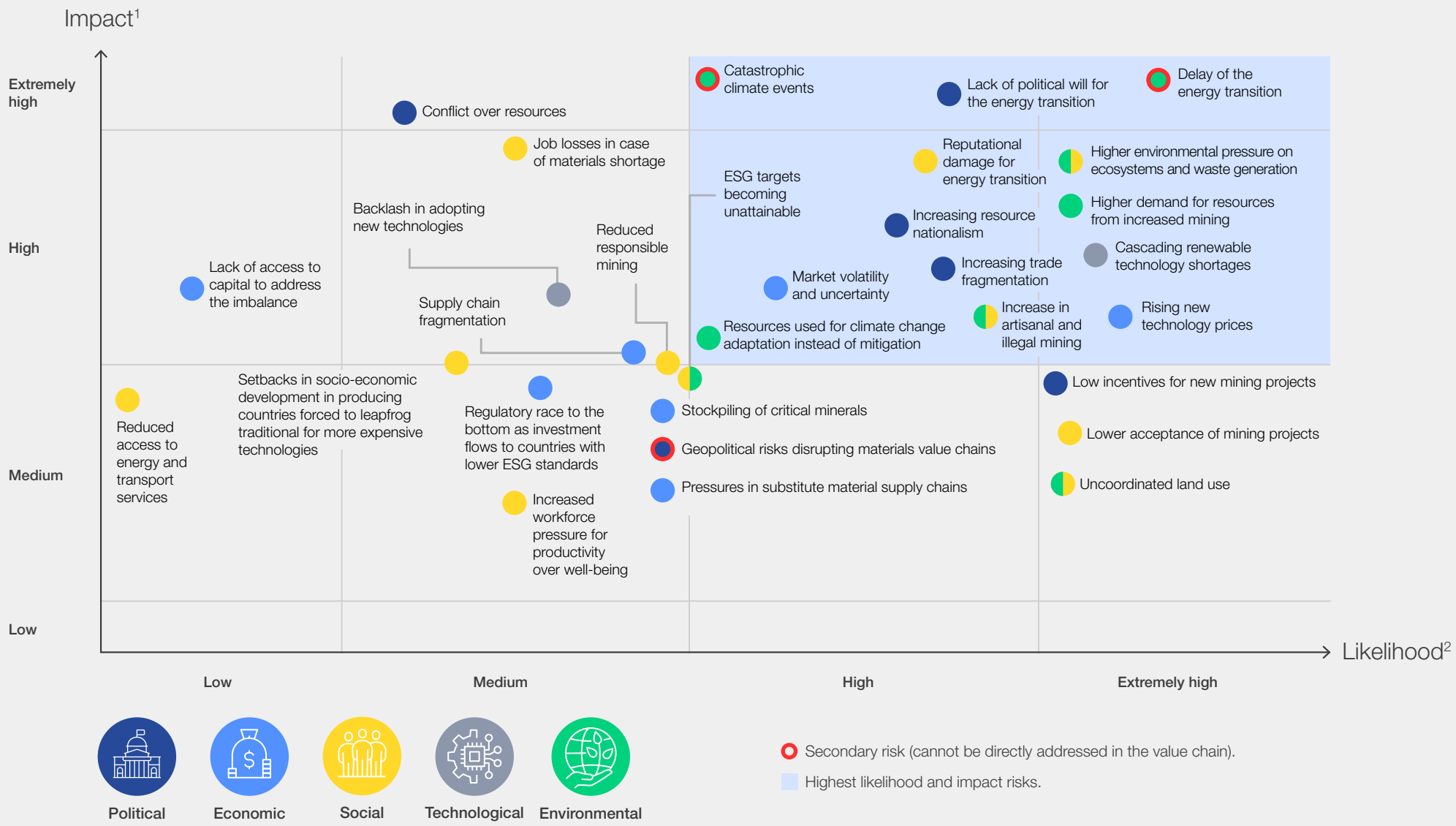
Identifying and understanding key risks across multiple dimensions is crucial to manage potential obstacles for the energy transition.

Two types of risks are evident: (i) risks associated with the *inability* to close the supply-demand gap, and (ii) risks associated with *efforts* to close the supply-demand gap, both of which threaten to significantly delay the energy transition. The SMET initiative has explored ecosystem risks, namely, risks not only to the primary stakeholders in the value chain (such as raw mineral suppliers, technology producers, original equipment manufacturers (OEMs) and intermediaries) but also secondary stakeholders (including consumers, governments and the wider society and the environment).

The SMET initiative has identified and prioritized these risks through workshops with a diverse group of stakeholders, including international organizations and private sector companies from across the value chain. The participants assessed the risks based on their potential impact on the ecosystem and the likelihood of their occurrence. Although several risks could affect the ecosystem, only the most relevant ones were considered for the priority list.

These priority risks span five categories, chosen in line with the PESTEL framework,[3] considering political, economic, social, technological and environmental risk dimensions. For likelihood to happen, “low” represented a risk that is not likely to happen and “extremely high” a risk that is very likely to occur. For impact on the ecosystem, “low” represented a minor impact and “extremely high” represented a catastrophic impact on human lives or society. The risks are likely to differ across geographies and time. The main risks identified and scored are summarized in Figure 2, across the likelihood-impact matrix.

FIGURE 2 | **Ecosystem risks from the supply demand imbalance of critical materials**



Note: 1. Impact on the ecosystem: "Low" represents minor impact and "Extremely high" represents catastrophic impact on human lives, societies and the planet.
2. Likelihood to happen: "Low" represents a risk that is not likely to come to pass and "Extremely high" a risk that is very likely to occur.

Source: Risk identification based on insights from risk characterization workshop, "Securing Minerals for the Energy Transition", and McKinsey analysis.
Assessment structure from World Economic Forum Global Risks Report 2017. The risks identified in the workshop are renamed and placed in the matrix based on the assessment.

2 Addressing the risks

Effective risk management necessitates concerted efforts by all stakeholders to collectively reduce and adapt to risks.

Proper risk mitigation needs coordinated efforts. Risk management strategies must proactively identify, assess and mitigate supply-demand imbalances, ensuring a smoother and more resilient transition towards a sustainable energy future. While efforts are currently on to manage supply risks across key geographies and minerals, more coordinated action is needed and at an accelerated pace.

The top 10 high-priority strategies selected for implementation are:

1. **Decrease the resource intensity of mining activities while improving resource efficiency and reuse.**
   The environmental impact of mining operations can be reduced by adopting more sustainable practices that minimize the consumption of natural resources such as minerals and water. This involves employing efficient technologies and implementing closed-loop systems to extract, process and reuse minerals. Some examples include adopting circularity models such as urban mining (e.g. extracting critical minerals like REEs from end-of-life electronics), reducing waste by extracting more from lower-quality ores through leaching technologies, and the creation of a secondary market for critical minerals.[4]

2. **Mobilize international private and institutional investment for the transition.**
   Investment from private and institutional sources can increase the supply of critical minerals to support the transition. Without sufficient financing, technological innovations that facilitate exploration, mining productivity and efficiency, and processing and recycling processes, are unlikely to bridge the supply-demand gap for critical minerals. Further investments can be encouraged by institutionalizing ESG principles in foreign investments and through digital platforms that connect responsible investors to responsible projects.

3. **Leverage alternative financing instruments in challenging markets.**[5]
   Alternative financing instruments (i.e. financial products and services that are designed to raise capital outside of traditional channels) can reduce investor risks, especially for markets with limited finance readiness. These instruments can be leveraged by local governments and industry leaders to increase transparency, reduce risks and enhance climate finance readiness. Examples of alternative financing instruments include concessional and blended finance, impact investing and green bonds.

4. **Increase data transparency on supply and demand.**
   Improved data transparency in the mining industry and critical mineral supply chains can help stakeholders make well-informed decisions to secure critical minerals. Sharing accurate and up-to-date information on supply and demand dynamics can enable stakeholders to take proactive measures that address potential shortages or excesses of critical minerals. This can include mineral tracking systems throughout the supply chain to predict future demand trends. Collaborative platforms for sharing global and national demand data for minerals can also increase transparency.

5. **Address price uncertainty due to limited information.**
   The creation of stable trading relationships can address price uncertainty. Stakeholders can use financial instruments like hedging strategies, or explore long-term contracts to provide greater price stability for both producers and consumers. Further, there is a need for price transparency measures such as facilitating greater use of spot pricing transactions, particularly in those mineral markets where the information is covered in long-term, undisclosed commercial agreements and offtake contracts between buyers and sellers.

6. **Increase value-add for local communities.**
   Mining companies can take steps to reduce the impact that land use, extraction and pollution have on nature, while increasing the socio-economic benefits of their projects. When beginning new projects and expanding current operations, mining companies can foster sustainable development through jobs and skills creation, local development and the promotion of equality and inclusion. This will require collaboration between companies and governments to identify strategic priorities for local socio-economic development.

7. **Encouraging dialogue on policy design.** Policy-makers must foster a conducive environment for investment in the minerals needed for the energy transition and to ensure equitable and long-term access. They must consider the interconnectedness of environmental, social and economic factors when formulating regulations. A holistic, global-level collaboration and policy discussion between governments and public and private sector organizations is essential.

8. **Accelerate the pace of innovation.** Innovation in technologies and practices can either reduce the demand for a critical mineral at its end use or increase its supply by promoting efficiency in production throughout the value chain. Research and development, as well as collaboration between academia and industry, can drive the adoption of cutting-edge technologies and methods that can help reduce both current and future shortages. Recognition platforms or accelerator programmes can help incentivize, promote and scale innovations throughout the value chain.

9. **Address the lack of consistency among mining ESG standards.** Harmonized regional and international mining ESG standards can help create a level playing field for companies. To achieve this, it is important to harmonize existing frameworks to remove roadblocks in ESG performance, reporting and tracking. These standards will promote responsible mining, enhance the transparency of ESG metrics and ensure that environmental and social impacts are managed consistently across jurisdictions. This may reduce monitoring costs and increase trust throughout the value chain.

10. **Streamline and de-risk processes for approval and governance of mining projects.** Efforts to this end can reduce lead times and strengthen supply. Modernized and standardized permit and approval procedures like a single-window system, online submission platforms, digital record-keeping and real-time tracking can streamline approvals. Moreover, enhancing the governance and oversight of mining projects can ensure compliance with regulations.

3

The need for global collaboration

Worldwide collaboration can raise awareness and reduce disparity in the supply and demand of critical minerals.

Global collaboration, with the participation of multiple stakeholders including regulators, non-profits, researchers, industry associations and financiers, is essential to overcome the energy transition challenge.

The SMET community collaborated with leaders from over 15 initiatives to analyse the coverage of existing efforts related to minerals for the energy transition. This analysis showed that most of the initiatives do not encompass all dimensions of the energy triangle, namely security, equity and sustainability.

The absence of a unified effort to bridge the supply-demand gap may result in fragmentation across the critical mineral value chain for ESG factors, such as greenhouse gas (GHG) emissions, land use and pollution, water usage and contamination, biodiversity loss and the promotion of equality and inclusion. These fragmentations may exacerbate regional imbalances and disparities in access to these crucial resources.[6] Hence, a global collaborative effort is needed for collective action.[7]

A collaborative effort can enable key actors to discuss gaps, risks, solutions as well as good practices and benefit from key initiatives being undertaken by different institutions. Further, a collaborative group can identify gaps and prioritize topics and potential actions in the relevant spaces while convening stakeholders regularly to foster dialogue. Connecting actors to raise awareness around key themes will contribute to a more comprehensive understanding of the overall landscape and raise the urgency to take meaningful action.

4 Themes for collaborative action

SMET has prioritized themes for action to facilitate global collaboration.

The SMET community identified key themes for action from expert interviews and consultations with public and private stakeholders from the critical minerals value chains. Assessed with respect to their coverage by existing initiatives and their importance in facilitating the minerals transition, the five highest-scoring themes for collaborative action to improve upon the coverage of existing initiatives are:

1. **Facilitate policy dialogue:** Support an enabling environment for policy dialogue among stakeholders and signpost policy for businesses to reduce roadblocks to the availability of minerals needed for the energy transition.

2. **Support investment mobilization:** Understand investment needs across the critical minerals value chains and mobilize investment to bridge the supply-demand gap.

3. **Accelerate innovation:** Spur private-sector innovation by identifying new technologies and systematic innovations for scaling up.

4. **Evaluate gaps in current ESG standards:** Streamline existing ESG frameworks by connecting voluntary standards groups with international standards bodies.

5. **Build skills across the value chain:** Analyse gaps and opportunities in the needs for skills and build capabilities across the value chain.

Facilitate policy dialogue

Policy analysis can facilitate dialogue by providing stakeholders with the evidence and insights they need to make informed decisions. Taxonomies offer a foundation for analysis by tracking and organizing regional policies based on their purpose, method and outcomes. While much has been done to facilitate policy analysis at a global level, such as the IEA's Critical Mineral Policy Tracker,[8] more is needed at the regional level to address localized supply risks.

Open policy dialogue can facilitate conversations between the public and private sectors on the best practices for securing access to critical minerals. Regional forums can also provide a venue for stakeholders to discuss risks and policy discrepancies through moderated dialogue. Many of these forums already exist. For instance, the European Raw Materials Alliance (ERMA)[9] brings together stakeholders from industry, academia and government to analyse policies and to develop recommendations for the security of the stakeholders' access to raw materials. Similarly, the International Renewable Energy Agency (IRENA) has convened members for its Collaborative Framework on Critical Materials for the Energy Transition.[10]

Policy signposts can provide increased visibility to investors, reducing frictions in the market by guiding businesses through an evolving regulatory landscape. These signposts refer to indicators or signals that suggest the direction of government policy on critical minerals. Investors can use these to monitor and predict the implications of new regulations, which may reduce policy-induced market fluctuations. Focus group discussions involving representatives from both private and public sector organizations are a useful tool, aiding businesses in navigating complex policy environments more effectively. Regular newsletters and other communication tools can keep businesses updated on recent policy developments and implications.

Finally, efforts to de-risk approvals and governance in mining projects can improve the supply of critical minerals. Best practices can be applied to streamline permit and approval processes. Additionally, clear governance guidance specific to mining projects can be established, outlining roles and responsibilities for all stakeholders. Such measures can ensure compliance with regulations, social responsibilities and safety standards, while reducing conflicts and disruptions.

Support investment mobilization

Current investment for many critical minerals falls short of what is needed to support an accelerated deployment of emissions reduction technologies. The lack of information on risks can dissuade investments into critical minerals' value chains. Further, the long-term nature of mining investments, often requiring a decade for returns, may be incompatible with the short-term focus of financial markets, hindering private investments in mining.

This is especially true in the low commodity prices environment.

Collaborative initiatives to analyse investment needs and ways of de-risking investments are crucial. Without efforts to scale up investment analytics, stakeholders may be unable to identify how to optimally invest in technology innovation, recycling and supply chain resilience. The collective effort may include gap analyses that can compare supply chain performance against demand, identify areas of improvement and determine how stakeholders can allocate resources effectively. Further, collective action can reduce and adapt to various economic risks across the value chain to ensure optimal investment levels.

Regional public-private sector forums can help stakeholders identify investment needs. To mobilize funds, actors need to ensure their investments are evidence-based, cost-effective and align with their priorities. Investors and public organizations can use forums to encourage knowledge-sharing that identifies localized supply risks. For example, Investing in African Mining Indaba[11] convenes annually to discuss African mining, including supply chain and localized risks, and provides a venue for innovators and stakeholders to secure funding and to form new partnerships to unlock potential investable projects. Similar forums can enable stakeholders to identify investment opportunities that bridge the gap between supply and demand through improvements in exploration, recycling, supply diversification, innovation and stockpiling.

Working groups with key private and public sector players can also ensure that investment risks do not diminish the returns on investments or limit access to financing. Economic risks and information asymmetry can lead to a lower than efficient level of investment. This can reduce the incentives to invest in, for example, innovative technologies that increase the supply of a critical mineral.

Cross-collaborations between companies across the critical minerals value chains and between policy-makers and private organizations can devise risk management strategies that reduce and adapt to economic risks. Instruments such as blended public-private finance can be used to reduce the risks taken by the private sector and increase incentives to invest in challenging markets. Transparency and risk reduction can enable investors to create financial instruments to make investment easier and incentivize long-term investments in mineral exploration and mining. This can scale up finance and bridge the critical gap between the demand and supply of minerals.

Accelerate innovation

Innovation is essential to bridging the impending supply-demand gap for critical minerals. Businesses must identify priority areas, and then deploy and amplify the appropriate technological and other solutions. On the demand side, it's possible to reduce reliance on critical minerals by exploring mineral substitution options within existing technologies, such as using lithium-iron-phosphate batteries instead of nickel-cobalt-aluminum batteries. On the supply side, it's possible to increase the supply of critical minerals by investing in new technologies to extract more minerals from existing assets.

In-depth research in priority areas for innovation can catalyse change. Criticality assessments can be particularly important for determining where innovations can reduce vulnerabilities to supply disruptions or where critical minerals can be used to reduce environmental and social impacts associated with their extraction and use. These assessments can identify priority areas and inform funding for innovation research, development and implementation.

It is necessary to prioritize innovations and advancements across the value chain for the benefit of all stakeholders. Further research and development (R&D) is needed in priority areas to identify opportunities for increasing the supply of critical minerals and reducing the demand for emissions-reduction technologies.

For more advanced innovations, public-private partnerships (PPPs) can be used to scale up financing, and can be particularly beneficial when scaling up large-scale projects. For example, the Mining Innovation Commercialization Accelerator Network[12] is a government-backed initiative that supports innovations, such as Copper Destiny's[13] green additive that reduces capital expenditure and power usage in the copper leaching process.

Industry leaders can amplify innovations to expedite uptake and create synergies. By connecting innovators with established players in the field, collaborations can be fostered that leverage existing expertise and resources. This can be facilitated through regional innovation forums and focus groups that connect public and private players, enabling them to collaborate on innovation activities and build partnerships in value chains. These forums can create a space for innovators to showcase their solutions, attract investment and forge relationships that can streamline the transition to sustainable critical minerals.

Conclusion

The energy transition is essential to achieving a sustainable future, but it is also fraught with risks of a supply shortfall of critical minerals. These risks must be identified and understood across the political, economic, social, technological and environmental dimensions.

Public, private and governmental entities can collaborate to raise awareness of the critical minerals supply-demand disparity, diagnose risks throughout the value chain and develop holistic risk management strategies that address resource intensity, investment, data transparency, local value-add, policy design, innovation, ESG standards and approval processes. Collaboration is key, and this report has outlined various approaches to facilitate it.

The World Economic Forum's global convening power is a unique asset that can significantly accelerate collaborative action for high-priority risk management strategies for critical minerals. By bringing together stakeholders throughout the value chain and leveraging its knowledge partnerships, the Forum can propel the transition to more sustainable and equitable minerals value chains to the benefit of not only stakeholders but also secondary businesses, consumers, governments and the natural environment.

Contributors

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Endnotes

1. McKinsey & Company, *McKinsey Basic Materials Insights*, 2023.
2. IEA, *Critical Minerals market Review 2023*, 2023.
3. The PESTEL framework includes the legal dimension, though the latter is currently not covered for risk characterization.
4. The creation of secondary markets for critical minerals is at the centre of another World Economic Forum-McKinsey knowledge collaboration: the Circularity in the Built Environment initiative. This initiative explores avenues to close material and mineral loops and lower emissions through circular solutions while investigating cross-industry opportunities and business models.
5. Challenging market conditions refer to less institutional or regulatory support on critical mineral topics.
6. IMF, *World Economic Outlook, Navigating Global Divergences - Chapter 3: Fragmentation and Commodity Markets: Vulnerabilities and Risks, October 2023*.
7. Some public-private collaborative initiatives are already making a difference. For instance, the World Bank's Climate Smart Mining Initiative serves as a platform for providing technical assistance and for supporting investments in resource-rich developing countries to achieve low-carbon and responsible sourcing. The Global Battery Alliance is a collaboration across the battery-automotive value chain to achieve goals in relation to circularity, sustainability and responsible sourcing. Despite the existing initiatives on minerals, there is still a need for global-level action to foster dialogue, unify efforts, address critical mineral challenges and ensure stable supply while mitigating regional imbalances.
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