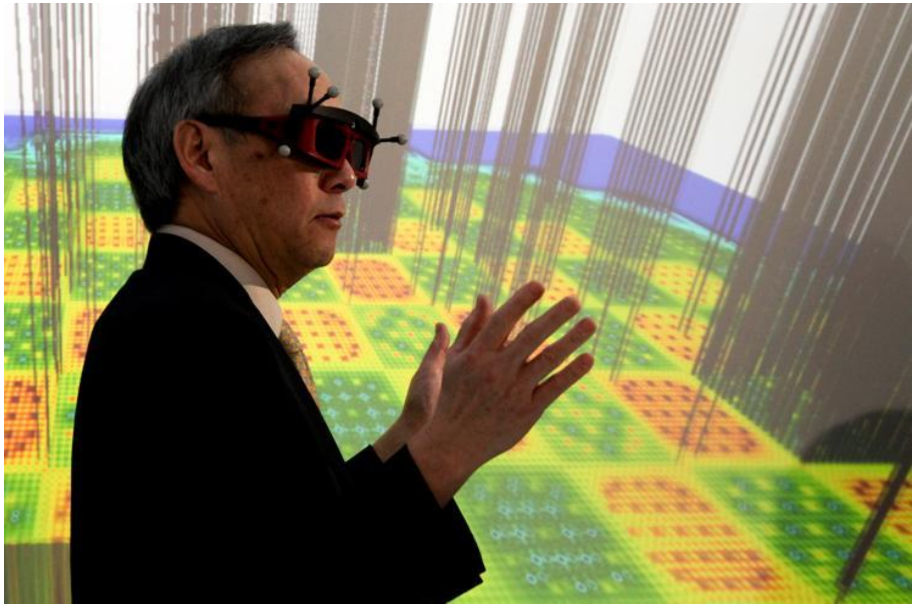
CMI

Accelerating Energy Innovations

# Critical Materials Institute

U.S. DEPARTMENT OF ENERGY

# What are Energy Innovation Hubs?



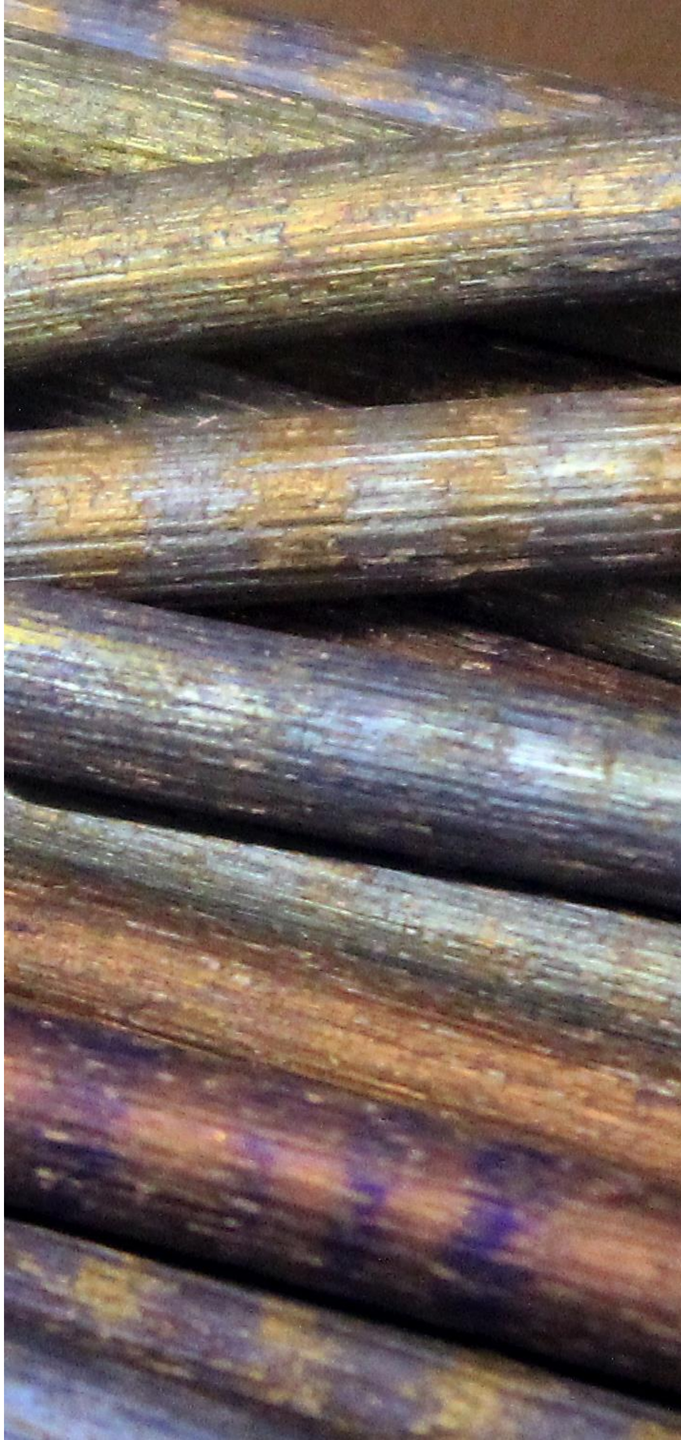
Integrated research centers that combine basic and applied research with engineering to accelerate scientific discovery in critical energy issue areas.

- Leadership is vested in scientists who are given the authority to assign funds where they are most effectively used
- $20M - $25M per year, for 5 years, renewable for an additional five.

- CASL: Consortium for Advanced Simulation of Light-Water Reactors
- EEB: Energy Efficient Buildings Hub
- JCAP: Joint Center for Artificial Photosynthesis
- JCESR: Joint Center for Energy Storage Research
- CMI: Critical Materials Institute

# What is a "Critical Material?"

- Any substance used in technology that is subject to supply risks, and for which there are no easy substitutes.
- Or, in plain English – stuff you really need but can't always get.
- The list of materials that are considered critical depends on *who*, *where* and *when* you ask.
- CMI focuses on clean energy technologies, in the US, over the next 10 to 15 years.



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# Critical Materials are Not New

- "The stone age did not end because we ran out of stones" – Steven Chu.

- The copper age replaced the stone age because copper was better for some things.

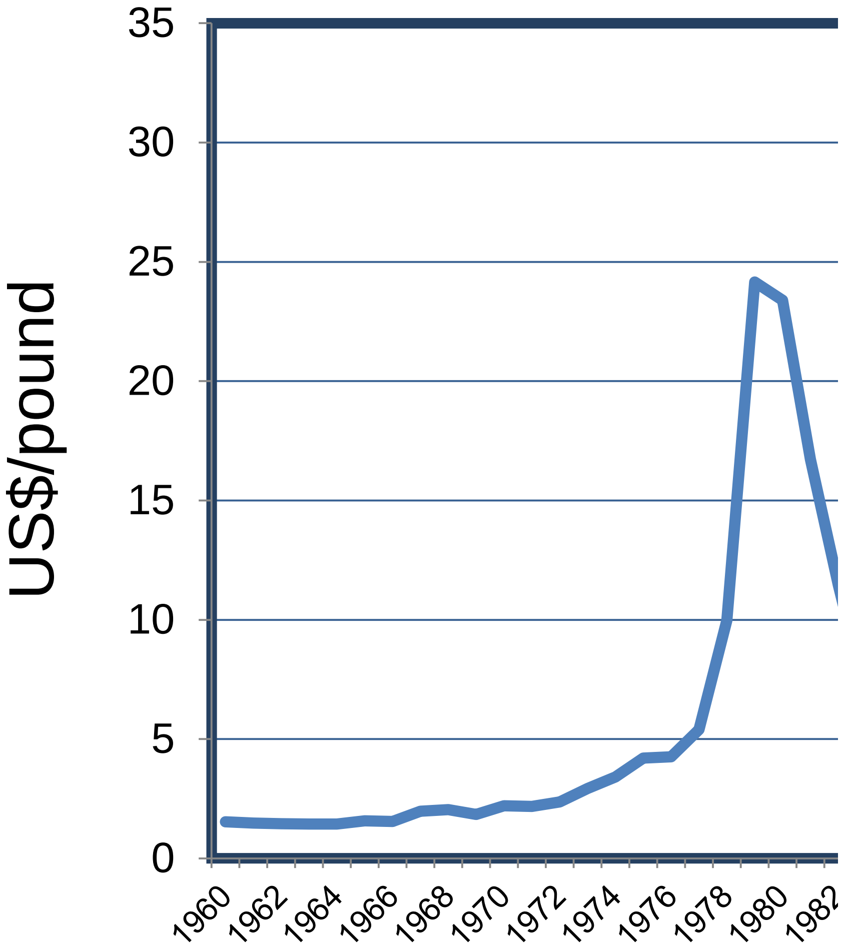
- The bronze age replaced the copper age because bronze was better than copper.

- But the bronze age was *not* replaced by the iron age. It ended because copper was unavailable.

# The Bronze Age Collapse
~1200 BC

- Bronze becomes unavailable
  - Possibly because Cyprus is overtaken by war, making copper inaccessible.
- Responses include
  - Recycling
  - Source Diversification
  - Materials Substitution
- Results
  - Collapse of civilization; collapse of trade
  - Strengthening of Egypt, which had alternative sources in Africa
  - Eventual emergence of the iron age

# Annual Average Cobalt Prices



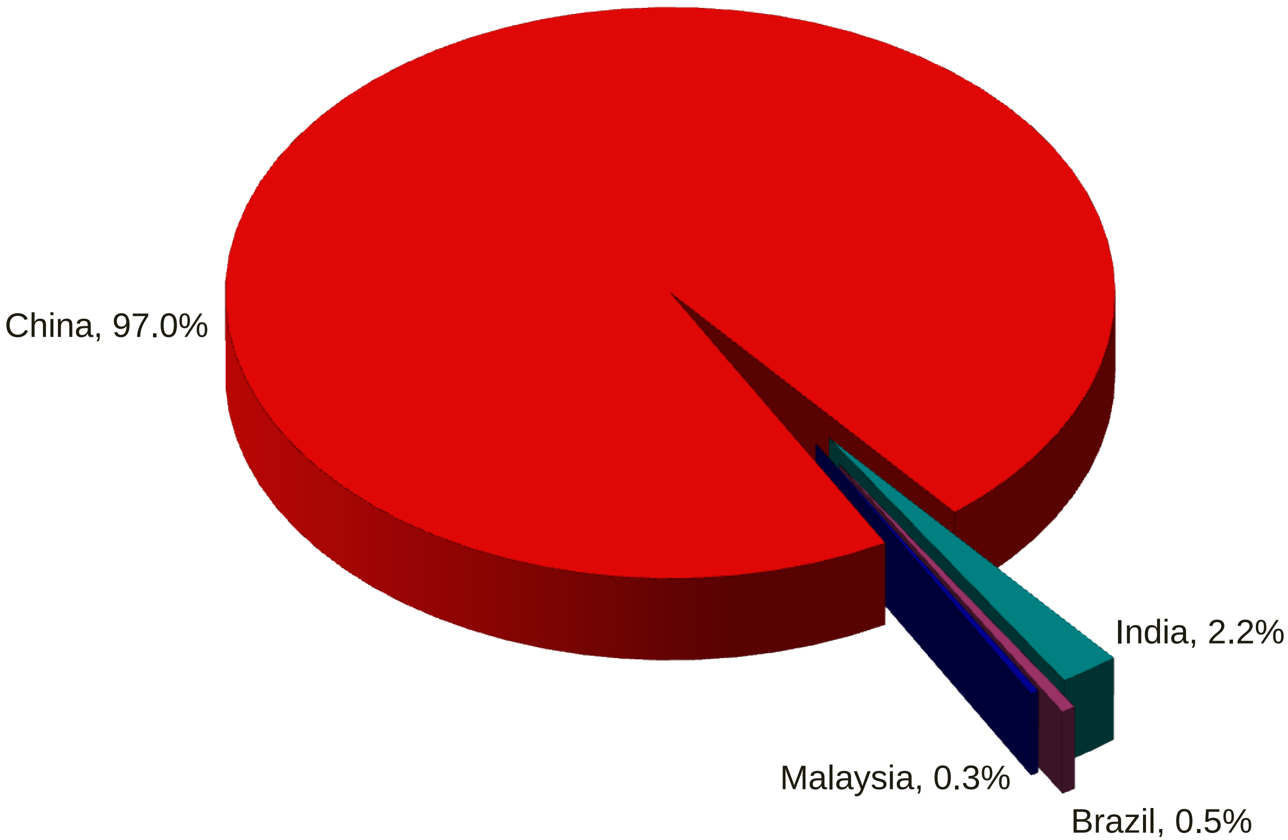
# Materials criticality is affecting us today

- The target date for transition to high-output T5 fluorescent lamps has been delayed by two years because manufacturers claim that there is a shortage of Eu and Tb for the phosphors.


- Utility-scale wind turbine installations are overwhelmingly gearbox-driven units, despite the high failure-rate of the gearboxes, because of the cost and unavailability of Nd and Dy required for direct-drive units.

# World Rare Earth Production in 2008

124,000 metric tons of contained rare-earth oxide (REO)

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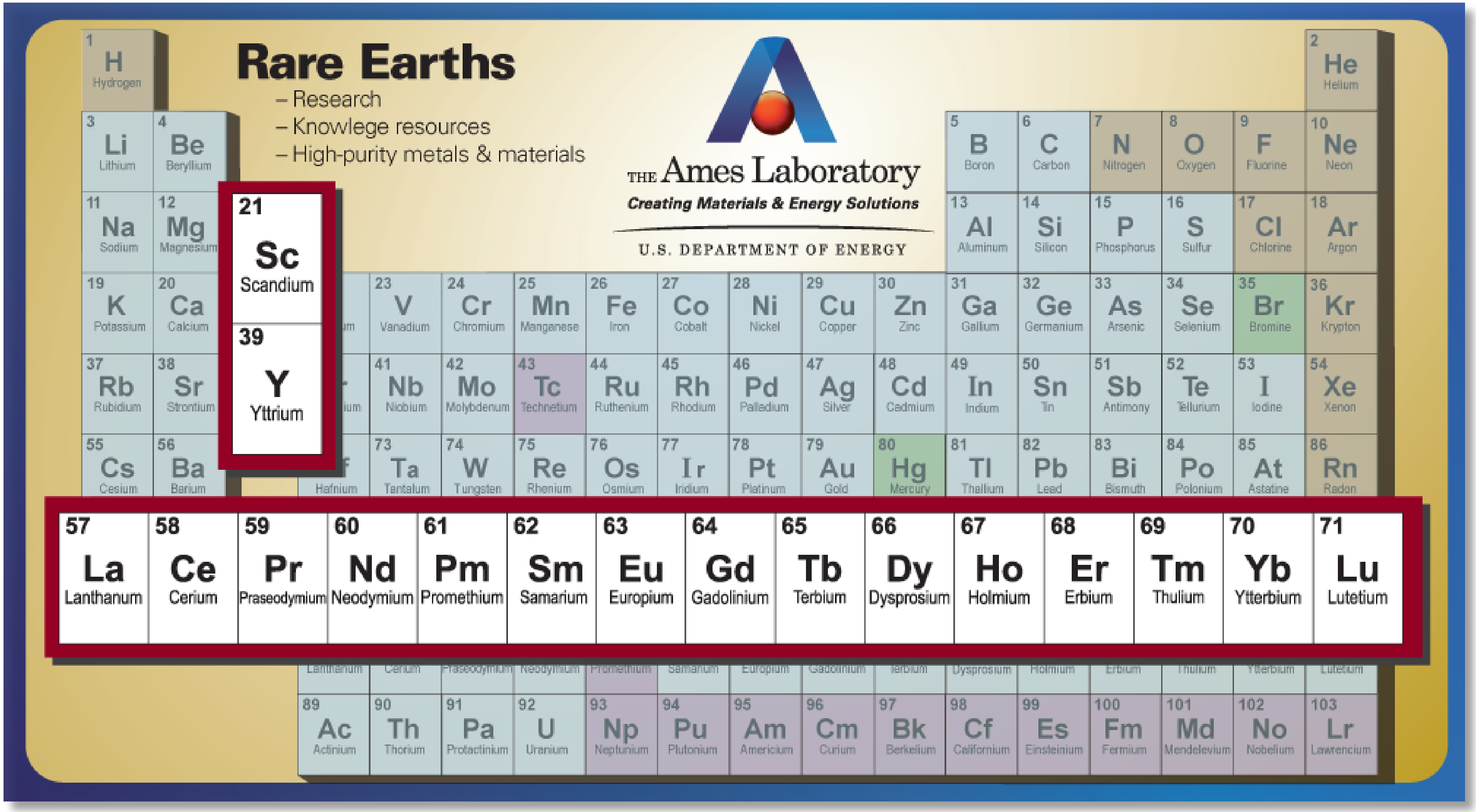
# Most solutions take effect “tomorrow”

- Mine development, *where there is a known resource*, takes at least 10 years.

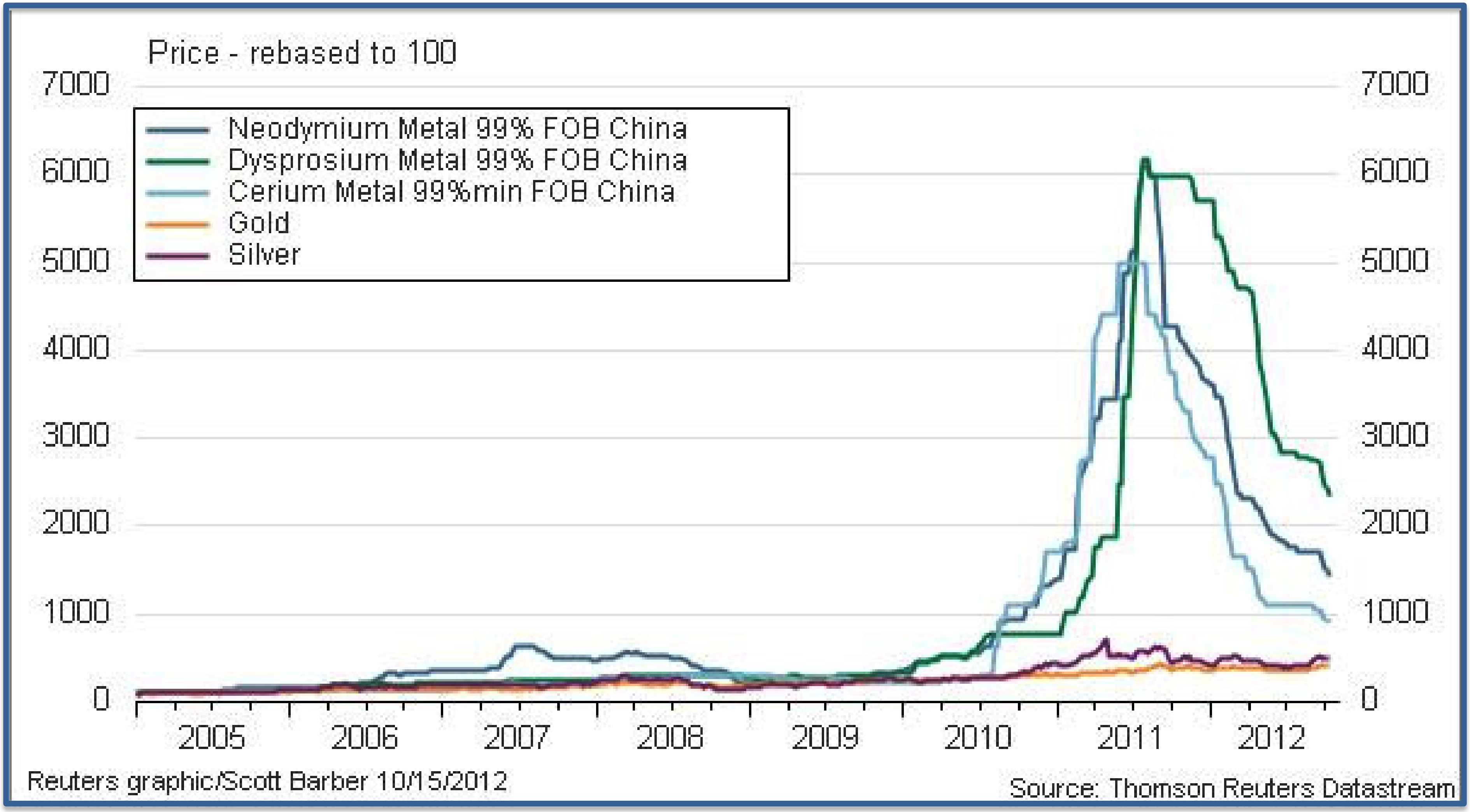
- Deployment of substitute materials, *when there is an existing option*, takes an average of 4 years.

- Development and deployment of *new* substitute materials takes an average of 18 years.

# The Ames Laboratory is the world's leading rare earth research center



# Rare Earth Prices compared to Gold & Silver

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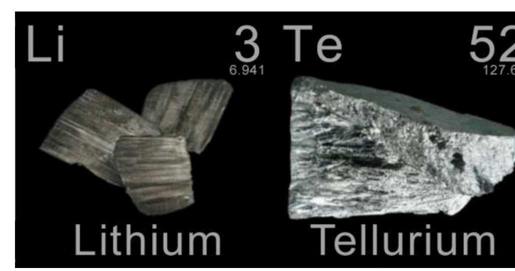
# The Mission of CMI

Eliminate materials criticality
as an impediment to the commercialization
of clean energy technologies
for today and tomorrow.

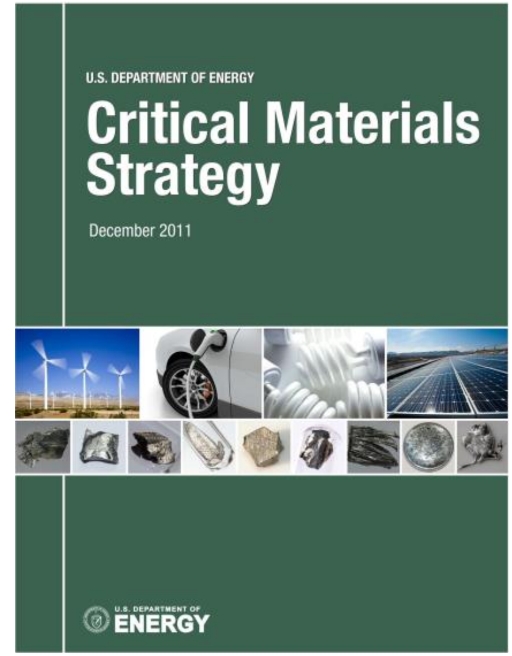
# Four CMI Outcomes

Workers at Acciona Wind Power in West Branch, Iowa assemble a casing around the nacelle of a wind turbine. *Credit Clay Masters / IPR*

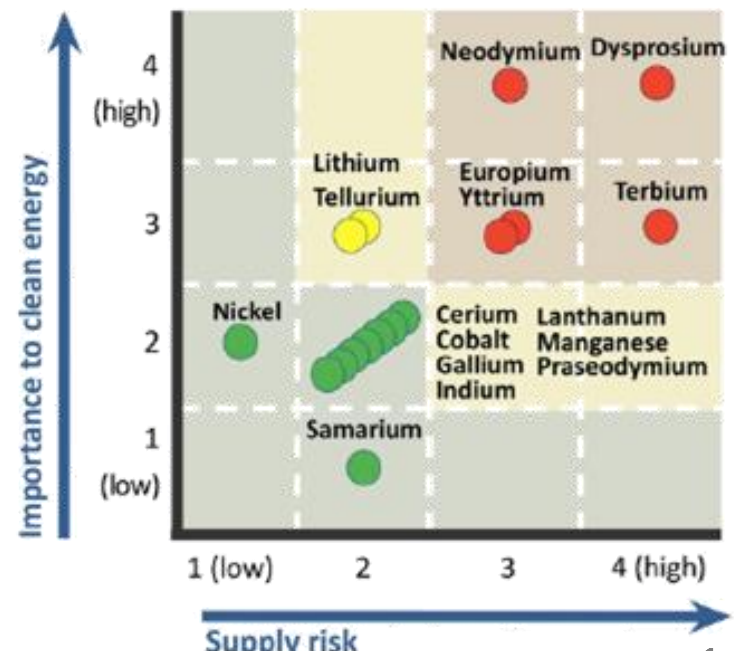
- Materials supply chains assured for clean energy manufacturing in the US
  - Current critical materials issues solved
  - Future criticality issues identified and averted
- Supplies of technical talent and expertise assured
- Critical materials information provided to researchers, producers & OEMs
- Federal critical materials research efforts coordinated for maximum impact

# Three-D Approach

- Diversify supply
- Develop substitutes
- Drive reuse, recycling, and efficient use of materials in manufacturing




*Essentially following DOE's Critical Materials Strategy, but applying it very selectively*




Medium Term Outlooks:
2015 – 2025

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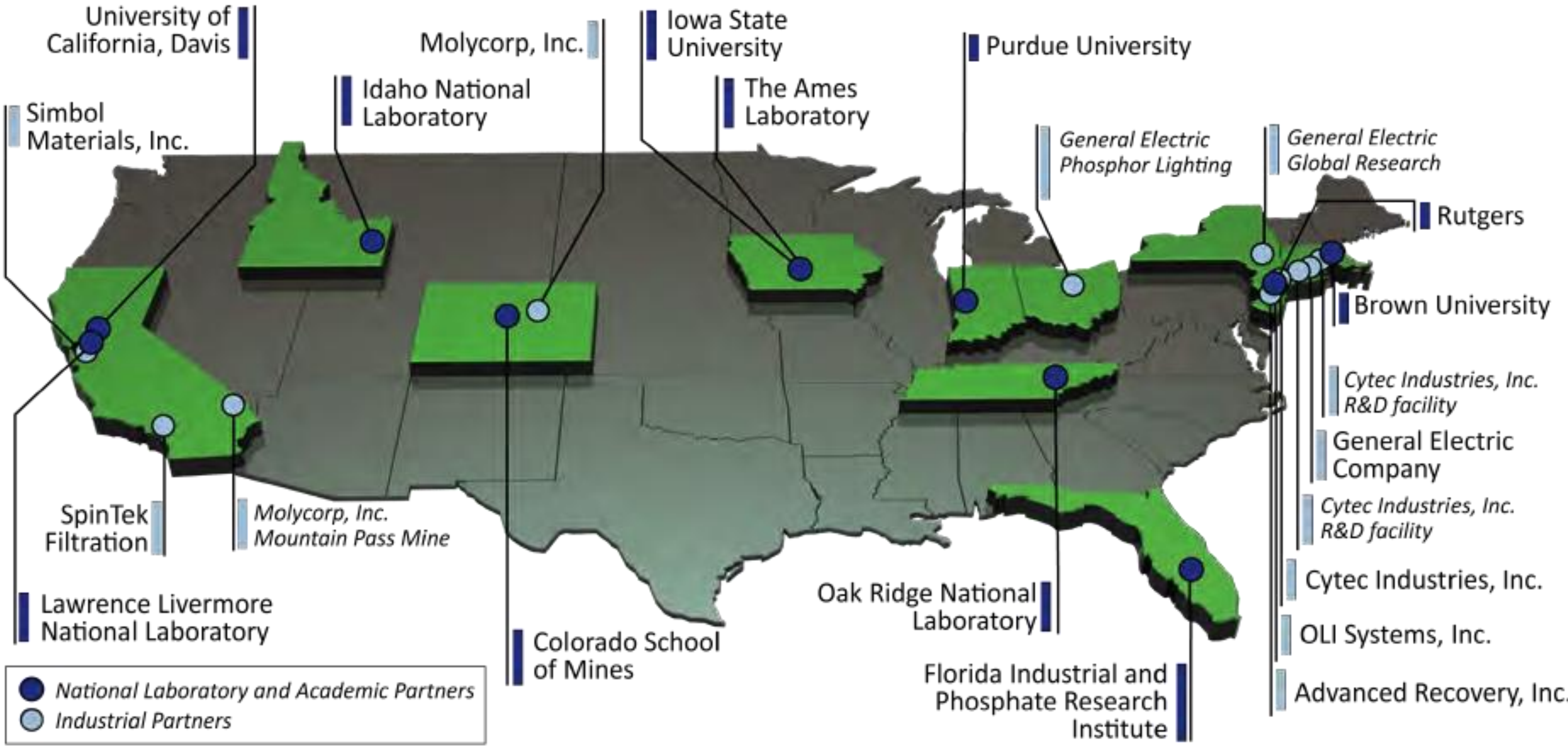
# Two Guiding Principles

- Produce more

- Use less

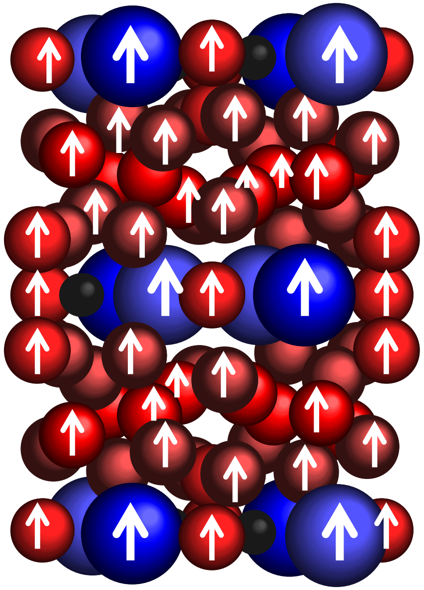
- We have to address the entire materials lifecycle, going from birth through death, and beyond, to include resurrection.

# One Integrated Team



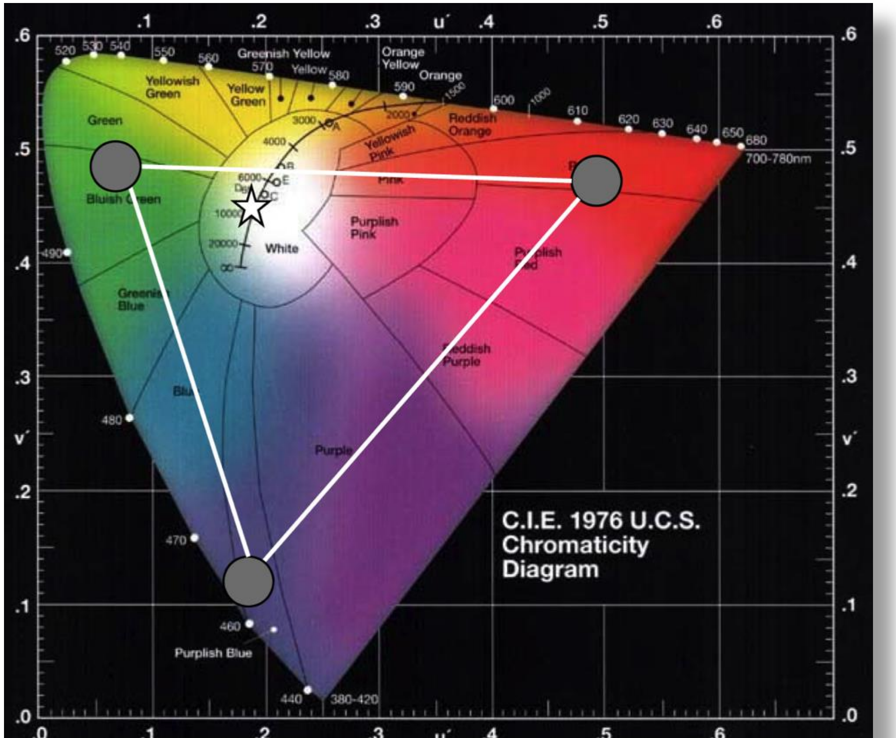
# Neodymium

- Used for high-performance magnets
- Traditional uses:
  - Hard disk drive spindle motors
  - Portable electronics - loudspeakers & microphones
  - Small motors in vehicles
- Emerging uses:
  - Traction motors in electric vehicles
  - Wind turbine generators



# Terbium & Europium

- Provide green and red light emission
- Traditional uses:
  - CRTs
  - Long-tube fluorescent lamps
  - Flat panel color displays and TVs
- Current uses:
  - Compact fluorescent lamps
  - Personal electronics
- Future uses:
  - LED lighting
  - OLED displays



# Thank You!

Questions?