

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

AMMTO & IEDO JOINT PEER REVIEW

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Critical Materials – The Building Blocks for the Clean Energy Transition

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This presentation does not contain any proprietary, confidential, or otherwise restricted information



Background: Critical Minerals & Materials

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- Critical materials
 - have a high risk of a supply chain disruption;
 - serves an essential function in one or more energy technologies;
 - critical minerals as defined by USGS.
- AMMTO's research, development, demonstration (RD&D) portfolio is an innovation engine that will build connective tissue in DOE's Critical Materials RDD&OD Program
- AMMTO provides thought leadership across DOE and the US government

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

Batteries for electric vehicles (EV) & grid storage

Lithium, Cobalt, Nickel, Manganese, and Graphite

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; efficient lighting

White House Goals

- 100% clean electricity by 2035
- Net-zero economy by • 2050

DOE Goals

- 30 GW offshore wind by 2030
- 50% EV adoption by 2030

AMMTO Mission

Decarbonization

Challenges & Barriers

• Unprecedented critical materials demand driven by decarbonization goals



Growth to 2040 by sector

 Domestic supply chain vulnerabilities based on geographic concentration and lack of domestic capabilities



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Securing America's Clean Energy Supply Chain



<u>11 deep dive assessment documents</u>:

- carbon capture materials,
- electric grid including transformers and high voltage direct current
- energy storage,
- fuel cells and electrolyzers,
- hydropower including pumped storage hydropower (PSH),
- neodymium magnets,
- nuclear energy,
- platinum group metals and other catalysts,
- semiconductors,
- solar photovoltaics (PV), and
- wind.

2 crosscutting topics:

- commercialization and competitiveness, and
- cybersecurity and digital components.

https://www.energy.gov/policy/supplychains

DOE Critical Minerals/Materials (CMM) Vision & Strategy

Vision:

- Reliable, resilient, affordable, diverse, sustainable, and secure domestic critical mineral and materials supply chains
- Support the clean energy transition and decarbonization of the energy, manufacturing, and transportation economies
- Promote safe, sustainable, economic, and environmentally just solutions to meet current and future needs

CMM Strategy & Program:



https://www.energy.gov/critical-minerals-materials

DOE is an integral part of an <u>All-of-Government Strategy</u>

Critical Minerals/Materials Portfolio: Strategy & Objectives

White House & DOE Climate Goals

A net-zero economy by 2050 that leads to equitable outcomes





Opportunity Space: Addressing Supply Chain Gaps

AMMTO is uniquely positioned to accelerate industrial adoption of cutting-edge technologies to • maintain domestic competitive edge



Battery Critical Materials

Critical Minerals/Materials Portfolio: Overview



Critical Minerals/Materials Portfolio: Overview



Critical Materials Institute – an Energy Innovation Hub



Focused on advancing cost-effective extraction, separation, processing, metallization, substitution, and recycling of critical materials, to support U.S.-based supply chains for high-value add technologies that rely on these materials (permanent magnets, energy storage, electronics).



People: 250+ strong, bolstered by education and workforce development

Innovative Ecosystem: network of 45+ active team members across critical material supply chains



Portfolio: 45 early-stage research projects that have resulted in 500+ publications, 7 R&D100 Awards, 32 patents, and licensed 18 technologies to industry





Demonstration Projects to Address Supply Chain Gaps



Field Demonstration of Battery Grade Lithium Hydroxide from Domestic Claystone Resources (American Battery Technology Company)



 \$57.7M follow-on funding from MESC (BIL 40207) to commercialize battery-grade lithium hydroxide from unconventional domestic sedimentary resources



- \$10M follow-on funding (\$10M) from VTO (BIL 40208) to advance an integrated lithium-ion battery recycling system
 - Includes INL/CMI technology to improve water utilization during processing of spent batteries





Process scheme for combined water-selective extraction and Dimethyl ether (DME) driven fractional crystallization

Lithium RD&D Virtual Center

- Eight projects selected from the AMO FY20 Critical Materials FOA
- Bi-annual Lithium RD&D Coordination meetings
- Build an innovation ecosystem and facilitate rich scientific and technical exchange and discussion
- Coordination with other related federally funded efforts



- TEA considers 15-year project life _
 - MPSE-X CapEx is about 50% of comparable technology ٠
 - Breakeven year for cash flow is >50% earlier than comparable technology
 - Plant erection time is 50% of comparable tech.



MPSE-X:

Monolith

36 Slope Channels

~50 ml/min

PPV: Single Sloped Channel Device

1 Slope Channel 1-2 ml/min



TRL 5 MPSE-X100

MPSE-Y: Numbered-up with coated glass inserts Numbered-up



100 Slope Channels ~50-200 ml/min

100 Slope Channels ~100-600 ml/min

Funding Opportunity Announcement (FOA): Lithium Extraction & Conversion from Geothermal Brines

- Joint FOA with the Geothermal Technologies Office
- The goals of this FOA are to:
 - Enable environmentally and socially responsible domestic manufacturing of battery-grade (i.e. high purity) lithium hydroxide from geothermal brines;
 - Diversify the domestic supply of lithium hydroxide;
 - Validate and demonstrate domestic pilot plants and related technologies to support the transition to U.S. manufacturing; and
 - Mature nascent technologies, processes, and methods that improve one or more unit operations of direct lithium extraction systems.
- AMMTO anticipates making up to 6 awards across 2 topics

Topic Area	Full Applications	Max. Project Funding	Estimated # Projects	Total Estimated Funding
1: Field Validation	6	\$5M	1-2	\$10 million
2: Applied R&D	39	\$500K	2-4	\$2 million

Future Work: Approach



Future Work: Current Efforts



Critical Materials Assessment

- Results will inform DOE's CM Program and eligibility for the Inflation Reduction Act 48C tax credit
- AMMTO intends to issue a Request for Information to solicit public comment on the results and methodology on May 31

Education & Workforce Development

- April Workshop
- Summer Report



- E-waste Recycling
 - Request for Information closed on May 1



Medium-term (2020-2030) criticality matrix

Critical Materials –

The Building Blocks for the Clean Energy Transition

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https://www.energy.gov/critical-minerals-materials

https://www.energy.gov/eere/ammto/critical-minerals-andmaterials

Backup Slides

Critical Minerals & Materials (CMM) RD&D in AMMTO

AMMTO's CMM portfolio addresses high-impact opportunities and challenges across the entire life cycle of high priority CMM for energy technologies

- Research, development, and demonstration for high-priority critical minerals and materials, aligned with the DOE **Critical Minerals and Materials Strategy, to:**
 - Build resilient domestic supply chains to support the clean energy transition
 - Accelerate adoption of innovative S&T solutions to improve efficiency and reduce negative impacts
 - Foster a robust innovation ecosystem to meet industry and research workforce needs



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Hub

Pillars of the CMM Strategy



Diversify & Expand Supply: Diversify and expand critical minerals and materials supply from varying sources while preserving functionality, minimizing waste, and increasing techno-economic coproduction of materials



Develop Alternatives: Innovate alternative materials and/or manufacturing components



Materials and Manufacturing Efficiency: Use and process materials efficiently across the entire supply chains and life cycle



Circular Economy: Remanufacture, refurbish, repair, reuse, recycle, and repurpose



Enabling Activities: Cross-cutting functions, such as criticality assessments, stockpiling, advanced theoretical, computational, and experimental tools.

DOE and the Federal Landscape

- DOE's primary role is to advance research, development, demonstration, and deployment spanning basic science to technology innovation.
 - Supported by analyses, domestic and international standards, and international collaboration with allied countries
- DOE does not have regulatory authority to issue permits for critical minerals or materials activities.
- DOE partners with other federal agencies and departments
 - Federal Strategy on Critical Minerals
 - Mining Reform
 - National Blueprint for Lithium Batteries
 - American Battery Materials Initiative
 - International Conference on Critical Materials
 - Minerals Security Partnership



Unprecedented Critical Materials Demand Driven by Decarbonization Goals

Mineral demand for clean energy technologies by scenario



Growth to 2040 by sector

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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.

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

Sustainable Development Scenario = SDS

Supply Chain Vulnerabilities

- → Up-to-mid stream capabilities *are geographically concentrated*
- → Lack of midstream capabilities are a gap that limit growth of upstream supply and downstream value-add manufacturing

Geographic concentration of supply chain stages for sintered NdFeB magnets





https://www.energy.gov/policy/securing-americas-clean-energy-supply-chain