POLICY BRIEF

2025. 05

TRANSITION MINERALS:

CHALLENGES TOWARD A SUSTAINABLE ENERGY TRANSITION

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1. Introduction: The Era of Climate Crisis and Rising Mineral Demand

1. Surging Mineral Demand Driven by Carbon Neutrality and the Energy Transition

- **Countries worldwide are accelerating the transition to renewable energy and adopting carbon neutrality targets in response to the climate crisis.**
  - This is leading to a dramatic rise in the demand for key mineral resources due to the rapid deployment of low-carbon technologies.
    - According to the International Energy Agency (IEA)'s Net Zero Emissions (NZE)* scenario, global demand by 2040 is projected to[1]:
      - Increase by approximately 8 times for lithium
      - 4 times for graphite
      - 2 times for nickel, cobalt, and rare earth elements
      - 1.5 times for copper

      *NZE: A scenario outlining a pathway to limit global warming to 1.5°C by achieving net-zero carbon emissions by 2050.
    - Demand from clean energy technologies is the key driver of mineral growth, with electric vehicles (EVs) and energy storage expected to account for over 90% of total lithium consumption.
  - The energy transition is reshaping the global structure of mineral demand at a fundamental level.

2. Intensifying Geopolitical Competition for Mineral Resources

- **Major countries are pursuing strategies such as resource development, export restrictions, and supply chain diversification to secure access to critical minerals.**
  - China has strengthened its strategic management of minerals since 2008 through its *National Mineral Resource Plan*.
    - State-owned enterprises have expanded their dominance in both overseas mining and refining

1 IEA, Global Critical Minerals Outlook 2024.

stages.

- China produces about 60% of global rare earth elements and refines approximately 90% of rare earths, and 60–70% of lithium and cobalt.[2]
- China has strategically restricted the export of rare earth elements such as gadolinium, dysprosium, and samarium in response to U.S. tariffs.

○ The United States, under the Biden administration, launched the *Minerals Security Partnership (MSP)** and enacted the *Inflation Reduction Act (IRA)*** in 2022.

*MSP: A U.S.-led international initiative joined by Canada, the EU, Korea, Japan, and others to enhance the security and transparency of critical mineral supply chains.

**IRA: A U.S. federal law providing tax credits for batteries using critical minerals that are mined or refined in the U.S. or allied countries.

- These initiatives aimed to strengthen cooperation with allies and diversify mineral supply chains.
- However, under the second Trump administration, the U.S. is reinforcing direct competition and diplomatic pressure to secure overseas resources.

○ The European Union has enforced the Critical Raw Materials Act (CRMA) in 2024.

- By 2030, it sets targets to domestically extract 10%, refine 40%, and recycle 25% of critical raw materials.
- It also aims to reduce dependence on any single country to below 65% to strengthen the supply chain.

○ Indonesia is leveraging its vast nickel reserves to ban raw ore exports, while promoting domestic smelting, EV manufacturing, and industrial upgrading.

○ Key lithium-producing countries in Latin America are advancing resource sovereignty through nationalization and joint ventures.

- Argentina, Chile, Bolivia, and Brazil are discussing a "Lithium OPEC" to coordinate production and influence market prices.

3. Environmental and Social Impacts of Rising Mineral Demand

Environmental and Social Impacts from Mining and Production

○ Mineral extraction and production cause significant environmental degradation, such as deforestation, water and soil pollution, and waste generation. These activities also lead to violations

2 IEA, Energy Technology Perspectives 2023: Clean Energy Supply Chains Vulnerabilities.

of community and labor rights.

- Common impacts include ecosystem destruction around mine sites, deterioration of water quality, and reduction of carbon sinks (e.g., forests).
- Smelting is a major source of air pollution and greenhouse gas emissions.
- Indigenous and local communities often suffer rights violations during mining operations.
- Cases frequently neglect the principle of Free, Prior and Informed Consent (FPIC)*.

  *FPIC: A principle ensuring Indigenous peoples' full and effective participation in decisions affecting their lands, resources, and livelihoods.
- In some regions, serious labor rights violations—such as child labor and forced labor—are occurring.
- Community displacement and loss of livelihood due to mine development are also critical issues.

Limitations in Supply Chain Transparency and Accountability

- As global supply chains grow more complex, it becomes increasingly difficult to trace and verify environmental and social impacts from mining to end product.
- Human rights abuses and environmental destruction are often hidden, with accountability blurred.
- The UN Secretary-General's Panel on Critical Energy Transition Minerals emphasized that "The urgency of the energy transition cannot justify irresponsible practices in mineral supply chains."[3]
  - It proposed principles to ensure human rights, environmental protection, and inclusion throughout the supply chain.
- This global awareness signals the urgent need for a systemic approach to address the risks associated with increasing mineral demand in the energy transition.

Purpose of This Brief

- This policy brief:
  - Diagnoses the environmental and social challenges driven by increasing mineral demand
  - Reviews key strategies for addressing these challenges
  - Proposes an integrated and responsible policy approach focused on demand management and supply chain sustainability

3 UN Secretary-General's Panel on Critical Energy Transition Minerals, Resourcing the Energy Transition: Principles to Guide Critical Energy Transition Minerals Towards Equity and Justice, 2024.

II. What Are Transition Minerals?

1. Definition and Key Technological Uses

■ **'Transition minerals' refer to minerals that are essential in the shift from fossil fuel-based energy to renewable energy sources.**

- While there is no globally unified definition of transition minerals, the term is commonly used by international organizations, academia, and NGOs to describe minerals needed in the energy transition process.
  - The United Nations Environment Programme (UNEP) defines transition minerals as "naturally occurring substances, primarily found in rocks, that are ideally suited for use in renewables."[4]

■ **Low-carbon technologies introduced during the energy transition are significantly more mineral-intensive than fossil fuel-based energy production.**[5]

- **Lithium, nickel, cobalt, manganese, graphite:** Essential for improving battery performance, lifespan, and energy density.
- **Rare earth elements:** Critical for manufacturing permanent magnets used in wind turbines and electric vehicle motors.
- **Copper, aluminum:** Crucial for expanding transmission and distribution networks to meet rising electricity demand; copper, in particular, is a key material for all electricity-related technologies.

<Table 1> Essential minerals for the clean energy transition

Mineral	Solar PV	Wind	EVs and battery	Hydro	Hydrogen fuel cells	Geothermal
Bauxite	O	O	O	O	O	
Chromium		O	O	O		O
Cobalt			O		O	
Copper	O	O	O	O	O	O
Indium	O					
Iron	O	O	O			
Lead	O	O	O	O		
Lithium			O			
Manganese		O	O	O		O
Molybdenum	O	O		O		O
Nickel	O	O	O	O	O	O
Rare Earths		O	O		O	
Silver	O					
Titanium				O	O	O
Zinc	O	O	O	O		

Source: Roche et al. (2023)

4 UNEP, What are energy transition minerals and how can they unlock the clean energy age?, 2024.

5 World Bank, Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition, 2020.

2. The Political Economy of the Terminology: "Critical Minerals" vs. "Transition Minerals"

Governments designate minerals essential to strategically key industries as "critical minerals" and manage them accordingly

- Criteria vary by country but generally include import dependence, supply risk, substitutability, and production concentration.
- Most countries include minerals for renewable energy in this category, but many also classify defense-related minerals as critical.
  - The Trump administration, for example, emphasized policies to secure critical minerals and strategically managed rare earth elements, largely driven by defense industry demands[6]
- In South Korea, the Ministry of Trade, Industry and Energy has identified 33 types of minerals, including lithium, nickel, cobalt, and rare earth elements, as critical minerals under its "Critical Minerals Security Strategy"

Terminological Differences: "Critical Minerals" vs. "Transition Minerals"

- The term critical minerals is primarily used by governments and industries, with a focus on the urgency and importance of securing supply chains
- In contrast, transition minerals is a term more widely used by academia, human rights and environmental movements, and international organizations such as the IEA and UNEP
  - Critics argue that the term "critical" can obscure or downplay the human rights and environmental issues arising from mineral extraction.
  - The **SIRGE Coalition (Securing Indigenous People's Rights in the Green Economy)**, an alliance of Indigenous groups, recommends using the term transition minerals.[7]

Policy Implications of Terminology

- The term critical minerals can be used to justify mineral policies centered on national security and industrial strategy
- Meanwhile, the term transition minerals helps highlight the environmental and social responsibilities associated with the energy transition.
- Thus, the choice of terminology carries significant political implications for setting priorities in mineral policy.

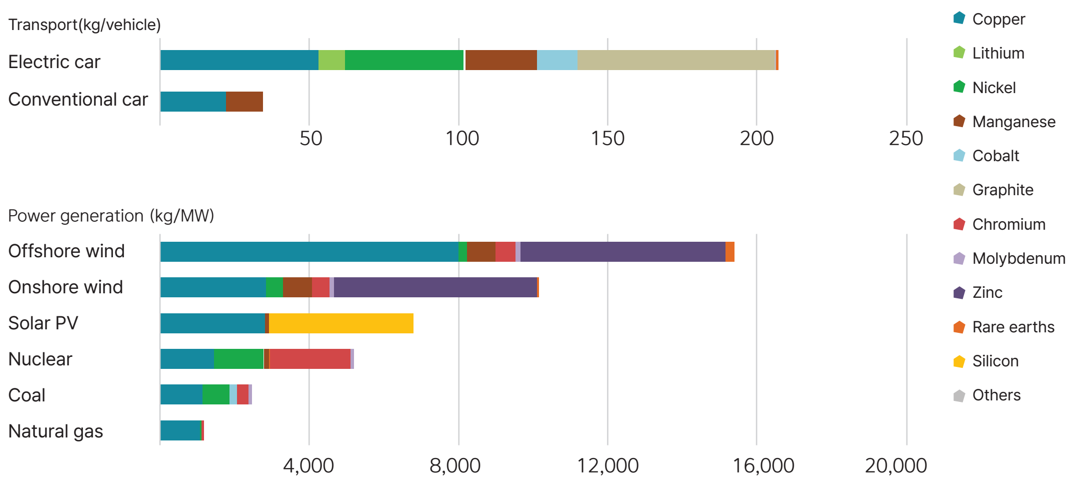
6 Global Witness, Critical minerals were once for renewables. Now they're for war, 2025.

7 Mongabay, "Energy transition minerals: questions, consent and costs are key", April 9, 2024.

3. Projected Increase in Demand for Transition Minerals

- **According to the IEA (2022), electric vehicles require about six times more minerals than internal conventional vehicles, and onshore wind power plants require nine times more minerals than gas-fired power plants.**
  - ○ As clean energy technologies continue to spread, the demand for various minerals—including lithium, nickel, cobalt, manganese, graphite, copper, zinc, silicon, and rare earth elements—is expected to surge.

[Figure 1] Minerals used in selected clean energy technologies

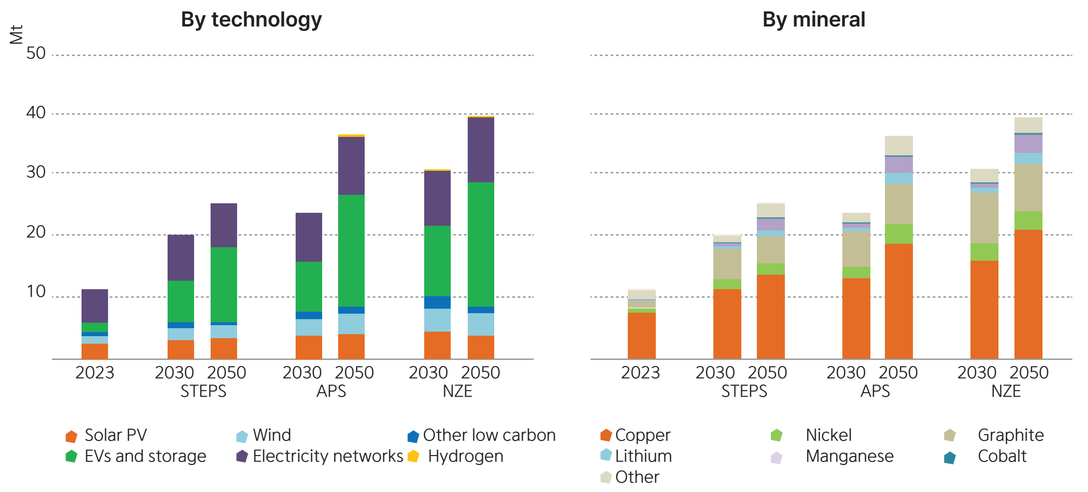


Notes: kg = kilogramme; MW = megawatt. Steel and aluminium not included. See Chapter 1 and Annex for details on the assumptions and methodologies

Source: IEA(2022)

- **According to the IEA's Net Zero Emissions (NZE) scenario (2024), mineral demand for clean energy technologies is projected to increase nearly threefold by 2030 and fourfold by 2050 compared to 2023 levels.**
  - ○ Electric vehicle production is expected to be the largest driver of this increase, accounting for approximately 50% of total mineral demand for clean energy technologies by 2050.

[Figure 2] Mineral requirements for clean energy technologies by scenario



*STEPS(Stated Policies Scenario)provides a sense of the prevailing direction of travel for the energy system, based today's policy settings.
*APS(Announced Pledges Scenario) assumes that governments will meet, in full and on time, all of the climate-related commitments that they have announced, including longer term net zero emissions targets and pledges in nationally determined contributions (NDCs).

Note : Includes most of the minerals used in various clean energy technologies but does not include steel and aluminum.

Source: IEA(2024)

■ **Under the NZE scenario, the demand for key minerals such as copper, lithium, nickel, cobalt, and rare earth elements is expected to surge:**

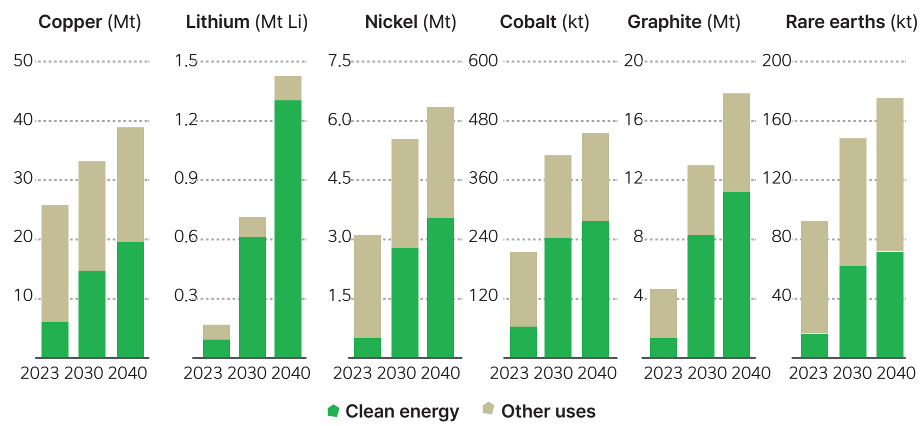
○ **Lithium:** Demand is projected to increase approximately 8.7 times by 2040 compared to 2023, with around 91% of this demand driven by electric vehicles.

○ **Nickel, cobalt, graphite:** By 2040, demand is expected to grow by about 2.1 times, 2.2 times, and 3.9 times respectively compared to 2023 levels.

○ **Rare earth elements:** Demand is forecast to double by 2040 due to rising needs for EV motors and wind turbines.

○ **Copper:** As a critical material for all clean energy technologies—including EVs, solar, wind, and transmission and distribution networks—copper demand is expected to increase by 1.5 times by 2040 relative to 2023.

[Figure 3] Global critical minerals demand in the NZE Scenario



Notes: The figures for copper are based on refined copper. Those for rare earth elements are for magnet rare earth elements only. Growth rates (in blue) are between 2023 and 2040.

Source: IEA(2024)

III. Environmental, Climate, and Social Impacts of Securing Transition Minerals

1. Ecosystem Degradation and Environmental Pollution

Deforestation and Ecosystem Damage

- Between 2001 and 2020, approximately 1.4 million hectares of forest were lost globally due to mining activities, with a significant portion being tropical rainforests and land used by Indigenous communities.[8]
- Large-scale deforestation has been reported in nickel mines in Indonesia[9] and copper mines in the Philippines[10] due to increasing demand for transition minerals.

8 World Resources Institute, Mining Is Increasingly Pushing into Critical Rainforests and Protected Areas, 2024.

9 Mighty Earth, From Forests to Electric Vehicles, 2024.

10 Global Witness, The 'Green' Transition's Dirty Bootprint, 2024.

Water Pollution

- Chemicals and heavy metals used in mining and refining processes lead to the contamination of rivers, lakes, and groundwater.
- In southern China and areas along the Myanmar border, rare earth elements are mined using in-situ leaching*, which involves injecting chemicals like ammonium sulfate and oxalic acid into the ground, resulting in contamination of nearby water bodies, soil, and air.[11]

  **In-situ leaching*: A method where chemicals are injected underground to extract rare earth elements in their compound state, which are then collected in ponds.

Water Scarcity

- At least 16% of transition mineral mines, deposits, and ore bodies are located in areas with high water stress*.[12]

  **Water stress*: A condition where the demand for water exceeds available supply, making it difficult to meet the needs of humans and ecosystems.
- In the Atacama Desert, which holds around 70% of the world's lithium reserves, brine-based lithium extraction has led to freshwater depletion, surface cracking, and sinkholes.

Marine Ecosystem Disruption

- Mining developments near coastal areas and the construction of docks lead to sediment inflows, water pollution, and habitat destruction, causing long-term damage to marine ecosystems, including coral reefs and fish populations.
- In Sulawesi, Indonesia, sediment runoff from nickel mines has covered coral reefs near the coastline, while additional marine pollution has resulted from dock construction near the mining areas.[13]

Air Pollution and Health Impacts

- Dust, toxic substances, and greenhouse gases generated during the mining, transportation, and processing of minerals contribute to deteriorating air quality in nearby areas.
- In Indonesia's nickel industrial complex, coal power plants emit large quantities of fine particulate matter and sulfur dioxide, leading to an increase in respiratory and skin diseases.[14]

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11 Global Witness, Fuelling the Future, Poisoning the Present: Myanmar's Rare Earth Boom, 2024.

12 World Resources Institute, More Critical Minerals Mining Could Strain Water Supplies in Stressed Regions, 2024.

13 Steven Brown, Nickel Powerhouse, 2023.

14 Mongabay, "Disease surges in Indonesia community on frontline of world energy transition", February 6, 2025.

Biodiversity Loss

- 75% of transition mineral mines that have already been developed or are planned are located in areas that are critical for biodiversity conservation.[15]
- Nickel mining in Sulawesi and Maluku poses a serious threat to the unique flora and fauna of Wallacea, one of the world's most biodiverse regions, putting many endemic species at risk of extinction.[16]
- In the Philippines, more than a quarter of the planned mining sites for transition minerals are located in protected areas, biodiversity hotspots, or Ramsar wetlands, raising concerns about biodiversity loss.[17]

Risks of Mine Waste and Tailings Dam Failure

- Mining for transition minerals generates mine waste such as waste rock and tailings*, which can pollute water and soil, and intensify ecological destruction and health problems for local communities due to tailings dam failures and acid mine drainage.**

  *Tailings: Residual material left after extracting valuable minerals, often containing heavy metals and toxic chemicals, requiring strict waste management

  **Acid mine drainage: Acidic wastewater formed when sulfide minerals are exposed to air and water
- In Zambia and the Democratic Republic of the Congo, home to the copper-cobalt belt, water, soil, and air pollution from tailings dam leakage has been reported.[18]
- In Brazil, the 2019 Brumadinho tailings dam collapse killed 289 people and caused severe contamination of rivers and soil with heavy metal waste, resulting in devastating impacts on local ecosystems and communities.

2. Climate Impacts

High energy intensity and greenhouse gas emissions

- The mining sector accounts for approximately 38% of global industrial energy consumption and about 15% of electricity use, largely relying on fossil fuels.[19]
- Smelting and refining processes consume enormous amounts of energy and emit significant

15 S&P Global Sustainable1, Rocks and hard places: The ecosystem risks of mining for energy transition minerals, 2024.

16 Steven Brown, Nickel Powerhouse, 2023.

17 Global Witness, The Green Transition's Dirty Bootprint, 2024.

18 Kˇríbek, B et al., Impact of Mining and Ore Processing on Soil, Drainage and Vegetation in the Zambian Copperbelt Mining, 2023.

19 Igogo T et al., Integrating renewable energy into mining operations: Opportunities, challenges, and enabling approaches, 2021.

greenhouse gases.

- In Indonesia, about 15% of total coal consumption is used for coal-fired power plants in industrial zones processing minerals such as nickel, with coal use increasing since 2020.[20]

Increased energy consumption due to ore grade decline

- Declining ore grades for key minerals such as copper and nickel are driving up energy consumption for mining and processing.
- Indonesian nickel ore is refined using high-pressure acid leaching (HPAL), a method that entails especially high energy use.

  *High-Pressure Acid Leaching: A hydrometallurgical refining method that enhances nickel purity by adding sulfuric acid to nickel ore and applying high temperature and pressure

Deforestation and Greenhouse Gas Emissions

- The destruction of tropical rainforests, mangrove forests, and peatlands contributes to increased greenhouse gas emissions by releasing carbon dioxide and methane.
- In Halmahera, Indonesia, nickel mine development has cleared at least 5,331 hectares of tropical rainforest, which is estimated to have released 2.04 metric tons of carbon.[21]

20 Mongabay, "Indonesia's coal burning hits record high — and 'green' nickel is largely why", July 3, 2023.

21 Climate Rights International, Nickel Unearthed, 2024.

3. Violations of the Rights of Indigenous Peoples, Local Communities, and Workers

Violation of Indigenous Rights and the FPIC Principle

- More than half of transition mineral development projects are located on or near the territories of Indigenous Peoples and peasants.[22]
- Indigenous land rights must be protected regardless of whether they are formally registered, and all projects must adhere to the principle of Free, Prior and Informed Consent (FPIC); however, numerous violations have been reported.
- These violations have led to land grabbing and forced displacement in countries such as Indonesia, Peru, and the Philippines.
- When transition mineral mining occurs on the territories of Indigenous Peoples in voluntary isolation and initial contact*, it poses a serious threat to their survival.

  *Indigenous Peoples in voluntary isolation and initial contact: Indigenous Peoples who avoid regular interaction with mainstream society or have only recently begun limited contact.

  - In Halmahera, Indonesia, the Hongana Manyawa—an Indigenous group in voluntary isolation and initial contact—are being displaced and their survival threatened by nickel mining projects in their territory.[23]

Health Impacts and Violations of the Right to Food

- Communities living near mines are exposed to polluted water and air, leading to deteriorating health and infringements on their right to food.
- In the Copper-Cobalt Belt of the Democratic Republic of the Congo, severe water pollution has caused local residents to suffer from various illnesses, with gynecological issues among women being particularly reported.[24]

Labor Rights Violations, Forced Labor, and Industrial Accidents

- In the Democratic Republic of the Congo, 78% of cobalt mine workers are exposed to forced labor, with widespread child labor reported particularly in the artisanal and small-scale mining (ASM)*

22 John R. Owen et. al, Energy transition minerals and their intersection with land-connected peoples, 2023.

23 Mongabay, “BASF, Eramet drop $2.6b Indonesian nickel project that threatens isolated tribe”, July 1, 2024.

24 RAID, Beneath the Green: A critical look at the environmental and human costs of industrial cobalt mining in DRC, 2024.

sector.[25]

*ASM: Mining activities carried out by individuals, families, or communities with minimal or no machinery.

- The use of hazardous chemicals has led to various illnesses among workers, and fatal accidents have occurred.
- At the nickel smelters in Indonesia's Morowali Industrial Park, repeated explosions have resulted in numerous deaths and injuries

Threats to Human Rights and Environmental Defenders

- Human rights and environmental defenders who oppose transition mineral mining face threats, harassment, criminalization, and even the risk of murder.
- Approximately one-quarter of human rights and environmental conflicts related to transition mineral development involve persecution of human rights and environmental defenders.[26]
- Mining is the most lethal industry for human rights and environmental defenders, with at least 25 individuals killed in 2023 alone for opposing mining-related activities.[27]

25 United States Department of Labor, Forced Labor in Cobalt Mining in the Democratic Republic of the Congo, 2023.

26 Business and Human Rights Resource Centere, Transition Mineral Tracker: 2024 Analysis, 2024.

27 Global Witness, Missing voices: The violent erasure of land and environmental defenders, 2024.

IV. Approaches to Addressing Transition Mineral Challenges

1. Responsible Mining and Key Certification Schemes

- **The mining sector is adopting responsible mining approaches to minimize environmental and social impacts at mining sites and is implementing voluntary certification schemes to support this effort.**
  - Certified mines benefit from greater access to global supply chains, enhanced investor trust, and improved ESG risk management.
  - Major global companies such as Tesla, BMW, Apple, and Google require or prefer certified sources in their supply chains for key minerals like nickel, cobalt, and copper.

- **The most widely used certification schemes in the mining sector include:**
  - **IRMA** (Initiative for Responsible Mining Assurance), **ICMM** (International Council on Mining and Metals), **TSM** (Towards Sustainable Mining), **Copper Mark**
  - These schemes evaluate companies based on standards covering human rights, environmental protection, biodiversity conservation, Indigenous rights, and climate action.
  - Certification is granted based on an independent third-party audit that assesses whether the company meets relevant criteria.

- **A shared principle across certification schemes is the phased approach of: (1) Avoidance → (2) Mitigation → (3) Restoration → (4) Offsets**
  - First, avoid environmental and social harm altogether
  - If unavoidable, minimize harm to the greatest extent
  - Where damage has occurred, restore affected ecosystems or communities
  - Finally, offset any residual harm that cannot be reversed

Limitations of Certification and the Need for Improvement

- According to reports from *Lead the Charge (2024)*, *Mighty Earth*, and *Rainforest Foundation Norway (2024)*, current certification schemes share several limitations:
  - Lack of strong forest and land-use safeguards:
    - Weak provisions for preventing deforestation or prioritizing its avoidance, limiting protection for *Key Biodiversity Areas (KBA)**

      *KBA: Ecologically significant areas essential for biodiversity conservation, designated based on criteria such as endemic species and ecosystem threats.
  - Limited stakeholder participation:
    - Private sector-led operations
    - Restricted participation of Indigenous peoples, workers, and local communities
    - Weak multi-stakeholder governance
  - Lack of transparency:
    - Audit results are often unpublished or inaccurate
    - Grievance mechanisms are underdeveloped
  - Insufficient long-term monitoring:
    - Most certifications rely on one-time or short-term audits
    - Heavy dependence on corporate self-assessments undermines credibility
- To address these gaps, certification schemes must:
  - Strengthen avoidance-first provisions
  - Expand stakeholder participation
  - Reinforce transparency and independent auditing systems

2. Supply Chain Human Rights and Environmental Due Diligence Systems

To address the limitations of voluntary certification, legally binding human rights and environmental due diligence (HREDD)* systems are being adopted, particularly in the EU.

*HREDD: A system requiring companies to identify, prevent, and remedy human rights and environmental risks throughout their supply chains, with active stakeholder engagement.

- A typical due diligence process includes:
  - Identification:
    - Detect risks of harm to human rights and the environment in business operations, supply chains, and subsidiaries.

- Prevention and Mitigation:
  - Take action to prevent confirmed risks or minimize harms that have already occurred.
- Monitoring:
  - Continuously assess the effectiveness of risk management measures.
- Disclosure and Communication:
  - Transparently disclose due diligence efforts and communicate with stakeholders.
- Remedy:
  - Provide remedy to victims in cases of harm or rights violations.
  - All these steps require meaningful consultation with stakeholders, including affected communities, civil society, and investors.

Status of Due Diligence Regulations in Korea

○ The National Human Rights Commission of Korea has recommended integrating human rights management into public institution performance evaluations.

- However, the system has faced limitations, such as formalistic human rights impact assessments and insufficient stakeholder participation.

○ In August 2023, a draft law titled the "Act on Human Rights and Environmental Protection for Corporate Sustainability" (the Korean due diligence bill) was introduced but ultimately discarded without passage.

Global Due Diligence Legislation

○ EU Corporate Sustainability Due Diligence Directive (CSDDD)

- Imposes mandatory due diligence on both company operations and their value chains ("chain of activities").
- Applies to:
  - EU companies with over 1,000 employees and €450 million in global revenue
  - Non-EU companies with over €450 million in revenue generated within the EU, regardless of employee count
- Includes provisions on director liability, sanctions, and civil litigation
- Member states must transpose the directive into national law by July 2027; phased implementation begins in 2028
- An *Omnibus Package** announced by the European Commission in February 2025 could result in the removal or relaxation of certain regulatory provisions

*Omnibus Package: A legislative package that proposes delaying or easing enforcement of key ESG rules including the CSDDD, CSRD, CBAM, and EU Taxonomy.

○ EU Battery Regulation
- Imposes due diligence obligations on critical minerals for batteries (cobalt, lithium, nickel, natural graphite)
- Requires battery producers, importers, and distributors to develop policies, conduct risk assessments, prepare mitigation plans, and undergo third-party verification and reporting
- Also mandates reporting on recycling rates and carbon footprint
- Enforced since 2023, with due diligence provisions entering into effect from 2025

○ France's Law on the Duty of Vigilance of Parent and Lead Companies
- In effect since 2017
- Requires large French companies to identify risks, develop vigilance plans, and implement them across their supply chains
- Stakeholders such as NGOs and trade unions may demand compliance or initiate legal proceedings in court
- Integration with or complementarity to the CSDDD will be coordinated in the future

○ Other Countries
- Germany's Supply Chain Due Diligence Act (LkSG) is expected to be replaced by the CSDDD but will remain in effect during the transition
- Countries such as Switzerland and Norway have implemented or are developing similar legislation, often combining OECD-based voluntary implementation with binding regulation

■ Challenges and Limitations of Supply Chain Due Diligence

○ Despite the spread of new regulations, ensuring effective implementation and on-the-ground impact remains a challenge.
- Complex global supply chains, information asymmetry, and limited field access make risk identification difficult.
- Current due diligence standards lack consideration of site-specific contexts, such as Indigenous rights and biodiversity conservation.
- To avoid mere box-ticking or self-assessment, due diligence must be supported by:
  - ● Continuous monitoring

- Transparent and independent audits
- Victim access to remedy
- Broader stakeholder engagement

3. Circular Economy: Building Systems for Reuse and Recycling

■ To reduce reliance on new mining and minimize environmental and social impacts, it is essential to establish circular economy systems centered on reuse and recycling.

○ Organizations such as the IEA (2024) and UNEP (2023) consistently highlight the need to strengthen reuse and recycling frameworks as key policy priorities.

- Leading countries are revising regulations, expanding infrastructure, and offering tax incentives to promote circular practices.

○ The EU, through the *Battery Regulation*, has established mandatory targets for recycling rates and recycled content in key battery minerals.

- The *Critical Raw Materials Act* (CRMA) complements this by promoting circularity across the broader raw materials sector and boosting recycling capacity within the EU.

<Table 2> EU Recycling Targets for Battery Minerals

Law	Item	Target
Battery Regulation	**Recovery Targets from Waste Batteries**	
	Lithium	50% (by end-2027) → 80% (by end-2031) *(subject to adjustment)*
	Copper, Cobalt, Lead, Nickel	90% (by end-2027) → 95% (by end-2031)
	Minimum Levels of Recycled Content in New Batteries	
	Cobalt	16% (2031) → 26% (2036)
	Lithium	6% (2031) → 12% (2036)
	Nickel	6% (2031) → 15% (2036)

Source: IEA, EU Sustainable Batteries Regulation, 2024. IEA Policy Database

- The United States, under the IRA, provides subsidies for battery materials that are manufactured or recycled domestically and considers them "American-made."
  - ● If recycled content exceeds a certain threshold, companies receive a 30% Investment Tax Credit (ITC), plus a 10% bonus credit, totaling up to 40%.

- In Korea, the *National Strategy for Securing Critical Minerals* includes a target to increase the share of recycled resources to over 20%.
  - ● The proposed Act on Promoting the Used Battery Industry (introduced in 2025) lays the groundwork for an integrated management system encompassing collection, distribution, and utilization, and the institutionalization of public trading platforms.

■ Circular systems go beyond waste disposal—they aim to incorporate resource efficiency into product design from the outset.

○ Efforts are already underway, particularly in the EU, to institutionalize:

- the use of recycled materials during the manufacturing stage
- the development of improved collection and sorting systems for end-of-life products.
- This include the development of specific implementation tools such as the Digital Product Passport (DPP)*

*DPP: A system that digitally records and manages information on a product's materials, energy use, and recyclability to support transparency and sustainability.

■ Challenges in the Transition to a Circular Economy

○ Technical limitations

- Most transition minerals—such as lithium, cobalt, nickel, and rare earth elements—are used in alloys or composite forms, making physical and chemical separation extremely difficult.

○ Existing recycling technologies also face environmental and safety challenges.

- Dry processes (e.g., high-temperature incineration or smelting) require excessive energy relative to the amount of recovered metals and inevitably emit greenhouse gases such as CO_2.
- Wet processes (e.g., acid or alkali leaching) achieve higher recovery rates but generate toxic wastewater, solid waste, and hazardous gases, raising concerns about water pollution and hazardous material management.

○ Reuse strategies—such as repurposing used batteries into energy storage systems (ESS)—are gaining attention as a way to overcome technological limits in recycling.

- However, reuse also has structural limitations, including inconsistent lifespan and performance, safety risks, and lack of standardization.

- Policy support is needed to establish systems for residual life assessment, quality certification, and expanded applications for reused batteries.

○ Governments must support a systemic transition by investing in reuse and recycling technologies, developing standards, and creating infrastructure for collection and sorting.

○ Companies should incorporate circular economy principles at the design stage and actively participate in building necessary infrastructure.

4. Resource Demand Reduction Strategies

■ **Beyond diversifying supply chains and expanding reuse and recycling, reducing overall resource demand has emerged as a key strategic priority.**

○ Reducing mineral demand fundamentally decreases the environmental and social impacts associated with extraction and production.

○ It also enhances resource security and mitigates supply chain risks.

■ **International organizations increasingly emphasize demand-side strategies and advocate for a shift away from carbon- and resource-intensive consumption patterns.**

<Table 3. Approaches to Resource Demand Management by Major International Organizations>

Organization	Approach
International Energy Agency (IEA)	Focus on improving supply efficiency through technology optimization, life-cycle management, resource minimization, and design improvements
International Resource Panel (IRP)	**Specifies the absolute reduction of material use.** Also outlines systemic approaches to reduce total resource throughput, including circular economy strategies, improved resource productivity, and product redesign.
United Nations Environment Programme (UNEP)	Frames sustainable consumption and production (SCP) as central, highlighting behavioral change, education, public procurement, reuse, and remanufacturing

Source: IEA(2024), IRP(2020), UNEP(2024)

- **The EU, its member states, and civil society are gradually developing structural policy tools to support demand reduction.**
  - ○ The EU is institutionalizing demand-side policies—such as product light-weighting, durability, and facilitation of repair and reuse—through instruments like the Ecodesign for Sustainable Products Regulation (ESPR).
  - ○ Key member states like Germany and France are extending product life cycles through eco design measures, remanufacturing, and sharing-based consumption.
    - – France, in particular, has become the first country to legally ban the destruction of unsold new products.
  - ○ European environmental organizations go further by promoting the concepts of sustainable resource management* and sufficiency** as central policy pillars.[28]

    *Sustainable resource management: Using resources to meet human needs within planetary boundaries

    **Sufficiency: A value-driven approach to reducing resource and energy use while ensuring human well-being
    - – Proposed measures include setting a legal material footprint cap of 5 tons per capita by 2050.*

    *As of 2022, the EU average was 14.8 tons—nearly six times higher than that of low-income countries.
    - – Their approach combines behavioral change (e.g., shifting from ownership-based to service-based consumption), expanding public repair infrastructure, and co-designing policies through citizens' assemblies.

- **Challenges of Demand Reduction Strategies**
  - ○ Technical barriers:
    - – Innovation is still required to develop lightweight and high-efficiency materials, and to ensure the performance and safety of remanufactured and reused products.
  - ○ Market acceptance:
    - – The success of sufficiency-based products (e.g., durable and repairable designs) and services (e.g., vehicle sharing) depends on shifts in consumer perception and demand.
    - – Policy tools such as price incentives, labeling, and green public procurement are needed to support this transition.
  - ○ Integrated policy design:
    - – Demand-side management must be integrated with circular economy strategies and broader policies for resource reduction.

28 Sufficiency Coalition & Resource Use Reduction Taskforce, Take Action Now: Reduce Resource Use for a Fairer, Cleaner, and More Resilient Europe, 2024.

- This requires coordinated policymaking across sectors including industry, energy, and urban planning.

- Political prioritization:
  - Unlike efficiency-focused technological investment, demand reduction requires political persuasion and broad public support.
  - Institutional support must be grounded in participatory governance and legal mandates to build social legitimacy.

5. The Need for an Integrated Approach

- **Responsible mining, due diligence, circular economy, and demand reduction are each important response strategies, but none is sufficient on its own to address the structural environmental and social challenges posed by rising mineral demand.**
  - Each approach has its own limitations:
    - Certification schemes face limits due to their voluntary nature.
    - Due diligence suffers from weak enforcement.
    - Recycling is constrained by technological and environmental issues.
    - Reuse struggles with inconsistent performance and lack of standards.
    - Demand reduction faces low social acceptance and institutional underdevelopment.
  - These strategies must therefore function in a complementary manner,
    - and a life-cycle approach spanning extraction, consumption, and disposal is essential.
  - Governments, companies, and the international community must design and implement policies that account for the synergies and linkages among all strategies.

V. Policy Recommendations

■ This chapter presents policy directions that address the environmental and social challenges associated with the sourcing and use of transition minerals. Recommendations are organized by actors (government and corporations) and cover the full supply chain cycle (upstream–midstream–downstream).

1. Role of Governments: Establishing Regulatory Foundations and Policy Incentives

① Strengthening demand-side management and the shift to a circular economy

- Set quantitative targets for the reuse and recycling of transition minerals and develop phased implementation roadmaps
- Mandate design requirements for reuse and recyclability in batteries and key products, and establish related technical standards and guidelines
- Promote strategies to reduce overall mineral demand through product life extension, lightweight design, and sharing economy models
- Launch national-scale demonstration projects and infrastructure development for battery reuse

② Ensuring supply chain sustainability and institutionalizing due diligence

- Enact legislation mandating human rights and environmental due diligence across the entire supply chain
- Develop evaluation systems that link due diligence implementation with public subsidies and procurement eligibility
- Establish origin tracking systems and strengthen corporate disclosure to secure responsible sourcing practices
- Ensure access to remedy for affected parties and guarantee participation of key stakeholders (including Indigenous peoples, workers, and civil society)

③ Building local-level circular economy ecosystems

- Establish local reuse and recycling hubs; expand pre-processing and collection infrastructure; and build the foundations for local circular economy systems
- Introduce a Digital Product Passport (DPP) system for key products such as batteries, and strengthen data-sharing mechanisms

2. Role of Companies: Implementation and Transparency Across the Supply Chain

① Upstream - Mining and Sourcing

- Prohibit mining in primary forests, high carbon stock (HCS)* forests, high conservation value (HCV)** areas, and key biodiversity areas

*HCS: Forests with high carbon storage and biodiversity value that must not be cleared for mining or plantation development

**HCV: Areas of high ecological, social, or cultural conservation importance

- Prohibit mining in the territories of Indigenous Peoples in voluntary isolation and initial contact, and designate these areas as permanent 'no-go zones' for mineral development.
- Fully implement the principle of Free, Prior and Informed Consent (FPIC) for Indigenous communities
- Ensure fair compensation and access to information for local communities
- Identify human rights and environmental risks throughout the supply chain; restore damaged areas and implement sustainable rehabilitation post-closure

② Midstream - Processing and Manufacturing

- Limit the use of fossil fuels in smelting and refining processes and promote the transition to renewable energy
- Expand product design focused on high efficiency and reusability; increase investment in circular economy technologies
- Regularly disclose supply chain due diligence outcomes and risk mitigation measures

③ Downstream - Consumption and Circularity

- Adopt product design that enables component reuse and extends product lifespan
- Strengthen international cooperation and invest in infrastructure to build collection and sorting systems for end-of-life batteries and key products.
- Increase the use of recycled materials and strengthen supply chain management responsibilities based on human rights and environmental due diligence

■ **Governments and companies must clearly define their respective roles while working in close coordination to transition mineral supply chains in a sustainable and just direction.**

- ○ It is essential to address supply chain impacts across the full life cycle, establish legally binding frameworks, ensure transparent disclosure, and enhance cooperation with the international community.
- ○ Beyond promoting resource circulation and responsible sourcing, a structural transition toward reducing total mineral consumption—and building public consensus around it—must also be pursued in parallel.

VI. Conclusion

1. Rethinking the Logic of Extraction in the Energy Transition

■ **The energy transition must proceed in a way that does not exacerbate environmental or human rights crises.**

- ○ Unregulated mining in tropical forests and Indigenous lands is accelerating biodiversity loss and social conflict.
- ○ To ensure that efforts to address the climate crisis do not justify new forms of inequality, a fundamental rethinking and restructuring of current development approaches is necessary.

2. Moving Beyond Technological Fixes Toward Structural Demand Reduction

■ **While the types of minerals in demand may change, the environmental and social impacts of resource extraction persist.**

- ○ Technological innovation can shift—rather than eliminate—resource pressures.
  - – For example, sodium-ion batteries may reduce dependence on lithium and cobalt, but could trigger new demand for alternative minerals such as trona (a sodium carbonate source) and bauxite (the primary ore of aluminum).
- ○ Therefore, the adoption of new technologies must be accompanied by structural demand-side policies aimed at reducing the total volume of resource consumption.

3. Reorienting Policy Priorities Toward a Just and Sustainable Transition

■ **A shift is needed from supply-expansion policies to those focused on systemic transformation.**

- ○ Strengthen strategies to reduce overall resource demand:
  - – Reduce consumption through product life extension, lightweight design, and the expansion of sharing-based consumption models.
- ○ Build a stronger circular economy foundation:
  - – Expand reuse and recycling, and establish institutional mechanisms to track and share data on resource circulation.

- Ensure due diligence and accountability across the supply chain:
  - Institutionalize human rights and environmental due diligence frameworks and ensure accessible remedy systems for affected communities.

4. Building International Solidarity and Joint Response Mechanisms

A just transition of transition mineral supply chains cannot be achieved without global cooperation.

- Solidarity is needed to address the asymmetrical environmental and social burdens between producing and consuming countries.
  - As mineral demand increases to support the energy transition, some producing countries—particularly in the Global South—face growing environmental degradation and social costs, while consuming countries reap the benefits of a green transition.
  - A collaborative framework is needed to reduce harm in producing countries and to protect the rights of local communities.
- Multilevel international mechanisms must be established to enable supply chain monitoring, coordinated policy response, and victim protection.
  - These mechanisms must ensure the meaningful participation of civil society and local communities.

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Authors: **Hyelyn Kim**
Head of Resource Conservation, Climate Ocean Research Institute (CORI)

Shinyoung Chung
Attorney, Advocate for Public Interest Law (APIL)

Published by: Climate Ocean Research Institute (CORI)

Advocate for Public Interest Law (APIL)

Contact: hyelyn.kim@cori.re.kr
sychung@apil.or.kr

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