CREaTe
consortium for RARE EARTH technologies

ROADMAPPING EFFORT

- EXTRACTING
  Government policies and incentives would help offset existing market dynamics.
- PROCESSING
  Domestic supply chain needs more vertical integration to ensure extracted minerals stay in the U.S. for processing.
- RECLAIMING
  Annual assessments of current inventory and demand forecasts for reclaimed REE elements and product forms are needed.
- RARE EARTH ALTERNATIVES
  Investment into computational simulation is needed to predict performance of REE alternatives.

The Consortium for Rare Earth Technology (CREaTe) presents this report on:

Key Findings and Recommendations from the Roadmapping Workshop

The CREaTe mission is simple: **to develop technologies for extracting, processing, reclaiming and finding alternatives for Rare Earth Elements (REE) with improved economic feasibility and reduced environmental impact.**

CREaTe focuses on enabling collaborative technology development from pre-competitive roadmapping up through prototype development and production for the benefit of the entire U.S. industrial base. The end goal is to **leverage collaboration to achieve U.S. Rare Earth Element Independence.**

In June 2022, members of CREaTe and key government stakeholders conducted a roadmapping workshop to identify technology gaps, and the enabling technologies needed to close the gaps. The workshop was divided into four separately facilitated sessions:

1. Extracting
2. Processing
3. Reclaiming
4. Rare-Earth Alternatives

A list of facilitators and participants is provided in Appendix 1.

The following pages contain a summary of the key findings and recommendations from each of the four sessions.

EXTRACTING SESSION: Key Recommendations

1. Companies that perform extracting need more insight into end user demand. This includes the need to better understand the types of materials required, quantities, interest in extracting byproducts, and stronger connections between extractors, researchers, and end-users.
2. Many environmental feedstocks (e.g., ore, coal ash) have associated radioactive elements (Thorium, Uranium) or other hazardous substances (Arsenic) that are difficult and costly for the extraction industry to handle, especially at scale. Investment is needed into: 1) technology that can selectively remove uranium or thorium early in the extraction process, 2) effort that help extractors form partnerships with companies permitted to handle radioactive or hazardous materials, and 3) developing new wasteforms for toxic substances to mitigate the long-term hazards.
    a. Funding estimate: $5M-$10M
    b. Timeline estimate: 3-5 years
3. Government policies and incentives are needed to make extracting more profitable, increase market stability, offset international market controls, and to counteract anti-mining sentiment to make it easier to develop domestic supplies of critical minerals. Domestic extractors would benefit from “buy American” policies as well.
4. Lithium is the critical feedstock for rechargeable, and the U.S. has limited domestic production. Investment into new sorptive or reactive technologies to separate lithium within brines would greatly decrease the energy cost of lithium extraction.
    a. Funding estimate: >$10M
    b. Timeline estimate: >5 years
5. Other ideas included investments to: 1) extract uranium from seawater, 2) extract noble gases from air, and 3) extracting other rare earths from alumina “red mud”, acid mine drainage, or mining waters leftover from the extraction of primary metals from ore bodies.

PROCESSING SESSION: Key Recommendations

1. The domestic supply chain needs to be recreated to support more vertical integration so that extracted minerals stay in the U.S. for processing. Investment into domestic solvent extraction and alternative technologies to separate individual REE metals from mining material is needed.
    a. Funding estimate: >$100M
    b. Timeline estimate: 3-5 years
2. Foreign processors benefit from larger scale operations and looser environmental restrictions, and U.S. processors need policies and incentives to help them operate at scale, while complying with environmental regulations. Domestic processors would benefit from quicker permitting, offtake agreements, and buy American policies.
3. Investment into new separation technologies, including the ability to separate light REEs from heavy REEs, is needed.
4. Teaming with allies and friendly countries should be encouraged. Studies are needed to better understand what resources and capabilities our partner nations have, and how the U.S. can collaborate with them to reduce dependence on existing foreign sources.

RECLAIMING SESSION: Key Recommendations

1. Annual assessments of current inventory and demand forecasts for reclaimed REE elements and product forms are needed.
2. Government policies and incentives are needed to encourage companies and citizens to recycle end of life products containing REE materials.
3. An assessment of existing domestic and foreign recycling capabilities, and the associated economics is needed to identify where additional investments should be made to increase domestic reclaiming capabilities.

RARE EARTH ALTERNATIVES SESSION: Key Recommendations

1. Better insight into the priorities of end users and their applications is needed in order to identify which REEs have the greatest need for alternatives, and what property characteristics are most sought after.
2. Investment into computational simulation is needed to predict the required process flow, resulting microstructure and mechanical properties, and performance characteristics of REE alternatives.
3. Efforts to redesign products may need to be part of the equation. For example, in some instances where a magnet is used, instead of trying to find alternate materials that replicate REE properties used in magnets, can the application be re-designed so that something else entirely different then a magnet is used to accomplish the function?

APPENDIX 1
Facilitators and Participants

WORKSHOP FACILITATORS

CTC
Batelle
SRI International
Edison Welding Institute
Advanced Technology International

WORKSHOP PARTICIPANTS

Ames Laboratory	Materion	TechConnect
Applied SBC Systems	MPI Materials	Total Energetics
ATI	National Energy Technology Laboratory	Tussar Corp.
Booz Allen Hamilton	OSK	University of Arizona
Department of Defense	Pangea	University of Central Florida
DPA Title III	Penn State	University of Kentucky
Egor R&D Inc	PerkinElmer	University of Nevada
Guided Particle Systems	Powdermet Inc.	University of Tennessee
Graphene Laboratories	Questek Innovations	UTR
GreenMet	Sandia National Lab	VIP Global Net LLC
HII	Savannah River National Lab	Virginia Tech
Idaho National Laboratory	SMI, Inc.	VPI Engineering
JA Green & Co	SNJ LLC	Weinberg Medical Physics
Katz Water Tech	Southern Company	Worchester Polytechnic Institute
Lawrence Livermore National Laboratory	SRI International	XSB, Inc.
Leidos	TdVib/REECCyling	