Critical Minerals Traceability for Energy and Economic Security

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Source: IEA.
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Website: www.iea.org

Acknowledgements

This report was prepared by the International Energy Agency's (IEA) Office of the Legal Counsel, the Office of the Chief Energy Economist of the Directorate of Sustainability, Technology and Outlooks, as well as other IEA units. The lead authors are **Félix Gagnon**, **Alexandra Hegarty** and **Joyce Raboca**, with valuable guidance from K.C. Michaels and Tae-Yoon Kim. Tim Gould provided indispensable feedback.

Nicolas Moinier provided valuable contributions. Zuzana Nohova provided essential support. The report was copyedited by Adam Majoe. Thanks also to the IEA Communications and Digital Office for their help in producing the report, particularly Jethro Mullen, Curtis Brainard, Astrid Dumond, Liv Gaunt, Julia Horowitz, Oliver Joy, Poeli Bojorquez, Irina Paun and Grace Gordon.

This report draws on the results from a survey jointly designed and administered by the IEA and the Organisation for Economic Co-operation and Development (OECD). For the purposes of this report, the IEA analysis includes responses collected between October and December 2025. The OECD extended the survey until January 2026 and will release a separate report on the role of traceability in supporting resilient and responsible supply chains. The present report was prepared with input from the IEA's Critical Minerals Working Party (CMWP).

Many experts from outside of the IEA provided essential input and/or reviewed preliminary drafts of the report. Their comments and suggestions were of great value. They include:

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Mélanie Blanc	America Government of Switzerland
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Executive summary

Risks to energy and economic security from high levels of concentration in critical mineral supply chains became a reality in 2025. All of the IEA's six focus minerals – copper, lithium, nickel, cobalt, graphite and rare earth elements – are set to see strong demand growth, driven by their central role in energy and strategic industrial applications. Yet diversification has lagged demand, with processing and refining remaining highly concentrated. Risks from concentration materialised in 2025 as new export controls threatened the supply of materials critical to strategic and economically important industries.

Recent years have seen a proliferation of new policies and strategies to address these security risks. Policy approaches differ across countries, reflecting variations in their strategic priorities. Producing countries tend to adopt policies that encourage domestic projects or enhance domestic oversight over use of mineral resources. Consuming countries, by contrast, have focused more on reducing concentration, enabling diversification and promoting responsible practices across global mineral supply chains, often through introduction of sourcing requirements.

Traceability is a foundational tool for implementing effective policies. It enables governments and companies to track where minerals originate, how they move through supply chains, who has custody of them and how they are transformed. Traced material can have further data attached – such as sustainability or quality attributes – which can become relevant depending on the policy objective. Together, these data can underpin measures contingent on origin or performance, such as diversified sourcing incentives, requirements linked to responsible production and conditions attached to public finance and procurement.

The IEA and the OECD conducted a joint survey on traceability with more than 80 respondent companies active in critical mineral supply chains. Based on insights from the survey, this report sets out the current state of play and identifies priority actions to strengthen the role of traceability in supporting energy and economic security. The OECD is set to release a separate report on the role of traceability in supporting resilient and responsible supply chains.

Companies have begun implementing traceability systems, but uptake remains uneven across minerals, regions and supply chain segments. Based on the IEA-OECD joint survey, two-thirds of respondent companies report having some form of traceability system – 30% with full coverage and 40% across selected minerals or supply chains. Upstream companies are implementing traceability systems at twice the rate of downstream and midstream actors. Adoption across all supply chain segments is most advanced in cobalt supply chains, reflecting long-standing efforts to improve visibility, followed by graphite and copper. Lithium and nickel supply chains see the strongest adoption in the upstream, where around 50% of companies reported having a traceability system. Companies operating in rare earth supply chains show strong future intent to implement traceability, driven by growing geopolitical concerns, although implementation has so far been constrained by persistent structural challenges.

While adoption of traceability systems is relatively high, depth and end-to-end coverage remain limited. Nearly all companies with traceability systems report collecting country of origin data, while more detailed provenance information is less widely covered. Corporate transparency or environmental data collection are collected at around half the rate. Companies in the midstream and downstream segments report environmental indicators at higher rates than those in the upstream, reflecting greater exposure to regulatory pressures in key consuming countries. End-to-end traceability nevertheless remains limited, with coverage typically dropping sharply beyond companies' direct suppliers, underscoring ongoing challenges in extending implementation across multiple tiers of the supply chain.

Companies adopt traceability for different reasons, reflecting their position in the value chain and exposure to risk. Nearly two thirds of surveyed companies cite brand or reputational considerations and customer demand among their top three drivers, while over 40% cite compliance with regulatory requirements. Downstream companies are primarily driven by market-facing pressures linked to product sales, whereas upstream companies are more strongly motivated by regulatory compliance. This reflects differing exposure to consumer scrutiny, risk and market access conditions along the supply chain. Survey responses also indicate that traceability can serve as a de-risking mechanism to attract investment, particularly in more nascent supply chains, such as graphite, rare earths and lithium, where respondents more often cited geopolitical risk management and investor obligations as key drivers.

Traceability is beginning to support market differentiation, but price signals remain weak. Only one quarter of surveyed companies reported receiving some form of premium for differentiated materials, either linked to verified origin or to specific performance-related attributes such as low-emissions production or social audit certification. This suggests that while traceability can already support differentiated sourcing, price signals are not yet sufficiently widespread or consistent to drive market-based sourcing decisions at scale. This pattern is reflected in current traceability data collection practices. Most surveyed companies collect core data elements on provenance and ownership that provide a foundation for policy tools that support diversification based on origin (e.g.

sourcing requirements). Far fewer collect environmental, social or corporate transparency data, which would be necessary to underpin a broader range of policy approaches, such as standards-based markets.

Cost, lack of interoperability and limited incentives for sharing information are significant barriers that continue to constrain the scaling of traceability systems. High implementation costs were selected as the primary barrier by over half of surveyed companies, reflecting the substantial upfront investment required for digital infrastructure, system integration and staff capacity. Companies also cite limited interoperability between systems, commercial confidentiality concerns and weak incentives to share information beyond suppliers as key challenges. These challenges are not evenly distributed across the supply chain: constraints are particularly acute at the midstream stage, where blending, aggregation and commercial sensitivities frequently create bottlenecks for data transmission and chain-of-custody along the supply chain.

Government actions can help to support wider uptake of traceability systems. Around three-quarters of surveyed companies indicate that they are willing to increase investment in traceability over the next three years. A phased approach can help translate growing momentum into practical outcomes, focusing initial efforts on a few mineral supply chains with greater ease of implementation. This can help identify challenges and implement improvements. Over time, measures can be introduced in more complex supply chains and with other data fields. As traceability systems mature, governments can leverage verified supply chain data to enable mechanisms that reward diversified and responsible production. This report presents five recommendations for policymakers:

1. **Strengthen incentives for collecting and sharing verified data across the supply chain,** combining regulatory and financial or market-based measures.
2. **Provide financial support for traceability infrastructure,** lowering upfront and operational costs particularly for upstream and smaller actors.
3. **Collaborate at the international level to harmonise traceability standards,** improving interoperability, comparability and trust between market actors and across jurisdictions.
4. **Enhance co-operation between upstream and downstream jurisdictions,** including through technical assistance and shared platforms.
5. **Adopt a pragmatic approach focusing on less complex supply chains and an initial set of core data elements,** scaling up to more complex supply chains and additional data fields over time.

Background

High concentration of mineral supply chains

Critical minerals are vital for both energy and economic security. Each of the six focus minerals identified by the International Energy Agency (IEA) – copper, lithium, nickel, cobalt, graphite and rare earth elements – plays a vital role in energy and strategic sectors, with demand set to rise rapidly over the coming years.

Diversification is the backbone of energy security. However, concentration in critical mineral supply chains has never been higher, particularly in processing and refining. In 2024, the market share of the top three refining countries for key energy minerals was 86%, up from 82% in 2020. People's Republic of China (hereafter: China) is the leading refiner for 19 out of a broader set of 20 strategic materials,[1] with an average market share of 70%. Mining and refining concentration is expected to remain high for most energy minerals over the coming decade, making the associated risks increasingly difficult to ignore.

High concentration in mining and refining operations poses risks for energy and national security, as it increases vulnerability to supply shocks, particularly when supply from a top producing country is disrupted by natural disasters, social unrest, trade measures or geopolitical tensions. Governance-related shocks can further amplify these risks. Enforcement actions against illegal mining, regulatory non-compliance or corruption can trigger abrupt facility closures, temporarily removing large volumes of supply from the market. Potential disruptions can significantly impact strategic sectors such as energy, automotive, defence and artificial intelligence data centres, with cascading effects on technology prices, inflation, manufacturing competitiveness and the broader economy.

This is no longer a hypothetical concern, with half of the 20 strategic minerals already subject to some form of export controls. The rare earth export controls introduced in April 2025 have already forced some automotive factories around the world to cut utilisation rates or even temporarily shut down. If the export controls subsequently announced and then suspended in October 2025 were fully enacted, the economic value of downstream production at risk would reach USD 6.5 trillion per year for countries outside China, amounting to almost 10% of their combined annual gross domestic product.

[1] These minerals include gallium, graphite, manganese, rare earths, silicon, molybdenum, cobalt, tellurium, antimony, germanium, indium, lithium, titanium, vanadium, tantalum, tungsten, copper, nickel, chromium, and zirconium.

Understanding traceability

Traceability refers to the capacity to track and verify a product's provenance and is usually understood as the ability to track four elements: (1) origin; (2) geographical path; (3) chain of custody; and (4) physical evolution. If an entity can track these four elements for a particular product with a reasonable degree of confidence, the product can be said to be "traceable".

In parallel with these four core data elements, traceability mechanisms can also be used to obtain information on a product's performance metrics. These performance metrics can correspond either to sustainability factors (e.g. greenhouse gas emissions, compliance with labour standards or compliance with tax regulations) or to product quality (e.g. engineering specifications or purification levels). When tracing a product, data on sustainability or quality can be attached to provide a more complete picture of the product's performance. For example, when tracing a mineral product incorporated into a battery, information on greenhouse gas emissions can be attached along the supply chain, providing an indication of the battery's environmental performance compared to other batteries available on the market. Traceability systems can also be expanded to include information on whether a product incorporates recycled material, supporting secondary supply and reducing dependence on concentrated primary supply.

Traceability can take various forms. Some approaches require full separation of materials down to the batch level (e.g. product segregation), while others allow varying degrees of mixing with untraced material (e.g. mass balance and controlled blending) or decouple physical supply from its attributes (e.g. book-and-claim).

Tracing a product usually requires the implementation of a traceability system, with clearly defined processes for recording and sharing information along the supply chain. An effective traceability system should be based on four core criteria: robust technical infrastructure, well-defined and standardised data collection, supply chain collaboration, and governance and verification.

Throughout this report, the term "traceability" is used to refer to mechanisms that enable the tracing of one or more of the four core data elements mentioned above (origin, geographical path, chain of custody and physical evolution). It is not used to encompass distinct but related approaches such as supply chain mapping, product transparency or due diligence.

Potential benefits of traceability for energy and economic security

Traceability can enable governments and companies to achieve a range of security, resilience and reliability objectives. In this report, energy and economic security is understood primarily in relation to the resilience of mineral supply chains that underpin the deployment of energy technologies and other strategic industrial applications. Energy and economic security encompass several elements, including uninterrupted availability of energy and strategic technologies at affordable prices, underpinned by reliable access to minerals. Achieving security requires that supply chains have low exposure to supply chain concentration, have taken action to mitigate risks of disruption (geopolitical, environmental, social or market-driven) and have incorporated measures to ensure continuity of production for sectors such as energy, automotive, defence and digital infrastructure. Traceability can contribute to these objectives both directly and indirectly.

First, traceability can directly contribute to energy and economic security by supporting the implementation of policy measures that bolster supply chain security and promote diversification. Today, in many cases, downstream companies face considerable difficulties in establishing the provenance of their mineral inputs. Building the necessary traceability infrastructure can enable downstream operators to obtain detailed origin-related information about their mineral inputs, including the location of origin, geographical path and chain of custody. This enhanced visibility can allow companies to comply more efficiently or effectively with policy measures that seek to unlock alternative sources of supply. For example, if governments introduce policy measures to promote diversified supply chains (e.g. origin-based tax credits or trade measures), companies with traceability systems can use the data collected to demonstrate compliance and access incentives, stimulating diversified supply and contributing to energy security.

Second, traceability can indirectly contribute to energy and economic security by providing the necessary foundation for the development of sustainable and responsible supply chains. This is crucial for bolstering security, as it can unlock supply in non-incumbent countries and reduce supply chain concentration while mitigating the risk of supply chain disruptions associated with poor practices.[2] Traceability supports sustainable and responsible supply chains by enabling the

[2] Inadequate environmental, social and governance practices can affect security of supply in many ways. For example, community concerns about water use and biodiversity impacts can lead to local opposition, slowing project development or disrupting operations. Similarly, corruption can result in delays or increased project costs. Poor labour standards can lead to strikes, protests and demonstrations, or even stop-work orders from government authorities. Human rights and Indigenous Peoples' rights violations and high greenhouse gas emissions can create legal or regulatory barriers for market access in consuming countries.

collection of performance metrics. This can allow midstream and downstream companies to develop a more informed understanding of the impacts and quality of purchased materials, while enabling upstream producers with higher standards to differentiate their products from those associated with poorer practices (including high-performing upstream producers located in countries and regions that may otherwise be designated as higher risk). By enabling the collection and disclosure of performance-related data, traceability thus provides the bedrock for the emergence of performance-based purchasing by midstream and downstream companies. In turn, this could support the emergence of "high-performance price premiums" or "low-performance grey discounts", contributing to the development of a market for responsible and sustainable mineral products (though premiums may be constrained by tight operating margins and price volatility in some sectors and may need to be supported through regulatory intervention). As part of the G7 Critical Minerals Action Plan, countries committed to promoting standards-based markets that reflect the real costs of responsible extraction, processing and trade, including by strengthening traceability as a necessary measure.

While this report focuses primarily on traceability's contribution to energy security and supply chain resilience, it is important to recognise that traceability can also be useful for broader governance and rights-based functions within critical mineral supply chains.

Industry perspectives on traceability practices

The IEA and the Organisation for Economic Co-operation and Development (OECD) launched a joint survey in October 2025 as a follow-up to the 2025 report, The Role of Traceability in Critical Mineral Supply Chains, and to gain deeper insight into how traceability systems are used within companies and across critical mineral supply chains.[3] The survey explored the prevalence and implementation of traceability in companies across the critical mineral supply chain, as well as the current barriers and challenges companies face. This report draws on the results of this jointly designed and administered survey.

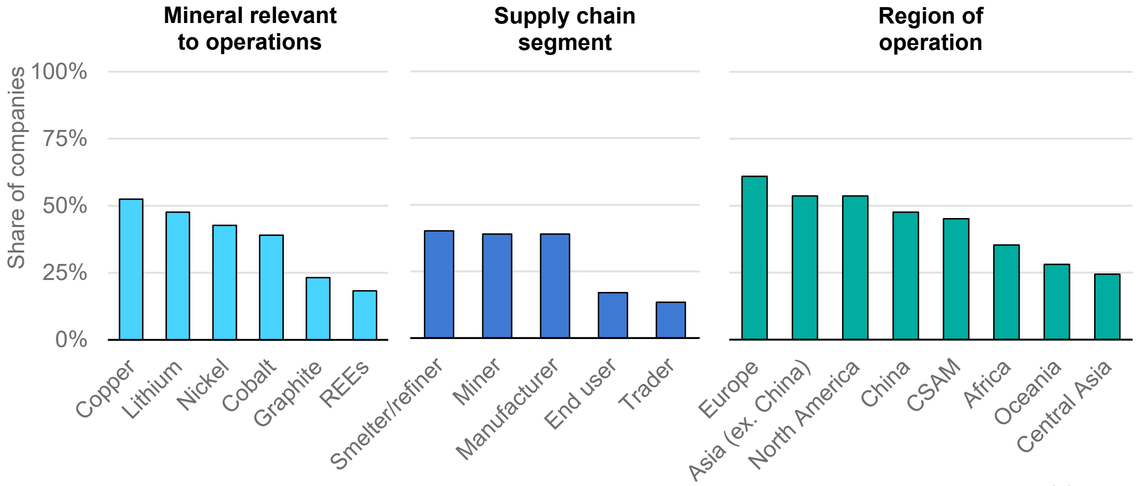
A total of 82 companies participated in the survey, spanning all continents. Survey participants represent all stages of the mineral supply chain, including miners (about 40%), smelters/refiners (40%), manufacturers (about 40%) and end users (about 20%). Many respondent companies are active at multiple stages of the supply chain and combine different roles, for example operating as both a miner and smelter/refiner or as both a manufacturer and end user.

The respondent companies are most present in copper supply chains, followed by lithium, nickel and cobalt. The upstream companies surveyed mostly operate within lithium, copper, nickel and cobalt supply chains. Companies operating in the manufacturing, end user and recycling segments have operations spanning more evenly across all minerals, reflecting the fact that multiple minerals are often used in end use applications, such as battery chemistries.

Geographically, companies operating in Europe are the most represented, largely as manufacturers, smelters/refiners and end use companies. This is followed by companies operating in Asia (excluding China), North America, China and Central and South America.

[3] The survey was administered online to 500 individual companies and industry networks. For the purposes of this report, the IEA analysis covers responses collected between October and December 2025, resulting in a total of 82 responses received in four languages (English: 63; Spanish: 9; Mandarin: 8; Indonesian: 2). The OECD extended the survey until January 2026, with its analysis drawing on 90 responses. As with any survey-based data, the results are subject to methodological limitations. The sample is not necessarily statistically representative of the global critical minerals sector and should not be interpreted as such. Responses reflect voluntary participation and may therefore be subject to selection bias. In some cases, respondents may have been government affairs representatives rather than technical experts within their organisations, which could introduce bias in the responses. The findings should therefore be interpreted as indicative of prevailing trends and perspectives, rather than as a comprehensive or definitive assessment of traceability implementation across the sector.

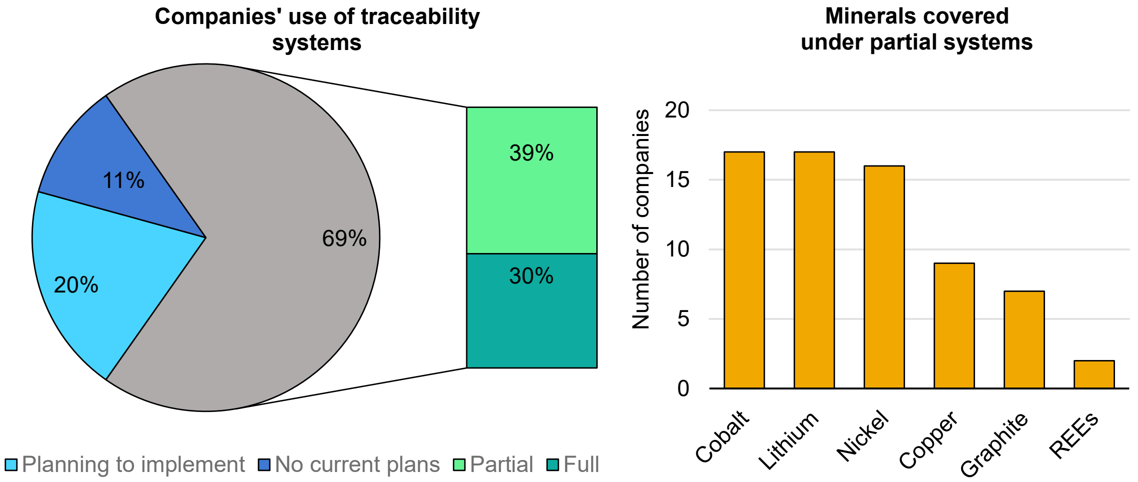
Figure 1.1 Share of companies surveyed by mineral, supply chain segment and region of operation



Notes: CSAM = Central and South America. REEs = rare earth elements. Companies could select multiple minerals, supply chain segments and regions. The percentages reflect the share of respondents selecting each option.
Source: IEA analysis based on IEA/OECD survey.

Over two-thirds of the companies surveyed have a traceability system in place.[4] Of these, 30% cover all minerals and customers or suppliers relevant to their operations, while 40% cover only selected minerals, customers or suppliers. Companies with partial coverage seem to be prioritising cobalt, lithium and nickel supply chains, which may reflect differences in the feasibility of implementation across minerals, as well as varying risk profiles. Among companies that indicated that their traceability systems only cover selected minerals, around one third report covering more than 60% of the volume of their mineral inputs.

Figure 1.2 Companies' use of traceability and minerals covered under partial systems



Notes: REEs = rare earth elements. Companies could select multiple minerals covered by their traceability systems.
Source: IEA analysis based on IEA/OECD survey.

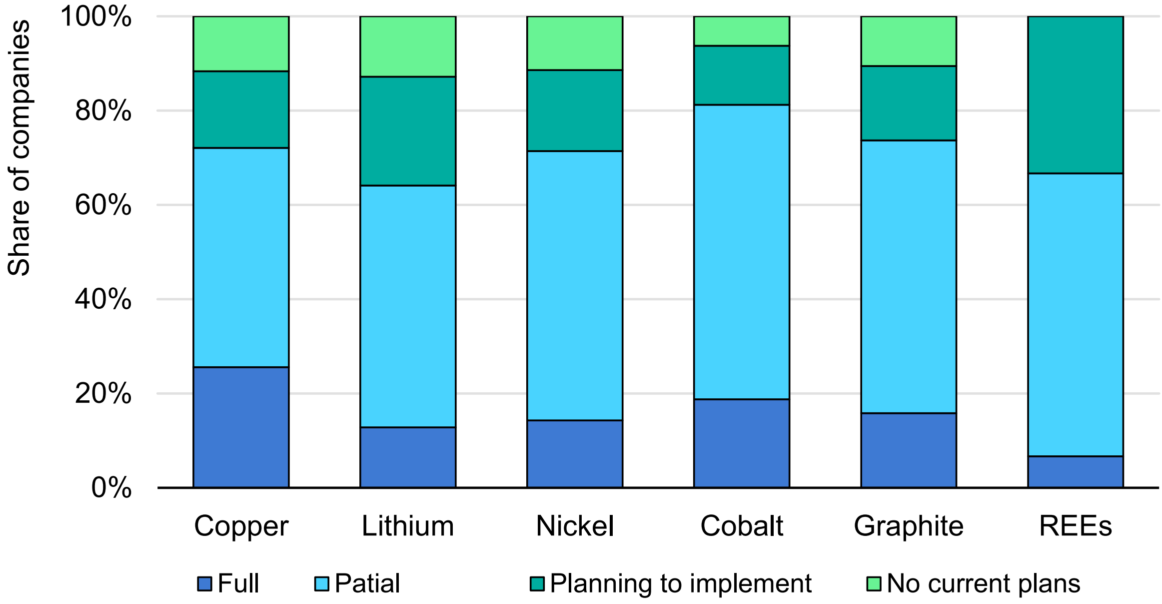
[4] In the survey, respondents were given the definition of traceability that is used in this report.

Among the IEA's six focus minerals, companies operating in cobalt supply chains show the highest uptake of traceability systems, whether full or partial. This reflects long-standing efforts to improve visibility in cobalt supply chains. In the Democratic Republic of the Congo, which supplies around 70% of global cobalt, human rights concerns, particularly in the artisanal and small-scale (ASM) mining sector, prompted sustained legal, regulatory and civil-society pressure. This contributed to the creation of formal standards such as the Responsible Minerals Initiative and the Responsible Critical Mineral Initiative's Cobalt Refiner Supply Chain Due Diligence Standard, released in 2018. These developments laid the groundwork and infrastructure that downstream companies then built upon for traceability. Around the same time, early traceability initiatives also started to emerge, such as RCS Global's Better Mining Initiative, which was largely driven by downstream companies seeking to improve visibility in their cobalt supply chains.

After 2020, the scope of traceability initiatives started to expand to encompass a broader set of minerals related to energy technologies. Increased exposure to downstream pressure in those supply chains led to partnerships between original equipment manufacturers (OEMs) and raw material suppliers, for example between Tesla and various upstream companies through Re|Source in 2021 and Volvo and SQM in 2023. Among companies that participated in the survey, adoption of traceability systems is high for all six energy minerals, with graphite, nickel and copper showing the largest shares of any type of system after cobalt.

Even companies active in supply chains where full or partial traceability systems are less prevalent reported plans to establish them. Companies operating in rare earths supply chains showed the greatest intention to set up traceability systems – the highest across the six focus minerals surveyed – with none saying they had no plans to do so. This may reflect the growing need to mitigate geopolitical risks in rare earth supply chains, which is driving companies to establish traceability systems, alongside structural constraints that have thus far complicated implementation, including the small quantities of rare earths in components, their production as by-products, generic or non-specific labelling, and business confidentiality concerns.

Figure 1.3 Companies' use of traceability systems across the six energy mineral supply chains

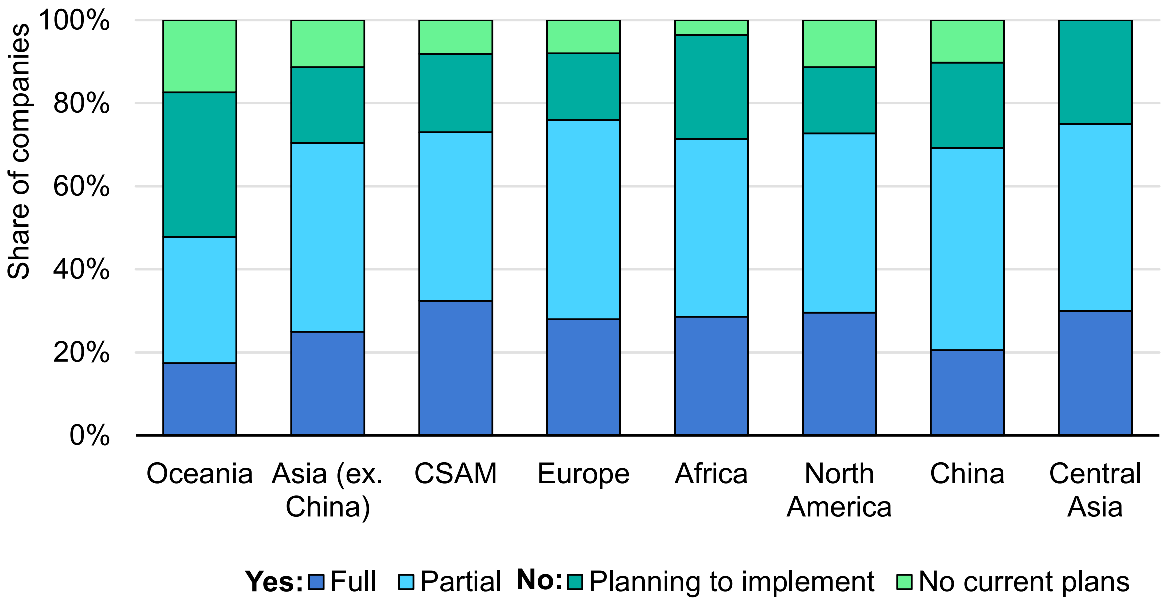


Notes: REEs = rare earth elements. Companies could select multiple mineral supply chains in which they operate.
Source: IEA analysis based on IEA/OECD survey.

Companies operating in Europe, Central and South America, North America and Central Asia reported the highest shares of full or partial traceability systems, though this is affected by regional differences in the number of respondents. Strong uptake in Europe, Central and South America, and North America may reflect growing regulatory or OEM pressures to implement these systems, as well as a desire among companies in those regions to position themselves strategically.

By contrast, companies operating in Oceania reported significantly fewer traceability systems. While this likely reflects the much smaller number of respondents in the region, it is noteworthy that a large share of companies operating in Oceania did indicate plans to establish these systems. Among companies without any traceability system in place, those operating in Africa and Central Asia expressed the strongest intentions to develop one. Beyond reflecting growing interest in developing critical mineral supply chains in these regions, this may also indicate a strategic effort to attract investment and advance both global diversification goals and regional value-addition objectives. It may further reflect a desire to maximise value captured locally by reducing illicit mineral laundering, tax evasion and other forms of corruption. It may additionally indicate that traceability is increasingly being viewed as a prerequisite for accessing certain markets and for benefiting from policy incentives that are increasingly tied to verified provenance and performance.

Figure 1.4 Companies' use of traceability systems across regions

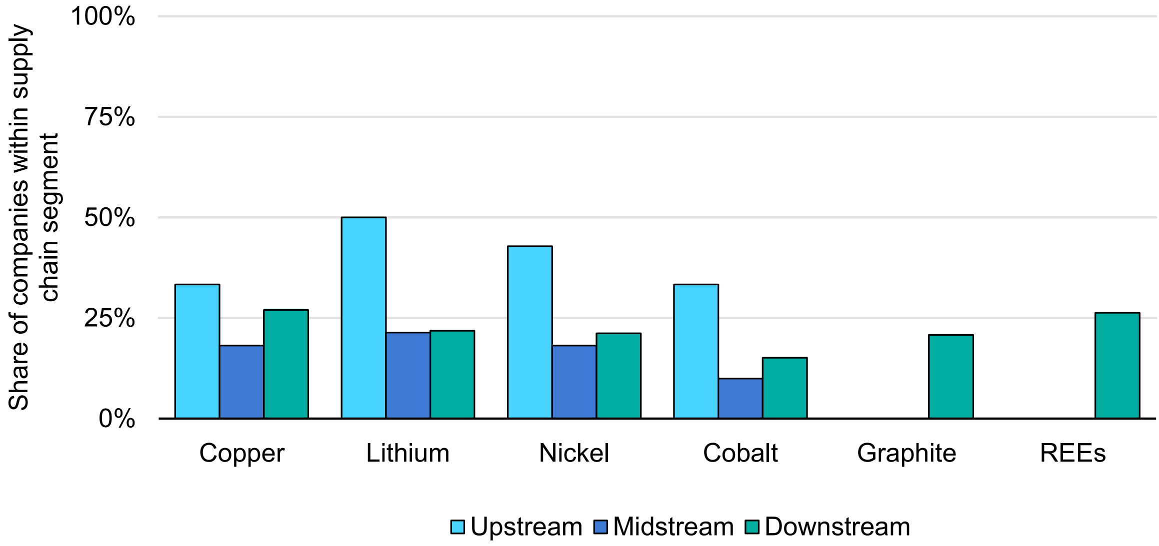


Note: CSAM = Central and South America. Companies can select multiple regions that they operate in.
Source: IEA analysis based on IEA/OECD survey.

The survey results also reveal marked differences in the distribution of companies across supply chain segments, both by region and by mineral, with important implications for how traceability is being implemented in practice. Across all respondents, 80% of upstream companies indicated they had some form of traceability system, compared with around 40% of midstream and downstream companies.

Across minerals, traceability systems have a strong presence among companies operating in lithium and nickel supply chains, particularly upstream, where around 50% of companies reported having a traceability system. Cobalt and copper also show notable upstream presence, consistent with the history of mine-level scrutiny in the Democratic Republic of the Congo. For graphite and rare earth elements (REEs), the surveyed companies are concentrated downstream, and the limited number of surveyed upstream and midstream respondents (5) do not have traceability systems in place. This suggests that for those minerals, visibility and reach to companies in the earlier stages of the supply chain are particularly constrained, and that the actors most capable of driving the adoption of traceability systems may be downstream manufacturers and end users.

Figure 1.5 Share of companies by supply chain segment that have a full or partial traceability system across minerals



Notes: "Upstream" refers to miners; "midstream" to smelters/refiners, traders and recyclers; and "downstream" to manufacturers and end users. Companies can operate across multiple minerals and supply chain segments; percentages are calculated within each mineral-segment subset and are not additive.
Source: IEA analysis based on IEA/OECD survey.

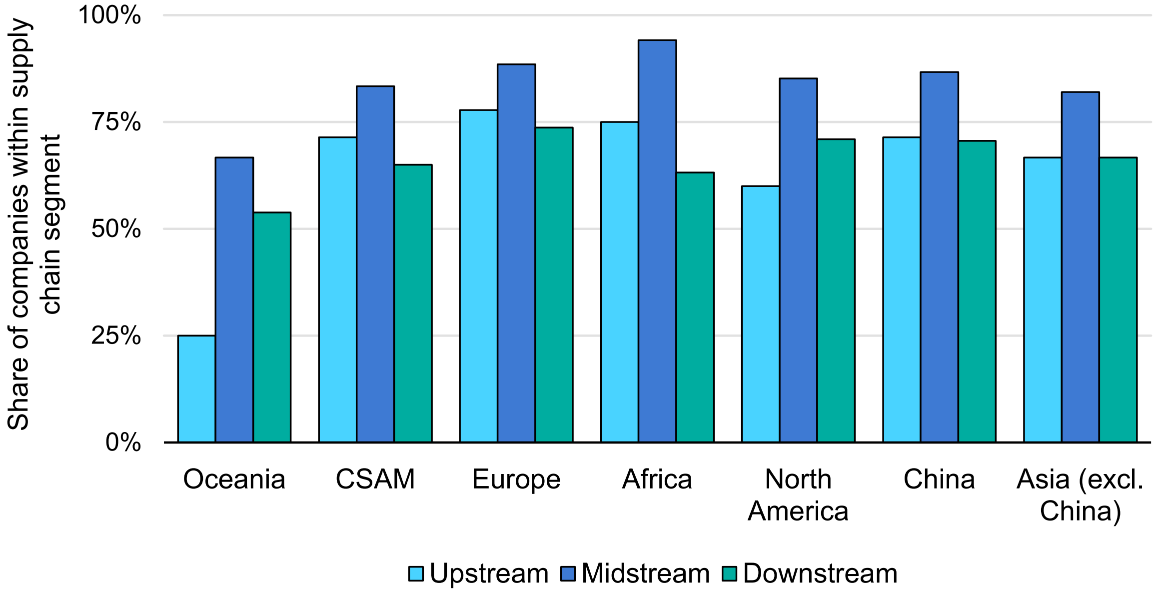
Several regional patterns also emerge. Companies operating in the midstream consistently reported the highest uptake of traceability systems across all regions, with an average uptake of around 85% compared to below 70% for upstream and downstream. The high midstream uptake across regions largely reflects the structure of the survey, where companies were able to select multiple regions in which they operate. Midstream companies are more likely to operate across multiple jurisdictions and source from a diverse set of upstream suppliers. As a result, these companies are more frequently represented across regional categories, contributing to consistently high uptake levels in regional comparisons.

This aligns with the widely recognised role of the midstream as a structural bottleneck for traceability, where multiple upstream sources converge and mixing can occur. Europe and China show particularly strong midstream participation among firms with traceability systems, consistent with their relatively large processing sectors and with lower levels of mining. This could reflect the effect of government regulations and market makers' audit programmes, often based on OECD Due Diligence Guidelines, which frequently place due diligence expectations on refiners and processors as key control points in the supply chain.

Regional differences in traceability uptake are more pronounced upstream than downstream. Europe and China show relatively higher upstream coverage than Oceania and North America, perhaps highlighting a gap at the extraction stage, where data collection can be challenging. Meanwhile, Africa and Central and

South America stand out for higher upstream participation among firms using traceability, aligning with their significant mining activity and higher real or perceived risk. Downstream companies in Europe, North America and China report higher levels of traceability coverage, potentially reflecting higher regulatory or OEM pressure.

Figure 1.6 Share of companies by supply chain segment that have a full or partial traceability system across regions



Notes: CSAM = Central and South America. "Upstream" refers to miners; "midstream" to smelters/refiners, traders and recyclers; and "downstream" to manufacturers and end users. Companies may operate across multiple regions and supply chain segments; percentages are calculated within each region-segment subset and are not additive.

Source: IEA analysis based on IEA/OECD survey.

According to the survey, the mass balance approach is the most commonly used traceability model, selected by about 40% of companies, followed by identity preservation (28%). This pattern is consistent across all six energy minerals, suggesting that most existing systems prioritise aggregate tracking of flows rather than full segregation. This is particularly the case in supply chains with many actors and complex production processes where material is frequently blended and full segregation is difficult to maintain.

Book-and-claim systems were the third most selected method for companies operating across energy minerals, but uptake is uneven across minerals: use is notably higher in graphite and rare earths, and much lower in nickel and lithium. This likely reflects differences in supply chain structure, as well as the greater technical and logistical challenges of physically tracing blended or highly processed materials.

Across supply chain segments, midstream companies report the highest use of mass balance, reflecting the prevalence of blending and aggregation at this stage of the value chain. Identity preservation is used far less consistently: almost two thirds of traders selected this approach, compared with only around 20% of miners and end users.

Bulk commodity approaches are more rarely used, with less than 10% of miners, recyclers, smelter/refiners and end users reporting their use. Traders are an exception, with around one-third relying on bulk commodity methods. A similar, but less pronounced, pattern is observed for book-and-claim systems, which are used by roughly 10% of miners, smelters/refiners and recyclers, compared with 20% of end-users, traders and manufacturers.

From the survey results, companies often implement mineral traceability systems in response to external pressure, whether from customer or OEM demand, or regulatory requirements. Almost two-thirds of the companies surveyed stated that brand or reputation was one of the three primary drivers for pursuing traceability, along with customer/OEM demand (61%), compliance with regulatory requirements (41%), ethical sourcing commitments (41%) and sustainability risk reduction (38%). Financial incentives were rarely cited as a top driver, implying that current incentive structures are either insufficient, poorly targeted or not clearly linked to traceability investments.

Examining companies' motivations for pursuing traceability across minerals, supply chain segments and regions reveals some notable differences. Companies operating across all six mineral supply chains ranked their top three drivers consistently, with compliance with regulatory requirements as the leading driver in all except copper, where brand/reputation was selected as the top driver. Companies in the copper, lithium, nickel and cobalt supply chains chose brand/reputation and customer/OEM demand slightly more than companies in graphite and REE supply chains.

In contrast, companies active in graphite and REE supply chains, which in the sample are downstream operators, appeared more driven by ethical sourcing commitments and sustainability risk management (although the number of graphite and REE companies was around half that of the other minerals). Their downstream position likely exposes them more directly to reputational scrutiny, regulatory expectations and consumer-facing pressures, which shape their priorities.

Interestingly, graphite, REE and lithium companies selected geopolitical risk management and investor obligations more often than copper, nickel and cobalt companies. This likely reflects the more nascent nature of these industries, where smaller players depend on external financing to scale production. In these sectors, traceability may serve not only as a reputational tool but also as a de-risking mechanism to help secure investment.

Differences in the top drivers are more pronounced across supply chain segments. Upstream and midstream operators were driven much more by brand/reputation and customer/OEM demand than downstream companies, suggesting that pressure to implement traceability systems often flows up the value chain rather than originating upstream. On the other hand, downstream users seem more likely to cite ethical sourcing commitments, sustainability risk management and compliance with regulatory requirements as the top drivers, reflecting their greater exposure to consumers. Companies operating in the downstream cited investor expectations as a driver much less than upstream companies. This likely reflects the fact that, for upstream actors, traceability may serve as a de-risking mechanism, whereas downstream actors use it largely to support brand reputation and regulatory compliance, with a less direct connection to financial incentives.

Use of traceability as a policy instrument: State of play

Ensuring the security and sustainability of critical mineral supply chains has become a front-of-mind issue for governments. This is reflected in the dramatic increase in mineral policies and regulations in recent years. These have sought to achieve a range of policy objectives, including promoting exploration, production and innovation; ensuring supply reliability and security; encouraging sustainable and responsible practices; and boosting minerals recycling. Governments are increasingly turning to traceability as a tool to support these objectives, as reflected in the G7 Critical Minerals Action Plan. Many countries have introduced policy measures that either directly mandate companies to implement traceability systems or require companies to provide specific traceability information to access economic incentives. Some policy measures have been introduced as part of wider due diligence frameworks, while others have focused more specifically on energy security and reducing concentration (see Annex I).

This section provides an overview of how traceability is being used as a policy instrument across producing and consuming economies. It also integrates the survey results to show how industry is responding to these policies through the adoption, design and operation of traceability systems. However, as the survey sample is limited, the results should not be considered exhaustive.

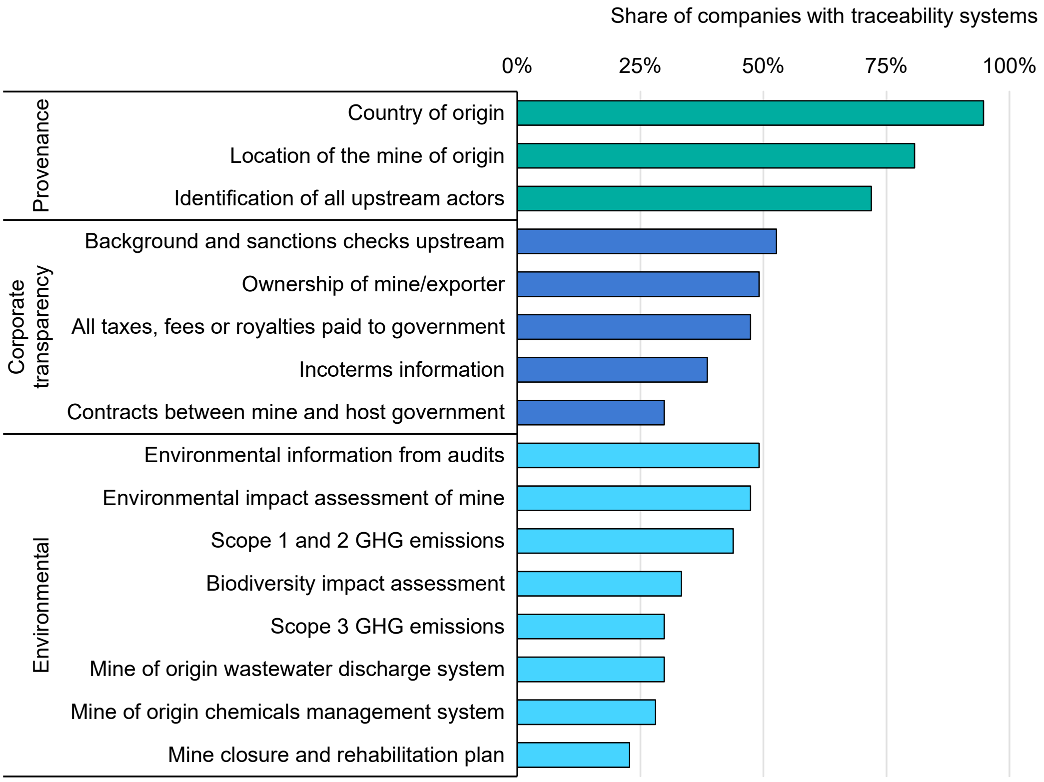
For the purposes of this report, current traceability policies were reviewed and categorised by economy type, distinguishing between producing and consuming economies. Producing economies are countries that maintain a significant market share in the global supply chain through primary extraction of raw ores or specialised chemical processing and refining of those materials into technology-grade products. These include Australia, Canada, China, the Democratic Republic of the Congo and Indonesia. Consuming economies are those that drive substantial demand for critical minerals for the manufacturing and deployment of technologies such as electric vehicle (EV) batteries, wind turbines and power grids. These include the European Union, Korea, Japan, the United Kingdom and the United States. It should also be noted that many countries serve as both producers and consumers, though their policy priorities often align more closely with one role depending on their position in global supply chains.

In many cases, traceability systems reflect the strategic priorities of the countries that design and implement them. Broadly speaking, producing economies use traceability to limit illegal mining, increase oversight of domestic mineral resources and enhance opportunities for high-performing producers. By contrast, consuming economies use traceability to reduce supply chain disruptions, promote diversification and mitigate adverse impacts in mineral supply chains. This is examined in more detail below.

While consuming and producing countries differ in their strategic use of traceability, current approaches may offer useful lessons for countries looking to use traceability to achieve their policy objectives. For example, producing countries (particularly those at earlier stages of developing their production capacity) can learn from and collaborate with other producing countries to strengthen traceability at the source, increase oversight of domestic mineral supplies and enhance market access opportunities for domestic producers. Similarly, consuming countries can learn from other consuming countries with more advanced experience in implementing traceability systems, helping them reduce supply chain dependencies. More broadly, there is growing scope for co-operation between producing and consuming economies to reduce fragmentation and establish more harmonised data collection and verification standards.

The divergence in policy approaches between producing and consuming economies is reflected in industry practices. The survey results indicate that most companies already collect provenance information, particularly country of origin, whereas fewer collect corporate transparency or environmental data. Where additional information is collected, ownership and environmental impact data appear to be most consistently covered, reflecting the fact that such data are increasingly becoming a requirement for companies seeking to meet regulatory requirements and access incentives across jurisdictions.

Figure 2.1 Information collected under surveyed companies' traceability systems



Notes: Incoterms = International Commercial Terms. The total number of companies with full or partial traceability systems is 57 (out of 82 total companies surveyed).
Source: IEA analysis based on IEA/OECD survey.

Use by producing countries

In producing countries where traceability frameworks have been established, traceability requirements are typically embedded within national regulations on mining, refining and export. Traceability data are used to enforce compliance with regulatory requirements such as production quotas, tax or royalty payments and licences. Objectives pursued by producing countries through traceability can be broadly divided into three categories: (1) preventing illegal mining and tax fraud; (2) enhancing governmental oversight of domestic mineral supplies; and (3) improving market access opportunities for high-performing producers.

Preventing illegal mining and tax fraud

One of the primary objectives that producing countries, particularly emerging markets and developing economies, seek to achieve through traceability is curbing illegal mining, limiting illicit trade and preventing tax fraud.[5] In many producing countries, including China, Colombia, the Democratic Republic of the Congo and Indonesia, traceability frameworks are being implemented to track mineral flows at various stages of the supply chain, including mining, refining and export.

These traceability systems typically require the covered companies to collect data on production volumes and mineral transactions. Mining companies are often required to record the volume of ore produced and sold, while refining companies are required to report how much ore or concentrate is shipped to them, where it is sourced from (e.g. the location of the mine of origin) and how much refined material is produced.

For example, under China's recently enacted Rare Earth Management Regulations, Chinese companies active in rare earth supply chains, including miners and refiners, are required to implement a company-level traceability system that records data on production volumes, quantities sold, date of sale, batch numbers, product specifications and invoices. Similarly, in Colombia, mining operators are required to record production volumes and mineral transactions. Processing plants and mineral traders must do the same and must also verify the identity of the operators from whom they purchase material, including through biometric identification.

To render collected data more useful for government entities, many producing countries are establishing centralised digital platforms designed to consolidate data submitted by companies. Indeed, without centralisation, collected data may

[5] In this report, illegal mining refers to mining and trading activities conducted outside applicable licensing, fiscal or regulatory frameworks. Illegal mining does not necessarily refer to artisanal and small-scale mining (ASM); rather, ASM often operates across a spectrum from formal to informal, and traceability efforts can support its formalisation and integration into legal supply chains.

remain scattered across different government agencies or companies. Accordingly, several producing countries have established mandates requiring companies to upload data onto government-run digital platforms.

For example, under China's new rare earth traceability system, China's Ministry of Industry and Information Technology is responsible for setting up a government-level traceability system, to be operated by a special third-party entity. Rare earth companies must register onto the government-level traceability system and upload the required information on a monthly basis. In Colombia, companies must upload data on mineral transactions and production volumes onto a centralised digital platform. In Indonesia, a digital platform called SIMBARA has been established that combines the monitoring systems of various government ministries and incorporates data on mining quotas, royalty payments, production volumes and sourcing locations. In Zambia, a centralised platform called the Mineral Output Statistical Evaluation System (MOSES) has been created to monitor the flow of minerals from extraction to export.

The introduction of mandatory data reporting requirements for companies active in mineral supply chains, coupled with the creation of centralised digital platforms, can enable regulatory authorities in producing countries to better detect illegal mining. For example, access to centralised data can allow officials to cross-reference reported information with official records (e.g. mining production quotas) and detect mismatches between ore volumes sent to refiners (on the one hand) and volumes of refined material produced by refiners (on the other hand). Such a mismatch would indicate that mining companies are producing more ore than officially reported, pointing to a possible violation of mining production quotas and allowing state authorities to take enforcement action against such violations.

Increased detection of illegal mining can result in tighter enforcement of production quotas. Stricter compliance with production quotas can reduce oversupply and support price stability, particularly in markets where one player controls the majority of production. It can also limit tax fraud by enabling better detection of unpaid taxes and royalties for mining production, leading to increased state revenues. The Indonesian government, for example, claims that SIMBARA has so far allowed government authorities to avoid IDR 3.47 trillion (around USD 200 million) in potential losses from unpaid taxes and royalties. Reduced illegal mining can also limit environmental damage, a problem that China has faced for a number of years.

The potential for traceability systems to limit illegal mining and tax fraud is supported by the survey results. Companies reported that their traceability systems collect a range of information relevant to curbing illegal mining and tax fraud. This includes information on taxes, fees or royalties owed to the government, International Commercial Terms information, contracts between the mine of origin and the host government, and background and sanction checks on upstream actors. In the survey, 47% of companies with traceability systems reported collecting data on taxes, fees or royalties paid to governments, while 28, or about 50%, of companies with traceability systems indicated that they collect information on ownership and beneficial ownership structures of mines or exporters.

Enhancing governmental oversight of domestic mineral supplies

A secondary objective pursued by producing countries through traceability is to increase state oversight of mineral resources. As noted, many producing countries are implementing traceability systems that require companies active in mineral supply chains to collect mineral-related data, including information on sourcing locations, shipments, production volumes and mineral transactions, and to upload these data to government-managed digital platforms.

Access to production and pricing data can give government actors better visibility over the production, sale and export of mineral products within their jurisdictions. Enhanced visibility over mineral flows can enable state authorities to pursue a range of industrial policy objectives, both domestically and from an export perspective.

At the domestic level, a centralised traceability platform can allow state authorities to obtain near real-time information on sales to downstream actors. This can enable them to refine planning, adjust production quotas as necessary and ensure that domestic supply remains sufficient to meet domestic demand.

Visibility on sale transactions can also support the enforcement of government-set benchmark prices. For example, in Indonesia, the government has established a floor price for nickel, which domestic operators are required to follow in mineral transactions. The floor price, which is updated monthly by the Ministry of Energy and Mineral Resources, is designed to balance profitability for miners with the need to remain competitive internationally. Indonesia's SIMBARA system can allow government authorities to verify that domestic miners and smelters are complying with the government-set floor price, supporting the growth of Indonesia's nickel sector.

Requiring domestic actors to record data on mineral transactions can also support the creation of state-backed commodity exchanges and related price indexes. For example, under China's rare earth traceability system, Chinese companies must collect and report pricing and invoice data. These data, together with transaction data, have been used to launch the Baotou Rare Earth Products Exchange Rare Earth Price Index in December 2025, allowing for better price transparency in the Chinese rare earth elements (REEs) market and solidifying the emergence of a Chinese REE benchmark price.

From an export perspective, traceability can allow state authorities to better detect illegal exports and the smuggling of mineral resources. Many producing countries' traceability platforms, including in China and Indonesia, integrate data on ore production volumes, refined material production volumes and mineral exports. For example, if refiners report receiving less ore than what is officially produced by mining companies – based on data uploaded to the digital platform – this could alert state authorities to possible illegal ore exports.

Improved detection of illegal ore exports can allow state authorities to strengthen the enforcement of sanctions and export controls, preventing restricted entities from gaining access to strategic materials and supporting foreign policy objectives. For example, the Chinese government has expressly declared that one of its objectives is to achieve "full-chain control over strategic mineral exports" in order to "prevent the illegal outflow of strategic minerals" and safeguard national security.

In addition, strengthened detection of illegal ore exports can help ensure that more ore is retained within the country for domestic processing rather than smuggled abroad, supporting local value addition. Indonesia, for example, progressively banned nickel ore exports throughout the 2010s to support its domestic nickel processing industry. Through its SIMBARA system, Indonesia aims to strengthen the detection of possible illegal nickel ore exports, an issue it has faced since implementing its down streaming policies.

Traceability can also help domestic actors compete more effectively in global markets. As noted, many producing countries' traceability systems integrate data on mineral sales and pricing. For example, under China's rare earth traceability system, Chinese companies must collect and report pricing and invoice data, including data on sales to downstream manufacturers for purchases of Chinese rare earth products. Access to sales and pricing data can provide government entities with insight into value added and margins at different stages of the supply chain. These insights can be used to support domestic downstream processors (e.g. domestic magnet manufacturers) in competing internationally.

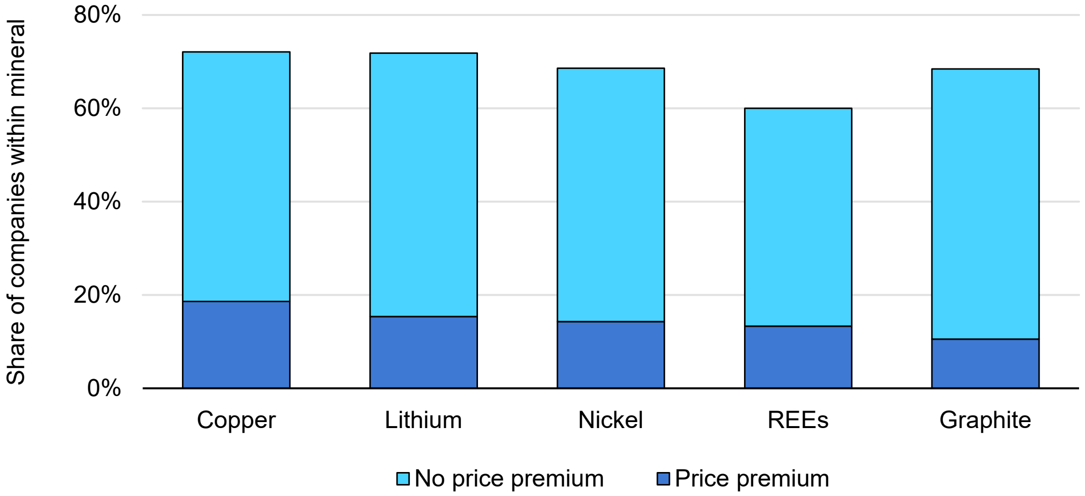
The survey results indicate that traceability systems can provide governments with substantial visibility over domestic mineral flows, particularly at the upstream and midstream stages of the supply chain. Respondents most commonly reported that their traceability system covers processing or refining (45 respondents), the mine site (43), while fewer extend traceability to final manufacturers (22) and recyclers (20). A majority of respondents also reported tracing a substantial share of their mineral inputs by volume, with about 20 respondents indicating that more than 90% of their inputs are covered by traceability systems.

Improving market access opportunities and rewarding high-performing producers

In some producing countries, traceability is also being used to improve market access opportunities for high-performing operators. As noted, traceability can be used to obtain information on the performance of mineral products, which can correspond either to sustainability-related factors or quality-related ones. Some producing countries, particularly those with higher environmental, social and governance standards, are using traceability as a way for domestic producers to demonstrate the high performance of their products. In Canada, for example, the Government of British Columbia has launched a pilot that allows mining operators to use digital credentials to prove the origin and sustainability of their products. In Finland, a EUR 5.8 million (USD 6.8 million) project has been launched to develop traceability methods to verify the origin of battery raw materials and prove their performance.

Developing traceability systems that allow domestic operators to demonstrate high performance can enable these operators to access markets that prefer or require higher performance. It can also potentially allow high-performing operators to obtain price premiums for their performance. Although 60% of the surveyed companies stated that they are not yet receiving any premium for high-performance materials, the responses indicate that premiums are beginning to emerge: just over one-quarter of companies indicated receiving some form of premium, stemming from a range of factors including social audit certificates, low-greenhouse gas (GHG) emissions materials and origin-based differentiation.

Figure 2.2 Share of companies that indicated price premiums across the six key focus minerals



Notes: REEs = rare earth elements. As companies were allowed to select multiple minerals relevant to their operations, the data may include instances of double counting. “Price premium” includes companies that answered: the price differentiation depends only on origin; price premium for low GHG emissions material; and/or price premium for material with social audit certificates. The remaining percentages reflect companies that either reported discounts for non-certified material, provided their own response (e.g. “n/a” or “not yet tracked”) or did not answer.

Source: IEA analysis based on IEA/OECD survey.

Strengthening traceability systems and the information they collect, alongside creating the appropriate downstream incentives, will be essential to building a stronger market for differentiated goods. As part of the G7 Critical Minerals Action Plan released in June 2025 and the Roadmap to Promote Standards-Based Markets for Critical Minerals released in October 2025, G7 countries recognised that traceability is a necessary bedrock for building standards-based markets and committed to progressively increasing supply chain traceability.

Use by consuming countries

Consuming countries, typically advanced economies, are expressing growing concerns about securing access to critical minerals vital for energy technologies, defence capabilities and industrial competitiveness. They are also increasingly attentive to the negative impacts that their consumption can cause for upstream stakeholders. Faced with these concerns, consuming countries are turning to traceability as a tool to shed light on mineral supply chains, particularly regarding upstream actors and impacts. Broadly speaking, objectives pursued by consuming countries through traceability can be divided into two categories: (1) enabling supply chain diversification and reducing supply chain risks; and (2) encouraging sustainable and responsible practices.

Enabling supply chain diversification and reducing supply chain risks

Given the current high concentration of mining and refining activities for energy minerals, the primary concern of consuming nations is supply chain resilience: ensuring that access to key inputs is not disrupted by geopolitical tensions, market manipulation or natural disasters. In this context, many consuming nations are implementing, or considering, policy measures aimed at reducing concentration and enhancing diversification. Traceability systems can directly support these objectives by mapping the origin of materials, monitoring supply routes and assessing exposure to strategic dependencies, including by providing information on whether a mineral input was sourced from a dominant producer or a non-incumbent supplier. This information can in turn be used to unlock alternative sources of supply, thus promoting diversification and reducing exposure to geopolitical risks.

In some cases, policy measures may directly require companies to trace product origin. For example, since 2023, defence contractors that provide magnets with critical minerals in them to the US government are required to disclose the provenance of the magnets, including information on the country where the minerals were mined, the country where the minerals were refined into oxide, the country where the minerals were made into metal or alloy, and the country where the magnets were sintered or bonded and magnetised. If the contractor is unable to provide this information, the government can require the contractor to establish and implement a supply chain tracking system to obtain the required information. In parallel to these tracing requirements, the US government has, since 2024, been prohibited from procuring certain magnets (i.e. samarium-cobalt magnets and neodymium-iron-boron magnets) produced in China. As another example, the European Union's Critical Raw Materials Act requires large manufacturers of strategic technologies to conduct supply chain mapping exercises at least every three years. Mandatory traceability systems and mapping exercises can help companies and government actors identify supply chain vulnerabilities, facilitating the implementation of policy measures that seek to enhance diversification.

In other cases, policy measures may offer economic incentives (e.g. tax credits, loans or grants) conditional on proof of product origin, prompting companies to implement traceability schemes to meet legal requirements and qualify for support. This can stimulate supply in non-incumbent countries, though the effectiveness of such incentives depends on robust assurance mechanisms that verify the accuracy of the information reported by companies.

An example of such an incentive is the US Inflation Reduction Act, which previously offered a USD 7 500 consumer tax credit for battery-powered electric vehicles. Of this amount, USD 3 750 was conditional on a minimum share of the battery's minerals being either extracted or processed in the United States or in a country with which the United States had a free trade agreement, or recycled in North America. In addition, the tax credit was not available if the battery's minerals were extracted, processed or recycled by a "foreign entity of concern". This created an incentive for vehicle manufacturers to trace the provenance of mineral inputs to ensure their vehicles qualified for the credit. While the clean vehicle tax credit has been discontinued under the One Big Beautiful Bill Act of 2025, the Act expanded the "foreign entity of concern" restriction to six additional clean energy tax credits. Under these provisions, a company seeking to claim certain clean energy tax credits (e.g. for battery manufacturing) cannot benefit if it sources more than a specified share of its components from a "prohibited foreign entity".

Encouraging responsible and sustainable practices

Consuming countries are increasingly aware of the potential impacts of mining and refining activities and the implications these impacts can have for security of supply. In response, consuming nations are progressively adopting policy measures that seek to promote sustainable and responsible practices in global supply chains. While some of these policies have recently been pared down in the European Union and the United States, companies continue to face sustained regulatory expectations to prevent or minimise adverse impacts within their supply chains.

In some economies, for example the European Union, France, Germany and Norway, legislation has been adopted requiring large companies to conduct due diligence in their supply chains by identifying, assessing and mitigating adverse impacts. In other countries, such as Mexico and the United States, measures are being implemented to prohibit or restrict the entry of products associated with certain adverse impacts (e.g. banning the importation of goods made wholly or in part with forced labour). In the European Union, the Batteries Regulation requires economic operators placing batteries on the EU market to conduct due diligence, including by operating a traceability or chain of custody system that identifies upstream actors in the supply chain.

The recent rise in sustainability-related regulatory requirements is driving increased uptake of traceability among companies active in global mineral supply chains. To comply with emerging requirements, downstream actors in consuming nations are increasingly rolling out traceability systems. Tracing mineral products can help downstream actors conduct proper due diligence by identifying and mitigating potential adverse impacts in their supply chains. It can also enable upstream actors to maintain market access by providing evidence that an imported product (or its components) is not associated with negative impacts (e.g. forced or child labour).

Just over 40% of survey participants reported that their traceability systems collect information on responsible and sustainable practices. While this reflects a growing industry focus on potential adverse impacts from mining and refining activities, it also reflects increasing regulatory pressure on companies active in global mineral supply chains. Companies operating in the midstream and downstream segments report environmental indicators at higher rates than those in the upstream, perhaps reflecting their more direct exposure to regulatory pressures, particularly in key consuming countries.

Taken together, policy objectives and the survey results suggest that traceability systems are not neutral tools but adaptive mechanisms that reflect national policy priorities, with important implications for interoperability, data comparability and international co-ordination.

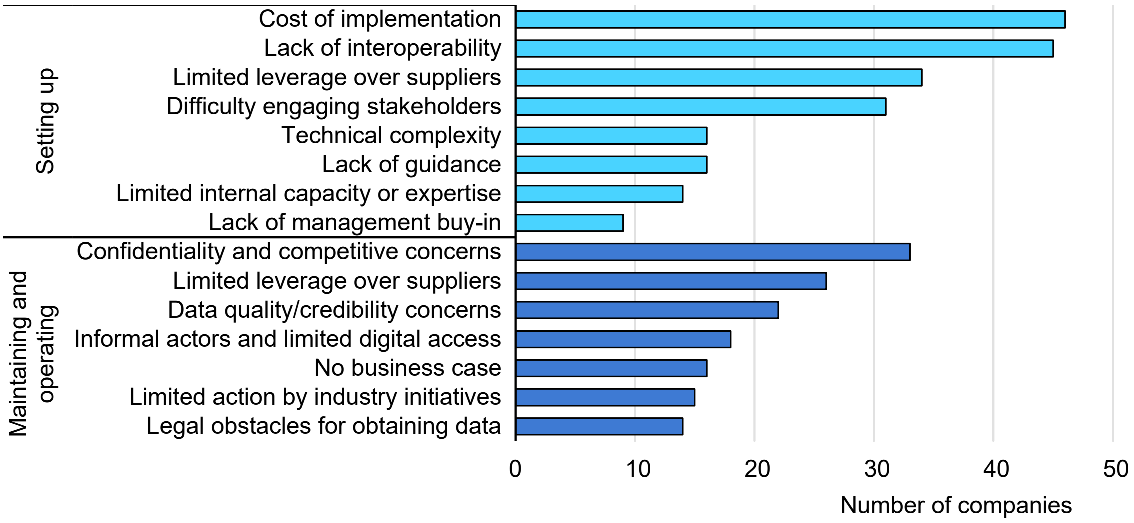
Challenges and barriers to adoption

Traceability has the potential to bolster energy security by promoting supply chain diversification and contributing to the development of sustainable and responsible supply chains. However, the implementation of traceability systems faces numerous challenges. According to the survey, companies indicated that the top three barriers for setting up a new traceability system are the cost of implementation (56% of companies included this among the top three challenges), lack of interoperability between traceability systems along the supply chain (55%), and limited leverage over suppliers (41%).

Companies also face challenges with maintaining and operating traceability systems. The surveyed companies identified that the three main obstacles for maintaining and operating a traceability system are business confidentiality and competitive concerns (46% of companies included this among the top three challenges), limited leverage over suppliers to obtain information (40%), and limited quality or credibility of the data collected (32%). This section will examine these challenges in detail.

While the top barriers for implementation and the challenges in maintaining and operating systems are broadly shared across minerals, segments and regions, there are some notable variations. These are explored in detail below.

Figure 3.1 Main challenges for setting up and maintaining and operating an effective traceability system



Note: Companies were asked to select the top three challenges for a) setting up a new traceability system and b) maintaining and operating a traceability system.
Source: IEA analysis based on IEA/OECD survey.

Implementation costs

Tracing mineral products can often be cost-intensive, though costs can vary depending on the technology used and the complexity and specific requirements of a company's supply chain. In the survey, the cost of implementation was the most selected obstacle to setting up a new traceability system, with 46 companies (56%) identifying it as one of their top three obstacles. Companies across all focus minerals, supply chain segments and regions consistently ranked cost as one of the top barriers. Interestingly, cost as a barrier was chosen overwhelmingly by companies operating in the trader segment of the supply chain: 82% identified it among their top three challenges, far higher than end users, where only 36% did so. This likely reflects traders' exposure to a greater number of upstream and downstream companies that must be captured within their traceability systems.

Setting up traceability systems can require significant upfront investment in physical and human capital, such as new technological infrastructure, additional human resources and employee training. Upfront costs may be particularly high for companies with minimal or non-existent data infrastructure, for example artisanal and small-scale miners. Similar challenges also affect small- and medium-sized enterprises with limited administrative or technical capacity, which may struggle to invest in dedicated traceability systems. In the survey, 27% of respondents (22 out of 82 companies) indicated that informality among upstream actors and/or suppliers' lack of access to digital infrastructure is one of the top three obstacles to maintaining and operating a traceability system. Traders once again selected this as a top three challenge at a much higher rate than other segments of the supply chain: 45% compared with around 20% of miners and smelters/refiners and around 30% of manufacturers and end users.

Tracing products can also involve considerable ongoing operational costs, such as computing power, regular maintenance and skilled technical support. In the survey, 17% of respondents (14 out of 82 companies) indicated that they face a lack of internal capacity or expertise on traceability. Companies operating upstream and midstream chose this as a top three challenge much more often than downstream users, suggesting that capacity building efforts should be prioritised in those earlier stages of the supply chain. It may also be useful to target projects in early development or in supply chains that have not yet reached large production scales, as establishing traceability systems at these stages can be more cost-effective as the project or sector grows.

Companies were also asked to report whether they have undertaken a cost estimate for implementing traceability and, if so, the estimated cost per tonne of material tracked (in US dollars). Interestingly, even though approximately half of the companies identified cost as a top obstacle, the majority (83%) responded that they have not carried out such a cost estimate.

Only a small share of companies reported quantified cost estimates, which were largely split between costs per tonne between USD 1 and USD 10 and over USD 10. These differences appear to reflect variations in system design, scope and verification intensity, although the sample is very limited, with only eight companies providing any estimate at all.

Although traceability can involve significant upfront and ongoing costs, systems that provide detailed information, such as mine origin or material properties, can support improved operational and product performance. For example, if a company identifies that inputs from a specific mine correlate with enhanced end-use performance (e.g., battery efficiency), it can adjust its sourcing strategies to optimise performance and reduce production variability or costs. In the survey, almost 50% of companies reported that they observed tangible benefits from traceability initiatives (e.g. performance optimisation and reduced sourcing risk), compared with only 20% that did not. When asked to describe the benefits, companies most frequently highlighted improved supply chain visibility, enhanced risk management capabilities, stronger support for compliance and audit processes, greater operational efficiencies and increased brand credibility. The remaining companies indicated that it is too early to tell. Improved operational efficiencies could also widen cost margins, potentially allowing companies to recoup investments in traceability systems.

Inconsistent standards for technical infrastructure and data reporting

Tracing mineral products requires actors along the supply chain to record and share data with each other. At present, operators along the supply chain often use different systems to store and exchange data, ranging from paper-based methods to information technology systems. This variety means systems are not always interoperable, meaning they may not "talk" seamlessly to each other. Fragmentation between systems can increase costs, create inefficiencies and hinder the widescale adoption of traceability along the supply chain. This problem is compounded by the recent rise in government-run digital traceability platforms, which are not necessarily interoperable with data systems in other jurisdictions and may exacerbate costs for smaller non-incumbent players. It is also compounded by the proliferation of voluntary standards, initiatives and frameworks in recent years.

In the survey, 55% of respondents (45 out of 82 companies) identified lack of interoperability as one of the top three barriers to setting up a traceability system, making it the second most frequently chosen implementation obstacle. Companies operating in copper supply chains selected it as a top challenge more frequently than those in other energy mineral supply chains, perhaps reflecting the particularly large number of companies active in copper operations. Upstream and midstream companies also selected it more frequently, perhaps due to a higher prevalence of legacy reporting systems at the mining and processing stages, as well as greater fragmentation in data systems, given the need to interact with multiple midstream and downstream actors that may use different systems.

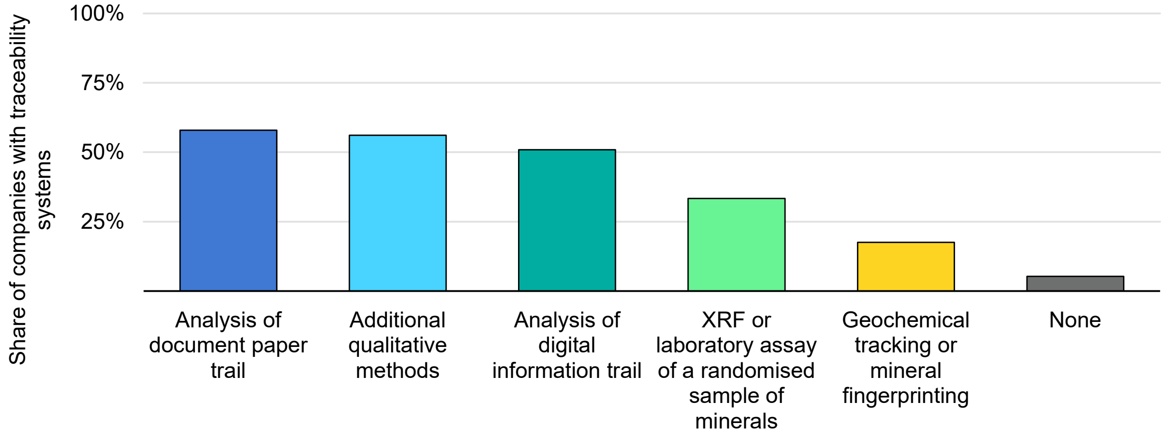
A related challenge is inconsistent data reporting standards. Currently, there is no shared understanding of what data need to be collected and in what format. Different actors may collect different information, with no common understanding of what should be recorded or how. The problem is compounded by a lack of common standards for verification methods, which affects the reliability of collected data: in the survey, 32% of respondents (26 out of 82 companies) indicated that limited data quality or credibility is one of their top three challenges for maintaining and operating an effective traceability system. This was consistent across companies operating in all six focus mineral supply chains. However, almost two-thirds of recycling companies identified this as a top three barrier compared with only one-third across all other supply chain segments, consistent with the relatively limited availability of data collection standards in that segment.

For traceability to be effective, information collected and shared by operators must be accurate, reliable and trustworthy. Traceability systems must include appropriate safeguards to prevent fraud. A lack of proper verification mechanisms can lead to inaccurate or falsified data, undermining the objective of establishing a traceability system.

There are multiple tools and strategies that traceability systems can use to verify the information they collect. These can range from qualitative methods (such as stakeholder engagement on the ground or audits) to digital methods, and from manual analysis to more complex technological approaches such as geochemical tracing. According to the survey, companies with traceability systems use qualitative and quantitative methods in roughly equal measure, as seen in the chart below. Only 5% of companies (3 companies) with traceability systems said they do not use any method to verify information.

Despite current difficulties associated with interoperability between systems, some efforts are underway to harmonise traceability frameworks. In particular, the United Nations Transparency Protocol (UNTP) and the associated Critical Mineral Raw Materials extension seek to address gaps by providing an interoperability toolkit to allow for data exchange across supply chains, sectors and jurisdictions. Several initiatives are already utilising UNTP infrastructure, such as the Global Battery Alliance's Battery Passport and the Responsible Minerals Initiative.

Figure 3.2 Systems or methods used to verify information collected under companies' traceability systems



Notes: XRF = X-ray fluorescence. The chart only includes companies with either a full or partial traceability system.
Source: IEA analysis based on IEA/OECD survey.

Transmission of information along the supply chain

Effective traceability requires that companies active in global mineral supply chains exchange information with other actors. Currently, operators along the supply chain may not always have clear incentives or leverage to promote data sharing along the supply chain.

Midstream and downstream producers cite commercial confidentiality concerns as a reason for limiting data sharing with customers and other stakeholders, though the specific competitive risks are not always clearly defined. The midstream segment, in particular, is consistently identified as a bottleneck, given technical, commercial and sometimes political constraints that make data sharing and chain-of-custody implementation particularly challenging. Midstream operators may be reluctant to share information about upstream suppliers for fear of being passed over by purchasers. Some midstream operators may also be reluctant to provide detailed information on certain data points for fear that competitors or customers could use it to compete more effectively or request price discounts.

In addition to commercial confidentiality concerns, buyers in the downstream segment may also have limited incentive to demand traceability data from suppliers, especially if this results in increased prices with no clear benefit. Downstream buyers may also have limited ability to demand traceability information from suppliers, especially in concentrated markets with few suppliers.

In the survey, 46% of respondents (38 out of 82 companies) cited business confidentiality and competitive concerns as a top limitation for maintaining and operating a traceability system, the most frequently reported operational obstacle. This was consistent across all focus minerals and regions. Recyclers chose it as a top concern at a much higher rate, at three-quarters compared with two-thirds for traders and end users, and close to half for miners, smelters and manufacturers. This may reflect the structure of the industry, where recyclers and downstream actors often rely on proprietary information about feedstock sourcing, material composition, recovery yields and commercial relationships, and therefore face higher perceived risks from data disclosure. By contrast, upstream actors such as miners and smelters tend to operate with more standardised production processes and publicly known assets, which may reduce concerns about the competitive sensitivity of traceability-related data.

Limited leverage over suppliers was also selected by many companies as a major obstacle for setting up a traceability system. Of the respondents, 40% highlighted difficulties in identifying and engaging with suppliers as a top concern. Companies operating in graphite supply chains stand out, as 80% selected this as a top concern, compared with 60% in rare earths and around 50% for all others. This likely reflects the structure of graphite supply chains, which are characterised by many small, geographically dispersed producers and intermediaries, as well as high processing concentration, making supplier visibility and engagement more challenging.

Downstream companies also selected limited leverage at over three times the rate of upstream and midstream companies, potentially reflecting their greater distance from primary production, reliance on multiple tiers of suppliers, and more limited contractual leverage over upstream actors to require data sharing or participation in traceability systems. Collaborative initiatives across downstream sectors have already started to emerge to address this gap. For example, the Global Battery Alliance's Battery Passport has been developed with battery manufacturers and their Tier 1 suppliers.

Survey results indicate that traceability system coverage declines sharply beyond a company's immediate supply chain tier. Miners, traders, and smelters or refiners tend to have strong visibility at the mine site and refining or processing stages, but this visibility weakens considerably at the final manufacturing stage. For example, while 74% of mining companies report covering the refining or processing stage of the value chain, only about 20% extend traceability to final manufacturing. Similarly, fewer than 15% of traders or smelters or refiners report coverage at this stage. Manufacturers and end-users, by contrast, show stronger visibility within the downstream part of the chain, with coverage falling from around 80% at the refining or processing to only 55% at the mine site.

Table 3.1 Extent of traceability beyond own supply chain tier for companies with a traceability system

Operates in / traceability covers	Mine site	Refining/ Processing	Final manufacturing	Recycling/ reuse	Transport/ logistics	No tracking beyond tier-1 suppliers
Miner	95%	74%	21%	11%	21%	0%
Trader	80%	90%	10%	40%	20%	0%
Smelter/ refiner	95%	90%	15%	45%	10%	0%
Manufacturer	63%	83%	54%	29%	0%	17%
End-user	50%	80%	70%	50%	0%	20%
Recycler	71%	86%	29%	57%	0%	0%

Notes: Blue colour indicates tier of supplier, with darker blue indicating closer tier. The rows indicate the supply chain segment in which a company operates, while the columns show the segments that the company's traceability system covers. Many respondent companies operate at multiple stages of the supply chain, explaining why traceability within a company's own tier does not always add up to 100%.

Source: IEA analysis based on IEA/OECD survey.

Complex and geographically concentrated supply chains

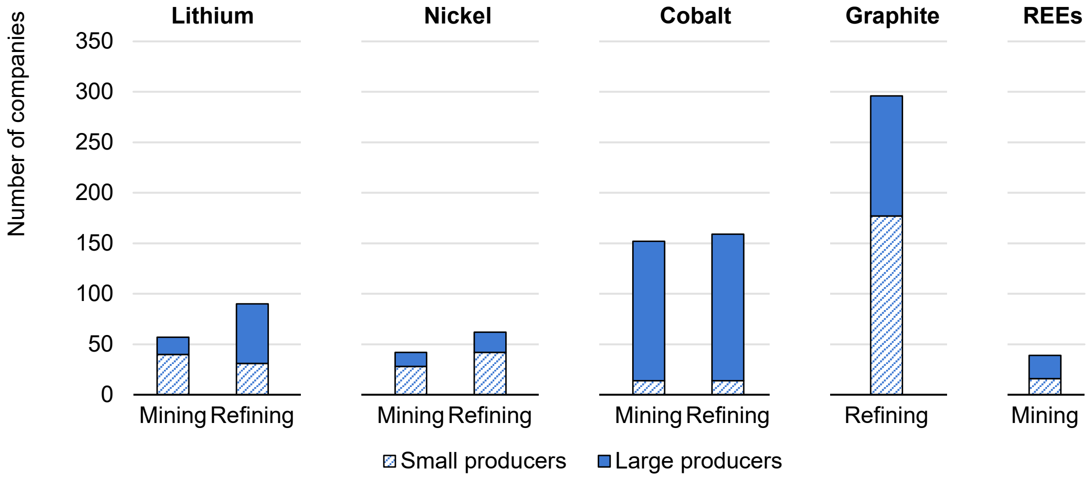
Critical mineral supply chains can be highly complex, involving numerous actors operating at every stage of the supply chain. Graphite, for example, has almost 300 companies active in its supply chain. However, there are differences across supply chains in the concentration of production between companies. In some critical mineral supply chains, output is highly concentrated among a small number of very large producers. In cobalt mining and refining, for instance, while around 155 companies are active, operations producing below the average production account for only about 10% of companies, indicating that the bulk of production is controlled by a limited set of dominant players.

Differences in mineral market structure are also a key determinant of how difficult it is to set up traceability systems. For traded commodities such as copper, the large number of actors and frequent blending at the refining stage can make end-to-end visibility significantly more complex. By contrast, battery mineral markets have a higher prevalence of direct contracts between upstream and downstream actors, making it relatively less challenging to implement traceability. In the survey, 20% of respondents (16 out of 82 companies) mentioned technical complexity as one of the top three obstacles for setting up a traceability system. This challenge was most pronounced in copper, lithium, nickel and cobalt supply chains, potentially reflecting greater levels of material blending and a larger number of suppliers. Notably, no trading companies selected this as a top barrier, which may reflect their role as intermediaries that are less directly exposed to the operational and system integration challenges associated with implementing traceability at the production and processing stages. Upstream companies selected technical complexity at a higher rate than downstream companies.

In parallel with their complex supply chains, several minerals are also characterised by high levels of geographical concentration. In some cases, mining and refining are concentrated in jurisdictions where access to data may be limited. This can be due, for example, to local data protection laws prohibiting the sharing of traceability data between domestic producers and foreign customers or to high levels of artisanal and small-scale mining (ASM) in particular regions, which can complicate efforts to trace mineral products back to their mine of origin. Where ASM is present, traceability challenges typically stem from fragmented production, limited digital infrastructure and complex aggregation at the midstream stage, rather than from the legal status of ASM itself. Cobalt, for example, is heavily concentrated in the Democratic Republic of the Congo. Over the last decade, ASM has accounted for 5-15% of cobalt mining output on average in the country.

The high concentration of mining and refining operations in opaque jurisdictions, combined with the large number of companies participating in critical mineral supply chains and the processing complexities of critical minerals, can heighten the challenges associated with tracing mineral products. At the same time, some supply chains are relatively less complex and concentrated. Lithium, for example, has fewer companies active in its supply chain (about 60 active mining companies and 90 active refining companies) and a greater level of diversification compared to other mineral supply chains, facilitating the implementation of traceability measures within this supply chain.

Figure 3.3 Company concentration by critical mineral supply chain, 2024



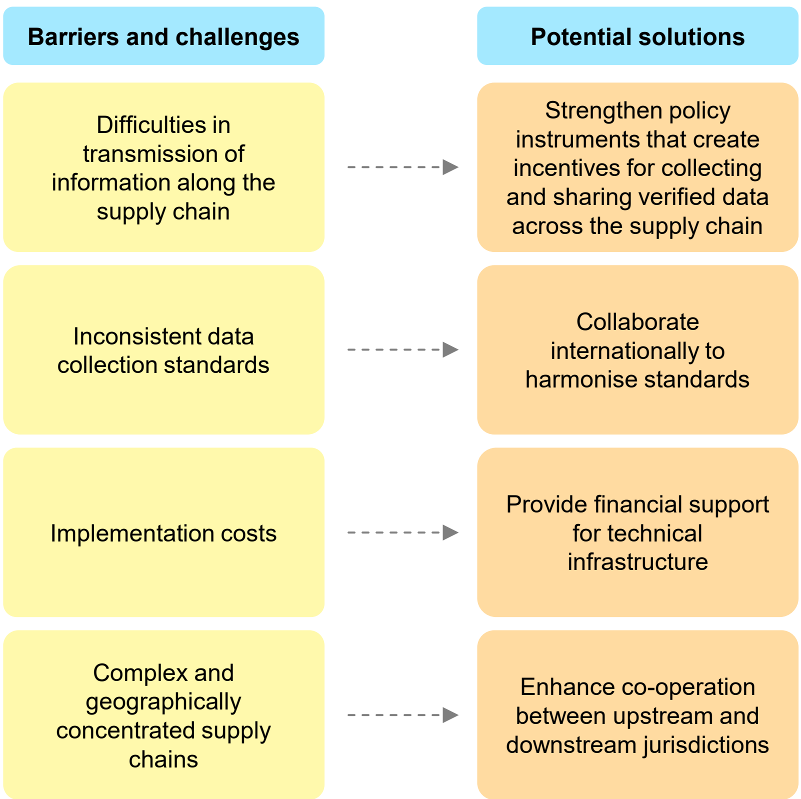
Note: Small producers are defined as those with less than the average amount of production per company. Nickel and cobalt consider the number of owners, whereas lithium, REEs and graphite consider the number of operators. For some minerals, data only cover a percentage of total production: lithium mining, 100%; lithium refining, 90%; nickel mining, 43%; nickel refining, 91%; graphite, 100%; and REE mining, 95%.

Opportunities to enhance traceability for energy and economic security

According to the IEA/OECD survey, around three quarters of surveyed companies are either very likely or somewhat likely to increase their investment in traceability over the next three years. In order of importance, respondents identified the most helpful enablers for scaling traceability as more consistent regulations or standards across jurisdictions, industry-wide data infrastructure, cost sharing or financial incentives, access to technology and capacity building or training.

Building on these insights and drawing on broader IEA analysis, the following recommendations outline how governments can strengthen the role of traceability in supporting energy and economic security objectives.

Figure 4.1 Current challenges and proposed solutions for enhancing mineral traceability



Strengthen policy instruments that create incentives for collecting and sharing verified data across the supply chain

Companies active in mineral supply chains, whether in the upstream, midstream or downstream segments, may currently have limited incentives to collect, share or demand verified traceability information. Governments can address this by embedding incentives for traceability directly into critical mineral policy instruments. A combination of regulatory, financial and market-based measures can strengthen uptake across the supply chain, and a strategic combination of "push" and "pull" mechanisms can significantly boost effectiveness.

On the "push" side, governments can provide incentives that reduce the costs of implementing and maintaining traceability systems for mining and refining operators located in their territory, for example through direct funding or relevant tax breaks. Governments can also require companies that receive export credit financing or public procurement contracts (e.g. for stockpiling purposes) to establish and operate traceability systems. In addition, governments can issue verifiable credentials in digital form (e.g. business identification numbers, licences and permits and origin certificates) to mining and refining operators, enhancing the trustworthiness of information shared along the supply chain, as the Government of British Columbia (Canada) has been piloting since 2024. Such credentials can support access to sustainability-focused markets and compliance with origin requirements in downstream jurisdictions.

On the "pull" side, governments can roll out measures that incentivise downstream companies to demand traceability information from upstream and midstream operators. One avenue in this regard is to offer tax credits or deductions for products containing minerals sourced from non-dominant producers, similar to what the United States previously did under the Inflation Reduction Act. Another avenue is to implement regulatory measures that require the tracing of mineral inputs (as the European Union has done under the Batteries Regulation) or that discourage or penalise the sourcing of unsustainable products (for example due diligence legislation or import measures). However, governments should be careful not to implement such measures in a manner that disrupts market efficiencies or generates supply chain issues.

Consuming economies can also work with downstream companies to create joint sector-wide initiatives. A joint initiative can aggregate downstream companies' leverage and facilitate the gathering of traceability-related data from midstream operators. Such initiatives can pool resources and enable cost-sharing among participating companies. Governments in consuming economies can also encourage downstream companies to prioritise direct contracts with upstream mineral producers, providing better control of materials and reducing bottlenecks at the midstream stage.

How traceability strengthens critical mineral policy instruments

Policy instruments can both incentivise the adoption of traceability and benefit from it, as traceability data can strengthen the implementation of measures aimed at diversifying and securing critical mineral supply chains.

Countries are increasingly mobilising public finances to diversify and strengthen critical mineral supply chains, deploying a range of policy tools including offtake agreements, grants and concessional loans, tax incentives, guarantees and direct equity participation. While these instruments help de-risk projects and attract private investment, their effectiveness depends heavily on the quality and reliability of information about mineral production, movement and compliance with policy conditions.

By providing verified data on production volumes, mineral specifications, delivery fulfilment and compliance with policy conditions, traceability systems reduce information asymmetries and build confidence among private-sector partners and government stakeholders. When integrated into financing mechanisms, they enable more effective monitoring of policy compliance, more accurate pricing and compensation calculations, and lower administrative burdens for government agencies.

Traceability systems, which track minerals from extraction through processing and trade, can strengthen policy tools for de-risking and financing critical mineral projects, from offtake agreements to strategic stockpiling.

Table 4.1 Role of traceability in strengthening policy tools for critical mineral supply chains

Category	Instrument	How traceability systems enhance effectiveness
Offtake agreements or price support	*Floor price*	• Authenticate origin if the floor price applies only to domestic production or production from specific jurisdictions • Verify eligible material sources to prevent substitution
	Contract for difference	• Authenticate origin for jurisdiction-specific agreements • Verify eligible material sources to prevent substitution with non-compliant material during transport or storage
	Take or pay	• Authenticate provenance of committed quantities • Verify eligible material sources to prevent substitution with non-contracted sources
	Direct offtake agreement	• Authenticate provenance and prevent substitution • Verify responsible sourcing if required by government procurement standards • Provide chain-of-custody from mine to government purchaser (e.g. to support procurement) • Embed traceability requirements at the contract design stage to ensure systems are operational from first production and reduce retrofit costs

Category	Instrument	How traceability systems enhance effectiveness
Loan or cash grant	*Forgivable loan*	• Verify responsible sourcing and track performance against conditions • Authenticate compliance with any origin or processing location requirements
	Cash grant	• Authenticate provenance and processing requirements for grant eligibility (e.g. domestic processing) • Authenticate responsible sourcing if required
	Risk-free rate loan	• Authenticate compliance with origin or processing requirements, confirming outputs meet qualifying production and quality criteria
Tax-related incentive	*Corporate tax reduction*	• Verify domestic processing and local content requirements to validate eligibility for tax benefits • Authenticate origin for jurisdiction-specific tax benefits
	Refundable tax credits	• Verify production activities and volumes to determine credit eligibility • Authenticate compliance with local content or domestic processing requirements
Risk absorption	*Direct equity participation*	• Provide government shareholders with transparent, verified production and operational data • Verify compliance with responsible sourcing commitments if applicable
	Guarantees	• Authenticate provenance and responsible sourcing to assess guarantee risk, if applicable • Support loan guarantee claims with documented production and delivery records
	Regulatory facilitation	• Verify environmental and social compliance to support accelerated permitting • Provide authorities with real-time monitoring data for ongoing compliance and responsible sourcing credentials
Other	*Stockpiling*	• Authenticate provenance and mineral specifications for strategic reserve composition • Verify responsible sourcing for government procurement standards • Support offtake agreements tied to stockpile build-up through verified delivery data and transparent supply chain information

When incorporated into financing frameworks, traceability can also support broader policy objectives such as responsible sourcing, environmental compliance and supply chain resilience, provided that financing frameworks are deliberately designed to incorporate specific sustainability and responsibility criteria and enforcement mechanisms. Strategic stockpiling initiatives present a related but distinct use case: while traceability can provide verified data on material quality and specifications to ensure stockpiled materials meet technical requirements for deployment during supply disruptions, this function is separate from the verification of performance related to responsible sourcing objectives.

Provide financial support for traceability infrastructure

Building an effective traceability system can often require significant upfront investments and ongoing operational expenditure. In the survey, respondent companies identified the cost of implementation as the largest barrier to setting up a traceability system. Governments can help reduce these costs by providing financial support for traceability systems.

Upfront expenditure (e.g. new IT infrastructure, additional human resources and employee training) can be reduced by providing grants to local companies, industry associations or technology providers. The Government of Canada, for example, launched a CAD 675 000 project (USD 490 000) in 2023 to fund commercial-stage pilot traceability projects for mineral supply chains, while the Government of Québec (Canada) has announced that it will establish a support programme to drive adoption of traceability systems within mining companies. Funding can be targeted at specific pilot projects, which can facilitate the expansion of traceability solutions across the wider sector.

Ongoing operational costs (e.g. computing power, regular maintenance and skilled technical support) can be reduced by offering tax credits or deductions to local companies that implement and operate traceability systems, particularly during the initial years of operation.

Governments can also fund research and innovation projects that seek to develop technological solutions for traceability, as the European Union has done through its EUR 11 million (USD 13 million) Material and Digital Traceability for the Certification of Critical Raw Materials project that aims to develop digital, geochemical and artificial intelligence-based approaches for critical raw material traceability.

Collaborate at the international level to harmonise traceability standards

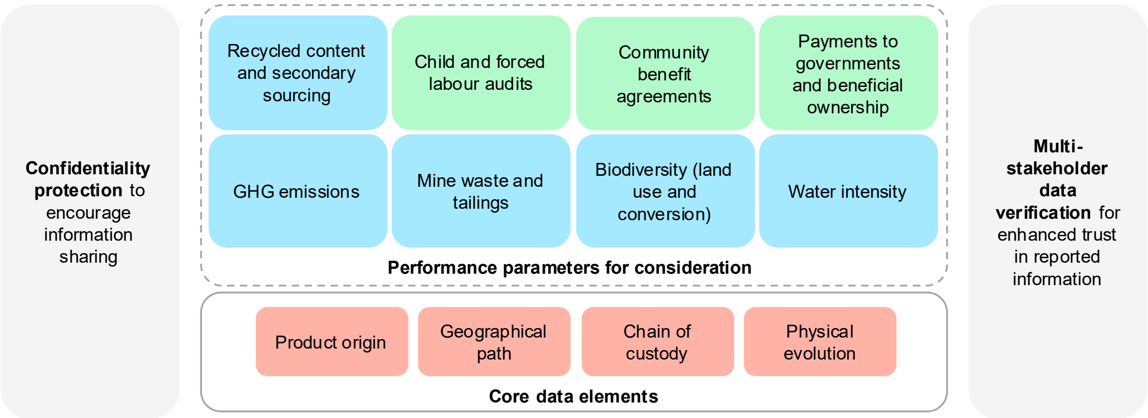
At present, companies active in global mineral supply chains often have incompatible traceability-related technical infrastructure and data collection standards. Data systems are disparate and lack a standardised "data handshake", preventing the seamless flow of information between actors along the supply chain. This fragmentation can create inefficiencies and exacerbate costs. It can also reduce the comparability and reliability of collected traceability information and performance attributes, hindering the development of a market for sustainable and responsible mineral products.

To enhance traceability along the supply chain, governments can collaborate internationally to harmonise traceability practices and set common standards. Discussions could be launched towards the creation of a common framework for collecting, sharing and verifying traceability-related information along mineral supply chains, including standardised data definitions and reporting expectations. This could build on, or expand, work initiated as part of existing international initiatives, for example the United Nations Transparency Protocol or the International Organization for Standardization's Mass Balance Standard.

In setting up a common framework, governments should ensure that it covers both technical infrastructure (i.e. how data are collected, stored and exchanged) and data collection (i.e. what data are collected and passed along the supply chain). Key data points to consider include product origin, geographical path, chain of custody and physical evolution, as well as performance-related metrics. Countries that have imposed mandatory reporting requirements and set up centralised digital platforms should also examine how these can be harmonised with the common framework.

Governments should also take measures to ensure that confidential business information shared in accordance with the common framework is protected, encouraging further transmission of information along the supply chain. Options to protect commercially sensitive information include using performance scores that anonymise sensitive data, non-disclosure agreements signed between suppliers and customers, and arrangements that limit disclosure of sensitive data to responsible sourcing teams within companies. A related matter is to clarify whether collected data will be shared with governments or whether data will remain with companies to protect business confidentiality. Particular attention should also be paid to how collected data are verified, leading to enhanced trust in reported information.

Figure 4.2 Key data points to consider for harmonised traceability standards



Note: The performance parameters are suggested starting points and are neither prescribed nor exclusive; as such, they depend on government priorities and mutual agreement among relevant stakeholders.

Harmonised standards should refrain from mandating which technology or software must be used to collect and share information and should instead preserve flexibility for operators to choose their preferred technology or software, as long as they comply with the standards.

To foster greater uptake of the framework among industry actors, harmonisation discussions should occur in consultation with industry associations and companies active in mineral supply chains. Existing industry-led initiatives – including the Global Battery Alliance's Battery Passport and the Responsible Business Alliance's Responsible Business Transparency Protocol – can be leveraged in developing the common framework, though caution should be taken not to perpetuate the proliferation of multiple parallel frameworks, which could create further fragmentation and increase costs for operators (see Annex II).

Harmonisation discussions should also be multi-stakeholder and involve civil society organisations (CSO) and Indigenous Peoples' representatives. Governments can leverage existing CSO tools and frameworks, for example the Extractive Industries Transparency Initiative Standard, to verify company claims and enhance the credibility of reported data.

International fora that involve both major producers and consumers (such as the IEA's Working Party on Critical Minerals or the G7) could be leveraged to advance discussions on a unified traceability framework. A harmonised traceability framework with common technical infrastructure and data collection standards has the potential to spur greater sharing of information along the supply chain, enhance the reliability and credibility of collected data, and facilitate the comparability of traceability information and related performance attributes. Together, these elements can pave the way for the formation of standards-based markets (with potential incentives for high-performing operators), leading to greater supply chain diversification and enhanced energy security. Such a framework would align with the G7's Roadmap to Promote Standards-based Markets for Critical Minerals, released in October 2025, which called for a progressive increase in traceability and for the development of a global interoperability framework.

Enhance co-operation between upstream and downstream jurisdictions

An effective traceability system requires the exchange of information between different actors along the supply chain. Downstream companies seeking to trace their products will often need to collaborate with actors located in foreign jurisdictions. Some upstream actors may be located in jurisdictions with limited access to digital technology (especially in emerging market and developing economies) or with data protection laws that hinder the disclosure of traceability data.

Collaboration between upstream and downstream jurisdictions can reduce barriers and promote data-sharing, driving wider adoption of traceability in mineral supply chains. Co-operation between jurisdictions can take various forms, including bilateral co-operation mechanisms, technical assistance initiatives in producing countries and multi-stakeholder dialogue platforms for relevant commodities.

Countries have several tools at their disposal to increase co-operation on traceability systems. For example, downstream jurisdictions can direct public funding towards the implementation of traceability systems in upstream jurisdictions, particularly those with limited access to digital infrastructure. Downstream jurisdictions can also provide technical assistance and training on traceability to upstream operators. Moreover, upstream and downstream jurisdictions can work together to establish collaborative frameworks under which downstream companies transfer relevant technology and equipment (e.g. hardware and software infrastructure) to upstream producers in exchange for long-term verifiable data.

Adopt a gradual and pragmatic approach focusing on less complex supply chains and core data elements

Global mineral supply chains are highly complex and involve numerous actors across dispersed jurisdictions, some located in opaque contexts with high levels of artisanal and small-scale mining (ASM). These realities can complicate the ability of downstream companies to trace information further up the supply chain, especially if downstream companies are expected to collect multiple data elements.

To accommodate these realities, like-minded countries can adopt a pragmatic and progressive approach focusing on the least complex supply chains and the most basic data elements. Focusing on supply chains that are less concentrated in opaque jurisdictions can reduce the risk that downstream operators will be unable to gather traceability information from upstream actors. Similarly, supply chains with fewer actors at certain steps may prove less complex or costly to set up and operate traceability systems, particularly at the midstream stage, where mixing or blending and confidentiality concerns can create bottlenecks. Where possible, traceability requirements should be introduced at the earliest stages of project development, including permitting and initial offtake negotiations, to ensure traceability benefits are realised from the outset and to avoid costly retroactive system design.

Like-minded countries can concentrate efforts to enhance mineral traceability by focusing on one mineral and a few core data elements. For example, they can initiate harmonisation discussions by focusing on one particular mineral and complement this with co-ordinated public funding for the implementation of traceability systems within that mineral's supply chains. A progressive approach of this nature can allow governments and operators to identify challenges and implement improvements. This experience can then be used to progressively roll out traceability to other, more complex supply chains and data fields. Existing industry-led initiatives, such as Catena-X, which has developed standardised data exchange frameworks for automotive supply chains, can offer useful models for how shared data infrastructure can be built incrementally across multiple stakeholders (see Annex II).

To choose which mineral supply chain to concentrate initial traceability efforts on, governments can prioritise minerals where implementation is most feasible, based on factors such as geographic concentration, company concentration, jurisdictional transparency, degree of ASM, diversity of end-use applications, market transparency, existing breadth of traceability implementation and processing complexity. Starting with the least-complex mineral supply chains maximises the likelihood of concrete progress and can provide a replicable model for expansion to other mineral supply chains. In addition to ease-of-implementation, a mineral's strategic importance and risk level are also relevant considerations for choosing which minerals to target first, and this should inform sequencing over the medium and long term.

One possible option would be to focus initial policy efforts on lithium supply chains. Lithium is central to battery production, including batteries for electric vehicles, grid storage and defence applications. Implementing traceability systems within lithium supply chains could be relatively less complex compared to other mineral supply chains. Lithium has a relatively diversified supply chain compared to the IEA's other focus minerals, with a significant proportion of mining production located in OECD member countries (e.g. Australia and Chile) with high jurisdictional transparency. ASM involvement is lower compared to other minerals, and the number of companies active in lithium mining and refining is relatively limited. As a primary product, production volumes are tracked and reported independently rather than as a byproduct of another ore. Lithium is also a relatively liquid and transparent market compared to other battery metals, and its end-use applications are relatively homogenous (with 80% of demand by 2035 expected to come from electric vehicle batteries).

In parallel with focusing on lithium supply chains, harmonisation discussions could be directed towards the core data elements of origin, geographical path, chain of custody and product transformation. Initial discussions could also incorporate sustainability-related data, for example water consumption. Lithium is primarily sourced from brines in Latin America (mainly Argentina and Chile) and hard rock in Australia, which together accounted for around 60% of production in 2024. Both sources play a critical role in battery supply chains: brine lithium is used for a broad range of applications, while hard rock spodumene remains the preferred precursor for lithium hydroxide used for high-nickel cathodes in long-range EVs.

Reducing water intensity is one of the key issues in brine lithium production, as brine extraction can be a highly water-intensive process and typically occurs in arid regions where water scarcity is already a concern. By contrast, the more significant sustainability challenge for hard-rock lithium production relates to greenhouse gas (GHG) emissions intensity, driven in part by the energy-intensive refining processes required to convert spodumene into battery-grade lithium hydroxide. Tracing water consumption and GHG emissions in lithium supply chains is therefore a useful starting point for assessing lithium's sustainability performance, and policy efforts to develop traceability frameworks should be calibrated to capture the distinct sustainability profiles of each type of production.

As traceability systems mature, governments can leverage verified supply chain data to enable standards-based market mechanisms that reward responsible sourcing. Traceability provides the foundational infrastructure for certifying minerals against environmental, social and governance standards, creating market differentiation between responsibly sourced and conventional materials. By creating market value for traced and certified minerals, these mechanisms provide commercial incentives for operators to participate in traceability systems, complementing regulatory requirements with economic rewards. For instance, battery manufacturers seeking to meet increasingly stringent sustainability criteria may be willing to pay premiums for lithium with verified low-carbon processing and ethical sourcing, premiums that can only be credibly demonstrated through robust traceability systems.

Annexes

Annex I.

Selected traceability policies and regulations

Country/ Region	Title of policy	Strategic purpose	Measure(s)	Data required	Applicable critical minerals
Colombia	Mining Traceability and Transaction Control System (2024)	Value capture	National platform with mine inspections and registry integration, intended to eventually feed into Colombia's national mining information platform (Genesis portal)	• Origin declaration • Production volumes • ASM validation • Royalty payment	All minerals
Canada	Fighting Against Forced Labour and Child Labour in Supply Chains (2023)	Sustainable and responsible supply	Requires due diligence for human rights and environmental risks	**	All minerals
The Democratic Republic of the Congo	Cobalt export quota system (2025)	Value capture	New rules for exporting material require a verification certificate, to be awarded once samples of material have been taken, weighed and analysed by a government laboratory	• Historical export volumes • Origin or sales declarations • Physical inspection results • Royalty pre-payment • Chain of custody	Cobalt
European Union	Critical Raw Materials Act (CRMA) (2024)*	Supply security; Sustainable and responsible supply	Supply chain mapping for strategic and critical minerals	**	All strategic raw materials, including cobalt, lithium, nickel, copper, natural graphite, rare earth elements

Country/ Region	Title of policy	Strategic purpose	Measure(s)	Data required	Applicable critical minerals
European Union	Batteries Regulation (2023)	Supply security; Due diligence	Digital product passports and due diligence for battery minerals	• Battery identifier, model, type, chemistry • Location of manufacturing plant • Carbon footprint by lifecycle stage • Material composition • Percentage of recycled cobalt, lithium, nickel and natural graphite • Third party audit certification	Cobalt, natural graphite, lithium, nickel
Germany	Act on Corporate Due Diligence Obligations in Supply Chains (2021)	Sustainable and responsible supply	Requires due diligence for human rights and environmental risks	**	All minerals
India	National Critical Mineral Mission (2025)*	Value capture	Government-developed national traceability system under the National Critical Mineral Mission	• Production or exploration data • Traceability (to be determined)	All minerals
Indonesia	SIMBARA (2023)	Value capture	Inter-agency monitoring platform for nickel and tin production volume, tracking government revenue	• Production quotas • Inventory reports • Ore source registration • Royalty payment • Shipment/transport data	Nickel, tin
United States	Uyghur Forced Labor Prevention Act (2021)	Supply security; Sustainable and responsible supply	Importers requesting exceptions are required to submit supply chain documentation showing the roles of each entity and tracing the supply chain from raw materials to the imported good, demonstrating that the supply chain is outside of Xinjiang and unconnected to the listed entities, or that the imports are free of forced labour	• Country of origin • Full supply chain mapping • Labour practices evidence	All minerals

Country/ Region	Title of policy	Strategic purpose	Measure(s)	Data required	Applicable critical minerals
United States	Sec. 857(a), National Defense Authorization Act (2023)	Supply security	Provenance tracking for rare earths in permanent magnets	• Origin declaration • Magnet provenance	Rare earth elements and strategic materials used in permanent magnets
China (People's Republic of)	Regulations on the Management of Rare Earths (2024)	Supply security; Illegal mining	Product flow records and traceability for rare earths	• Monthly product flow record • Quota compliance data • Export declarations	Rare earths with specific mention of magnets in the context of recycling
China (People's Republic of)	Interim Provisions on the Traceability Management of Power Battery Recycling in New Energy Vehicles (2018)	Supply security	Lifecycle tracking of EV batteries via battery codes	• Battery codes • Production/installation data • End-of-life disposition • Repurposing records	EVs
Uganda	Mineral Licensing Reform Strategy *	Sustainable and responsible supply; Value Capture	Policy reform to improve licensing transparency and efficiency	*Not yet enacted*	All minerals
Zambia	Mineral Output Statistical Evaluation System (MOSES) (2016)	Illegal mining	Monitoring platform on trade and production volume for government revenue	• Monthly production returns • Sales/purchase data • Export permit data	All minerals (mainly copper)

Notes: *India's traceability system has been launched but specific data requirements are still being defined by government; Uganda's licensing reform strategy has been announced but not yet enacted into law; and for the EU CRMA, most company-level data requirements will be specified through delegated and implementing acts that are still being finalised.

** Due diligence frameworks (Canada, Germany, UFLPA) require disclosure of processes and findings rather than standardised data submission, and specific data points are determined by the reporting entity.

Sources: IEA analysis based on IEA Critical Minerals Policy Tracker.

Annex II.

Operational multi-stakeholder traceability initiatives for critical minerals end use

Initiative	Architecture	Sector focus	Description	Approach to interoperability	Maturity
Catena-X / EcoPass KIT *Catena-X Automotive Network e.V.*	Federated platform	Automotive manufacturing and battery components	• Open-source platform with participation of a network of OEMs, suppliers, service providers, recyclers, etc. to exchange operational and lifecycle data across the entire automotive value chain • Targets use cases such as quality management, supply chain risk and disruption management, product carbon footprinting, circularity, and regulatory compliance (e.g. traceability, digital product passports)	• The Catena-X Automotive Network e.V. sets and publishes the standards for interoperability, data sovereignty and security, and coordinates release cycles and certification. • Participants connect via certified applications and connectors that implement Catena-X standards, with reference architectures and modular "use case" building blocks.	• Live and scaling, with more than 180 members • Cross-border interoperability with Japan's Ouranos Ecosystem demonstrated in March 2025
GBA Battery Passport *Global Battery Alliance (GBA)*	Decentralised credentials	Full battery value chain from mine to recycling	• Sustainability reporting and certification scheme for batteries, built as a Digital Product Passport that makes supply chains transparent, and aggregates, verifies and scores data on environmental, social and governance (ESG) performance along the supply chain. • The GBA Greenhouse Gas Rulebook defines globally harmonised rules for "cradle-to-gate plus recycling" battery carbon footprints, including data quality, allocation and update frequency, to make PCFs comparable and trustable. • The Battery Benchmarks contains harmonised ESG and due diligence metrics for salient risks across battery supply chains, underpinned by a comprehensive 3rd party assurance scheme.	• Mass-balance based chain-of-custody model designed to be interoperable across jurisdictions; can be made interoperable with other chain of custody standards and traceability methodologies. • GBA is a registered extender of UN Transparency Protocol for battery passports. Open data exchange protocol, fully interoperable with in-house or commercial digital solutions and other protocols. • The Battery Benchmarks distil over 4 000 regulatory and voluntary standard clauses into ~300 benchmarks for streamlined and interoperable reporting across standards.	• In 2024, second wave of pilots completed with 10 consortia led by manufacturers representing over 80% of global EV battery market share. • Further developing chain of custody requirements through ongoing operational trials. • ESG benchmarking framework is being finalised based on trialling and public consultation feedback. • The GBA will evolve the pilots into a globally scalable Battery Passport and battery certification scheme by 2027.

Initiative	Architecture	Sector focus	Description	Approach to interoperability	Maturity
Responsible Business Transparency Protocol (RBTP) *Responsible Business Alliance (RBA)*	Decentralised credentials	Electronics & electrical products, automotive (full supply chain inc. critical minerals)	• Enables multi-tier supply chain visibility and traceability through portable digital credentials that can be issued, verified, and reused across organisations and systems	• RBTP is an industry-specific extension of the United Nations Transparency Protocol (UNTP). • Uses verifiable credentials and related open standards to represent claims (e.g. provenance, sustainability, due diligence outcomes) in a cryptographically secure, machine-readable way. • Platform-agnostic and enables supply chain actors to retain control over their own data.	• Recently completed large-scale collaborative pilot focused on copper, cobalt and lithium used in batteries and related applications to demonstrate proof of concept across platforms in real, complex supply chains • Digital credentials are available for all RBA and RMI led assessments and made available for all 600+ RBA members facilities and supplier sites. Further developing tools and resources and convening industry working groups to support companies & software implementers in adoption and implementation.

Notes: The examples listed are limited to cross-industry initiatives implementing traceability systems with running pilots. GBA covers upstream to mining and refining, RBTP has prioritised critical minerals and are testing implementation with printed circuit boards and semiconductors, while Catena-X focuses on the manufacturing and assembly tier.

Abbreviations and acronyms

ANM	National Mining Agency (Agencia Nacional de Minereda)
ASM	artisanal and small-scale mining
CAD	Canadian dollar
CRMA	Critical Raw Materials Act
CSAM	Central and South America
CSO	civil society organisation
CSDDD	Corporate Sustainability Due Diligence Directive
DRC	Democratic Republic of the Congo
EU	European Union
EUR	euro
EV	electric vehicle
G7	Group of Seven
GBA	Global Battery Alliance
GHG	greenhouse gas
IDR	Indonesian rupiah
IT	information technology
ISO	International Organization for Standardization
MOSES	Mineral Output Statistical Evaluation System
NDAA	National Defense Authorization Act
OEM	original equipment manufacturer
OECD	Organisation for Economic Co-operation and Development
PCF	product carbon footprint
RBA	Responsible Business Alliance
RBTP	Responsible Business Transparency Protocol
RCI	Responsible Critical Mineral Initiative
REE	rare earth elements
RMI	Responsible Minerals Initiative
SIMBARA	Inter-Ministry/Institutional Mineral and Coal Information System
UN	United Nations
UNTP	United Nations Transparency Protocol
USD	United States dollar
US	United States
UFLPA	Uyghur Forced Labor Prevention Act
XRF	X-ray fluorescence

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