RISK AND CRITICALITY

Innovating for Raw Materials Security

Ian Rinehart

Associate Research Director

WHALE OIL: A CRITICAL RESOURCE

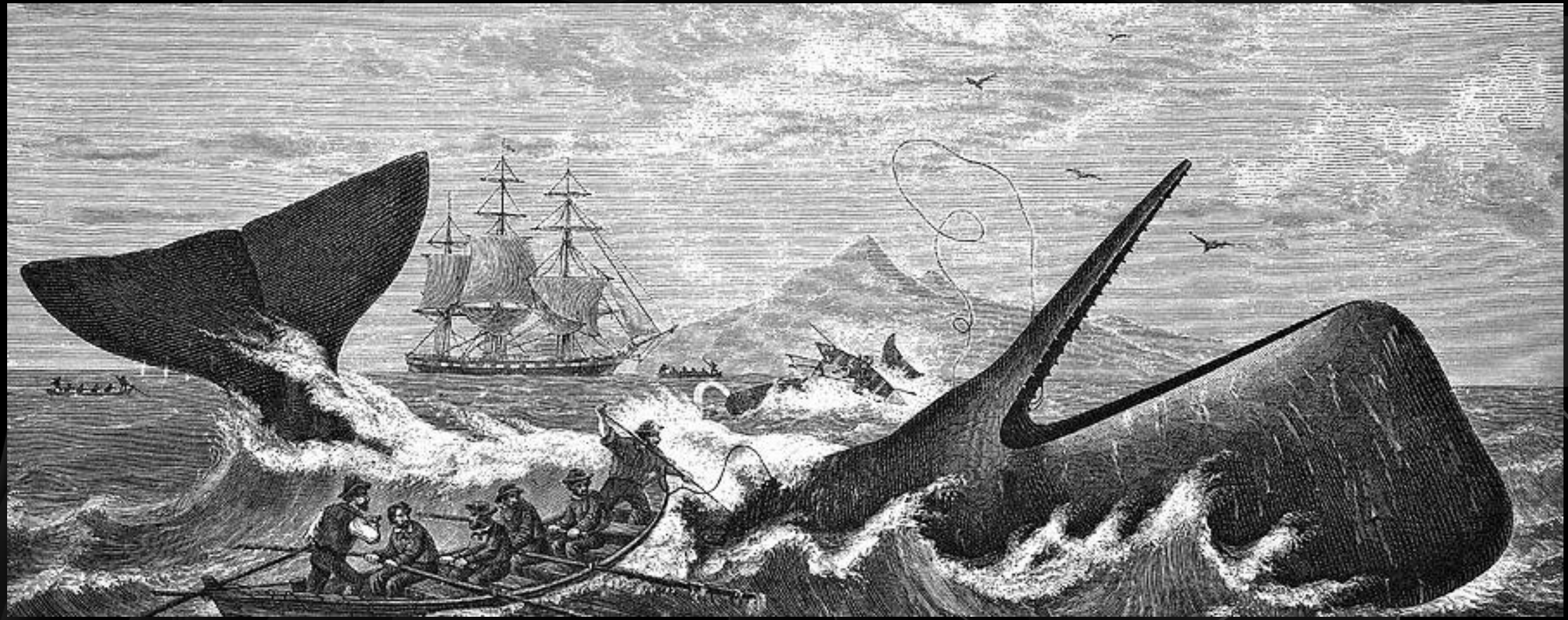
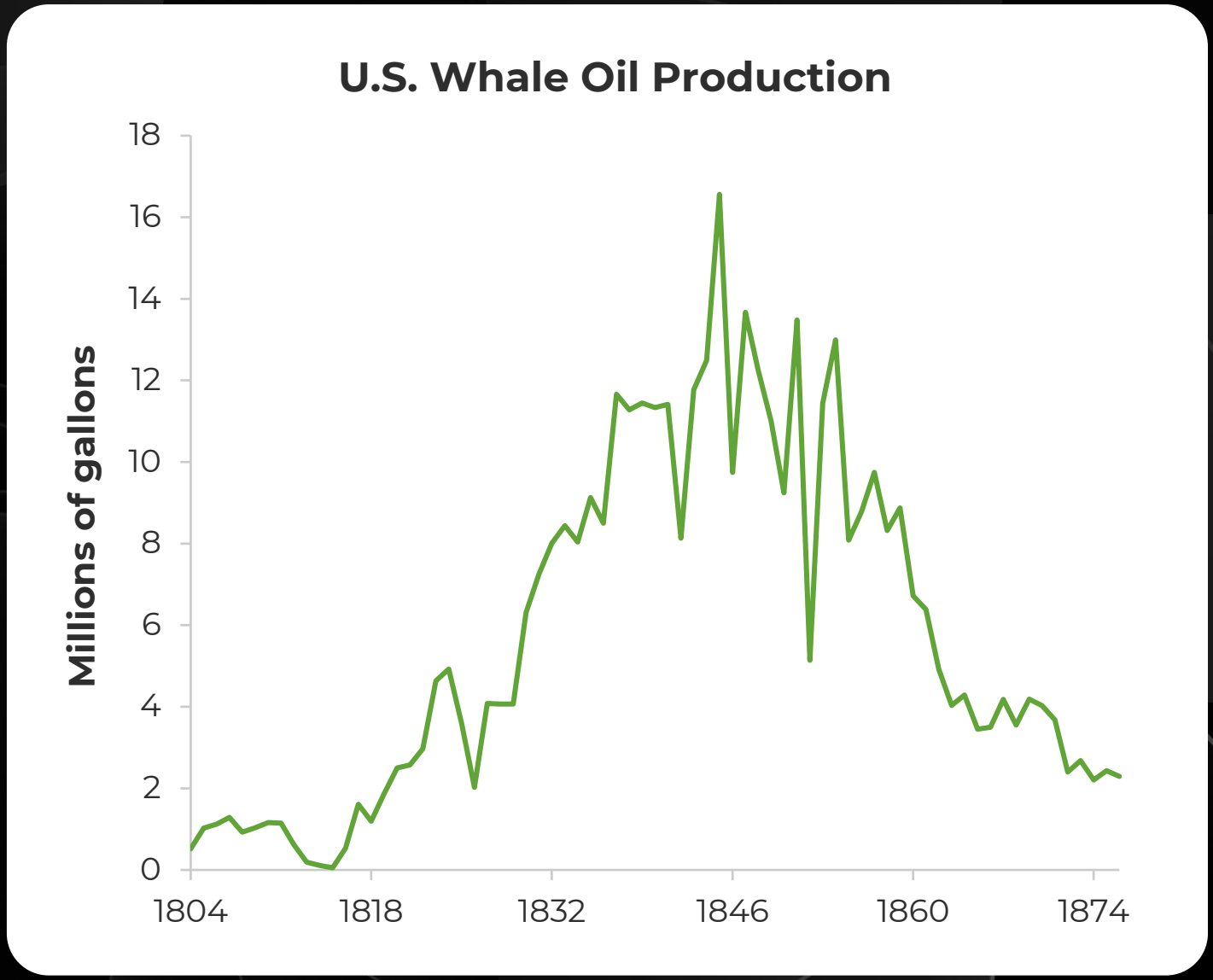


Image source: Science Photo Gallery

NOT ENOUGH WHALES

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



Source: Bardi et al. "Lessons from the Case of Whaling in the 19th Century."

INNOVATIONS RESOLVED THE SHORTAGE

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

WHAT TO EXPECT

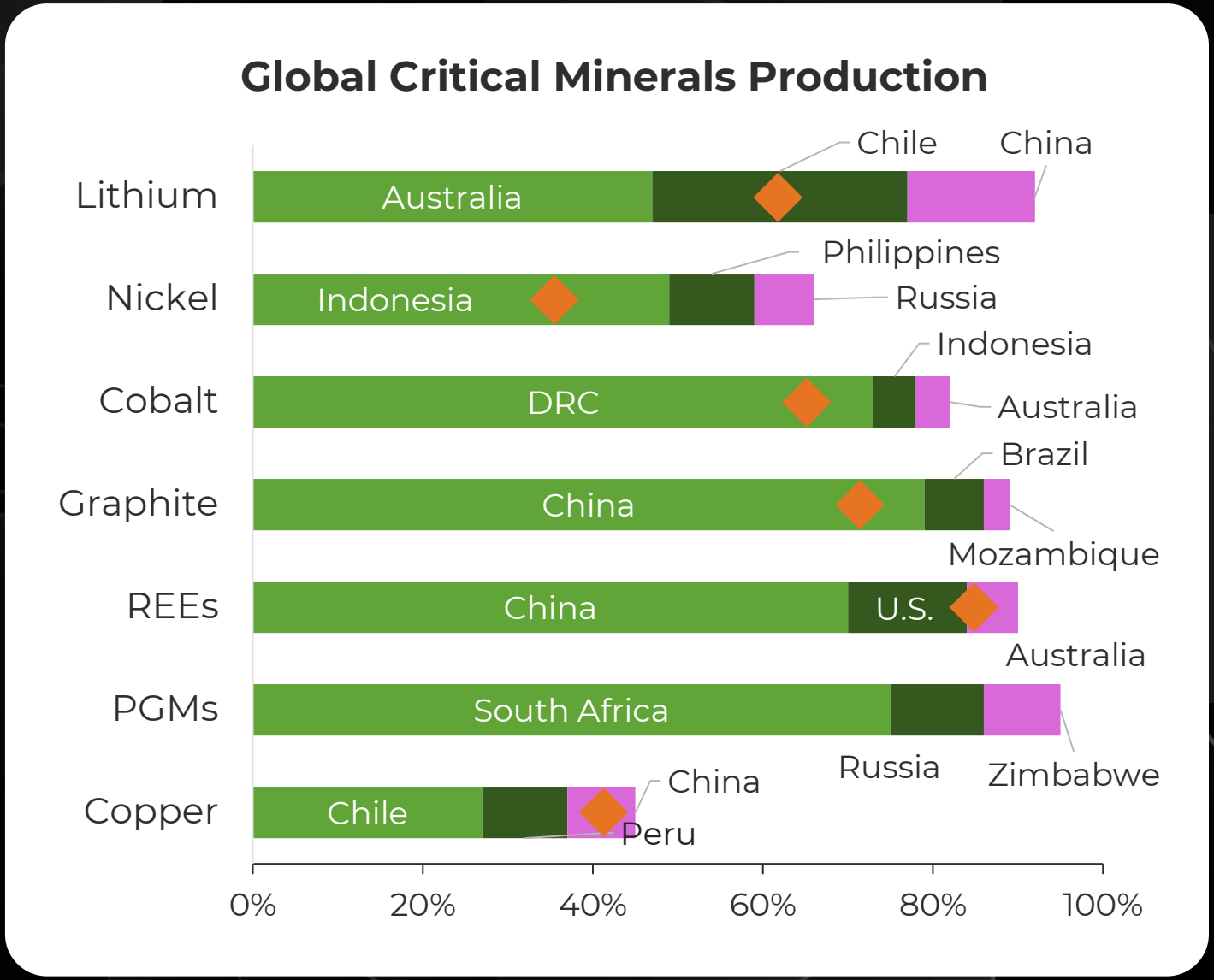
01 **Review the status of critical minerals supply chains and the geopolitical context for economic security**

02 Leverage Lux's Raw Materials Criticality Framework to assess raw materials criticality and supply risk and uncover four outlook scenarios

03 Build a portfolio of innovation strategies to mitigate raw materials risks and put growth on a foundation of resilience

CRITICAL MINERALS SUPPLY CHAIN

- Production is heavily concentrated
- China hosts more than 60% of refining capacity in most value chains



Source: International Energy Agency (IEA), 2023 (adapted by Lux Research)

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

REUTERS

China to limit antimony exports in latest critical mineral curbs

CNN BUSINESS

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

REUTERS

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.

BBC

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

SPOTLIGHT ON INDONESIA

2020 export ban on nickel ore put Indonesia in a dominant position

- Grew nickel market share to 50%
- Spurred downstream industry

Image source: Dialogue Earth

SPOTLIGHT ON CHINA

Critical raw materials are a point of leverage in trade wars

- Restricted key mineral exports
- Banned equipment exports
- Investing downstream overseas

Image source: Inter-China Chemical

WHAT TO EXPECT

01 Review the status of critical minerals supply chains and the geopolitical context for economic security

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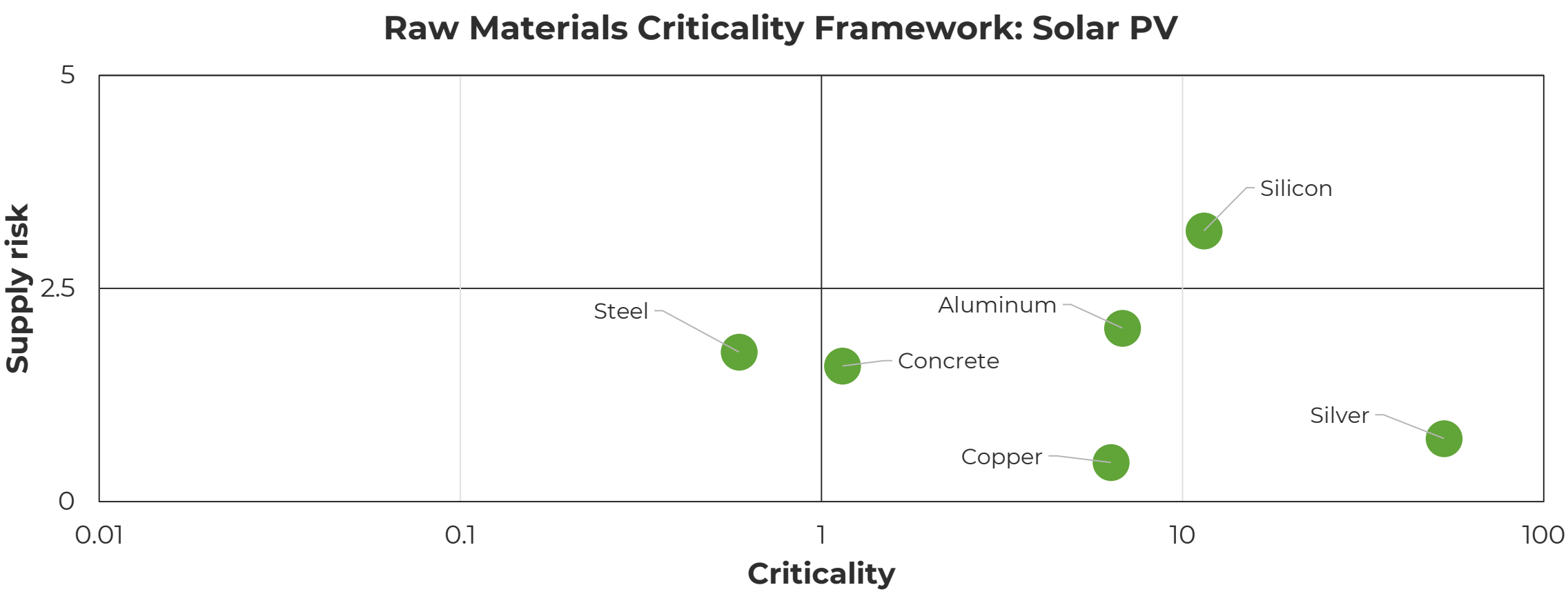
03 Build a portfolio of innovation strategies to mitigate raw materials risks and put growth on a foundation of resilience

RAW MATERIALS CRITICALITY FRAMEWORK



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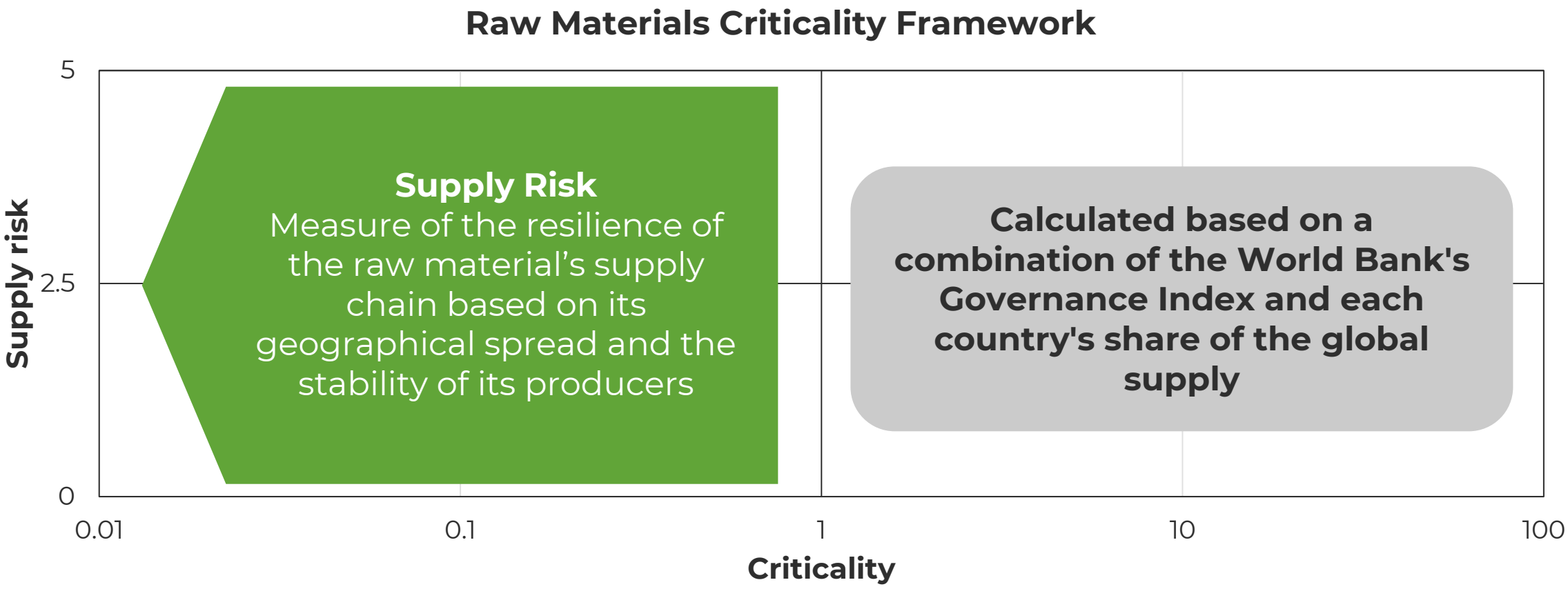

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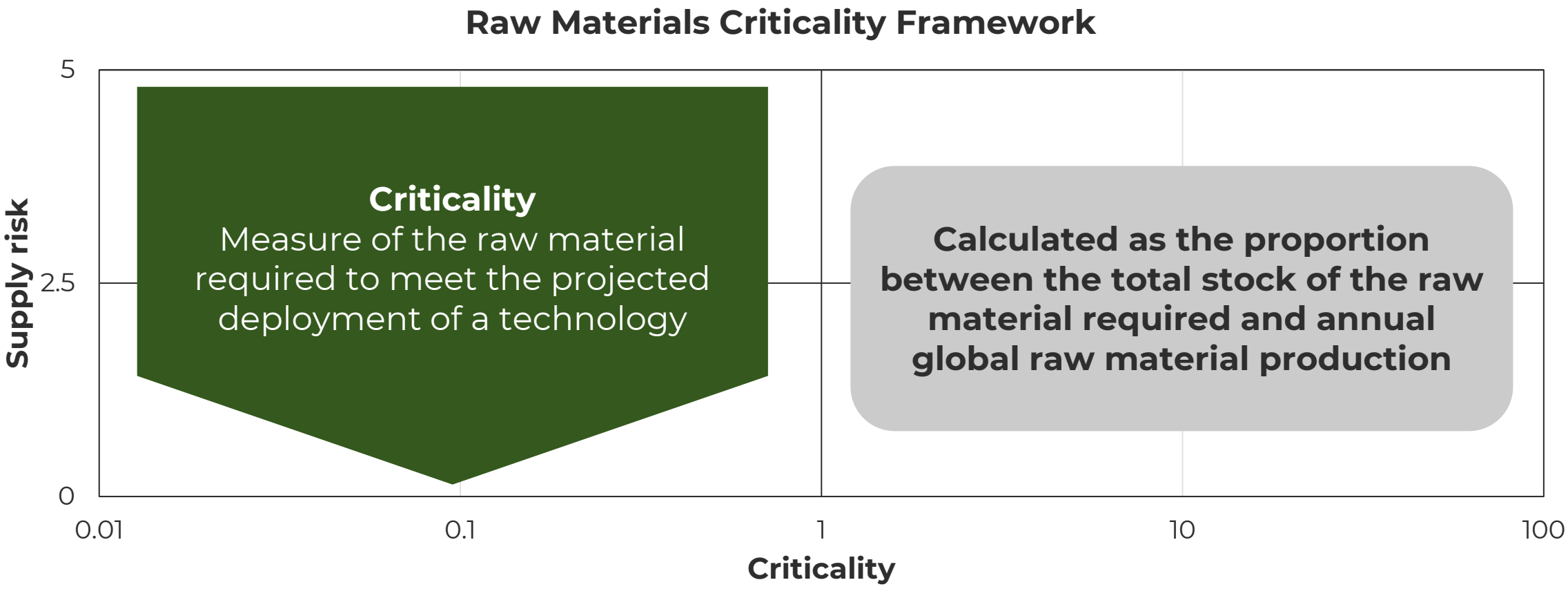
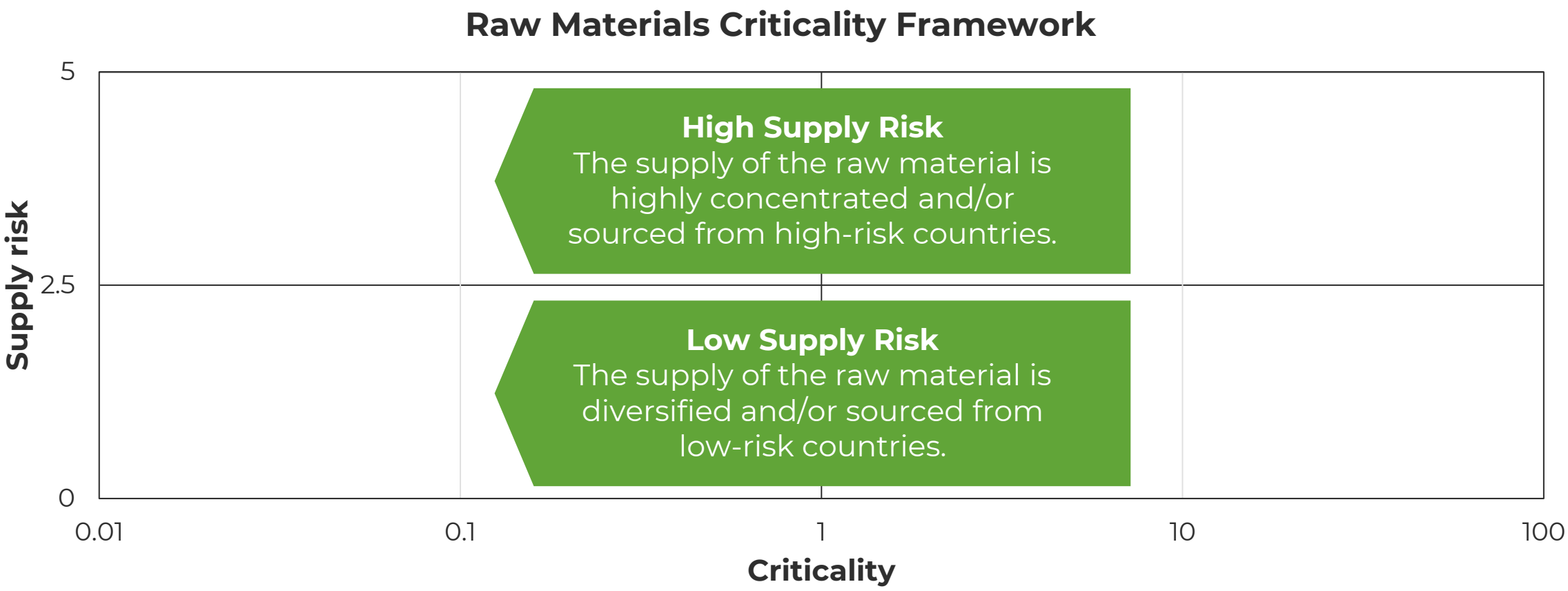


WHAT DOES THE FRAMEWORK TELL US?



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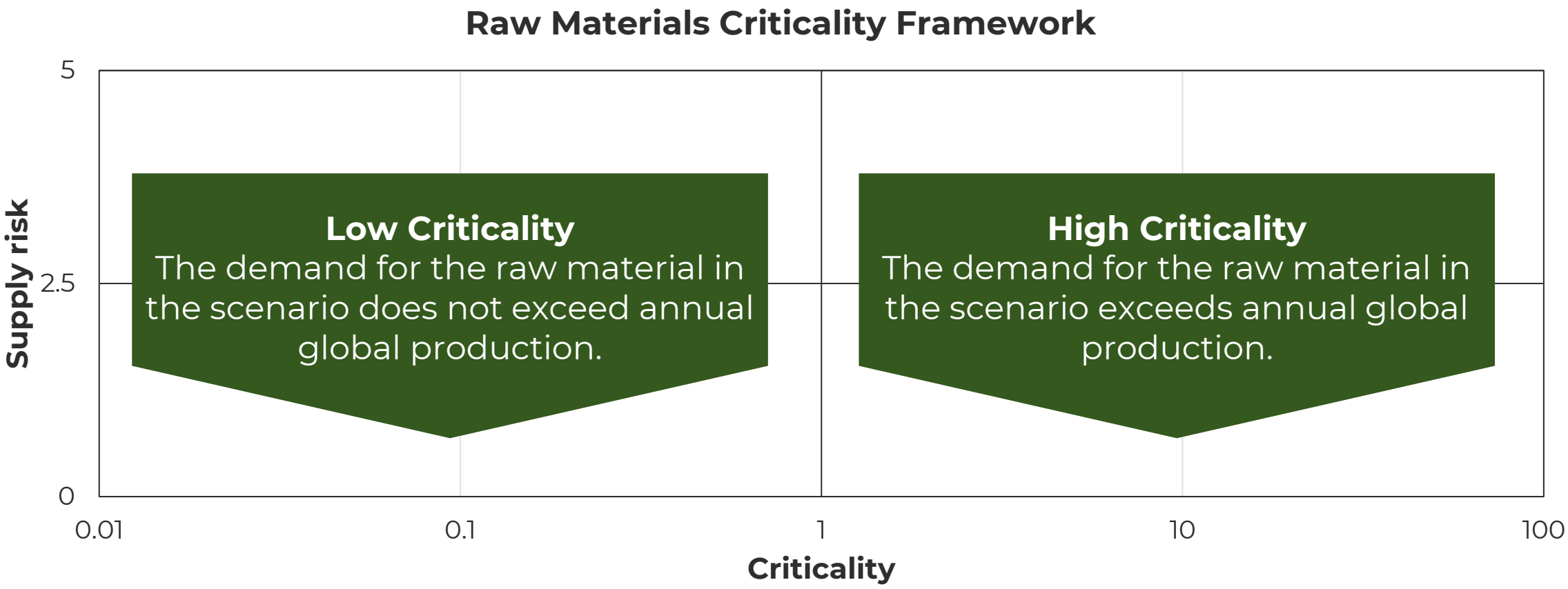
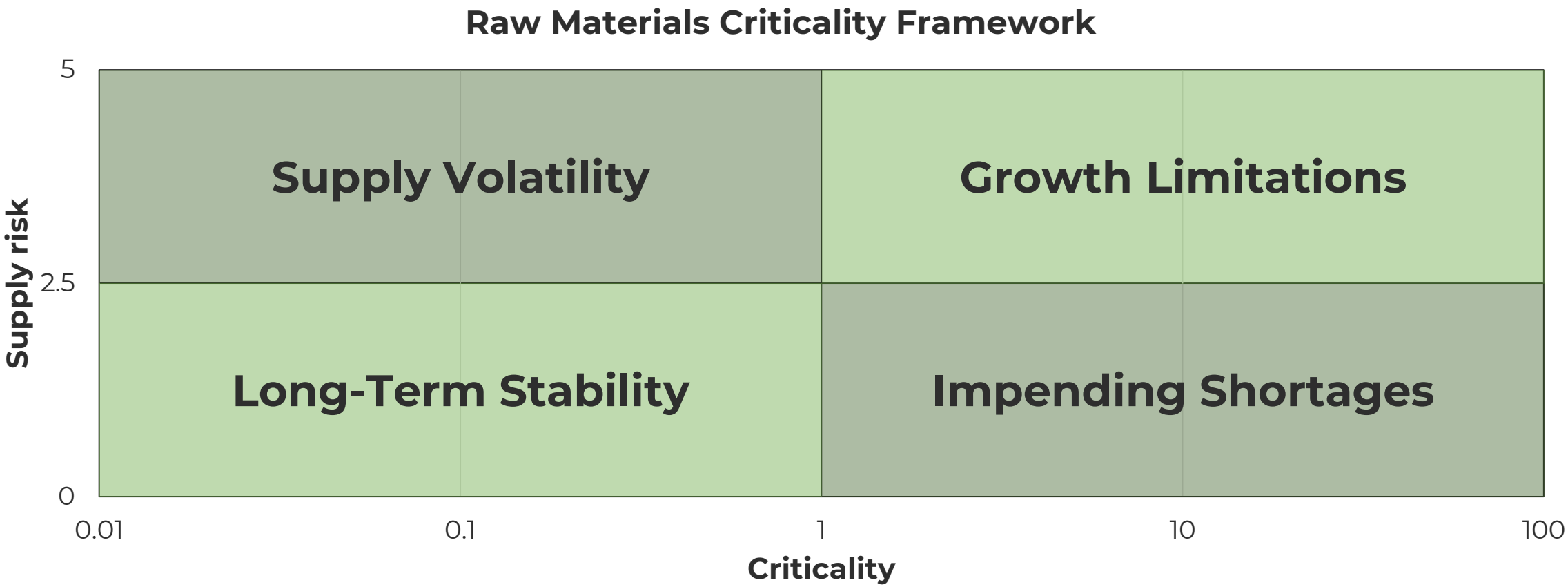


4 SCENARIOS



So, what are we supposed to do now?

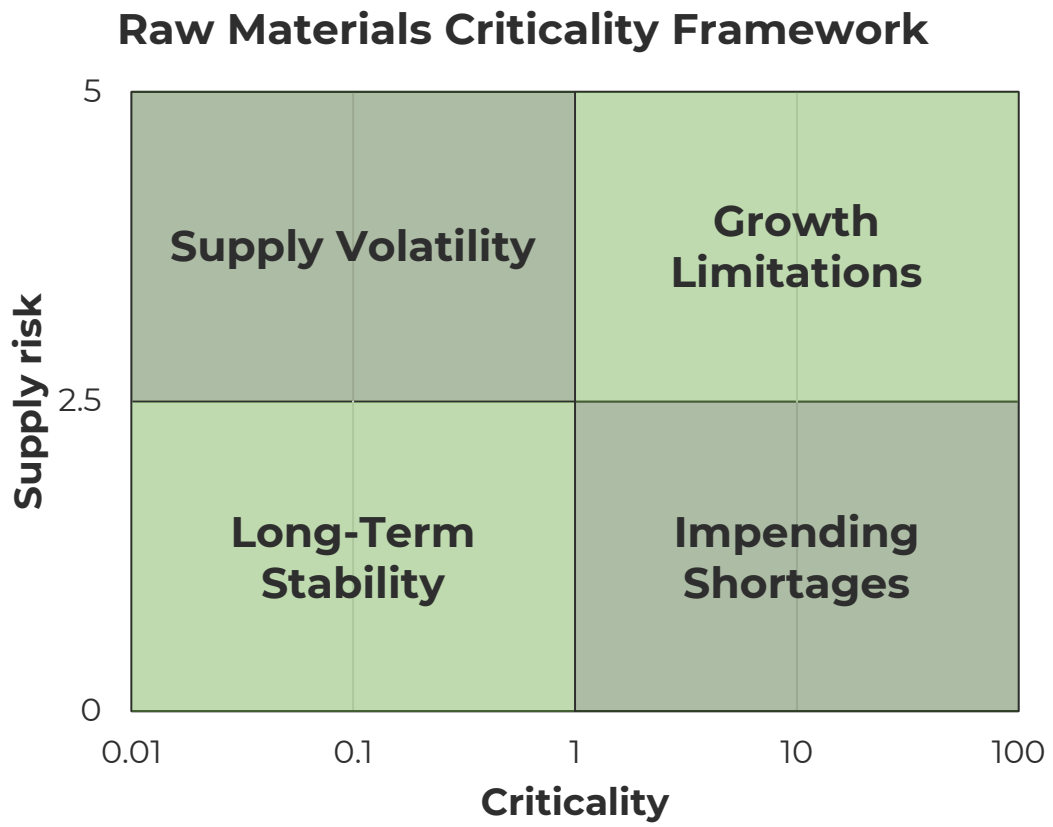
WHAT TO EXPECT

01 Review the status of critical minerals supply chains and the geopolitical context for economic security

02 Leverage Lux's Raw Materials Criticality Framework to assess raw materials criticality and supply risk and uncover four outlook scenarios

03 **Build a portfolio of innovation strategies to mitigate raw materials risks and put growth on a foundation of resilience**

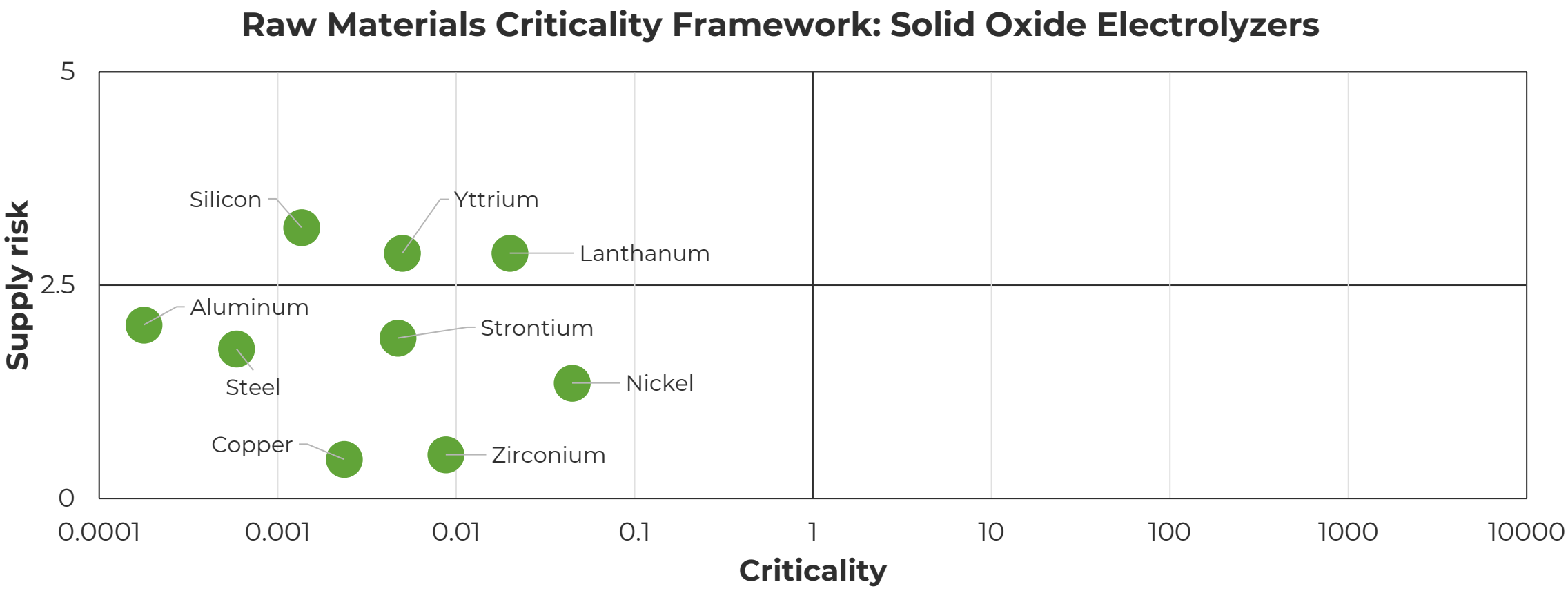
STEP 1: ASSESS YOUR RAW MATERIALS RISKS



STEP 2: SELECT YOUR INNOVATION STRATEGIES

- Novel Sources
- Materials Optimization
- Alternative Materials
- Recycling & Circularity

VOLATILITY: RARE EARTHS



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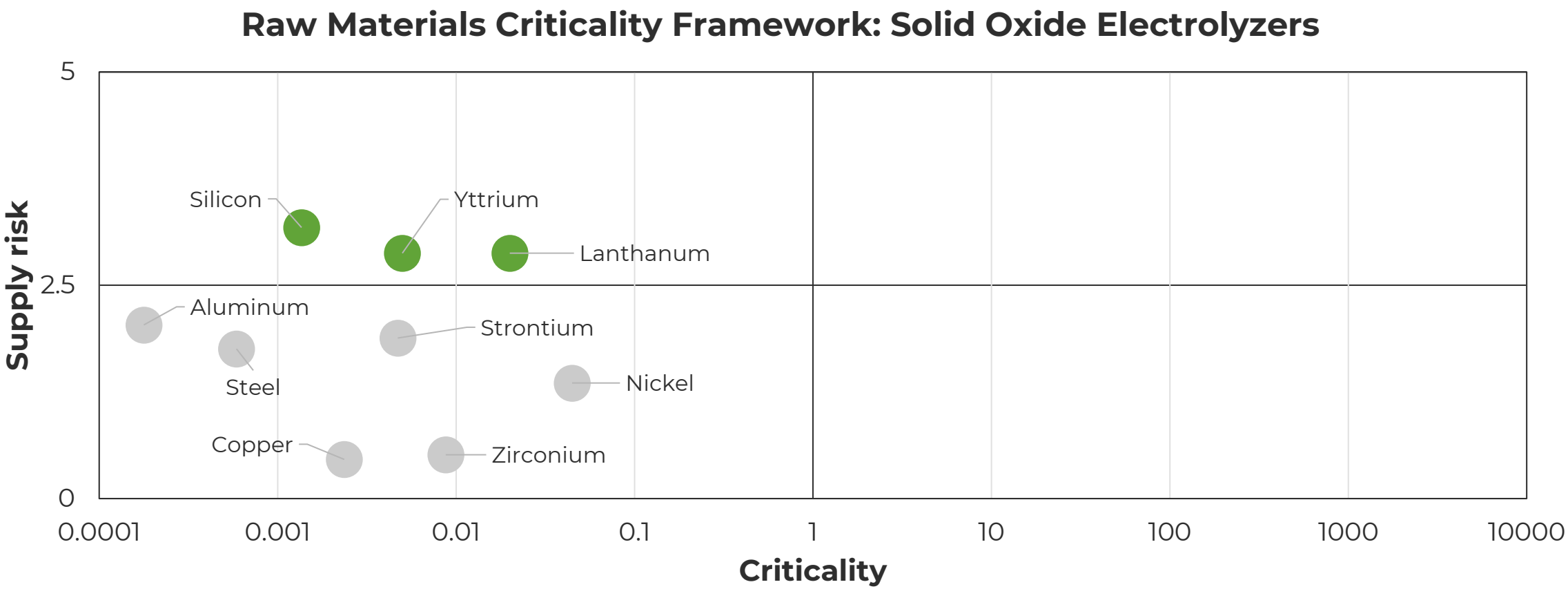


NOVEL SOURCES

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

Image source: Ceibo

INDUSTRIAL BYPRODUCTS

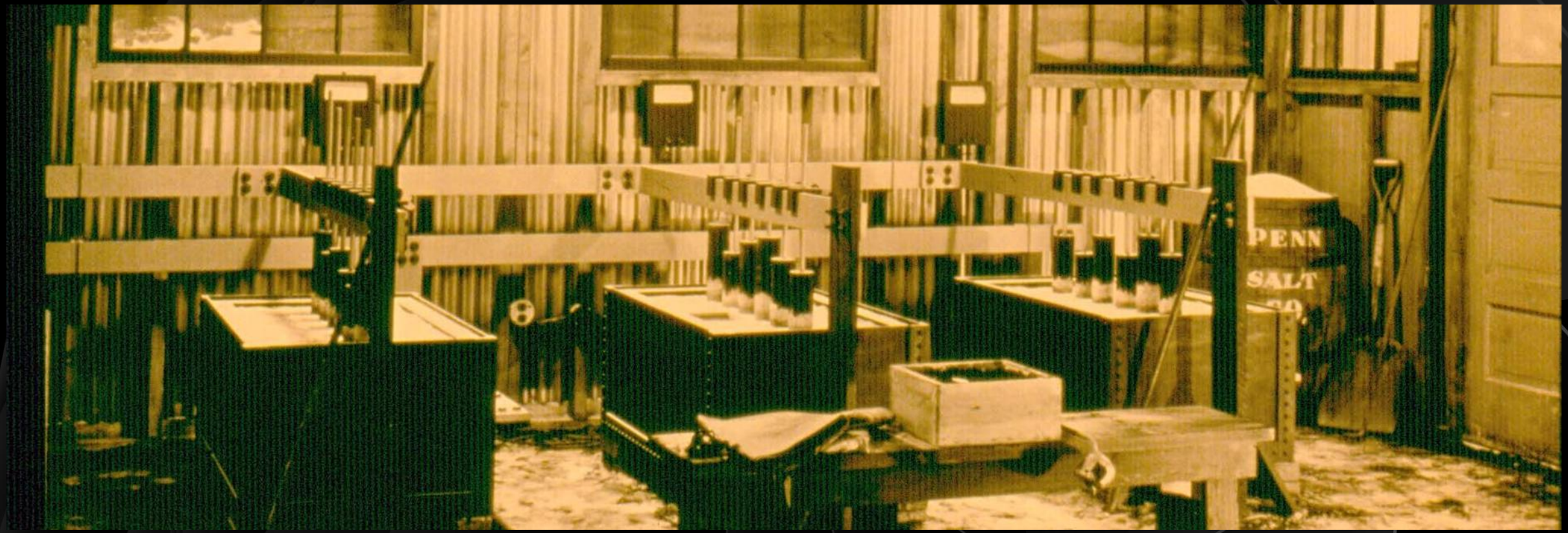
DEEP-SEA MINING

PHYTOMINING

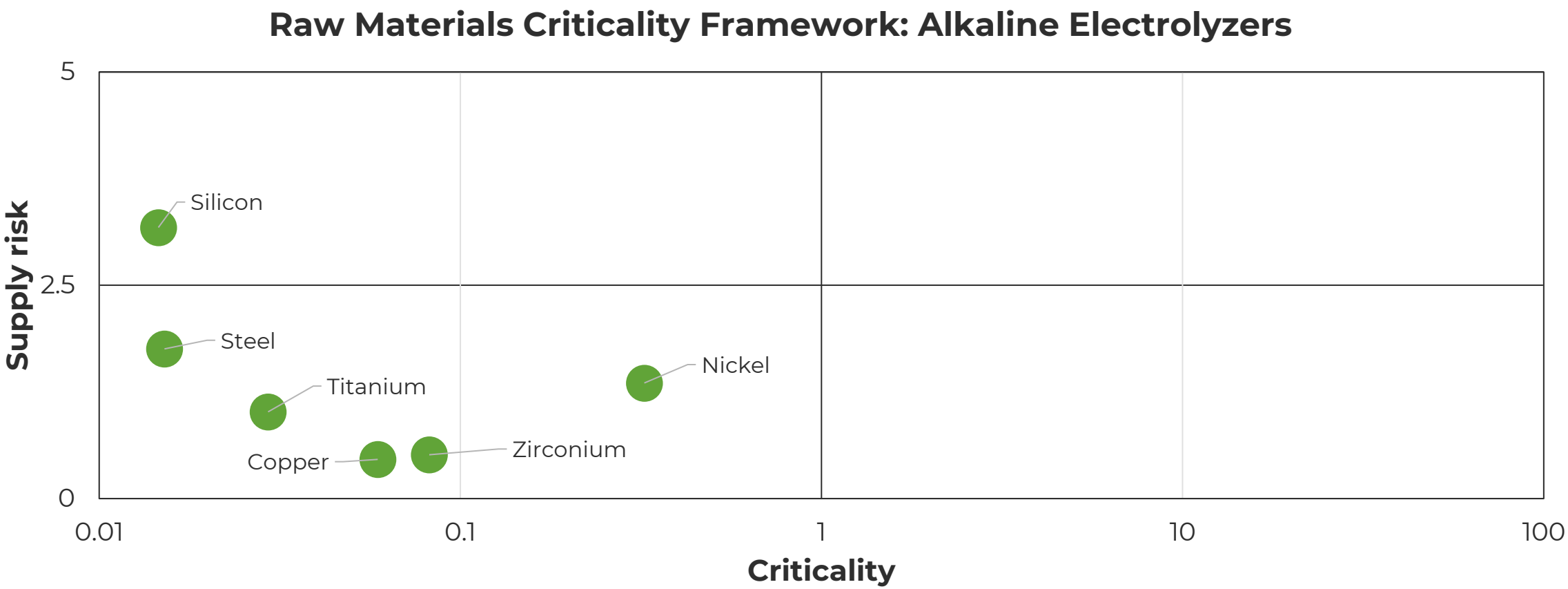
Image sources: Impossible Metals (center), Singularity Hub (right)

FLASHBACK: ALUMINA FROM BAUXITE

Once sourced from cryolite, Al was more valuable than Au



STABILITY: ALKALINE ELECTROLYZERS



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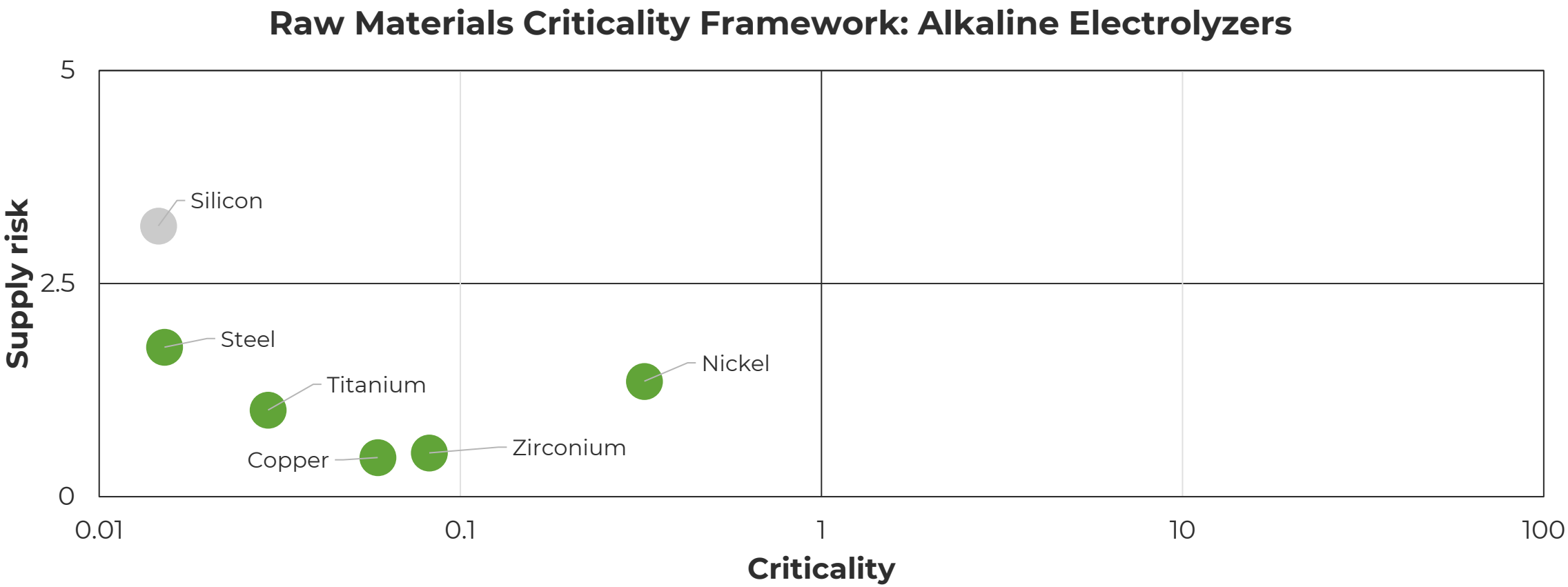


MATERIALS OPTIMIZATION

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

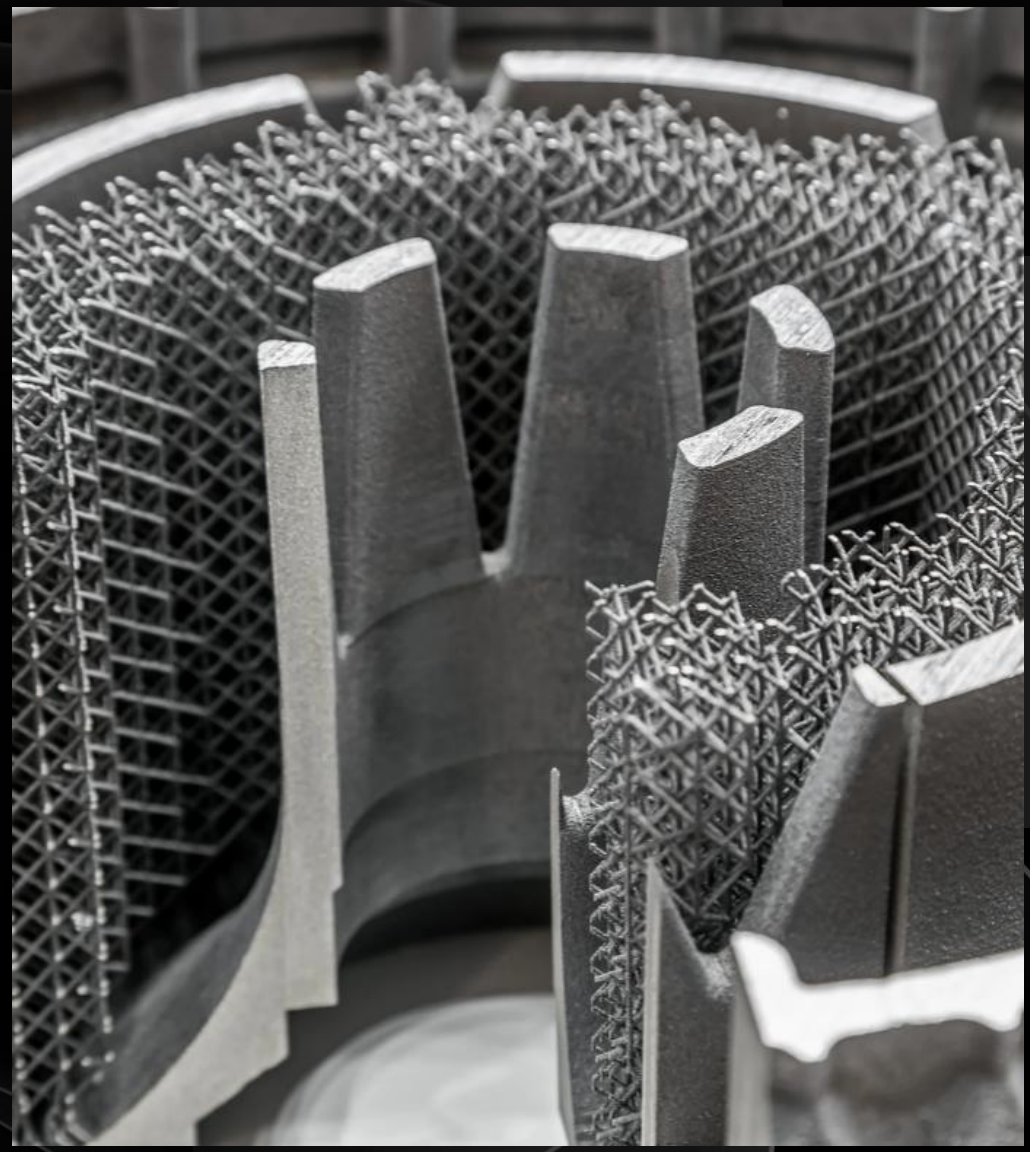
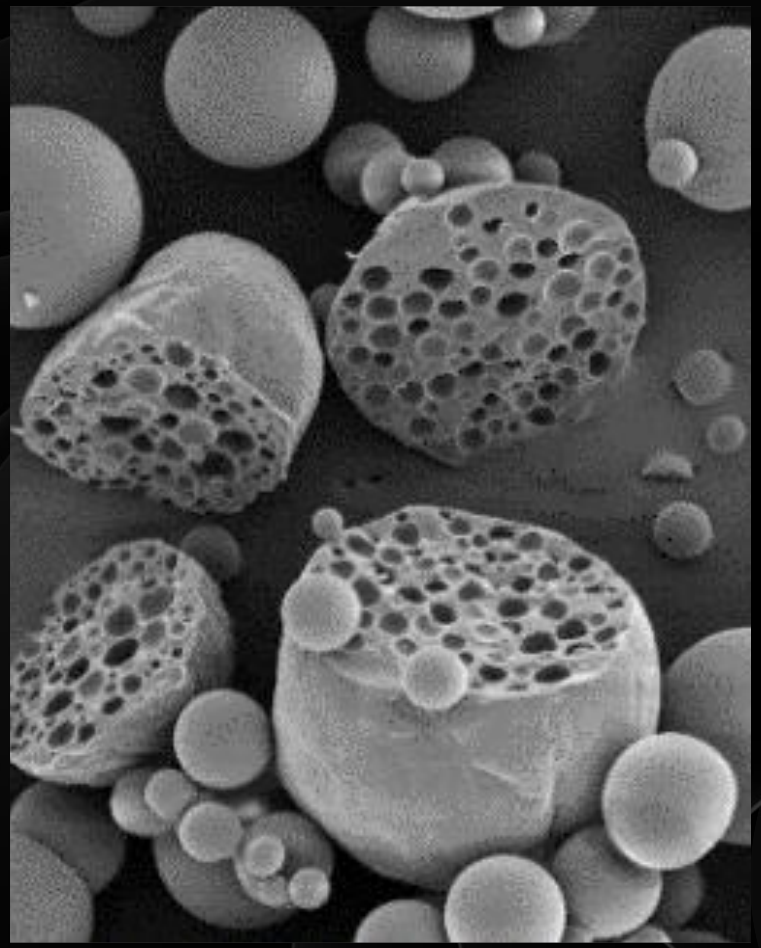


Image source: Tempus 3D

NOVEL CATALYSTS

MATERIAL STRUCTURE



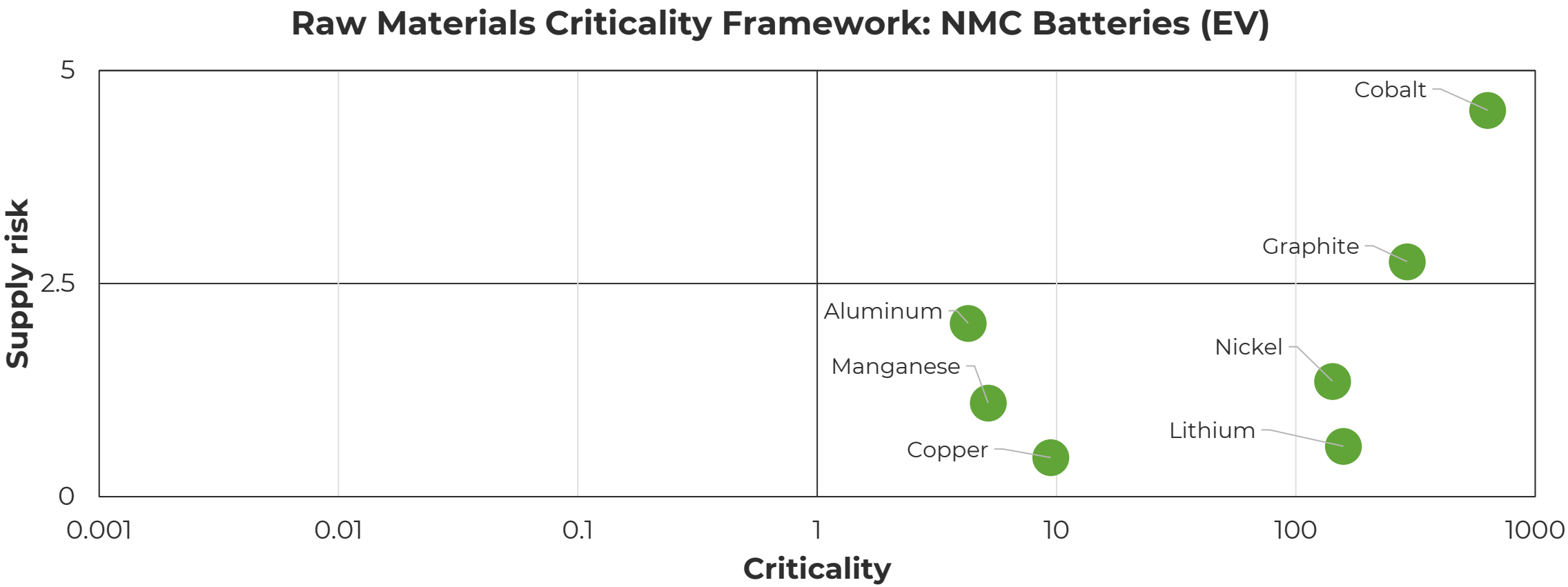
THIN-FILM DEPOSITION

Image sources, left to right: Mattiq, Nestle, Von Ardenne

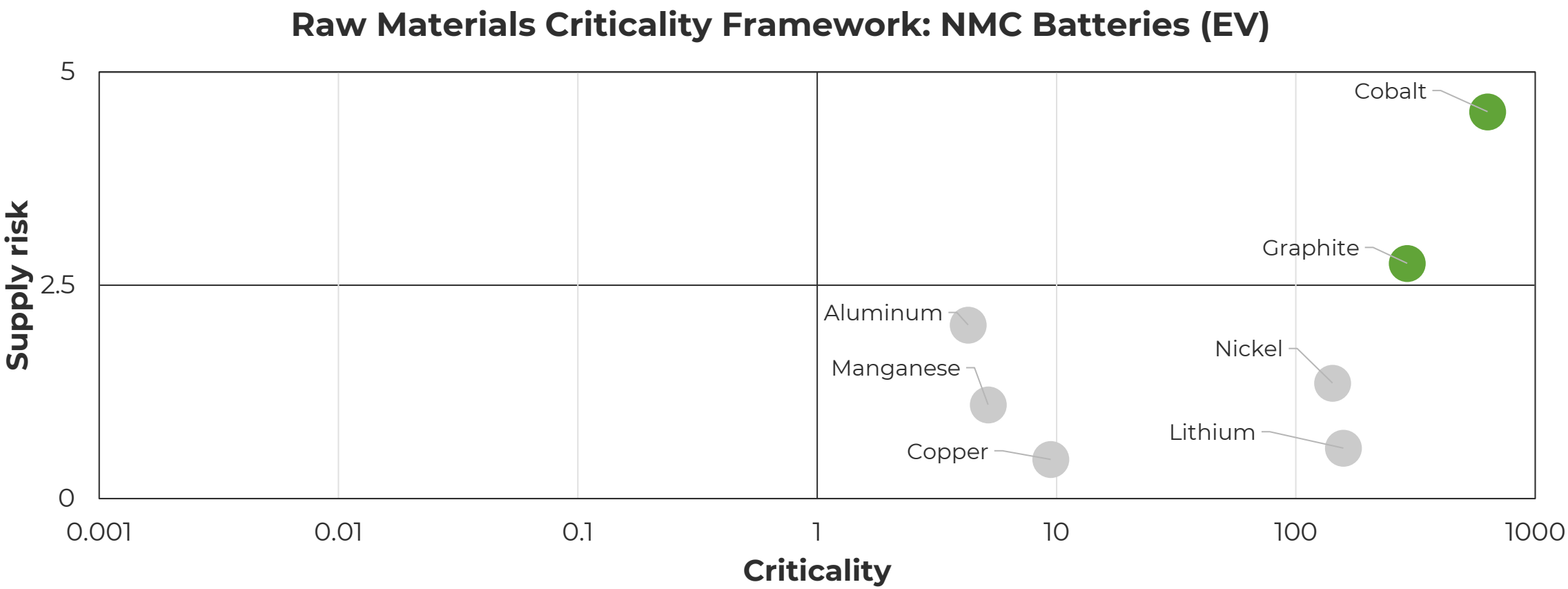
FLASHBACK: CATALYTIC CONVERTERS

Palladium and rhodium substitute for platinum

LIMITATIONS: COBALT AND GRAPHITE



LIMITATIONS: COBALT AND GRAPHITE



ALTERNATIVE MATERIALS

Identify innovations that can functionally replace a material input

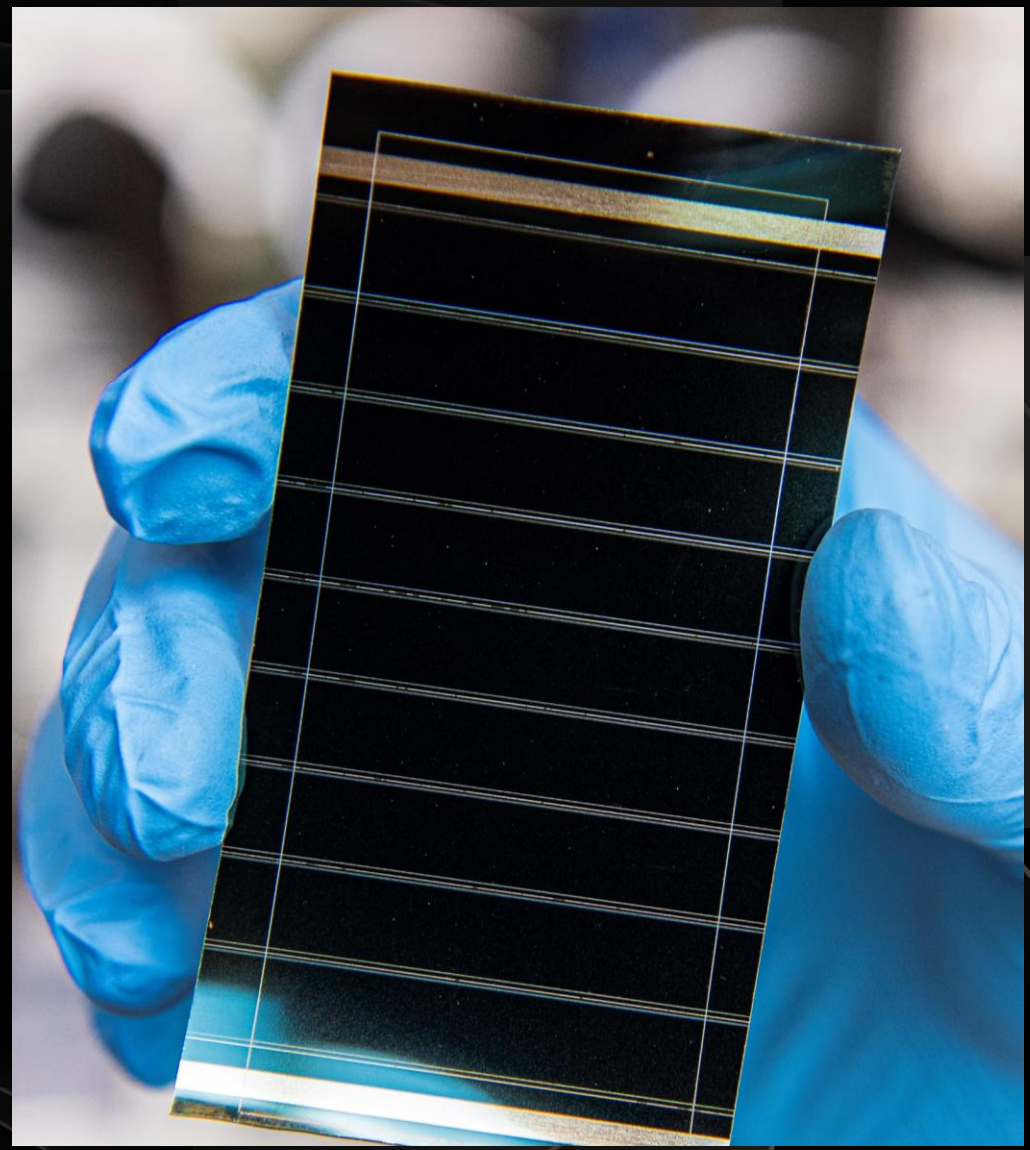
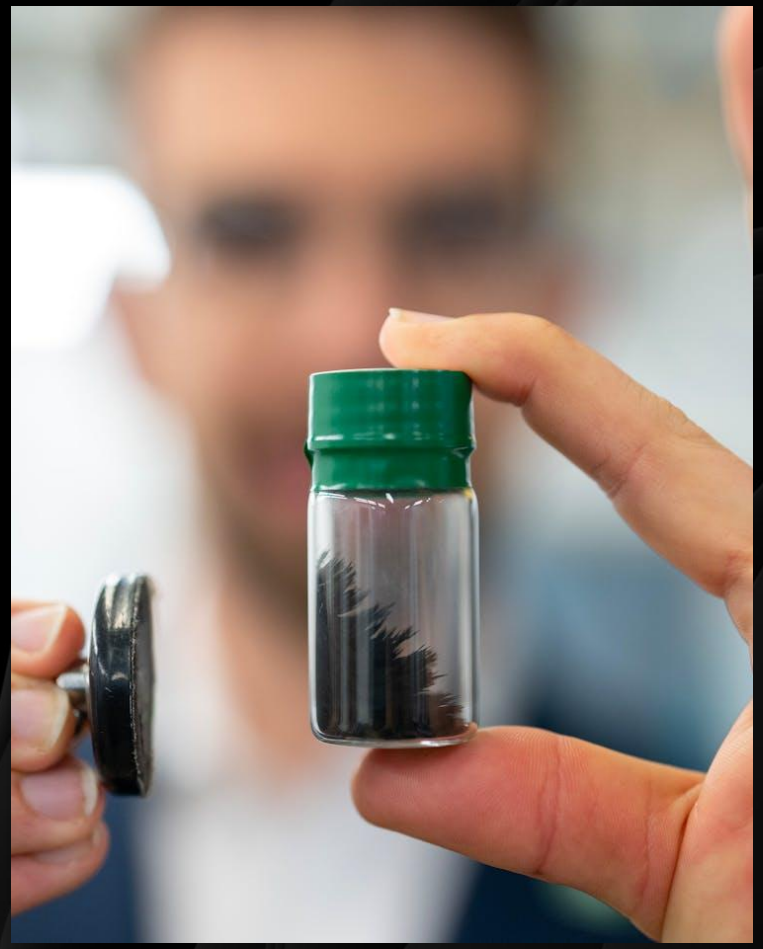


Image source: U.S. Department of Energy

ALTERNATIVE CHEMISTRIES



SYNTHETIC REPLACEMENT

STEER CLEAR

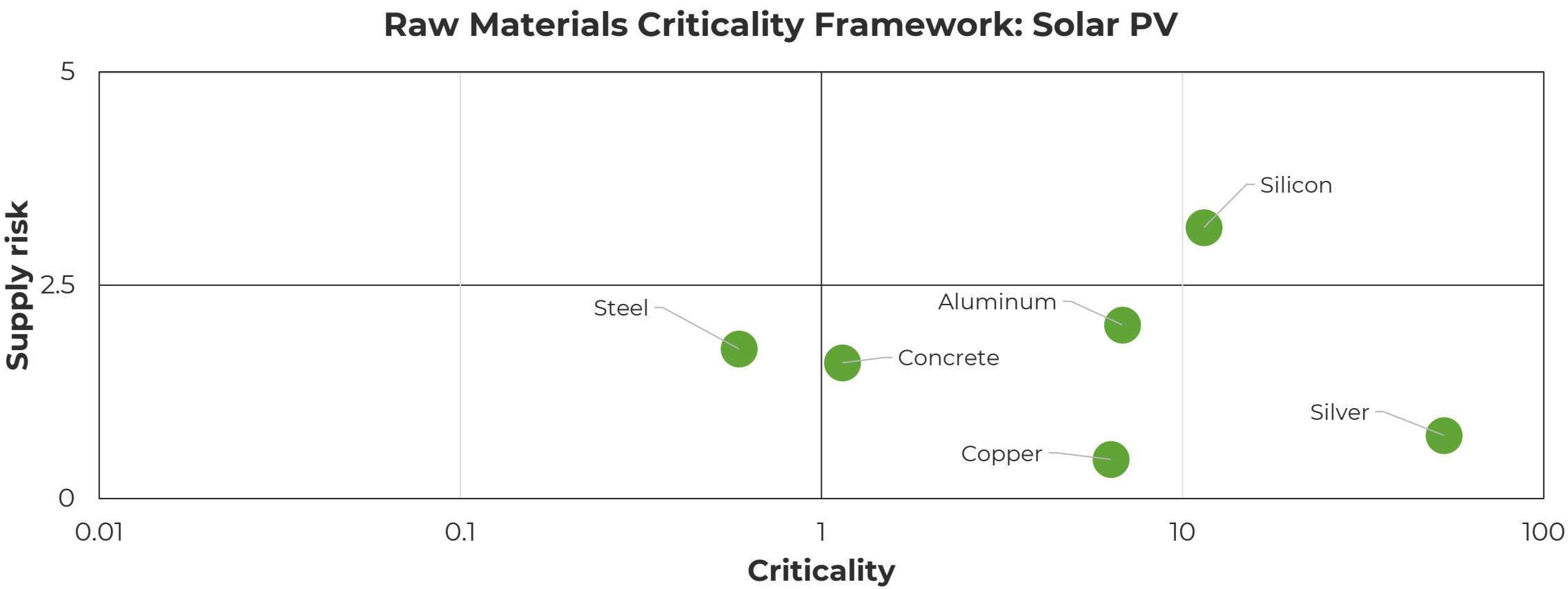
Image sources, left to right: Niron Magnetics, Prometheus Materials, MG Energy Systems

FLASHBACK: SYNTHETIC RUBBER

World War II sparked urgent innovation to replace natural rubber

Image source: Science History Institute

SHORTAGES IN SOLAR PV



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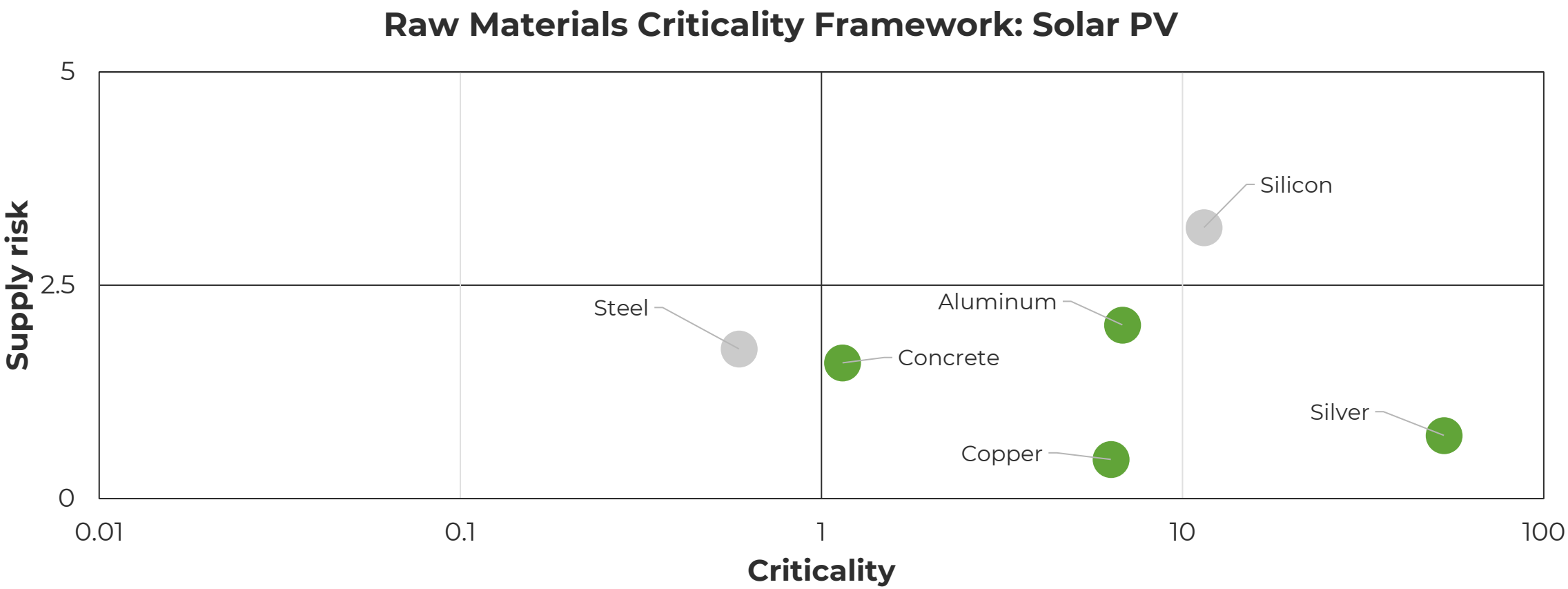


RECYCLING & CIRCULARITY

Maximize recovery of resources from products within your reach

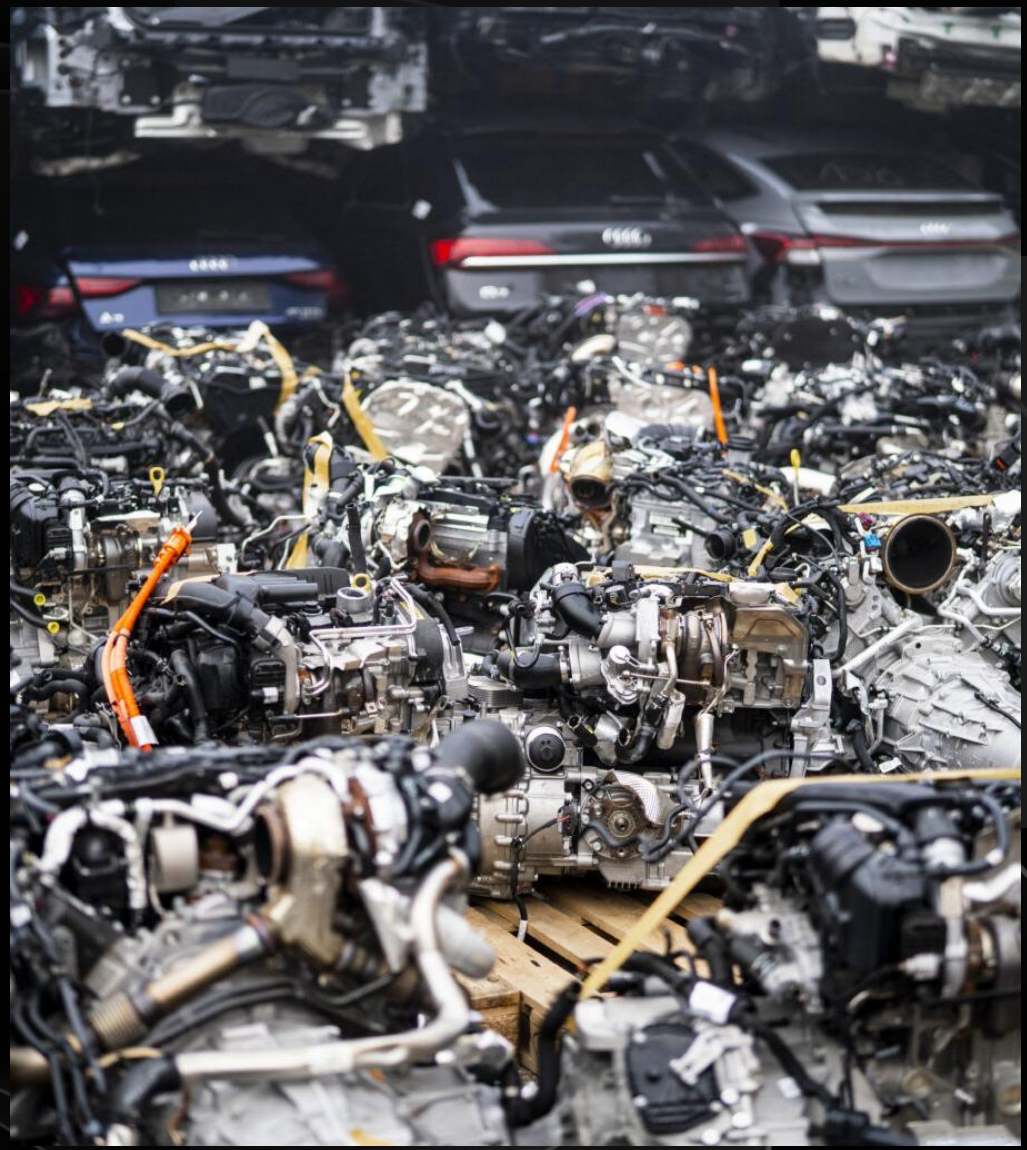
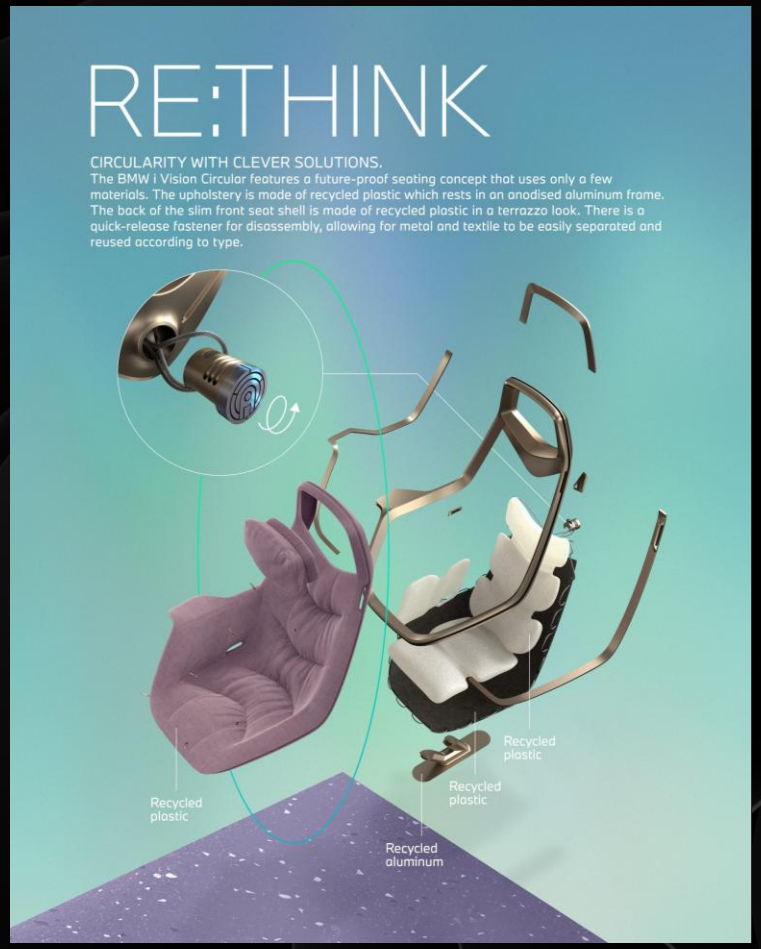


Image source: Audi

NOVEL RECYCLING TECH

DESIGN FOR CIRCULARITY



COLLECTION SCHEMES

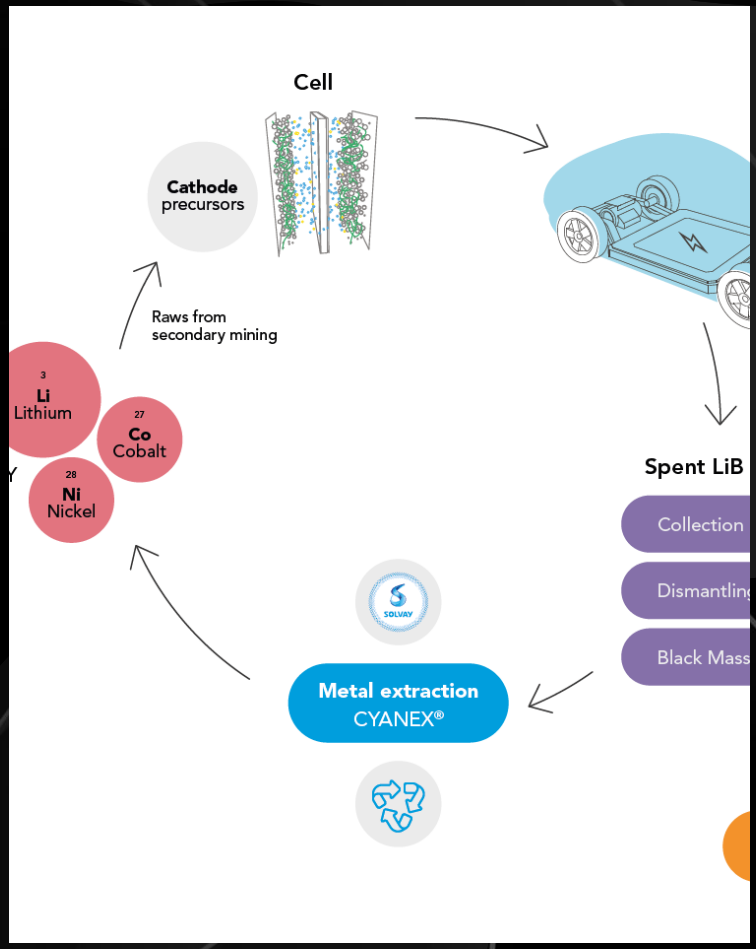


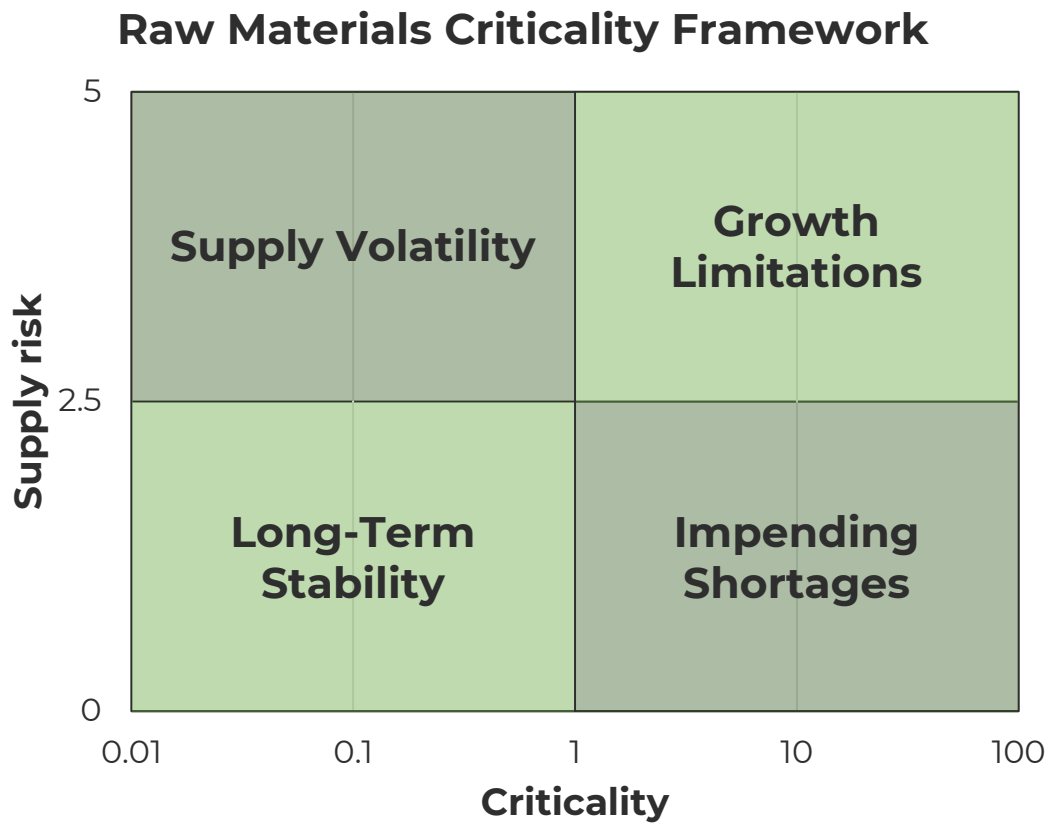
Image sources, left to right: University of Birmingham, BMW, Solvay

FLASHBACK: STEEL RECYCLING

Electric arc furnaces enabled large-scale secondary steel production

Image source: Advantage Valley

STEP 1: ASSESS YOUR RAW MATERIALS RISKS



STEP 2: SELECT YOUR INNOVATION STRATEGIES

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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 don't 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 the future supply challenges.

THANK YOU

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