U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

AMMTO & IEDO JOINT PEER REVIEW

May 16th-18th, 2023

Washington, D.C.

Critical Materials Institute| AMMTO

Thomas Lograsso, Ames National Laboratory

ED2802 | Budget year 10

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Project Overview

DOE's Energy Innovation Hub with a mission to accelerate innovative scientific and technological solutions to develop resilient and secure supply chains for rare-earth metals and other materials critical to the success of clean energy technologies.

Project Outline

Innovation: Mineral and materials processing improvements including alternatives

Project Lead: Thomas Lograsso, Ames National Laboratory

Project Partners: Ames National Laboratory, Colorado School of Mines, Idaho National Laboratory, Lawrence Livermore National Laboratory, Oak Ridge National Laboratory

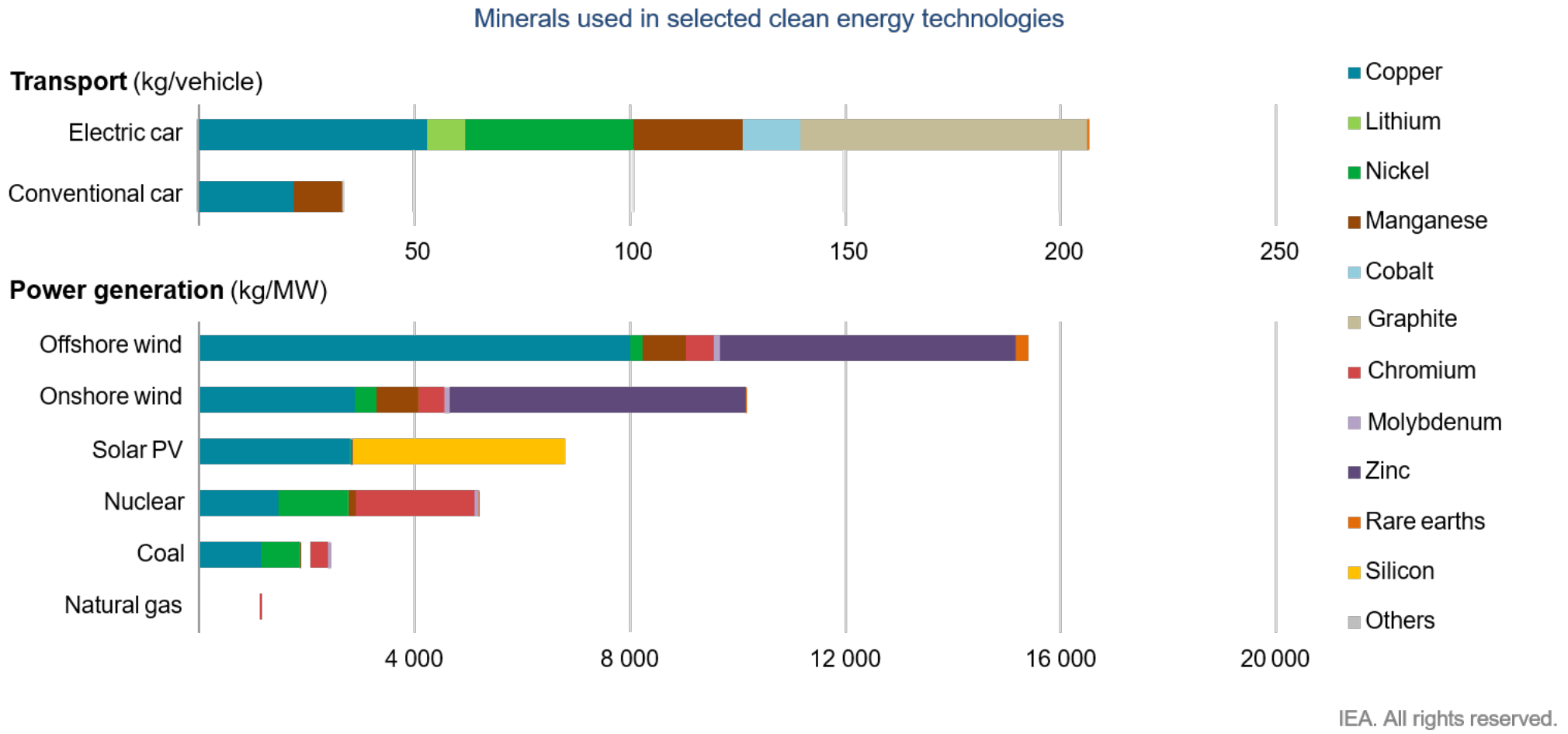
Timeline: 5-Year authorization – 2018-2023, 95%

Budget:

	FY21 Costs	FY22 Costs	FY23 Costs	Total Planned Funding
DOE Funded	$22,925,695	$24,692,578	$11,296,438	$58,914,711
Project Cost Share	$848,204	$1,959,194	$424,216	$3,231,614

End Project Goal: Develop critical materials technology that is adopted by industry through private and public investment, licensing, and commercialization activities.

Background & Strategic Approach



Notes: kg = kilogramme; MW = megawatt. Steel and aluminium not included. See Chapter 1 and Annex for details on the assumptions and methodologies.

Battery graphite, nickel, cobalt, manganese, MagREO: Adamas Intelligence Production: USGS, Morgan Stanley, BP, Fitch, Excl. synthetic graphite Copper, Aluminum (vehicle): USB estimates of ChevyVolt

Background & Strategic Approach

Critical Materials Priorities

Diversify and expand the supply of materials in the appropriate quantities needed for the clean energy transition through unlocking of domestic sources.

Reduce chemical, material, and energy intensity of mineral and materials processing.

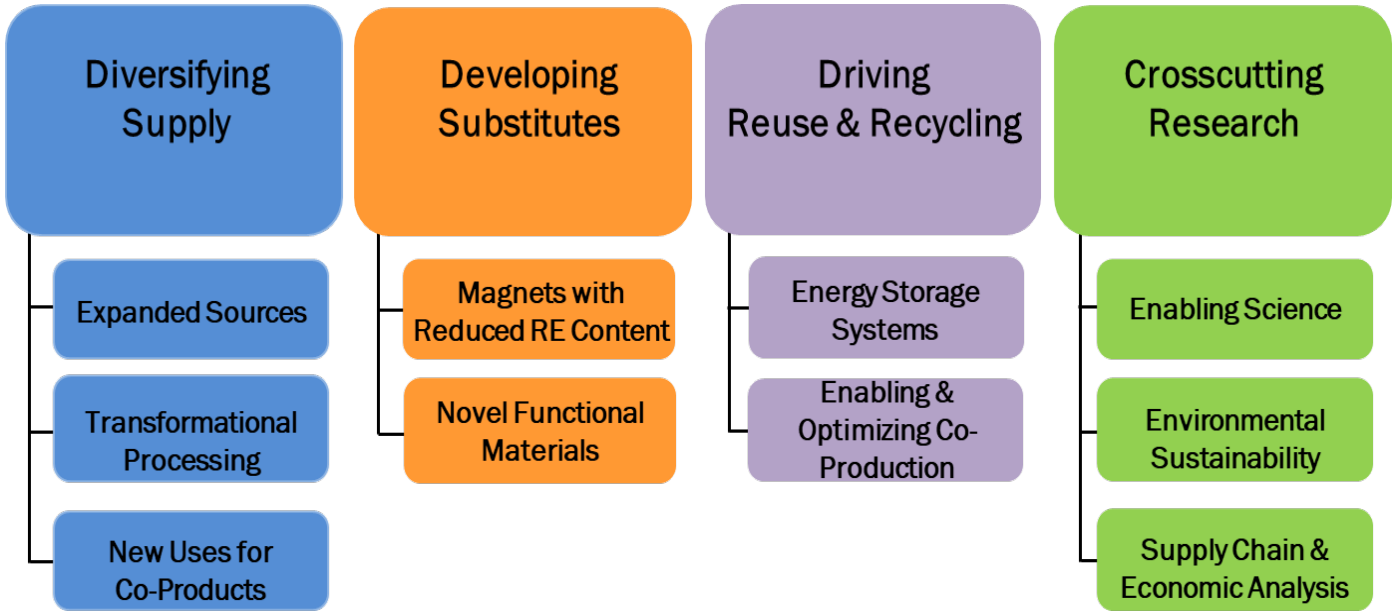
Decrease environmental, health, and water usage associated with critical materials recovery and usage through circularity principles to approach zero waste processing.

Background & Strategic Approach

Portfolio: 46 early-stage research projects that have resulted in 570+ publications, 90+ inventions, 25+ patents and 19 licenses

Innovative Ecosystem: network of 55+ active team members and 50+ affiliates

People: 275+ researchers, bolstered by strong education and workforce development



AMES NATIONAL LABORATORY
Creating Materials & Energy Solutions

MINES

INL
Idaho National Laboratory

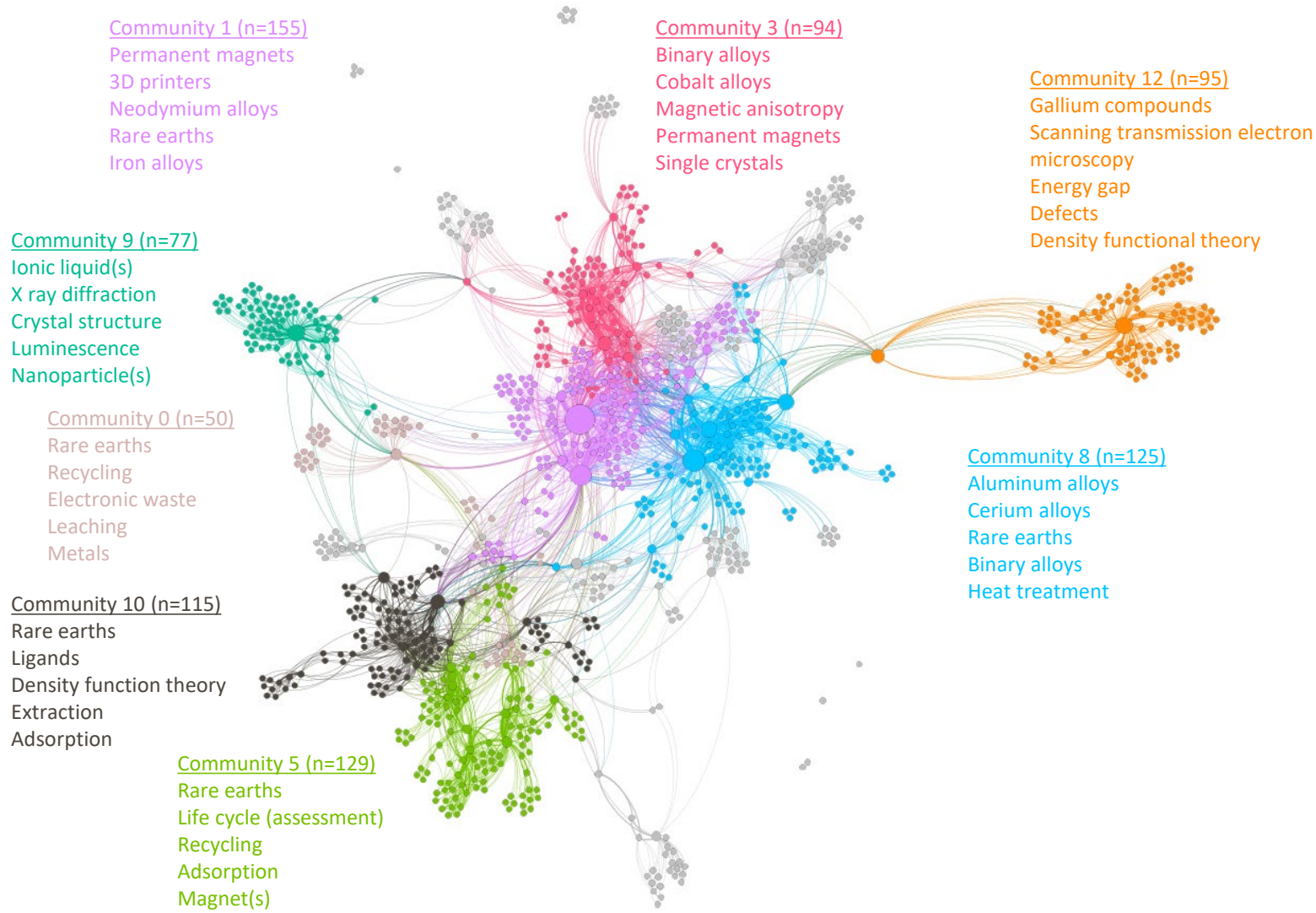
Lawrence Livermore National Laboratory

OAK RIDGE National Laboratory

Results and Achievements

Preliminary results of citation analysis of 545 CMI publications (through 2022):

- Average Field-Weighted Citation Impact (FWCI) = 1.51
- 98.7% of 1,039 individual authors connected to other CMI publications



Results and Achievements

Rare Earth Magnets

- Marshallton Research Laboratories plans to scale up commercial synthesis of CMI's diglycolamide extractants with separation factors 2-3 times over existing extractants.
- Alternative low temperature direct metal refining to metals and magnet alloys at a 10 Kg-batch scale by Terves LLC.
- Western Digital is currently evaluating the use of CMI's La-Nd-Fe-Co-B magnet in their hard disk drives.
- Recycling of e-waste for magnet recovery by Acid-free methods licensed by TdVib. Pilot plant operations (8000 kg batch size) near completion.

Solvent Extraction Testbed Facility with centrifugal contactor system

Results and Achievements

Li-ion Battery

- Lithos has licensed a bundle (6) patents for lithium recovery technology from produced waters.
- CMI is developing new concepts to improve Rio Tinto Boron planned lithium recovery from borate mining tails.
- Exergy Systems, Inc. has licensed a CMI technology for the recovery of high purity lithium and manganese salts from waste batteries
- Quantum Ventura, Inc. is piloting CMI technologies (E-RECOV and EC-Leach) for energy- and cost-efficient recovery of rare-earths and battery metals from e-waste.

E-RECOV pilot plant at Faraday Technology

QUANTUM VENTURA

FARADAY TECHNOLOGY®

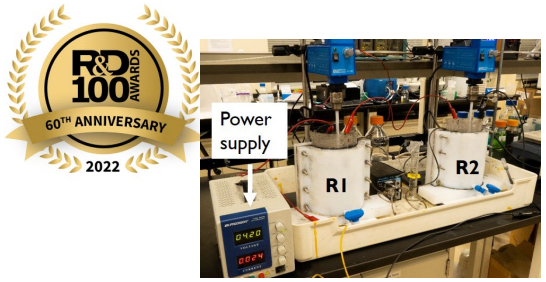
Results and Achievements

Metrics

- 103 Invention Disclosures (193 cumulative)
- 26 Awarded Patents (32 cumulative)
- 15 Technologies Licensed/Optioned (19 cumulative)
- 308 Publications (569 cumulative)

EC-Leach

Uses renewable energy, instead of chemicals, to lower carbon footprint of recycling.



Acid-free dissolution recycling REE, Co

Eliminates operational hazards and negative environmental impacts.

Additively printed high performance magnets

Performance of additive manufactured magnets is comparable to injection molded magnets

Tough SmCo

Creating mechanically robust magnets for more efficient manufacturing

RE-Metal

A method for electrochemical reduction of rare earth (RE) metal ions in a non-aqueous solvent system.

ACE: The Ageless Aluminum Revolution

Al-Ce alloy creates new uses for cerium

Future Work, Technology Transfer, & Impact

Future Work:

- Renewal of CMI for a Phase III operational period is under review.

Impact:

- CMI maintains a balance portfolio of science capabilities and expertise and technology maturation projects
- CMI portfolio address technology needs identified in magnet and battery roadmaps (see poster session)
- CMI has developed technologies along the various stages of the supply chains for both rare earth materials as well as battery materials
- CMI has created an innovation ecosystem that facilitates the transition of technology from the lab scale into pilot scale operations through follow-on public/private investments

Questions?

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