Eliminating Supply Risks, Enabling Energy Technologies

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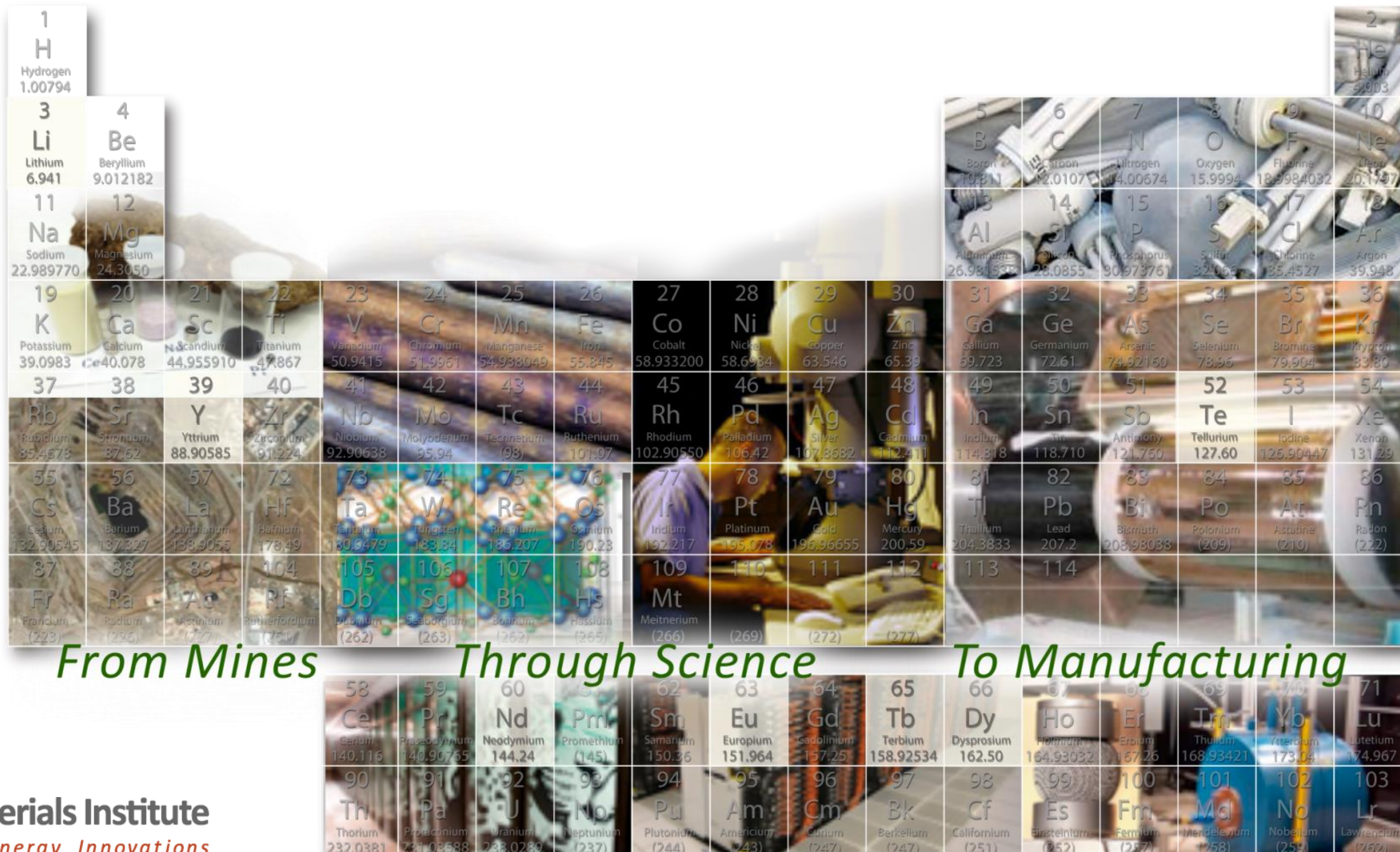

Critical Materials Institute
Accelerating Energy Innovations

CMI Overview

- What: Research to reduce supply risks for materials essential to clean-energy technologies; up to $120 million over 5 years
- Why: To remove impediments to technology development and deployment, to accelerate innovation
- How: Develop technologies to (a) increase & diversify supply and (b) reduce demand
- Who: A consortium of 18 institutions

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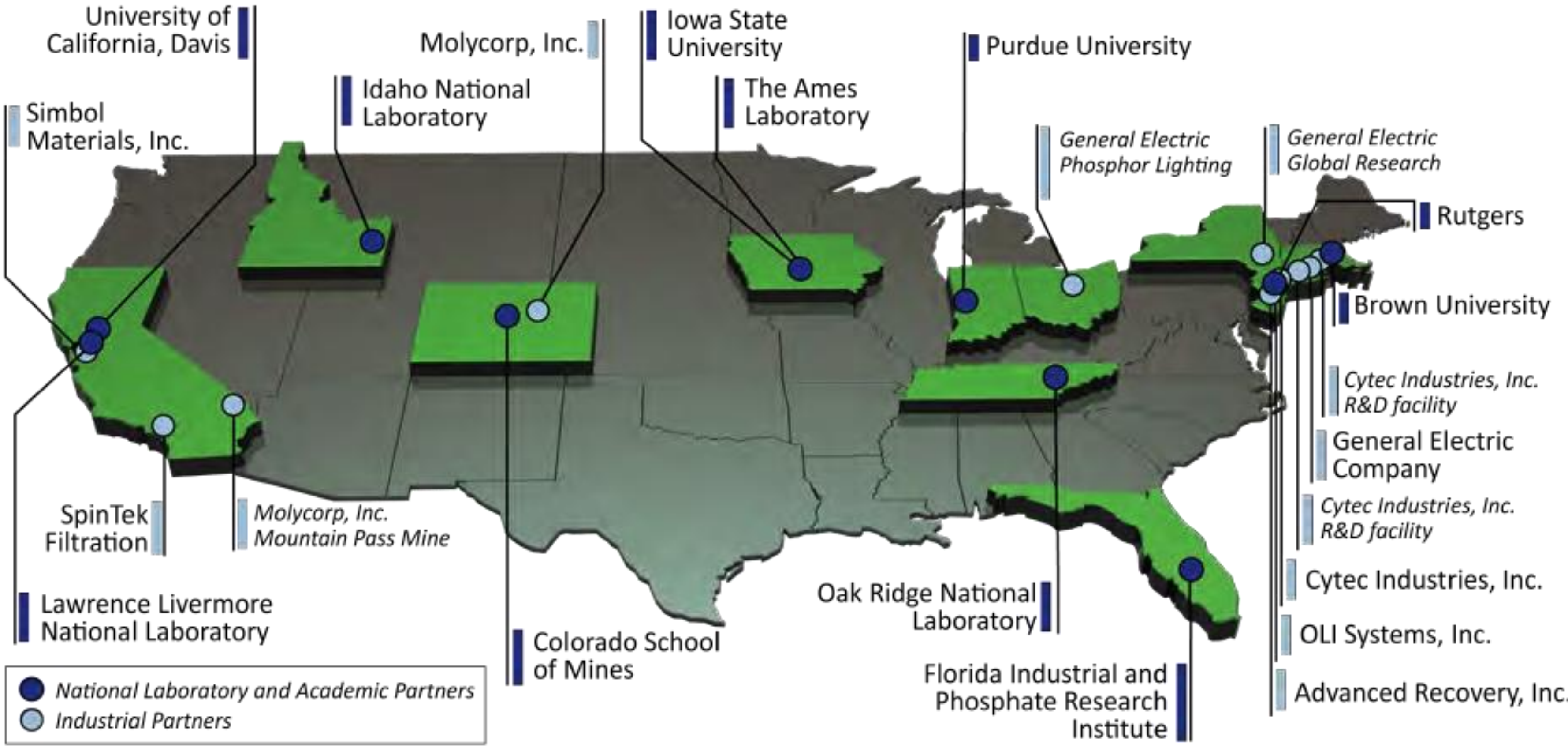
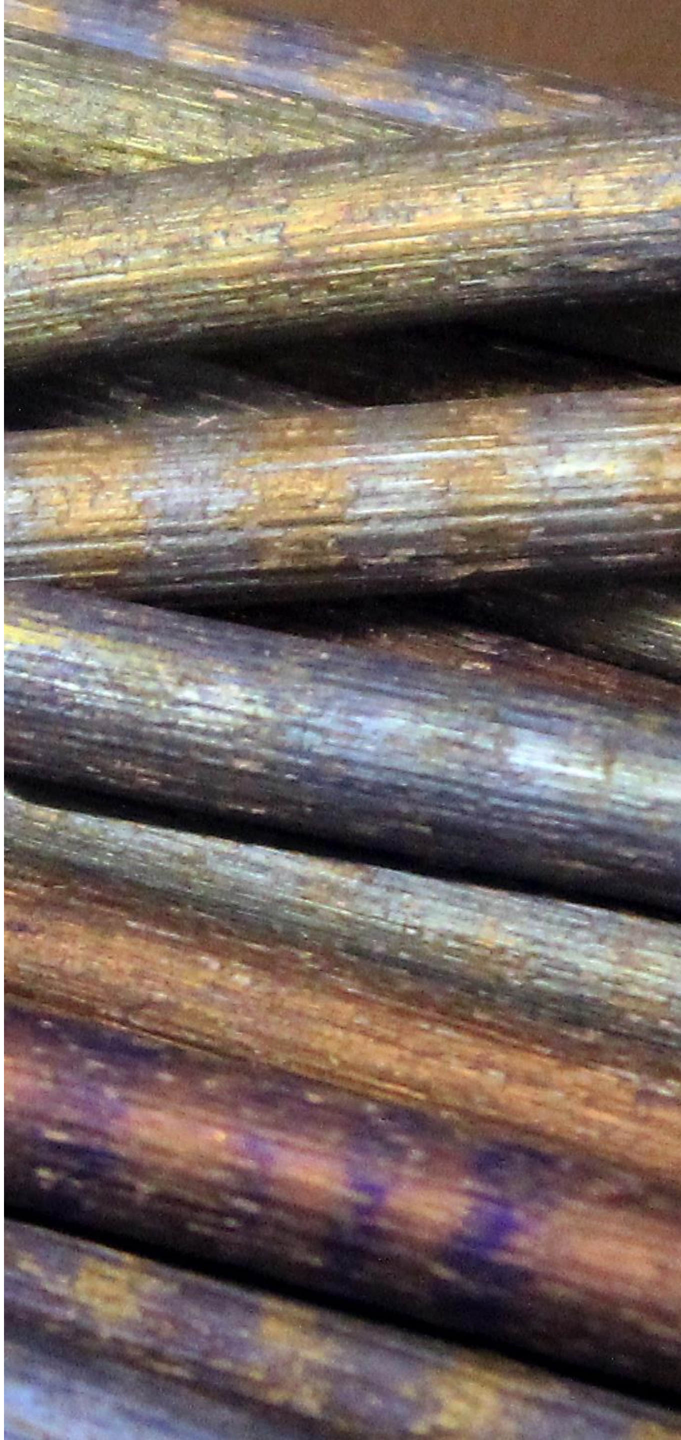
The CMI Partnership



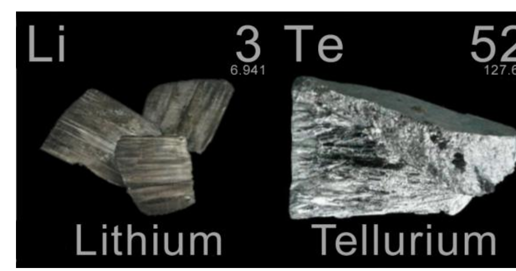
What is a “Critical Material”?

- Any substance used in technology that is subject to supply risks, for which there are no easy substitutes
- Or, stuff you really need but can’t always get
- What is ‘critical depends on *who*, *where* and *when* you ask
- For CMI: clean-energy technologies, in the U.S., over the next 10 to 15 years

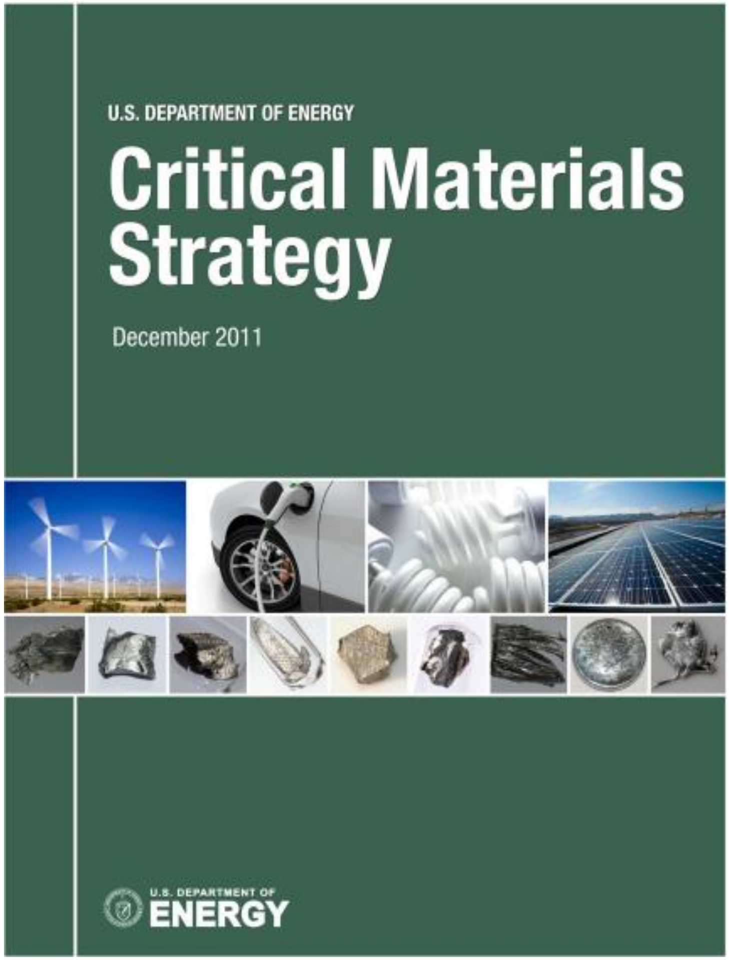


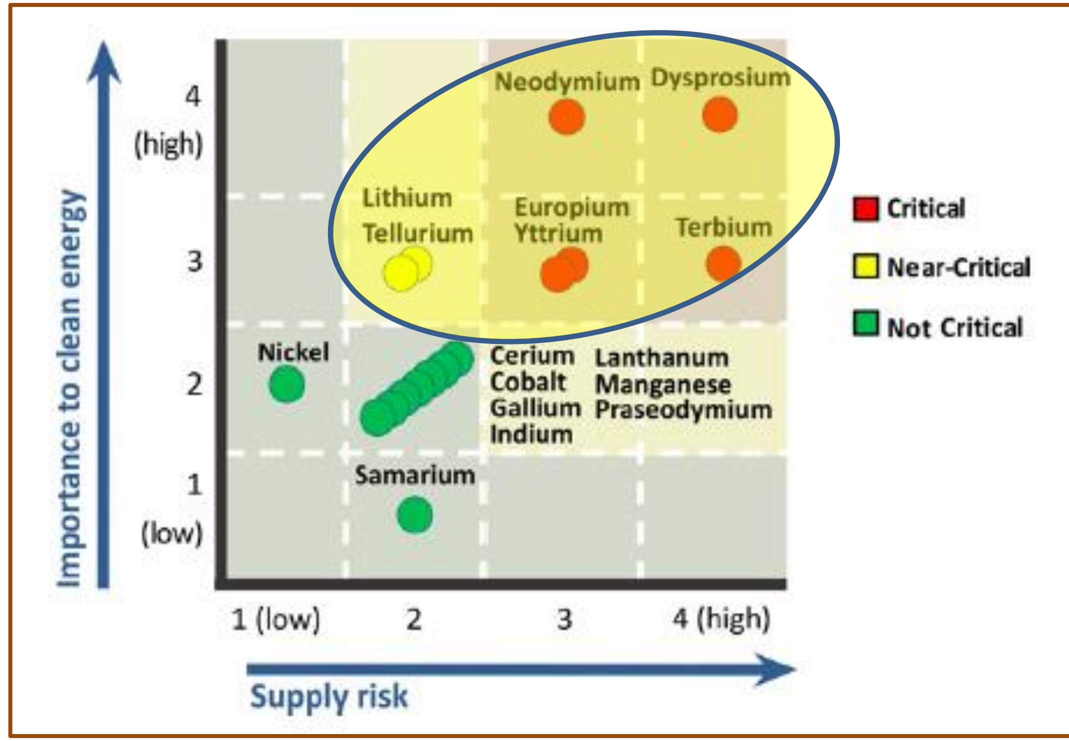
Initial CMI Focus

- 7 elements
- 4 technologies
  - magnets
  - phosphors
  - batteries
  - photovoltaic materials



Implementing DOE's *Critical Materials Strategy*

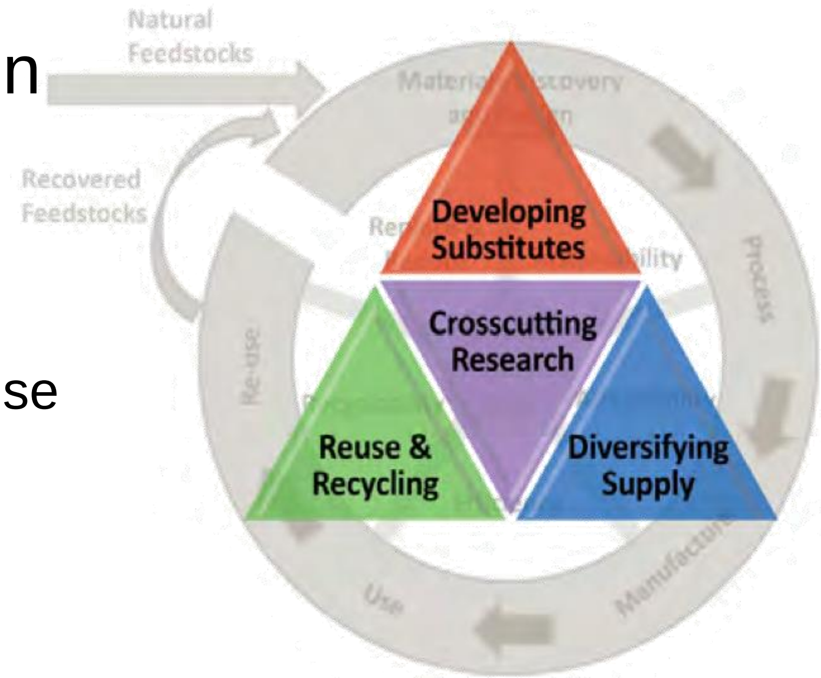




Medium Term: 2015 – 2025

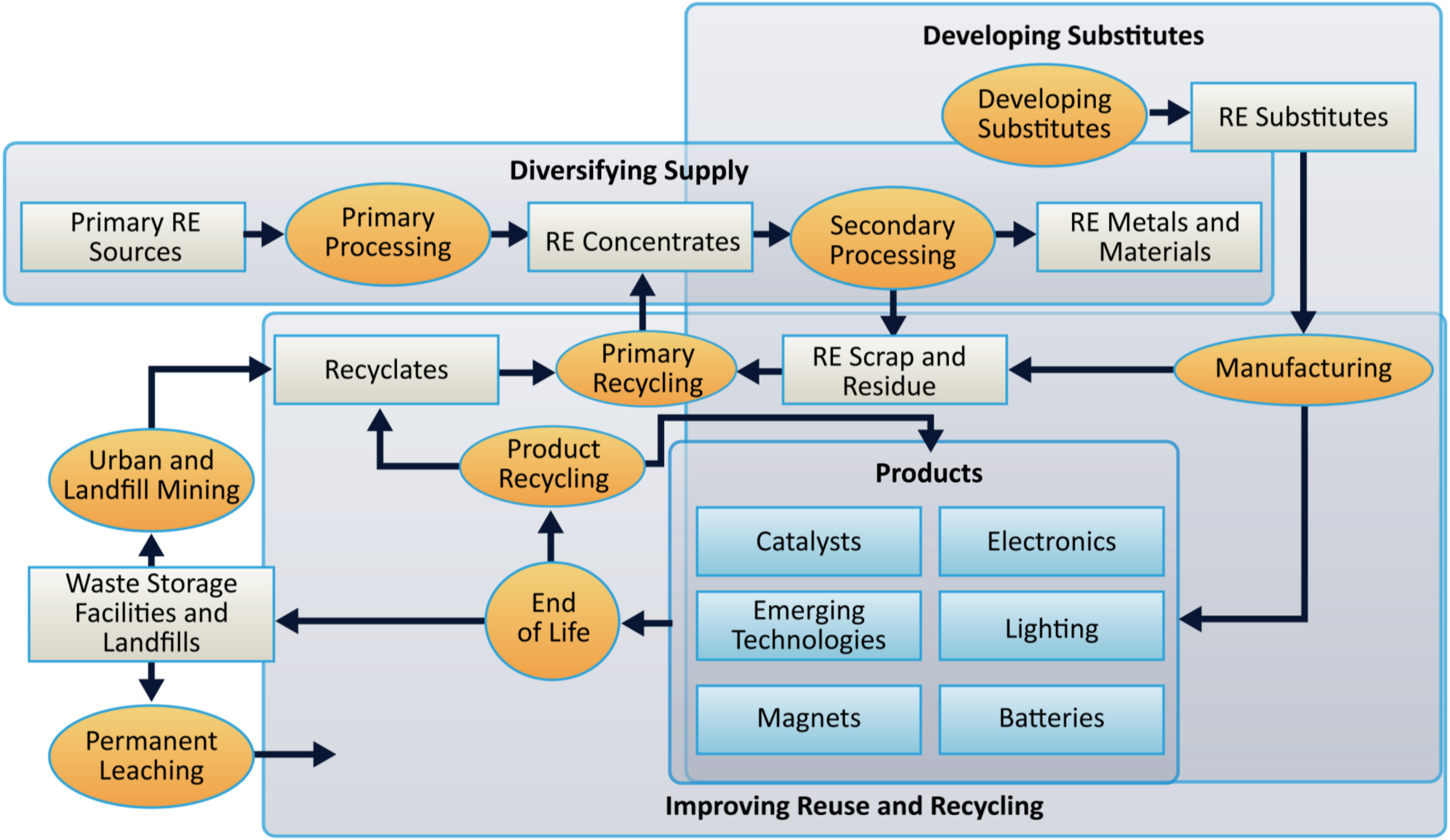
“Produce more, use less”

- Research across the supply chain to:
  - Diversify global supply chains
  - Develop substitute materials
  - Enhance recycling, reuse and efficient use of materials
  - Support the activities above



…but not *ALL* of these in *EVERY* case!

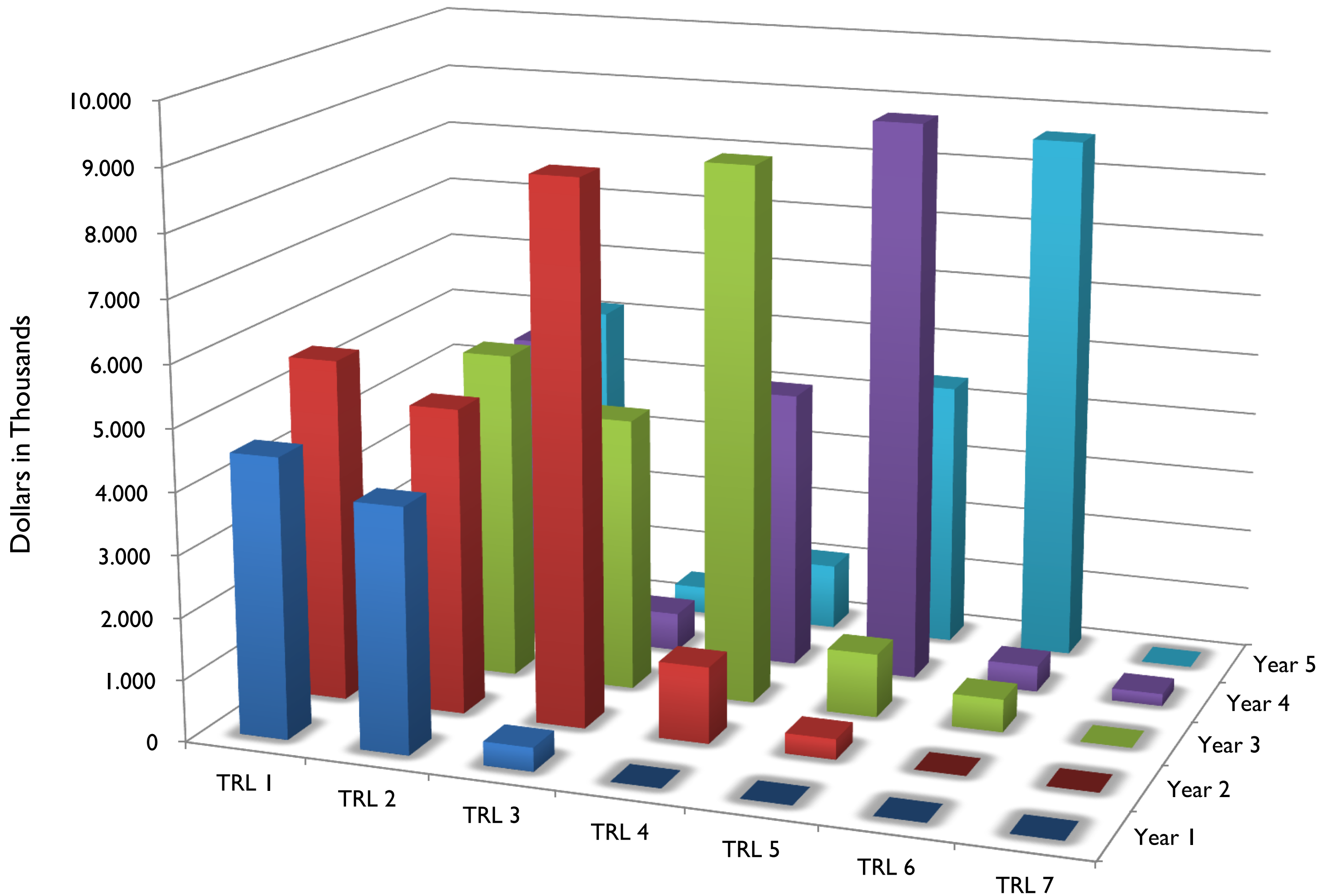
Supply Chain and Economic Analysis



Project selection & management

- 35 initial projects, selected on the basis of . . .
  - Industry need
  - Realistic timeframe
  - Opportunities for multi-institution collaboration
  - Clear path to deployment
- Annual evaluation (milestones, deliverables)
- Projects will be terminated (failure to meet milestones, or the world changes)

Progressing Toward Deployment:
Budget Distribution by Technology Readiness Levels



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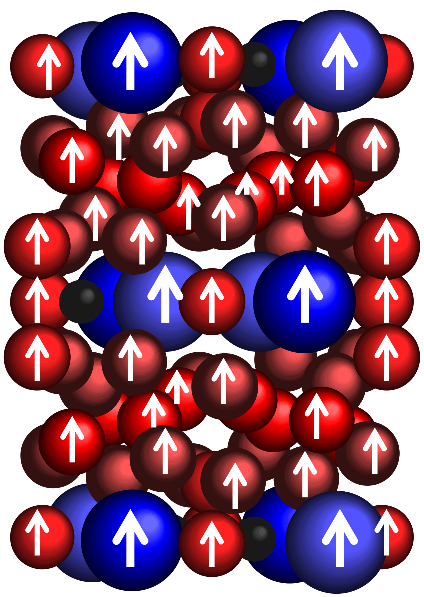
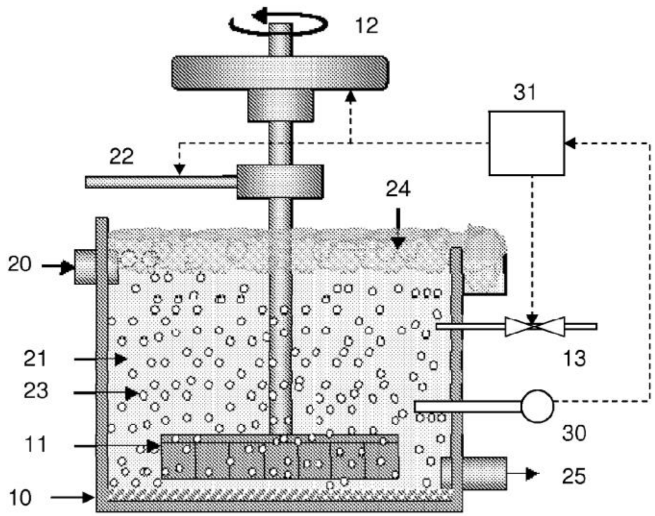
Neodymium

- 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



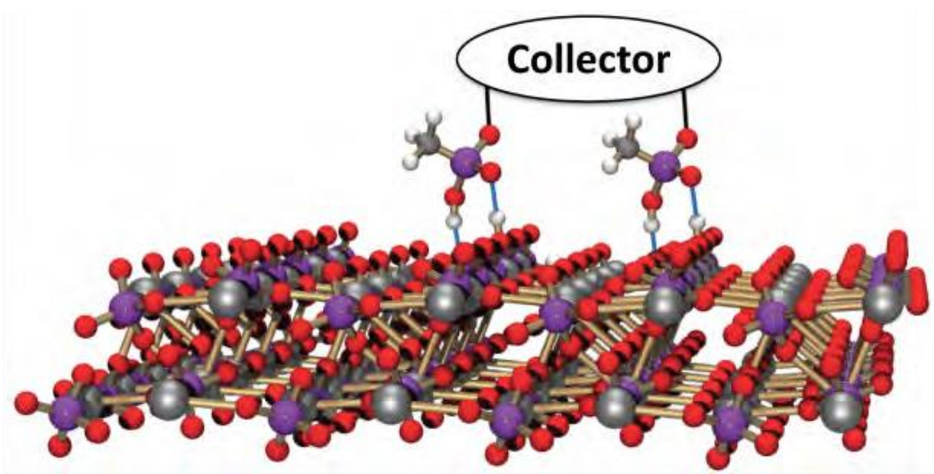
Classical Froth Flotation

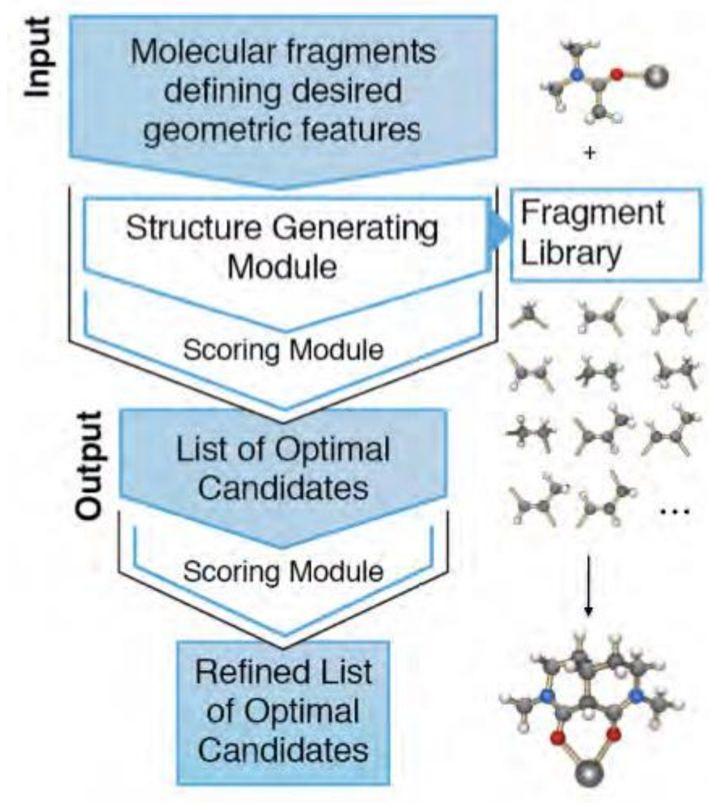


- Separates valuable ore from the associated gangue.
- Concentrates bastnaesite, but not monazite.
- Monazite contains more of the higher-value heavy rare earths, but currently goes to the tailings heap.

Quantum Froth Flotation

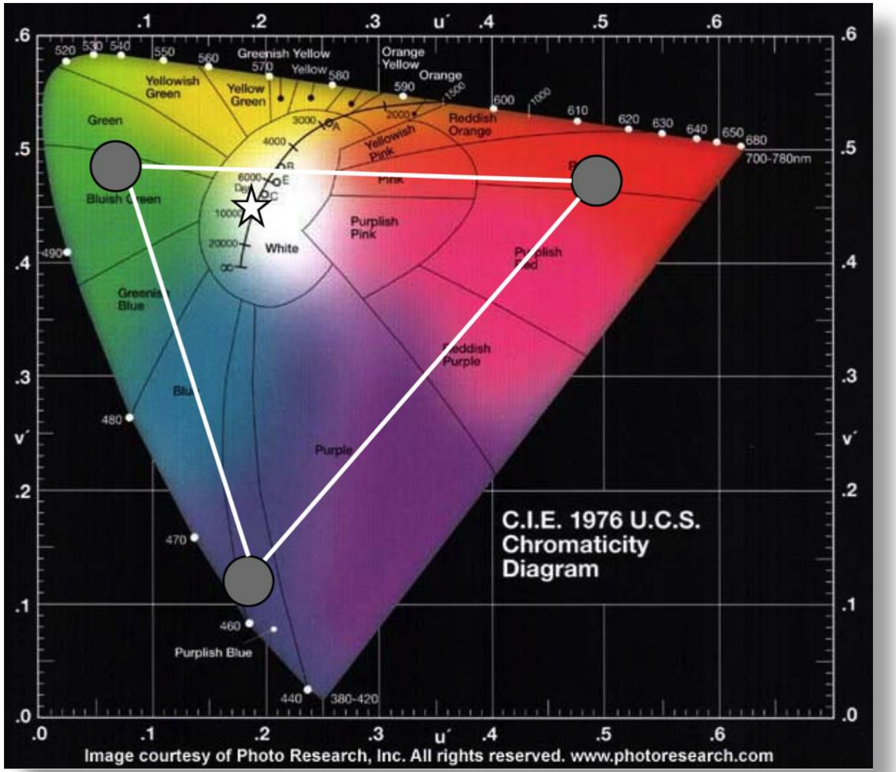
- Solution: find collector molecules that bind monazite to air bubbles
- Quantum chemistry computations at Ames and Oak Ridge
- Pilot-scale testing at Idaho
- US-based chemical manufacturers
- Deployment to US mines





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



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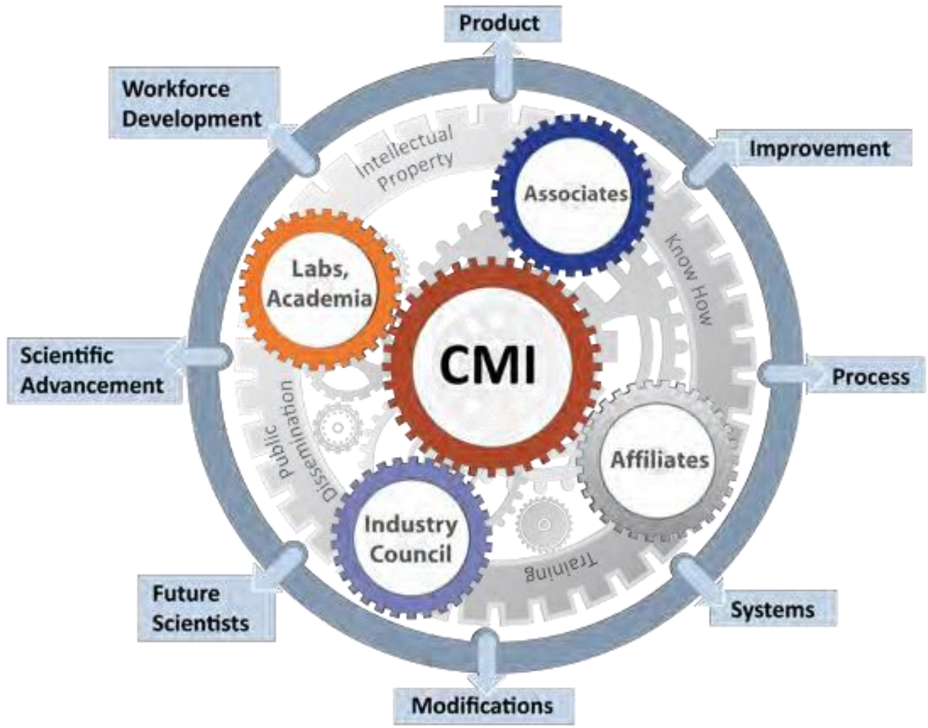
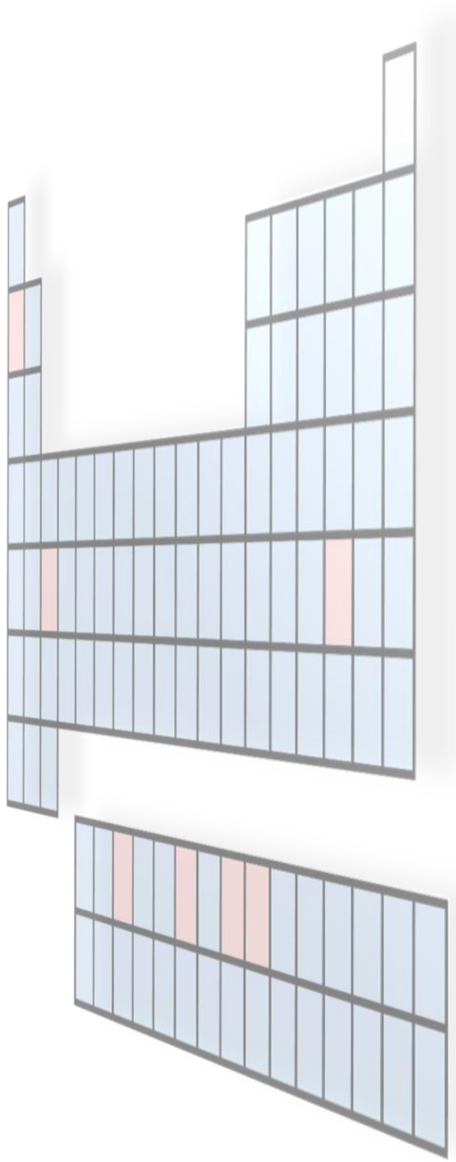
CMI's Integrated Approach



CMI Today and in the Future

- Mantra: eliminate supply risks, enable energy technologies
- How?
  - Innovate to produce more, use less
  - Develop the next generation of scientists and technical experts
  - Anticipate rather than respond to material-supply crises

- Finally: develop mutually beneficial international collaborations



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