Energy and mineral supply chains and the circular economy

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Federal strategy on critical mineral supply chains

National Science & Technology Council – Critical Minerals Subcommittee (2011–)

• Definitions of criticality, for multiple sectors

Executive Order 13817 (2017)

• List of Critical Minerals (2018)
• Interagency Federal strategy on critical minerals (2019)

1. Advance Transformational R&D Across Critical Mineral Supply Chains
2. Strengthen America’s Critical Mineral Supply Chains and Defense Industrial Base
3. Enhance International Trade and Cooperation Related to Critical Minerals
4. Improve Understanding of Domestic Critical Mineral Resources
5. Improve Access to Domestic Critical Mineral Resources on Federal Lands and Reduce Federal Permitting Timeframes
6. Grow the American Critical Minerals Workforce
Mineral commodities are essential to energy applications.

**Renewable energy**
- Thin-film solar PV
- Offshore direct drive wind turbine

**Gas turbines**
- Aluminum (Al)
- Chromium (Cr)
- Cobalt (Co)
- Nickel (Ni)

**Oil drilling and refining**
- Barium (Ba)
- Platinum (Pt)
- Rhenium (Re)

**Electric vehicles and energy storage**
- Lithium (Li)
- Carbon (C)
- Cobalt (Co)
- Nickel (Ni)
- Manganese (Mn)
- Chromium (Cr)
- Molybdenum (Mo)
- Tantalum (Ta)
- Ruthenium (Ru)
- Tungsten (W)
- Hafnium (Hf)
- Rhenium (Re)
- Barium (Ba)
- Platinum (Pt)
- Rhenium (Re)

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- Testbourne, Ltd.
- General Electric
- Tesla, Inc.
# Commodity supply risks to the U.S. manufacturing sector

## Advanced Supply Risk

Nassar et al., 2020, *Science Advances*

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Supply Risk</th>
<th>Leading Producers</th>
<th>Most Vulnerable Applications</th>
<th>2016 EV scores</th>
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</tr>
</tbody>
</table>

*USGS*

Nassar et al., 2020, *Science Advances*
United States reliance on imports is growing

2019 U.S. net import reliance

Growing U.S. net import reliance

Number of mineral commodities

Net import reliance (as % of apparent consumption)
- 25 to 50
- >50 to <100
- 100

Source:
Production of many minerals is highly concentrated

Share of each element’s global production from selected countries

Data source: USGS Minerals Yearbooks
Not all elements assessed
Global production trends over 20 years

China’s share of global primary production

<table>
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<tr>
<th>Element</th>
<th>Symbol</th>
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<td>Li</td>
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<td>Cs</td>
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<tr>
<td>Fr</td>
<td>Ra</td>
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</table>

EXPLANATION

Element symbol: Zn

China’s share of global primary production (0-100%)


Data source: USGS Minerals Yearbooks
Import reliance can highlight interdependencies and competition potential.

Trends in trade exposure: Lanthanum

China's threats to cut off supplies drive global prices for rare earths to unprecedented levels.

Production outside China, mainly in Australia, ramps up.

Rare earth prices fall significantly due excessive capacity and illegal production in China.
Additional causes of supply chain disruption: Natural hazards

Spatial concentration of mineral production in tectonically active areas may pose a higher risk of supply disruption

Schnebele et al., 2019, Resources Policy
Many byproduct minerals are required for advanced technologies.

Share of element’s primary production obtained as a byproduct

Nassar et al., 2015, Science Advances
Tracking mineral commodities throughout their life cycle

Global flows of tantalum
(metric tons of Ta content, circa 2015)

Nassar, 2017, Resources, Conservation and Recycling
Summary

- Federal strategy
- Potential futures
- Sectoral dependencies
- Foreign supply dependencies
- Domestic supply dependencies
- Potential for unconventional resources