

Critical Minerals

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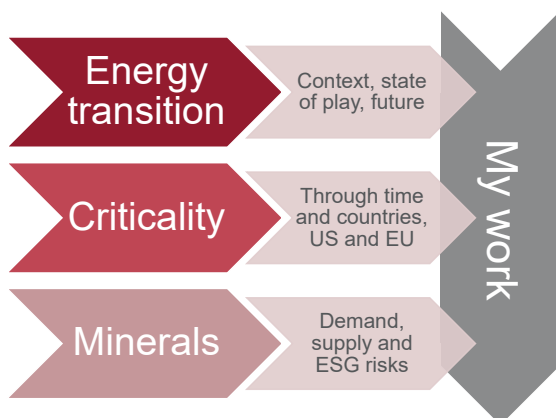
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CEEPR
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MSL

OUR JOURNEY



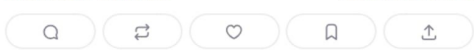
AN INCREASINGLY “CRITICAL” TOPIC



I am announcing a 50% TARIFF on Copper, effective August 1, 2025, after receiving a robust NATIONAL SECURITY ASSESSMENT. Copper is necessary for Semiconductors, Aircraft, Ships, Ammunition, Data Centers, Lithium-ion Batteries, Radar Systems, Missile Defense Systems, and even, Hypersonic Weapons, of which we are building many. Copper is the second most used material by the Department of Defense! Why did our foolish (and SLEEPY!) "Leaders" decimate this important Industry? This 50% TARIFF will reverse the Biden Administration's thoughtless behavior, and stupidity. America will, once again, build a DOMINANT Copper Industry. THIS IS, AFTER ALL, OUR GOLDEN AGE!

568 ReTruths 2.12k Likes

Jul 09, 2025, 8:29 PM

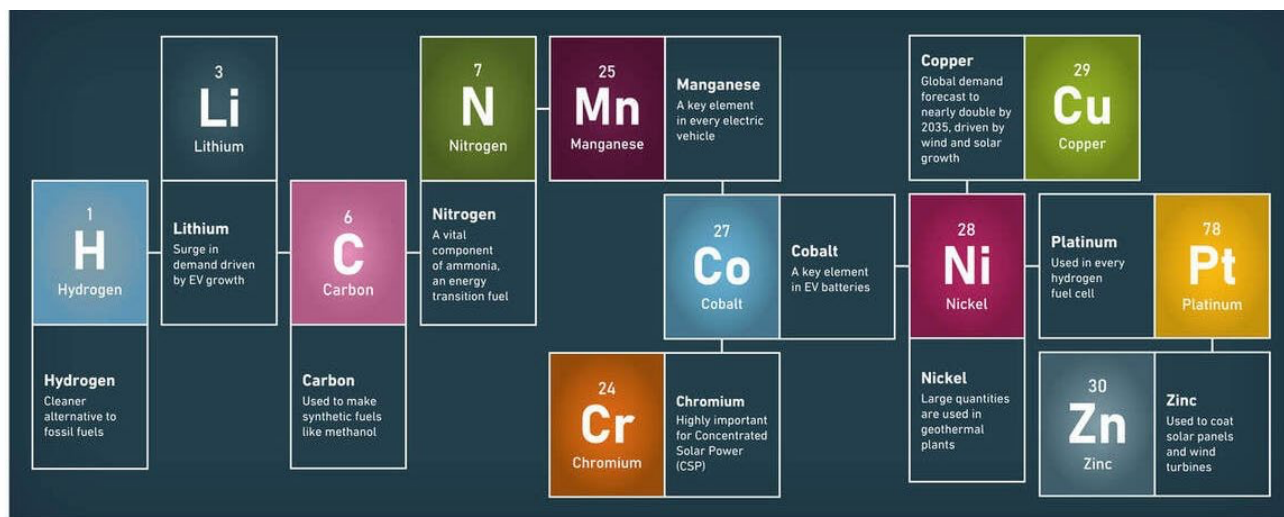


China announces new export controls for critical mineral



MIT Center for Energy and Environmental Policy Research

CRITICAL MINERALS FOR THE ENERGY TRANSITION



MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP



MIT Center for Energy and Environmental Policy Research

CRITICAL, NOT ONLY FOR THE ENERGY TRANSITION



CRITICAL, NOT ONLY FOR THE ENERGY TRANSITION

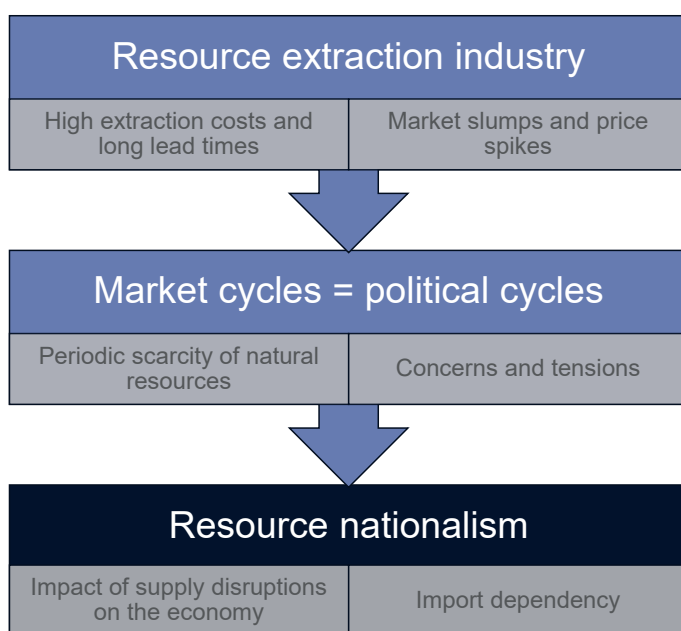
CRITICAL MINERALS	DOD USE	EXAMPLE OF DOD SYSTEM
Gallium	Wide-bandgap chips for high-frequency transmitters and receivers	 Phased-array radars Electronic warfare systems
Niobium	Superalloys and heat-resistant materials	 Fighter jets Hypersonic weapons
Rare Earth Elements	Permanent magnets Energy amplification and detection	 Precision-guided munitions Laser targeting systems Radar and sonar
Cobalt	High-capacity batteries Component in nickel superalloys	 Uncrewed vehicles Jet engines
Tungsten	Armor penetrating projectiles Balance weights	 Ammunition Aircraft

Source: CSIS analysis based on information contained in "Materials of Interest," Defense Logistics Agency, <https://www.dla.mil/Strategic-Materials/Materials/>.

Criticality



Resource criticality



Definition of critical mineral

- A mineral or element that is essential for modern technology and cannot be easily substituted with a different mineral

AND

- There is a risk that the supply of that mineral could be disrupted.

What makes a critical mineral?

It depends where you are in the supply chain:

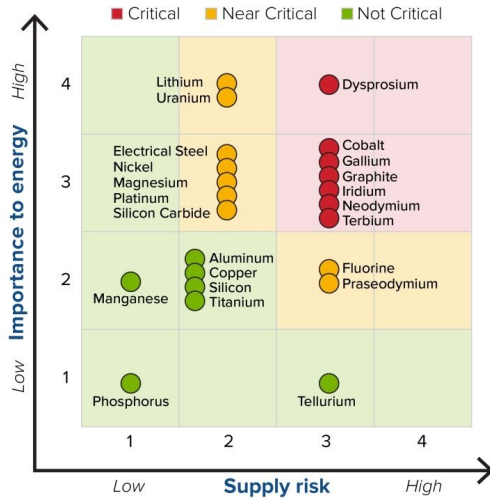
- Import dependence risk focus: "...metals and minerals which are of high economic importance to a particular industry, sector or spatial area and are at risk of supply shortage"

VERSUS

- Value capture and investment focus: "...mineral raw materials that [a state] has in abundance, and for which it can use its dominant position in global supply chains to gain an international competitive advantage"

Definition of critical mineral: US Department of Energy

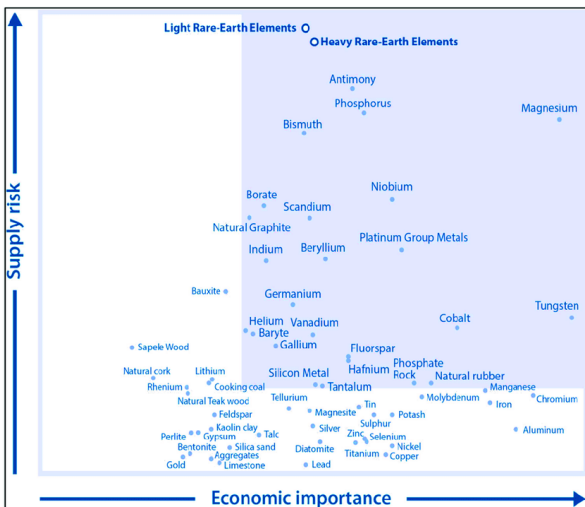
SHORT TERM 2020-2025



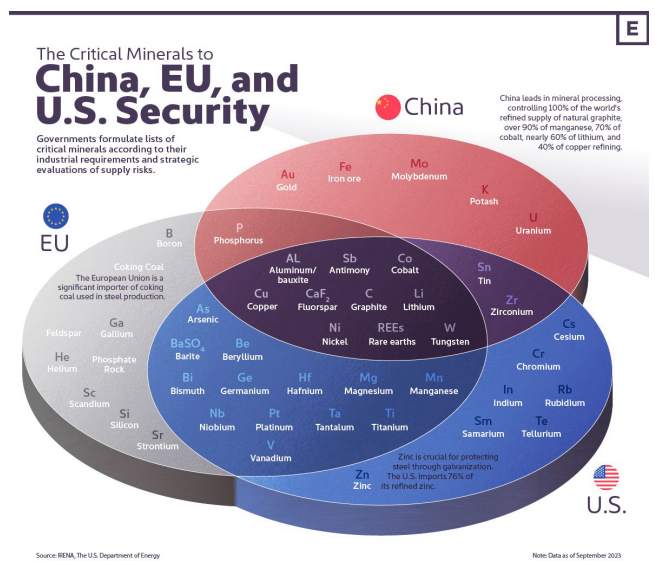
MEDIUM TERM 2025-2035



Definition of critical mineral: European Union



EU vs. China vs. US





Region

United States

Policy status

☒ In force

☐ Announced

☐ Ended

Ensuring supply reliability and resiliency

Strategic plans ⓘ

11

Strategic mineral lists ⓘ

4

International coordination mechanisms ⓘ

8

Stockpiling mechanisms ⓘ

1

Public investment ⓘ

2

Trade mechanisms ⓘ

3

Promoting exploration, production and innovation

Financing ⓘ

11

Tax incentives ⓘ

2

Enhanced geological surveys ⓘ

1

Recycling support ⓘ

11

Innovation funds ⓘ

13

Encouraging sustainable and responsible practices

Environmental standards ⓘ

2

Social standards ⓘ

3

Transparency norms ⓘ

3

Due diligence obligations ⓘ

1

Permitting regimes ⓘ

7

Minerals recycling

Strategic plans ⓘ

Extended producer responsibility ⓘ

11

Financial incentives ⓘ

2

Cross-border trade ⓘ



Region

People's Republic of China

Policy status

In force

Announced

Ended

Ensuring supply reliability and resiliency

Promoting exploration, production and innovation

Encouraging sustainable and responsible practices

Minerals recycling

Strategic plans

Strategic mineral lists

International coordination mechanisms

Stockpiling mechanisms

Public investment

Trade mechanisms

Financing

Tax incentives

Enhanced geological surveys

Recycling support

Innovation funds

Environmental standards

Social standards

Transparency norms

Due diligence obligations

Permitting regimes

Strategic plans

Extended producer responsibility

Financial incentives

Cross-border trade

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Region

European Union

Policy status

In force

Announced

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Innovation funds

Environmental standards

Social standards

Transparency norms

Due diligence obligations

Permitting regimes

Strategic plans

Extended producer responsibility

Financial incentives

Cross-border trade

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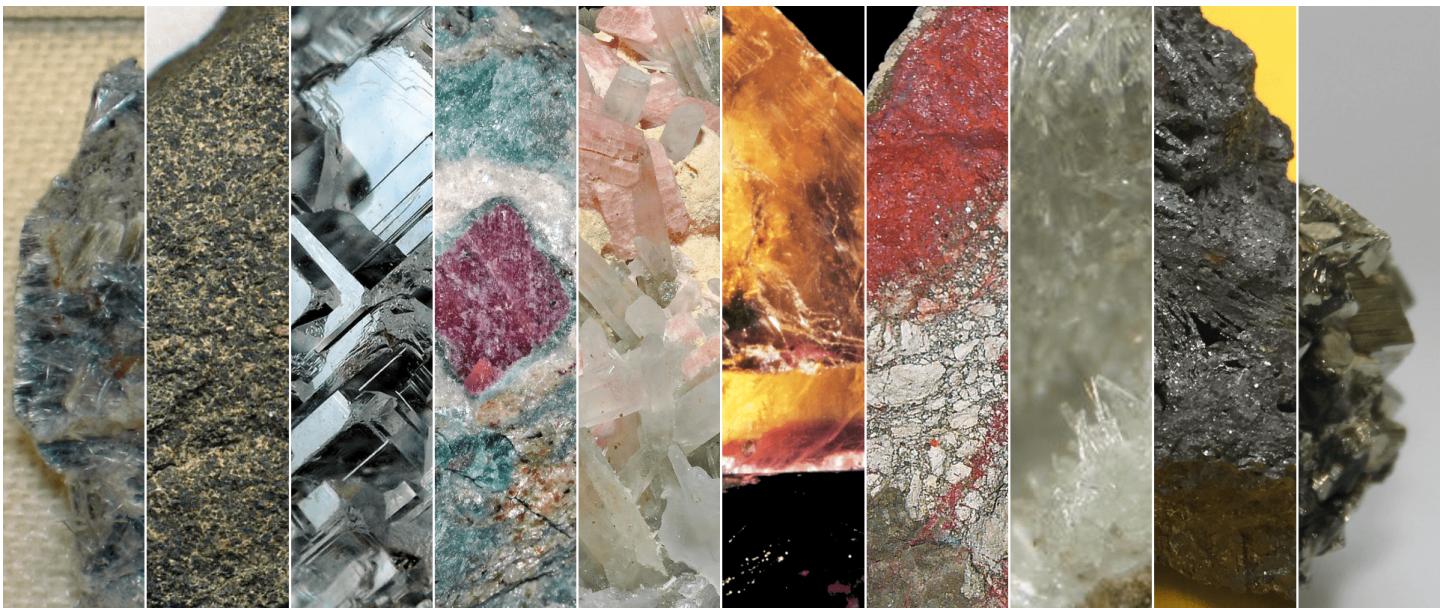
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From IEA: Critical Minerals Policy Tracker



MIT Center for Energy and Environmental Policy Research

The minerals



MIT Center for Energy and Environmental Policy Research

Critical... Strategic... Rare... Minerals... Metals... What?!

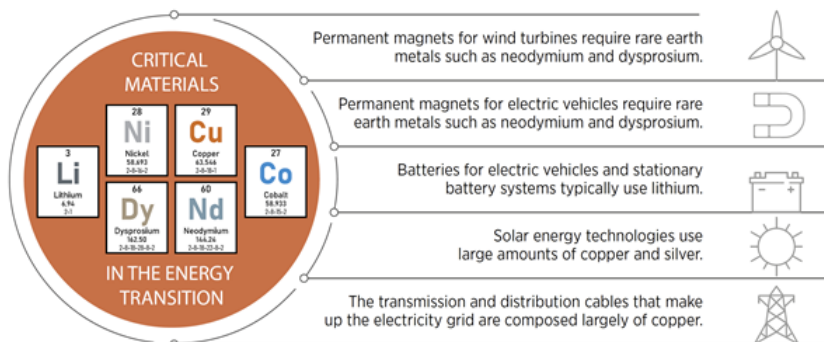
- **Minerals** are solid, naturally occurring inorganic substances found in the Earth's crust. They have a unique chemical composition and crystal structure. There are thought to be well over 4,000 different minerals, many of which contain metallic elements.
 - **Metals** are elementary substances that naturally occur in minerals.
 - **Precious** metals: gold, silver, platinum.
 - **Base** metals: copper, nickel, iron.
 - **Ferrous** metals: with iron, manganese, molybdenum are common in steel.
 - **Non-ferrous** metals: a large number of uses unrelated to steel.
 - **Rare earth** metals: not common in steel. scandium, yttrium, lanthanum.
 - **Alloys**: These are made by mixing two or more metallic elements to form a new, unique substance that has differing chemical and physical properties to its component parts. Over 90 per cent of the metals in use today are alloys.
- Caveat:** most minerals actually are chemical elements that appear on the periodic table. In nature, these elements combine with others to form minerals.

Geology emphasizes the predominant mineral ores from which they are extracted.

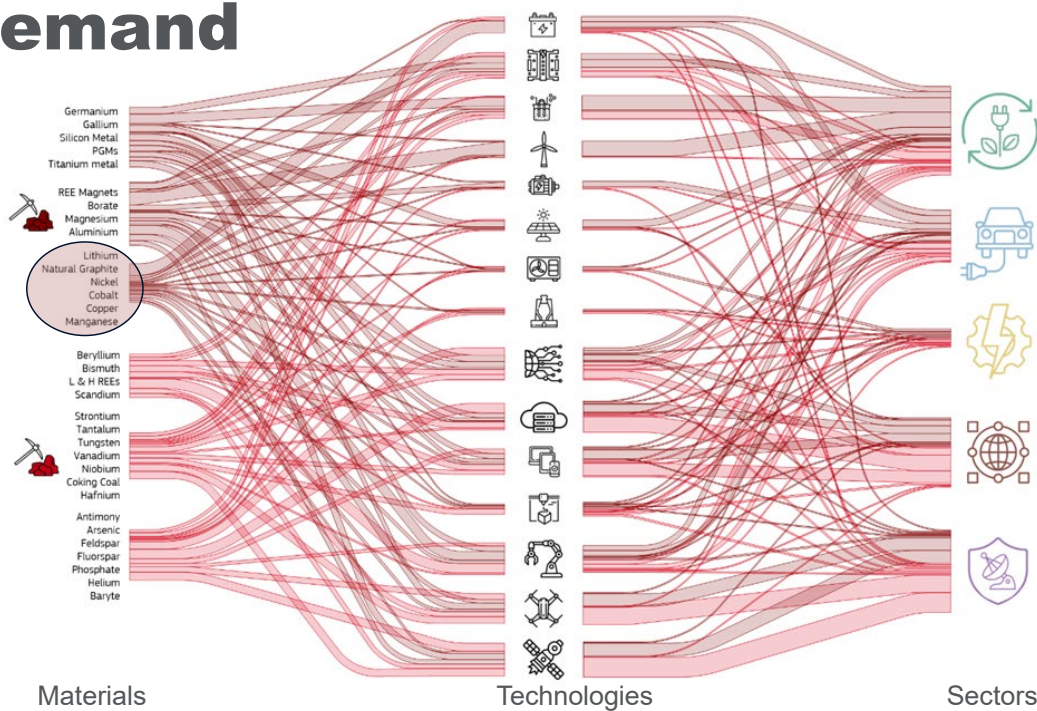
Chemistry / materials science describes them either in elemental form or as compounds (e.g., whether they are combined with oxygen, hydrogen, carbon, etc.).

13

Demand



Demand



15

DEMAND MODELLING

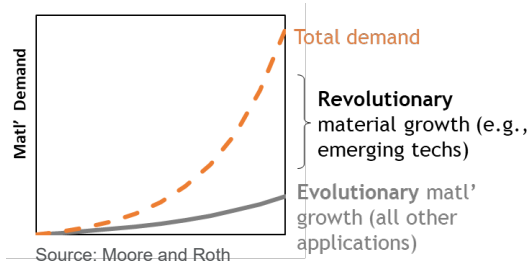
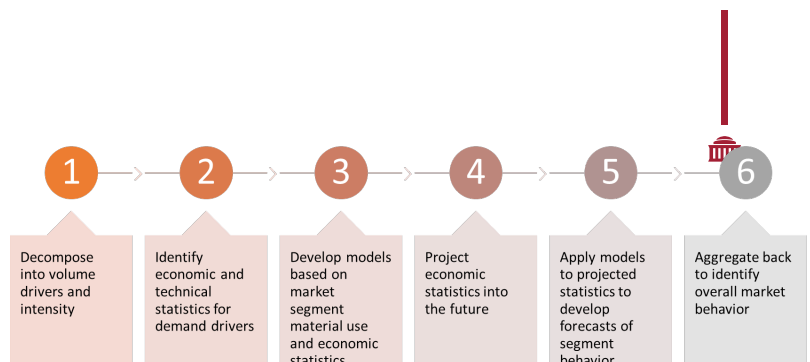
Generic approach:

To model the shape of the demand curve and how it shifts over time, we need to understand how the use of metals grows across all prices.

To shift the curve over time, we assert a growth rate for volume driver (EV sales) and rate of change for intensity (nickel per EV) ← consider economic growth and tech. changes.

Combination of top-down and bottom-up analyses

- Evolutionary: historical industry economic growth rates (by sector and/or region), e.g., industrial spending (volume driver) x total nickel by sector (intensity)
- Revolutionary: emerging technology effects, e.g., vehicle sales (volume driver) x nickel per vehicle (intensity)



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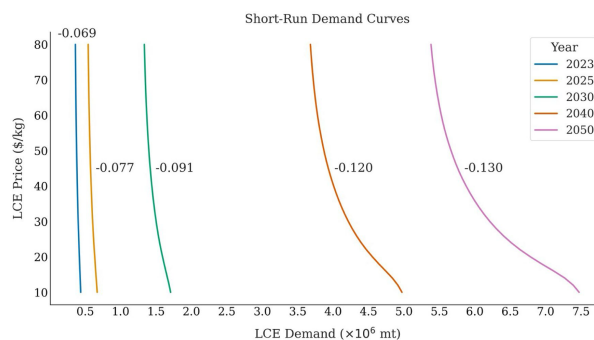
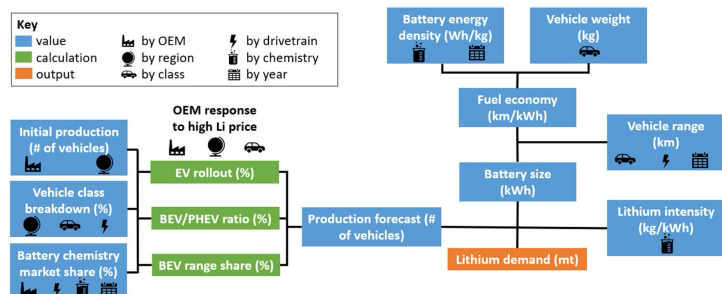
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DEMAND MODELLING - LITHIUM

Volume drivers (and their growth) x Intensity drivers

- Volume driver (e.g., GDP) increases demand
- Rising prices can decrease demand via long-run substitution and dematerialization



Source: Analysis of the impact of automaker strategies on lithium price elasticity using a novel bottom-up demand model, Resources, Conservation and Recycling, 2025 <https://doi.org/10.1016/j.resconrec.2025.108477>

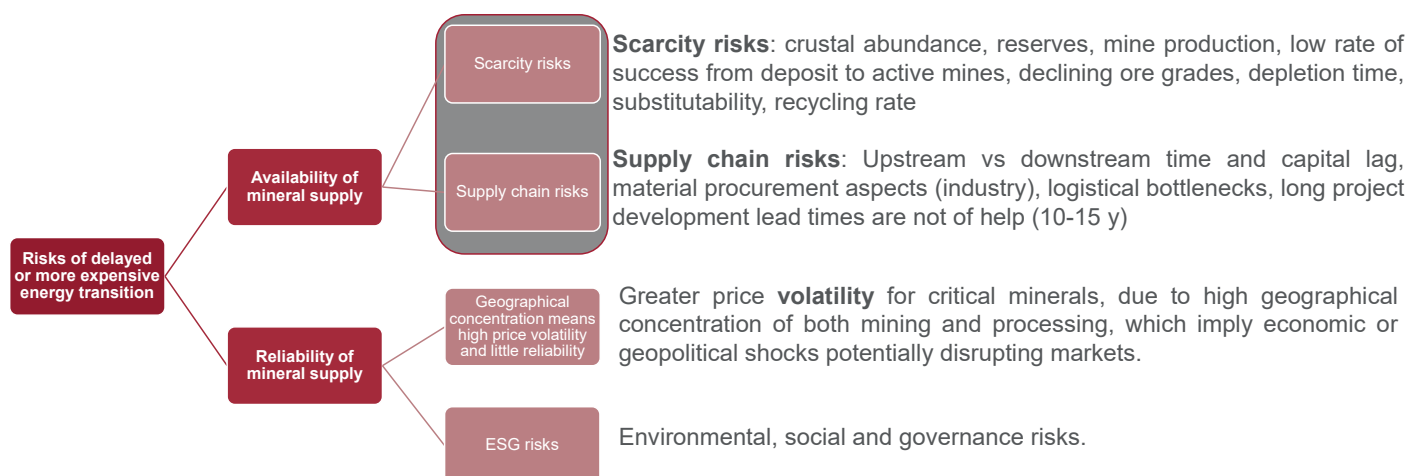


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Supply

RISKS OF DELAYED OR MORE EXPENSIVE ENERGY TRANSITION COME FROM THE AVAILABILITY AND RELIABILITY OF MINERAL SUPPLY



AVAILABILITY OF MINERAL SUPPLY

Scarcity risks: crustal abundance, reserves, mine production, depletion time, substitutability, recycling rate

Supply modelling

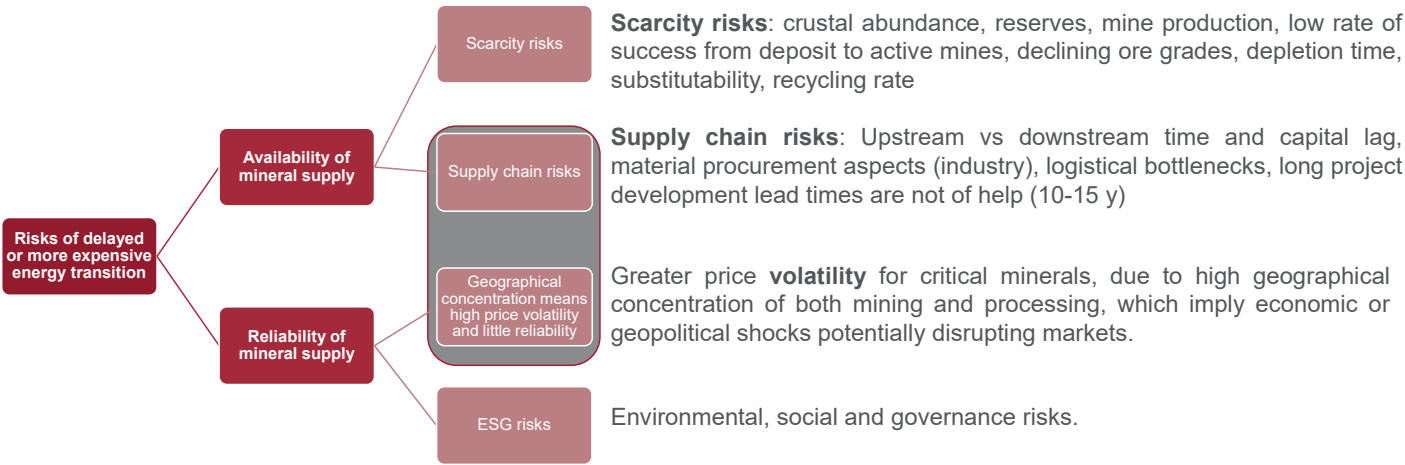
Supply chain risks: Upstream vs downstream time and capital lag, material procurement aspects (industry), logistical bottlenecks

Supply chain modelling



Supply

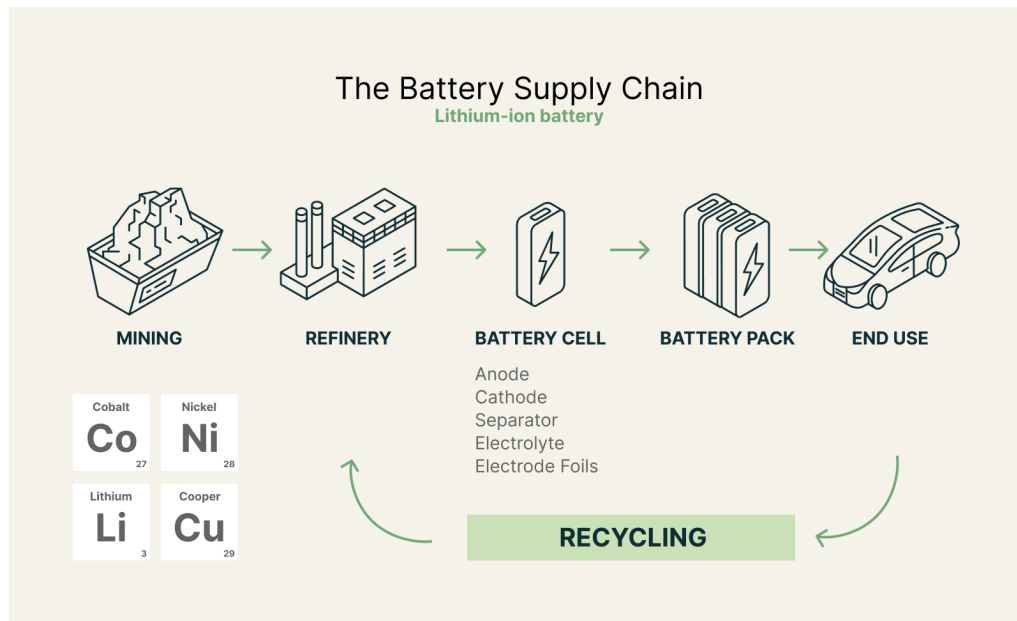
RISKS OF DELAYED OR MORE EXPENSIVE ENERGY TRANSITION COME FROM THE AVAILABILITY AND RELIABILITY OF MINERAL SUPPLY



SUPPLY CHAIN RISKS

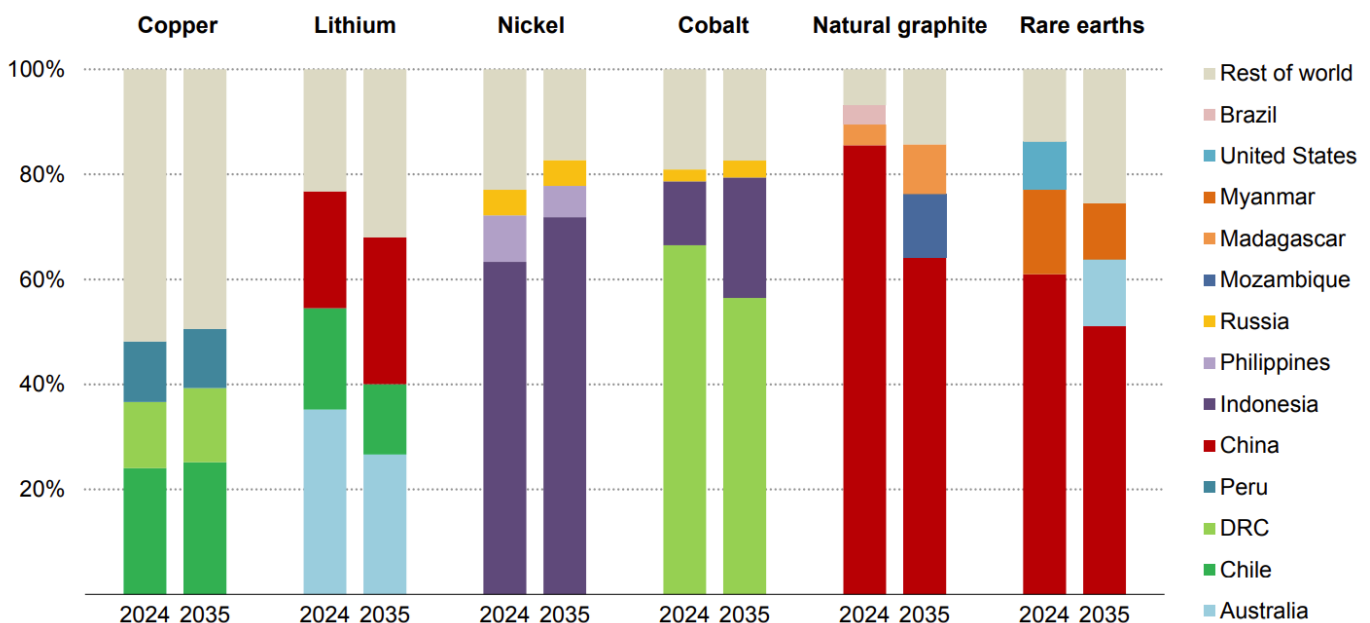


Supply chain modelling



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GEOGRAPHICAL DISTRIBUTION OF RAW MATERIAL PRODUCTION

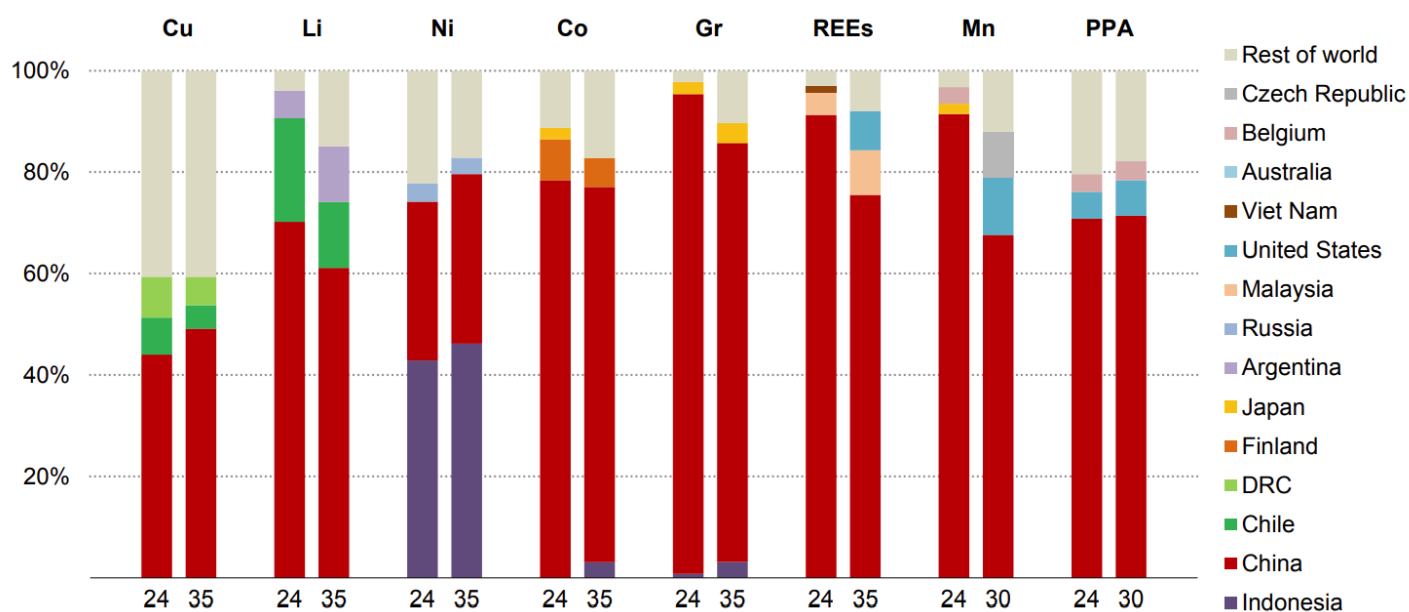


IEA. CC BY 4.0.



MIT Center for Energy and Environmental Policy Research

GEOGRAPHICAL DISTRIBUTION OF REFINED MATERIAL PRODUCTION



IEA. CC BY 4.0.

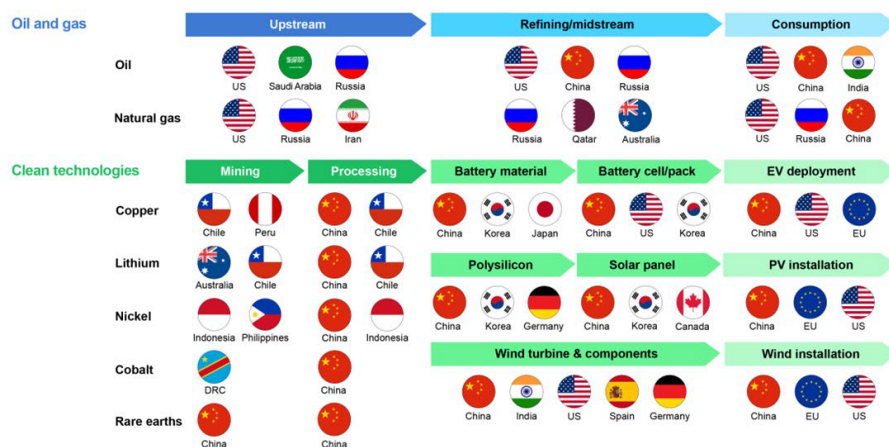


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RELIABILITY OF MINERAL SUPPLY – MARKET RISKS

The transition to a clean energy system brings new energy trade patterns, countries and geopolitical considerations into play

Indicative supply chains of oil and gas and selected clean energy technologies



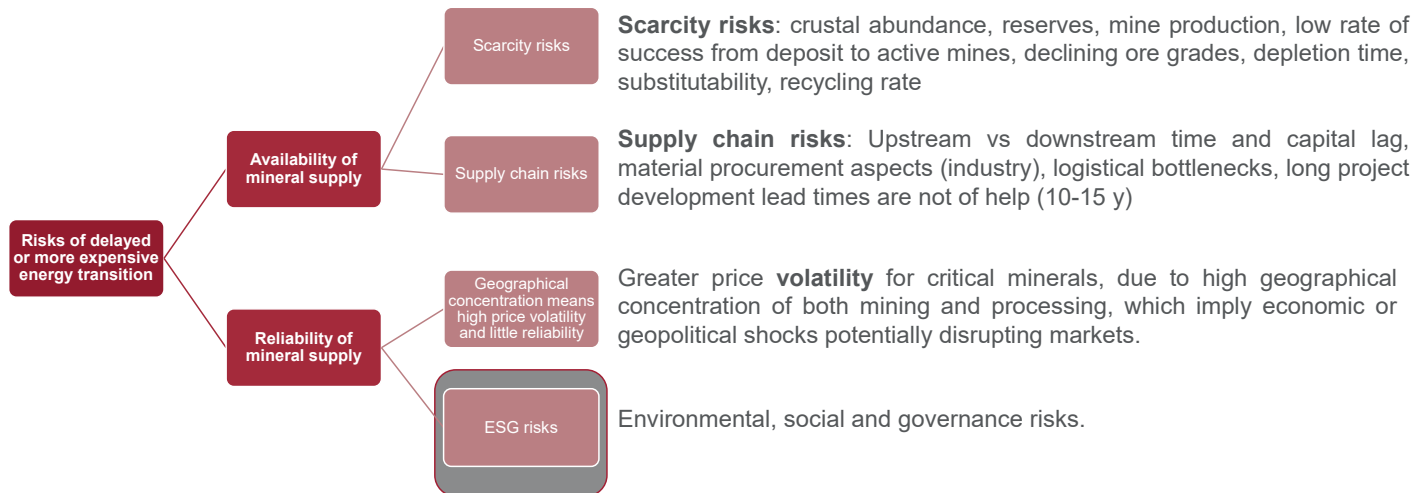
IEA. All rights reserved.



MIT Center for Energy and Environmental Policy Research

Supply

RISKS OF DELAYED OR MORE EXPENSIVE ENERGY TRANSITION COME FROM THE AVAILABILITY AND RELIABILITY OF MINERAL SUPPLY



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RELIABILITY OF MINERAL SUPPLY

ESG Risks: Environmental pollution (Mining & Processing) and life cycle emissions

- Physical disturbances ← mine workings (open pits > underground) and waste tailings and deposits
- Pollution of soil and water ← Acid Mine Drainage ← sulfuric acid from the oxidation of sulfide minerals & toxic substances from processing phases
- Air contamination → Acid rain
- Changes in the wider geography (e.g. habitat fragmentation) ← supporting infrastructure



Acid mine drainage in the Rio Tinto River (Spain)

36

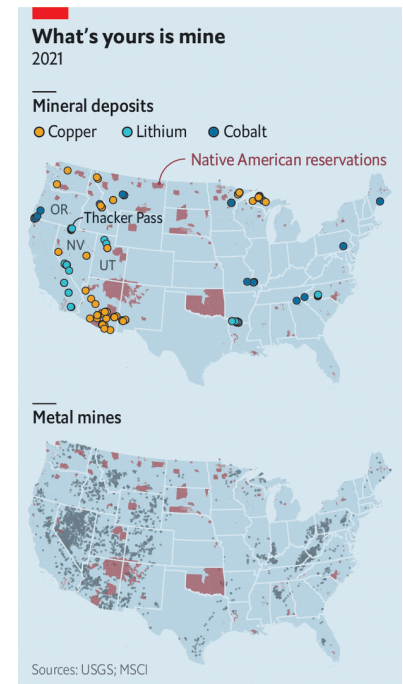
RELIABILITY OF MINERAL SUPPLY

ESG Risks: human health

- Mining environments emit dust and aerosol particles that can mobilize toxic elements
- Miners ← contaminated air, dusts and noise pollution & non-environmental effects such as mining accidents
- Surrounding communities ← potential air, water, soil, and plant contamination & social and emotional impact



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The Economist



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RELIABILITY OF MINERAL SUPPLY

ESG Risks: Social License to Operate vs NIMBY (Mining)

- Adverse health impacts on surrounding communities
- **NIMBYism** occurs when communities can recognize the positive benefits of a development in general, but oppose the development for the negative impacts it brings locally.
- **Social License to Operate (SLO)** approach: mining companies see community approval as a prerequisite to development.
- A NIMBYism approach would dismiss community concerns as unfounded and unwilling to cooperate, whereas a SLO approach would integrate community concerns in the design phases of the project to reach an informal social contract (Komnitsas, 2020).



Widespread protests in Serbia cost Rio Tinto in 2022 its Jadar lithium project.

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RELIABILITY OF MINERAL SUPPLY

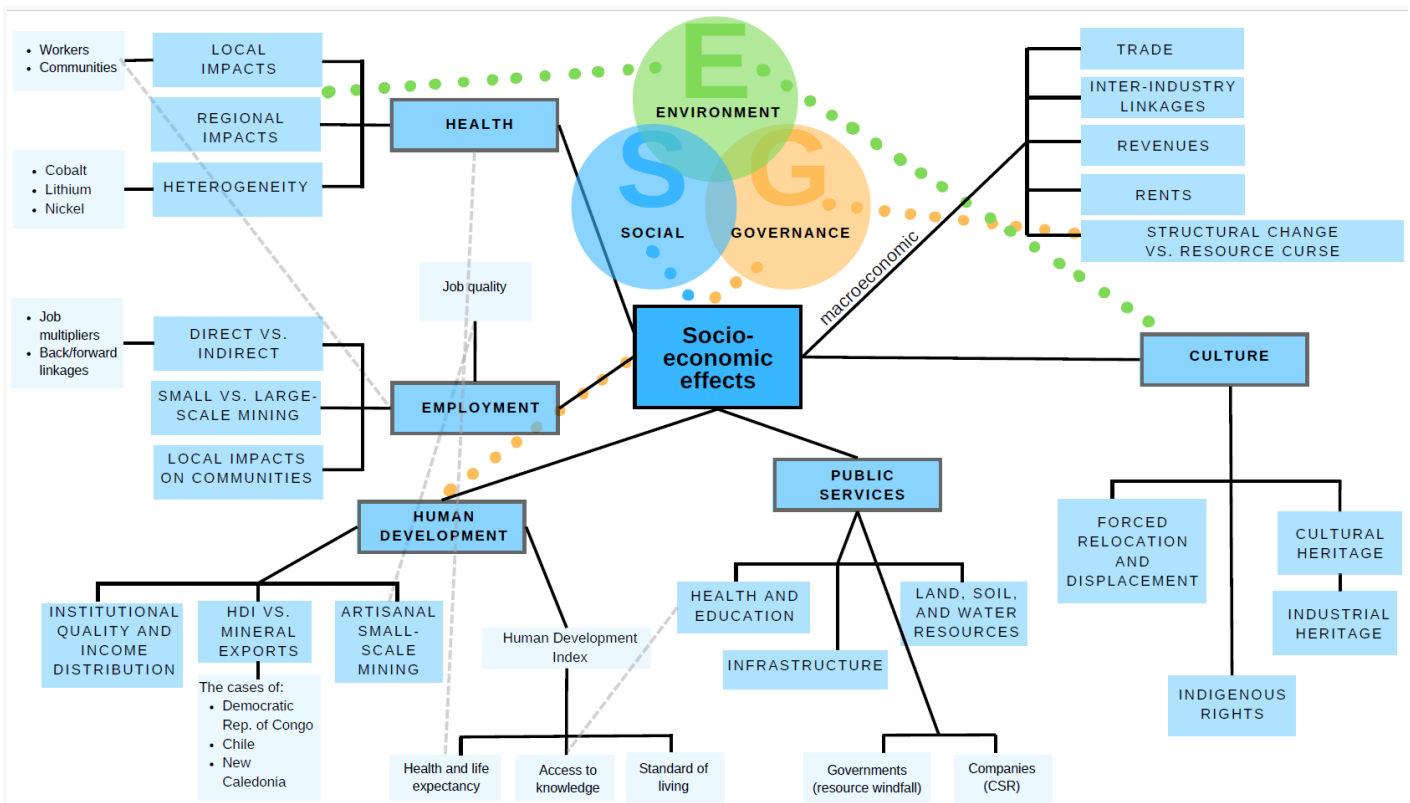
ESG Risks: Corruption & Human Rights

- The case of the Democratic Republic of the Congo (DRC)
- Producing 70% of the world's cobalt
- Ethnic conflicts, violence, corruption, and health crises & mineral abundance (Dutch disease)
- Artisanal mining and child labour
- The case of nickel mining in Indonesia
- Producing 39% of the world's nickel
- Destruction of rainforests → soil erosion → flooding & soil contamination
- Armed confrontations between local communities and miners



A general view of artisanal miners working at the Shabara artisanal mine near Kolwezi (DRC)

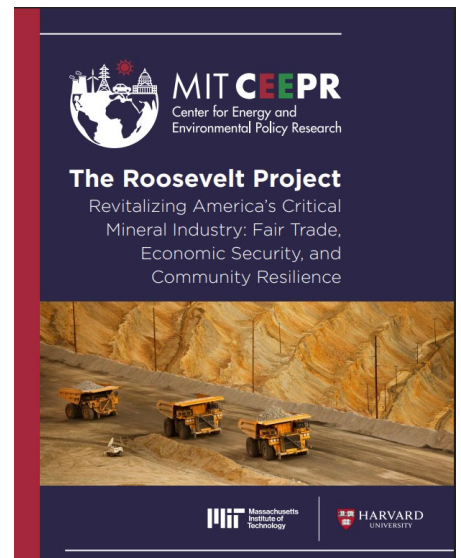
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The Roosevelt Project – with MIT CEEPR
<https://ceepr.mit.edu/roosevelt-project/>

The Roosevelt Project takes a multidisciplinary approach to examine the **transitional challenges** associated with progress toward a deeply **decarbonized U.S. economy**. The project aims to chart a path forward through the transition that minimizes **worker** and community dislocations and enables **at-risk communities** to sustain employment levels by taking advantage of the economic opportunities present for regional economic development.

In the third phase, we assess the state of **North American mining** and propose **best practices** for supporting the mineral demands of the energy transition.



THANK YOU!

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