AURUS MINING

The Critical Minerals Constraint

From geological potential to qualified, connected and financeable supply

WP16 | EXPLORE

MINING | INFRASTRUCTURE | ENGINEERING | ENVIRONMENT

OUR POSITION

Critical-minerals supply is constrained by a coupled system. Geology sets the boundary, but supply emerges only when data, processing routes, infrastructure, market qualification, standards alignment and capital formation mature together and stay aligned under policy and price volatility.

EVIDENCE FIRST | DECISIONS MADE EXPLICIT | DELIVERY CONDITIONS STATED

Contents

Executive summary

Policy and industry often speak as if mineral endowment directly converts into supply. The observed constraint is broader. Demand for several transition minerals is growing quickly, and energy applications account for most of the demand growth for key battery metals. At the same time, supply concentration has increased in both mining and refining, which raises the consequence of disruptions and policy interventions. The practical implication is that supply-readiness is a system property. It depends on coordinated maturation of datasets, processing pathways, infrastructure access, market qualification and bankable risk controls, more than on finding more mineralisation.

Sources: WP16-01, WP16-03, WP16-18

Current market structure reinforces the systems constraint. Top-three country concentration has risen since 2020, and the refining side is even more concentrated than mining. China is described as the top refiner for 19 of the 20 minerals analysed, with material processing shares for several minerals reported at roughly 60 to 90%. For buyers and financiers, this structure shifts attention from headline resources to choke points such as conversion capacity, specification compliance and traceability readiness. For project teams, it elevates early-stage decisions about mineralogy, processing route and product definition, because these choices determine which qualification gates apply and which counterparties remain available.

Sources: WP16-18, WP16-19, WP16-20

Volatility and investment pacing amplify the constraint. Reported prices fell sharply across several critical minerals in 2024, while mining investment growth slowed and was only modest in real terms after cost inflation. The IEA also reports announced-project shortfalls versus projected demand by 2035 for copper and lithium under the stated scenario framing. These statements are not a forecast for any single jurisdiction or asset. They are a signal that the financing environment can tighten at the same time that strategic urgency increases. This combination forces sharper evidence standards for resource confidence, processing testwork and downstream qualification before capital can commit at scale.

Sources: WP16-27, WP16-28, WP16-30

Trade and policy now act as supply variables rather than background conditions. Export restrictions on industrial raw materials have risen more than fivefold since 2009, with a large jump in newly affected products recorded for 2023. Commodity-specific actions also show how quickly routing can change, including a temporary cobalt export ban and then quotas for contained cobalt in the DRC in 2025, and tightened export controls for several rare earths from China in 2025 with a defined one-year suspension for part of the later expansion. A supply plan that ignores these mechanisms can remain geologically attractive and still fail to become qualified, connected and financeable.

Sources: WP16-23, WP16-10, WP16-14

At a glance

Six evidence markers establish the scale, threshold or decision condition carried into the chapters that follow.

~USD 500 billion (

MINING CAPITAL REQUIRED 2024-2040, STEPS

Source: WP16-29

~USD 600 billion

MINING CAPITAL REQUIRED 2024-2040, APS

Source: WP16-29

77% (2024)

TOP-THREE MINING-COUNTRY SHARE, AVERAGE ACROSS ANALYSED MINERALS

Source: WP16-18

86% (2024)

TOP-THREE REFINING-NATION SHARE, AVERAGE ACROSS ANALYSED MINERALS

Source: WP16-18

~30%

ANNOUNCED-PROJECT SHORTFALL VS PROJECTED DE-MAND BY 2035 FOR COPPER (SCENARIO: IE

Source: WP16-30

~40%

ANNOUNCED-PROJECT SHORTFALL VS PROJECTED DE-MAND BY 2035 FOR LITHIUM (SCENARIO: I

Source: WP16-30

Method and boundaries

This paper is a bounded synthesis of registered public evidence. Source identifiers remain visible so that each quantitative or framework statement can be traced to its dossier row.

INTENDED READERS

- Mining executives and technical leaders
- Exploration and resource geologists
- Metallurgy and processing teams and advisors with scoping responsibilities (non-design)

READING METHOD

- Read each chapter opener as a decision frame.
- Use the three section exhibits as working review instruments.
- Return to the evidence ledger before reusing any number or requirement.

BOUNDARIES

- All quantitative statements are restricted to the WP16 evidence dossier row IDs listed in each paragraph, exhibit and key figure. No additional numbers, forecasts or jurisdiction-specific claims are introduced.
- World Bank mineral-demand statements are vintage-labelled (2020) and are not updated or re-forecast in this paper.
- Price information is limited to public point indications reported by USGS and selected IEA statements on year-on-year movements; no proprietary continuous price series is used.
- Concentration shares and production shares are presented with source and vintage context. Where different sources use different vintages or methods, the paper does not blend them and does not infer reconciled values.
- Framework references to OECD Due Diligence Guidance, IFC Performance Standards, Equator Principles and GISTM are qualitative only. The paper does not attach unverified performance claims to these frameworks.
- Policy events reported by USGS are treated as dated and commodity-specific. The paper does not predict future policy actions beyond the recorded dates, quantities and statuses provided in the dossier.

PUBLICATION DISCIPLINE

- No client identity or company-age claim is published.
- No Aurus delivery result is inferred from public guidance.
- Dated forecasts retain their institution and vintage.

01

SYSTEM FRAMING

Critical is a system property

Demand growth, concentration, disruption exposure and policy intervention combine to make supply-readiness a coupled system. The constraint shows up where interfaces fail: mine to refinery, refinery to qualified product, and project risks to finance terms.

85%

ENERGY SECTOR SHARE OF DEMAND GROWTH FOR BATTERY METALS | WP16-03

N-1

SUPPLY SECURITY FRAMING USED TO STRESS CONCENTRATION RISK | WP16-31

Hold

DECISION LABEL: DO NOT TREAT GEOLOGY AS THE ONLY READINESS GATE | WP16-18

1.1 Define the constraint as an interface problem

Under the IEA stated scenario framing to 2040, lithium demand grows fivefold, graphite and nickel roughly double, cobalt and rare earths rise 50 to 60%, and copper rises around 30%. In 2024, lithium demand rose nearly 30% and other battery-related minerals grew 6 to 8%. Those statements describe a scaling problem that reaches beyond orebody discovery. The constraint is the ability of the system to expand at the interfaces that convert rock into qualified products. When any interface lags, the system reacts through price, policy or allocation, and the effect can propagate across value chains that share the same conversion assets and logistics.

WP16-01, WP16-02

Concentration reinforces why the constraint is systemic. The average top-three mining-country share rose from 73% in 2020 to 77% in 2024, while the top-three refining-nation share rose from about 82% to 86%. The IEA also describes supply security using an N-1 stress, where supplies outside the leading producer meet only about half of remaining demand in 2035 on average, with graphite and rare earths at 35 to 40%. These are not project-specific probabilities. They are signals that supply-readiness depends on distributed capacity, redundancy and qualification across multiple nodes, more than on a single asset's resource size.

WP16-18, WP16-31

DECISION INSTRUMENT

Interface map for supply-readiness

Use this checklist-style map to identify which interfaces can fail before the orebody becomes a qualified product stream. Treat each interface as a gate with evidence requirements.

TEST	EVIDENCE READING	DECISION RESPONSE
Demand pull and product definition	Demand growth rates vary by mineral and chemistry, including rapid lithium growth and LFP adoption.	Lock a product definition and target customer segment before major testwork spend.
Conversion and refining chokepoints	Refining concentration is higher than mining concentration, and China is described as top refiner for 19 of 20 minerals analysed.	Select processing route with clear conversion capacity options and qualification pathway.
Stress and disruption framing	N-1 stress indicates limited ability to replace the leading supplier for some minerals.	Build a redundancy plan and document alternative routing early.
Policy triggers	Export restrictions and quotas can change routing quickly.	Treat policy as a design input and include it in commercial risk registers.

Sources: WP16-01, WP16-06, WP16-18, WP16-19, WP16-31

1.2 See concentration where it matters most

The IEA describes China as the top refiner for 19 of the 20 minerals analysed and reports that China processes roughly 60 to 90% of the world's lithium, cobalt and rare earths. It also highlights specific conversion and recycling nodes, including China's production of purified phosphoric acid and high-purity manganese sulphate, and that two-thirds of global battery-recycling capacity growth since 2020 has been in China. These statements are not a comment on any single mine plan. They define the context for feasibility. A project can be technically successful at producing concentrate and still be constrained if conversion capacity, chemical quality or recycling credits become required to access target markets.

WP16-19, WP16-20, WP16-22

Market structure also changes how buyers and financiers interpret risk. If refining capacity is concentrated and projected to move from about 45% toward about 50% for China's share, then qualification and conversion contracts become as important as head grade and throughput. This is why supply planning must connect geology to downstream requirements early. It is also why trade actions on intermediate products can matter as much as actions on raw ore. A systems account makes these dependencies explicit and forces early choices about product form, impurity thresholds, and which counterparties can credibly qualify the material.

WP16-19, WP16-21

DECISION INSTRUMENT

Concentration check for project routing

A decision tool for identifying where concentration converts into schedule and qualification risk. Use at pre-feasibility scoping and update at each routing change.

TEST	EVIDENCE READING	DECISION RESPONSE
Mining concentration exposure	Top-three mining-country share averaged 77% in 2024 across analysed minerals.	Document alternative sourcing and blending options for any critical reagent or feed.
Refining concentration exposure	Top-three refining-nation share averaged 86% in 2024; China is top refiner for 19 of 20 minerals analysed.	Require at least two conversion paths with clear qualification steps.
Conversion-node dependency	High-purity conversion products and recycling capacity growth are concentrated in China.	Test whether product must enter specific conversion nodes to meet end-market specs.
Forward stress framing	By 2035 top-three refined-material share is projected to decline only marginally to 82%.	Do not assume concentration resolves on its own within project timelines.

Sources: WP16-18, WP16-19, WP16-21, WP16-22

1.3 Treat policy and climate exposure as design inputs

Export restrictions on industrial raw materials have risen more than fivefold since 2009, and in 2023 over 500 new raw-mineral products were newly affected. The OECD notes that export taxes and licensing are common, and that quantitative restrictions such as prohibitions and quotas have increased sharply. USGS also records commodity-specific actions, including a temporary cobalt export ban in the DRC in February 2025 followed by export quotas for contained cobalt later in 2025 and for 2026 and 2027. These records show that policy can change the effective supply curve without any change to reserves. A project plan should therefore define policy monitoring, triggers and rerouting actions as part of readiness.

WP16-23, WP16-10

Physical disruption exposure is also part of the system. The IEA reports that 7% of global copper supply was at risk of disruption from floods or droughts in 2024. This single statistic does not specify which operations were affected or how. It does establish that climate-linked disruption is already material enough to be quantified at global scale. For project teams, the practical response is to embed site water risk and corridor vulnerability into scoping, because downstream contracts and finance terms will look for credible mitigation. The objective is not to claim certainty. It is to show that the system risks are recognised, bounded and managed with evidence.

WP16-32

DECISION INSTRUMENT

Policy and disruption readiness gate

A gate instrument for deciding whether to advance studies when policy and disruption exposure could change routing or financeability.

TEST	EVIDENCE READING	DECISION RESPONSE
Export restriction environment	OECD records a large rise in export restrictions since 2009 and a spike in newly affected products in 2023.	Add a policy scenario annex to the routing plan before committing to fixed off-take terms.
Commodity-specific controls	USGS records DRC cobalt export ban and subsequent quota regime; USGS records rare-earth export control changes in China in 2025.	Define alternative sales channels and inventory strategy under control scenarios.
Climate-linked disruption	IEA quantifies copper supply at risk from floods or droughts in 2024.	Require corridor and water-risk screening as a prerequisite to long-lead procurement.
Trade friction on intermediates	USGS documents antidumping and countervailing duties on Chinese active anode material in 2025.	Separate product qualification plan from trade routing plan so one change does not break both.

Sources: WP16-23, WP16-10, WP16-14, WP16-32, WP16-12

02

UPSTREAM REALITY

Geology and exploration

Geological potential is necessary but it does not determine which products can be made, where they can be converted, or whether a project can meet qualification and finance gates. Exploration strategy should be shaped by downstream constraints visible today.

37,000,000 t

WORLD LITHIUM RESERVES (USGS) | WP16-07

>75,000,000 t

WORLD RARE EARTH RESERVES (USGS) | WP16-13

Scope

DECISION LABEL: EXPLORATION SCOPE MUST INCLUDE DOWNSTREAM FIT CHECKS | WP16-19

2.1 Translate endowment into supply options, more than tonnes

USGS reports substantial reserve and production figures across several critical minerals, including world lithium reserves of 37,000,000 t and 2025 mine production of about 290,000 t excluding the US. It also reports world rare earth reserves greater than 75,000,000 t and 2025 mined production of about 390,000 t, and world graphite reserves of 310,000,000 t with 2025 production of about 1,800,000 t. These figures show that geological endowment is large in absolute terms. The supply question is instead which portion of that endowment can be delivered as qualified product through existing conversion capacity and under current policy settings. Exploration programs should therefore record the likely product pathway as a core output, not as a later commercial add-on.

WP16-07, WP16-11, WP16-13

Concentration data explains why downstream fit must shape exploration choices. The IEA reports that the top-three mining-country share rose to 77% in 2024 while the top-three refining-nation share rose to 86%. It also states that China processes roughly 60 to 90% of the world's lithium, cobalt and rare earths. These context facts mean that exploration decisions that change the expected concentrate quality or impurity profile can also change which refineries are practical, which in turn changes trade and policy exposure. In this setting, drilling density and resource expansion are not the only determinants of project value. The exploration model should include routing assumptions and test them as explicitly as the geological model.

WP16-18, WP16-20

DECISION INSTRUMENT

Exploration outputs required for downstream fit

A framework checklist for exploration teams to report supply-relevant outputs that link geology to processing and market pathways.

TEST	EVIDENCE READING	DECISION RESPONSE
Product pathway hypothesis	Refining is concentrated and routing options can be constrained by geography and capacity.	State a primary and secondary product pathway with the assumptions behind each.
Concentration and policy exposure note	High processing shares and rising export restrictions change routing risk.	Tag each pathway with policy exposure triggers to monitor during exploration.
Scale relative to demand growth	IEA demand growth is strong for lithium and other minerals under STEPS.	Use demand context to prioritise targets with plausible, near-term qualification paths.
Resource reporting alignment	USGS shows large reserves globally, but supply depends on what can be converted.	Avoid reporting-only milestones that do not improve conversion or qualification confidence.

Sources: WP16-18, WP16-20, WP16-01, WP16-07

2.2 Diversification is visible in current production and resources

USGS production data shows diversification opportunities that are already material. African producers appear prominently in 2025 figures, including the DRC at about 230,000 t cobalt and about 3,200,000 t copper mine production, Zimbabwe at 28,000 t lithium and Mali at 9,400 t lithium, and multiple graphite producers including Madagascar, Tanzania and Mozambique. USGS also records measured and indicated lithium resources for several African countries, including the DRC at 3,000,000 t, Mali at 1,200,000 t and Zimbabwe at 860,000 t. These rows do not claim that any single corridor or project will succeed. They do show that exploration portfolios can be built around existing production context and reported resources, which can shorten the path to qualified supply if the rest of the system is addressed.

WP16-33, WP16-34

The same diversification lens applies to copper, where USGS reports world mine production of about 23,000,000 t and identifies resources of 2.1 Bt from a 2015 USGS assessment, with undiscovered resources of about 3.5 Bt. USGS also reports Zambia copper mine production of 940,000 t in 2025 with reserves of 21,000,000 t. These statistics establish geological scale and regional relevance without implying any particular development timeline. For exploration strategy, the message is to align target selection with the ability to generate resource confidence and processing evidence fast enough for the investment environment described by the IEA. That alignment is a technical choice as much as a commercial one.

WP16-16, WP16-35, WP16-28

DECISION INSTRUMENT

Diversification screen for exploration portfolios

A decision instrument to screen whether an exploration portfolio can support diversified, financeable supply routes under current concentration and investment pacing.

TEST	EVIDENCE READING	DECISION RESPONSE
Current production adjacency	USGS shows significant current production for cobalt, copper, lithium and graphite across multiple African producers.	Prefer targets that can plausibly connect to existing producing regions or skills base.
Resource presence signal	USGS lists measured and indicated lithium resources across several African countries.	Use resource presence as a prioritisation input, not as a development promise.
Copper scale context	USGS reports large identified and undiscovered copper resources globally and specific reserve figures for Zambia.	For copper, stress test corridor and refinery access early due to large, competitive supply base.
Investment timing	IEA notes slower mining investment growth in 2024 after cost inflation.	Select targets where data can reach decision quality within capital-cycle constraints.

Sources: WP16-33, WP16-34, WP16-16, WP16-35, WP16-28

2.3 Integrate chemistry and policy into target ranking

Battery chemistry and end-use shifts can change which minerals are pulled through the system. The IEA reports that LFP batteries are now nearly half the electric-car market, up from under 10% in 2020. This does not eliminate demand for nickel, cobalt or manganese, but it does show that product pathways can reweight quickly within a decade. Exploration target ranking should therefore account for more than one plausible demand pathway, using published scenario framing rather than a single point forecast. The goal is to avoid building a technical case around an assumed product mix that later becomes harder to qualify or finance. By grounding target decisions in published demand and technology adoption statements, teams can justify flexibility without inventing numbers.

WP16-06

Policy can also change which targets are attractive, even at early stage. OECD reports that export restrictions affect a large share of trade for some commodities, including cobalt at 67% and rare earth elements at 46%. USGS records that in April 2025 China tightened export controls on several rare earths, later expanding them and then suspending part of the expansion for one year while earlier controls remained in effect. These actions are not geological. They can still affect whether a given mineralisation can access conversion routes and end markets in a way that supports financing. For exploration, this means adding a policy exposure tag to each target that links expected product form to known control mechanisms and their dated status.

WP16-24, WP16-14

DECISION INSTRUMENT

Target ranking add-ons beyond geology

A structured add-on to standard target ranking, focused on demand, chemistry and policy constraints that can affect later qualification and routing.

TEST	EVIDENCE READING	DECISION RESPONSE
Chemistry sensitivity	IEA reports rapid growth of LFP share in the electric-car market.	Rank targets higher if they retain value across multiple battery chemistry outcomes.
Trade restriction exposure	OECD quantifies trade affected by export restrictions for cobalt and rare earth elements.	Flag targets that depend on restricted export pathways and require a mitigation plan.
Export control vintage tracking	USGS records dated changes and partial suspension for rare-earth export controls in 2025.	Maintain a dated policy log so study assumptions can be audited and updated.
Qualification dependency	Concentrated refining implies fewer qualification routes.	Only advance targets with a credible, evidence-backed qualification pathway hypothesis.

Sources: WP16-06, WP16-24, WP16-14, WP16-19

03

EVIDENCE QUALITY

Resource confidence

Resource confidence extends beyond a reporting exercise. It determines which processing testwork is credible, which contracts can be signed, and whether capital will treat the project as financeable under volatility and concentration.

5%

MINING INVESTMENT GROWTH IN 2024 (NOMINAL) | WP16-28

~2%

MINING INVESTMENT GROWTH IN 2024 (REAL, AFTER COST INFLATION) | WP16-28

Gate

DECISION LABEL: FREEZE ASSUMPTIONS ONLY WHEN EVIDENCE SUPPORTS QUALIFICATION | WP16-30

3.1 Resource confidence must match the decision being made

The IEA notes that mining investment growth slowed to 5% in 2024 and was about 2% in real terms after cost inflation. In this environment, resource confidence becomes a financing variable. Decision makers ask whether the evidence base supports the next commitment, such as pilot-scale testwork, long-lead infrastructure negotiation, or conditional offtake discussions. The problem is not whether a resource exists. The problem is whether uncertainty in grade distribution, deleterious elements and variability can be bounded tightly enough to support downstream qualification. When announced-project shortfalls are discussed for copper and lithium by 2035 under the IEA scenario framing, the implied requirement extends beyond more projects. It is more projects that can pass evidence gates quickly, under scrutiny and within capital-cycle constraints.

WP16-28, WP16-30

USGS commodity summaries illustrate why confidence must be expressed in decision-ready terms. For lithium, USGS reports rapid production growth in 2025 and sizable global reserves. For copper, USGS reports both large mine output and even larger identified resources, plus a quantified estimate of undiscovered resources from a 2015 USGS assessment. These rows show that scale exists, but they do not identify which individual deposits are financeable. To close that gap without inventing project-level metrics, teams should tie resource confidence to specific downstream obligations. Examples include demonstrating likely feed consistency for a conversion route that is already concentrated, or showing that a planned product form can route around export restrictions or conversion bottlenecks. Confidence is therefore a system alignment exercise, more than a geological one.

WP16-07, WP16-16, WP16-19

DECISION INSTRUMENT

Decision-linked resource confidence register

A register template that links each upcoming decision to the minimum evidence required from the resource model and sampling program.

TEST	EVIDENCE READING	DECISION RESPONSE
Decision: choose processing route for scoping	Refining concentration and processing shares imply limited tolerance for uncertainty in feed behaviour.	Require evidence of variability and likely impurity ranges sufficient for route screening.
Decision: enter conditional marketing discussions	Trade restrictions and policy actions can affect routing and product acceptance.	Require dated policy exposure assumptions and a documented alternative pathway.
Decision: advance to capital studies	Investment growth slowed and cost inflation reduced real growth.	Require audit-ready data lineage and uncertainty disclosure tailored to financiers' diligence.
Decision: corridor commitments	Disruption exposure is quantified for copper at global scale.	Require corridor risk screening and contingency logic before binding commitments.

Sources: WP16-19, WP16-24, WP16-28, WP16-32

3.2 Tie resource work to conversion chokepoints

Where conversion capacity is concentrated, the penalty for unqualified feed is high. The IEA reports that China processes roughly 60 to 90% of the world's lithium, cobalt and rare earths, and that the top-three refining-nation share averaged 86% in 2024. In practice, this means resource work must support tonnage confidence and product suitability and predictability. If a deposit's variability is not understood, a refinery or converter may require conservative terms or may decline qualification. That outcome is not visible in a resource statement alone. It is visible when resource evidence is designed around the interface needs of downstream conversion. Therefore, sampling strategies should explicitly seek to characterise domains that drive metallurgical response and impurity behaviour, because those are often the variables that set qualification time and cost.

WP16-20, WP16-18

Battery metals also interact through demand dynamics. The IEA reports that battery metals accounted for 85% of total demand growth for lithium, nickel, cobalt and graphite. When multiple minerals share demand drivers, processing and conversion networks can become coupled, which magnifies the impact of any single qualification bottleneck. This is one reason to treat resource confidence as a system input. If a project aims to supply a market where buyers adjust chemistries quickly, such as the recorded shift toward LFP, then the acceptable product specifications and impurity constraints can change across time. Resource evidence should be organised so that the project can pivot product definitions without re-drilling the entire orebody. This is not a promise of flexibility, it is a disciplined data design choice.

WP16-03, WP16-06

DECISION INSTRUMENT

Conversion-aware sampling and domaining prompts

Prompts for structuring resource data so it can support conversion and qualification discussions without overclaiming precision.

TEST	EVIDENCE READING	DECISION RESPONSE
Metallurgy-driving domains	Conversion pathways are constrained by concentrated refining and processing capacity.	Define domains that can be tested and defended in qualification dialogues.
Impurity and specification risk	High processing shares in limited geographies imply strict acceptance windows.	Add impurity tracking into domaining logic and report uncertainty explicitly.
Demand-coupled market shifts	Battery metals drove most demand growth; LFP adoption changed market shares quickly.	Design datasets to support alternative product definitions if market requirements shift.
Auditability under capital scrutiny	Investment growth slowed in real terms, raising diligence pressure per dollar committed.	Keep a traceable chain from sample to model to decision assumption.

Sources: WP16-20, WP16-18, WP16-03, WP16-06, WP16-28

3.3 Use price and policy volatility to set evidence thresholds

USGS and the IEA document material price moves, including IEA's report that lithium fell over 80% since 2023 and that graphite, cobalt and nickel fell 10 to 20% in 2024. USGS provides point price indications for lithium carbonate and spodumene in 2025, and reports that copper prices were projected to average a record level in 2025, attributed largely to tariff uncertainty. This combination highlights the planning challenge. Volatility is not an argument to stop building datasets. It is an argument to set explicit evidence thresholds before committing to capital-intensive studies. Resource confidence programs should therefore define which uncertainties must be reduced to proceed under low-price stress, and which can be deferred because they do not affect qualification or routing. That framing makes resource spend defensible to both technical and financial reviewers.

WP16-27, WP16-08, WP16-17

Policy volatility similarly affects evidence standards. OECD reports sharp growth in quantitative restrictions, and USGS records dated policy events such as DRC cobalt export quotas and changing rare-earth export controls in China in 2025. For a resource team, these statements imply that a project may need to substantiate alternative product forms or alternative routing more rigorously than in prior cycles. If a concentrate route could be disrupted by a quota regime, then evidence supporting on-site upgrading or alternative customer qualification becomes strategically valuable. The key is to keep claims bounded. The evidence dossier does not specify which policy will apply next year. It does show that policy changes have occurred recently and with defined quantities and dates. That is enough to justify higher discipline in assumption tracking and scenario documentation.

WP16-23, WP16-10, WP16-14

DECISION INSTRUMENT

Evidence thresholds under volatility

A gate framework for setting minimum evidence before committing to higher-cost work in a volatile price and policy environment.

TEST	EVIDENCE READING	DECISION RESPONSE
Price downside test	IEA reports large declines in several mineral prices in 2024; USGS provides point prices for 2025 lithium products.	Define a downside case and list the specific uncertainties that must be reduced to survive it.
Policy scenario test	OECD shows rising restrictions; USGS records specific quota and control events with dates and quantities.	Require documented scenarios with dated assumptions and rerouting actions.
Tariff and trade uncertainty	USGS links copper price projection in 2025 partly to tariff uncertainty; USGS records trade duties for anode material.	Separate qualification feasibility from trade routing so one change does not invalidate both.
Investment pacing test	IEA notes slower investment growth in 2024.	Prioritise evidence that directly improves financeability and qualification, more than size narratives.

Sources: WP16-27, WP16-08, WP16-23, WP16-10, WP16-14

04

PROCESS REALITY

Mineralogy and processing

Processing readiness depends on mineralogy, impurities and conversion routes that can reach a qualified, tradable product. Concentrated conversion capacity and changing battery chemistry raise the value of early, decision-focused test-work.

60 to 90%

CHINA PROCESSING SHARE FOR LITHIUM, COBALT AND RARE EARTHS (RANGE) | WP16-20

95%

CHINA SHARE OF HIGH-PURITY MANGANESE SULPHATE PRODUCTION | WP16-22

Trace

DECISION LABEL: PROCESSING ROUTE MUST REMAIN TRACEABLE TO MARKET SPECS | WP16-37

4.1 Start from product specification, more than recovery

Concentrated conversion changes how processing choices should be framed. The IEA reports that China processes roughly 60 to 90% of the world's lithium, cobalt and rare earths, and that it produces 95% of high-purity manganese sulphate and 75% of purified phosphoric acid. Those statements indicate that some product specifications are effectively tied to a limited set of conversion ecosystems. For a project, the processing route must therefore be defined in terms of the product to be qualified, more than metallurgical recovery. Recovery can be high and still fail the market if impurities or physical properties block qualification at the relevant converters. Testwork programs should be designed to generate evidence that speaks to specification compliance, variability and downstream acceptability, because those are the gates that determine whether product can be sold into the intended demand stream.

WP16-20, WP16-22

Technology mix affects which product specifications dominate. The IEA reports that LFP batteries are now nearly half the electric-car market, up from under 10% in 2020. This adoption statement does not prescribe a single mineral pathway, but it does confirm that downstream technologies can shift quickly. That volatility makes early product definition a technical risk issue. If a project expects to sell into battery supply chains, then the form and quality of intermediate products can determine eligibility under trade actions and supply-chain requirements. USGS documents trade duties on Chinese active anode material in 2025 and notes rising Chinese exports of natural graphite in the same year. Together these rows support a practical approach: define multiple product options where feasible, and align testwork to show whether each option can meet likely qualification gates under evolving market and trade conditions.

WP16-06, WP16-12

DECISION INSTRUMENT

Processing route definition worksheet

A worksheet-style exhibit for fixing a processing route definition that is anchored in product specification and qualification steps, more than in recovery targets.

TEST	EVIDENCE READING	DECISION RESPONSE
Define target product and customer class	Downstream technology adoption shifts, including rapid LFP growth, change what is demanded.	Write a primary product spec and a secondary spec that remains plausible under tech shifts.
Identify conversion ecosystem dependency	Processing and conversion capacity for some products is concentrated, including high-purity reagents.	State which conversion ecosystem is required and the fallback route if it is unavailable.
Trade and intermediate-product exposure	USGS reports duties on active anode material and graphite export volumes.	Map which intermediate forms are exposed to trade actions and which can route differently.
Evidence plan for qualification	Concentration raises the cost of failed qualification attempts.	Sequence testwork to answer qualification-critical questions first.

Sources: WP16-06, WP16-20, WP16-22, WP16-12, WP16-19

4.2 Use mineral statistics to anticipate processing bottlenecks

Commodity statistics help identify where processing bottlenecks are likely. USGS reports that China produced about 82% of the world's natural graphite in 2025, and that China accounted for about 69% of rare earth mine production in 2025, with reserves heavily concentrated as well. These rows do not describe mineralogy at deposit scale. They do indicate that for some commodities, a large share of global material may compete for access to the same conversion pathways and qualification slots. Where a project's mineralogy leads to non-standard impurities or unusual physical behaviour, it may face longer iteration cycles to reach an acceptable product. In such commodities, testwork discipline and early engagement with qualification requirements become a material part of schedule control. The objective is to reduce surprises at the conversion interface, not to claim a universal processing solution.

WP16-11, WP16-13

Nickel and cobalt statistics also signal how processing ecosystems can change quickly. USGS reports that Indonesia produced about 67% of the world's mined nickel in 2025, while the DRC produced about 73% of the world's mined cobalt in 2025. These figures are dated estimates and they do not prescribe processing routes. They do show that supply ecosystems can become dominated by a single geography, which tends to attract associated conversion capacity and downstream contracts. When a project sits outside the dominant ecosystem, it must prove conversion compatibility and qualification credibility, often with fewer reference plants. This is a processing readiness issue. It argues for early, high-quality testwork and for product forms that can enter multiple conversion options. It also supports the need to track policy actions such as DRC export quotas, which can alter feed availability and pricing for converters and change qualification urgency.

WP16-15, WP16-09, WP16-10

DECISION INSTRUMENT

Bottleneck anticipation screen

A structured screen to anticipate where processing and qualification bottlenecks are likely based on concentration and policy signals in published statistics.

TEST	EVIDENCE READING	DECISION RESPONSE
Commodity concentration signal	USGS reports high mine concentration for graphite and rare earths; IEA reports high processing shares for several minerals.	Assume fewer qualification routes and plan testwork accordingly.
Ecosystem dominance signal	USGS reports Indonesia 67% of nickel mine output and DRC 73% of cobalt mine output in 2025 estimates.	If outside the dominant ecosystem, require additional qualification evidence and timeline buffers.
Policy volatility signal	USGS records DRC cobalt export quotas and China rare-earth export control changes in 2025.	Include policy-triggered route changes in the processing option set.
Intermediate-product trade signal	USGS documents trade duties on Chinese active anode material in 2025.	Test alternative intermediate forms that reduce trade and routing dependence.

Sources: WP16-11, WP16-13, WP16-20, WP16-15, WP16-09

4.3 Build processing readiness into responsible and financeable practice

Processing decisions also sit inside responsible sourcing and project-finance frameworks. The OECD Due Diligence Guidance provides a five-step risk-based framework for mineral supply-chain due diligence, and the IFC Performance Standards and the Equator Principles are reference frameworks for environmental and social requirements in project finance. The Global Industry Standard on Tailings Management is a reference framework for tailings facilities. These are established frameworks and are cited here qualitatively, not as numeric performance claims. For processing readiness, the implication is practical. If a proposed processing route changes tailings characteristics, water use or stakeholder risk, then those changes can directly affect financeability and qualification, because counterparties and lenders may require alignment with these frameworks. Processing testwork and design choices should therefore be documented in a way that supports due diligence, more than metallurgical optimisation.

WP16-37, WP16-38

Disclosure expectations add another layer. The IEA reports that about 85% of 25 major mining companies disclosed sustainability performance in 2023, up from 60% in 2020. This disclosure trend does not define a standard for any single project, but it does indicate rising expectations for evidence and transparency. Processing readiness packages should therefore include clear records of assumptions, testwork provenance and decision rationales that can be disclosed or audited if required. This approach reduces friction later when offtakers, regulators or financiers request traceable evidence. It also supports a disciplined response to policy changes and trade restrictions, because the project can demonstrate how it manages supply-chain risks within a recognised due diligence framing. The outcome sought is not publicity. It is lower transaction friction and fewer late-stage redesigns driven by missing evidence.

WP16-36, WP16-37

DECISION INSTRUMENT

Processing readiness and due diligence alignment

A decision-oriented alignment tool linking processing choices to due diligence and finance frameworks without adding unverified performance claims.

TEST	EVIDENCE READING	DECISION RESPONSE
Supply-chain due diligence framing	OECD Due Diligence Guidance provides a five-step risk-based framework.	Map processing route risks and controls to the five steps before offtake negotiations.
Project-finance E&S framing	IFC Performance Standards and Equator Principles are reference project-finance frameworks.	Screen processing options for E&S implications that could affect finance terms.
Tailings governance framing	GISTM is a reference framework for tailings facilities.	Ensure tailings implications of the processing route are defined early enough for governance design.
Disclosure expectation	IEA reports high and rising sustainability disclosure rates among major mining companies.	Prepare a traceable evidence pack for processing assumptions and testwork provenance.

Sources: WP16-37, WP16-38, WP16-36

05

CONNECTIVITY

Infrastructure and corridors

A supply plan is only as strong as its corridors. Concentrated refining, trade friction and quantified disruption exposure mean that infrastructure is not a background assumption. It is a core readiness gate.

7%

GLOBAL COPPER SUPPLY AT RISK FROM FLOODS OR DROUGHTS IN 2024 | WP16-32

82%

PROJECTED TOP-THREE REFINED-MATERIAL SHARE BY 2035 (STEPS) | WP16-21

Gate

DECISION LABEL: CORRIDOR READINESS IS A GO OR NO-GO CRITERION | WP16-31

5.1 Corridors are part of the product, more than logistics

If refining remains concentrated, corridors become part of the product definition. The IEA projects that by 2035 the top-three refined-material share declines only marginally to 82% under STEPS. It also states that China is the top refiner for 19 of 20 minerals analysed. These statements imply that for many products, the practical corridor extends beyond mine to port. It is mine to qualified converter, with intermediate handling, storage, inspection and compliance steps. A corridor plan should therefore specify where material changes custody, where quality is verified and where trade rules apply. This is a technical planning task because it affects contamination risk, sample integrity, and the ability to demonstrate that the delivered product matches the qualified specification. Treating corridors as a late-stage commercial issue often creates schedule and cost shocks when qualification evidence has to be rebuilt around a different routing option.

WP16-21, WP16-19

USGS trade data illustrates how corridor assumptions can be disrupted. USGS reports preliminary antidumping duties on Chinese active anode material at 93.50% and countervailing duties from 11.58% to 721.03% by company in 2025. This is a specific, dated policy setting affecting an intermediate product class. It shows that corridor planning must include trade compliance and alternative routing, more than freight. The same logic applies to export restrictions quantified by the OECD. If trade is affected by an export restriction for cobalt at 67% and for rare earth elements at 46%, then corridor choices can be constrained by licensing, quotas or prohibitions. The corridor plan should therefore include a policy watch function and documented rerouting options, with triggers tied to published mechanisms rather than speculation.

WP16-12, WP16-24

DECISION INSTRUMENT

Corridor definition gate

A gate instrument for deciding whether corridor definition is sufficient to proceed with downstream qualification and contracting discussions.

TEST	EVIDENCE READING	DECISION RESPONSE
Converter access mapping	Refining concentration is high and projected to remain high through 2035 under STEPS.	Map at least two credible converter-access corridors and identify the evidence required for each.
Custody and quality checkpoints	Qualification depends on consistent product quality through transit and handling.	Define custody handoffs and quality verification points aligned to the product specification.
Trade action exposure	USGS documents substantial duties for active anode material in 2025.	Add an alternative corridor that avoids the most exposed intermediate products where possible.
Export restriction exposure	OECD quantifies trade affected by restrictions for cobalt and rare earths.	Document licensing and quota assumptions and the contingency corridor if rules change.

Sources: WP16-21, WP16-19, WP16-12, WP16-24

5.2 Design corridors for disruption, not for average conditions

The IEA reports that 7% of global copper supply was at risk of disruption from floods or droughts in 2024. This statistic does not identify which corridors failed or by how much. It is still a clear signal that corridor disruption is already material at a global supply level. For project planning, the response is to build corridor resilience into early study assumptions. That includes identifying single points of failure in transport, water supply, power or border processes that can prevent delivery to converters. Because corridor failures can interrupt qualification batches, they can also reset customer confidence. The appropriate planning standard is therefore not average uptime. It is the ability to sustain qualified delivery under plausible disruption conditions, with evidence that the project has identified the vulnerabilities and has contingencies that do not depend on unverified infrastructure expansions.

WP16-32

Supply security stress framing reinforces why redundancy matters. The IEA N-1 framing states that supplies outside the leading producer meet only about half of remaining demand on average in 2035, with graphite and rare earths at 35 to 40%. This is not a corridor statistic. It is an argument that redundancy is structurally limited in some markets. Where redundancy is limited, corridor reliability becomes more valuable and the tolerance for delivery variability drops. This affects how projects should think about storage, inventory buffers and alternative conversion paths. It also interacts with policy. If a leading producer introduces quotas, as USGS records for cobalt exports from the DRC, then the rest of the system may not be able to compensate quickly. Projects should therefore build corridor plans that can exploit alternative markets or product forms without breaking due diligence requirements.

WP16-31, WP16-10

DECISION INSTRUMENT

Disruption-resilient corridor checklist

A decision checklist for designing corridor plans that can withstand disruption and concentration stress without relying on unverified assumptions.

TEST	EVIDENCE READING	DECISION RESPONSE
Single point of failure scan	IEA quantifies disruption risk for copper supply from floods or droughts in 2024.	Identify and mitigate corridor single points of failure before committing to qualification timelines.
Redundancy scan using N-1 framing	N-1 indicates limited replacement capacity for some minerals by 2035.	Require an alternate corridor or product pathway for minerals with low redundancy.
Policy shock routing	USGS records quota-based export controls for cobalt from the DRC.	Create a rerouting playbook that remains compliant under quota regimes.
Qualification continuity	Concentrated refining increases the impact of missed deliveries.	Plan inventory buffers and batch management to protect qualification continuity.

Sources: WP16-32, WP16-31, WP16-10, WP16-18

5.3 Corridors influence capital and schedule credibility

Investment requirements and investment pacing make corridor definition a credibility test. The IEA reports mining capital required from 2024 to 2040 of about USD 500 billion under STEPS and about USD 600 billion under APS, and it reports slower investment growth in 2024. These numbers do not allocate capital to any specific corridor. They frame a competitive environment where capital selects projects with clear execution pathways. Corridor ambiguity is therefore not a minor omission. It becomes a diligence issue that can delay financing or increase contingency requirements. Projects should treat corridor definition as an evidence pack that includes routing assumptions, trade compliance logic and disruption contingencies. This supports finance discussions by reducing unknowns that lenders and offtakers often treat as unpriceable. It also ensures that the chosen processing route remains feasible under real transport and border constraints.

WP16-29, WP16-28

Corridor choices can also shift policy exposure, which affects schedule credibility. OECD documents the increase in export restrictions and a sharp rise in quantitative restrictions, while USGS documents dated policy actions for rare earths and cobalt. If a corridor depends on a jurisdiction that introduces licensing or quotas, then delivery may be delayed even when the mine performs. For schedule credibility, the corridor plan should therefore include dated policy assumptions and the ability to re-route while maintaining product integrity and due diligence alignment. This is not an argument that restrictions will increase in a particular year. It is a demonstration that restrictions have increased historically and that the project has prepared for that operating reality. Schedule credibility is earned through explicit assumptions and defined alternatives, not through confidence statements.

WP16-23, WP16-14, WP16-10

DECISION INSTRUMENT

Corridor evidence pack for finance readiness

A structured list of corridor evidence that supports schedule and capital credibility without adding unverified infrastructure claims.

TEST	EVIDENCE READING	DECISION RESPONSE
Capital context alignment	IEA quantifies large capital requirements under STEPS and APS, and slower investment growth in 2024.	Treat corridor definition as a bankability workstream with named deliverables and dates.
Policy assumption audit	OECD and USGS document restriction growth and specific policy events with dates and quantities.	Include a dated policy log and rerouting triggers in the corridor evidence pack.
Trade compliance mapping	USGS documents duties on active anode material.	Map trade exposure by product form and corridor, and preselect compliant alternatives.
Disruption contingency logic	IEA quantifies disruption risk for copper supply from floods or droughts.	Document contingency routing and inventory strategy that protects qualification batches.

Sources: WP16-29, WP16-28, WP16-23, WP16-10, WP16-12

06

CUSTOMER GATES

Market qualification

Qualification is where projects fail quietly. The market buys a specified, auditable product delivered through acceptable corridors, not a resource. Concentration, trade actions and chemistry shifts raise the value of early qualification planning.

93.50%

US 2025 PRELIMINARY ANTIDUMPING DUTY ON CHINESE ACTIVE ANODE MATERIAL | WP16-12

71%

US IMPORT SOURCES FOR RARE-EARTH COMPOUNDS AND METALS FROM CHINA (2021-24) | WP16-26

Gate

DECISION LABEL: QUALIFICATION PLAN MUST BE EXPLICIT BEFORE SCALING STUDIES | WP16-19

6.1 Qualification starts with product definition and evidence

Qualification is a system gate shaped by concentration. The IEA reports that China is top refiner for 19 of the 20 minerals analysed and processes roughly 60 to 90% of the world's lithium, cobalt and rare earths. When few converters dominate, qualification capacity and acceptance windows can tighten. A project therefore needs an explicit qualification plan that defines product form, specification targets, sample protocols and the sequence of qualification steps. This is not an argument that any specific buyer will behave in a certain way. It is a response to published market structure. A qualification plan also protects technical work from drifting into generic optimisation. It forces each testwork stage to answer a qualification question, such as impurity management or physical property consistency, and it forces routing choices to stay compatible with the identified conversion ecosystems.

WP16-19, WP16-20

Technology shifts amplify the need for explicit product definition. The IEA reports that LFP batteries are now nearly half the electric-car market. USGS reports graphite market and trade data, including China's dominant natural graphite production share and US trade measures on Chinese active anode material in 2025. These facts indicate that qualification can be affected by both end-use shifts and trade settings, even when geology is unchanged. A qualification plan should therefore include alternative product definitions and a clear rule for when to switch between them. For example, a project might need to decide whether to qualify a concentrate, an intermediate chemical, or a more processed material, depending on which form faces lower trade friction and has more conversion options. The dossier does not specify which choice is best. It does justify the need to pre-define the decision logic.

WP16-06, WP16-11, WP16-12

DECISION INSTRUMENT

Qualification plan skeleton

A skeleton structure for a market qualification plan that connects technical evidence to customer and converter acceptance without relying on unverified buyer claims.

TEST	EVIDENCE READING	DECISION RESPONSE
Define product form and spec	Conversion is concentrated, making acceptance windows and qualification capacity important.	Publish a primary spec and secondary spec with a trigger for switching.
Evidence sequence	Qualification depends on consistency and traceability from sample to shipment.	Sequence testwork and sampling to answer qualification-critical questions first.
Trade and routing constraints	USGS documents trade duties on active anode material and high graphite concentration.	Choose a product form that remains viable under plausible trade settings.
Converter and refiner mapping	IEA identifies dominant refining positions and high processing shares.	Map which converters can accept the product and what evidence they require.

Sources: WP16-19, WP16-20, WP16-12, WP16-06

6.2 Trade and import reliance shape qualification pathways

Qualification cannot be separated from trade and sourcing policies. USGS reports that the US is reliant on China as a major source for 14 of 33 critical minerals on which the US most depends on imports, and that rare-earth compounds and metals imports in 2021 to 2024 came 71% from China, 13% from Malaysia, 5% from Japan and 5% from Estonia. These are not project selection criteria by themselves. They show that qualification strategies may be designed around import reliance and the policy responses it triggers. USGS also notes the US Final 2025 List of Critical Minerals and its additions relative to 2022. Such list updates can change which materials are prioritised for domestic policies or procurement. Projects should therefore track list status and import reliance statistics as part of the qualification context, while keeping their claims bounded to what the sources state.

WP16-26, WP16-25

OECD adds a broader lens on trade restrictions. It reports that export restrictions affect 67% of cobalt trade and 46% of rare earth elements trade, and that quantitative restrictions have risen sharply. These quantified exposures indicate that qualification plans must include compliance workstreams, more than technical workstreams. If licensing, quotas or prohibitions can change availability, then buyers may require stronger assurances on continuity and responsible sourcing. A project cannot control external restrictions, but it can control its readiness to respond. Qualification plans should therefore include contingency routes, alternative product forms, and pre-defined communication packages for counterparties when policy changes occur. The goal is to keep the project within qualification tolerance under policy volatility, rather than restarting qualification each time a rule changes.

WP16-24, WP16-23

DECISION INSTRUMENT

Trade-aware qualification decision tree

A decision tree to integrate import reliance, critical mineral list status and export restriction exposure into qualification planning without predicting policy outcomes.

TEST	EVIDENCE READING	DECISION RESPONSE
Import reliance context	USGS reports reliance on China for 14 of 33 critical minerals and provides rare-earth import source shares.	Decide whether the qualification strategy must include non-dominant sourcing narratives and evidence.
List status context	USGS records the US Final 2025 List of Critical Minerals and additions vs 2022.	Track list status and align documentation to the most scrutinised materials.
Export restriction exposure	OECD quantifies trade affected by restrictions for cobalt and rare earth elements and notes a rise in quantitative restrictions.	Build contingency qualification paths that remain compliant under quotas or licensing.
Intermediate-product duty exposure	USGS documents duties on active anode material in 2025.	Select product forms and routes that reduce exposure to duty-sensitive intermediates where possible.

Sources: WP16-26, WP16-25, WP16-24, WP16-12

6.3 Qualification evidence must be auditable and responsible

Responsible sourcing frameworks influence qualification expectations, especially for conflict-affected and high-risk contexts. The OECD Due Diligence Guidance is referenced as a five-step risk-based framework for mineral supply-chain due diligence. The IEA also reports that about 85% of 25 major mining companies disclosed sustainability performance in 2023. These points do not mandate a single reporting format, but they indicate that qualification often requires auditable evidence on supply-chain risk management. A project should therefore build a qualification dossier that includes provenance of samples and shipments, risk assessment logic and management responses. This dossier should be designed for scrutiny and revision, since trade restrictions and policy controls can change, as documented by OECD and USGS. The objective is to make qualification resilient, so that a new compliance question does not force rework of basic technical evidence.

WP16-37, WP16-36, WP16-23

Finance frameworks also interact with qualification because lenders and insurers can require alignment with project-finance E&S standards. IFC Performance Standards and the Equator Principles are cited as reference frameworks, and GISTM is a reference framework for tailings facilities. Even without adding new numeric claims, it is clear that qualification evidence often extends beyond chemistry. For example, a buyer may ask how tailings and environmental controls are managed, or how community and labour risks are assessed. The technical team should therefore structure qualification evidence so that it connects processing choices and corridor plans to due diligence frameworks in plain language. This reduces the risk that late-stage E&S diligence forces changes to processing or routing that would invalidate qualification batches. The dossier supports citing these frameworks qualitatively, so the paper keeps the claim scope to recognition and alignment, not to performance outcomes.

WP16-38, WP16-37

DECISION INSTRUMENT

Qualification dossier contents

A contents checklist for a qualification dossier that can be audited by buyers and financiers while staying within the bounds of established frameworks.

TEST	EVIDENCE READING	DECISION RESPONSE
Due diligence mapping	OECD Due Diligence Guidance provides a five-step framework.	Map supply-chain risks and controls to the five steps and keep evidence links current.
Disclosure readiness	IEA reports high rates of sustainability disclosure among major mining companies.	Prepare a disclosure-ready summary of qualification evidence and risk controls.
E&S framework alignment	IFC Performance Standards, Equator Principles and GISTM are reference frameworks.	Cross-reference processing and corridor decisions to E&S controls to avoid late redesign.
Policy change response	OECD and USGS document restriction growth and dated control events.	Include a procedure for re-validating qualification when policy changes affect routing.

Sources: WP16-37, WP16-36, WP16-38, WP16-23, WP16-14

07

FINANCEABILITY

Capital and policy

Capital formation depends on evidence, contractability and policy risk controls. Recent price moves, investment pacing and the spread of export restrictions mean projects must show disciplined readiness before large commitments.

~USD 500 billion

MINING CAPITAL REQUIRED 2024-2040 UNDER STEPS | WP16-29

More than fivefold

INCREASE IN EXPORT RESTRICTIONS SINCE 2009 (INVENTORY THROUGH END-2023) | WP16-23

Gate

DECISION LABEL: FINANCE TERMS FOLLOW EVIDENCE MATURITY, NOT NARRATIVE STRENGTH | WP16-28

7.1 Capital competes across projects, not across resources

The IEA quantifies mining capital required from 2024 to 2040 at about USD 500 billion under STEPS and about USD 600 billion under APS, about 15% higher. It also reports that mining investment growth slowed to 5% in 2024, about 2% in real terms after cost inflation. These numbers do not describe any single balance sheet. They frame a system where capital is scarce relative to ambition and where diligence pressure increases when real growth is modest. In this setting, financeability depends on evidence maturity across the supply system, including corridor definition, processing route evidence and qualification plans. Projects that remain framed only as geological opportunities struggle to compete because financiers need to see how the asset becomes a tradable, compliant product under volatility. The appropriate response is a staged evidence plan that ties each dollar of study spend to a specific de-risking outcome relevant to qualification and routing.

WP16-29, WP16-28

Shortfall statements reinforce why capital focuses on readiness. The IEA reports announced-project shortfalls versus projected demand by 2035 of about 30% for copper and about 40% for lithium under its scenario framing. This does not mean any project will be funded automatically. It means the system must translate a large pipeline into delivered supply, which requires that projects clear technical and commercial gates faster and with fewer late-stage resets. Financing therefore rewards projects that can demonstrate decision quality early, including clear product definition, credible conversion routing and policy-aware contingency planning. The evidence dossier also includes quantified disruption exposure for copper supply in 2024. That exposure can show up in diligence as a requirement for corridor resilience planning. Financeability is therefore earned through explicit interfaces and controlled assumptions, not through optimism about macro shortfalls.

WP16-30, WP16-32

DECISION INSTRUMENT

Financeability gate stack

A gate stack that links capital commitments to evidence maturity across the supply system, consistent with published investment and shortfall context.

TEST	EVIDENCE READING	DECISION RESPONSE
Gate 1: product and qualification definition	Concentration implies limited qualification routes and higher cost of failure.	Do not seek major capital commitments without a written qualification plan and evidence sequence.
Gate 2: processing route evidence	Conversion chokepoints and high-purity reagent concentration shape feasibility.	Advance only when testwork supports a credible product spec and routing option set.
Gate 3: corridor definition and disruption contingency	Disruption exposure is quantified for copper supply at global scale.	Require corridor plans with contingency logic before long-lead commitments.
Gate 4: policy and trade scenario readiness	Export restrictions have risen sharply and affect large shares of trade for some minerals.	Include policy scenarios and rerouting triggers in the investment case.

Sources: WP16-19, WP16-22, WP16-32, WP16-23

7.2 Policy instruments can change supply and finance terms quickly

OECD reports that export restrictions on industrial raw materials rose more than fivefold since 2009 and that in 2023 over 500 new raw-mineral products were newly affected. It also quantifies the share of trade affected by an export restriction for cobalt at 67% and for rare earth elements at 46%, and notes a sharp rise in quantitative restrictions such as prohibitions and quotas. These rows establish that policy instruments have become widespread and can materially affect trade. For capital providers, this translates into questions about contract enforceability, routing optionality and compliance costs. For project teams, the required response is disciplined scenario documentation. It is not enough to say policy risk exists. The investment case should show how the project can remain compliant and deliverable if licensing, quotas or prohibitions change. The evidence base should include dated assumptions and a process to update them as new restrictions appear.

WP16-23, WP16-24

USGS provides examples of dated, commodity-specific policy actions. For cobalt, it records a temporary export ban in the DRC in February 2025 and a later replacement with export quotas for contained cobalt for the rest of 2025 and up to 96,600 t per year in 2026 and 2027, including a national strategic reserve quantity. For rare earths, it records tightening export controls in China in April 2025, later expansion in October, and a one-year suspension of the October controls from November 2025, while April controls remained in effect. These are concrete policy mechanisms with dates and quantities. They justify treating policy change as a design input for financeability, including stress tests for inventory, alternative customers and alternative product forms. The dossier does not justify predicting next actions. It does justify building readiness for them.

WP16-10, WP16-14

DECISION INSTRUMENT

Policy readiness annex for investment cases

A structured annex outline to include in investment cases so policy risk is handled as a set of mechanisms with triggers, not as a generic disclaimer.

TEST	EVIDENCE READING	DECISION RESPONSE
Restriction mechanism inventory	OECD identifies export taxes, licensing and rising quantitative restrictions.	List which mechanisms could apply to the product and where they would bind the value chain.
Commodity-specific event log	USGS documents dated cobalt quota regime and rare-earth export control changes in 2025.	Maintain a dated log and link each event type to an action in the commercial plan.
Trade and duty exposure	USGS documents duties on active anode material in 2025.	Model alternative product forms and routes with lower duty exposure where feasible.
N-1 stress linkage	IEA N-1 framing shows limited replacement supply in 2035 for some minerals.	Where redundancy is limited, require stronger policy contingency evidence before financing.

Sources: WP16-23, WP16-10, WP16-14, WP16-12, WP16-31

7.3 Standards alignment is a condition for capital access

Responsible sourcing and E&S standards are now embedded in many qualification and finance processes. The OECD Due Diligence Guidance is referenced as a five-step risk-based framework for mineral supply-chain due diligence. IFC Performance Standards and the Equator Principles are referenced as project-finance E&S frameworks, and GISTM is referenced for tailings facilities. The dossier treats these as qualitative framework references, and the paper keeps them in that role. For capital and policy readiness, the implication is that projects should structure their evidence so it can be mapped to these frameworks without rework. This includes documenting governance, risk assessment and mitigation actions tied to processing and corridor decisions. It also includes supply-chain traceability evidence that can withstand scrutiny when trade restrictions and policy controls change. Standards alignment does not replace technical performance, but it can determine whether technical performance can be financed and sold.

WP16-37, WP16-38

Disclosure trends support the same conclusion. The IEA reports that about 85% of the 25 major mining companies disclosed sustainability performance in 2023. This does not mean all disclosures are equivalent, and the dossier does not evaluate their quality. It does indicate that disclosure has become normal practice among major operators, which can shape counterparties' expectations for transparency. For projects seeking capital, this trend means that evidence packaging matters. Technical work should be presented in a way that supports disclosure and diligence, including traceable data lineage and clear boundaries on what has and has not been tested. This also supports policy engagement. When governments update critical mineral lists or impose restrictions, projects with clear evidence packs can respond faster and with fewer contradictions. Capital follows clarity under uncertainty, because it reduces the risk of later disputes over what was assumed and why.

WP16-36, WP16-25

DECISION INSTRUMENT

Standards alignment checklist for capital access

A decision checklist for aligning project evidence with due diligence and finance frameworks, consistent with documented disclosure trends.

TEST	EVIDENCE READING	DECISION RESPONSE
Supply-chain due diligence mapping	OECD Due Diligence Guidance is a reference five-step framework.	Create a crosswalk from project controls to the five steps and keep it current.
E&S framework readiness	IFC Performance Standards and Equator Principles are reference frameworks.	Ensure processing and corridor plans include E&S control evidence suitable for lender review.
Tailings governance readiness	GISTM is a reference framework for tailings facilities.	Establish governance and evidence expectations for tailings early in process selection.
Disclosure packaging	IEA reports high disclosure prevalence among major mining companies.	Package evidence so it can be disclosed and audited without overclaiming outcomes.

Sources: WP16-37, WP16-38, WP16-36

08

INTEGRATION TOOL

The supply-readiness matrix

A supply-readiness matrix makes coupled constraints visible and actionable. It helps teams avoid advancing one dimension, such as resource size, while others, such as qualification and corridors, lag and later force resets.

Matrix

DECISION LABEL: USE A MATRIX, NOT A SINGLE READINESS SCORE | WP16-18

N-1

STRESS LENS TO TEST REDUNDANCY AND ROUTING OPTIONS | WP16-31

Scope

DECISION LABEL: READINESS SCOPE MUST COVER MINE-TO-MARKET INTERFACES | WP16-19

8.1 Define the matrix dimensions from published constraints

The matrix dimensions should be derived from published constraints, not from internal preference. Demand growth under the IEA stated scenario framing, concentration in mining and refining, and the N-1 supply security stress framing together define why multiple dimensions matter. If lithium demand grows fivefold under STEPS to 2040 and refining remains concentrated with a top-three share of 86% in 2024, then readiness must include qualification and conversion routing, more than geology and mining. If the N-1 stress indicates that supplies outside the leading producer meet only about half of remaining demand on average in 2035, then redundancy and alternative routing must also be scored. The matrix is not a forecast. It is a governance tool to keep decisions consistent with published system constraints and to prevent late-stage surprises at interfaces.

WP16-01, WP16-18, WP16-31

Policy and volatility should be explicit matrix dimensions because they have documented, dated effects. OECD reports a more than fivefold increase in export restrictions since 2009 and a sharp rise in quantitative restrictions, while USGS documents specific quotas and export controls with dates for cobalt and rare earths. The IEA documents price declines for several minerals in 2024 and slower investment growth. These facts justify a readiness dimension for assumption control. A project that cannot track and update policy, trade and price assumptions will struggle to defend its plans to counterparties. Therefore, the matrix should include an assumption audit column that records scenario labels, vintage and the evidence row IDs supporting each key assumption. This keeps the readiness discussion factual and reduces the risk of mixing incompatible vintages, which the dossier explicitly flags as a risk in some share comparisons.

WP16-23, WP16-10, WP16-27, WP16-28

DECISION INSTRUMENT

Supply-readiness matrix dimensions

A dimension set for a readiness matrix derived directly from published demand, concentration, policy and volatility constraints. Use as the top-level governance view.

TEST	EVIDENCE READING	DECISION RESPONSE
Demand and product definition	IEA reports strong demand growth under STEPS and technology adoption changes such as LFP share increase.	Define product spec and customer class before scaling studies.
Resource and data confidence	Investment pacing and diligence pressure increase when real investment growth is modest.	Tie data collection to upcoming decisions and qualification needs.
Processing and conversion routing	Refining is concentrated and China is described as top refiner for 19 of 20 minerals analysed.	Require at least two conversion routes with evidence-backed feasibility.
Policy, trade and assumption control	OECD and USGS document rising restrictions and specific dated control events; IEA documents price volatility.	Maintain a dated assumption log with triggers and rerouting actions.

Sources: WP16-01, WP16-06, WP16-28, WP16-19, WP16-23

8.2 Score readiness as gates with evidence, not as narratives

Scoring should use gates, because gates force evidence discipline. For example, a processing gate can be set as evidence that a defined product form can be qualified through at least one realistic converter route given current concentration data. A corridor gate can be set as evidence that delivery can be sustained under disruption exposure, supported by the IEA statistic that 7% of global copper supply was at risk from floods or droughts in 2024. A policy gate can be set as evidence that the project has a dated log of relevant restriction mechanisms and a rerouting playbook, supported by OECD and USGS policy rows. These gates are not numeric performance promises. They are yes or no decisions about whether evidence is sufficient to proceed without creating hidden schedule risk. Gate language also helps align technical and commercial teams, because it makes clear which evidence closes which risk.

WP16-19, WP16-32, WP16-23

The N-1 stress lens can be used as a matrix stress test. The IEA reports that under N-1, supplies outside the leading producer meet only about half of remaining demand on average in 2035, with graphite and rare earths only 35 to 40%. This statement supports a practical scoring rule. If a mineral sits in a low-redundancy category, then the readiness matrix should require stronger evidence of alternative routing and qualification before advancing to high-cost commitments. The same rule can be applied when trade friction is documented, such as the USGS duties on active anode material. The point is to adjust evidence thresholds to the documented system constraint, not to apply a one-size standard. This also reduces the risk of over-investing in resource expansion when the true bottleneck is qualification or corridor resilience.

WP16-31, WP16-12

DECISION INSTRUMENT

Gate-based scoring rubric

A rubric for scoring each matrix dimension as a gate with explicit evidence requirements tied to published constraints, not to subjective confidence.

TEST	EVIDENCE READING	DECISION RESPONSE
Gate: qualification path exists	Refining and processing are concentrated, limiting qualification routes.	Proceed only with a documented qualification plan and identified converters.
Gate: corridor is defined and resilient	IEA quantifies disruption exposure for copper supply from floods or droughts.	Proceed only with a corridor plan that includes contingencies and custody checkpoints.
Gate: policy scenarios are documented	OECD and USGS document restriction growth and specific quota and control actions.	Proceed only with a dated assumption log and rerouting triggers.
Gate: redundancy matches N-1 stress	N-1 indicates limited replacement supply for some minerals by 2035.	Raise evidence thresholds for minerals with low redundancy and high concentration.

Sources: WP16-19, WP16-32, WP16-23, WP16-31

8.3 Use the matrix to manage portfolios and sequencing

The matrix becomes most useful when it governs sequencing across a portfolio. USGS shows that different minerals have different production concentration and policy contexts, including DRC dominance in cobalt, China dominance in graphite production and strong shares in rare earths, and Indonesia dominance in nickel mine output in 2025 estimates. The matrix can therefore prevent false equivalence across projects by applying different evidence thresholds where the system constraint is tighter. For example, a graphite project may face different qualification and trade dynamics than a copper project, even if both are geologically attractive. The matrix also supports diversification planning by using published production and resource context for regions, including African production and lithium resource rows. This allows portfolio decisions to be grounded in published context while keeping project claims bounded to evidence. The portfolio outcome is a staged pipeline where each project advances only when its system interfaces are ready.

WP16-09, WP16-11, WP16-15, WP16-33

Sequencing should also reflect capital and policy timing. The IEA investment and capital requirement rows suggest a competitive environment for capital, while OECD and USGS policy rows show that restrictions can change quickly and with dated horizons. Therefore, portfolio sequencing should prioritise work that raises financeability across multiple scenarios, such as building qualification dossiers aligned to due diligence frameworks, and defining corridor alternatives that can absorb policy shocks. The matrix can encode this by awarding readiness only when assumptions are traceable and scenario-labelled. It can also prevent teams from advancing to engineering detail when basic routing or policy gates remain open. This discipline is not bureaucratic. It is the practical response to a system where supply is constrained by interfaces and where shocks can raise costs quickly, including the IEA statement that a supply shock could raise battery-pack prices 40 to 50%. That specific consequence reinforces why readiness must be proven before exposure is taken.

WP16-29, WP16-23, WP16-10, WP16-31

DECISION INSTRUMENT

Portfolio sequencing using the readiness matrix

A portfolio-level decision instrument that uses the readiness matrix to sequence work and capital allocation under concentration, policy and volatility constraints.

TEST	EVIDENCE READING	DECISION RESPONSE
Sequence by bottleneck, not by discovery date	Different minerals sit in different concentration and redundancy contexts.	Advance the projects that have the fewest open interface gates, regardless of resource size narratives.
Prioritise scenario-resilient work	Export restrictions have increased and can be quota-based; investment growth slowed in real terms.	Fund work that improves routing optionality and assumption control across scenarios first.
Embed due diligence frameworks early	OECD Due Diligence Guidance and IFC Performance Standards are reference frameworks.	Require a due diligence and E&S evidence plan before large qualification commitments.
Stress test with N-1 and shock consequence	IEA N-1 framing and battery-pack price shock consequence describe system sensitivity.	If shock sensitivity is high, require stronger redundancy and contingency evidence before scale-up.

Sources: WP16-11, WP16-31, WP16-23, WP16-28, WP16-37

Decision checklist

Use these questions before the next gate, assurance review or capital commitment.

01 State the target product form and specification before committing to large testwork spend.

02 Map at least two credible conversion and refining routes that can accept the target product form.

03 Define corridor plans from mine to converter, including custody and quality verification points.

04 Maintain a dated log of policy and trade assumptions and link each to a rerouting action.

05 Set gate-based evidence thresholds for resource confidence, processing readiness and qualification readiness.

06 Align supply-chain documentation to the OECD Due Diligence Guidance five-step framework.

07 Screen processing and corridor options against project-finance E&S frameworks and tailings governance expectations.

08 Use N-1 style stress thinking to test redundancy and contingency plans for minerals with high concentration.

09 Keep scenario labels and vintage dates attached to all macro assumptions used in decisions.

10 Do not advance to capital commitments while any interface gate remains open without a documented mitigation plan.

11 Re-validate qualification and corridor plans when trade duties, quotas or export controls change.

12 Package evidence so it can be audited and disclosed without overclaiming outcomes.

Evidence ledger 1 of 2

Only dossier rows used in this edition are listed. Concise excerpts identify each registered statement; the source audit retains the complete dossier reference.

ROW	REGISTERED EVIDENCE EXCERPT	REGISTERED SOURCE
WP16-01	Under STEPS to 2040: lithium demand grows fivefold; graphite and nickel demand roughly double; cobalt and rare earths +50 to 60%; copper +30%	IEA, Global Critical Minerals Outlook, 2025 (Stated Policies Scenario)
WP16-02	2024 outturn: lithium demand rose nearly 30% (vs ~10%/yr through the 2010s); nickel, cobalt, graphite and rare earths each +6 to 8%	IEA, Global Critical Minerals Outlook, 2025
WP16-03	Battery metals (lithium, nickel, cobalt, graphite): the energy sector accounted for 85% of total demand growth	IEA, Global Critical Minerals Outlook, 2025
WP16-06	LFP batteries now nearly half the electric-car market, up from under 10% in 2020	IEA, Global Critical Minerals Outlook, 2025
WP16-07	Lithium: world mine production (excl. US) rose 31% to ~290,000 t in 2025 (from 222,000 t 2024); consumption 263,000 t (+20%); world reserves 37,000,000 t. Leading producers 2025:...	USGS, Mineral Commodity Summaries, 2026
WP16-08	Lithium prices 2025: China spot lithium carbonate c.i.f. rose from ~$9,300/t (Jan) to ~$10,300/t (Nov); US fixed-contract carbonate averaged $9,000/t, down 31% on 2024; Australian...	USGS, Mineral Commodity Summaries, 2026
WP16-09	Cobalt: DRC the leading mine source, ~73% of world total (230,000 t of 310,000 t 2025); Indonesia 14% (44,000 t); world reserves 12,000,000 t (DRC 6,000,000 t). China the leading...	USGS, Mineral Commodity Summaries, 2026
WP16-10	Cobalt policy: in February 2025 DRC temporarily banned cobalt exports; in October replaced it with export quotas of 18,125 t contained cobalt for the rest of 2025 and up to 96,600...	USGS, Mineral Commodity Summaries, 2026
WP16-11	Graphite (natural): China ~82% of world production (1,400,000 t of 1,800,000 t 2025); world reserves 310,000,000 t. Tanzania more than doubled output to 75,000 t; Mozambique...	USGS, Mineral Commodity Summaries, 2026
WP16-12	Graphite trade friction: US 2025 preliminary antidumping duty on Chinese active anode material 93.50%, countervailing 11.58% to 721.03% by company; China exported 115,000 t...	USGS, Mineral Commodity Summaries, 2026
WP16-13	Rare earths: China ~69% of mined production (270,000 t of 390,000 t 2025); world reserves >75,000,000 t (China 44,000,000 t); US mined 51,000 t REO valued $240 m	USGS, Mineral Commodity Summaries, 2026
WP16-14	Rare-earths policy: April 2025 China tightened export controls (samarium, gadolinium, terbium, dysprosium, lutetium, scandium, yttrium); October expanded to europium, holmium,...	USGS, Mineral Commodity Summaries, 2026
WP16-15	Nickel: world mine production +5% to ~3,900,000 t 2025; Indonesia 2,600,000 t (~67%), +13%; Australia -54% (care and maintenance); Philippines -24%; world reserves >140,000,000 t...	USGS, Mineral Commodity Summaries, 2026
WP16-16	Copper: world mine production ~23,000,000 t, refinery production ~29,000,000 t 2025; leading refiners Chile, China (refinery 14,000,000 t), DRC 3,200,000 t mine; world reserves...	USGS, Mineral Commodity Summaries, 2026
WP16-17	Copper price: COMEX projected to average a record $4.80/lb in 2025, +14% on $4.22/lb 2024, attributed largely to US copper-tariff uncertainty	USGS, Mineral Commodity Summaries, 2026
WP16-18	Average market share of the top three mining countries rose from 73% (2020) to 77% (2024); of the top three refining nations from ~82% (2020) to 86% (2024)	IEA, Global Critical Minerals Outlook, 2025
WP16-19	China is the top refiner for 19 of the 20 minerals analysed; refining share projected to move from ~45% toward ~50%	IEA, Global Critical Minerals Outlook, 2025
WP16-20	China processes roughly 60 to 90% of the world's lithium, cobalt and rare earths	IEA, Global Critical Minerals Outlook, 2025

Evidence ledger 2 of 2

Only dossier rows used in this edition are listed. Concise excerpts identify each registered statement; the source audit retains the complete dossier reference.

ROW	REGISTERED EVIDENCE EXCERPT	REGISTERED SOURCE
WP16-21	By 2035 the top-three refined-material share is projected to decline only marginally, to 82%	IEA, Global Critical Minerals Outlook, 2025 (STEPS)
WP16-22	China produces 75% of the world's purified phosphoric acid and 95% of high-purity manganese sulphate; two-thirds of global battery-recycling capacity growth since 2020 has been in...	IEA, Global Critical Minerals Outlook, 2025
WP16-23	Export restrictions on industrial raw materials rose more than fivefold since 2009 (inventory through end-2023); in 2023 over 500 new raw-mineral products were newly affected,...	OECD, Inventory of Export Restrictions on Industrial Raw Materials, 2025
WP16-24	Trade affected by an export restriction: cobalt 67%, rare earth elements 46%; export taxes and licensing most common, with a sharp rise in quantitative restrictions (prohibitions...	OECD, Inventory of Export Restrictions on Industrial Raw Materials, 2025
WP16-25	US Final 2025 List of Critical Minerals published 7 November 2025 (90 FR 50494); additions vs the 2022 list: copper, lead, potash, rhenium, silicon, silver, plus boron,...	USGS, Mineral Commodity Summaries, 2026
WP16-26	US critical-minerals import reliance: reliant on China as a major source for 14 of the 33 critical minerals on which the US most depends on imports; rare-earth compounds and...	USGS, Mineral Commodity Summaries, 2026
WP16-27	2024 prices: lithium fell over 80% since 2023; graphite, cobalt and nickel fell 10 to 20% in 2024	IEA, Global Critical Minerals Outlook, 2025
WP16-28	Mining investment growth slowed to 5% in 2024 (from 14% in 2023); ~2% in real terms after cost inflation	IEA, Global Critical Minerals Outlook, 2025
WP16-29	Mining capital required 2024 to 2040: ~USD 500 billion (STEPS); ~USD 600 billion (APS), about 15% higher	IEA, Global Critical Minerals Outlook, 2025 (scenario labels mandatory)
WP16-30	2035 announced-project shortfalls vs projected demand: copper ~30%; lithium ~40%	IEA, Global Critical Minerals Outlook, 2025
WP16-31	Supply security (N-1): supplies outside the leading producer meet on average only half of remaining demand in 2035; graphite and rare earths only 35 to 40%; lithium and cobalt...	IEA, Global Critical Minerals Outlook, 2025
WP16-32	7% of global copper supply was at risk of disruption from floods or droughts in 2024	IEA, Global Critical Minerals Outlook, 2025
WP16-33	African producers on the 2025 board: DRC cobalt 230,000 t (73% of world) and copper mine 3,200,000 t; Zimbabwe lithium 28,000 t and Mali 9,400 t (from 770 t 2024); Tanzania...	USGS, Mineral Commodity Summaries, 2026
WP16-34	African lithium resources: DRC 3,000,000 t, Zimbabwe 860,000 t, Ghana 200,000 t, Mali 1,200,000 t, Namibia 230,000 t (measured and indicated)	USGS, Mineral Commodity Summaries, 2026
WP16-35	Zambia copper mine production 940,000 t 2025 (from 823,000 t 2024); reserves 21,000,000 t	USGS, Mineral Commodity Summaries, 2026
WP16-36	~85% of the 25 major mining companies disclosed sustainability performance in 2023, up from 60% in 2020	IEA, Global Critical Minerals Outlook, 2025
WP16-37	OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas: the reference five-step risk-based framework for mineral...	OECD, Due Diligence Guidance for Responsible Mineral Supply Chains (framework reference)
WP16-38	IFC Performance Standards on Environmental and Social Sustainability (PS1 to PS8) and the Equator Principles: the reference project-finance E&S framework; Global Industry Standard...	IFC Performance Standards; GISTM (framework references)

Glossary

STEPS

IEA Stated Policies Scenario used in the IEA Global Critical Minerals Outlook 2025.

APS

IEA Announced Pledges Scenario used in the IEA Global Critical Minerals Outlook 2025.

N-1 stress (supply security)

IEA stress framing that tests supply security if the leading producer is removed from supply.

Qualification

The set of technical, commercial and compliance steps required for a material to be accepted as a specified product by downstream converters and buyers.

Export restriction

OECD inventory category covering policy measures such as export taxes, licensing and quantitative restrictions that affect trade in raw materials.

Due diligence (minerals supply chain)

Risk-based process referenced in the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas.

IFC Performance Standards and Equator Principles

Reference frameworks for environmental and social requirements commonly used in project finance.

GISTM

Global Industry Standard on Tailings Management, a reference framework for tailings facilities governance.

LFP

Lithium iron phosphate battery chemistry referenced by IEA adoption statistics for the electric-car market.

Converter

Downstream facility that transforms mined or refined materials into higher-purity chemicals or intermediate products used in manufacturing supply chains.

Refining concentration

The degree to which refining capacity is held by a small number of countries, as quantified by IEA top-three share statistics.

Trade duty

Tariff measure applied to imported goods, referenced in USGS reporting on duties for active anode material in 2025.

Critical minerals list

A government-published list identifying minerals considered critical, referenced by USGS for the US Final 2025 List of Critical Minerals.

Supply-readiness matrix

A governance tool that scores readiness across multiple coupled dimensions, such as resource confidence, processing route evidence, corridor readiness, qualification plan maturity and policy scenario control.

Battery metals

Lithium, nickel, cobalt and graphite, referenced by IEA as the set where the energy sector accounted for 85% of demand growth.

High-purity manganese sulphate

Conversion product referenced by IEA as having highly concentrated production in China.

Purified phosphoric acid

Conversion product referenced by IEA as having highly concentrated production in China.

Quantitative restriction

Export restriction type including prohibitions and quotas, referenced by OECD as rising sharply.

References and limitations

International Energy Agency (IEA) (2025)

Global Critical Minerals Outlook 2025. Scenario references include STEPS and APS; includes concentration, demand growth, investment and N-1 stress framing.

United States Geological Survey (USGS) (2026)

Mineral Commodity Summaries 2026. Commodity summaries for lithium, cobalt, graphite, rare earths, nickel and copper, including production, reserves, prices and dated policy events.

Organisation for Economic Co-operation and Development (OECD) (2025)

Inventory of Export Restrictions on Industrial Raw Materials 2025. Inventory through end-2023; includes quantified growth in restrictions and trade affected.

World Bank (2020)

Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. Vintage-labelled framing for mineral demand to 2050 and relative emissions footprint.

Organisation for Economic Co-operation and Development (OECD) (n.d.)

Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. Referenced as the five-step risk-based due diligence framework.

International Finance Corporation (IFC) (n.d.)

Performance Standards on Environmental and Social Sustainability (PS1 to PS8). Referenced as a project-finance environmental and social framework.

Equator Principles Association (n.d.)

The Equator Principles. Referenced as a project-finance environmental and social framework.

Global Tailings Management Institute and partners (n.d.)

Global Industry Standard on Tailings Management (GISTM). Referenced as a tailings facilities governance framework.

USE LIMITATIONS

- All quantitative statements are restricted to the WP16 evidence dossier row IDs listed in each paragraph, exhibit and key figure. No additional numbers, forecasts or jurisdiction-specific claims are introduced.
- World Bank mineral-demand statements are vintage-labelled (2020) and are not updated or re-forecast in this paper.
- Price information is limited to public point indications reported by USGS and selected IEA statements on year-on-year movements; no proprietary continuous price series is used.
- Concentration shares and production shares are presented with source and vintage context. Where different sources use different vintages or methods, the paper does not blend them and does not infer reconciled values.
- Framework references to OECD Due Diligence Guidance, IFC Performance Standards, Equator Principles and GISTM are qualitative only. The paper does not attach unverified performance claims to these frameworks.
- Policy events reported by USGS are treated as dated and commodity-specific. The paper does not predict future policy actions beyond the recorded dates, quantities and statuses provided in the dossier.

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