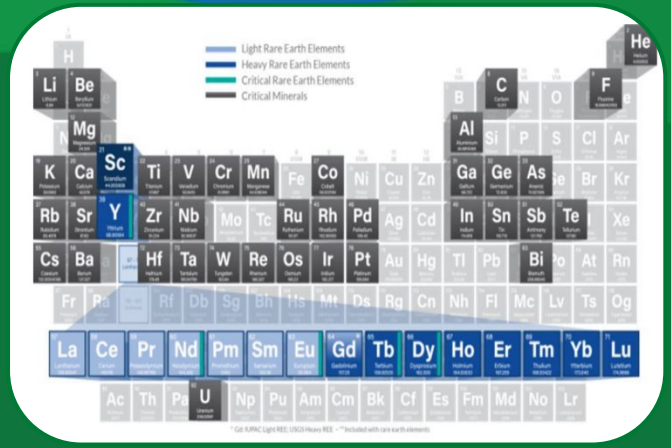
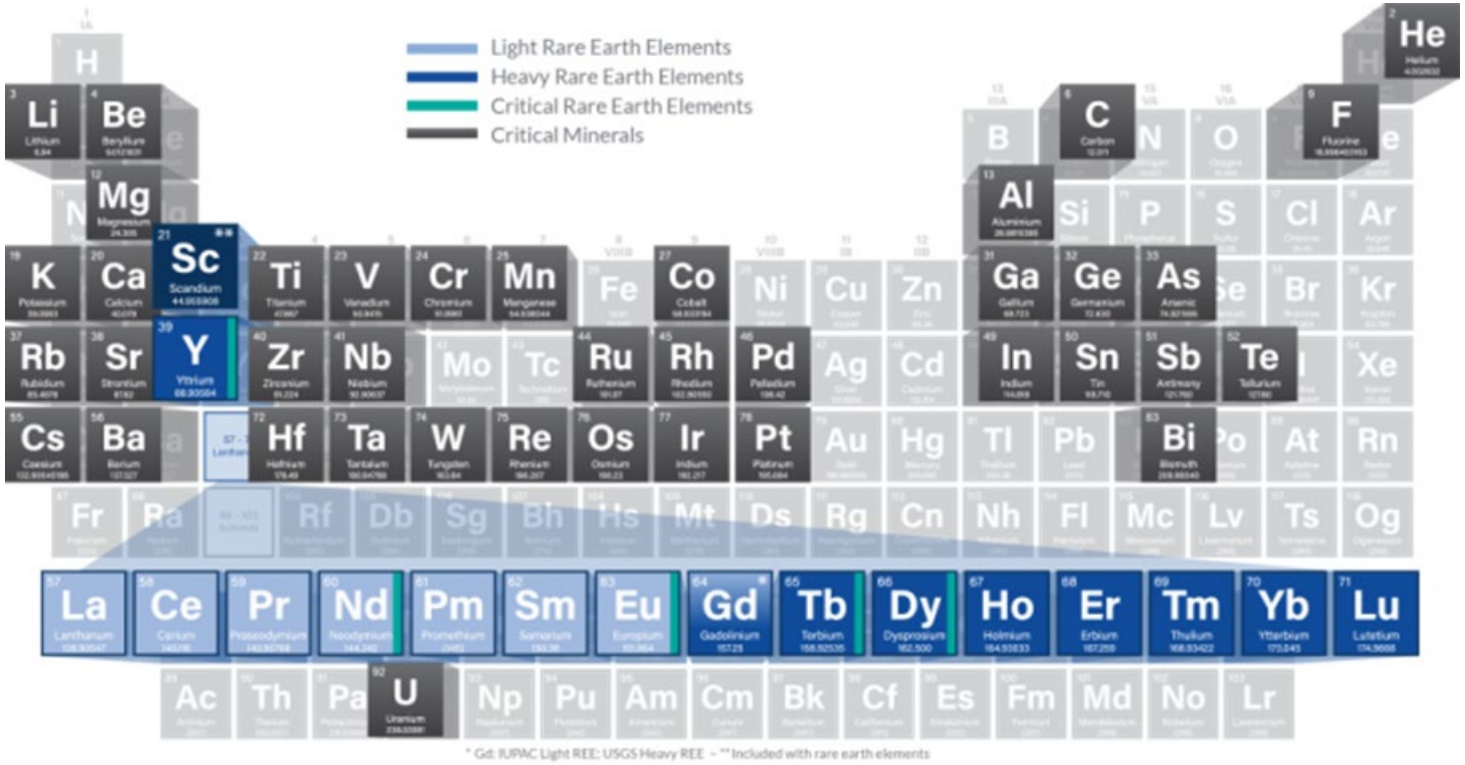
U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

CORE-CM Initiative Background and Introduction

USEA CORE-CM Workshop
December 2, 2021



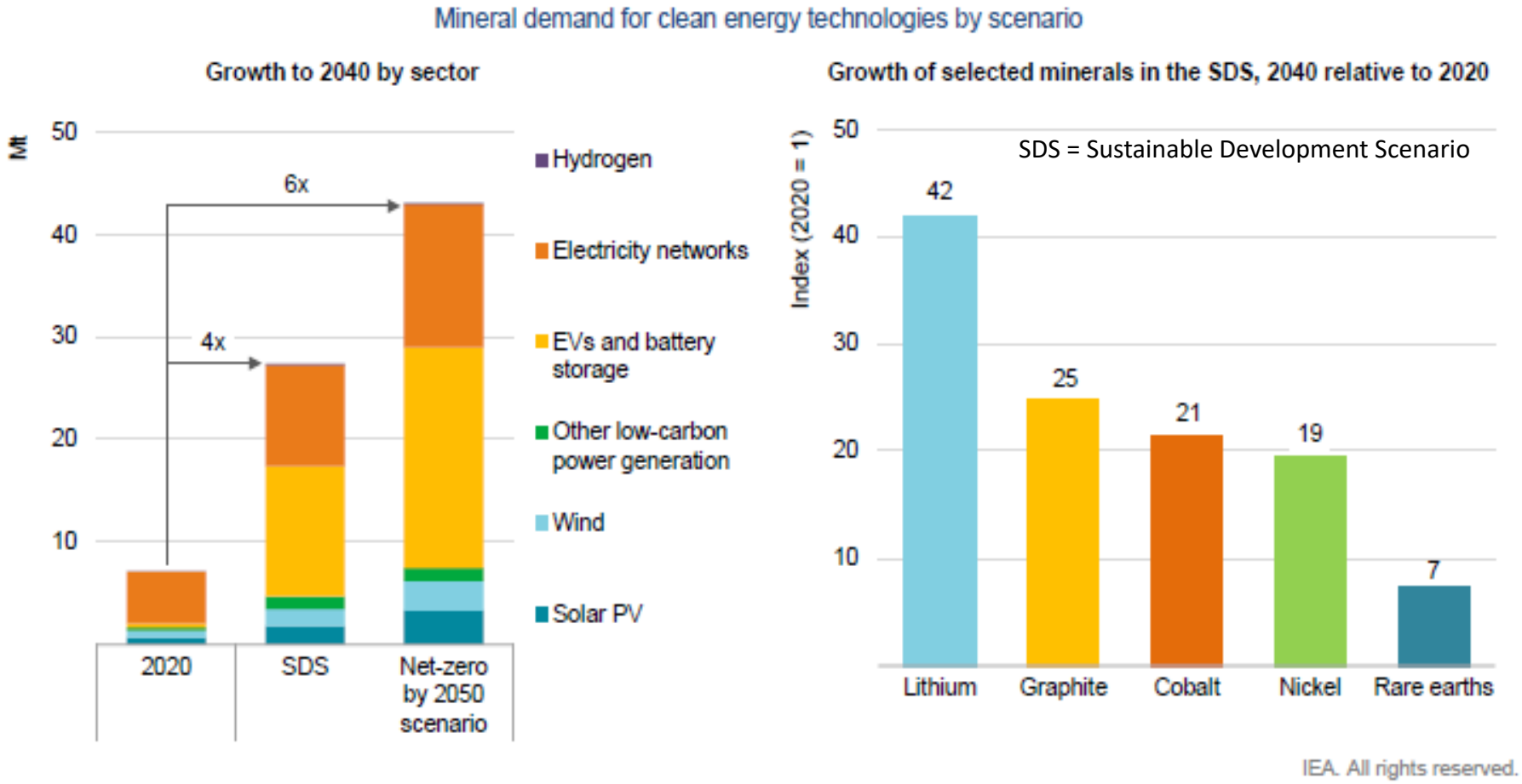
Challenge: Lack of Domestic Supply Chains



- Import-dependent (>50% from foreign source) on 32 of 35* critical minerals
- Import-reliant (100% from foreign source) for at least 14 critical minerals

*Source: USGS Minerals Commodity Summaries

Challenge: Significant Projected Growth for Clean Energy



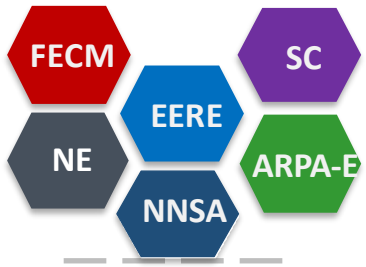
Notes: Mt = million tonnes. Includes all minerals in the scope of this report, but does not include steel and aluminium. See Annex for a full list of minerals.

IEA, 2021

Source: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary

DOE Strategy to Address Critical Materials Challenges

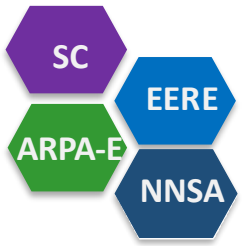
Diversify Supply



Technologies: Non-traditional sources; mine tailings; uses for co-products; advanced separations/extraction

Long-term goals: Diverse, secure, and resilient domestic sources and supply chains; resource mapping, characterization and fundamental geoscience understanding

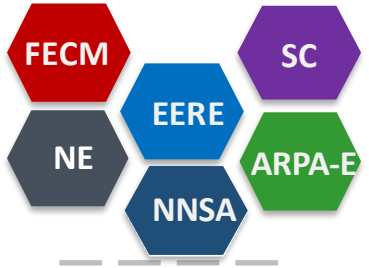
Develop Substitutes



Technologies: New alloys, phosphors, catalysts; new components and systems

Long-term goals: Alternative materials, chemistries, systems, components that provide enhanced functionality for key energy technologies

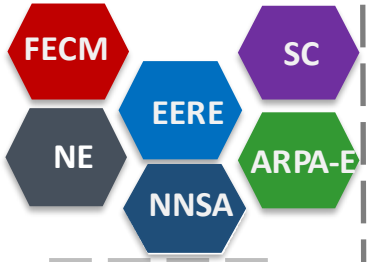
Recycling & Reuse



Technologies: Recovery from products; chemical/ biochemical extraction; additive manufacturing

Long-term goals: Economical and energy efficient recovery from products to enable circular economy for critical materials

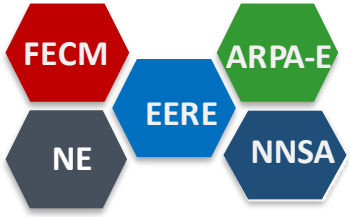
Systems Analysis



Technologies: Modeling/simulation; systems approach to supply chain; Advanced characterization; techno-economic and life-cycle tools

Long-term goals: Integrated suite of systems, TEA, and LCA tools to assess and mitigate future criticality issues and support domestic supply; multi-scale physics/chemistry models

Demonstrations



Technologies: Prototypes and demonstration pilots, including FEED and pre-FEED studies

Long-term goals: Accelerate FEED and demonstrations to support commercial scale production

Stakeholder Engagement: Access to foreign markets, foreign partners, and financing. Coordinating policy – international and NSC driven

Market Analysis: To support decision making

Government-Wide Engagement

- Minerals Sustainability Division (MSD) actively participates in the National Science and Technology Council (NSTC) Subcommittee on Critical Minerals
- Relationships with EPA and DOI (e.g., USGS and OSMRE) are critical to reaching our goals
- International engagements are important both on our technology development front, and in establishing standards for sustainability
- MSD Leadership in the ISO on Lithium and REE standards

NSTC Subcommittee Members

Minerals Sustainability Division

Pillar 1

Resource Characterization & Technology Development

- Characterization for opportunities
- Resource assessment and predictive capabilities
- Web-based platform for integrated database system with AI/ML

Pillar 2

Sustainable Resource Extraction Technology Development

- Transformation, conventional and unconventional extraction technologies
- Integration of industrial beneficiation/ concentration methods and technologies
- Remediation of existing sites and abandoned mine residuals

Pillar 3a

Processing, Refining, & Alloying Technology Development

Critical Materials

- Advanced extraction, purification, and reduction technologies through refining and alloying materials
- Enable commercial production through innovations
- First mover and second-generation large-scale pilot projects

Pillar 3b

Processing and Manufacturing Technology Development

Carbon Ore

- Housing and infrastructure development
- Advanced carbon material (carbon fiber, graphene, and nanomaterial) production
- Reinvest in critical (graphite and silicon) supply chains

International Engagements, Standards and Supply Chain Development

Ni, CO, Cr for Superalloys

- Identify co-production sources to meet increased demand in these metals
- Application of innovative processing, refining, and alloying technologies to increase purity from the waste materials

Carbon Ore to Products

- Assessment and characterization of coal and waste materials
- Environmentally responsible extraction and beneficiation
- Co-production of high purity carbon and critical material products

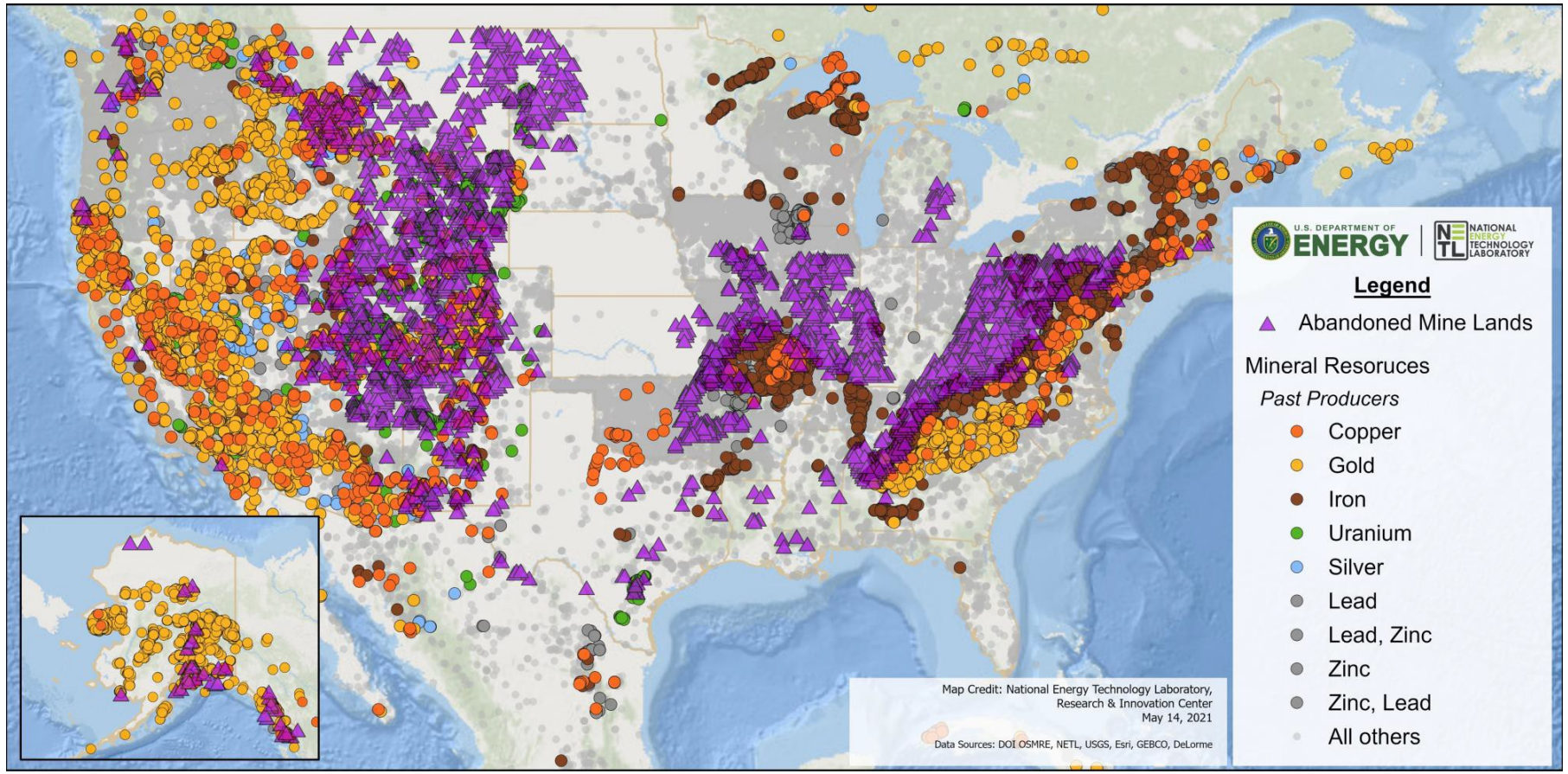
CM—Unconventional, Secondary Sources

- **High-Level Resource Potential Estimates**
  - **11 - 17 million tonnes** REE from known coal reserves, ~30,000t/yr based on current production
  - 12,300 t/yr REE (2018*; 50% recovery) from active refuse
    - 68,000 t from Appalachia coal refuse
  - Over 10,000 t/yr REE (2018*; 50% recovery) from active ash
    - 331,000 t from PA ash impoundments.
  - Between 400-1700 tons/yr REE (50% recovery) from Appalachia AMD

- **FOAK small-scale projects demonstrated technical feasibility to produce high purity (>98%) from dilute sources (coal, refuse, ash and acid mine drainage)**

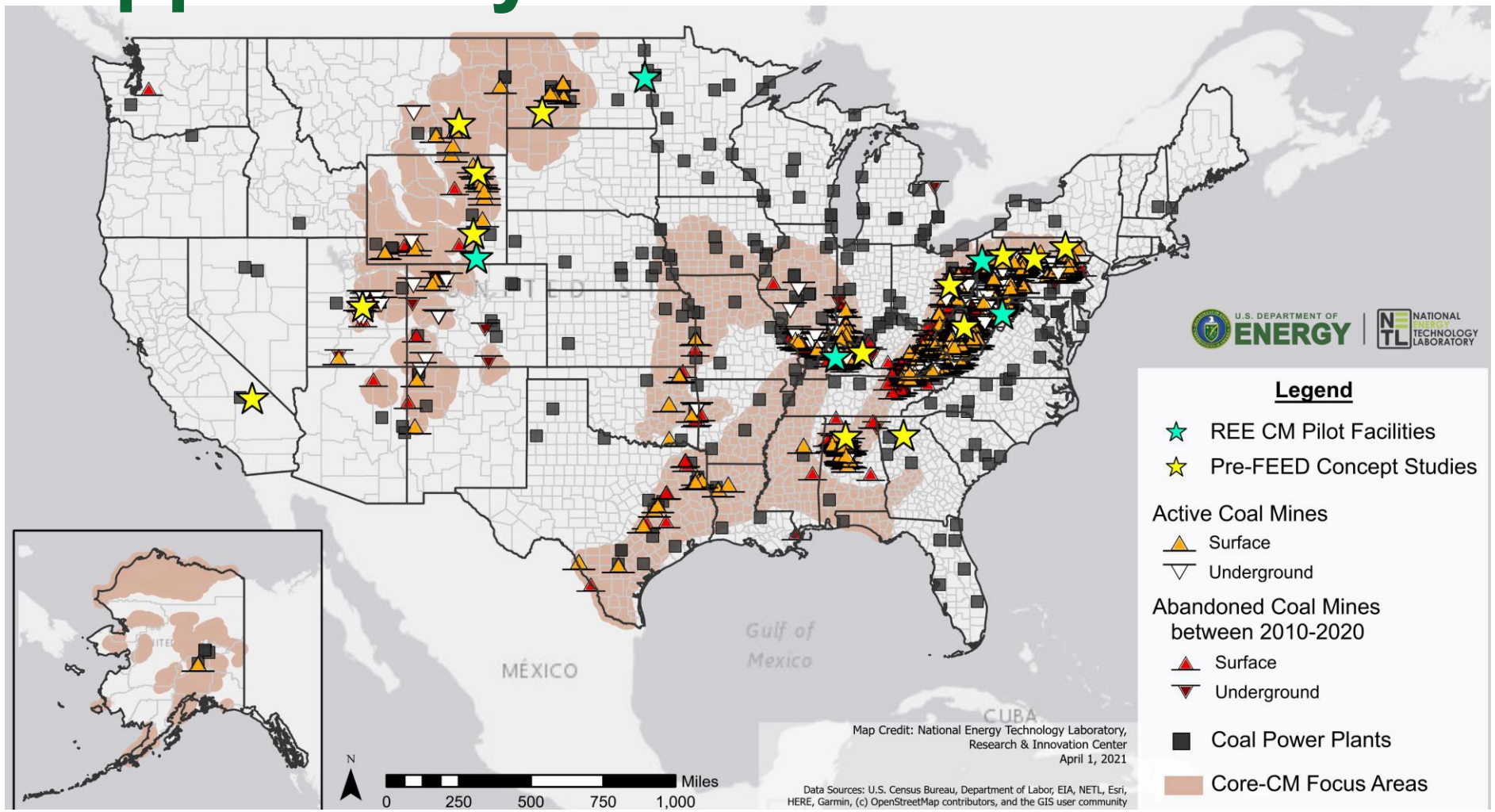
- **Pre-FEED studies for large-scale pilot projects (1-3 metric tons/day CM-REE)**
  - integrate conventional with advanced separation technologies and novel techniques
  - economically recoverable and environmentally sustainable production of CM-REE

The Opportunity: Abandoned Mines

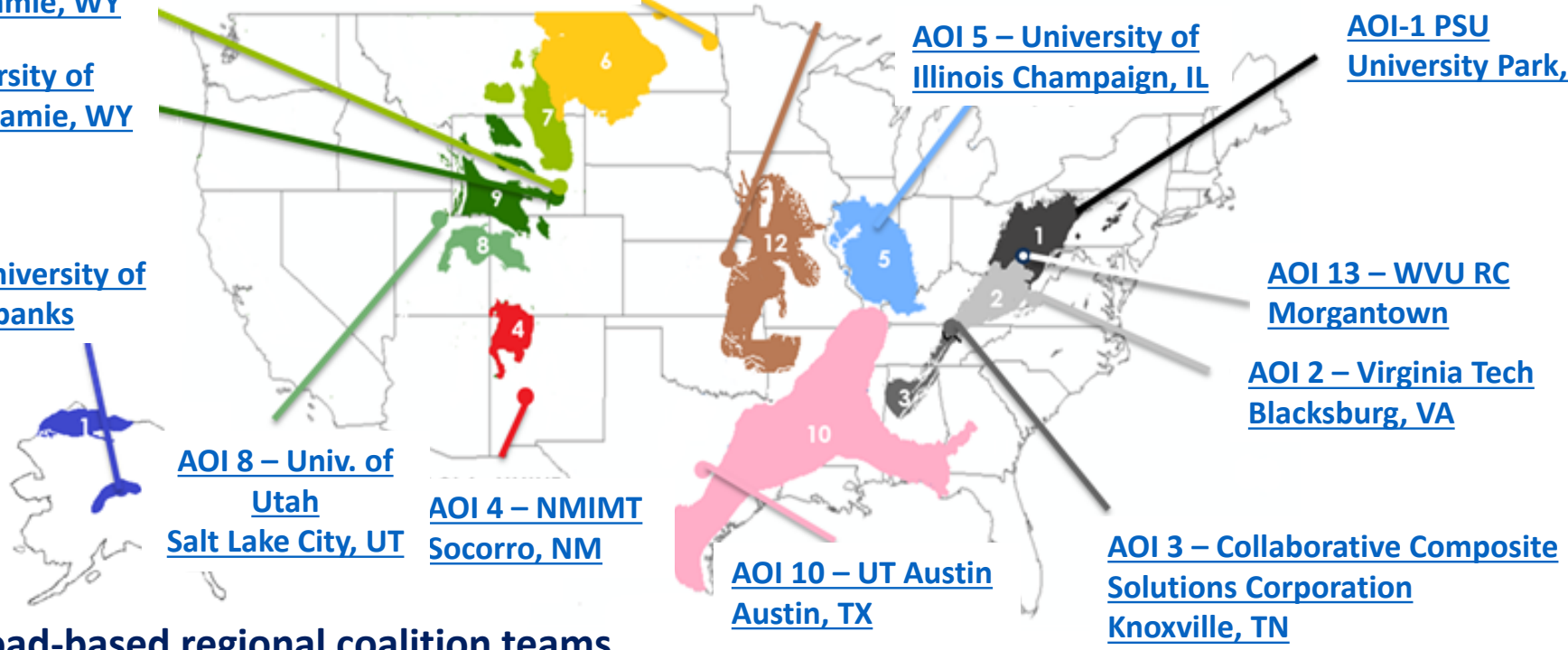


USGS MRDS lists 64,883 sites as past producers, inactive metal mines

The Opportunity: Unconventional Sources



CORE-CM Assessing Regional Opportunities



- Build broad-based regional coalition teams
- Investigate regional resources (materials, facilities, infrastructure, workforce)
- Catalyze regional economic growth and job creation
- Enable production of REE, CM and high-value, nonfuel, carbon-based products

CORE-CM Addressing Regional Challenges

- The primary objective is to build coalition teams that consist of private industry, university, state, local and federal government personnel, who will develop and implement strategies that enable each specific U.S. basin to realize its full economic potential for producing REE, CM and high-value, nonfuel, carbon-based products from basin-contained resources.
- Catalyze regional economic growth and job creation by realizing the full potential value of natural resources by expanding and transforming the use regional resources
- Integrate and leverage each region's unique attributes through coalitions of private industry, universities, and state, local and federal governments.
- Address the upstream and midstream critical minerals supply chain and downstream manufacturing of high-value, nonfuel, carbon-based products, to accelerate the realization of full potential for carbon ores and critical minerals within the U.S basins

CORE-CM Initiative – Phase 1

Phase 1: CORE-CM Basin Assessment (Basinal Foundation)

Initial identification/characterization of carbon ore-based resources and other unconventional and secondary resources

- Assessment of technology needs and initial field testing for future deployment
- Understanding of industrial and energy needs within each basin
- Strategies for how the region's natural resources, infrastructure, industrial needs, and environmental reclamation and remediation opportunities and innovation centers could be integrated

CORE-CM Initiative – Phases 2 and 3

Phase 2: CORE-CM Planning and Initial Basin Assessment Implementation

- Further build on Basinal Foundation (characterization, technology development and field validation)
- Develop and initiate basinal strategies (economical/environmentally sustainable manner)
- Conventional and novel carbon products should be considered
- Design of Regional Innovation Centers

Phase 3: CORE-CM Strategic Plan Implementation

- Implement the strategic plan including execution of technical pathways/commercialization
- Technology development and validation field-testing
- Programs for outreach, education and training

CORE-CM Crosscutting Themes

- Environmental Justice
- Characterization Methodologies
- Separations and Extraction Processes
- Technology Innovation Centers
- Engagement/outreach
- Remediation Opportunities

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Questions?