Rare Earth Elements and Critical Minerals 2021 Virtual Project Review Meeting

Mary Anne Alvin

Rare Earth Elements & Critical Minerals Technology Manger

May 25-26, 2021

Courtesy of NETL REE-CM Website

NATIONAL ENERGY TECHNOLOGY LABORATORY

Agenda – Tuesday, May 25, 2021

10:00 AM	**Program Overview** Mary Anne Alvin, National Energy Technology Laboratory
	Pilot-Scale Separation Systems
10:30 AM	**Demonstration of Scaled-Production of Rare Earth Oxides and Critical Minerals from Coal- Based Sources Using Innovative, Low Cost Process Technologies and Circuits (FE0031827)** Rick Honaker, University of Kentucky
11:00 AM	**High Yield and Economic Production of Rare Earth Elements from Coal Ash (FE0027167)** Dorin Preda, Physical Sciences, Inc.
11:30 AM	**Development and Testing of an Integrated AMD Treatment and Rare Earth/Critical Mineral Plant (FE0031834)** Paul Ziemkiewicz, West Virginia University
12:00 PM	**Rare Earth Element Extraction and Concentrate at Pilot-Scale from North Dakota Coal-Related Feedstocks (FE0031835)** Nolan Theaker, University of North Dakota
	12:30 PM BREAK

Agenda – Tuesday, May 25, 2021

Systems Analysis, Critical Minerals Separation, Geospatial Modeling

1:00 PM	**Rare Earth Elements-Critical Minerals - Systems Analysis (FWP-NETL)** Morgan Summers, National Energy Technology Laboratory
1:30 PM	**Rare Earth Elements-Critical Minerals - Separations Technology (FWP-NETL)** Christina Lopano, National Energy Technology Laboratory
2:00 PM	**Rare Earth Elements-Critical Minerals - Separations Technology (FWP-NETL)** Circe Verba, National Energy Technology Laboratory
2:30 PM	**Rare Earth Elements-Critical Minerals - Geospatial Sedimentary Modeling (FWP-NETL)** Kelly Rose, National Energy Technology Laboratory

Agenda – Wednesday, May 26, 2021

NATIONAL ENERGY TECHNOLOGY LABORATORY

Rare Earth Separation and Detection

10:00 AM	**Evaluation of Novel Strategies and Processes for Separation of Rare Earth Elements from Coal-Related Materials (FWP-LANL)** George Goff, Los Alamos National Laboratory
10:30 AM	**Application of Biosorption from REE Recovery from Coal By-Products (FWP-LLNL)** Yongqin Jiao, Lawrence Livermore National Laboratory
11:00 AM	**Evaluation of Laser-Based Analysis of Rare Earth Elements in Coal-Related Materials (FWP-LANL)** Samuel (Sam) Clegg, Los Alamos National Laboratory
11:30 AM	**New Sensing Mechanisms for Rare Earth Detection in Coal and Coal By-Product (FWP-INL)** Yoshiko Fujita, Idaho National Laboratory
12:00 PM	**Recovery of Rare Earth Elements from Coal Byproducts: Characterization and Laboratory-Scale Separation Tests (FE0029900)** Roe-Hoan Yoon, Virginia Polytechnic Institute and State University
12:30 PM	**Current Uses and Future Opportunities for US Industry in Rare Earth Elements and Critical Materials Technologies and Markets: Knowledge-Base Tool Development (FE0026825)** Randy Vander Wal, Pennsylvania State University

Rare Earth Elements and Critical Minerals

Aligned with Biden Administration

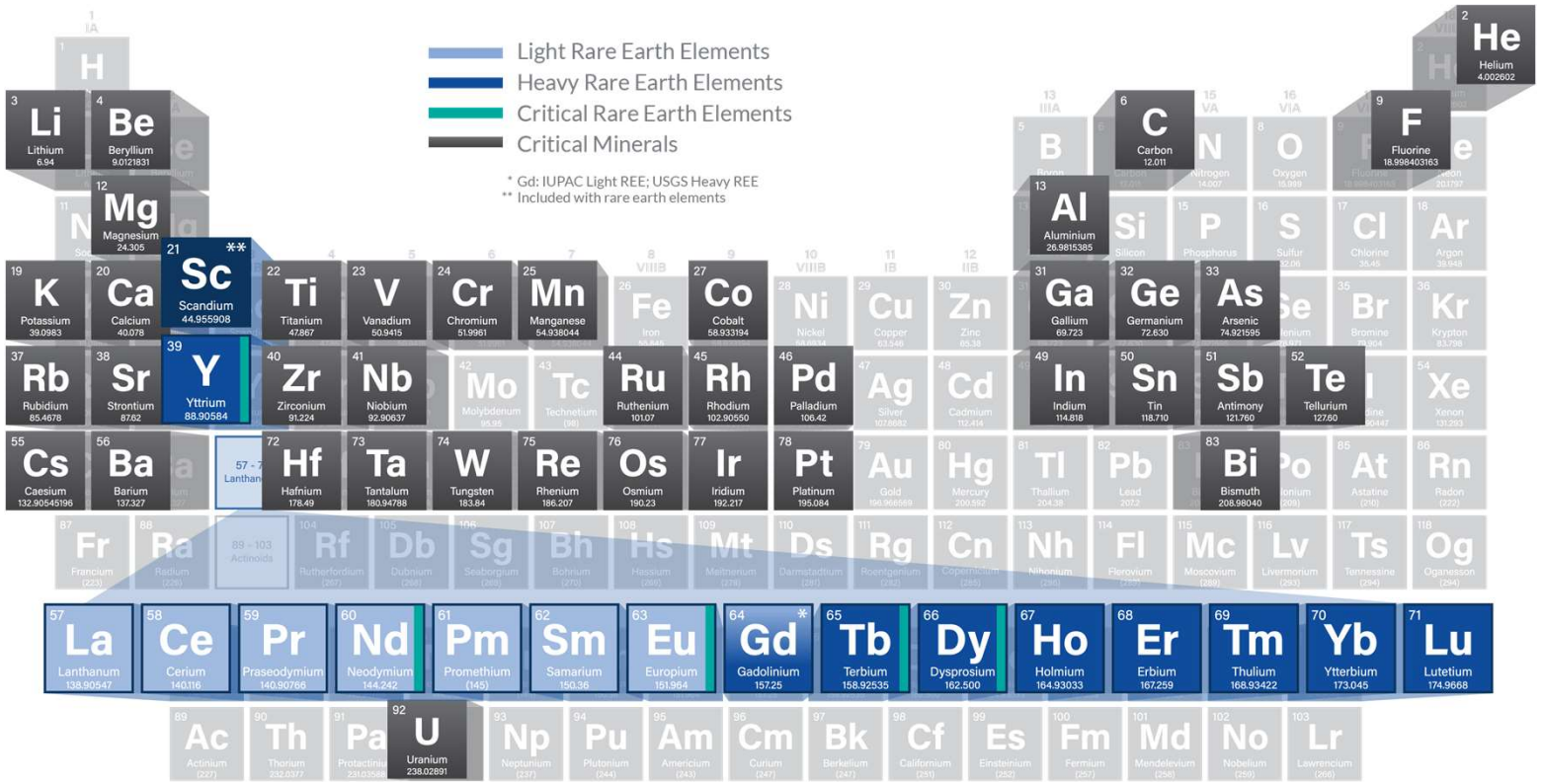
- Executive Order 14008 of January 27, 2021 – Tackling the Climate Crisis at Home and Abroad
- Executive Order 14017 of February 24, 2021 – America's Supply Chains

- ✓ ***Environmental Justice***
- ✓ ***Justice40 & Related Policies***
- ✓ ***Securing America's Critical Supply Chains***
- ✓ ***Good-Paying American Jobs***
- ✓ ***Technology Deployment (Pilot or Demo) by 2024***

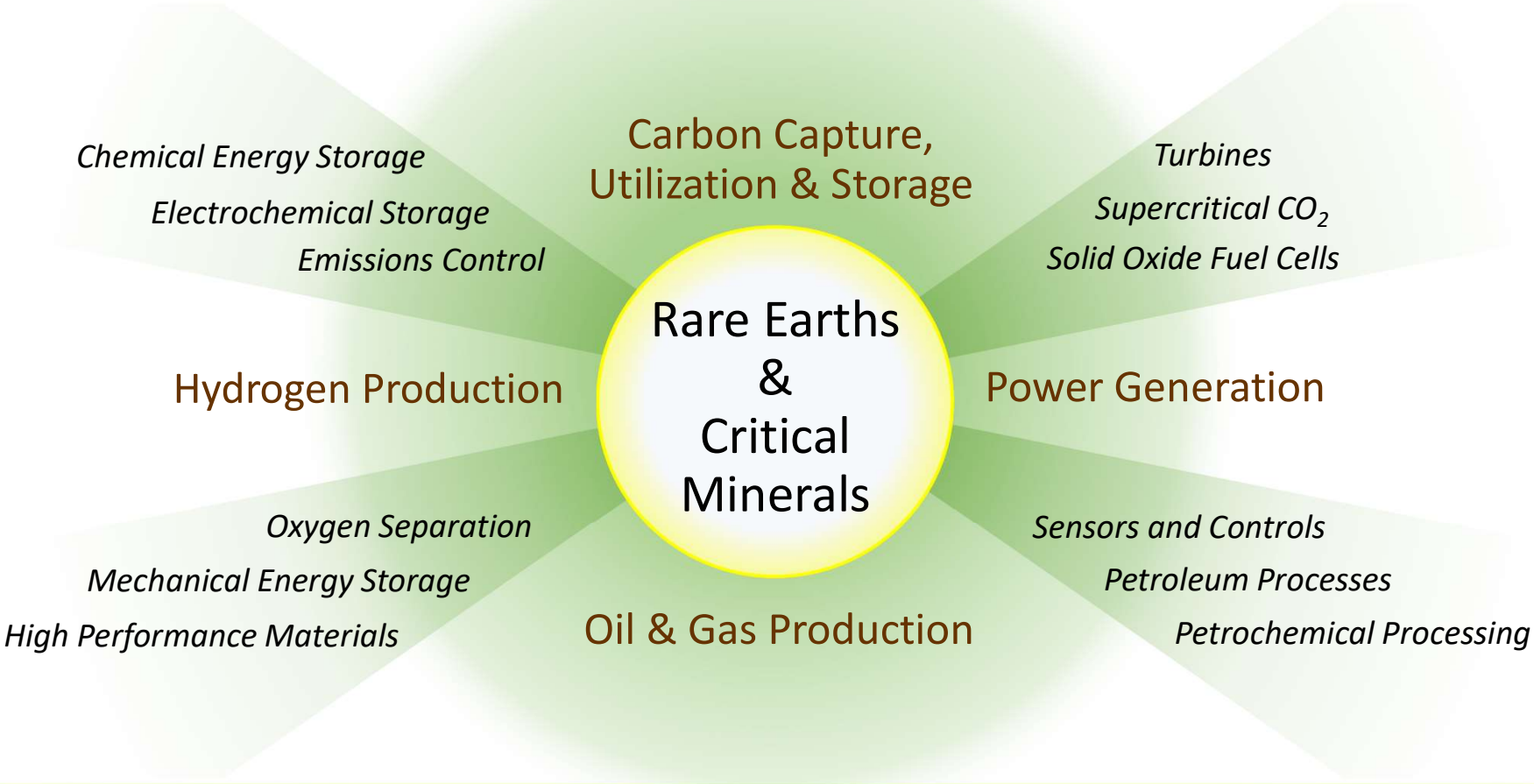
INITIAL REPORT TO THE PRESIDENT ON EMPOWERING WORKERS THROUGH REVITALIZING ENERGY COMMUNITIES: "Energy Communities and workers could be well-positioned to see new industrial jobs extracting critical materials from the waste left behind by coal mining and coal power plants in many communities."

https://netl.doe.gov/IWGInitialReport

Rare Earth Elements and Critical Minerals



REE-CM Critical Commodity & Technology



REE-CM Program

Mission

- Develop Economic, Competitive, Sustainable Domestic REE-CM Supply
- Economic and National Security

Objectives

- Recovery from Unconventional Resources
- Development & Utilization of Advanced REE-CM Separation Systems

Drivers & Challenges

- Off-Shore Supplier Dominance
- Market Volatility & Potential Price Fluctuation/ Manipulation
- Low REE-CM Content in Heterogenous Unconventional Resources

REE-CM Program

Goals

- Accelerate Domestic Engineering-Scale Prototype Facility Demonstration
- Demonstrate Technical-Economic REE-CM Production under Environmentally Benign Process Operating Conditions
- Produce Commercial-Grade Mixed REO/RES Concentrates & Beyond
- Realize the Full Potential Value of Natural Resources across Basins throughout the U.S.

Metrics

- Production of 1-3 tonnes (MT)/day of Mixed REO/RES
- Minimum REO/RES Concentration – 75% by weight

REE-CM Program – Commercialization Pathway

COMMERCIALIZATION
Technology available for wide-scale market use

DEMONSTRATION
System demonstrated in operational environment

SYSTEM TESTING
System performance confirmed at pilot-scale

DEVELOPMENT
Technology component validated/integrated

DISCOVERY

Program Initiated 2014

PROSPECTING | PROCESSING | PRODUCTION

TRL 7-8

Engineering-Scale Prototype Facility
1-3 tonnes MREO/day – Planned

FEED Study
Planned

FOA-2404
Advanced Processing Phase 1

FOA-2404
Advanced Processing *Phase 2 Planned*

FOA-2346
CORE-CM Phase 1

FOA-2346
CORE-CM *Phase2; Phase 3 Planned*

RFP
Concept & Feasibility (Pre-FEED) Studies

FOA-2003
REE System Optimization & Efficiency Improvements – **CM Production**

TRL 5-7

***Operational* – First-of-a-Kind Small Pilot-Scale Facilities**

FOA-1718
Transformational Separation

TRL 3-5

FOA-1202
Conventional REE Separation & Recovery – **80-90% Purity**

RFP 9067 & RFP 10982
Field Prospecting

2015 2020 2025

Enabling Technologies – Sensors, TEA, LCA, REE-SED

REE-CM Program

Process Development

DE-FOA-0001202

Opportunities to Develop High Performance, Economically Viable, and Environmentally Benign Technologies to Recover Rare Earth Elements (REEs) from Domestic Coal and Coal Byproducts

Status: Projects Completed/Near Completion
POP: Bench 3/1/2016 – 12/31/2019
Pilot 3/1/2016 – 6/30/2020 (10/31/2021)
Number of Awards: 4 (Phase 1 & Phase 2)

Performers

Pilot-Scale Facilities

- University of Kentucky – Coal Refuse & AMD
- Physical Sciences Inc – Ash

Bench-Scale Facilities

- West Virginia University – AMD
- University of North Dakota – Lignite

DE-FOA-0002003

Process Scale-Up and Optimization/Efficiency Improvements for Rare Earth Elements (REE) and Critical Materials (CM) Recovery from Coal-Based Resources

Status: Projects On-Going
POP: 10/1/2019 – 3/21/2022 (6/30/22)
Number of Awards: 3

Performers (AOI-2)

- University of Kentucky – Coal Refuse & AMD
- West Virginia University – AMD
- University of North Dakota – Lignite

REE-CM Program

Major Accomplishments

Three First-of-a-Kind Bench & Small Pilot-Scale Facilities Operational by 2019 Using Diverse Unconventional Feedstock Materials

Demonstrated REE Separation – Technical Feasibility

Production of Small-Quantities of High Purity (max ~98^{+}%) MREO/MRES

Co-Production of CM

~100% Recovery of REE from AMD

HREE/LREE >1 for AMD & Coal-Based Materials

Organic REE Association in Lignite

* Incorporation of Transformational Separation Concepts – Bio-Oxidation/H_2SO_4 Circuit –

* Demonstrated Production of 90% Lanthanum Oxide via Electrowinning

* Ion Flotation/Modified Lixiviants Enhance Simple Ion Exchange of REE in Coal Refuse Shales/Clays

** FOA-1718 Transformational Concept Development*

Two Additional Small Pilot-Scale Facilities to Be Commissioned by Fall 2021

REE-CM Program – 2021 Initiatives

DE-FOA-0002364

Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) Initiative for U.S. Basins

Status: Projects Selected
POP: 24 months
Number of Awards: 13

Objectives

- Catalyze regional economic growth and job creation by realizing the full potential value of natural resources, such as coal, across basins throughout the U.S.
- Address the upstream and midstream CM supply chain and downstream manufacturing of high-value, nonfuel, carbon-based products.
- Feedstock Materials: U.S. coals and associated by-products and waste streams

DE-FOA-0002404

Advanced Processing of Rare Earth Elements and Critical Minerals for Industrial and Manufacturing Applications

Status: Applications under Review
POP: 9 months
Number of Awards: TBD

Objectives

- Modular innovated REE and CM midstream processing technologies for the purification, recovery, individual separation and reduction to metals
- Processes are environmentally benign and sustainable
- Processes have the potential for reduced CAPEX/OPEX
- Feedstock Materials: Coal and coal by-products; Remediation and reclamation materials

REE-CM Program – 2021 Initiatives

RFP-89243320RFE000032 Production of Mixed Rare Earth Oxides (REOs) from Coal-Based Resources

Concepts
Status: Projects Completed
POP: 10/1/2020 – 12/30/2020
Number of Awards: 13

Feasibility (Pre-FEED)
Status: Projects Initiated
POP: 4/20/21-5/3/21 – 11/16/21-3/7/22
Number of Awards: 8

Performers

- Energy Fuels Resources
- Materia USA LLC
- MP Mines Operation LLC
- Tetra Tech, Inc.
- Texas Mines Resources Corp.
- University of North Dakota
- West Virginia Research Corp.
- Winner Water Services Inc.

PSU RFP 2019-5 (UCFER)

University Coalition for Fossil Energy Research – Topic Area V: Rare Earth Elements

Status: Project Initiated
POP: 4/1/2021 – 3/3/22
Number of Awards: 1

Performer

- The Pennsylvania State University – *Current Uses and Further Opportunities for U.S. Industry in Rare Earth Elements and Critical Minerals Technologies and Markets; Knowledge Base Tool Development*

REE-CM Program – 2021 Initiatives

DE-FOA-0002359 (SBIR)

FY 2021 Phase 1 Release 1 – Topic 27 Rare Earth Elements

A. Advanced Technology Development for Production of Rare Earth Metals
B. Transformational Technology Development for the Separation and Recovery of Rare Earth Elements (REE) and Critical Minerals (CM) from Coal-Based Resources

Status: Projects Initiated – February 21, 2021
POP: 9-12 months
Number of Awards: 2

Performers:

- Polykala Technologies, LLC - *Hydrogen Plasma Reduction of REOs/Salt for REMs Production (Subtopic 27A)*
- Skyhaven Systems, LLC – *Rare Earth Metal Separation and Recovery (Subtopic 27A)*

DE-FOA-0002360 (SBIR)

FY 2021 Phase 1 Release 2 – Topic 24 Rare Earth Elements

A. Advanced Technology Development for Production of Individually Separated, High Purity, (ISHP) Rare Earth Oxides/Rare Earth Salts (REO/RES)
B. Advanced Technology Development for Production of Rare Earth Metals
C. Production of Critical Minerals from Coal-Based Resources
D. Other

Status: Projects To Be Initiated – June 28, 2021
POP: 6-12 months
Number of Awards: TBD

Performers: TBD

REE-CM Program

Field Work Proposal (FWP) Projects

NATIONAL ENERGY TECHNOLOGY LABORATORY
Research and Innovation Center

- Real Time Aqueous REE Fiber Optic Sensors & LIBS
- U.S. Coal Basin Sedimentary Assessment
- REE-CM Embedded Database – Industry Impact; TEA & LCA
- Technology Commercialization Funding (TCF)
  - NETL - University of Wyoming Small Pilot-Scale Facility for REE Recovery from Powder River Basin Coal Ash

Los Alamos NATIONAL LABORATORY EST.1943

- Chemistry & Mineralogy of Coal-Based Resources
- Raman-LIBS Back-Pack Instrumentation (Mars)

Idaho National Laboratory

- Rapid Luminescent Sensing of Lanthanides in Fluoride Hosts (Coal Fly Ash Leachates)

Los Alamos NATIONAL LABORATORY EST.1943

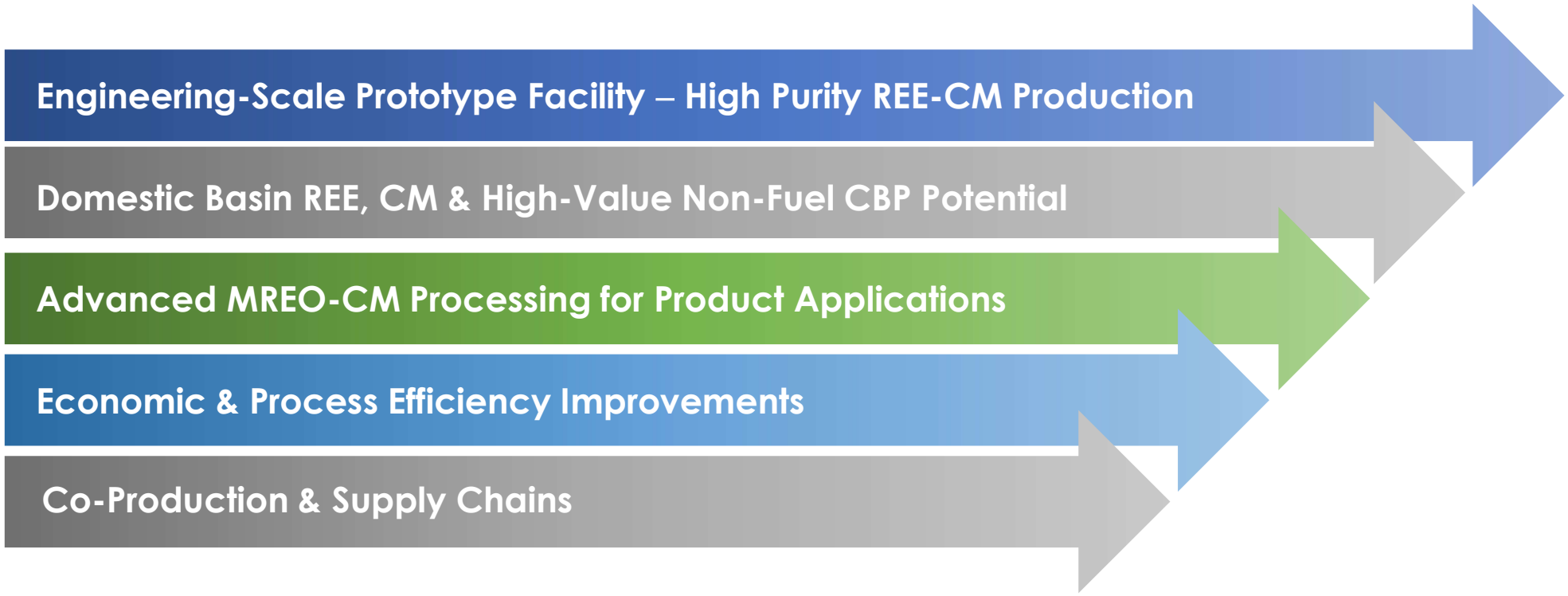
- Technology Transfer of Actinide Separation to REE Lanthanide Recovery

Lawrence Livermore National Laboratory

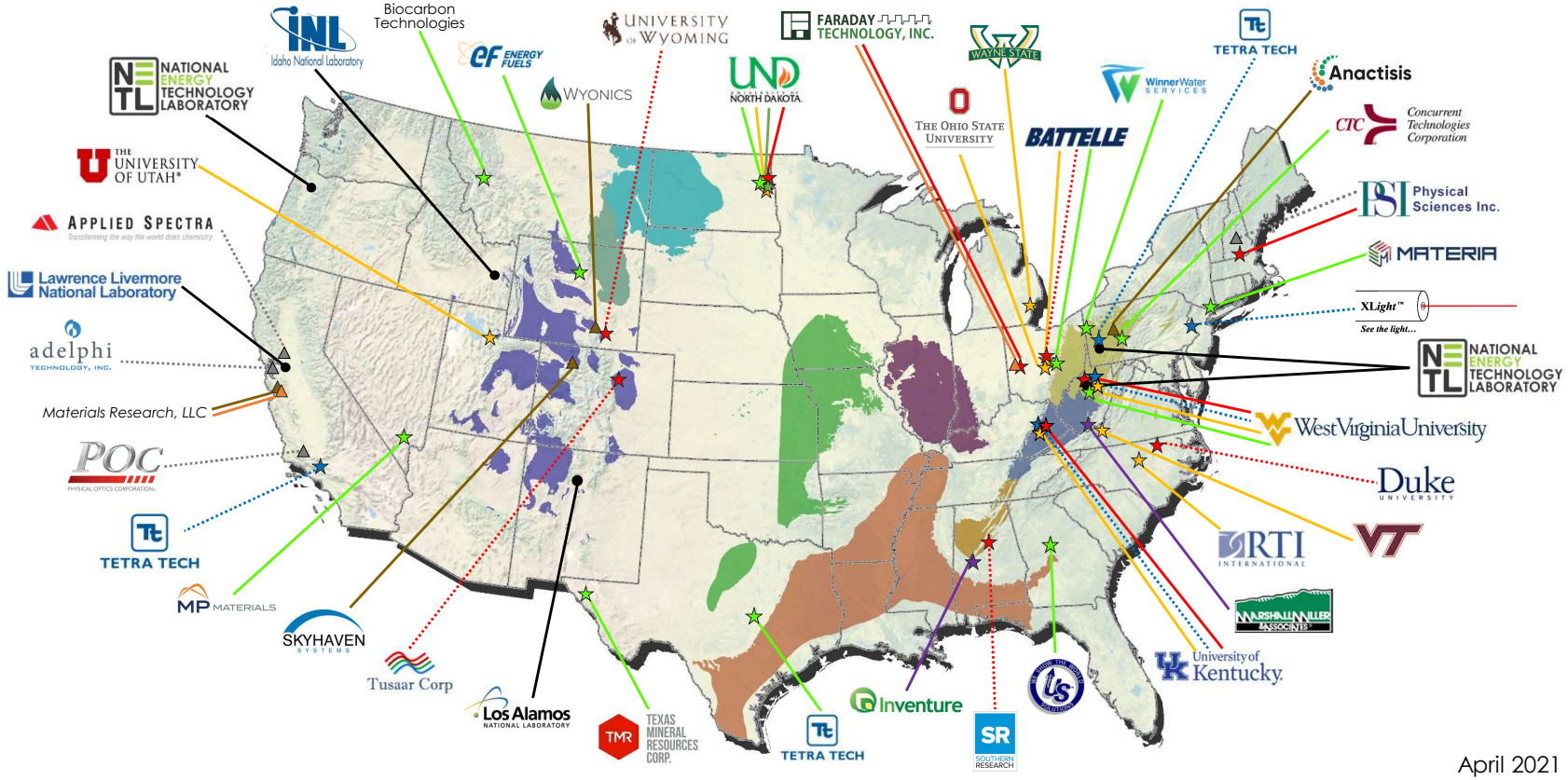
- Continuous Bioreactor System for REE Capture
- Technology Commercialization Funding

REE-CM Program

Program Direction



REE-CM Program – Acknowledgments



April 2021

REE-CM Program – Contact Information

Courtesy of NETL REE-CM Website

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National Energy Technology Laboratory

Visit Us at:

http://www.netl.doe.gov/research/coal/rare-earth-elements/

https://edx.netl.doe.gov/ree/

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