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Making Critical Minerals Bankable: Policy Tools to Unlock Investment

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Foreword



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At a moment of extraordinary technological possibility, our collective progress remains grounded in the material world. The availability of critical minerals increasingly shapes the pace at which we can deploy energy technologies, scale up the digital economy and strengthen global security. From copper and lithium for electrification to rare earths for semiconductors, these inputs underpin 21st-century competitiveness and sovereignty.

Demand is expected to rise significantly in the coming years. Meeting it will require doing more with less: improving material efficiency, scaling-up circularity and secondary markets, and accelerating innovation and substitution where feasible. Yet it remains essential to strengthen primary supply, particularly where end-use needs are expanding faster than alternatives can keep up.

To help address these challenges, the World Economic Forum, through its Securing Minerals for Energy and Technologies (SMET) initiative and in collaboration with its finance community, has developed this report to advance practical solutions for strengthening critical mineral value chains and unlocking investment.

The report focuses on a practical constraint: not geological scarcity, but investment readiness. Many projects face a mismatch between their risk profiles – long lead times, high upfront capital requirements, permitting complexity, policy uncertainty – and the mandates of private capital. Copper illustrates the challenge: despite a projected supply shortfall of 30% by 2035, investment projections reveal a \$250 billion gap by 2030. Without sufficient copper supply, grids, EVs, data centres and defence technologies may fail to scale up at their expected pace.

No single financial instrument can address all the barriers to investment across different minerals and contexts. Mobilizing capital will require interventions calibrated to market structures, project stages and jurisdictional risk profiles, with clear roles for public, private and development finance.

The objective is not only to increase supply, but to diversify it. Concentration at upstream stages of critical mineral value chains creates exposure to disruption, with cascading implications for industrial competitiveness, technology deployment and energy security. To build a more distributed and resilient supply network, it will take coordinated action across

governments, industry, financial institutions and development finance partners to strengthen enabling conditions and deploy catalytic tools that crowd in, rather than displace, private capital.

For mineral-rich nations, this drive for diversification is a unique opportunity to turn natural endowments into sustained growth and long-term economic development.

In an era when geostrategic considerations shape extraction, processing and trade, the race for minerals need not be zero-sum. With clearer risk allocation, credible policy frameworks and cooperative approaches, investments in diverse markets can accelerate and build a stronger global supply base, including supporting shared goals of growth, security and the timely delivery of energy and digital technologies.

Executive summary

Unlocking the resilient mineral supply that governments and value chains seek requires targeted financial instruments that lower risks for investors.

Critical minerals sit at the intersection of energy technology delivery, industrial competitiveness and economic resilience. Demand is expected to rise this decade, yet investment and capacity expansion remain uneven across minerals, jurisdictions and value-chain stages. The constraint is often not geological availability or capital but bankability; many projects still lack the risk allocation, revenue certainty and delivery confidence required by mainstream private finance.

Some barriers mirror those found in other capital-intensive sectors: high upfront costs, long development timelines, complexity around permitting and social licence, infrastructure needs and policy or fiscal uncertainty. However, critical minerals introduce three additional frictions:

- Although often bundled as one policy category, they are not a single market. Pricing transparency, liquidity and contracting norms vary significantly by mineral and product specification, limiting price discovery and hedging.
- Concentration at key processing and refining steps can shape offtake terms and increase perceived market-access risk for new projects.
- Qualification cycles and buyer specifications can delay revenue visibility, even after production is feasible.

These dynamics mean one-size-fits-all approaches, whether broad subsidy programmes or undifferentiated funds, often miss the binding constraint, deliver uneven results and fail to crowd in private capital. To deliver resilient supply, strategies must be designed to make projects financeable at the specific market and stage where capital currently stalls.

This paper proposes a de-risking framework that matches interventions to three dimensions: mineral market structure, jurisdiction risk profile and project stage. The aim is to deploy public instruments where they can most effectively crowd in other capital sources, stepping down support as risks decline and projects mature.

The framework groups tools into six policy levers, each linked to a distinct constraint:

1. **Upfront capital support:** grants, concessional loans and guarantees to address

early-stage capital expenditure (CapEx) and construction risk.

2. **Offtake and demand anchors:** procurement, prepayment and strategic stockpiles to strengthen revenue and market access.
3. **Revenue stabilization and price certainty:** contracts for difference and price floors where volatility or weak benchmarks undermine debt capacity.
4. **Risk mitigation:** political risk insurance and completion guarantees for higher-risk jurisdictions and fragile policy environments.
5. **Structural enablers:** permitting reform, shared infrastructure and public geoscience to reduce time, cost and uncertainty.
6. **Tax and royalty mechanisms:** production and investment credits to improve marginal economics.

The paper illustrates the framework with mineral archetypes to show why interventions must vary by market structure. In mature, liquid markets (e.g. copper), constraints often sit in permitting, infrastructure and delivery risks, making enabling conditions and risk-transfer instruments more material than price support. In highly concentrated value chains (e.g. rare earths), demand anchors and revenue-risk tools may be required to establish viable non-incumbent supply. In volatile emerging markets (e.g. lithium), contracting structures and targeted revenue-stabilization measures can help projects reach financial close. In opaque, specification-driven markets (e.g. graphite), qualification pathways, offtake certainty and market transparency are often decisive. For small by-product markets, targeted cost-sharing and strategic procurement can unlock incremental supply.

Across contexts, the message is practical: precision and sequencing matter. The framework helps users to identify the binding constraint for a given mineral, jurisdiction and stage, then to select the minimum fit-for-purpose set of instruments to close the bankability gap and crowd in capital. In this way, targeted interventions can translate strategic priorities into investment-ready pipelines – accelerating delivery, diversification, resilience and sustainability – while ensuring public resources unlock, rather than replace, private capital and enable competitive markets.

1

Introduction

Demand for critical minerals is rising, but investment does not scale up reliably when risk, timelines and revenues are hard to underwrite.

1.1 The critical minerals investment gap

“ For lenders and long-term investors, risk-adjusted returns can be unattractive once technical complexity, long delivery timelines and policy uncertainty are priced in.

Despite strong long-term demand projections and growing policy momentum, private investment in critical minerals¹ is not scaling up at the necessary pace. Across minerals and jurisdictions, the constraint is often bankability: many projects do not yet offer the risk allocation, revenue certainty and delivery confidence required by mainstream private finance. For lenders and long-term investors, risk-adjusted returns can be unattractive once technical complexity, long delivery timelines and policy uncertainty are priced in.

Critical minerals projects typically require substantial upfront capital, face long and sometimes unpredictable permitting processes and carry material execution risk, from geological uncertainty and cost overruns. While the International Energy Agency (IEA) and other organizations point to strong demand growth,² this does not always translate into near-term price signals or contract structures that lenders can underwrite. For several minerals, prices are volatile or opaque and hedging tools are limited, reducing revenue visibility and raising the cost of capital.

A related constraint is the limited set of demand signals and commercial arrangements that gives investors confidence in future cash flows. Limited midstream processing capacity can make it difficult to secure creditworthy offtakes and long-tenor contracts. In many cases, demand may exist but remains import-served, diffuse or intermediated through concentrated global supply chains, leaving few local counterparties able to sign bankable offtake agreements. In this context, “demand pull” is not simply end-use consumption, but having investment-grade buyers and clear, predictable routes to market; for example, defined standards

and procurement rules, transparent eligibility requirements and contracting mechanisms that translate demand into predictable revenues.

Policy and trade dynamics add another layer of uncertainty. For many transition minerals, supply — especially processing and refining — remains concentrated across a small number of jurisdictions. This can create bottlenecks: when trade measures change, or when disruptions occur, alternative sources may be limited in the short term.

In concentrated markets, changes in export licensing, tariffs, or related measures can contribute to price volatility, contract uncertainty and delivery delays. Figure 1 illustrates concentration in refining across energy-related strategic minerals and Figure 2 shows concentration in both mining and refining for selected minerals, highlighting where diversification opportunities and vulnerabilities are most pronounced. Taken together, these factors can reduce revenue certainty and raise perceived risk, increasing the cost of capital and delaying final investment decisions. This creates a persistent gap between diversification ambitions and investment outcomes. Copper illustrates the challenge: despite an expected supply shortfall of 30% by 2035,³ investment projections indicate a \$250 billion gap by 2030. Although investment had picked up in recent years with 14% growth in 2023, it slowed to just 5% growth in 2024.

To address such investment gaps more effectively, this paper proposes a structured approach to de-risking that links financial and policy instruments to mineral market structure, jurisdictional risk and project stage, so that interventions improve bankability where it is most constrained.



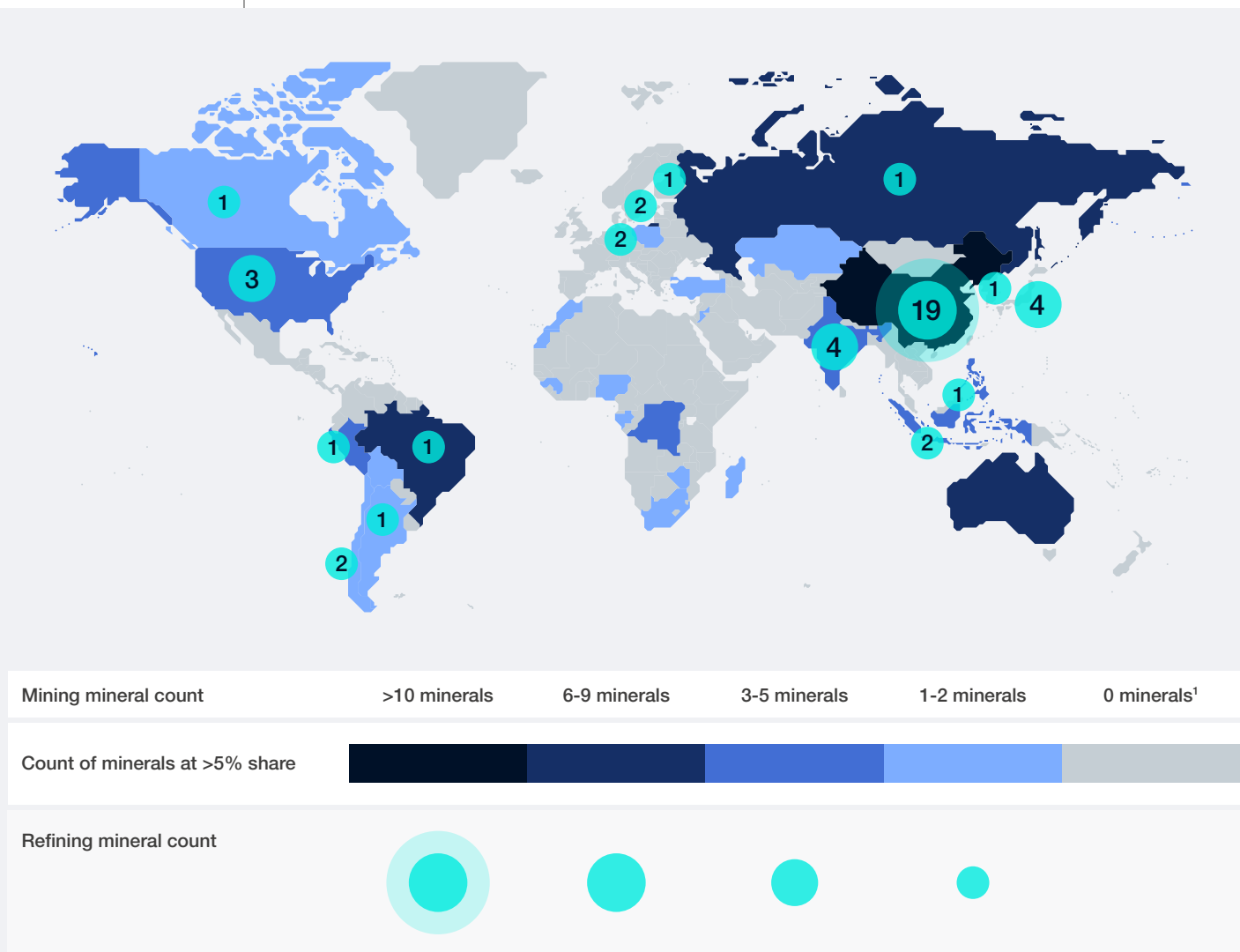
FIGURE 1 | Share of top refining country for energy-related strategic minerals (2024)



Source: International Energy Agency (IEA).⁴



FIGURE 2 | Countries with $\geq 5\%$ share of mined and refined production of select minerals (2024)



Note: ¹ Includes countries that are involved in mining and/or refining but do not constitute $\geq 5\%$ market share for the tracked minerals.

Sources: See endnote.⁵

1.2 Why “one-size-fits-all” fails

“ Critical minerals are not a single market: each mineral differs materially in market structure, participants, pricing mechanisms, end-use demand and risk profile.

Critical minerals, though often bundled as one policy category, are not a single market. Each mineral differs in market structure, participants, pricing mechanisms, end-use demand and risk profile. As a result, there is no universal pathway to bankability. Policy measures and financial instruments must be tailored to the mineral and to specific points along the value chain, from extraction to refining to end-use manufacturing, where price formation, demand drivers and risk allocation vary significantly.

In mature commodities, such as copper and aluminium, liquidity and finance are reinforced by intermediaries. Major exchanges, including the London Metal Exchange (LME) and the Shanghai Futures Exchange (SHFE), provide standardized futures contracts that enable hedging, price discovery and transparency. Large trading houses further reduce risk through offtake agreements, prepayment structures and stronger visibility on market fundamentals. These mechanisms help traditional financial institutions participate with greater confidence.

By contrast, many critical mineral markets remain comparatively immature. Fewer than 20 of the 60 minerals on the United States Geological Survey (USGS) *List of Critical Minerals* have clearly

specified, standardized futures contracts on at least one major exchange. Limited intermediation can constrain liquidity, amplify volatility and increase perceived market risk, discouraging financial institutions from entering.

Instead, many minerals trade bilaterally under terms that vary by purity, processing level and end-use specification. Price reporting agencies (PRAs) such as Fastmarkets, Benchmark Mineral Intelligence and S&P Global support price discovery and more than two-thirds of the minerals on the USGS list are tracked by PRAs. However, compared with exchange-traded markets, transparency remains uneven, making it harder for banks and investors to value projects, assess downside risk and structure hedges, often translating into higher financing costs.

These differences determine which interventions are effective. Copper has traded on the LME since 1877, with roughly 23 million metric tonnes of global mine production in 2024 and deep liquidity across multiple exchanges. Graphite, by contrast, lacks robust benchmarks and is priced largely by specification including purity, flake size, coating and end-use requirements. As a result, bankability solutions for copper will differ from those needed for graphite, rare earths and smaller by-product minerals.

2

Policy toolkit: six categories of policy intervention

Six policy tools can bridge the gap between mineral market needs and investable projects.

Financing critical minerals is most effective when public and private instruments are tailored to the main bottleneck holding projects back – whether that is permitting, price and revenue certainty, processing capacity or country risk – and when those instruments are deployed predictably, on time and in a commercially credible way. In practice, policy responses too often default to familiar tools applied broadly across minerals and market conditions that differ fundamentally – diluting impact and increasing the risk that public support crowds out private capital, rather than crowding it in.

Mining and processing investments face distinct challenges across capital and operating expenditure (CapEx and OpEx) cycles, project stages, mineral types and jurisdictions and involve multiple counterparties. Some projects are constrained by high upfront costs and long lead times; others are technically viable but struggle with opaque pricing, volatile revenues or political risk. No single instrument can address these barriers across contexts.

A fit-for-purpose approach therefore starts by identifying and prioritizing the constraints:

which factor is most limiting – early-stage capital, revenue certainty, exposure to political and macro shocks, or weaknesses in the enabling environment?




Instruments can then be matched accordingly, for example:

- Upfront capital tools can address CapEx barriers.
- Offtake agreements and revenue stabilization tools can strengthen market access and reduce cash flow volatility.
- Risk-mitigation instruments can reduce jurisdictional and political risk.
- Structural enablers and tax mechanisms can improve timelines, costs and underlying project economics.

Used selectively and sequenced to the appropriate project stage, these tools can convert strategic priorities into investment-ready pipelines and crowd in private capital.



Policy instrument 1: Upfront capital support

<p> Purpose</p>	<p>Covers high initial costs that often deter private investment during exploration, feasibility and construction, when uncertainty is high and there is no cash flow to service debt.</p>
<p> Key instruments</p>	<p>Grants, concessional loans, loan guarantees and government equity stakes.</p>
<p> How it works</p>	<p>By absorbing a portion of early-stage risk, these tools help projects reach bankability and unlock larger volumes of commercial finance. They address the CapEx gap by lowering the cost of capital – this in turn extends tenors and/or strengthens balance sheets, enabling projects to meet investment committee requirements and lender credit tests.</p>

BOX 1 | **JOGMEC-Sojitz-Lynas Partnership – Australia/Japan**

Instrument: Government equity + concessional financing | Australia/Japan

Japan Organization for Metals and Energy Security (JOGMEC), a government agency, and the Japanese corporation Sojitz provided \$250 million in loans and equity to Australian mining company Lynas Rare Earths via joint venture JARE, securing a 10-year rare earth minerals supply commitment in return. The deal rescued Lynas from financial collapse and established the only

significant rare earth supply chain outside China. By absorbing early-stage commercial and market risk as anchor investor, Japan enabled Lynas to reach financial close. JOGMEC and Sojitz have since made additional investments, including AUD 200 million in 2023 to expand heavy rare earth minerals production.⁶

BOX 2 | **Upfront capital facilitation for mining – Saudi Arabia**

Instrument: Public financing support and investor-matching mechanisms | Saudi Arabia

Saudi Arabia is supporting mining sector financing, particularly in the capital-intensive post-exploration phase, through public financing institutions and new investor-linkage initiatives. Saudi officials have identified mine development financing as a major challenge and the Saudi Industrial Development Fund (SIDF) as a key support mechanism. In parallel,

the Future Minerals Forum, in partnership with BMO Financial Group, launched a “gateway to funding” initiative to connect mining companies and investors through targeted sessions and access-to-capital presentations. Together, these mechanisms aim to improve access to finance for mine development and help build a stronger pipeline of investable projects.



Policy instrument 2: Offtake and demand anchors

🎯 Purpose	Creates predictable long-term demand by securing future purchases of a project's output at a known price.
🔑 Key instruments	Government procurement, strategic stockpiles and backstop offtake commitments.
⚙️ How it works	Offtake agreements anchor demand and revenue, strengthening a project's ability to secure finance. By committing to purchase specified volumes at fixed or formula-based prices over multi-year terms, governments reduce market risk and signal credible demand to lenders. This is particularly valuable in thinly traded mineral markets where revenue forecasts are harder to evidence, supporting project-finance structures and helping justify investment.

BOX 3 | **JBIC-Codelco prepayment agreement – Japan/Chile**

Instrument: Prepayment agreement (offtake-linked financing) | Japan/Chile

Japan Bank for International Cooperation (JBIC) provided Codelco, Chile's state-owned copper mining company, with a \$466 million loan structured as a prepayment agreement, securing committed copper concentrate deliveries to Japanese manufacturers over the loan term. The arrangement gave Codelco affordable

capital for mine upgrades that it could not easily access commercially, while locking in Japan's supply security. By aligning financial and strategic interests through a single instrument, the deal crowded in public financing without displacing private capital from an already-bankable project.⁷



Policy instrument 3: Revenue stabilization and price certainty

Purpose	Protects producers from extreme price swings and weak benchmarks, guaranteeing minimum prices or revenue stream.
Key instruments	Contracts for difference, advanced market commitments, price-floor mechanisms and certain forms of metal-linked bonds or hedging support.
How it works	By guaranteeing a minimum price or revenue stream, these tools reduce market exposure and enable projects to secure debt and equity on viable terms. They strengthen bankability by stabilizing operating margins over time, helping projects withstand downturns. They are most relevant where spot markets are thin.

BOX 4

US Department of Defense (DoD)-MP Materials rare earth partnership – United States

Instrument: Price floor (contract-for-difference style) and government anchor demand | United States

In 2025, the DoD entered into a 10-year agreement with MP Materials that sets a \$110/kg price floor for the company's NdPr products* (including NdPr oxide). If market prices fall below the floor, the mechanism provides downside protection and revenue certainty, making cash flows more financeable for lenders and investors.⁸ The price floor was well above prevailing market levels at the time: MP reported realizing ~\$52/kg on average in Q2 2025 and Reuters noted the floor was close to double prevailing Chinese market prices.⁹ The agreement supported a

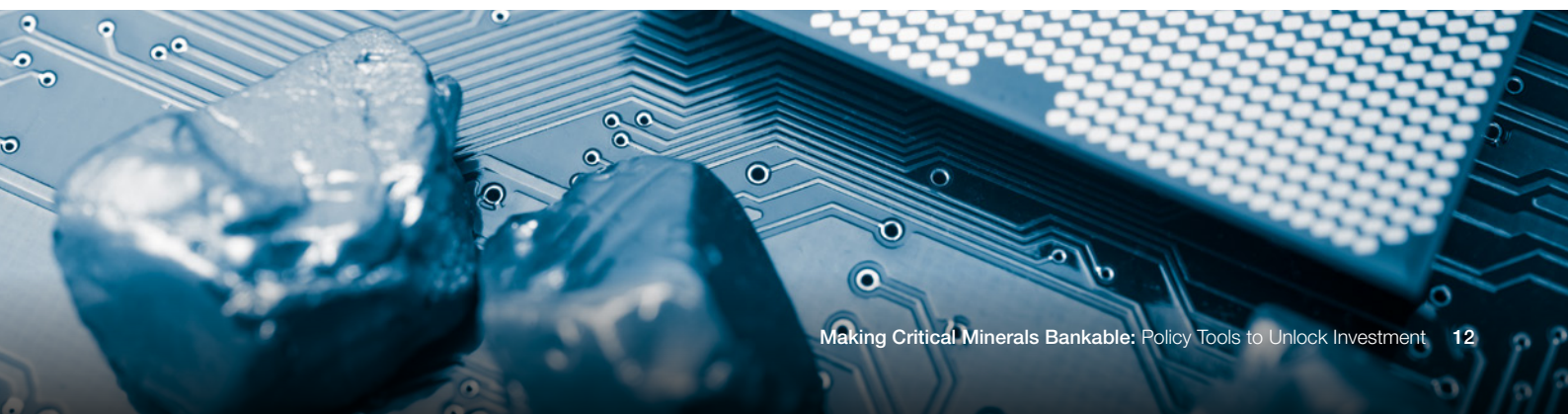
broader financing package to scale domestic processing and magnet supply chains, including a \$1 billion financing commitment from JP Morgan Chase and Goldman Sachs for MP's 10X facility, alongside DoD capital support.¹⁰ Overall, the DoD acted as an anchor by reducing price downside risk and helping crowd in private capital into strategic midstream capacity, substituting for the market certainty that that conventional project finance typically requires.¹¹

Note: * Neodymium-praseodymium (NdPr) is a mix of the two rare earth elements used in high-performance permanent magnets for electric vehicles, wind turbines and defence systems.



Policy instrument 4: Risk mitigation

Purpose	Protects investors and lenders from shocks that can derail otherwise solid projects. These shocks can include expropriation, contract breach, civil unrest, cost overruns or currency inconvertibility.
Key instruments	Political risk insurance, completion guarantees, first-loss capital, export-credit insurance and local currency liquidity facilities.
How it works	These instruments reallocate tail risks so private financiers can participate in higher-risk jurisdictions or complex projects. By reducing non-market risk, they lower required returns and the cost of capital. In policy-uncertain environments, they can be the decisive factor in whether institutional capital participates at all.



BOX 5 | Oyu Tolgoi copper-gold mine – Mongolia

Instrument: Political risk insurance and guarantees | Mongolia

The World Bank's Multilateral Investment Guarantee Agency (MIGA) provided a \$1 billion guarantee to Standard Chartered and a 15-bank consortium covering expropriation, currency inconvertibility, civil disturbance and contract breach over 12 years.¹² Combined with International Finance Corporation (IFC) and

multilateral financing, this unlocked a \$4.4 billion project finance package that conventional lending could not have supported. Oyu Tolgoi reached commercial production in 2022-23, demonstrating how layered public guarantees can make frontier-jurisdiction projects bankable without requiring governments to take direct equity stakes.¹³

Policy instrument 5: Structural enablers

 Purpose	Addresses regulatory, institutional and physical infrastructure bottlenecks that raise both CapEx and OpEx across entire jurisdictions or value chains.
 Key instruments	Exploration support and public geoscience, energy and infrastructure support, streamlined permitting, local content and inbound investment regimes and targeted trade or local-processing policies.
 How it works	These instruments strengthen the operating environment, reduce systemic risk, shorten timelines and lower input costs. By improving project economics for multiple users, they make private investment more viable and crowd in capital at scale.




BOX 6 | Queensland Resources Common User Facility (QRCUF) – Australia

Instrument: Publicly backed shared infrastructure | Australia

Early-stage mining companies (“junior” miners) often cannot individually afford the processing infrastructure needed to prove commercial viability, produce product samples or negotiate offtake – yet without these, private financing remains out of reach. Queensland government’s QRCUF in Townsville makes shared pilot-scale

processing equipment accessible to multiple companies, allowing them to trial production processes and prove technical feasibility without bearing the full capital costs. By de-risking the commercialization stage for many projects simultaneously, the facility crowds in private capital.¹⁴

Policy instrument 6: Tax and royalty mechanisms

 Purpose	Reduces the fiscal burden on mining and processing projects by directly improving project cash flows and competitiveness.
 Key instruments	Production tax credits, investment tax credits, accelerated depreciation and royalty reductions.
 How it works	These instruments reduce effective OpEx or CapEx per unit produced without picking winners. With clear eligibility rules and adequate duration, they provide predictable, rules-based support that investors can model into base-case economics and financing structures, while preserving a competitive, innovation-driven landscape. They are particularly valuable in higher-cost jurisdictions and for marginal deposits where pre-tax economics are borderline.

BOX 7 | US Inflation Reduction Act (IRA), Section 45X Advanced Manufacturing Production Credit – United States

Instrument: Production tax credit | United States

US critical minerals producers face structurally higher operating costs than incumbent competitors, making it difficult to compete on price or convince lenders of sustained profitability. The IRA's Section 45X credit provides support for

qualifying domestic production of applicable critical minerals, equal to a 10% production tax credit for qualifying domestic refining and processing, improving project economics and cash-flow predictability in ways investors can model.

BOX 8 | Royalty incentives for downstream transformation – Saudi Arabia

Instrument: Sliding scale royalty | Saudi Arabia

Saudi Arabia employs a “sliding-scale” royalty framework that incentivizes companies to move down the value chain. Instead of a flat tax on raw ore, the government grants exemptions or reductions for minerals refined or processed domestically. Under the Mining Investment Law, companies may benefit from a five-year royalty

holiday, with subsequent fees decreasing for minerals processed into intermediate or finished products locally. By linking royalty rates to the level of value addition, the policy encourages investment in capital-intensive smelting and refining, capturing greater economic value within the Kingdom rather than exporting raw materials.



3

Matching policy interventions to mineral markets

Successful capital mobilization depends on matching de-risking strategies to the structural archetypes of diverse mineral markets.

Market structure shapes bankability and determines which interventions work. Mature commodities with established benchmarks and hedging tools are broadly accessible to conventional project finance. Highly concentrated markets, where a handful of suppliers shape price formation and offtake terms, often require demand anchors or revenue-risk mechanisms to enable new entrants. Opaque, specification-driven markets typically need stronger transparency infrastructure and demand aggregation before long-tenor financing becomes viable.

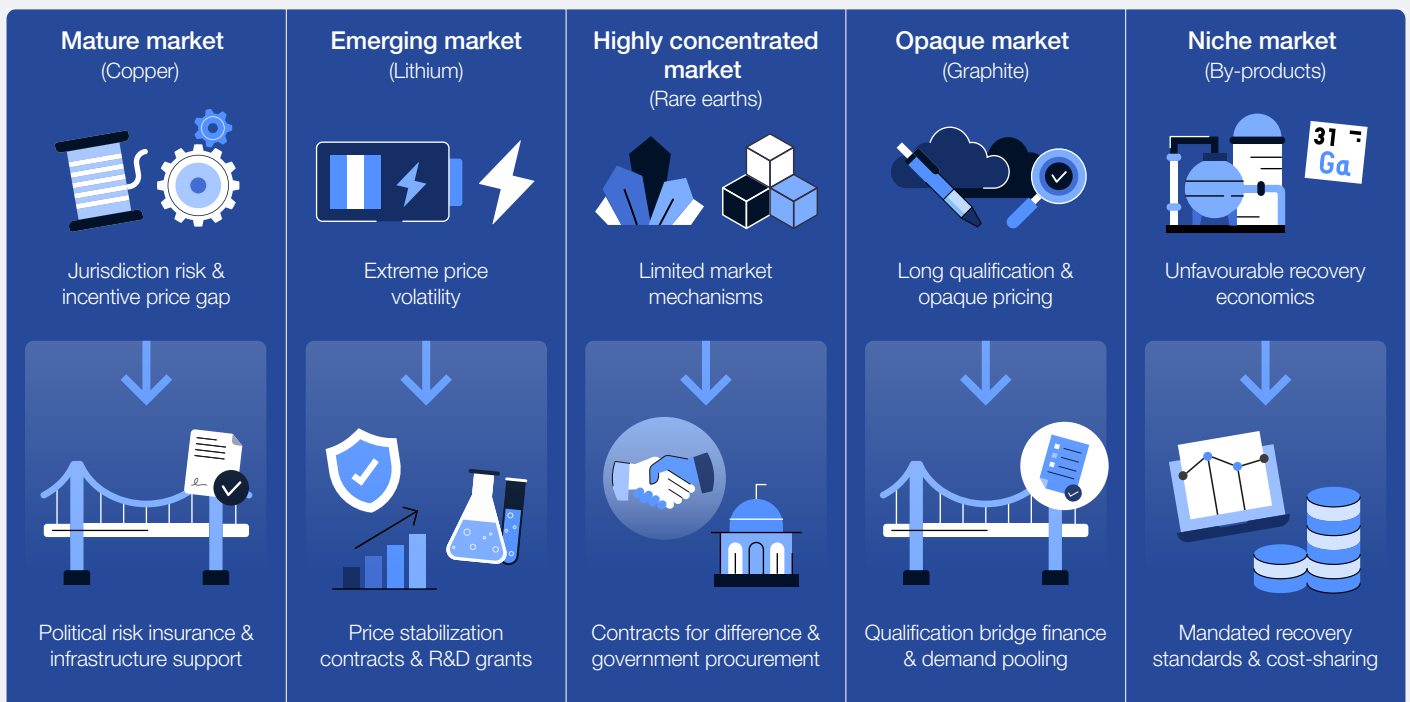
This section examines five minerals that capture the range of market archetypes, illustrating how

maturity, concentration, transparency and scale translate into distinct financing risks and policy requirements (see Figure 3):

- Mature market (e.g. copper)
- Emerging market (e.g. lithium)
- Highly concentrated market (e.g. rare earth elements)
- Opaque market (e.g. graphite)
- Niche market (e.g. by-product critical minerals)






FIGURE 3 Matching policy to the minerals market

Minerals market archetypes, primary constraints and key policy requirements



Source: World Economic Forum and Columbia SIPA.

TABLE 1 | Overview of global mineral market archetypes and financing risks

Financing risks	Market archetypes and mineral examples				
	Mature market	Emerging market	Highly concentrated market	Opaque market	Niche market
	 Copper	 Lithium	 Rare earths	 Graphite	 By-products
Pricing transparency	High (LME, COMEX) ¹	Medium (emerging benchmarks)	Low (bilateral, policy-driven)	Very low (bespoke contracts)	Very low (bilateral)
Supply concentration	Upstream: Low Midstream: Medium	Upstream: Low Midstream: High	Extreme	Extreme	Extreme
Hedging availability	Deep, liquid	Limited	None	None	None
Demand drivers	Broad (AI, electrification, construction)	Battery-dependent (EVs, grid storage)	Tech-specific (EVs, defence, wind)	Battery-dependent (anodes)	Niche
Primary constraints	Jurisdiction risk, incentive price gap, midstream pressure	Price volatility, market concentration, conversion capacity	High concentration, limited price transparency, technical scale-up challenges	Market concentration, opacity, qualification timelines	Market size, recovery economics, market concentration
Bankability without policy support	Moderate	Moderate	Very low	Very low	None

Note: ¹ LME = London Metal Exchange; COMEX = Commodity Exchange Inc., a major New York-based derivatives exchange for trading futures and options on metals, including gold, silver, copper and aluminium.

3.1 Mature market (e.g. copper)

“ Demand for copper could rise by ~24% over the next decade, requiring more than \$200 billion in investment, driven primarily by electrification and AI-related data-centre growth.

With established exchanges and broad market participation, copper is among the most liquid and transparent mineral markets. Copper has traded on the LME since 1877¹⁵ and global mined output in 2024 was about 23 million tonnes.¹⁶ Benchmark pricing and readily available hedging tools improve revenue visibility and enable more conventional debt financing than for other critical minerals. This transparency also broadens the investor base, bringing in institutional investors, commodity traders and sovereign wealth funds that are more comfortable allocating capital where price signals are reliable and liquidity is strong.

Key constraints

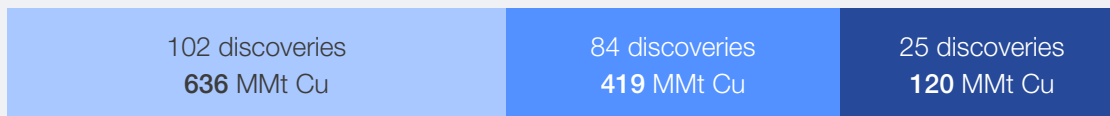
Despite copper's mature, liquid markets, policy support remains important to unlock the

next wave of supply. Consultancy firm Wood Mackenzie estimates demand for copper could rise by ~24% over the next decade, requiring more than \$200 billion in investment, driven primarily by electrification and AI-related data-centre growth.¹⁷

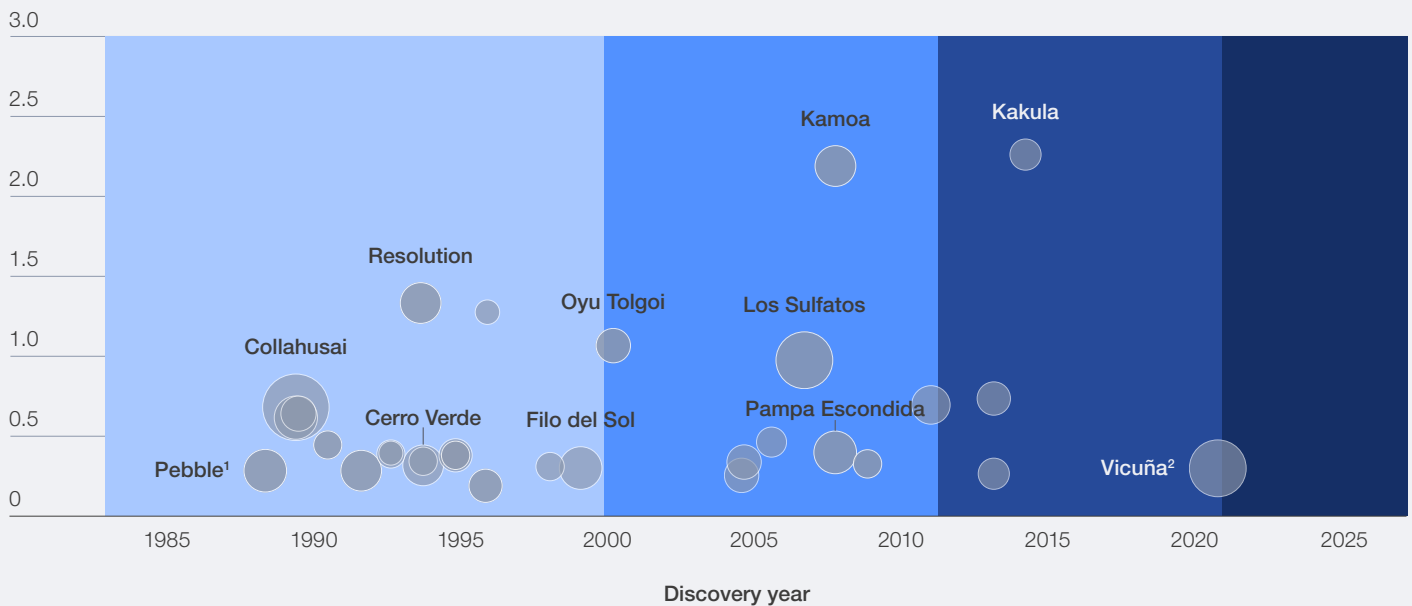
Supply, however, is tightening as ore grades decline, driving up costs. Exploration spending is also still well below where it was a decade ago,¹⁸ limiting new discoveries and slowing the project pipeline (see Figures 4 and 5). The projects that do move ahead are increasingly in remote locations or higher-risk jurisdictions, where weak infrastructure, slow permitting and execution risks raise both CapEx and OpEx. As a result, many mining companies and investors are prioritizing protecting cash flow and buying existing assets, rather than building new mines from scratch.

FIGURE 4 | Selected copper deposit discoveries (1985-2025)

Number of discoveries and total discovered copper reserves and resources

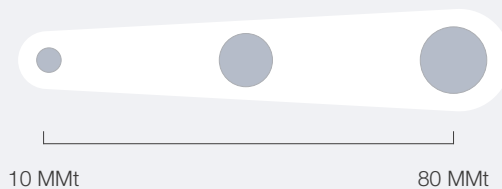


Average head grade (%) of the reserves and resources (R&R)



Cu content in the R&R

Bubble sizes correspond to the copper content in the R&R



Notes: The chart comprises deposits with at least 10 million metric tonnes (MMt) of copper reserves and resources and whose primary commodity is copper. Reserves represent what can be mined now, while resources represent future potential.

¹ The Pebble East deposit discovered in 2005 presents a head grade of 0.57% Cu (cut off CuEQ of 0.60%);

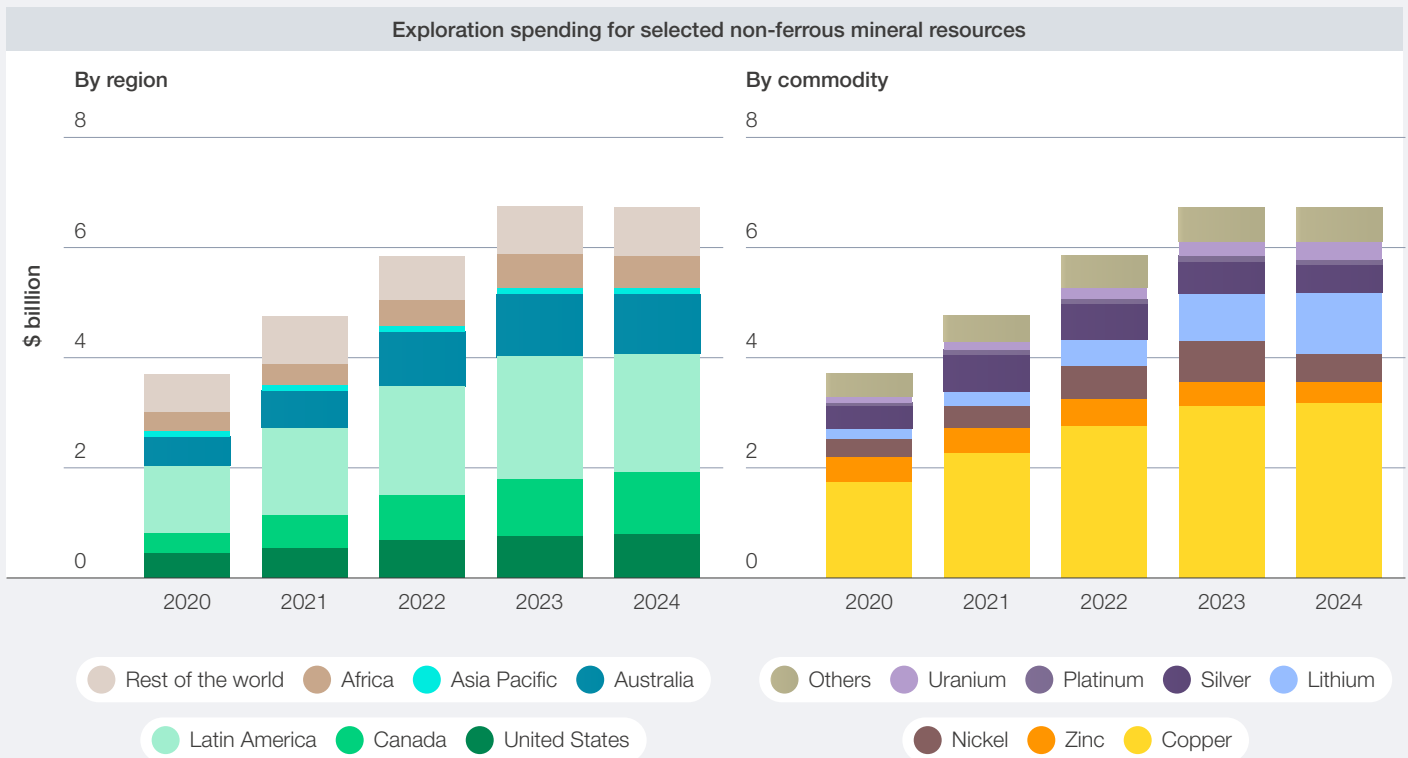
² Composed of multiple deposits, including Filo del Sol (2001), Josemaría (2004) and Los Helados (2009).

Source: S&P Global.¹⁹



FIGURE 5 | Exploration spending for selected non-ferrous mineral resources (2020-2024)

Exploration spending in 2024 was similar to levels in 2023, marking a pause in the strong growth trend that has been seen since 2020



Notes: Excludes budgets for iron ore, coal, aluminium, gold and diamonds. Others comprise cobalt, rare earth elements, potash/phosphate and many other minor metals.

Source: IEA analysis based on S&P Global.²⁰

Midstream dynamics reinforce the case for targeted intervention. China’s rapid expansion of smelting capacity amid oversupply has kept treatment and refining charges persistently weak, compressing margins and deterring

investment in processing elsewhere. Policy tools are therefore needed both to de-risk investment in higher-risk upstream projects and to support competitive midstream capacity to meet demand outside East Asia.

TABLE 2 | Recommended policy interventions | Copper

Intervention	Objective
Political risk insurance (PRI)	Reduce tail risks (expropriation, transfer restrictions, contract breach, civil unrest) that commercial lenders will not underwrite. Particularly important where future supply growth is concentrated in higher-risk jurisdictions.
Infrastructure support	Public co-investment in multi-user power, water, rail/road and port corridors to lower per-project CapEx, shorten timelines and improve risk profiles across multiple prospective mines.
Completion guarantees	Backstop cost overruns and delays during construction, improving tenor and pricing for senior debt where execution risk is highest.
Blended finance (first-loss capital plus concessional capital)	Improve bankability for early-stage projects facing long lead times, cost inflation, permitting uncertainty and higher discount rates.
Prepayment agreements	Provide upfront liquidity in exchange for future concentrate deliveries, well-suited to brownfield expansions and debottlenecking while securing feedstock for domestic industry.
Targeted production tax credits for strategic smelting and refining	Stabilize economics where margins are compressed, supporting reinvestment and modernization in priority jurisdictions.
R&D grants and demonstration support	Accelerate technologies that unlock near-term supply from stockpiles, tailings and lower-grade resources, often with faster timelines and lower capital intensity than greenfield development.

3.2 Emerging market (e.g. lithium)

“ Global lithium supply may need to roughly quadruple by 2040 to meet projected demand from electric vehicles and battery storage.

Lithium pricing has become more transparent in recent years, supported by benchmark assessments such as Shanghai Metals Market, Fastmarkets and Benchmark Mineral Intelligence and the launch of exchange-traded futures, including on the Chicago Mercantile Exchange (CME) and Guangzhou Futures Exchange (GFEX). However, transparency and hedging depth still lag mature commodities. International derivatives markets remain small relative to physical trade and most liquidity is concentrated in China, particularly in GFEX’s physically settled lithium carbonate futures.

Around the rest of the world, derivatives volumes are a fraction of physical production, limiting the ability of banks and investors to hedge multi-year price exposure.²¹ The result is often shorter loan tenors, higher costs of capital or reduced willingness to finance long-duration projects.

Despite strong long-term demand growth, lithium remains a relatively young market characterized by sharp boom-bust cycles and recurring supply-demand mismatches. The 2022 price surge followed by the 2023 collapse disrupted investment timelines and contributed to project delays. Most lithium still needs to be refined into battery-grade chemicals, but this is not concentrated in the same way across all products. Chile remains a major producer of lithium carbonate, while close to 60% of global lithium chemicals are produced in China (over 80% for lithium hydroxide).²²

As the world’s largest demand centre, China also plays an important role in how prices are set: many contracts outside the country reference benchmarks linked to Asian delivery markets (e.g. CIF Asia²³ price assessments), meaning global pricing often reflects Chinese and regional market conditions. For projects in other parts of the world, this can create a “double jeopardy”: revenues are tied to benchmarks shaped elsewhere, often with high volatility, while diversified offtake and processing options beyond incumbent suppliers remain limited.

Key constraints

As a result, targeted policy interventions, including demand-side incentives, remain necessary. Global lithium supply may need to roughly quadruple by 2040 to meet projected demand from electric vehicles and battery storage.²⁴ Greater price transparency, deeper market development and alternative conversion capacity are critical to finance new projects.

Tools such as price discovery infrastructure, strategic offtake support, midstream investment incentives and standardized reporting can reduce risk and accelerate supply growth. In the absence of reliable hedging instruments and given incumbent suppliers’ scale across resources, conversion and trading, these financing barriers are difficult to resolve through market forces alone.

TABLE 3 Recommended policy interventions | Lithium

Intervention	Objective
Long-term offtake contracts with price stabilization	Enable bankable, multi-year offtake indexed to transparent benchmarks. Governments can support through credit guarantees, procurement for strategic stockpiles or time-bound, competitively tendered contracts-for-difference that cap downside price risk.
R&D, pilot and demonstration grants for direct lithium extraction (DLE)	Reduce uncertainty around recoveries, costs and environmental performance by funding field pilots and first commercial demonstrations. Non-dilutive support helps validate site-specific processes, generate operating data and attract commercial partners and lenders.
Market infrastructure and transparency	Strengthen price discovery and contracting by supporting independent indices, common contract terms and credible benchmarks. Strategic reserves, forward-purchase programmes and facilitated hedging can also dampen extreme volatility, improving lenders’ confidence in revenue forecasts.
Production and investment tax credits	Improve project economics for new conversion capacity and integrated developments facing high upfront CapEx and strong competition from incumbent refiners. Investment tax credits lower build costs; production tax credits provide predictable, per-unit margin support over time.
Regulatory alignment and permitting for DLE	Clarify how DLE is treated within existing regimes, align requirements where appropriate with oil-and-gas processes and set clear rules on water reinjection to shorten timelines and reduce regulatory risk for first-of-a-kind projects.

3.3 Highly concentrated market (e.g. rare earth elements)

“ In 2024 China accounted for ~60% of mined rare earths and ~91% of refined output; for heavy rare earths used in high-performance magnets, the share is even higher.

China holds a leading position in the rare earth elements (REE) supply chain, from mining the ore to processing it into separated rare earth materials and then manufacturing rare earth metals and permanent magnets. These magnets are essential for electric vehicles, wind turbines, electronics and a range of defence applications and the scale and integration of incumbent suppliers have shaped global market structure and commercial norms across multiple value chain stages. The IEA estimates that in 2024, China accounted for ~60% of mined rare earths and ~91% of refined output;²⁵ for heavy rare earths used in high-performance magnets, the share is even higher.²⁶

Unlike mature commodities, rare earths lack standardized futures markets and deep exchange trading. Prices are often set through bilateral deals, with limited transparency and liquidity. For projects in diverse countries, this makes revenue forecasting and therefore debt sizing materially more uncertain.

Key constraints

Policy and pricing risk are tightly linked. Frequent changes in export rules, quotas and licensing create a persistent perception that trade can be re-priced or restricted for strategic purposes, raising geopolitical and regulatory risk premiums for new projects outside the incumbent market. Those projects also compete against an advanced incumbent: vertically integrated producers with scale, processing know-how and sustained state support.

These market features affect bankability. Where price benchmarks are limited, price reliability is weak and market concentration is high, revenue forecasting and debt sizing become more uncertain. In such settings, lenders often place greater weight on long-term offtake arrangements, contractual revenue support or other risk-sharing mechanisms to underpin financing. The aim is to support the emergence of diversified capacity and more transparent price discovery over time, through targeted, time-bound measures that address specific market bottlenecks.

TABLE 4 Recommended policy interventions | Rare earth elements

Intervention	Objective
Contracts for difference (CfDs)	Provide revenue floors for key oxides (e.g. NdPr, Dy, Tb), ¹ stabilizing cash flows while allowing upside-sharing when prices rise.
Government procurement and long-term offtake	Use defence, renewables and transport procurement programmes as anchor demand for new supply, improving revenue certainty and lender confidence across processing, metals and magnet manufacturing.
Upfront capital support (grants, forgivable loans, pilot funding)	Bridge high CapEx and first-of-a-kind technical risk in processing and magnet plants until projects reach bankable scale.
Strategic stockpiling and advanced market commitments	Support baseline demand and reduce extreme price swings by providing a reliable buyer during downturns, helping alternative suppliers stay viable and making it harder for dominant producers to use prolonged low prices to deter new investment.
Local or allied-content requirements ²	Create reliable demand for diversified supply chains if used in a time-bound way, helping projects in higher-cost locations secure contracts and attract investment.

Note: ¹ Along with neodymium-praseodymium (NdPr) mentioned earlier, dysprosium (Dy) and terbium (Tb) are critical rare earth elements used to manufacture high-performance permanent magnets for electric vehicles, wind turbines and defence systems.

² Rules in public procurement that require a certain share of inputs to come from domestic or trusted-partner suppliers.

3.4 Opaque market (e.g. graphite)

“ Graphite – both natural and synthetic – remains one of the most opaque and least standardized critical mineral markets.

Graphite – both natural and synthetic – remains one of the most opaque and least standardized critical mineral markets. Unlike exchange-traded metals, there are few widely used international benchmarks and most supply is sold through bilateral contracts tailored to product specification and customer requirements.

Natural graphite is mined (typically as flake) and processed into spherical graphite for battery use. Synthetic graphite is produced by high-temperature graphitization of petroleum coke or coal tar pitch, offering higher purity and tighter performance consistency, generally at a higher cost. Battery anode demand is met by both, but pricing is driven less by a single “graphite price” than by specification: purity, particle size distribution, flake size (for natural), coating and other processing parameters for anode active material. As with specialty chemicals, it is qualification and contracting – not public benchmarks – that shape commercial outcomes.

This market structure weakens investable signals for lenders and equity providers. With limited international benchmarks, shallow liquidity and little hedging, developers cannot rely on a transparent reference price, forward curve or hedge market to underwrite base-case revenues. As a result, graphite projects are often treated as bespoke, customer-dependent manufacturing risks rather than scalable mining investments.

Financing is further constrained by long battery qualification cycles (see Box 9 below) and by substitutability between natural and synthetic

graphite, both of which delay revenue visibility and increase volume uncertainty. Most transactions are secured through confidential, one-off bilateral contracts, limiting the predictability of cash flows and reducing eligibility for traditional project finance.

Market concentration compounds these challenges. Downstream anode production is concentrated in China, with more than 90% of global capacity and procurement concentrated among a small number of large producers and integrated cell makers. For new projects, offtake agreements are therefore frequently short-dated, conditional or volume-capped – insufficient to support long-tenor debt or justify large upstream and midstream investments. Recent policy and trade measures have highlighted how quickly supply conditions can change in highly concentrated markets, reinforcing the strategic rationale for diversification while increasing perceived commercial risk for new projects.

Key constraints

Market opacity, lengthy qualification timelines and concentration among anode processors and battery buyers create a bottleneck for new graphite and anode supply. Projects in higher-cost jurisdictions often struggle to reach financial close because investors cannot model revenues with confidence, while downstream customers are reluctant to onboard and validate new suppliers – confirming quality, consistency and scale – amid price volatility and shifting technology preferences.

BOX 9 Battery qualification – a key constraint

Battery qualification comprises cycles of performance tests that can last 18-36 months. As a result, it is a technical milestone that becomes a binding financing constraint. Anode materials must be validated against each customer’s proprietary cell chemistry through extensive charge-discharge testing to confirm capacity retention, swelling behaviour and safety performance under customer-specific conditions. Producers then

need to demonstrate batch-to-batch consistency over sustained production runs, showing that particle size distribution, impurity levels and coating uniformity remain stable at commercial scale. This is followed by integration testing on commercial electrode coating and cell assembly lines. For automotive applications, qualification must also align with vehicle development and safety certification timelines, which can extend the process further.

From a financing perspective, qualification effectively functions as an extension of the construction phase. During this period, projects have limited or no contracted revenues, even as operating costs, working capital requirements and inventory build increase. Even after qualification, volumes may remain uncertain because original

equipment manufacturers (OEMs) can dual-source, delay ramp-up or cap procurement. For lenders seeking predictable cash flows within defined time horizons, this introduces construction-like technical and revenue risk, constraining debt capacity and delaying investment decisions.

TABLE 5 | Recommended policy interventions | Graphite

Intervention	Objective
Contracts for difference (CfDs) for qualified anode products	Give projects a guaranteed minimum price for a defined volume over a set period, helping unlock debt financing. Target this support to near-commercial projects (advanced permitting, engineering and customer qualification) to accelerate investment without distorting the wider market.
Upfront capital support for vertical integration (mining-anode)	Deploy targeted public finance (grants, concessional loans, guarantees and blended structures) to close financing gaps for new integrated mining, refining and anode processing capacity, mitigating high upfront CapEx, scale-up risk and constrained offtake in a market with a single leading supplier, especially for advanced projects.
Local content-linked incentives	Link EV or battery incentives to minimum domestic or allied graphite/anode content with realistic phase-in schedules to create durable demand signals and crowd in upstream and midstream investment.
Tariff rate quotas (TRQs) on graphite and anode materials	Allow a defined import volume at low or zero tariffs, with higher duties above the threshold, preserving affordable inputs for battery manufacturers while supporting the ramp-up of domestic or allied supply.
Trade transparency and price reporting	Support trade data platforms and standardized reporting of contract ranges to improve price discovery, enable credible benchmarks and reduce perceived lender risk.
Testing, certification and qualification infrastructure	Publicly fund testing centres, pilot lines and independent certification to shorten qualification cycles, de-risk OEM adoption and accelerate the conversion of pilots into bankable offtake, particularly for newer producers.

3.5 Niche market (e.g. by-product and co-product critical minerals)

“By-product and co-product minerals are unlikely to be secured by “letting the market work” alone; targeted measures are often needed to make incremental recovery investable.”

By-product and co-product critical minerals include gallium, germanium, indium, hafnium, scandium, tellurium, rhenium, rubidium, bismuth and iridium. They are not typically mined or processed as stand-alone commodities. Instead, they are recovered alongside a primary metal such as copper, zinc or aluminium, often at the refining or smelting stage. Their markets are small and seldom generate enough revenue to justify dedicated capacity. Because these revenues are incremental to the host operation, prices for minor metals rarely drive investment decisions. Supply is therefore relatively inelastic and tends to track the economics, throughput and investment cycles of the primary metal rather than the minor metal’s own strategic importance.

Gallium illustrates these dynamics. It is a minor metal recovered primarily during bauxite-to-alumina refining (and also from zinc refining) and China accounts for nearly 99% of global primary output.²⁷ Despite compounds such as gallium arsenide being critical inputs for semiconductors and other advanced technologies, the global market remains opaque, highly concentrated and thinly traded. Volumes are small, with global production estimated at under 760 metric tonnes in 2024.

The position of incumbent suppliers has been reinforced through policy: alumina refineries were required to install circuits to extract gallium during the refining process and export restrictions were introduced in 2023 and 2024. Similar patterns apply across other minor metals, where production is concentrated in a limited number of refineries or smelters and trade is dominated by bilateral, non-transparent arrangements rather than widely used benchmarks.

Key constraints

Installing new recovery circuits or building incremental recycling capacity is rarely compelling on purely commercial terms, particularly given the scale and cost position of incumbent suppliers in these niche markets. For many private operators, the capital costs are difficult to justify against uncertain volumes, limited price transparency and higher volatility. As a result, by-product and co-product minerals often struggle to attract investment on purely commercial terms; targeted, time-bound measures can help make incremental recovery financeable where strategic need is high.

TABLE 6 | Recommended policy interventions | By-products and co-product critical minerals

Intervention	Objective
Targeted cost-sharing for recovery circuits	Co-fund retrofits and new recovery circuits to offset capital and operating costs that are rarely justified commercially. Competitive, plant-level support, such as the multi-government backing for Alcoa's gallium recovery facility in Western Australia, can unlock supply while limiting fiscal exposure to a small number of strategic assets.
Floor-price mechanisms and long-term offtake	Protect strategic recovery facilities from severe downturns and thin-market volatility. Pre-agreed price bands and long-term contracts improve revenue certainty while allowing public buyers to participate in upside when prices strengthen.
Public-private stockpiles and strategic reserves	Act as a buyer of last resort in weak markets and a release valve in tight markets. Stockpiles can reinforce offtake, sustain minimum economic throughput and reduce the risk that small disruptions trigger global shortages.
Production tax credits (PTCs) or investment tax credits (ITCs) for by-product recovery	Target production or investment tax credits (PTCs/ITCs) to the added costs or output of recovery, e.g. the extra CapEx required or the volume recovered, so they lower unit costs and keep projects operating even when market prices fall.
Testing and technical support for co-product recovery	Fund testing and pilot facilities to identify minor metals in ores and waste stream, prove viable extraction methods and reduce the technical risk of adding recovery units to existing operations, strengthening the investment case for by-product recovery.

4

Matching policy interventions to jurisdictions

Permitting delays and policy volatility raise investment risk – interventions must match jurisdiction types.

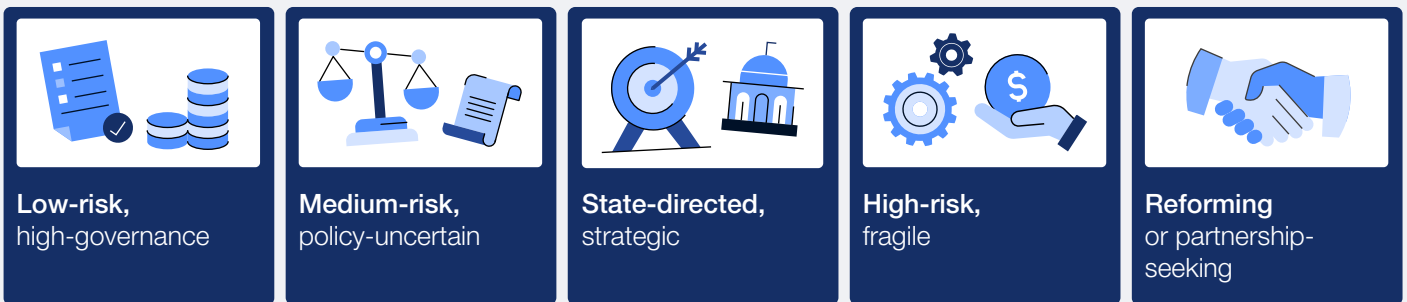
Beyond mineral-specific dynamics, political and governance conditions can materially shape investment risk. Permitting delays and uncertainty, policy volatility and ad hoc government intervention increase the likelihood of cost overruns, schedule slippage or project failure, amplifying the commercial and market risks described earlier. Investors therefore assess not only geology and project economics, but also the jurisdiction’s stability, predictability and administrative capacity.

This chapter reviews **five jurisdiction archetypes** that illustrate how governance environments can either enable or constrain financing across mining and processing:

- Low-risk, high-governance
- Medium-risk, policy-uncertain
- State-directed, strategic
- High-risk, fragile
- Reforming or partnership-seeking

These archetypes are simplified: in practice, many countries combine elements of multiple types and risk can vary significantly across regions and individual projects.

FIGURE 6 Matching policy to jurisdiction risk



Source: World Economic Forum and Columbia SIPA.

4.1 Low-risk, high-governance jurisdictions

These jurisdictions typically have strong rule of law, transparent institutions and predictable contract enforcement. Deep capital markets and well-established environmental, social and governance (ESG) standards, particularly on labour practices, Indigenous engagement and environmental protection, make them credible destinations for long-term institutional capital.

In such jurisdictions, the binding constraints are rarely expropriation or arbitrary contract changes. Financing is more often hindered by lengthy and uncertain permitting timelines, intensive compliance requirements and the high bar for securing and maintaining a durable social licence to operate. Third-party litigation, overlapping mandates and sequential approvals can further extend timelines and raise development costs.

In settings with more complex regulatory and permitting processes, long lead times between discovery and production increase pre-development capital needs, heighten exposure to cost inflation and reduce project net present value, sometimes making otherwise viable projects harder to finance. Developers must fund baseline studies, mitigation measures, stakeholder engagement

and workforce requirements – well before revenues begin.

In this context, policy measures that improve the predictability and sequencing of approvals, paired with tools that share early-stage risk, can materially strengthen bankability and help projects reach final investment decision (FID).

TABLE 7 Recommended policy interventions | Low-risk, high-governance jurisdictions

Instrument	Problem	Why?
Permitting reform	Projects stall at permitting despite low political risk	Statutory timelines, concurrent reviews, “one-stop” offices, clearer sequencing and increased staffing (geologists, hydrologists, Indigenous affairs and environmental experts) reduce timeline uncertainty – a key barrier to FID.
Exploration incentives	Small early-stage exploration companies often struggle to raise funding from investors and regulatory and compliance costs can discourage early-stage capital.	Reduce the effective cost of drilling and mapping, advancing prospects to the stage where larger investors and lenders can engage.
Infrastructure and energy co-financing	Remote locations push CapEx/OpEx beyond bankable thresholds	Public co-financing for shared infrastructure and power improves economics without distorting market structure.
Concessional loans	Long paybacks and construction risk price out commercial lenders	Long-tenor, low-cost public debt improves debt-service metrics and crowds in private lenders unwilling to take full exposure on market terms.
Contracts for difference (CfDs)	High fixed costs leave domestic processors exposed to state-backed competition	Minimum price support covers fixed costs and debt service in weak price periods; clawback provisions limit fiscal exposure in strong markets.
Production tax credits (PTCs)	Imports undercut domestic producers; downstream lacks secure local feedstock	Output-linked, rules-based credits lower effective operating costs and are modelled easily by investors – anchoring production and downstream supply chains.
Social licence and community benefit	Community opposition or litigation create delays beyond regulatory reform	Early benefit-sharing and consent-based engagement reduce permitting uncertainty and the likelihood of legal challenge for large, visible projects. Note – social licence and community benefit interventions should be implemented in every jurisdiction.



4.2 Medium-risk, policy-uncertain jurisdictions

Medium-risk jurisdictions often combine attractive geology with policy volatility. Investors may face shifting fiscal terms, inconsistent regulatory enforcement or episodic resource nationalism – often during commodity upswings. Tensions between national and subnational authorities can add uncertainty around royalties, taxation, licensing and export rules. Currency volatility, capital controls and restrictions on profit repatriation can further weaken financial planning and raise the cost of capital.

In these settings, geology alone rarely attracts sustained private investment. Improving bankability typically requires credible government signals: stable and transparent fiscal regimes, predictable permitting and clear rules on foreign exchange (FX) and capital mobility. Consumer countries and development finance institutions can complement this through political risk insurance, completion guarantees, blended finance and long-term offtake structures that reduce governance and currency exposure.

TABLE 8 Recommended policy interventions | Medium-risk, policy-uncertain jurisdictions

Instrument	Problem	Why?
Local currency liquidity and FX risk tools	Exchange rate volatility erodes margins; capital controls threaten hard currency debt service	Currency swaps, structured hedging and dual-currency escrow arrangements reduce currency mismatch and reassure lenders that hard currency repayments remain available during FX stress.
Exploration incentives	Strong geology goes unexplored because early-stage risk is unfinanceable	Refundable tax credits, co-funded drilling and data-sharing reduce upfront equity needs and improve subsurface information, enabling earlier private entry.
Fiscal regime and contract stabilization	Frequent royalty/tax changes undermine long-term cashflow modelling	Stability clauses lock key fiscal terms for a defined period; transparent model contracts and access to international arbitration reduce the risk that political turnover resets project economics.
Completion guarantees and political risk insurance (PRI)	Permitting reversals, land access disputes or infrastructure failures derail construction	Public and multilateral backstops protect lenders if government actions prevent completion; PRI converts diffuse political/execution risk into defined, insurable exposures that financiers can price.

4.3 State-directed, strategic jurisdictions

State-directed jurisdictions use industrial policy to steer investment towards domestic value addition. Instruments such as export restrictions, mandatory processing, state-linked joint ventures and local-content rules are used to align mineral development with broader economic objectives. This approach can accelerate midstream and downstream build-out, but it can also increase policy and commercial uncertainty if rules or requirements change over time.

For private investors, the core challenge is managing policy change risk while aligning with state priorities. Projects may face evolving export regimes, new processing obligations, revised partnership requirements or contract renegotiations. Targeted support from consumer countries such as political risk cover, sovereign-backed guarantees, concessional finance and strategic offtake commitments can help make projects financeable while remaining consistent with host-country development priorities.

TABLE 9 Recommended policy interventions | State-directed, strategic jurisdictions

Instrument	Problem	Why?
Capital support and joint venture (JV) frameworks	Private investors avoid direct operatorship due to opaque decision-making and policy discretion	Channel public equity via commodity traders, OEMs or specialist investors that form JVs with local state-owned enterprises (SOEs), securing access while shifting execution risk to partners with regional experience.
Infrastructure and shared-asset support	Existing infrastructure and contracting patterns can shape trade flows; high upfront costs can deter new investment.	Co-finance multi-user transport and infrastructure corridors and guarantee shared access to lower upfront costs and signal long-term commitment valued by host governments – reducing access and execution uncertainty for new projects.
Strategic offtake and long-term supply agreements	Full ownership exposes firms to sovereign, operational and ESG risk	OEM-/processor-backed offtakes secure supply without full ownership exposure, strengthen JV negotiating leverage and embed supply into diversified value chains.

4.4 High-risk, fragile jurisdictions

“ Investors face heightened risks of contract instability, expropriation, regulatory opacity and operational disruption; ESG concerns add further reputational exposure.

High-risk jurisdictions are characterized by weak governance, corruption, security challenges and limited enabling infrastructure, yet often host world-class ore bodies. Investors face heightened risks of contract instability, expropriation, regulatory opacity and operational disruption. ESG concerns, including conflict and human-rights issues add further reputational exposure and can materially shrink the pool of available financiers.

As a result, commercial financiers, particularly institutions with strict fiduciary and ESG

requirements, often stay on the sidelines unless risks are meaningfully mitigated. Where private finance withdraws, state-backed or highly risk-tolerant actors can dominate, reinforcing concentration across supply chains. Coordinated intervention by consumer governments, multilateral institutions and development finance institutions can therefore be pivotal. Layered political risk insurance, catalytic equity and debt, targeted enabling infrastructure and sustained diplomatic engagement can reduce risk to a level where diversified private investment becomes feasible.

TABLE 10 Recommended policy interventions | High-risk, fragile jurisdictions

Instrument	Problem	Why?
PRI and partial risk guarantees (PRGs)	Expropriation risks, political violence and currency inconvertibility block financing	Bundled PRI/PRGs (often across agencies) convert diffuse political hazards into defined, insurable exposures and increase coverage limits for large projects.
First-loss capital and concessional finance	Very high required returns and absence of long-term debt lock out commercial lenders entirely	First-loss absorbs initial downside so commercial banks can participate; concessional loans strengthen resilience through pre-revenue and ramp-up phases.
Sovereign/public equity investment	Host governments lack incentives to protect projects from arbitrary interference	Direct public stakes signal political importance to both sides, reducing renegotiation and arbitrary interference risk.
Infrastructure support	Missing roads, rail, power and ports drive costs and operational/social risk	Co-finance multi-user transport and energy corridors to reduce per-project CapEx and deliver local benefits that strengthen government buy-in.
Transparency-linked finance and governance conditionality	Corruption, poor digital-related infrastructure and opaque licensing create unmodelled renegotiation risk	Tie public/multilateral finance to contract publication, Extractive Industries Transparency Initiative (EITI) adherence and independent revenue audits – improving predictability and lowering corruption risk over time.

4.5 Reforming or partnership-seeking jurisdictions

“ In these settings, external support is less about offsetting acute political risk and more about consolidating reform gains and improving execution.

A growing set of jurisdictions is reforming to attract sustainable investment in critical minerals. Governments are updating mining codes, strengthening environmental and social standards and pursuing long-term partnerships with consumer countries and development finance institutions (DFIs). However, implementation capacity often lags ambition: administrative bottlenecks, uneven enforcement and infrastructure gaps can still undermine project economics and investor confidence.

In these settings, external support is less about offsetting acute political risk and more about consolidating reform gains and improving execution. Targeted concessional finance, selective political risk cover and technical assistance can help convert new rules into investable pipelines by strengthening institutions, permitting capacity and project preparation. As in other jurisdictions, strategic offtake arrangements and shared enabling infrastructure can further crowd in private capital, helping reforming jurisdictions to establish credibility as reliable, rules-based partners in diversified critical mineral supply chains.

TABLE 11

Recommended policy interventions | Reforming or partnership-seeking jurisdictions

Instrument	Problem	Why?
Reform-linked concessional finance	Reforming jurisdictions lack visible economic payoff; momentum stalls	Concessional loans unlocked by enacted reforms create a tangible “reform dividend”, signalling credibility and financing early emblematic projects under the new regime.
Co-financed flagship (“lighthouse”) projects	Investors doubt implementation; uncertainty persists despite new laws	DFI-/partner-backed projects demonstrate how rules function, build administrative know-how and signal openness to responsible, rules-based investment.
Technical assistance and capacity building	Under-resourced ministries drive delays regardless of legislation	Strengthen geological surveys, environmental review, community engagement and fiscal administration to improve decision quality and speed – reducing execution risk.
PRI and partial credit guarantees (PCGs)	Track-record deficit keeps risk premiums high	Bridge credibility gaps (contract breach, licence cancellation, payment default) with support phased down as a consistent record is established.
Shared infrastructure and industrial park support	Domestic support weakens if benefits are not visible	Co-finance power/transport links and industrial parks aligned with mining projects to deliver jobs and value addition, reinforcing a stable constituency for investor-friendly policy.

5

Matching policy interventions to the project lifecycle

Investment barriers reflect project lifecycle-specific risk: policy tools must match the stage at which private capital becomes scarce or costly.

Even in transparent markets and stable jurisdictions, projects can struggle to attract finance because risk concentrates differently at each stage of the project lifecycle and the capital available at each stage has distinct requirements. Exploration equity does not automatically convert into construction debt; first production does not remove vulnerability if ramp-up

underperforms or prices weaken. Identifying these stage-specific breakpoints is therefore critical.

Policy tools must be tailored to the stage in the project lifecycle where private capital repeatedly retreats or becomes prohibitively expensive (see Figure 7).

FIGURE 7 Matching policy to the project lifecycle








Source: World Economic Forum and Columbia SIPA.

Table 12 outlines key financing challenges and recommended policy interventions for the five stages in the project lifecycle presented in Figure 7. Midstream/refining projects have their own separate

project lifecycle; however they represent the next segment of the mineral supply chain after steady-state production and as such require significant policy intervention to support new projects.

TABLE 12 | Project lifecycle-specific financing challenges and policy interventions

Risk profiles and appropriate policy interventions shift materially at each stage of the project lifecycle				Next segment of minerals supply chain
 Exploration and early development	 Feasibility and construction	 Ramp-up and early operations	 Steady-state production	 Midstream/refining
Key financing challenges				
<ul style="list-style-type: none"> – Geology unproven; no cash flow – Long timelines; permitting uncertainty – Reliant on risk-tolerant equity only 	<ul style="list-style-type: none"> – Sharp CapEx escalation; no revenue – Cost overruns and permitting delays – Hardest phase for commercial finance 	<ul style="list-style-type: none"> – Below-nameplate – Debt service begins before stabilization – Host government may reassess fiscal terms 	<ul style="list-style-type: none"> – Royalty/tax regime changes – ESG tightening; labour and community risk – Life-extension reinvestment deterrence 	<ul style="list-style-type: none"> – High operating expenses compared to lower cost jurisdictions – High capital costs – Offtake uncertainty undermines investment case
Recommended policy interventions				
<ul style="list-style-type: none"> – Exploration grants – Early-stage risk capital – Public geoscience and cost-sharing 	<ul style="list-style-type: none"> – Concessional loans and guarantees – Completion guarantees – Long-term offtake agreements – Expedited permitting – Infrastructure co-investment 	<ul style="list-style-type: none"> – Contracts for difference (CfDs) – First-loss/subordinated debt – Contingency liquidity facilities – Fiscal stabilization agreements 	<ul style="list-style-type: none"> – Political risk insurance (PRI) – Production tax credits (PTCs) – Strategic stockpile purchases – Export credit and FX facilities 	<ul style="list-style-type: none"> – Production tax credits (PTCs) – Contracts for difference (CfDs) – Long-term offtake agreements – Upfront capital support
Decreasing risk intensity across minerals project lifecycle and supply chain				

Source: World Economic Forum and Columbia SIPA.

Policy tools must be tailored to the mineral and jurisdiction, as well to the different stages of the project lifecycle. Tables 13 and 14 take the policy interventions proposed throughout the report and synthesize them by both mineral market and jurisdiction type, within the overarching timeline of project lifecycle stages introduced in Table 12.

These tables are designed as decision tools. They can help policy-makers and financiers stress-test whether a support package is addressing the real constraint for a given mineral, in a given jurisdiction, at a given point in the project lifecycle. Their purpose is not to prescribe a single model, but to enable faster, more consistent choices – for example:

- Where early-stage capital is the constraint, prioritize upstream risk-sharing and structural enablers.
- Where revenue risk dominates, strengthen demand anchors and stabilization tools.
- Where jurisdiction risk is binding, layer political risk instruments and credibility mechanisms.
- Where opacity and qualification timelines prevent underwriting, build transparency and demand aggregation before expecting conventional project finance.

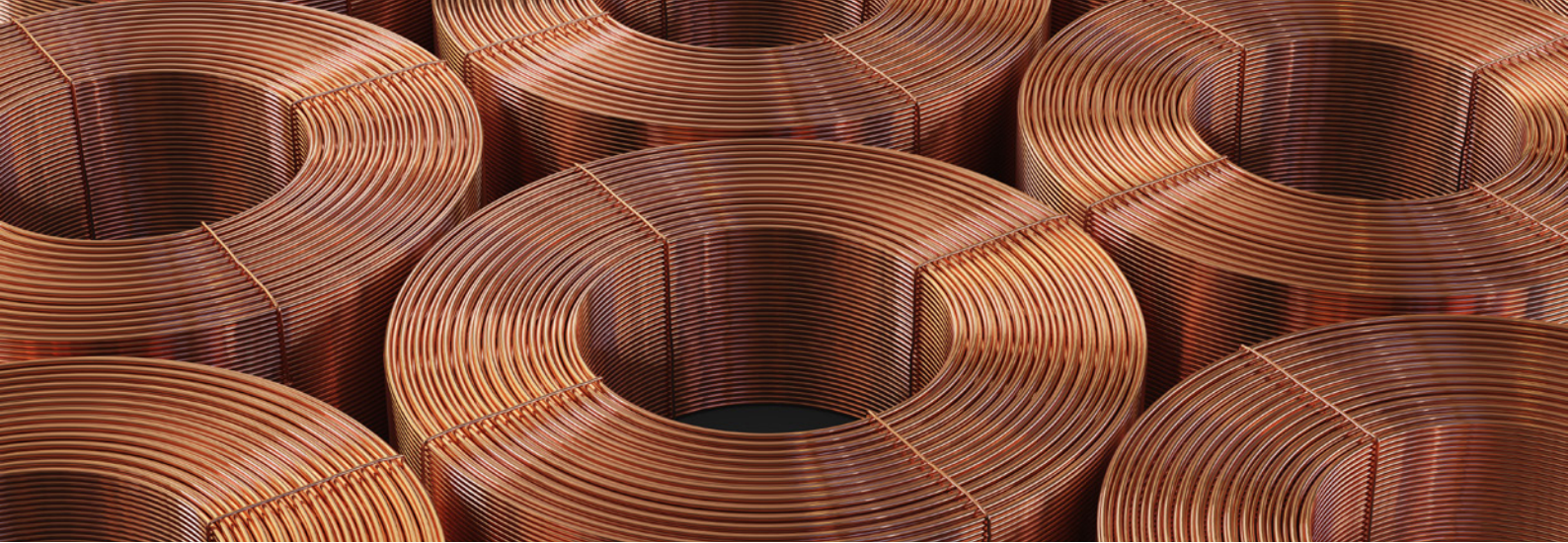







TABLE 13 | Policy interventions by mineral market and project lifecycle

Minerals market archetypes	Project lifecycle				
	1 Exploration and early development	2 Feasibility and construction	3 Ramp-up and early operations	4 Steady-state production	5 Midstream/refining
 <p>Mature market (Copper)</p>	<ul style="list-style-type: none"> – Exploration tax credits – Public geoscience and surveys 	<ul style="list-style-type: none"> – Infrastructure and energy planning – Blended finance structuring 	<ul style="list-style-type: none"> – Completion guarantees – PRI for higher-risk jurisdictions – Prepayment agreements 	<ul style="list-style-type: none"> – PRI (ongoing coverage) – Strategic stockpile purchases 	<ul style="list-style-type: none"> – PTCs for domestic smelting/refining – Prepayment facilities (brownfield)
 <p>Emerging market (Lithium)</p>	<ul style="list-style-type: none"> – Exploration incentives – DLE technology pilots and field trials 	<ul style="list-style-type: none"> – R&D grants for DLE demonstration – Permitting fast-track pathways 	<ul style="list-style-type: none"> – Investment tax credits (ITCs) – Concessional loans (conversion) – Long-term offtake with price bands 	<ul style="list-style-type: none"> – PTCs for battery-grade material – CfDs (volume-capped, competitive) 	<ul style="list-style-type: none"> – Market infrastructure support – Strategic reserves/forward-purchase – Midstream ITCs/PTCs
 <p>Highly concentrated market (Rare earths)</p>	<ul style="list-style-type: none"> – Targeted grants for separation R&D – Public characterization of REE deposits 	<ul style="list-style-type: none"> – Grants/forgivable loans (pilot plants) – Government procurement commitments 	<ul style="list-style-type: none"> – Upfront capital support (grants, concessional loans) – Long-term offtake agreements 	<ul style="list-style-type: none"> – CfDs for separated oxides (NdPr, Dy, Tb) – Strategic stockpiling (alloys) 	<ul style="list-style-type: none"> – CfDs for magnet production – Allied-content requirements – Government procurement
 <p>Opaque market (Graphite)</p>	<ul style="list-style-type: none"> – Public geoscience (flake deposits) – Exploration cost-share programmes 	<ul style="list-style-type: none"> – Qualification infrastructure (public testing facilities) – Pilot anode production support 	<ul style="list-style-type: none"> – Upfront capital (integrated plants) – Blended finance (first-loss + senior) 	<ul style="list-style-type: none"> – CfDs on qualified anode products – Demand pooling/bid windows 	<ul style="list-style-type: none"> – Qualification bridge finance – Standardized certification programmes – TRQs on anode imports
 <p>Niche market (By-products)</p>	<ul style="list-style-type: none"> – Co-product potential mapping – Characterization of waste streams 	<ul style="list-style-type: none"> – Tech. support for recovery design – Pilot recovery systems (gallium, germanium) 	<ul style="list-style-type: none"> – Cost-sharing for recovery retrofits (50-75% capital) – Mandated recovery standards 	<ul style="list-style-type: none"> – Floor-price mechanisms – PTCs for recovered volumes 	<ul style="list-style-type: none"> – Strategic reserves (defence/semiconductors) – Long-term offtakes (pre-agreed bands) – Public-private stockpiles

Note: Instrument selection varies by market structure – mature, emerging, highly concentrated, opaque and niche markets require distinct approaches.

Source: World Economic Forum and Columbia SIPA.

TABLE 14 | Policy interventions by jurisdiction type and project lifecycle

Jurisdiction type	Project lifecycle				
	1 Exploration and early development	2 Feasibility and construction	3 Ramp-up and early operations	4 Steady-state production	5 Midstream/ refining
Low-risk, high-governance	<ul style="list-style-type: none"> – Exploration tax credits – Public geoscience and surveys 	<ul style="list-style-type: none"> – Permitting fast-track – Infrastructure/energy planning 	<ul style="list-style-type: none"> – Concessional/programmatic loans – Shared-infrastructure co-finance 	<ul style="list-style-type: none"> – Production tax credits (PTCs) for battery-grade lithium, graphite 	<ul style="list-style-type: none"> – CfDs for strategic midstream – Local content-linked EV credits
Medium-risk, policy-uncertain	<ul style="list-style-type: none"> – Exploration incentives – FX hedging and local-currency facilities 	<ul style="list-style-type: none"> – Fiscal-regime stabilization – Political-risk insurance (light) 	<ul style="list-style-type: none"> – Partial-risk/credit guarantees – Co-financed enabling infrastructure 	<ul style="list-style-type: none"> – Long-term offtakes with price bands 	<ul style="list-style-type: none"> – Targeted CfDs or floor-price bands (select midstream)
State-directed, strategic	<ul style="list-style-type: none"> – State-to-state geological cooperation/data-sharing 	<ul style="list-style-type: none"> – JV frameworks with SOEs and strategic investors 	<ul style="list-style-type: none"> – Shared infrastructure and industrial parks (rail, ports, power) 	<ul style="list-style-type: none"> – Strategic offtake agreements (all mineral types) 	<ul style="list-style-type: none"> – Co-investment in midstream JVs (lithium, graphite, by-products)
High-risk, fragile	<ul style="list-style-type: none"> – Limited donor-funded geoscience and early pilots only 	<ul style="list-style-type: none"> – Political-risk insurance (PRI) – Partial-risk guarantees (PRGs) 	<ul style="list-style-type: none"> – First-loss capital/subordinated tranches – Corridor-scale infrastructure programmes 	<ul style="list-style-type: none"> – Sovereign/public equity stakes – Transparency-linked finance 	<ul style="list-style-type: none"> – Strategic reserves/offtakes (exceptional cases only)
Reforming / partnership-seeking	<ul style="list-style-type: none"> – Reform-linked concessional finance – Technical assistance for cadastre 	<ul style="list-style-type: none"> – Flagship co-financed projects (DFIs) – Capacity-building for regulators 	<ul style="list-style-type: none"> – Partial-credit guarantees/PRI (bridging credibility gap) 	<ul style="list-style-type: none"> – Transparent model contracts – Contract publication 	<ul style="list-style-type: none"> – Shared-infrastructure support – Demand-anchoring offtakes

Note: Interventions are indicative archetypes – many countries exhibit features of multiple jurisdiction types.

Source: World Economic Forum and Columbia SIPA.



Conclusion

Targeted policy, sequenced by stage and calibrated to market structure and jurisdictional risk, is key to mobilizing capital in mineral markets.

“ Demand-side architecture should be treated as infrastructure: without it, highly concentrated and opaque markets will struggle to produce bankable cash flows, regardless of headline capital availability.

The next phase of critical minerals strategy is less about new ambition and more about execution that moves capital. Demand signals are now widely understood; what remains difficult is turning strategic intent into investable, repeatable transactions across very different minerals, jurisdictions and value-chain stages.

The opportunity is to shift from broad programmes to bankability-by-design: interventions that are explicit about the constraint they solve, the risk they reallocate and the point in the project lifecycle where they unlock private finance.

A practical way forward is to treat critical minerals not as a single sector to “fund”, but as a set of markets that require different deal architectures. In some contexts, the priority is to shorten timelines and reduce delivery risk through stronger permitting capacity and shared infrastructure. In others, it is to create revenue visibility through demand aggregation, qualification pathways and credible offtake. Where jurisdictional risk is binding, layered risk mitigation and policy credibility mechanisms are often prerequisites for meaningful private participation. The common thread is discipline: fewer, better-designed tools deployed where they are catalytic, with clear additionality and step-down provisions as risks normalize.

This implies a near-term agenda focused on building closer relationships between policy and

transactions. Governments, development finance institutions and private lenders can align around a common diagnostic to identify the binding constraint and the minimum crowd-in package. They can then translate that diagnosis into standardizable templates – risk allocation principles, contracting options and stage-gated support designs – that reduce structuring time and improve investor confidence. Demand-side architecture should be treated as infrastructure: without it, highly concentrated and opaque markets will struggle to produce bankable cash flows, regardless of headline capital availability.

Finally, progress will depend on moving from frameworks to repeatable proof points. As a new wave of critical minerals transactions begins to gather momentum, there is a timely opportunity to spotlight best-in-class “lighthouse” deals across different minerals and jurisdictional contexts to show what works for implementation. Curating a small set of these examples can validate which combinations of instruments work in practice, capture execution lessons (from structuring through to delivery) and translate them into replicable templates that others can continue to refine and apply. With that discipline – precision, sequencing and replication – critical mineral strategies can shift from aspiration to delivery, accelerating diversified supply and resilience while ensuring public tools crowd in, rather than crowd out, private capital.

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Endnotes

1. The United States Geological Survey (USGS), drawing on the Energy Act of 2020 definition used for the US critical minerals list, defines critical minerals as those that meet three criteria: (1) essential to the economic or national security of the United States; (2) have a supply chain vulnerable to disruption; and (3) serve an essential function in manufacturing, where their absence would have significant economic or national security consequences.
2. International Energy Agency (IEA). (2025). *Global Critical Minerals Outlook 2025*. <https://iea.blob.core.windows.net/assets/ef5e9b70-3374-4caa-ba9d-19c72253bfc4/GlobalCriticalMineralsOutlook2025.pdf>.
3. International Energy Agency (IEA). (2025). *Global Critical Minerals Outlook 2025*. <https://iea.blob.core.windows.net/assets/ef5e9b70-3374-4caa-ba9d-19c72253bfc4/GlobalCriticalMineralsOutlook2025.pdf>.
4. International Energy Agency (IEA). (2025). *World Energy Outlook 2025*. Licence: CC BY 4.0 (Report); CC BY NC SA 4.0 (Annex A). <https://www.iea.org/reports/world-energy-outlook-2025>.
5. International Energy Agency (IEA), S&P Global, United States Geological Survey (USGS) and Kearney analysis. Reproduced from the following report: World Economic Forum. (2025). *From Minerals to Megawatts: Building Resilience for EVs, Data Centres and Power Grids*, p.22. https://reports.weforum.org/docs/WEF_From_Minerals_to_Megawatts_2025.pdf.
6. Sojitz Corporation & Japan Organization for Metals and Energy Security (JOGMEC). (2023). *Securing supply of heavy rare earths to Japan with additional investment to Lynas*. <https://www.sojitz.com/en/news/article/20230307.html>.
7. Japan Bank for International Cooperation (JBIC). (2025). *Loan to Corporación Nacional del Cobre de Chile*. https://www.jbic.go.jp/en/information/press/press-2025/press_00003.html.
8. MP Materials Corp. (2025). *MP Materials Announces Transformational Public-Private Partnership with the Department of Defense to Accelerate U.S. Rare Earth Magnet Independence*. <https://investors.mpmaterials.com/investor-news/news-details/2025/MP-Materials-Announces-Transformational-Public-Private-Partnership-with-the-Department-of-Defense-to-Accelerate-U-S--Rare-Earth-Magnet-Independence/default.aspx>.
9. Kalia, K. et al. (2025). MP Materials seals mega rare-earths deal with US to break China's grip. *Reuters*. <https://www.reuters.com/business/mp-materials-partners-with-department-defense-boost-us-rare-earth-magnet-supply-2025-07-10/>.
10. MP Materials Corp. (2025). *MP Materials Announces Transformational Public-Private Partnership with the Department of Defense to Accelerate U.S. Rare Earth Magnet Independence*. <https://investors.mpmaterials.com/investor-news/news-details/2025/MP-Materials-Announces-Transformational-Public-Private-Partnership-with-the-Department-of-Defense-to-Accelerate-U-S--Rare-Earth-Magnet-Independence/default.aspx>.
11. Moerenhout, T. (2025). *MP Materials Deal Marks a Significant Shift in US Rare Earths Policy*. Center on Global Energy Policy, Columbia University. <https://www.energypolicy.columbia.edu/mp-materials-deal-marks-a-significant-shift-in-us-rare-earths-policy/>.
12. World Bank Group, Multilateral Investment Guarantee Agency (MIGA). (2012). *Oyu Tolgoi LLC*. <https://www.miga.org/project/oyu-tolgoi-llc>.
13. Multilateral Investment Guarantee Agency (MIGA). (2015, 15 December). *IFC and MIGA to Provide More than \$2 billion for Oyu Tolgoi, Engine of Mongolian Jobs and Growth* [Press release]. <https://www.miga.org/press-release/ifc-and-miga-provide-more-2-billion-oyu-tolgoi-engine-mongolian-jobs-and-growth>.
14. Queensland Government, Office of the Coordinator-General. *Queensland Resources Common User Facility*. <https://www.coordinatorgeneral.qld.gov.au/work-with-us/project-and-infrastructure-delivery/project-delivery/queensland-resources-common-user-facility>.
15. Reuters. (2012). *History of the London Metal Exchange*. <https://www.reuters.com/article/business/history-of-the-london-metal-exchange-idUSBRE85E0ZL/>.
16. U.S. Department of the Interior and U.S. Geological Survey. (2025). *Mineral Commodity Summaries 2025*. <https://pubs.usgs.gov/periodicals/mcs2025/mcs2025.pdf>.
17. Cooper, C. et al. (2025). *Hire-wire act: Is soaring copper demand an obstacle to future growth?* Wood Mackenzie. <https://www.woodmac.com/horizons/soaring-copper-demand-obstacle-to-future-growth/>.
18. DeCoff, S. (2024). *New major copper discoveries sparse amid shift away from early-stage exploration*. S&P Global. <https://www.spglobal.com/market-intelligence/en/news-insights/research/new-major-copper-discoveries-sparse-amid-shift-away-from-early-stage-exploration>.
19. S&P Global. (2026). *Copper in the Age of AI: Challenges of Electrification*. https://www.spglobal.com/content/dam/spglobal/global-assets/en/special-reports/copper-in-the-age-of-ai/Copper%20in%20the%20Age%20of%20AI_January%202026.pdf.
20. International Energy Agency (IEA). (2025). *Global Critical Minerals Outlook 2025*. Licence: CC BY 4.0. <https://iea.blob.core.windows.net/assets/ef5e9b70-3374-4caa-ba9d-19c72253bfc4/GlobalCriticalMineralsOutlook2025.pdf>.

21. Epper, R., Handler, B., & Bazilian, M. (2024). *Revitalizing the future economy: Critical mineral derivatives could bring stability*. World Economic Forum. <https://www.weforum.org/stories/2024/04/revitalizing-the-future-economy-a-critical-mineral-derivative-market-could-bring-stability/>.
22. International Energy Agency. (2022). *The Role of Critical Minerals in Clean Energy Transitions*. <https://iea.blob.core.windows.net/assets/ffd2a83b-8c30-4e9d-980a-52b6d9a86fdc/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf>.
23. CIF stands for cost, insurance and freight – a shipping term indicating that the seller pays for the product, insurance and freight to the named destination (e.g. an Asian port/region). “CIF Asia” is used as shorthand for price assessments or contract benchmarks based on delivered pricing into Asian markets; contracts referencing such benchmarks effectively link revenues to pricing dynamics in those destination markets.
24. Benchmark Mineral Intelligence. (2024). *In Charts: How much must battery mineral supply grow to meet demand?* <https://source.benchmarkminerals.com/article/in-charts-how-much-must-battery-mineral-supply-grow-to-meet-demand>.
25. International Energy Agency. (2025). *Global Critical Minerals Outlook 2025*. <https://iea.blob.core.windows.net/assets/ef5e9b70-3374-4caa-ba9d-19c72253bfc4/GlobalCriticalMineralsOutlook2025.pdf>.
26. Bradsher, K. (2025). China Halts Critical Exports as Trade War Intensifies. *The New York Times*. <https://www.nytimes.com/2025/04/13/business/china-rare-earths-exports.html>.
27. U.S. Department of the Interior and U.S. Geological Survey. (2025). *Mineral Commodity Summaries 2025*. <https://pubs.usgs.gov/periodicals/mcs2025/mcs2025.pdf>.



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