

October 23, 2023

# Coal Waste Separations – Critical Mineral Recovery



U.S. DEPARTMENT OF  
**ENERGY**

Fossil Energy and  
Carbon Management

# Unprecedented Federal Investment in Critical Materials

Recent funding opportunities, selections, and awards include:



\$2.8 billion for **battery materials processing** and battery manufacturing recycling

\$74 million to advance domestic **battery recycling and reuse**

\$107 million to **expand CM production capacity for lithium-ion batteries**



\$350 million for **long-duration energy storage** demonstration

\$30 million lab call for **long-duration energy storage**



\$16 million for front-end engineering design studies for the **REE demonstration facility**

\$11 million for **lithium extraction and conversion from geothermal brines**



\$39 million for the Mining Innovations for Negative Emissions Resource Recovery  
**MINER program**



\$17.5 million to **commercialize critical material-free permanent magnets** through the  
**SCALEUP program**

The

# BRIDGE

LINKING ENGINEERING AND SOCIETY

## The Value of Engineering for Sustainability

Michael D. Lepech and James O. Leckie

## Engineering Carbon-Free Energy for All

Piotr D. Moncarz and Michal Kurtyka

## Engineering Clean Water

Glen T. Daigger

## Equitable Transportation Planning and Decision-Making to Support Small and Rural Community Resilience

Jeffrey LaMondia, Fernando Cordero, and Andrzej S. Nowak

## Engineering Natural and Industrial Systems for Integrated Designs

Benedict Schwegler

## Engineering the Sequestration of Carbon

Brol Dindoruk and Silviu Livescu

## K-12 Reform: An Endless Discussion, Finally Progress

Craig R. Barrett

## Domestic Wastes and Byproducts: A Resource for Critical Material Supply Chains

Evan J. Granite, Grant Bromhal, Jennifer Wilcox, and Mary Anne Alvin

The mission of the National Academy of Engineering is to advance the welfare and prosperity of the nation by providing independent advice on matters involving engineering and technology, and by promoting a vibrant engineering profession and public appreciation of engineering.

NATIONAL ACADEMY OF ENGINEERING

Fall 2023

THE VALUE PROPOSITION IN  
INNOVATIVE ENGINEERING

# Domestic Critical Minerals & Materials Supply Chains are Vital for the Clean Energy Transition

Neodymium, Praseodymium, & Dysprosium



Magnets for wind generators, electric and fuel cell vehicle motors, & industrial motors

Lithium, Cobalt, Nickel, Manganese, and Graphite



Batteries for electric vehicles & grid storage

Iridium & Platinum



Electrolyzers for green hydrogen production & platinum for fuel cells used in transportation & stationary energy storage

Gallium



Wide bandgap power electronics enable high voltage power generation to connect to the grid

Germanium



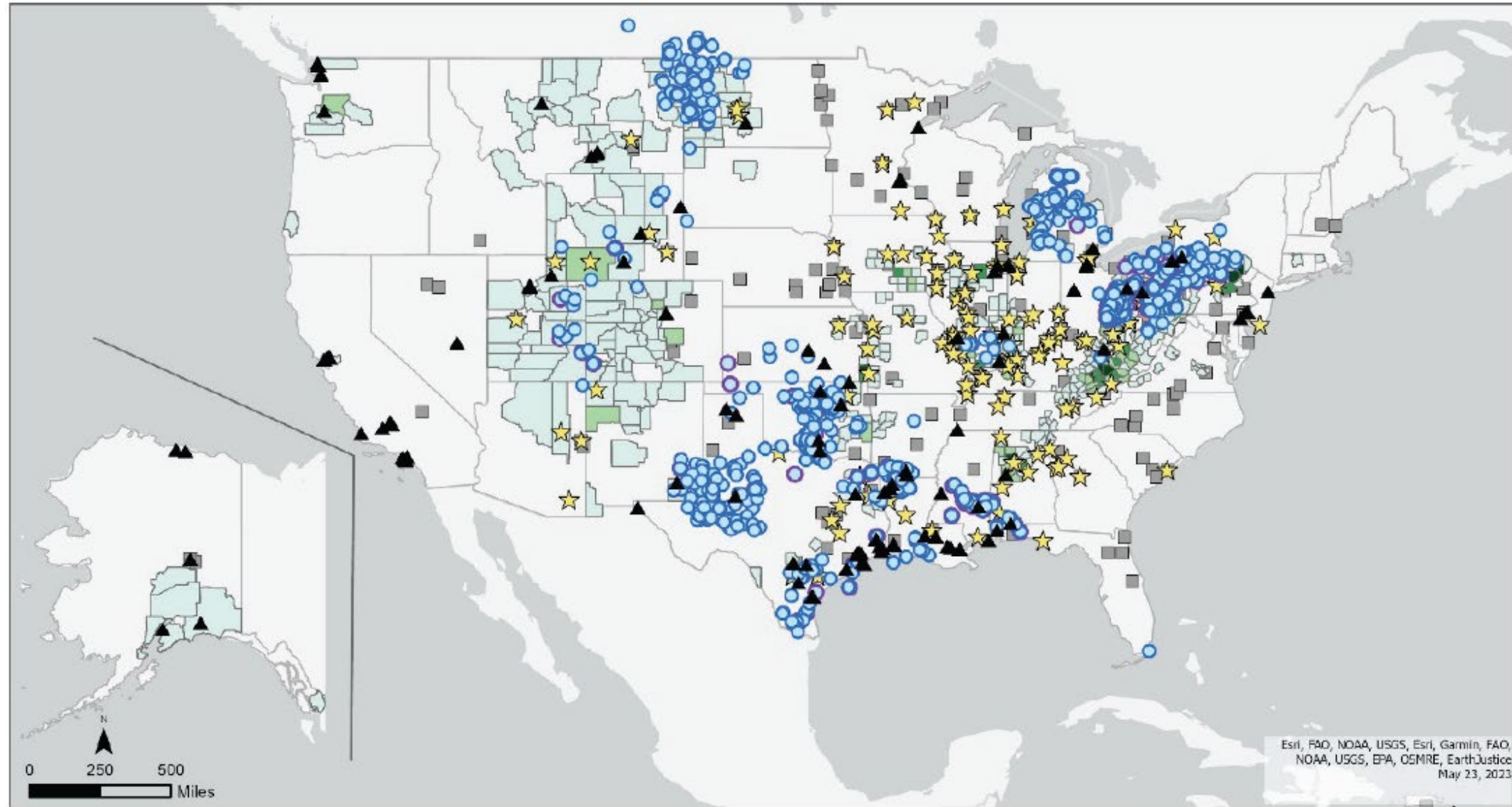
Semiconductors for sensors, data, and control; Fiber and infrared optics

## DOE Goals

100% clean electricity by 2035:  
30 GW offshore wind by 2030

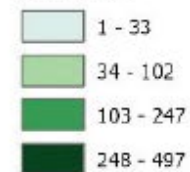
Zero-emission transportation including 50% EV adoption by 2030





## Potential Unconventional and Secondary Sources of Critical Minerals Across the United States

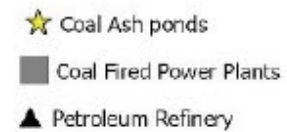
Priority 1 Abandoned coal mines



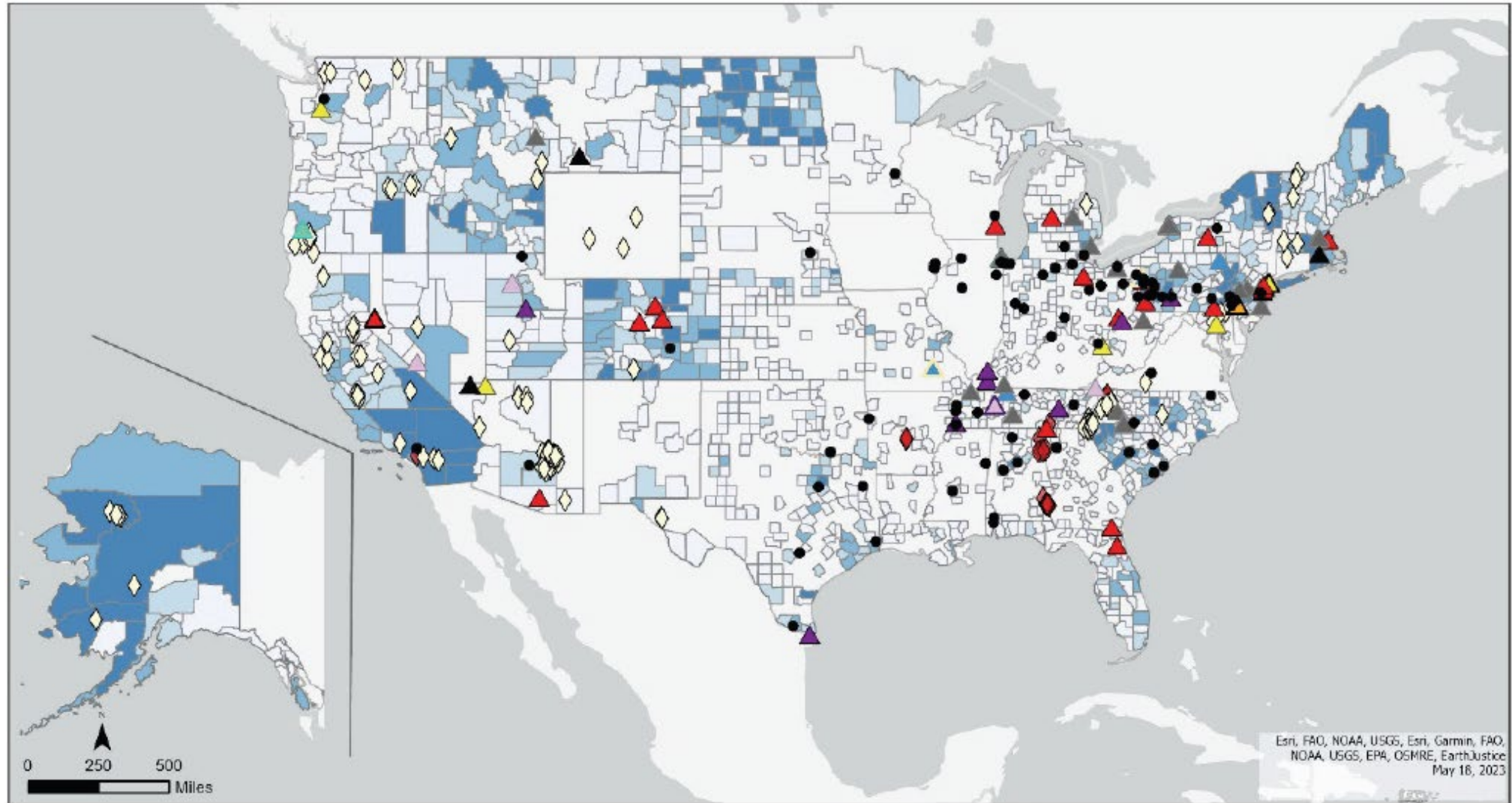
Produced Water Samples with concentrations



### Legend



▲ Petroleum Refinery



### Potential Unconventional and Secondary Sources of Critical Minerals Across the United States







**TABLE 2 Potential supply in US legacy coal ash, at current rates of consumption**

Critical Metal	Estimated Mass	Potential Supply (Years)
Nd	172,000 tons	40
Dy	62,000 tons	14
Li	288,000 tons	130
Co	110,000 tons	15
Ni	252,000 tons	1.1
Ir	40 tons	15
Pt	600 tons	15
Ga	20,000 tons	1,100
Ge	30,000 tons	3,900

# Unprecedented Federal Investment in Critical Materials

- **\$363 million in Fiscal Year 2023** enacted on critical minerals and materials
- **Bipartisan Infrastructure Law (BIL)** provided over **\$8 billion** in funding dedicated to critical minerals and materials advancement, such as:



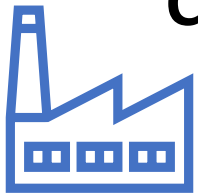
## Critical Materials RD&D Program

\$600 million



## Battery Mat'l Processing, Manufacturing and Recycling Grants

\$6 billion



## Critical Material Supply Chain Research Facility

\$75 million



## Clean Hydrogen Electrolysis Program

\$1 billion

# Inflation Reduction Act (IRA) – Energizing the Private Sector

- 30D Clean Vehicle Credit has critical mineral sourcing requirement
- 45X Advanced Manufacturing Production Credit has 10% production cost credit for critical mineral production
- 48C Advanced Energy Project Credit has investment tax credit for critical mineral production
- 50141 Funding allows DOE to provide loans for critical minerals processing, manufacturing, and recycling





# Critical Materials Collaborative (CMC)

- **Vision:** To integrate critical materials applied RD&D across DOE to **operationalize coordination and collaboration** while creating a **value-add to performers** by expanding their access to world-class expertise, capabilities, and facilities to accelerate the development of domestic material supply chains for the nation.
- **Mission:** Accelerate our critical materials RD&D to achieve national clean energy manufacturing, climate, and national security goals by:
  - Building a robust **innovation ecosystem**
  - **Training leaders** and workforce for critical materials for multiple sectors
  - Enabling industry adoption of the **cutting-edge technology**
  - Laying the scientific and technological groundwork for emerging challenges

# BIL--Rare Earth Element Demonstration Facility (\$140M)

## Phase 1 Awards

Start: Summer 2023. Duration: 18 month

Includes: FEED studies, NEPA, community benefits plan

Feedstock types: coal mine waste, acid mine drainage

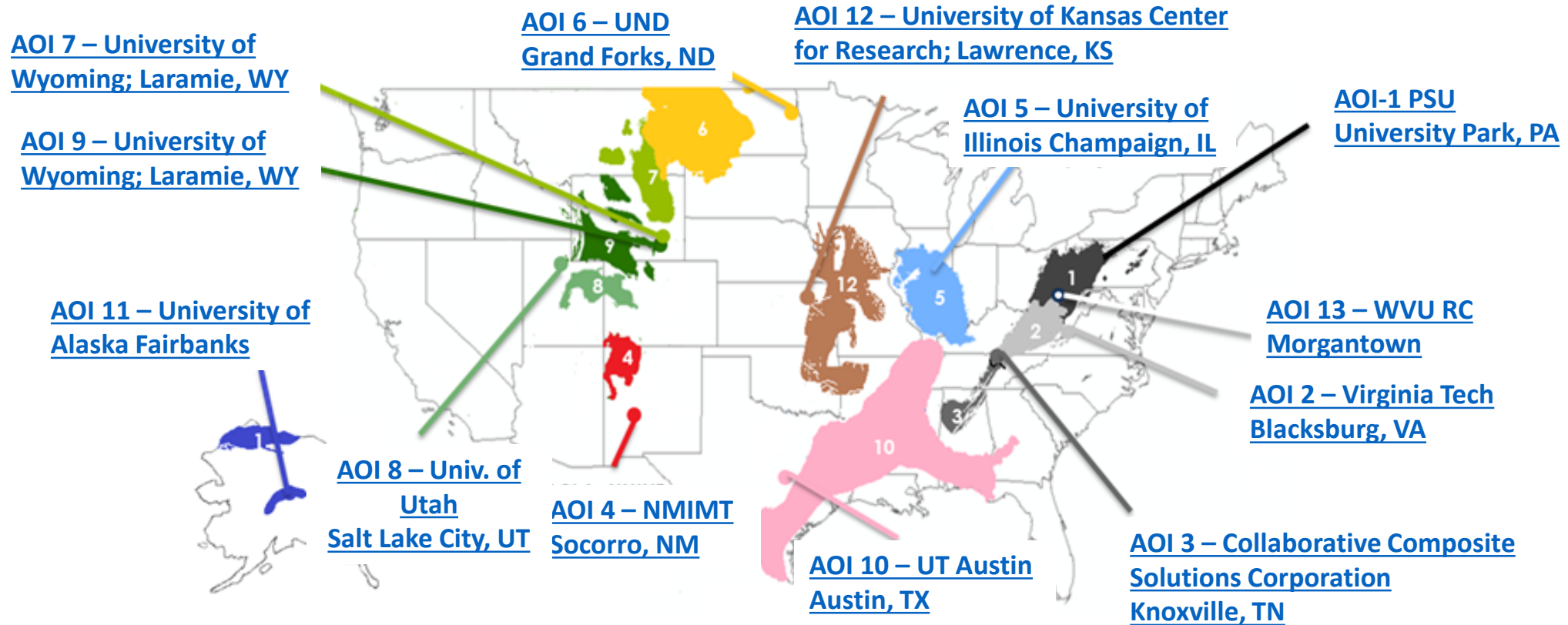
**1) Recovery and Refining of Rare Earth Elements from Lignite Mine Wastes — University of North Dakota** (Grand Forks, North Dakota)

**2) Integrated Treatment of Acid Mine Drainage and Rare Earth, Critical Materials Production — West Virginia University** (Morgantown, West Virginia)

## Phase 2: Construction of Demonstration Facility

**350-1,000 tonnes MREO/yr & CM through Metals Refining**

# CORE-CM: Developing National Prospectus by Assessing Regional Opportunities



- Build broad-based regional coalition teams, including Tribal Nations, local communities
- Investigate regional resources (materials, facilities, infrastructure, workforce), opportunities, and challenges
- Catalyze regional economic growth and job creation
- Address legacy waste and environmental and restorative justice
- Enable production of REE, CM and high-value carbon-based products





Illustration by Leif Gann-Matzen

U.S. JOURNAL

## COULD COAL WASTE BE USED TO MAKE SUSTAINABLE BATTERIES?

*Acid mine drainage has long been a scourge in Appalachia. Recent research suggests that we may be able to simultaneously clean up the pollution and extract the minerals and elements needed to power green technologies.*

By Eliza Griswold

August 26, 2022



# CORE-CM: Assessing Regional Opportunities

**Formed Working Groups to facilitate inter-regional collaboration and communication:**

- Develop ***standardized protocols*** and best practices for ***laboratory*** analyses and ***field*** collection methods
- Develop an ***assessment methodology*** for the calculation of CM ***potential*** in unconventional and secondary sources
- Develop a ***site prioritization*** methodology to rank sites of needing ***further investigation/development***
- Develop a ***best practices*** around ***permitting*** of sites
- Best practices for ***community engagement and benefits***

To develop the **first national prospectus** showing **CM potential** from coal-based and other unconventional and secondary feedstocks

Prospective Unconventional Sources for Critical Minerals



Unlocking the Potential of Unconventional Critical Mineral Resources  
A Story Map  
National Energy Technology Lab

# Standards Development/Engagement

**Responsible stewardship of critical materials is a domestic and international issue requiring high environmental standards across the entire supply chain**

FECM/MSD engages in ISO efforts to improve sustainability in global CM supply chains

- ISO TC 298 Rare Earth Elements
  - U.S. proposed developing a sustainability standards for rare earth mining, separation and processing to include environmental, economical and societal impacts
  - Working Group 5 has been established specifically for sustainability, and will be beginning work soon
- ISO TC 333 Lithium
  - New technical committee that is still developing strategic business plan, but is meant to include the full supply chain, excluding LIB as end products
  - Sustainability proposal put forth by the U.S. and is currently posted for a 12-week ballot

Working with EPA on certification standards for federal procurement

OSTP NSTC CMS, International Bilateral/Multilateral interactions are opportunities to coordinate responsible development of supply chains



# Accomplishments – MSD RD&D (Newly Funded)

- BIL FOA-2618: (\$16M) **REE Demonstration Facility**, Phase 1 FEED (\$16M) Issued 9/19/22. 2 projects kicked off August 2023
- BIL FOA-2854 (\$32M): **FEED Studies** for Production of CMM from Coal-Based Resources Issued 7/13/23
- BIL FOA-2619 (\$30M): **Advanced CMM Processing** for Industrial & Manufacturing Applications, Issued 8/21/23
- BIL FOA 3105 (\$150M): **Critical Materials Innovation**, Efficiency, and Alternatives. Issued Sept 6, 2023.
- BIL Lab Call (\$75M): Critical Materials **Supply Chain Research Facility**. Issued Sept 13, 2023.
- Lab Call, \$5.3M. **Advanced resource characterization** and technology development of unconventional and secondary sources of critical minerals. Funded winter 2023.

# Accomplishments – MSD RD&D

- In Conjunction with the WVDEP, West Virginia University's First-of-a-Kind, Small Pilot-Scale Facility Produces **Rare Earths and Critical Minerals from Acid Mine Drainage** (AMD)
- Semiconductor Critical Minerals – **Gallium and Germanium** Technology Developed to Produce at High Purity from Lignite
- **Sorbent for Li Recovery** Derived from Acid Mine Drainage Treatment Solids
- Produced high level estimates of **REE resource potential** from many Secondary and Unconventional Resources. Published in NAE's *The Bridge*, "Domestic Wastes and Byproducts: A Resource for Critical Material Supply Chains", Granite et al 2023
- Developed **catalyst to produce battery quality graphite** from coal at temperature reduction of more than 50%
- Semplastics' award-winning **Coal-Derived Battery Anodes** tested in EV industry standard batteries



# Thank You

## *Learn More About Us*

### The Office of Fossil Energy and Carbon Management

[\*https://www.energy.gov/fecm\*](https://www.energy.gov/fecm)

### Justice & Engagement

[\*https://www.energy.gov/fecm/justice-engagement-planning-societal-considerations-impacts-fecm-projects\*](https://www.energy.gov/fecm/justice-engagement-planning-societal-considerations-impacts-fecm-projects)

### Our Strategic Vision

[\*https://www.energy.gov/sites/default/files/2022-04/2022-Strategic-Vision-The-Role-of-Fossil-Energy-and-Carbon-Management-in-Achieving-Net-Zero-Greenhouse-Gas-Emissions\\_Updated-4.28.22.pdf\*](https://www.energy.gov/sites/default/files/2022-04/2022-Strategic-Vision-The-Role-of-Fossil-Energy-and-Carbon-Management-in-Achieving-Net-Zero-Greenhouse-Gas-Emissions_Updated-4.28.22.pdf)

### Join the Team! Come Lead our Division of Minerals Sustainability:

[\*https://www.usajobs.gov/job/755365700\*](https://www.usajobs.gov/job/755365700)