Creating Materials and Energy Solutions

THE Ames Laboratory
Creating Materials & Energy Solutions

U.S. DEPARTMENT OF ENERGY

IOWA STATE UNIVERSITY

US-EU ENERGY COUNCIL

Trans-Atlantic Workshop on Rare Earth Elements and Other Critical Materials for a Clean Energy Future

MIT, December 3, 2010

R. William McCallum

Thomas Lograsso

Objectives

exchange views on emerging challenges emerging form scarce availability of rare earths and other critical elements

identify opportunities for Trans-Atlantic cooperation

- Identify the most important materials for continued expansion of clean energy markets
  - Supply constraints over the next two decades
  - Prospects for exploration and development
- What kinds of advanced materials can substitute for the materials now in use?
  - What new technology pathways should we follow to find the substitutes we need?
  - Which are the priorities for research, particularly for the substitution of the use of critical elements?
  - How might wind turbines and electric vehicles be redesigned so they do not rely on scarce materials?

Organization

- **Keynotes: Setting the Scene - Critical Materials for a Clean Energy Future**
- **Strategies and Research for Finding Critical Material Substitutes**
- **Strategies and Research for Using Critical Materials More Effectively**
- **Opportunities for EU-US Cooperation on Critical Energy Materials**

Keynotes: Setting the Scene - Critical Materials for a Clean Energy Future

- *Highlights of the DOE Critical Materials Strategy*
- *Reports of study groups*
  - ***"Critical raw materials for the EU"*** Report of the Ad-hoc Working Group on defining critical raw materials
  - ***"Material Scarcity Report"*** Materials Innovation Institute M2i (Netherlands) M2i
  - **"*Energy Critical Elements Policy Study"*** by the APS and MRS
  - ***"Preliminary Findings on the Role of Rare Metals as Supply Chain Bottlenecks for Priority Energy Technologies"*** EC Joint Research Centre, Institute for Energy
- *Research outlooks*
  - ***"Future Directions in Rare Earth Research: Critical Materials for 21st Century Industry"***
- *US-Japan*
  - *Research Trends on Rare Earth Materials in Japan*
  - *Outcomes of U.S.-Japan Roundtable on Rare Earth Elements R&D for Clean Energy Technologies (18-19 November 2010)*

EU Critical Materials

- 41 raw materials analyzed
- **Time horizon: 10 years**
- Three main aggregated **indicators**
  - **economic importance**
  - **supply risks**
  - **environmental country risks**
- **14 target materials identified**
- **Evaluated every 5 years**

- **Recycling**
  - Improve collection
  - Prevent illegal exports of End-of-Life products
  - Promote research
- **Substitution**
  - Promote research
- **Material Efficiency**
  - Minimize raw material usage
  - Minimize raw material losses

Critical Materials Strategy

- EU
  - Ensuring access from International Markets
  - Appropriate policy for sustainable supply of critical materials within the EU
  - Resource efficiency and recycling
- US
  - Supply chain globalization
  - Material substitution in clean energy applications
  - Recycling, re-use, and more efficient use

Common Technology Focus

- Material demand for 4 energy technologies:
  - Wind turbines: magnets
  - Electric vehicles: batteries, magnets
  - Solar cells: PV films
  - Energy efficient lighting: phosphors

- Methodology to address the entire supply chain

****

- EU has greater emphasis on developing recycle/reuse
- US focus on new source development and materials substitution

Strategies and Research for Finding Critical Material Substitutes

- **Magnets and Motors**
  - **George Hadjipanayis,** Chairman, Department of Physics and Astronomy, University of Delaware, *Moving Beyond Neodymium-Iron Permanent Magnets for EV Motors*
  - **Spomenka Kobe**, Jozef Stefan Institut, *Rare Earth Magnets in Europe*
  - **John Hsu** and/or **Tim Burress,** Oak Ridge National Laboratory, *Flux Coupling Machines and Switched Reluctance Motors to Replace Permanent Magnets in Electric Vehicles*
- **Energy Generation**
  - **Bertrand Fillon**, Commissariat à l'Energie Atomique et aux Energies Alternatives, *Challenges for the Future Energy Generation, Distribution and Use*
- **Alternatives**
  - **Madhav Manjrekar**, Green Energy and Power Systems, Siemens Corporate Research, *Research Priorities for Critical Material Substitutes from a European Corporate Perspective*
  - **Anne de Guibert**, SAFT, *Critical Materials and Alternatives for Storage Batteries*

Strategies and Research for Using Critical Materials More Effectively

- **Processing**
  - **Iver Anderson,** Division of Materials Sciences and Engineering, The Ames Laboratory, *Current and Future Direction in Processing Rare Earth Alloys for Clean Energy Applications*
  - **Daniel Beat Müller,** Norwegian University of Science and Technology, *Material Flow Analysis*
- **Efficient Use**
  - **Steve Duclos,** Chief Scientist, GE Global Research, *Research Priorities for More Efficient Use of Critical Materials from a U.S. Corporate Perspective*
  - **Peter Dent**, Electron Energy Corporation, *Strategies for More Effective Critical Materials Use*
- **Recycling**
  - **Christian Hagelüken,** UMICORE, "*Opportunities and Limits to Recycling of Critical Materials for Clean Energies*
- **Alternatives**
  - **Michael Heine,** SGL Group - The Carbon Company, *Carbon Fibers in Lightweight Systems for Wind Energy and Automotive Applications: Availability and Challenges for the Future*

Areas Identified for Collaboration

Cross-Cutting Areas I

- Extraction – Geological Mapping :
  - R&D on how to locate critical material deposits
  - Sharing information across geological agencies
  - Urban mining opportunities (relates to recycling)
  - Harmonizing data formats in Europe, United States, globally
  - Pairing resources with extractive metallurgy techniques
- Processing of raw material – Separation and Refining:
  - R&D on environmentally friendly separation techniques (including recycling)
  - Pairing resources with separation techniques

Areas Identified for Collaboration

Cross-Cutting Areas II

- Reducing Critical Materials Needs in Device Components (maintaining functionality)
  - Modeling and design tools to find better or alternative materials
  - Substitution of non-critical materials
  - Nanotechnologies
  - Reducing catalysts
  - Process improvements
  - Reduce material needs for specific devices (see slides below)
- Recycling:
  - Cost-effective mechanisms for collection, separation, recovery,
  - Product design for recycling

Areas Identified for Collaboration

Cross-Cutting Areas

- Information exchange platform
  - Research results
  - Modeling tools and computer programs
  - Best practices and lessons learned
  - Researcher exchange
- Human capital development
  - Materials scientists and engineers
- Strategic and Systems Analysis
  - Economic analysis of material options
  - Life cycle analysis
  - Strategic risk management studies
  - Materials flow analysis

Areas Identified for Collaboration

Doing More with Less for Key Clean Energy Technologies

- Wind and EV Motor Magnets
  - PMs with less critical material
  - Devices without PMs
- PV cells
  - Thinner film layers
  - Less deposition waste
- Fluorescent lighting
  - LEDs with less RE phosphors
  - Organic LEDs
- Batteries and Fuel Cells

European initiatives

- New funding opportunities have recently been created for projects on:
  - Advanced underground technologies for intelligent mining
  - Substitution of critical raw materials
  - Coordination of activities in Member States in the area of the industrial handling of raw material

References

- *Reports of study groups*
  - ***"Critical raw materials for the EU"*** Report of the Ad-hoc Working Group on defining critical raw materials
    - **http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report-b_en.pdf**
  - ***"Material Scarcity Report"*** Materials Innovation Institute M2i (Netherlands) M2i
    - http://www.m2i.nl/images/stories/m2i%20material_scarcity%20report.pdf
  - "***Energy Critical Elements Policy Study"*** by the APS and MRS (workshop: final report not release)
    - http://web.mit.edu/miteicomm/web/reports/critical_elements/CritElem_Report_Final.pdf