



Critical Minerals:

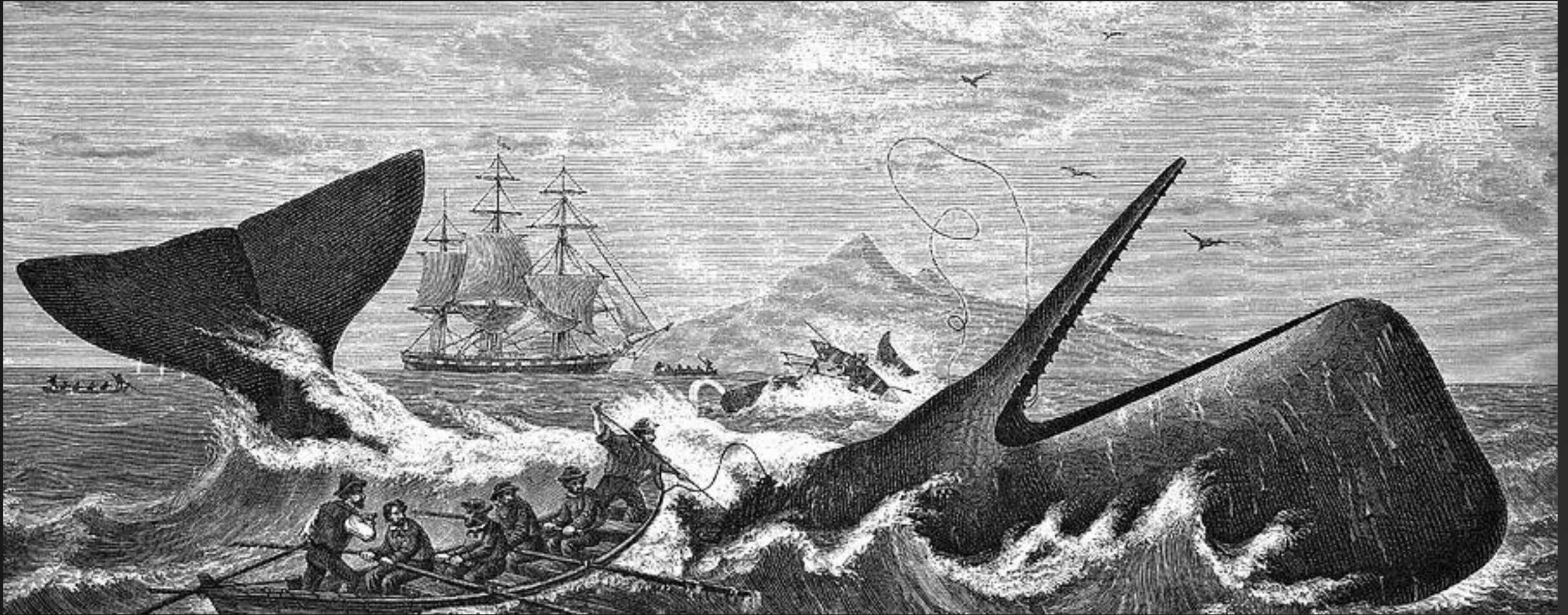
An Opportunity Worth Chasing?



Ian Rinehart

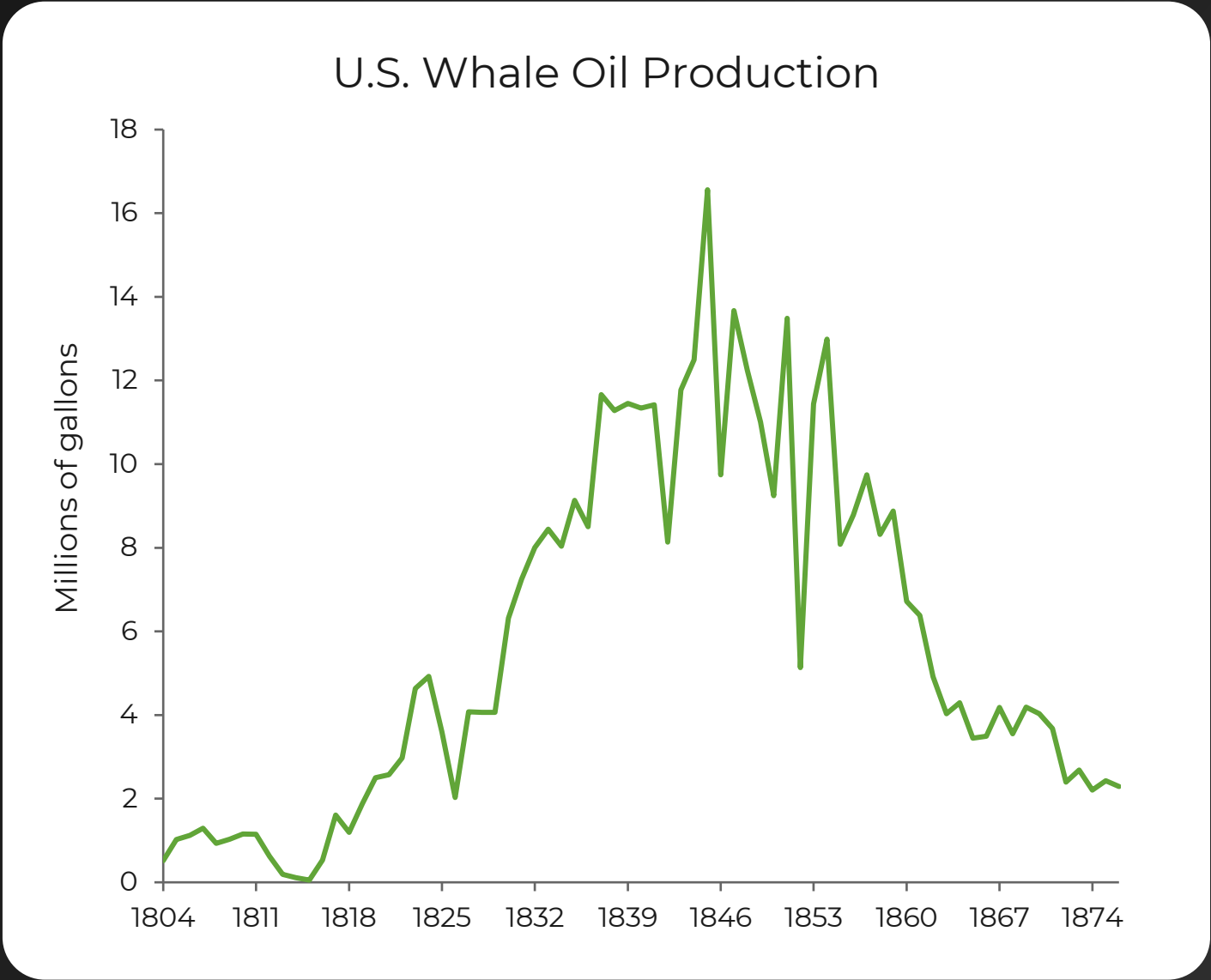
Principal Analyst

Whale oil: a critical resource



Not enough whales

- Inventors developed new oils from natural hydrocarbons.
- Eventually, petroleum production took over in the late 1800s.
- Disruption: electricity



Innovation resolved the shortage





**Are you hunting whales or
are you working on a lightbulb?**

What to Expect

01

Review the geopolitical context for critical minerals supply chains

02

Leverage Lux's Raw Materials Criticality Framework to assess raw materials supply risk

03

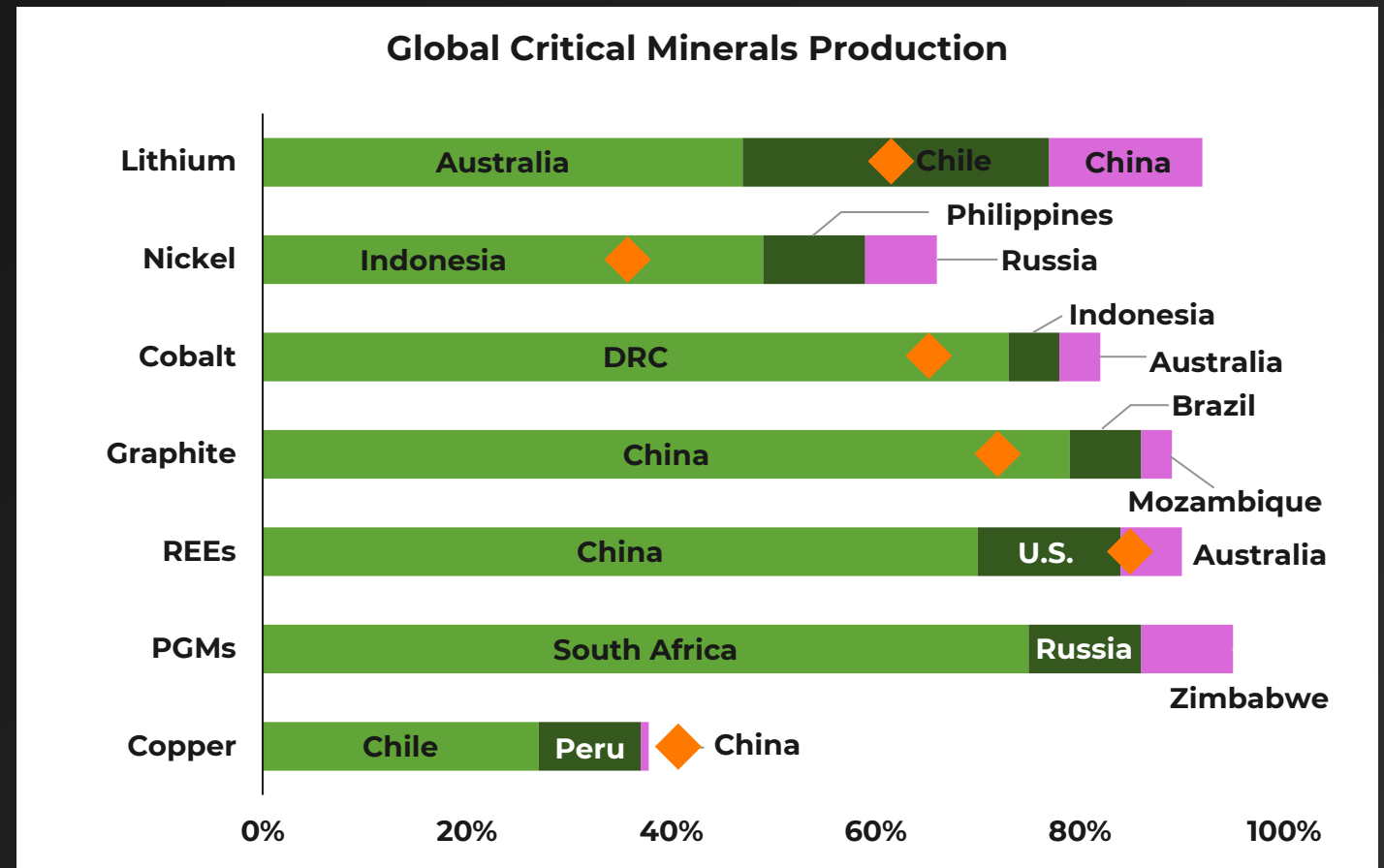
Build a portfolio of innovation strategies to put growth on a foundation of resilience

04

Outline key actions for innovation teams

Critical minerals supply chain

- Production is heavily concentrated.
- China hosts more than 60% of refining capacity in most value chains.
- U.S. overperforms in rare earth elements (REEs) and platinum-group metals (PGMs) but underperforms in lithium.



Globalization has shifted into reverse

Nations are using their resources for economic leverage.

Congo bans cobalt exports for four months to curb oversupply

By Ange Adihe Kasongo and Sonia Rolley

February 25, 2025 4:07 AM GMT+1 · Updated 6 days ago



China to limit antimony exports in latest critical mineral curbs



Chile plans to nationalize its vast lithium industry

By Alexander Villegas and Ernest Scheyder

April 21, 2023 10:15 AM GMT+2 · Updated 2 years ago



The New York Times

U.S. Pressing Tough Demands in Revised Deal for Ukraine's Minerals

The Trump administration wants revenues from Ukraine's natural resources, according to a draft obtained by The New York Times, with no security guarantee in exchange.



Greenland is getting a lot of international attention for its mineral resources – but what is hiding under the ice?

Supplier countries seek to enhance leverage

Policies to restrict exports aim to retain dominant supply chain position.

- Indonesia captured nickel market share.
- China restricts rare earth refining equipment exports.
- Overseas investments bolster countries' positions.



Buyer countries seek to balance market power

Europe and U.S. each organizing “buyers clubs,” funding projects, and making upstream deals

- U.S. launched Project Vault strategic reserve.
- U.S. taking equity stakes in technology developers and negotiating for mineral rights.
- EU launched the Raw Materials Mechanism to aggregate demand.



Energy companies staking out positions

Activity across the value chain in new energy technologies and materials

Upstream

Core adjacency in lithium extraction

- O&G majors developing own lithium projects

Midstream

Technology project partnerships

- Mineral recovery from produced water
- Geothermal power

Downstream

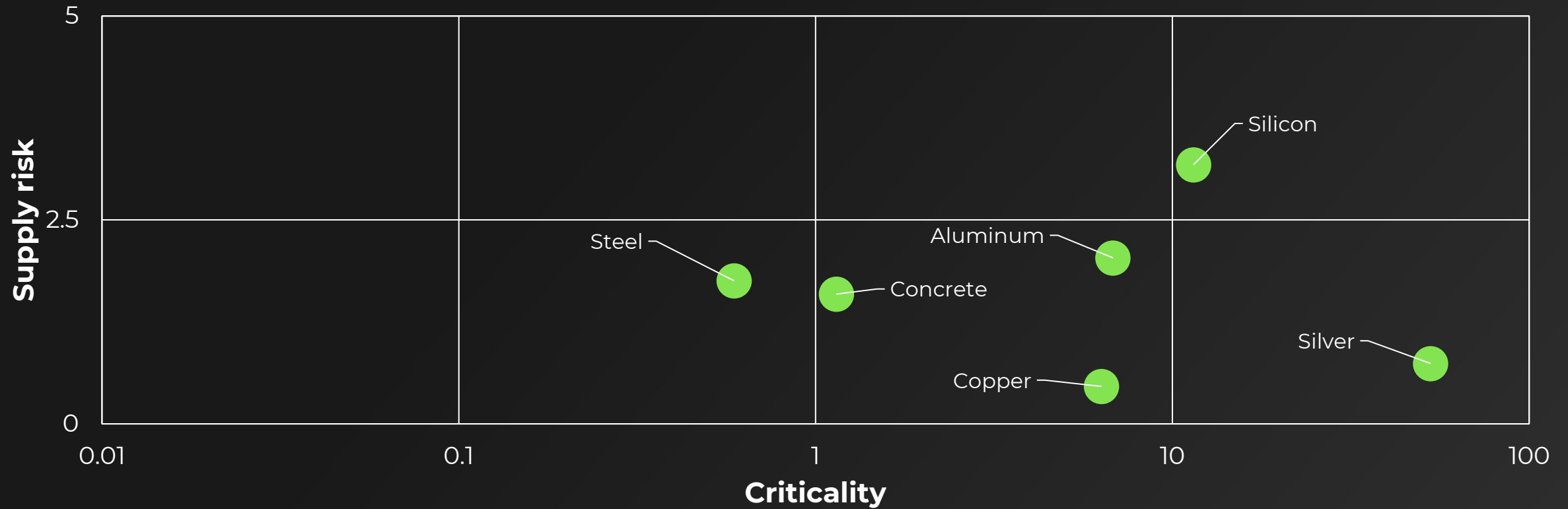
Buying energy equipment

- Water electrolyzers for green hydrogen
- Carbon capture

Lux's Raw Materials Criticality Framework

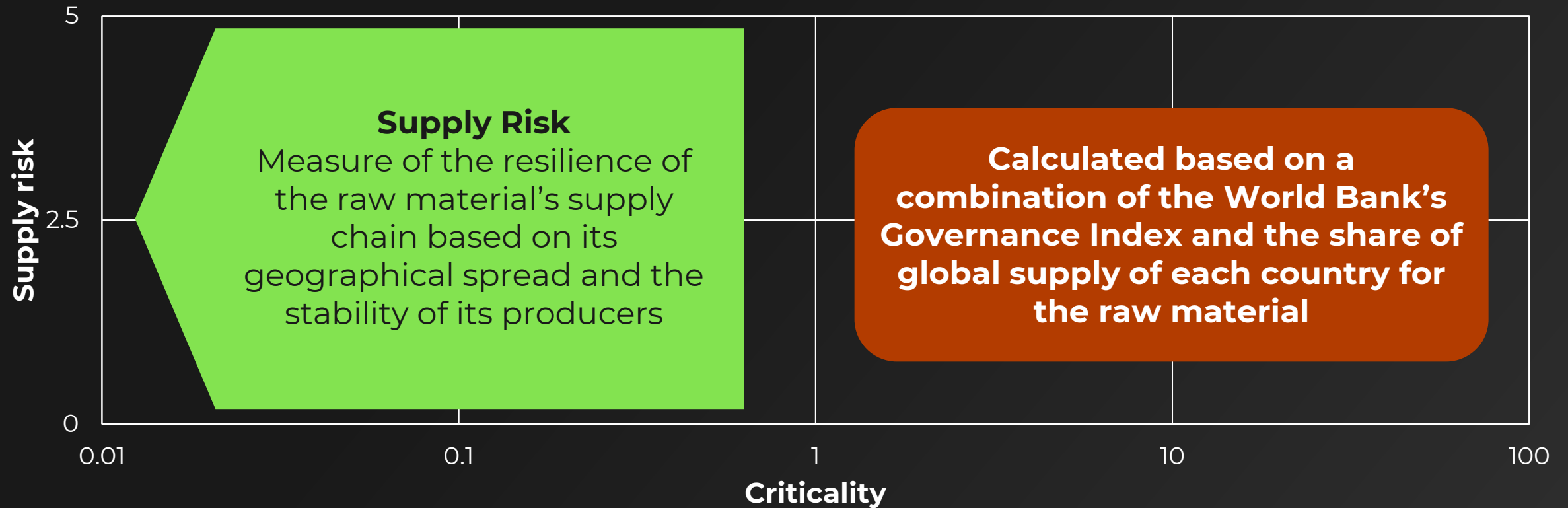
Raw Materials Criticality Framework

Raw Materials Criticality Framework: Solar PV



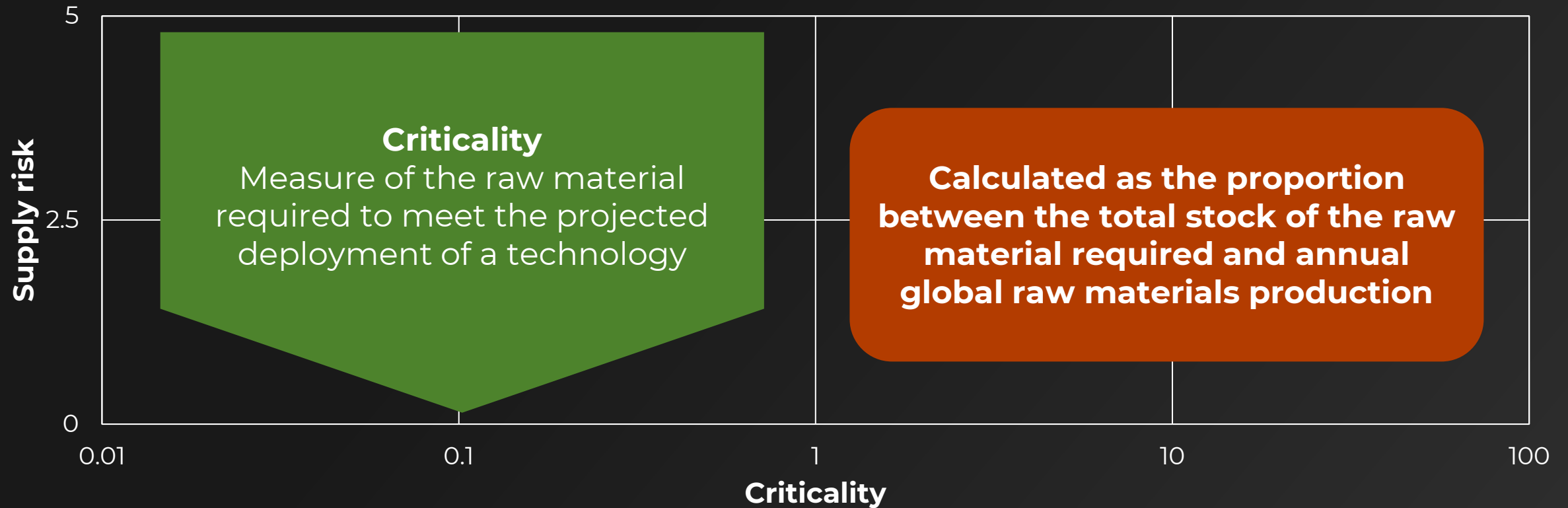
Raw Materials Criticality Framework

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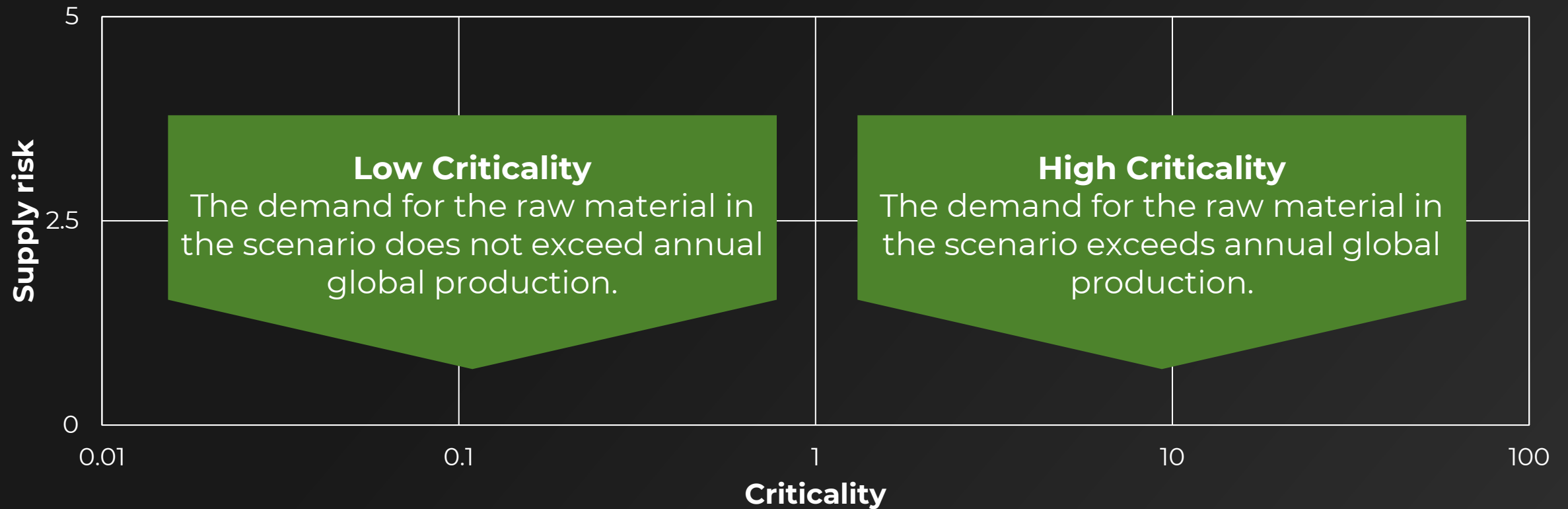
What does the framework tell us?

Raw Materials Criticality Framework



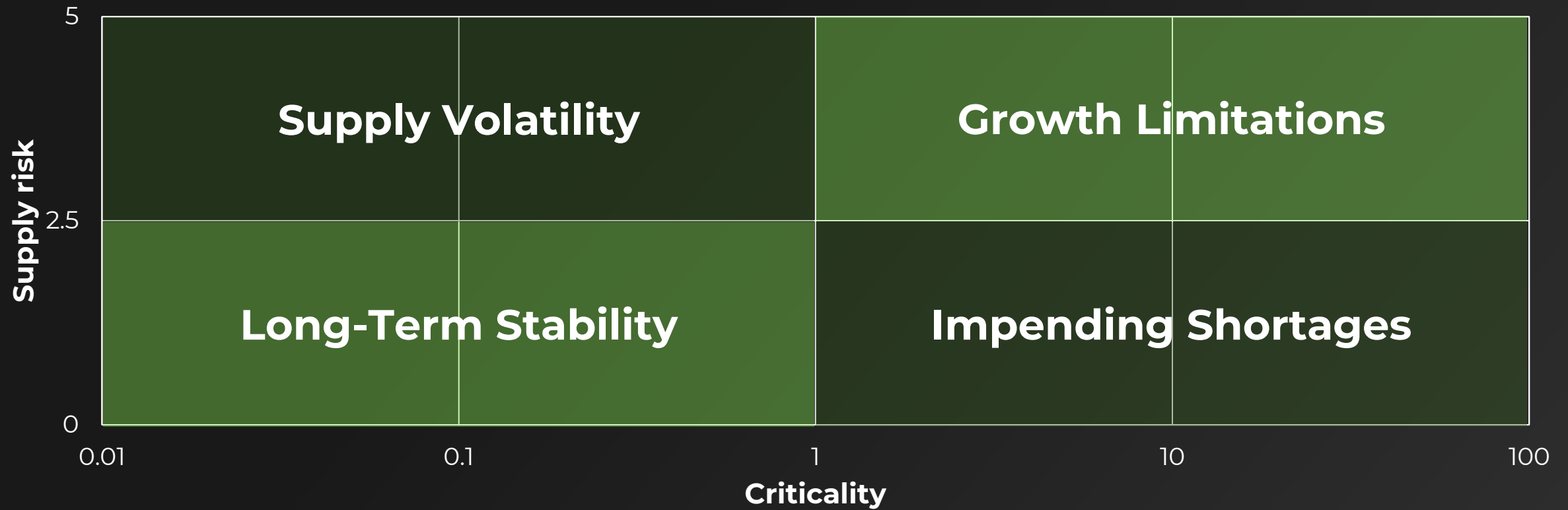
What does the framework tell us?

Raw Materials Criticality Framework



Four scenarios

Raw Materials Criticality Framework

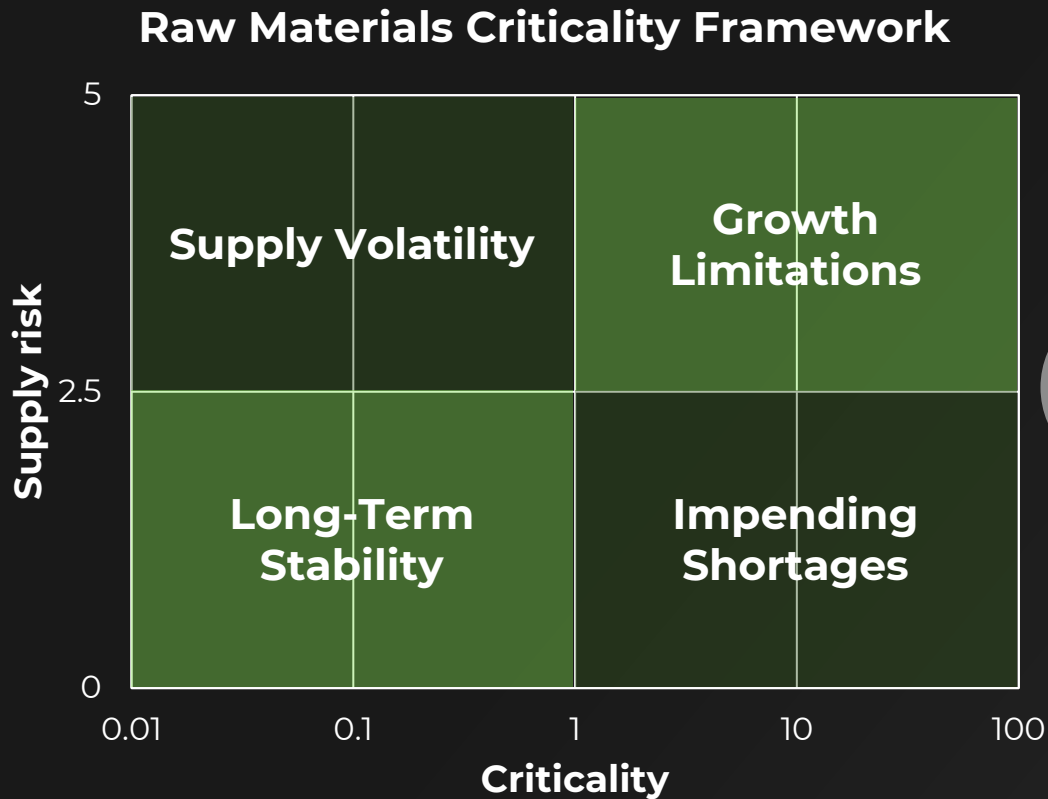




**So, what are we
supposed to do now?**

Step 1: Assess your raw materials risks

Step 2: Select your innovation strategies



Novel Sources

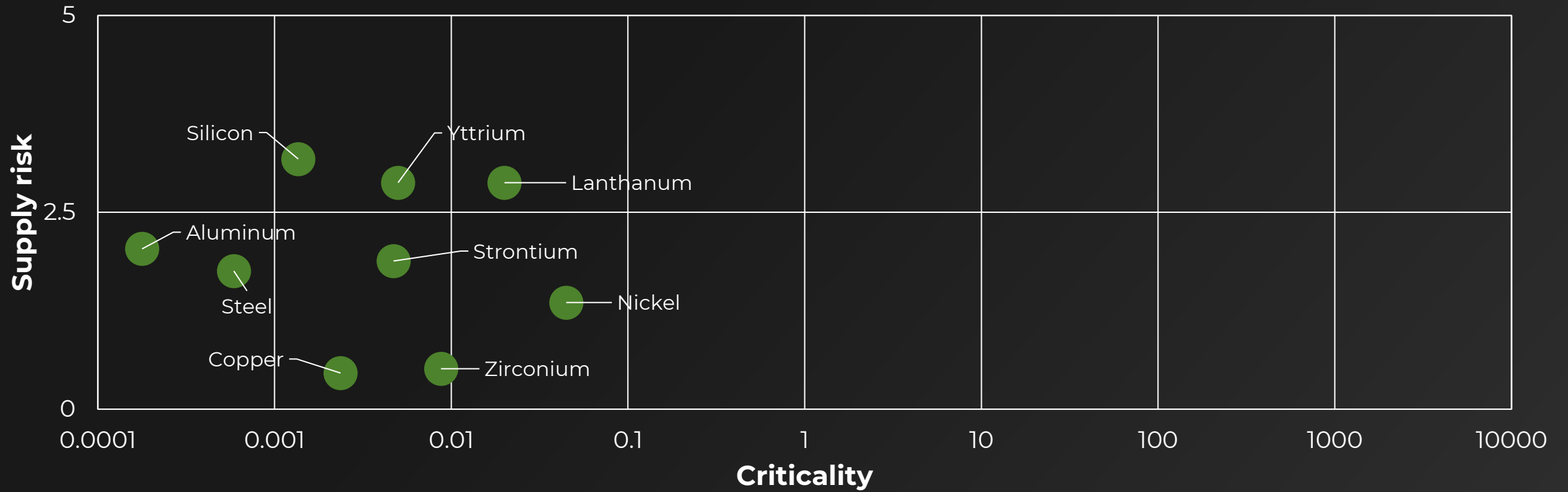
Materials Optimization

Alternative Materials

Recycling & Circularity

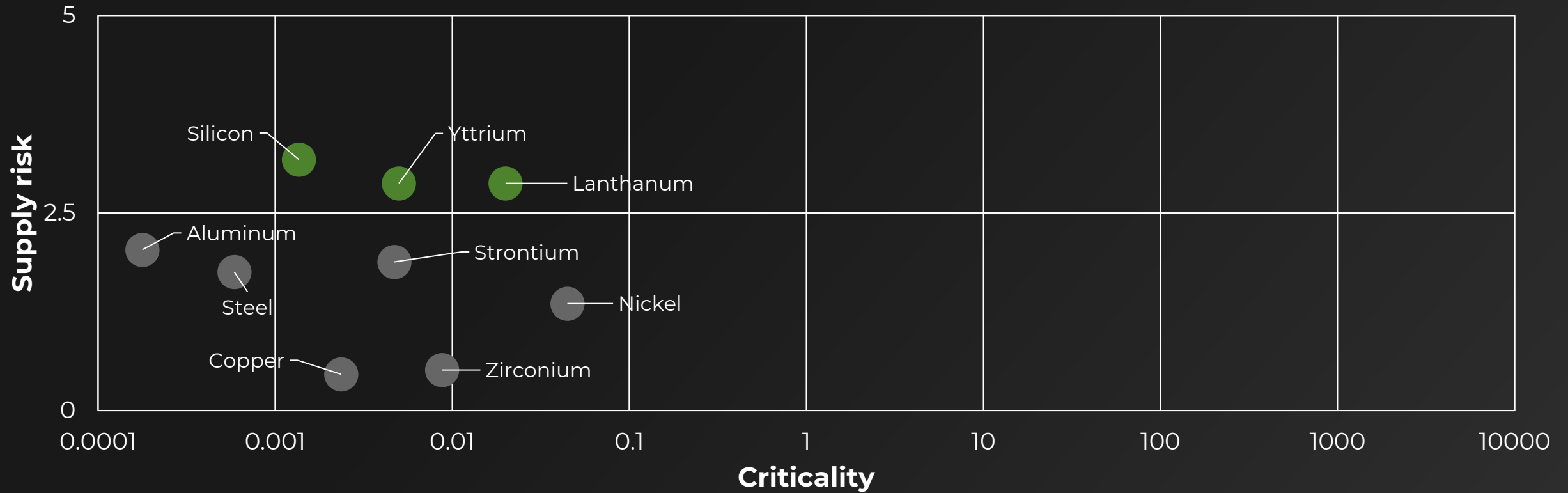
Volatility: Rare earths

Raw Materials Criticality Framework: Solid Oxide Electrolyzers



Volatility: Rare earths

Raw Materials Criticality Framework: Solid Oxide Electrolyzers



Novel sources

Support innovations that supply critical materials from waste streams and unexpected places



Industrial byproducts



Deep-sea mining



Phytomining



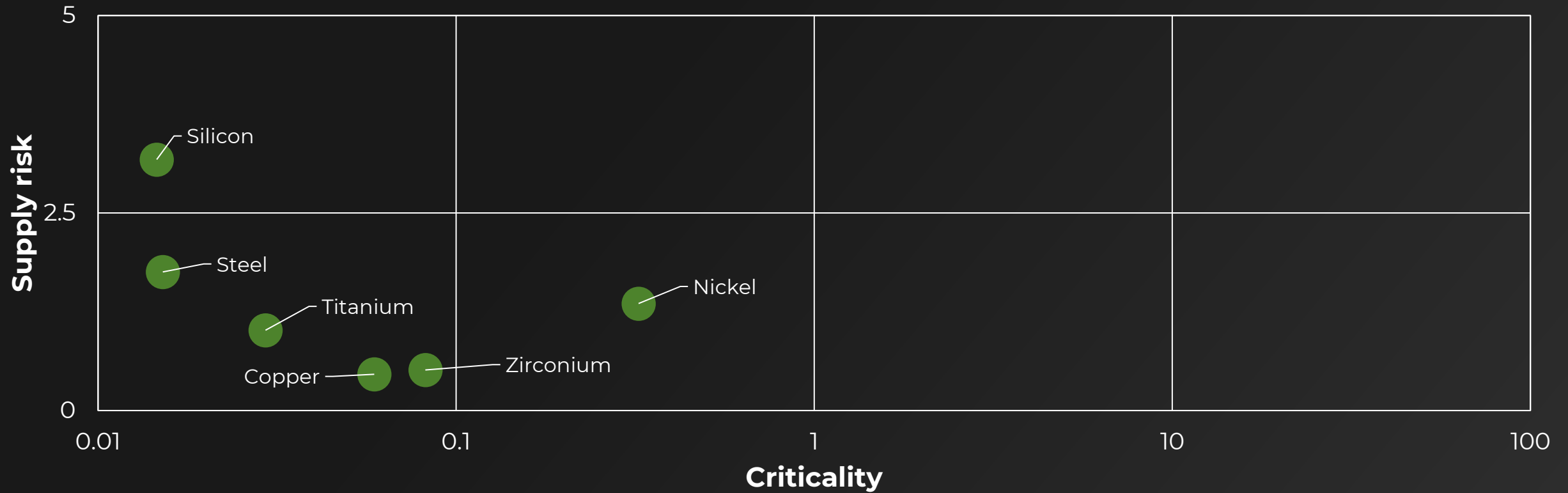
Flashback: Alumina from bauxite

Once sourced from cryolite, aluminum was more valuable than gold.



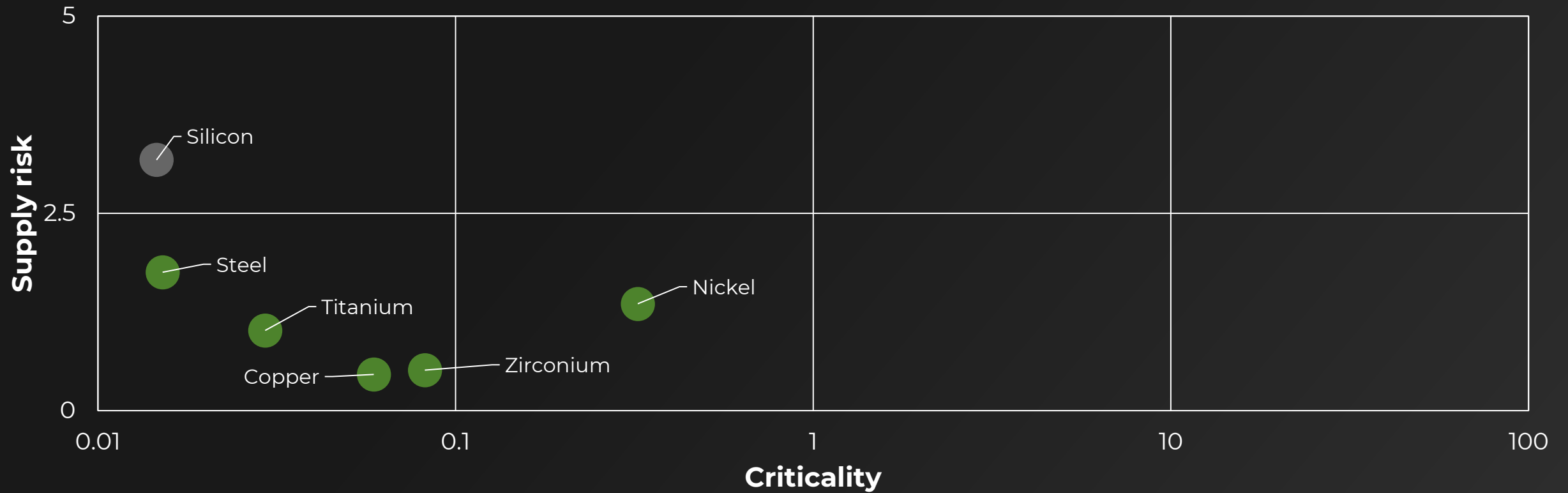
Stability: Alkaline electrolyzers

Raw Materials Criticality Framework: Alkaline Electrolyzers



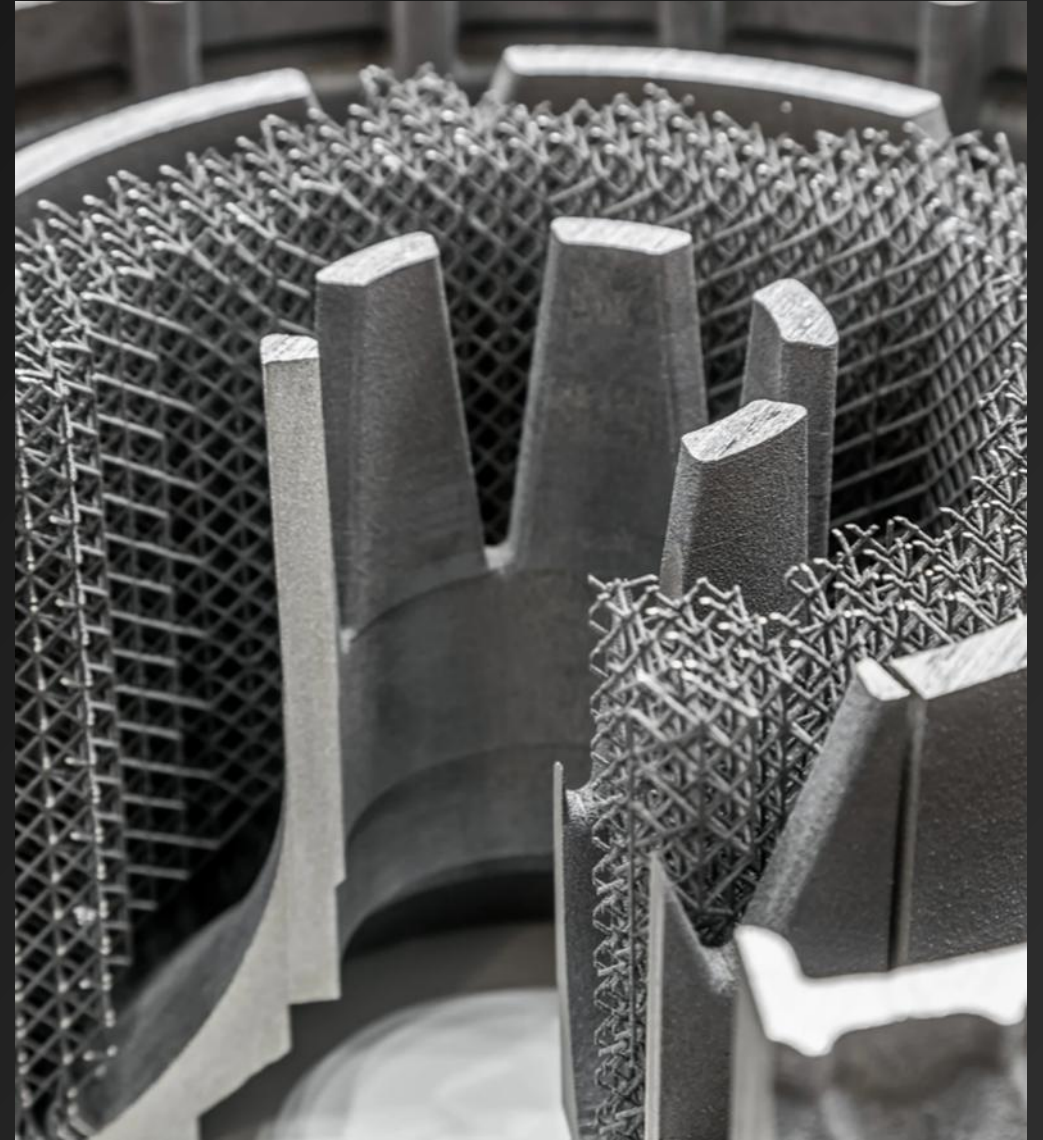
Stability: Alkaline electrolyzers

Raw Materials Criticality Framework: Alkaline Electrolyzers



Material optimization

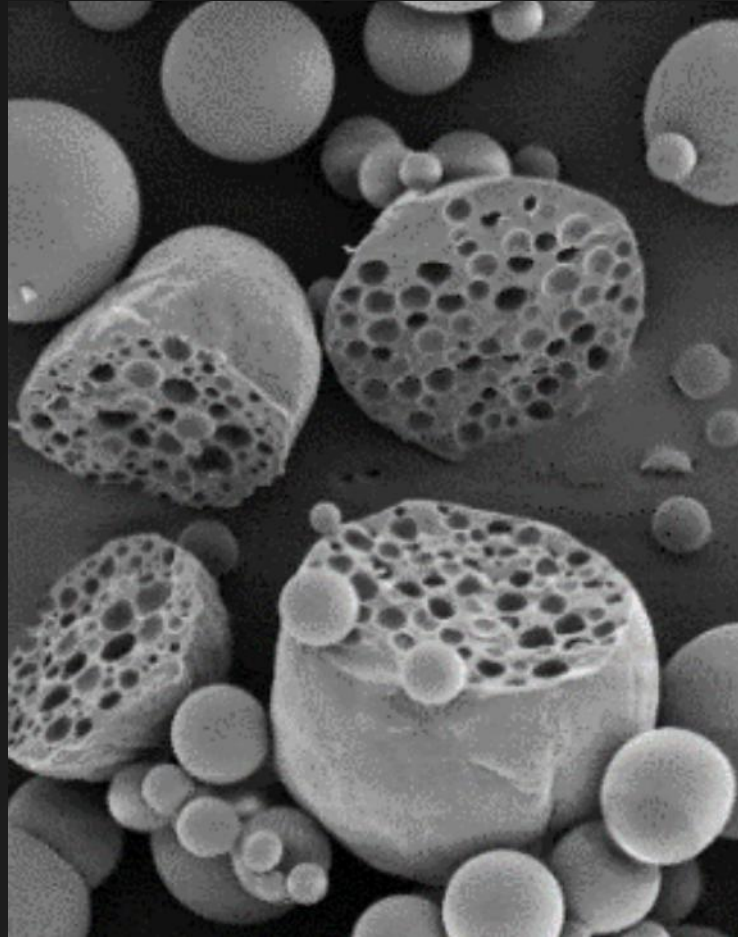
Allocate R&D resources to projects that can do more with less.



Novel catalysts



Materials structure



Thin-film deposition



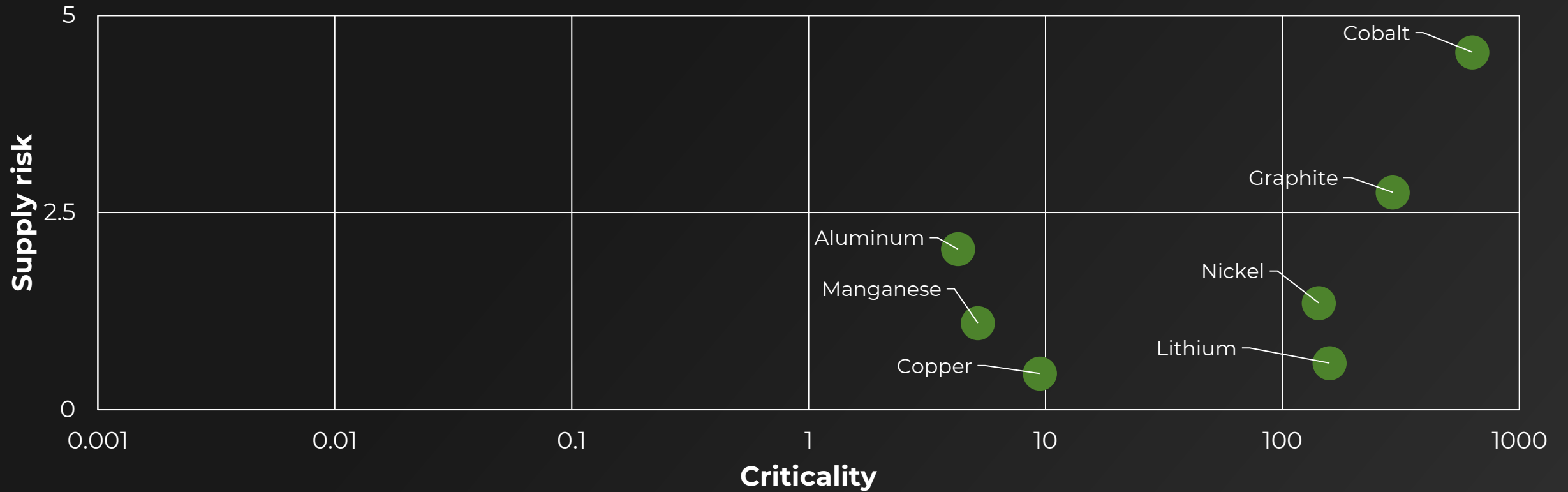
Flashback: Catalytic converters

Palladium and rhodium blend allowed reduction of platinum.



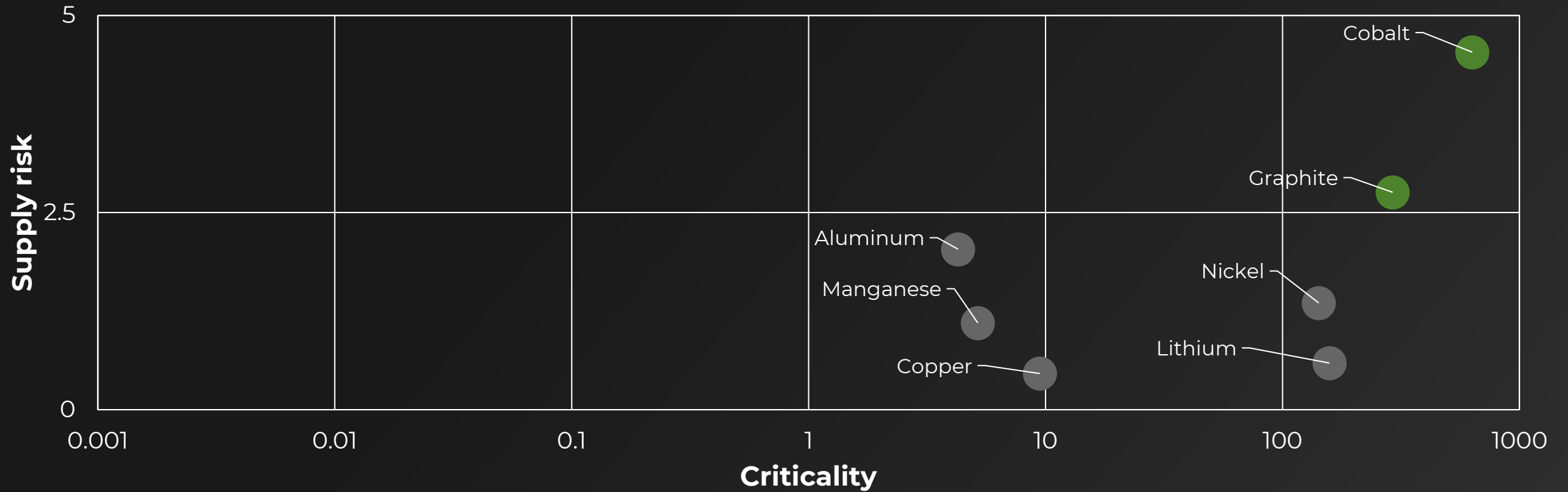
Limitations: Cobalt and graphite

Raw Materials Criticality Framework: NMC Batteries (EV)



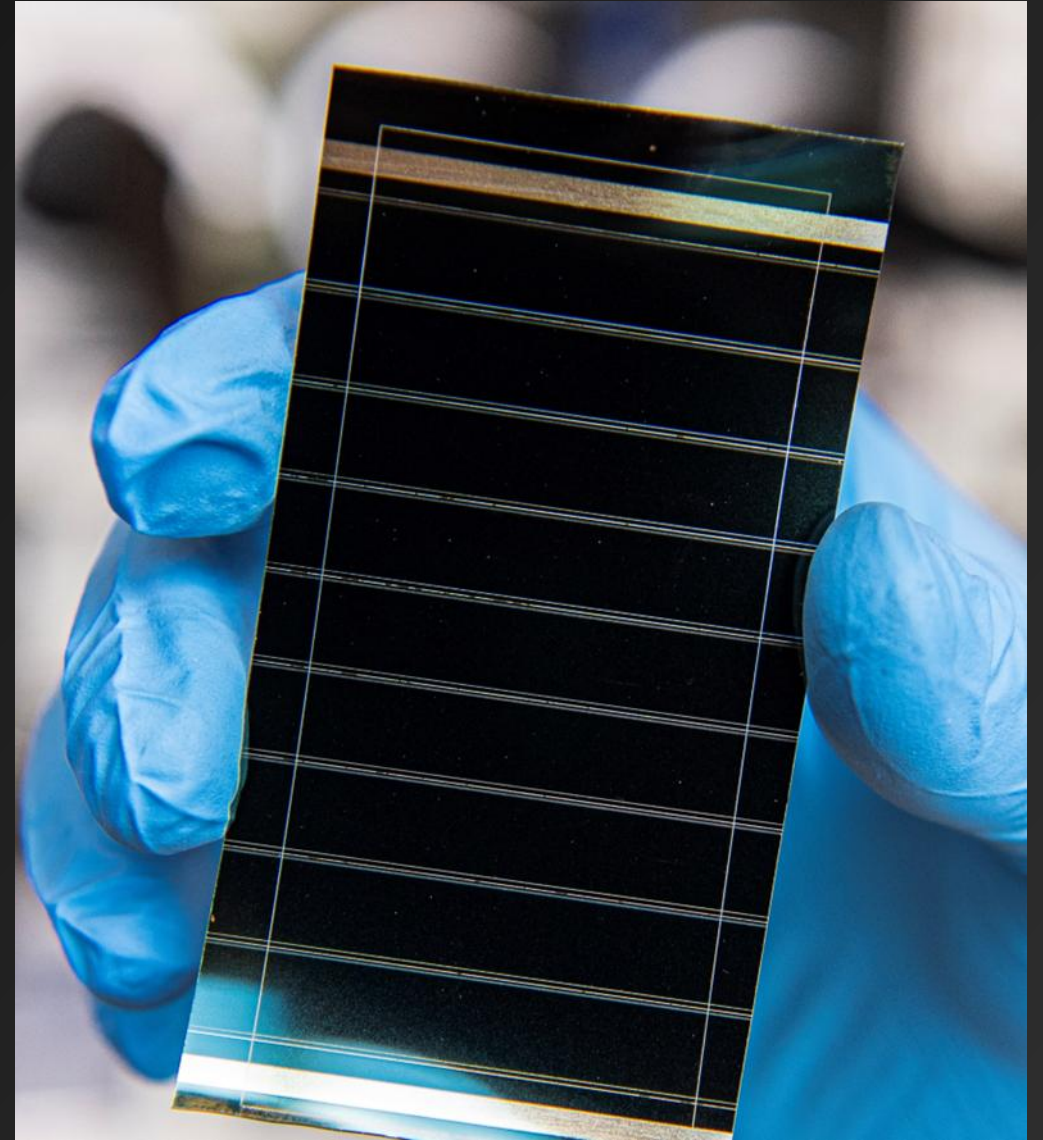
Limitations: Cobalt and graphite

Raw Materials Criticality Framework: NMC Batteries (EV)



Alternative materials

Identify innovations that that can functionally replace a material input.



Alternative chemistries



Synthetic replacement



Steer away



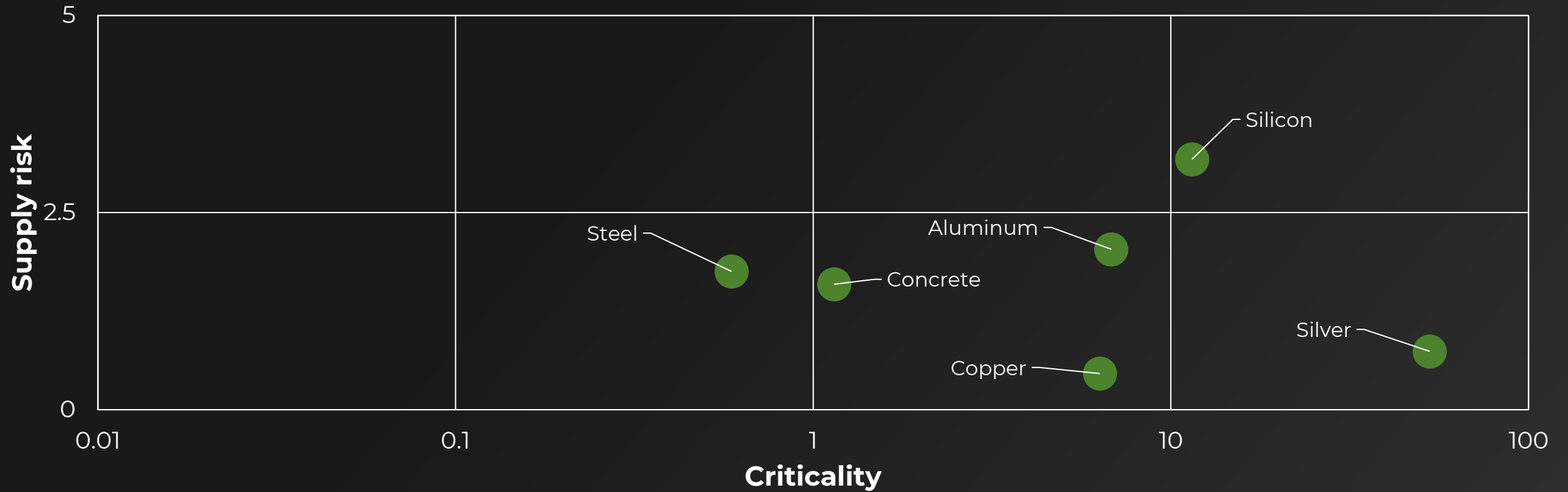
Flashback: Synthetic rubber

World War II sparked urgent innovation to replace natural rubber.



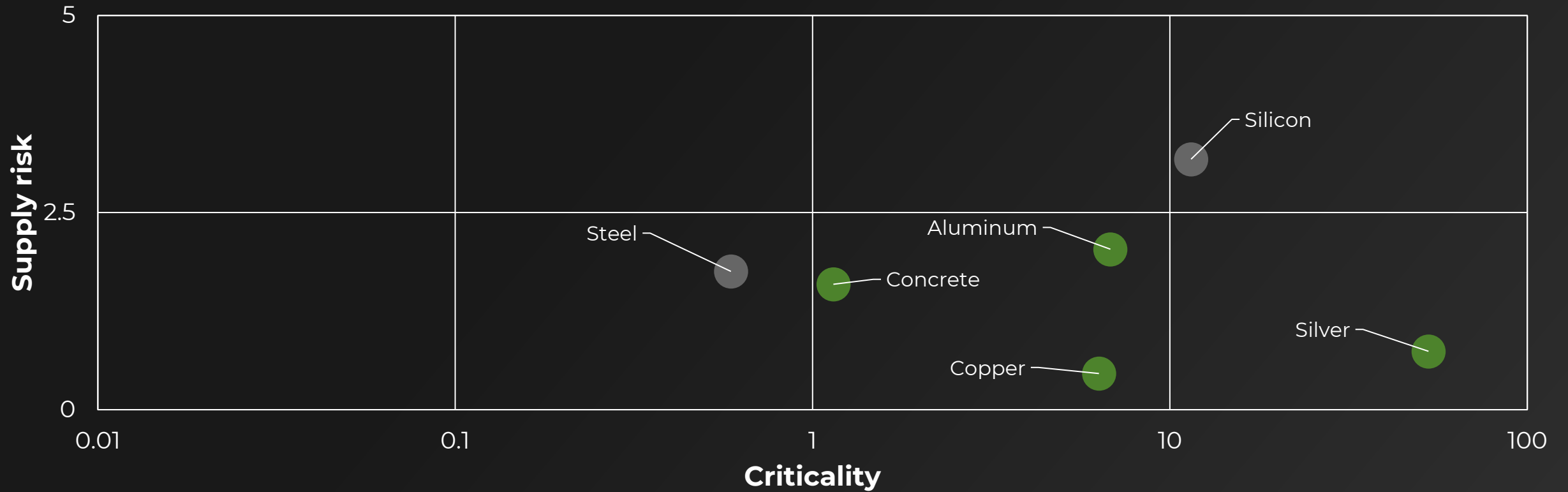
Shortages: Solar PV

Raw Materials Criticality Framework: Solar PV



Shortages: Solar PV

Raw Materials Criticality Framework: Solar PV



Recycling and circularity

Maximize recovery of resources from products within your reach.



Novel recycling tech



Design for circularity



Collection schemes



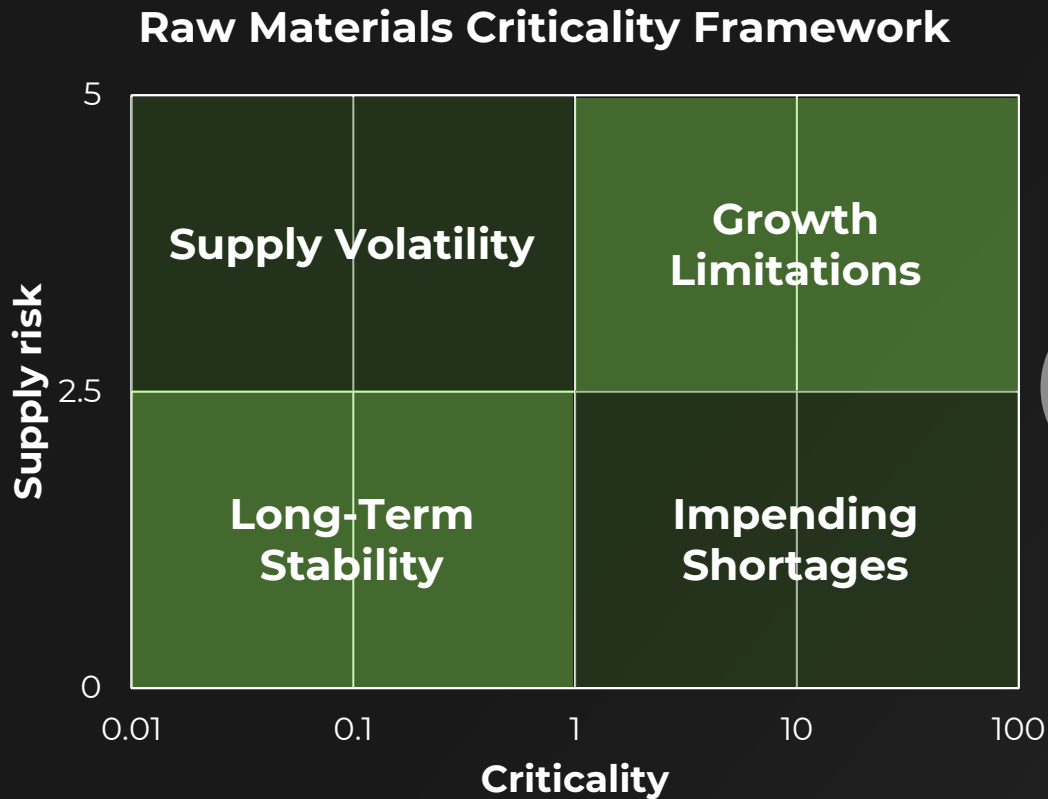
Flashback: Steel recycling

Electric arc furnaces enabled large-scale secondary steel production.



Step 1: Assess your raw materials risks

Step 2: Select your innovation strategies



Novel Sources

Materials Optimization

Alternative Materials

Recycling & Circularity



**Your innovation strategy puts
growth on a foundation
of resilience.**

Key Takeaways

1

Build resilience through investment, partnerships, and innovation.

A multilayered strategy that addresses supply risks from different angles will be the foundation of resilient growth in the future.

2

Understand the criticality of commodity materials.

The supply of base metals, steel, concrete, and polymers could become bottlenecks to deployment if companies do not manage their project portfolios to adapt to macroeconomic factors.

3

Technology variations result in shifting demand.

Among the several technology approaches to solve a particular challenge, the winners and losers will dictate future supply challenges.



Thank you



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Lux Research fuels innovators to not only imagine what's possible in the future but also operationalize innovation success in the near term. We deliver research and advisory services to inspire, illuminate, and ignite innovative thinking that reshapes and grows businesses. Using quality data derived from primary research, fact-based analysis, and opinions that challenge traditional thinking, our experts focus on finding truly disruptive innovations that are also realistic and make good business sense.

The “Lux Take” is trusted by innovation leaders around the world, many of whom seek our advice directly before placing a bet on a startup or partner — our clients rely on Lux insights to make decisions that generate fantastic business outcomes. We pride ourselves on taking a rigorous, scientific approach to avoid the hype and generate unique perspectives and insights that innovation leaders can't live without.

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