Critical Materials Institute
AN ENERGY INNOVATION HUB

1. What is the problem? Lack of secure supply chains for some raw materials critical to clean energy technologies hinders U.S. manufacturing and energy security.

   These critical materials (a) provide essential and specialized properties to advanced engineered products or systems for which there are no easy substitutes and (b) are subject to supply risk.

   Rare-earth elements, with essential roles in high-efficiency motors and advanced lighting, are the most prominent of the critical materials today. Rare-earth metals and alloys are not manufactured in the United States, despite geologic resources, because the processes required to separate individual rare earths from one another and then convert them to metals and alloys are inefficient, costly, polluting, and potentially damaging to worker health and safety. The solution is innovation throughout the rare-earth supply chain.

   Other critical materials today are lithium in batteries and tellurium in photovoltaic materials.

2. What is CMI's mission? To assure supply chains of materials critical to clean energy technologies—enabling innovation in U.S. manufacturing and enhancing U.S. energy security.

3. How will CMI secure supply chains of critical materials? By *developing*, *demonstrating*, and *deploying* technology (a) to diversify and expand the availability of these materials throughout their supply chains, (b) to reduce wastes by increasing the efficiency of manufacturing and recycling, and (c) to reduce demand by identifying substitutes for critical materials. In all three areas, the needs of US manufacturing drive CMI's research agenda. From the outset, every project has a commercialization plan. (See the addendum to this document for a list of selected research projects.)

4. What will CMI accomplish?
   Within its first five years, CMI will develop at least one technology adopted by U.S. companies in each of three areas:

   a. Diversify and expand production—(i) design separations agents to improve production efficiency, reduce costs, minimize environmental impact and thus enhance the commercial viability of new rare-earth mines, (ii) develop transformative and environmentally benign technologies that make possible domestic manufacturing of rare-earth metals, alloys, and other products, and

(iii) design new chemical extractants that will transform the recovery of lithium from highly concentrated brines.

b. Reduce wastes—(i) improve the efficiency with which rare earths are utilized in manufacturing, and (ii) enhance efficient reuse and recycling of manufacturing wastes and materials in discarded household products.

c. Develop substitutes—invent and qualify new materials for use in existing products, and redesign products to accommodate new materials.

5. Who are the partners in CMI? Led by the Ames Laboratory, Iowa, CMI consists of scientists and engineers at four national laboratories of the Department of Energy, seven universities, and six industrial partners.[1] CMI's leaders come from five of these institutions, and they manage CMI's geographically dispersed labs as if they were a single organization.

For more information, see http://cmi.ameslab.gov/.

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Addendum: Selected CMI Projects by Category

Diversify and Expand Production

- Recovery of rare-earth elements from phosphate ores
- Enhanced separation of rare-earth elements
- Conversion of rare-earth oxides to metals, alloys, and materials
- Improved methods for lithium extraction

Reduce Wastes

- Recovery and re-use of rare-earth metals from fluorescent lamps
- Cost-effective recycling of rare-earth magnets
- Bioleaching for recovery of recycled rare earths
- Beneficiation and recycling of photovoltaic materials

Develop Substitutes

- Reducing the rare-earth content of high-performance magnets
- Optimizing grain boundaries and interfaces in fine-particle magnets
- Replacing europium and terbium in advanced lighting systems

[1] The national laboratories are: Ames, Idaho National Laboratory, Lawrence Livermore National Laboratory, and Oak Ridge National Laboratory. The academic institutions are: Brown University, Colorado School of Mines, Florida Industrial and Phosphate Institute, Iowa State University, Purdue University, Rutgers University, University of California at Davis. Industry partners are: Advanced Recovery, Cytec, GE Global Research, Molycorp, OLI Systems, and Simbol Materials.