ENERGY CRITICAL ELEMENTS: IDENTIFYING RESEARCH NEEDS AND STRATEGIC PRIORITIES

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

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WEDNESDAY, DECEMBER 7, 2011

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Wednesday, December 7, 2011

ENERGY CRITICAL ELEMENTS: IDENTIFYING RESEARCH NEEDS AND STRATEGIC PRIORITIES

WEDNESDAY, DECEMBER 7, 2011

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:03 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Andy Harris [Chairman of the Subcommittee] presiding.

RALPH M. HALL, TEXAS
CHAIRMAN

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U.S. HOUSE OF REPRESENTATIVES

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Subcommittee on Energy & Environment Hearing

Energy Critical Elements: Identifying Research Needs and Strategic Priorities

Wednesday, December 07, 2011
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

The Honorable David Sandalow, Assistant Secretary for Policy and International Affairs, Department of Energy

Dr. Derek Scissors, Research Fellow, Heritage Foundation

Dr. Robert Jaffe, Jane and Otto Morningstar Professor of Physics, Massachusetts Institute of Technology

Dr. Karl Gschneidner, Senior Materials Scientist, Ames National Laboratory

Mr. Luka Erceg, President and CEO, Simbol Materials

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Energy and Environment

HEARING CHARTER

Energy Critical Elements: Identifying Research Needs and Strategic Priorities

Wednesday, December 7, 2011
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Purpose

On Wednesday, December 7, 2011, at 10:00 a.m. in Room 2318 of the Rayburn House Office Building, the Subcommittee on Energy and Environment will hold a hearing titled *"Energy Critical Elements: Identifying Research Needs and Strategic Priorities*." The purpose of this hearing is to receive testimony on research needs and priorities relating to Energy Critical Elements (ECE) and examine H.R. 2090, "The Energy Critical Elements Advancement Act of 2011."

Witnesses

- **The Honorable David Sandalow**, Assistant Secretary for Policy and International Affairs, Department of Energy
- **Dr. Derek Scissors,** Research Fellow, Heritage Foundation
- **Dr. Robert Jaffe,** Jane and Otto Morningstar Professor of Physics, Massachusetts Institute of Technology
- **Dr. Karl Gschneidner,** Senior Materials Scientist, Ames National Laboratory
- **Mr. Luka Erceg,** President and CEO, Simbol Materials

Background

Energy Critical Elements

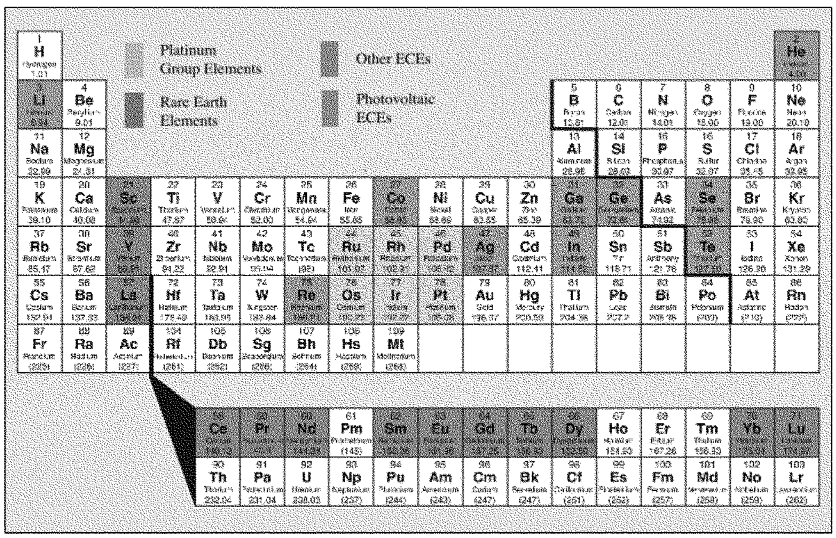
A recent report published by the American Physical Society (APS) and Materials Research Society (MRS) defines Energy Critical Elements as a "class of chemical elements that currently appear critical to one or more new, energy-related technologies. A shortage of these elements would significantly inhibit large-scale deployment, which could otherwise be capable of transforming the way we produce, transmit, store, or conserve energy."[1]

[1] American Physical Society & Materials Research Society, *"Energy Critical Elements: Securing Materials for Emerging Technologies,"* February 2011. Accessible at: http://www.aps.org/policy/reports/popa-reports/upload/elementsreport.pdf

ECEs are generally not widely extracted, nor is there a mature, commoditized ECE market. The APS-MRS study also notes ECEs may not be domestically available and "many potential ECEs are not found in concentrations high enough to warrant extraction as a primary product."[2]

As indicated by their name, ECEs are key components in many energy technologies. For example, neodymium is used for high-field permanent magnets required in wind turbines and hybrid cars. Tellurium is necessary for a new photovoltaic solar cell technology. Included as potential ECEs, the APS/MRS report identifies the platinum group of elements, located in the center of the periodic table, as well as elements frequently used in photovoltaic solar cells such as gallium (Ga), germanium (Ge), selenium (Se), indium (In), and tellurium (Te).

Figure 1 – Energy Critical Elements[3]



Rare Earths

Of particular interest and importance within ECEs is a family of elements known as rare earth elements (REE). Rare earth elements consist of yttrium, scandium, and the 15 elements contained within the Lanthanide series on the periodic table of elements with atomic numbers ascending from 57 to 71.

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[2] APS/MRS Report, p. 5
[3] Ibid.

Despite their moniker, REEs are not rare, but rather abundant in the Earth's crust. However, the concentrations of REEs are generally low, limiting the opportunity to economically mine and separate elements for processing and use. Some REEs are obtained as byproducts of mining more abundant ore, such as copper, gold, uranium, phosphates, and iron. [4]

REEs are generally classified as either light rare earth elements (LREE) or heavy rare earth elements (HREE). LREEs, elements with atomic numbers 57 to 63, are more abundant, more widely used, and easier to separate with mining techniques. HREEs, elements with atomic number 64 through 71, are generally less available and more difficult to extract. HREE's ability to withstand higher temperatures than LCEEs makes them more suitable for specific energy applications and the United States Geological Survey (USGS) describes HREEs as "particularly desirable."[5]

Figure 2 – Rare Earth Elements: Selected End Uses[6]

Light Rare Earths (more abundant)	Major End Use	Heavy Rare Earth (less abundant)	Major End Use
Lanthanum	hybrid engines, metal alloys	Terbium	phosphors, permanent magnets
Cerium	auto catalyst, petroleum refining, metal alloys	Dysprosium	permanent magnets, hybrid engines
Praseodymium	magnets	Erbium	phosphors
Neodymium	auto catalyst, petroleum refining, hard drives in laptops, headphones, hybrid engines	Yttrium	red color, fluorescent lamps, ceramics, metal alloy agent
Samarium	magnets	Holmium	glass coloring, lasers
Europium	red color for television and computer screens	Thulium	medical x-ray units
		Lutetium	catalysts in petroleum refining
		Ytterbium	lasers, steel alloys
		Gadolinium	magnets

[4] Congressional Research Service, *"Rare Earth Elements: The Global Supply Chain,"* September 6, 2011. p. 8
[5] Department of Interior, United States Geological Survey Fact Sheet 087-02, "Rare Earth Elements – Critical Resources for High Technology," 2002. Accessible at: http://pubs.usgs.gov/fs/2002/fs087-02/
[6] CRS Report, p. 3

The unique physical and chemical characteristics of REEs make them attractive for use in a number of key specialty applications. For example, alloys of numerous rare earth elements are key components of strong, permanent magnets desired in a wide range of hi-tech applications. End-use applications range from automobile catalysts to cell phones and televisions to medical devices. REEs are also of great importance for defense applications, such as jet engines and satellite systems.

Beyond rare earths, several other ECEs are also important to energy technologies. Examples include: lithium and lanthanum for use in high performance batteries; helium for cryogenics, advanced nuclear reactor designs, and energy sector manufacturing; platinum group elements for fuel cell catalysts; and rhenium for use in an alloy for advanced turbines.[7]

Production and Supply Chain

The rare earth production and supply chain involves numerous phases, each with its own complex market dynamics. This begins with mining ore, followed by separating the rare earth oxides, refining the material, turning the oxides into a metal alloy, incorporating alloys into components and manufacturing end-use products. As a result of the complexity, the location of REE geologic deposits and mining facilities is a major factor in determining where manufacturers produce goods. For example, neodymium, gadolinium, dysprosium, and terbium are all key components in permanent magnets. Current mining and production of those elements is almost exclusively located in China. As a result about 75% of all current permanent magnet production also located there.[8]

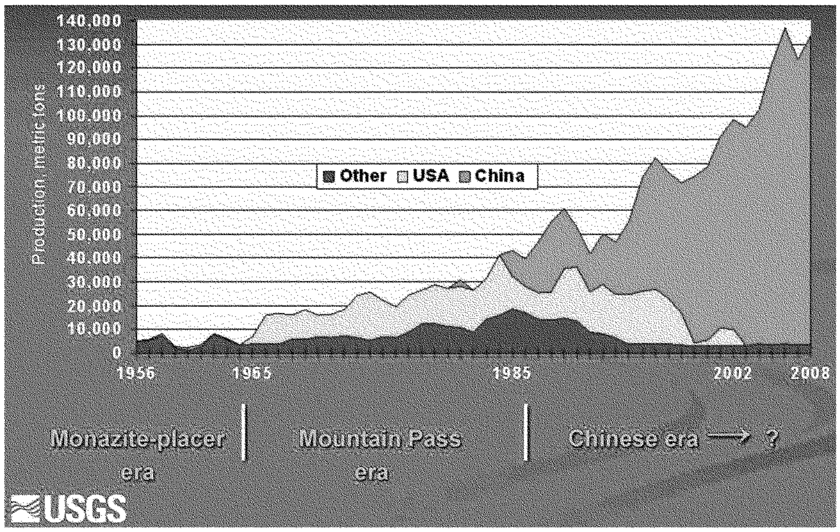
Market Conditions Impacting Energy Critical Elements

The United States was a dominant global producer of rare earth elements from the 1960's through the 1980's; however, downward price pressure from China and more restrictive environmental regulations in the United States drove REE production out of the United States and almost exclusively to China.

Prior to establishing market dominance, China developed a long range strategic action to exploit its rare earth natural resources. In 1992, Deng Xiaoping, a key figure leading China's economic reforms signaled this strategic direction, saying "there is oil in the Middle East; there is rare earth in China."[9] As China produced an increasing percentage of global REEs, the country began implementing policies to strengthen its market position.

[7] APS/MRS Report, p. 6
[8] CRS report. P. 2
[9] Peter Foster, "Rare earths: Why China is cutting exports crucial to Western technologies," The Telegraph, March, 19, 2011. Accessible at: http://www.telegraph.co.uk/science/8385189/Rare-earths-why-China-is-cutting-exports-crucial-to-Western-technologies.html

Figure 3 – Global rare-earth-oxide production trends[10]



Today, REEs are almost exclusively produced in China. The USGS estimates China produced 130,000 metric tons (mt) of rare earth ores, oxides, and metals in 2010, or 97% of global REE production.[11] While China currently produces almost all of the global REE supply, other countries have notable REE reserves yet to be extracted, including the United States, Australia, Brazil, India, Russia, South Africa, Malaysia, and Malawi.[12] As REE prices have risen, companies in numerous countries have announced plans to re-start and expand production.

However, China's stranglehold on current REE production has allowed it to disproportionately impact market prices and exploit their resource abundance through geopolitical means. Following a 2009 dispute with Japan on an unrelated matter, China suspended REE exports to its neighbor. Japan's high-tech economy is highly dependent on the availability of REEs and the country was forced to relent to China, resolve the incident, and resume REE imports.[13]

Soon thereafter, China reduced its export quota by 37 percent in 2010 from the prior year, ostensibly to limit the environmental impacts of mining REEs. Reducing the export quota placed

[10] Pui-Kwan Tse, "China's Rare-Earth Industry," USGS Report 2011-1042, 2011. Accessible at:

[11] USGS Mineral Commodities Summaries 2010. Accessible at:

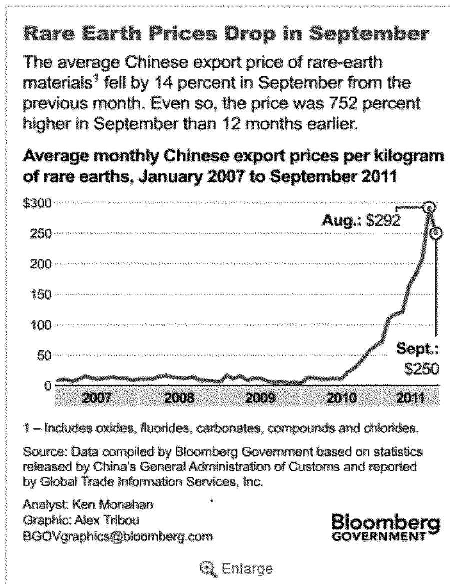
[12] CRS Report p. 9

[13] Yuko Inoue, *"China lifts rare earth export ban to Japan,"* Reuters, September 29, 2010. Accessible at:

further supply constraints on a market in which global demand already exceeds supply. Additionally, China levies a 15 to 25 percent tax on REE exports.[14] These policies drove up the price of products manufactured outside of China and exert great pressure on companies to locate manufacturing facilities in China for a price advantage. For example, Intematix, a California-based producer of phosphor materials and LED lighting, moved manufacturing to China to directly purchase rare earth materials, rather than pay higher prices for exports. Intematix Director of Worldwide Operations said, "We saw the writing on the wall – we simply bought the equipment and ramped up in China to begin with….I think this is what the Chinese government wanted to happen."[15]

Market Reaction

China's policies led to significant price increases in REEs in the global market. The average September 2011 price for Chinese REE exports was 752 percent higher than the previous year.[16] However, as prices increased, the global market began to react. A number of companies announced their intention to open new production facilities and REE prices fell approximately 40 percent from the peak in July.[17]



In reaction to falling REE prices, China has again sought to take advantage of its market position to manipulate supply and maintain artificially high prices. In October, the Chinese state-owned company Inner Mongolia Baotou Steel Rare Earth Hi-Tech Company declared it would suspend production of REEs for one month "in an effort to prop up prices."[18]

In 2010, REE demand was estimated to be 136,000 mt while global production stood

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[14] USGS 2011-1042 p. 8

[15] UPI, "Production shifts to China for rare earths," August 25, 2011. Accessible at: http://www.upi.com/Business_News/Energy-Resources/2011/08/25/Production-shifts-to-China-for-rare-earths/UPI-87711314293290/

[16] Ken Monahan, *"China's Monopoly on Rare-Earth materials: Implications for U.S. Companies,"* Bloomberg Government, November 16, 2011.

[17] Derek Scissors, *"Rare Earth Market Fine Without Government Interference,"* Heritage Foundation, November 2, 2011. Accessible at: http://www.heritage.org/research/reports/2011/11/rare-earth-market-fine-without-government-interference

[18] Leslie Hook, *"Largest rare earths producer halts output,"* Financial Times, Oct 16, 2011. Accessible at: http://www.ft.com/cms/s/0/eb817dd6-f976-11e0-bf8f-00144feab49a.html#axzz1fJYwvVtb

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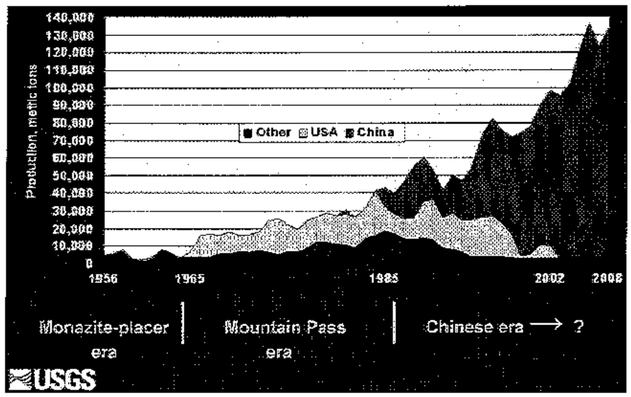

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[11] USGS Mineral Commodities Summaries 2010. Accessible at: http://minerals.usgs.gov/minerals/pubs/mcs/2011/mcs2011.pdf
[12] CRS Report p. 9
[13] Yuko Inoue, *"China lifts rare earth export ban to Japan,"* Reuters. September 29, 2010. Accessible at: http://www.reuters.com/article/2010/09/29/us-japan-china-export-idUSTRE68S0BT20100929

metals is a global automotive industry using rare-earth permanent magnets. That industry will engineer this stuff out."[25]

<u>Federal Activities</u>

A number of Executive Branch agencies are actively addressing ECE challenges. Since March 2010, the White House Office of Science and Technology Policy (OSTP) has coordinated an Interagency Working Group on Critical and Strategic Mineral Supply Chains. OSTP created a new Subcommittee on Critical and Strategic Mineral Supply Chains, with the purpose to "advise and assist [OSTP] on policies, procedures and plans relating to risk mitigation in the procurement and downstream processing of critical and strategic minerals. Functions of the Subcommittee include identifying critical and strategic minerals and identifying cross-agency research and development opportunities."[26]

Participants in the working group include the DOE, Department of Defense (DOD), USGS, Department of Commerce, Environmental Protection Agency, Department of Justice, Department of State, and the U.S. Trade Representative.

DOE Critical Materials Strategy

In December 2010, the Department of Energy released its *"Critical Materials Strategy"* to examine the "role of rare earth metals and other materials in the clean energy economy" and focus on the "role of key materials in renewable energy and energy-efficient technologies."[27] DOE describes plans to "(i)develop its first integrated research agenda addressing critical materials…(ii)strengthen its capacity for information-gathering on this topic; and (iii) work closely with international partners, including Japan and Europe, to reduce vulnerability to supply disruptions and address critical material needs."[28]

DOE's strategy is supported by three key points. Namely:

1. A"diversified global supply chain [is] essential." Supply risk must be mitigated by sourcing of critical materials from multiple sources. To achieve this, steps must be taken to "facilitate extraction, processing and manufacturing here in the United States, as well as encourages other nations to expedite alternative supplies;"
2. "[S]ubstitutes must be developed." Research and development of materials of equal material and technology veracity will allow the clean energy economy to satisfy their material needs, and;
3. "[R]ecycling, reuse and more efficient use could significantly lower world demand for newly extracted materials."

DOE's strategy only focused on the needs for REEs in the context of the energy sector. It did not consider the importance of REEs for other sectors, including defense, nor did it address material concerns beyond REEs. DOE will release an update to the report prior to the end of 2011.

[25] Ibid.
[26] Critical Materials Strategy, p. 58.
[27] Critical Materials Strategy p. 10
[28] Critical Materials Strategy, p. 6

DOE Research and Development Activity

DOE funds ECE-related research through numerous programs. Within the Office of Science, the Basic Energy Sciences' Materials Sciences and Engineering Division provided $5 million in Fiscal Year (FY) 2010 for materials research at Ames National Laboratory.

The Advanced Research Projects Agency – Energy (ARPA-E) funds high-risk, high-reward, transformational energy research. ARPA-E has funded 11 targeted research areas to date, including the Batteries for Electric Energy Storage in Transportation (BEEST) to develop new battery technologies that are less reliant on ECEs. ARPA-E also provided $2.2 million to General Electric Global Research to develop "next-generation permanent magnets with a lower content of critical rare earth materials" The new magnets would be more efficient and increase power density, while reducing the quantity of ECEs.[29]

Within the Office of Energy Efficiency and Renewable Energy (EERE), the Vehicle Technologies Program, Industrial Technologies Program, and the Wind Technologies Program fund ECE-related research. The research includes exploring new battery technologies, researching next generation materials research, and producing higher efficiency permanent magnets for increased performance in wind turbines.[30]

Critical Materials Energy Innovation Hub

The Administration's budget request proposed creating a new Energy Innovation Hub on Critical Materials to be overseen by EERE's Industrial Technologies Program. According to DOE:

> "The hub will fund R&D on novel approaches to reducing our dependencies on critical materials. The hub will focus on R&D leading to material and technology substitutes that will improve flexibility and help meet the material needs of the clean energy economy. Additional R&D goals include strategies for recycling, reuse, and more efficient use that could significantly lower world demand for newly extracted materials."[31]

The House-passed Energy & Water Appropriations bill included $20 million in FY 2012 for the Critical Materials Hub.

Department of Defense

In September 2011, DOD delivered its *Annual Industrial Capabilities Report* to Congress[32]. The report assessed the importance of rare earth materials to national security and concluded that:

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[29] Advanced Research Projects Agency – Energy, "GE Global Research: Transformational Nanostructured Permanent Magnets." Accessible at: http://arpa-e.energy.gov/ProgramsProjects/OtherProjects/VehicleTechnologies/TransformationalNanostructuredPermanentMagnets.aspx

[30] For more information on current DOE critical materials R&D, see Chapter 4 of the Critical Materials Strategy.

[31] Department of Energy, "FY 2012 Congressional Budget Request: Volume 3,." p. 257. Accessible at: http://www.cfo.doe.gov/budget/12budget/Content/Volume3.pdf

[32] Office of Manufacturing & Industrial Base Policy, "Annual industrial Capabilities Report to Congress," Department of Defense, September 2011. Accessible at: http://www.acq.osd.mil/mibp/docs/annual_ind_cap_rpt_to_congress-2011.pdf

> "The Department relies on RE materials in the production of many of its weapon systems and needs to ensure their continued availability to meet national security objectives and military superiority…It is essential that a stable non-Chinese source of REO be established so that the U.S. RE supply chain is no longer solely dependent on China's RE exports. It is also essential to develop non- Chinese RE sources that in total create an RE supply that meets the U.S. demand for both heavy and light rare earth elements (REEs)"

The report also recommended that DOD:

- "develop and implement risk mitigation strategies for the heavier elements, especially dysprosium, yttrium, praseodymium, and neodymium.";
- "identify and priorities [rare earth] product applications in order to mitigate/diminish supply and scheduling disruptions to selected DOD systems.";
- "partner with the domestic [rare earth] companies to determine what assistance may be needed to retain or obtain [rare earth] processing capabilities."; and
- "continue monitoring the health of the domestic [rare earth] companies in the supply chain."

Congressional Proposals

In the 112th Congress, ten bills have been introduced to address various ECE and REE issues (Appendix A). Additionally, multiple Congressional Committees, including the Science, Space, and Technology Subcommittee on Investigations and Oversight,[33] held hearings to consider ECE oversight issues and legislative proposals.

To date, one rare earth proposal has seen legislative action. On July 20, 2011, the House Natural Resources Committee passed H.R. 2011, the "National Strategic and Critical Minerals Policy Act of 2011," sponsored by Rep. Lamborn. H.R. 2011 currently awaits consideration by the full House.

H.R. 2090, the "Energy Critical Elements Advancement Act of 2011" was introduced by Representative Randy Hultgren on June 2 (Appendix B). The legislation directs the Department of Interior and DOE to improve resource assessments through direct coordination. The bill also designates USGS as the Principal Statistical Agency to gather ECE resource information. H.R. 2090 authorizes a DOE research program to "establish advance basic knowledge and enable expanded availability of designated energy critical elements; and develop and update biennially an integrated research plan to guide program activities."[34] Lastly, the bill requires OSTP to produce a report for Congress on recycling of energy critical elements.

[33] Committee on Science, Space, and Technology, Investigations and Oversight Subcommittee hearing "Critical Materials Strategy," June 14, 2011. More information can be found at: http://science.house.gov/hearing/investigations-and-oversight-subcommittee-hearing-critical-materials-strategy

[34] Congressional Research Service Bill Summary.

Appendix A

Rare Earth-Related Legislation in the 112th Congress[35]

H.R. 1388, the Rare Earths Supply Chain Technology and Resources Transformation Act of 2011

Introduced by Representative Mike Coffman on May 6, 2011, and referred to the House Committee on Science, Space, and Technology, Subcommittee on Energy and the Environment, and the Committees of Natural Resources and Armed Services. The bill is also referred to as the Restart Act of 2011. The bill seeks to reestablish a competitive domestic rare earths supply chain within DOD's Defense Logistics Agency (DLA).

H.R. 1540, the National Defense Authorization Act for FY2012

Introduced by Representative Howard McKeon on April 14, 2011. Section 835 would require the Defense Logistics Agency Administrator for Strategic Materials to develop an inventory for rare earths materials to support defense requirements, as identified by the report required by Section 843 of the National Defense Authorization Act for FY2011 (P.L. 111-383).

H.R. 1314, the Resource Assessment of Rare Earths (RARE) Act of 2011

Introduced by Representative Hank Johnson on April 1, 2011; referred on April 6 to the House Natural Resources Committee's Subcommittee on Energy and Mineral Resources. The bill would direct the Director of the U.S. Geological Survey through the Secretary of the Interior to examine the need for future geological research on rare earth elements and other minerals and determine the criticality and impact of a potential supply restriction or vulnerability.

H.R. 952, the Energy Critical Elements Renewal Act of 2011

Introduced by Representative Brad Miller on March 8, 2011; referred to the Committee on Science, Space, and Technology. The bill would develop an energy critical elements program, amend the National Materials and Minerals Policy Research and Development Act of 1980, establish a temporary program for rare earth material revitalization, and serve other purposes.

S. 383, the Critical Minerals and Materials Promotion Act of 2011

Introduced by Senator Mark Udall on February 17, 2011; referred to the Committee on Energy and Natural Resources. The bill would require the Secretary of the Interior to establish a scientific research and analysis program to assess current and future critical mineral and materials supply chains, strengthen the domestic critical

[35] Appendix A compiled by Congressional Research Service. Appendix in CRS Report R41347.

minerals and materials supply chain for clean energy technologies, strengthen education and training in mineral and material science and engineering for critical minerals and materials production, and establish a domestic policy to promote an adequate and stable supply of critical minerals and materials necessary to maintain national security, economic well-being, and industrial production with appropriate attention to a long-term balance between resource production, energy use, a healthy environment, natural resources conservation, and social needs.

H.R. 618, the Rare Earths and Critical Materials Revitalization Act of 2011

Introduced by Representative Leonard Boswell on February 10, 2011; referred to the Committee on Science, Space, and Technology. The bill seeks to develop a rare earth materials program and amend the National Materials and Minerals Policy, Research and Development Act of 1980. If enacted, it would provide for loan guarantees to revitalize domestic production of rare earths in the United States.

S. 1113, the Critical Minerals Policy Act of 2011

Introduced by Senator Lisa Murkowski on May 26, 2011; referred to the Committee on Energy and Natural Resources. The bill would define what critical minerals are, but would request that the Secretary of the Interior establish a methodology (in consultation with the National Academy of Sciences, the National Academy of Engineering and various Department Secretaries) that would identify which minerals qualify as critical. The Secretary of the Interior would direct a comprehensive resource assessment of critical mineral potential in the United States, including details on the critical mineral potential on federal lands. S. 1113 would establish a Critical Minerals Working Group to examine the permitting process for mineral development in the United States and facilitate a more efficient process; specifically, that would require a performance metric for permitting mineral development and report on the timeline of each phase of the process. The Department of the Interior (DOI) would produce an Annual Critical Minerals Outlook report that would provide forecasts of domestic supply, demand, and price for up to ten years. The proposed Annual Critical Minerals Outlook would also assess critical mineral requirements for national security, energy, and economic well-being, and provide analyses of the implications of potential supply shortfalls. It would provide projections for recycling and market penetration of alternatives and international trends associated with critical minerals. Section 109 proposes greater international cooperation with allies on critical minerals and supply chain issues. If it was determined that there is no viable production capacity in the United States, a series of activities may occur with allies, led by the Secretary of State and Secretary of the Interior.

DOE would lead research and development on critical minerals and workforce development that would support a fully integrated supply chain in the United States. Title II of the bill recommends mineral-specific action (led by DOE) for cobalt, helium, lead, lithium, low-btu gas, phosphate, potash rare earth elements, and thorium. For example, there would be R&D for the novel use of cobalt, grants for domestic lithium production R&D, and a study on issues associated with establishing a licensing pathway for the complete thorium nuclear fuel cycle. Title III would repeal 1980 Minerals Policy Act and Critical Minerals Act of 1984 and would authorize for appropriation, $106 million.

H.R. 2011, the National Strategic and Critical Minerals Policy Act of 2011

Introduced by Representative Doug Lamborn on May 26, 2011; referred to the Committee on Natural Resources. The bill would direct the Secretary of the Interior to prepare a report on public lands that have been withdrawn or are otherwise unavailable for mineral exploration and development, mineral requirements of the United States, the nation's import reliance on those minerals, a timeline for permitting mineral-related activities on public lands, and the impacts of litigation on issuing mineral permits, among other things. The bill provides an authorization for appropriation, to the Secretary of the Interior, of $1 million for fiscal years 2012 and 2013. The House Committee on Natural Resources marked up and reported out H.R. 2011 on July 20, 2011.

H.R. 2090, the Energy Critical Elements Advancement Act of 2011

Introduced by Representative Randy Hultgreen on June 2, 2011. The bill would require collaboration between the Secretary of the Interior and Secretary of Energy to improve assessments of "energy critical elements throughout the supply chain, supply, demand, disposal and recycling." Additionally it calls for more R&D on materials use substitution, recycling, and life-cycle analysis. The bill provides a list of energy critical elements.

H.R. 2184, the Rare Earth Policy Task Force and Materials Act

Introduced by Representative Mike Coffman on June 15, 2011. The bill would create a Rare Earth Task Force within the DOI and be composed of the Secretary or designees from DOE, DOC, DOS, DOD, USDA, OMB, and CEQ, chaired by the Secretary of the Interior. The task force would examine impediments to domestic development of a REE supply chain. The Secretary of the Interior would prepare a Materials Program Plan of R&D that would support and help ensure long-term viability of a domestic rare earth industry. The plan would support numerous activities related to improved assessment and development technology, processing technology, and end-use applications. The bill would encourage expanding opportunities for higher education in that it would support the build-out of the rare earth supply chain

Appendix B

H.R.2090

Energy Critical Elements Advancement Act of 2011

112th CONGRESS
1st Session
H. R. 2090

To improve assessments of and research about energy critical elements, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

June 2, 2011

Mr. HULTGREN (for himself, Mrs. BIGGERT, and Mr. LIPINSKI) introduced the following bill; which was referred to the Committee on Science, Space, and Technology, and in addition to the Committees on Natural Resources and Energy and Commerce, for a period to be subsequently determined by the Speaker, in each case for consideration of such provisions as fall within the jurisdiction of the committee concerned

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A BILL

To improve assessments of and research about energy critical elements, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the `Energy Critical Elements Advancement Act of 2011'.

SEC. 2. INFORMATION GATHERING, ANALYSIS, AND DISSEMINATION.

(a) Establishment- The Secretary of the Interior, acting through the Director of the USGS, and the Secretary of Energy, acting through the Administrator of the Energy Information Administration, shall collaborate to improve assessments of energy critical elements that includes--

(1) discovered and potential resources;
(2) production;
(3) use;
(4) trade;

(5) disposal; and
(6) recycling.

(b) Duties- The entity within the USGS that gathers the information for the assessments under subsection (a) shall--

(1) regularly survey emerging energy technologies and the supply chain for elements throughout the periodic table necessary for those technologies in order to forecast potential supply disruptions; and
(2) make available such information in the aggregate, with appropriate protection of proprietary information, to the United States scientific community, including industry, institutions of higher education, and the United States Department of Energy National Laboratories and Technology Centers.

(c) Designation- The Director of the USGS shall designate the entity within the USGS that gathers the information for the assessments under subsection (a) as a `Principal Statistical Agency'.

SEC. 3. RESEARCH.

(a) Establishment- The Secretary of Energy, in coordination with the Secretary of the Interior, shall establish a research program to advance basic knowledge and enable expanded availability of energy critical elements, including research on basic materials science, chemistry, physics, and engineering associated with energy critical elements, including materials characterization and substitution, recycling, and life-cycle analysis.

(b) Research Plan- In consultation with the Critical and Strategic Mineral Supply Chain Subcommittee of the National Science and Technology Council, the Secretary shall develop and update biennially an integrated research plan to guide program activities.

(c) Limitation- Research under subsection (a) shall be limited to areas that industry is not likely to undertake due to technical and financial uncertainty.

SEC. 4. REPORT.

Within 1 year after the date of enactment of this Act, the Critical and Strategic Mineral Supply Chain Subcommittee of the National Science and Technology Council shall submit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report on the recycling of energy critical elements, including--

(1) the logistics, economic viability, and research and development needs for completing the recycling process;

(2) options for both the Federal Government and industry, including an assessment of the strengths and weaknesses of such options, for improving the rates of

collection of post-consumer products containing energy critical elements; and

(3) an analysis of the methods explored and implemented in various states and countries, such as Japan and South Korea.

SEC. 5. DEFINITIONS.

In this Act, the following definitions apply:

(1) ENERGY CRITICAL ELEMENT- The term `energy critical element' means each of the following:

(A) Helium.
(B) Lithium.
(C) Scandium.
(D) Cobalt.
(E) Gallium.
(F) Germanium.
(G) Selenium.
(H) Yttrium.
(I) Ruthenium.
(J) Rhodium.
(K) Palladium.
(L) Silver.
(M) Indium.
(N) Tellurium.
(O) Lanthanum.
(P) Rhenium.
(Q) Osmium.
(R) Iridium.
(S) Platinum.
(T) Cerium.
(U) Praseodymium.
(V) Neodymium.
(W) Samarium.
(X) Europium.
(Y) Gadolinium.
(Z) Terbium.
(AA) Dysprosium.
(BB) Ytterbium.
(CC) Lutetium.
(DD) Any other element designated as an energy critical element by the Critical and Strategic Mineral Supply Chain Subcommittee of the National Science and Technology Council.

(2) USGS- The term `USGS' means the United States Geological Survey.

Chairman HARRIS. Good morning. The Subcommittee on Energy and Environment will come to order.

Welcome to today's hearing entitled "Energy Critical Elements: Identifying Research Needs and Strategic Priorities." In front of you are packets containing the written testimony, biographies and Truth in Testimony disclosures for today's witness panel. I now recognize myself for five minutes for an opening statement.

Good morning, and welcome to today's hearing. The purpose of this hearing is to examine the importance of and issues surrounding energy-critical elements, particularly as they relate to the government's role in supporting research and development.

Energy-critical elements are elements, including rare earths, which are of increasing importance to energy-related technology areas from high-performance magnets to photovoltaic solar cells to next generation batteries and fuel cells. They are also important to high-tech applications such as computers and cell phones and key defense uses such as jet engines and weapons systems.

While energy-critical elements encompass a broader set of elements beyond just rare earths, the growing demand for rare earths amidst a volatile market warrants particular attention and concern. China currently produces 97 percent of the global supply of rare earths. This is a result of a deliberate and decades-long strategy to develop its geologic reserves, undercut market price and drive out competition. The strategy succeeded, and China has recently reduced export quotas and increased levies on exported rare earth oxides in an attempt to exploit its position and manipulate the market. As a result, the rare earth marketplace of the last two years has suffered from instability, wild price swings, and uncertain supplies.

There are indications, however, that price spikes resulting from China's behavior have triggered positive market developments. In light of higher prices, producers in the United States and ally nations have announced plans to develop rare earth reserves around the world, and companies such as Toyota and General Electric are pursuing demand reductions through R&D on recycling, substitute materials and increased use efficiencies. This led one investor analyst to conclude that "the principal customer for rare earth metals is a global automotive industry using rare earth permanent magnets. That industry will engineer this stuff out."

While a responsive market will continue to drive toward solutions, there are reasonable and proper steps the Federal Government can and should pursue in this area. I believe Representative Hultgren's Energy Critical Elements Advancement Act sets forth the appropriate structure and direction to this end.

For example, a national resource assessment of potential geologic reserves would deliver key information to the market and benefit both producers and consumers of energy-critical elements. With respect to R&D, focusing federal efforts in basic material science and chemistry related to energy-critical elements will complement private sector efforts and enable accelerated innovations. By focusing limited taxpayer resources on basic science research, we can secure the greatest return on investment, while avoiding the common problem of picking technology winners and losers.

I look forward to hearing from the witnesses today on these and other policy issues related to this important topic.

[The prepared statement of Mr. Harris follows:]

PREPARED STATEMENT OF CHAIRMAN ANDY HARRIS

The purpose of this hearing is to examine the importance of and issues surrounding Energy Critical Elements, particularly as they relate to the government's role in supporting research and development. Energy Critical Elements are elements, including rare earths, which are of increasing importance to energy-related technology areas from high-performance magnets to photovoltaic solar cells to next generation batteries and fuel cells. They are also important to high-tech applications such as computers and cell phones and key defense uses such as jet engines and weapons systems.

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There are indications, however, that price spikes resulting from China's behavior have triggered positive market developments. In light of higher prices, producers in the U.S. and ally nations have announced plans to develop rare earth reserves around the world and companies such as Toyota and General Electric are pursuing demand reductions through R&D on recycling, substitute materials and increased use efficiencies. This led one investor analyst to conclude that, "the principal customer for rare-earth metals is a global automotive industry using rare earth permanent magnets. That industry will engineer this stuff out."

While a responsive market will continue to drive toward solutions, there are reasonable and proper steps the federal government can and should pursue in this area. I believe Representative Hultgren's *"Energy Critical Elements Advancement Act"* sets forth the appropriate structure and direction to this end.

For example, a national resource assessment of potential geologic reserves would deliver key information to the market and benefit both producers and consumers of energy critical elements. With respect to R&D, focusing Federal efforts in basic materials science and chemistry related to energy critical elements will complement private sector efforts and enable accelerated innovations. By focusing limited taxpayer resources on basic science research, we can secure the greatest return on investment, while avoiding the common problem of picking technology winners and losers.

Chairman HARRIS. I yield back the balance of my time and recognize Mr. Miller for his opening statement.

Mr. MILLER. Thank you, Mr. Chairman, and I thank you for calling this hearing.

When the Committee first looked at shortages in rare earths in 2010, we had hearings in the Subcommittee on Investigations and Oversight, which I then chaired, we were concerned because China had made it very clear that they would use their monopoly supply position to manipulate markets, to capture manufacturing jobs and extract excessive profit from a world that was just then discovering the critical nature of rare earth elements.

We wrote a bill that established the Office of Science and Technology Policy as the center for an interagency process designed to establish a continuing research effort. We wanted to ensure that our country and our employers and our consumers would not be held hostage by the Chinese government's manipulation of rare earth markets. The Department of Energy was also an important part of the response with responsibilities for research and for producing a new generation of experts who could contribute to work in this area.

That bill was introduced by my then-Vice Chair, Kathy Dahlkemper from Pennsylvania. It was marked up in Committee. It was passed by the House with 332 votes, obviously a bipartisan vote. And in this Congress, I have introduced that bill again, the bill introduced by Kathy Dahlkemper, with minor changes, and I hope that the Committee can take this matter up and consider that bill as well as Mr. Hultgren's and we can move forward in time for Senate action.

As I said, I am not the only member with a bill in this Congress or even on this Committee. My colleague, our colleague from Illinois, Mr. Hultgren, also has a bill, and there are some broad areas of agreement between us. We both put DOE at the center of a research effort. His bill is stronger than mine in its definition of critical materials and I prefer his language on that point. But my bill has some advantages as well, for example, its assignment of interagency responsibility to OSTP. I strongly believe that we would work out a compromise bill on an issue that affects every American and does not appear to straddle any of the many partisan fault lines in American politics. Surely neither party would want our leading frenemy to have a stranglehold on materials critical to our national security and to our economy.

I am glad that we are having this hearing, but I am surprised it has taken so long.

If we don't act, it may not matter in the short run. The Obama Administration deserves credit for quick and effective steps to establish an interagency planning and coordination process. They have also asked the Department of Energy to look aggressively at steps it can take to spur research and support emerging American supplies of critical materials. I am confident that the President, Dr. Holdren, and Secretary Chu are doing all they can in this area.

But my concern is what happens moving forward. Our government is sometimes quite good at responding to a sudden crisis. What we need is an ability to keep watch on critical materials, anticipate problems and create policies that head off rather than respond to a crisis only after it is upon us. I think that both Mr. Hultgren and I agree on this, though we structure the authorities for standing watch somewhat differently.

And there is ample evidence of market failure here. The argument that the market is working is based on the fact that prices for various rare earths have dropped, but we have seen that before. In the 1990s, prices dropped because the Chinese government was controlling its production and setting global prices to drive competitors, and the price rose because the Chinese government began to exploit the monopoly it had gained by pricing out competitors and then immediately drove prices up and used that stranglehold on supplies to coerce manufacturers who needed the materials to set up their manufacturing in China.

Even if current price drops were not mainly the result of a global recession, there is no reason to think that if we are not smart about how we support those industries, the Chinese government won't just make the same moves all over again. To believe that markets can work, when the greatest player in a particular industry is a hybrid Communist-capitalist state, a mixture of command and a market economy, is to cling to ideology in the face of ample evidence that it just ain't so.

I hope we can all work together to move a bill in this area. This Committee now has no bills that have been passed the House. Zero. None. And for this Committee, that is unprecedented. I encourage the majority to consider working on a bipartisan bill on critical materials as a strong candidate for markup and for being the first bill that this Committee gets passed by the House.

I yield back the balance of my time.

[The prepared statement of Mr. Miller follows:]

PREPARED STATEMENT OF RANKING MEMBER BRAD MILLER

I want to thank the Chairman for calling this hearing. When the Committee first looked at shortages in rare earths in 2010 we were concerned because China had made it plain that they would use their monopoly supply position to manipulate markets, capture manufacturing jobs and extract excessive profit from a world that was newly discovering the critical nature of rare earth elements.

We wrote a bill that established the Office of Science and Technology Policy as the center of an interagency process designed to establish a continuing research effort. We wanted to ensure that our country and our employers and our consumers could not be held hostage by the Chinese government's manipulation of markets. The Department of Energy was also an important part of the response with responsibilities for research and for producing a new generation of experts who could contribute to work in this area.

That bill, introduced by my then-Vice Chair, Kathy Dahlkemper, was marked up in Committee and passed by the House with 332 bipartisan votes in support. In this Congress, I have introduced that bill again, with minor changes, and I hope that the Committee can take this matter up and move it forward again in time for Senate action.

I am not the only Member with a bill in this Congress or even on this Committee. My colleague from Illinois, Mr. Hultgren, also has a bill. There are some broad areas of agreement between us. We both put DOE at the center of a research effort. His bill is stronger than mine in its definition of critical materials and I prefer his language on that. However, my bill has some advantages, for example, in its assignment of interagency responsibility to OSTP. I strongly believe that we could work out a compromise bill on an issue that affects every American and does not appear to straddle any of the many partisan fault lines in American politics. Surely neither party would allow our leading frenemy to have a stranglehold on materials critical to our national security and to our economy. I am glad we are having this hearing, but I am surprised it has been so long in coming.

If we don't act, it may not matter in the short run. The Obama Administration deserves credit for the quick and effective steps it has taken for establishing an interagency planning and coordination process. They have also asked the Department of Energy to look aggressively at steps it can take to spur research and support emerging American supplies of critical materials. I am confident that the President, Dr. Holdren, and Secretary Chu are doing all they can in this area.

However, my concern is what happens going forward. Our government is sometimes quite good at responding to a sudden crisis. What we need is an ability to keep watch on critical materials, anticipate problems and create policies that head those off rather than respond to a crisis only after it is upon us. I think that both Mr. Hultgren and I agree on this, though we structure the authorities for standing watch somewhat differently.

And there is ample evidence of market failure here. The argument that the market is working is based on the fact that prices for several rare earths have dropped. Of course we have seen prices drop before. In the 1990s the prices dropped because the Chinese government was controlling its production and setting global prices in such a way as to drive competitors out of business. And then the price rose because the Chinese government began to exploit its monopoly position to drive prices up and use its strangle-hold on supplies to coerce manufacturers who needed these resources to set up their manufacturing in China.

Even if the current price drops were not mainly the result of the global recession, there is no reason to think that if we are not smart about how we support these industries the Chinese government won't just make the same moves all over again.

To believe that markets can work, when the biggest player in a particular industry is a hybrid Communist-capitalist state, is to cling to ideology in the face of ample evidence that it just ain't so.

I hope we can all work together to move a bill in this area. I would just close by noting that this Committee currently has zero bills that have been passed by the House. Zero. None. For this Committee, that is unprecedented for the first session of a Congress, at least going back to Chairman Roe. I would encourage the Majority to consider a bipartisan bill on critical materials as a strong first candidate for markup and passage on the floor of the House.

Chairman HARRIS. Thank you very much, Mr. Miller, and I assure you that in the tradition of the Science Committee that we look forward to working with you and the minority on crafting a bipartisan deal to deal with this very important issue.

If there are members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I would like to introduce our witness panel. Our first witness today is the Hon. David Sandalow, Assistant Secretary for Policy and International Affairs for the Department of Energy. Prior to being confirmed as Assistant Secretary, he was an Energy and Environment Scholar and a Senior Fellow in the Foreign Policy Studies Program of the Brookings Institution as well as the Energy and Climate Change Working Group Chair at the Clinton Global Initiative.

Our next witness is Dr. Derek Scissors, Research Fellow at the Heritage Foundation. Dr. Scissors is also an Adjunct Professor at George Washington University, where he teaches a course on the Chinese economy. Before joining Heritage in August 2008, Dr. Scissors was an Economist at Intelligence Research with a specialty in Chinese economics.

Our third witness today is Dr. Robert Jaffe, Jane and Otto Morningstar Professor of Physics at the Massachusetts Institute of Technology. He is a fellow of the American Association for the Advancement of Science and the American Physical Society, where he chairs the energy and environment subcommittee of the APS Panel on Public Affairs. In 2010 to 2011, Professor Jaffe chaired a study, "Energy Critical Elements: Securing Materials for Emerging Technologies," jointly sponsored by the APS and the Materials Research Society.

Our fourth witness is Dr. Karl Gschneidner, Senior Materials Scientist at Ames National Laboratory. He is considered the world's foremost authority of rare earth science, technology, application and utilization. He has published over 488 papers in peer-reviewed journals, holds 15 patents, and given 303 invited presentations.

Our final witness today is Mr. Luka Erceg, President and CEO of Simbol Materials. Prior to founding Simbol Materials, Mr. Erceg worked in the oil and gas industry. He brings 12 years of transaction advisory experience, predominantly in the energy and energy technology sectors.

Thank you all for appearing before the Subcommittee today. As our witnesses should know, spoken testimony is limited to five minutes each after which the members of the Committee will have five minutes each to ask questions.

I now recognize our first witness, the Hon. David Sandalow, Assistant Secretary for Policy and International Affairs at the Department of Energy.

STATEMENT OF HON. DAVID SANDALOW, ASSISTANT SECRETARY FOR POLICY AND INTERNATIONAL AFFAIRS, DEPARTMENT OF ENERGY

Hon. SANDALOW. Thank you very much, Mr. Chairman. Thank you, Ranking Member Miller and members of the Subcommittee. I appreciate the opportunity to testify today. I would like to take the opportunity to speak about critical materials and the work that the Department of Energy is doing on this topic.

Earlier this year, I visited the Mountain Pass Mine in southern California. I was impressed by the facility and its potential to provide a domestic source of rare earth metals. According to the mine's owners, the mine will have a production capacity of about 19,000 tons of rare earths by the end of 2012 and 40,000 tons by early 2014 using modern technologies at a globally competitive cost. That is an important step in the right direction.

Now, the issue of critical materials is important and needs priority attention in the months and years ahead. The Department of Energy shares the goal of establishing a stable, sustainable and domestic supply of critical minerals, and we look forward to discussions with the Congress on ways to address this issue as we move forward.

Last year, the Department of Energy released its first Critical Materials Strategy. The report found that four clean energy technologies—wind turbines, electric vehicles, photovoltaic cells and fluorescent lighting—use materials at risk of supply disruptions in the next five years. In the report, five rare earth elements—dysprosium, neodymium, terbium, europium and yttrium—as well as indium, were assessed as most critical in the short term, and for this purpose, criticality was a measure that combined importance to the clean energy economy and the risk of supply disruption.

Now, our 2010 Critical Materials Strategy highlighted three pillars to address the challenges associated with critical materials in the clean energy economy. First, substitutes must be developed. Second, recycling, reuse and more efficient use can significantly lower global demand. And third, diversified global supply chains are essential, and within diversified global supply chains, domestic sources are the most important.

With all three of these approaches, we must consider all stages of the supply chain from environmentally sound material extraction to purification and processing, the manufacture of chemicals and components, and ultimately end uses.

Now, DOE's research and development with respect to critical materials aligns with these three pillars of our strategy. In the past year, the department has increased its R&D investment in magnet, motor and generator substitutes focused on reducing the rare earth usage in these applications.

In September of this year, the department's Advanced Research Projects Agency for Energy, known as ARPA–E, announced funding in a 36-month program for 14 early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes in two key areas: electric vehicle motors and wind-generators. DOE's Vehicle Technologies and wind energy programs have also issued relevant funding opportunity announcements this year.

These activities build on DOE's longstanding expertise on these topics. For example, our Office of Basic Energy Sciences has funded research at Ames Laboratory on the production of high-quality rare earth magnets, magnetic technology, synthesis technologies and superconductors for many years.

Now, an important point: R&D is also an excellent route toward developing the next generation of human capital and technical knowledge required for a sustainable rare earth supply chain. To succeed in the global marketplace, we need to develop not only our mines but also our minds.

Developing expertise in these areas depends in part on private and public sector research support. The research programs supported by DOE and other organizations provide valuable opportunities for post-docs, for graduate students, for mid-career scientists and more.

This month, DOE will issue its 2011 Critical Materials Strategy. In that report, DOE will update its analysis in light of rapidly changing market conditions. DOE will also report on the results of our analysis on rare earth elements in petroleum refineries and other applications not addressed in last year's report. Our 2011 Critical Materials Strategy will include updated criticality assessments and market analyses to assist in addressing critical materials challenges, and it will also include the R&D plan that we have discussed.

Now, I want to stress that DOE's work is closely coordinated with other federal agencies and, as mentioned, the White House Office of Science and Technology Policy leads an interagency effort on critical materials within the Administration. The Administration is currently reviewing H.R. 2090, and DOE has no comments on the specific content of this bill at this time but we share the goal of improving assessments and supporting a research agenda for materials critical to our future energy economy, and we look forward to discussing with Congress ways to address any issues as we move forward.

Thank you.

[The prepared statement of Mr. Sandalow follows:]

PREPARED STATEMENT OF THE HON. DAVID SANDALOW, ASSISTANT SECRETARY FOR POLICY AND INTERNATIONAL AFFAIRS, DEPARTMENT OF ENERGY

Chairman Harris, Ranking Member Miller, and Members of the Subcommittee, thank you for the opportunity to testify today. The Administration is currently reviewing H.R. 2090 and has no specific comments on it at this time, but I would like to take this opportunity to speak about the critical minerals that underpin the transition to a clean energy economy and the Department of Energy's (DOE) ongoing work on this topic.

Earlier this year I visited the Mountain Pass Mine in southern California. I was impressed by the facility and its potential to provide a domestic source of rare earth metals. According to the owners, the mine will have a production capacity of about 19,000 tons of rare earths by end of 2012 and 40,000 tons by early 2014, using modern technologies at a globally competitive cost. That's an important step in the right direction.

The issue of critical minerals is important and needs priority attention in the months and years ahead. The Department shares the goal of establishing a stable, sustainable and domestic supply of critical minerals, and we look forward to discussions with the Congress on ways to address this issue as we move forward.

GLOBAL CLEAN ENERGY ECONOMY

The world is on the cusp of a clean energy revolution. Here in the United States, we are making historic investments in clean energy. The American Recovery and Reinvestment Act was the largest one-time investment in clean energy in our nation's history—more than $90 billion. At DOE, we're investing $35 billion in Recovery funds in electric vehicles; batteries and advanced energy storage; a smarter and more reliable electric grid; and wind and solar technologies, among many other areas. We are aiming to double our renewable energy generation and manufacturing capacities from 2008 to 2012. We are working to deploy hundreds of thousands of electric vehicles and charging infrastructure to power them, weatherize a million homes, and help modernize our grid.

Other countries are also seizing this opportunity, and the market for clean energy technologies is growing rapidly all over the world. For example, over $50 billion was invested in China in clean energy last year. They are launching programs to deploy electric cars in over 25 major cities; connecting urban centers with high-speed rail; and building huge wind farms, ultrasupercritical advanced coal plants and ultra-high-voltage long-distance transmission lines. India has launched an ambitious National Solar Mission, with the goal of reaching 20 gigawatts of installed solar capacity by 2020. And Japan is introducing feed-in tariffs to support the scale-up of electricity from renewable sources.

In Europe, strong public policies are driving sustained investments in clean energy. Denmark earns more than $10 billion each year in the wind energy sector. Germany and Italy are the world's top installers of solar photovoltaic panels, accounting for nearly three-quarters of a technologies are growing, helping create jobs, promote economic growth and fight climate change. These technologies will be a key part of the transition to a clean energy future and a pillar of global economic growth.

DOE STRATEGY

Last year, DOE released its first Critical Materials Strategy. The report found that four clean energy technologies—wind turbines, electric vehicles, photovoltaic cells and fluorescent lighting—use materials at risk of supply disruptions in the next five years. In the report, five rare earth elements (dysprosium, neodymium, terbium, europium and yttrium), as well as indium, were assessed as most critical in the short term. For this purpose, "criticality" was a measure that combined importance to the clean energy economy and the risk of supply disruption.

The 2010 Critical Materials Strategy highlighted three pillars to address the challenges associated with critical materials in the clean energy economy. First, substitutes must be developed. Research and entrepreneurial activity leading to material and technology substitutes improves flexibility to meet the material demands of the clean energy economy. Second, recycling, reuse and more efficient use can significantly lower global demand for newly extracted materials. Research into recycling processes coupled with well-designed policies will help make recycling economically viable over time. Finally, diversified global supply chains are essential. To manage supply risk, multiple sources of material are required. This means encouraging other nations to expedite alternative supplies and exploring other potential sources of material in addition to facilitating environmentally sound extraction and processing here in the chain: from environmentally-sound material extraction to purification and processing, the manufacture of chemicals and components, and ultimately end uses.

DOE's research and development (R&D) with respect to critical materials is aligned to the three pillars of the DOE strategy: diversifying supply, developing substitutes and improving recycling. R&D is not the primary mechanism to encourage supply diversification. However, environmentally sound separation and processing innovations will require research and development. R&D plays a more central role in developing substitutes, which represents a large share of the current critical materials R&D portfolio. R&D challenges can also help to improve recycling and reuse. Across the three pillars, there is also the need for fundamental research—developing the modeling, measurement and characterization capability that is the basis for future innovations. Systems level engineering approaches—which would help inform R&D priorities apply throughout the supply chain. As DOE is ramping up its work in this area, critical materials R&D is integrated with other research objectives that are focused on clean-energy technologies or fundamentals. DOE's R&D plan is informing an interagency R&D roadmapping effort led by OSTP.

In the past year, the Department has increased its R&D investment in magnet, motor and generator substitutes, focused on reducing the rare earth usage in these applications. In September of this year, the Department's Advanced Research Projects Agency—Energy (ARPA-E) announced funding in a 36-month program for 14 early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes in two Energy Programs have also issued relevant Funding Opportunity Announcements this year.

In batteries and photovoltaic materials, DOE has historically supported broad technology portfolios including those that incorporate abundant materials. Investments in these core competency areas have continued. This diversity of materials makes over-reliance on particular materials less likely.

Moving forward, additional R&D opportunities are present in: separations and processing; substitution for critical materials in phosphors for lighting; and recycling. DOE is already taking the first steps in this direction. The FY 2012 DOE Small Business Innovation Research (SBIR) solicitation has several topics relevant to Rare Earth Elements (REE)—specifically improving separation and processing. Anticipated R&D could support the first steps toward improving separation and processing technologies.

These activities build on DOE's longstanding expertise on these topics. For example, the Office of Basic Energy Sciences (BES) has funded research at Ames Laboratory on the production of high quality rare earth magnets, magnetic technologies, synthesis technologies and superconductors for a number of years. The Office of Energy Efficiency and Renewable Energy (EERE) has funded several projects at Ames Laboratory and Oak Ridge National Laboratory addressing alternate magnet and motor designs.

R&D is also an excellent route toward developing the next generation of human capital and technical knowledge required for a sustainable rare earth supply chain. Developing expertise in these areas depends, in part, on private-and public-sector research support. The research programs supported by DOE and other organizations provide valuable opportunities for post-doctoral researchers and graduate students. They can also incentivize mid-career scientists in related disciplines to develop research programs which are relevant to critical materials. R&D funding not only supports innovation in clean energy technology, it also enables the development of the next generation of scientists and engineers.

DOE will issue its 2011 Critical Materials Strategy this month. In that report, DOE will update its analysis in light of rapidly-changing market conditions. DOE will also report on the results of our analysis on rare earth elements in petroleum refineries and other applications not addressed in last year's report. The 2011 Critical Materials Strategy will include updated criticality assessments and market analyses to assist in addressing critical materials challenges. It will also include the R&D plan described above.

In support of this year's analysis, DOE issued a Request for Information that focused on critical material content of certain technologies, supply chains, research, education and workforce training, emerging technologies, recycling opportunities, and mine permitting. We received nearly 500 pages of responses from 30 organizations, including manufacturers, miners, universities, and national laboratories. Many organizations shared proprietary data on material usage that will help us develop a clearer picture of current and future market conditions.

Managing supply chain risks is by no means simple. At DOE, we focus on the research and development angle. From our perspective, we must think broadly about addressing the supply chain in our R&D investments, from extraction of materials through product manufacture and eventual recycling. It is also important to think about multiple technology options, rather than picking winners and losers. We work with other Federal agencies to address other issues, such as trade, labor and workforce, and environmental impacts. The White House Office of Science and Technology Policy has been convening an interagency effort on critical materials and their supply chains.

The Administration is currently reviewing H.R. 2090, and the DOE has no comments on the specific content of this bill at this time. We share the goal of improving assessments and supporting a research agenda for materials critical to our future energy economy. We look forward to discussions with the Congress on ways to address any issues as we move forward.

CONCLUSION

One lesson we have learned through experience is that supply constraints aren't static. As a society, we have dealt with these types of issues before, mainly through smart policy and R&D investments that reinforced efficient market mechanisms. We can and will do so again. Strategies for addressing shortages of strategic resources are available, if we act wisely. Not every one of these strategies will work every time. But taken together, they offer a set of approaches we should consider, as appropriate, whenever potential shortages of natural resources loom on the horizon.

So in conclusion, there's no reason to panic but every reason to be smart and serious as we plan for growing global demand for products that contain critical minerals. The United States intends to be a world leader in clean energy technologies. Toward that end, we are shaping the policies and approaches to help prevent disruptions in supply of the materials needed for those technologies. This will involve careful and collaborative policy development. We will rely on the creative genius and entrepreneurial ingenuity of the business community to meet an emerging market demand in a competitive fashion. With focused attention, working together we can meet these challenges.

Chairman HARRIS. Thank you very much.

I now recognize our second witness, Dr. Derek Scissors from the Heritage Foundation.

STATEMENT OF DR. DEREK SCISSORS, RESEARCH FELLOW, HERITAGE FOUNDATION

Dr. SCISSORS. Thank you, Mr. Chairman, and thanks to the Committee for this opportunity. I want to especially thank the ranking member, Mr. Miller, because I am now going to skip my whole introduction and toss out my presentation because he has quite correctly gone to what for me is the heart of the matter, which is how this market works. Congressman Miller and I have points of agreement, and we have points of sharp disagreement, and I think it would be useful for the Committee to hear those.

The points of agreement—the Congressman is absolutely right that short-term price movements are not what we should be looking at. Prices are going up, prices are going down. That should not be driving our decision making. This is a long-term issue. I would actually extend that and say that government intervention on the basis of short-term price movements is also a terrible idea. So when the Committee hears about how prices are spiking and we must do something, that is not a good argument, just like when prices are dropping, it is not like, "okay, everything is fine, we don't have to do anything anymore." That is not what we should be evaluating.

I have completely thrown out my presentation, so pardon me for winging it here, but it is the ranking member's fault for jumping ahead in where I was going to go.

To get to his point, it is not that we trust the Chinese. I am going to talk a little bit about Chinese behavior in a second. It is that markets work on their own when new firms can enter. We are not trusting the Chinese, we are trusting the new firms that have come in in response to higher prices. We are not trusting the Chinese, we are trusting market clearing. Higher prices cause demand conservation. They cause substitution of other elements. They cause expansion of existing production. That is what we are trusting.

Mr. Miller is exactly right about Chinese predatory behavior. The market was created in a sense, not created, but it was radically altered by Chinese undercutting prices, making everything rare earth cheaper, but simultaneously driving everyone out of the market. They then discovered right after they drove everyone out of the market that there is an ecological problem here and so we can't export as much as we used to. This is just predation. There is no question about it. So there is no disagreement that the Chinese are predatory pricers in rare earths. The disagreement is, their market power is temporary. The chairman quoted 97 percent of rare earth production being Chinese. That number is probably closer to 90 now and it is dropping, and it is dropping for two reasons. One, the Chinese are restricting their own output because they want to charge everyone more money but also we are slowly getting more production from everywhere else, and the market is anticipating more production so that is what is driving prices down.

On fundamentals, we have an issue here of where rare earths and ECEs are located. It is a rapidly changing market. You have to do a lot of survey work, which is exactly something Congress should mandate. But we know that Chinese holdings of rare earth deposits are far below their production level. That is unsustainable. You can't produce more than you have for an extended period. So we know the Chinese market position is unsustainable. We know it is going to erode just on basics.

Now, that is the situation in the market. What should the government do? I am going to start with what the government should not do. The market is working fine. We are getting substitute and demand. We are getting expansion and supply, exactly what we want. That makes subsidies, government interference immediately a bad idea. Loan guarantees are a bad idea too. Loan guarantees cost the government less. That is important. But the point is, they alter market conditions. They bias the technology path. They pick out firms that shouldn't be picked out except by competition. So the difference between subsidies and loan guarantees is cost, which matters, but the interference in the market is the same.

And now I am going to play my role as a Heritage Foundation market fundamentalist and say that even applied research can be subsidy. If applied research picks out a particular firm or picks out a particular technology, it is acting as a subsidy. That compromises technological dynamism and it compromises efficiency.

So what should the government do? First, there is basic research that the private sector cannot do at present. The government should support that. Second, and I think all the bills do this and they are quite correct, it is a crucial role for the government to provide information, especially in a rapidly changing market where some of the information is not available to private firms. Private firms can't just go survey global rare earth and ECE deposits around the world. The U.S. Government has to do this, and here is another point where Mr. Miller and I agree. This is a long-term process. We don't need one survey. We need a long-term process where the government is providing needed information to market participants in a reliable and consistent fashion down the road so they know what is coming and they can operate accordingly. And the third thing the government might do is beyond my area of expertise but I will just throw it out there. Because this market is working properly, extending the market will bring a commercial return. That involves opening federal land to ECE exploration. I know there are many factors. I am not arguing for that. I am just saying it will bring a commercial return to do so, and the Committee will have to decide on those other factors.

Finally, I have a closing point to make. Thirty-five years ago, the supply of strategic minerals was threatened by conflict in southern Africa and apparent monopolization by a non-market economy, the Soviet Union. The private sector created rare earths as the response. When you are touting the importance of rare earths, you are touting the importance of private sector innovation. Now, as then, the market worked and we should let it work again. I am sorry for going ten seconds over.

[The prepared statement of Dr. Scissors follows:]

PREPARED STATEMENT OF DR. DEREK SCISSORS, RESEARCH FELLOW, HERITAGE FOUNDATION

My name is Derek Scissors. I am Asia economics research fellow at The Heritage Foundation. The views I express in this testimony are my own, and should not be construed as representing any official position of The Heritage Foundation.

Energy-Critical Elements: The Market Is Working
Derek Scissors, Ph.D.

It may have seemed as if the prices of rare earth elements could only rise, but they have recently dropped quite a bit. The drop—and what is behind it—is an excellent reminder of why governments should not use price fluctuations as a reason to intervene in energy markets.

High prices should not be used as a reason to endorse certain materials or existing firms through subsidies. Nor should the government skew technological development by favoring particular research paths. These actions are self-defeating and will lead to an uncompetitive industry, where market forces are already creating more competition and technological dynamism.

In rare earths, and in the wider category of energy-critical elements, the first role of government is to provide vital information that private actors cannot gather. Second, opening more federal land to evaluation, and possibly exploration, should be considered. Third, basic research, only, should be conducted under certain conditions.

Price Declines

Rare earth elements (REEs) are a group of 17 elements currently valuable in energy and military equipment. Energy-critical elements (ECEs) are a larger group, classified on the basis of their present uses, that include rare earths but also other elements.[1] REEs receive more attention but, where possible, it is more informative to assess ECEs.

REEs gained global attention when prices began to rise in 2009, a trend that continued into 2011. During this two-year period, a debate began between those calling for the U.S. government to ensure supply and those arguing that both market supply and market demand should be allowed to work unimpeded.[2]

Recent evidence favors those who prefer market forces, as old and new players have responded and driven prices down. Contemporary adjustment has been driven primarily by changes in demand. Higher prices led to demand destruction, as always. Some of this demand weakness is due to conservation, in particular new recycling processes from Hitachi's narrow focus on magnets to Umicore's broad-spectrum efforts. Another effect of higher prices is to cause substitution of other elements (for example, in powering batteries).[3]

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[1] American Physical Society Panel on Public Affairs and The Materials Research Society, "Energy Critical Elements: Securing Materials for Emerging Technologies," February 2011, at *http://www.aps.org/policy/reports/popa-reports/upload/elementsreport.pdf* (December 2, 2011).
[2] Derek Scissors, "Rare Earths: Cause for Worry, not Panic," Heritage Foundation *The Foundry*, October 6, 2010, at *http://blog.heritage.org/2010/10/06/rare-earths-cause-for-worry-not-panic/* (December 2, 2011).
[3] David Fickling, "Lynas Shares Rise as Price Fall Brings Surety to Customers," Dow Jones Newswires, November 30, 2011, at *http://www.theaustralian.com.au/business/mining-energy/lynas-shares-rise-as-price-fall-brings-surety-to-customers/story-e6frg9df-1226209983105* (December 2, 2011) and Frik Els, "Price of Abundant Rare Earths

On the supply side, higher prices have encouraged new producers to enter the market and existing suppliers to expand. In the U.S. and elsewhere, new firms have been created, existing ECE firms have mushroomed in size, and new deposits have been discovered, as one would expect with the greater incentive to explore.[4] The market response has progressed to the point where transnational alliances have been struck between established consumers and nascent producers, as in Molycorp's agreement in late November with Japan's Daido Steel and Mitsubishi.[5]

It is not that a great deal of new physical supply has become available; that process has only started. In the same way, inadequate supply actually caused only some of the prior price explosion. Prices have been moving in large part in response to anticipation of future shortages, previously skyrocketing in anticipation of durable future shortage but correcting as the shortfall now seems less acute.

Falling prices are the inevitable result of the demand destruction and new incentives in supply. By August, the prices of all REEs had begun to drop,[6] a decline that has persisted through the end of November and brought costs down about one-third from their peak. This should have been no surprise: If permitted, markets naturally correct.

Beyond the general downward trend, snapshots of the market are not very informative. Not only have REE prices been changing rapidly, but trading in some elements is not sufficiently developed to generate reliable estimates. Among those that are more heavily traded, Cerium has dropped over 40 percent in the past three months, while the decline for Samarium started later and has been smaller through the end of November.[7] This variation is natural due to differing supply (some REEs are not actually rare) and differing demand, especially between heavy and light elements.

The trend of broadly declining prices will continue until further supply expansion, recycling, conservation, and substitution are no longer commercially appealing. When that happens is less

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Could Halve as Hybrid Makers Find Alternatives," Mining.com, September 29, 2011, at *http://www.mining.com/2011/09/29/price-of-abundant-rare-earths-could-halve-as-hybrid-makers-find-alternatives/* (December 2, 2011).

[4] "Lynas Raises 170m in Capital Raising," Associated Press, October 28, 2009, at *http://metalsplace.com/news/articles/30854/lynas-raises-170m-in-capital-raising/* (October 31, 2011); Press release, "USMMA Welcomes New Member Companies Texas Rare Earth Resources and Stans Energy," Business Wire, July 19, 2001, at *http://www.businesswire.com/news/home/20110719006647/en/USMMA-Welcomes-Member-Companies-Texas-Rare-Earth* (October 31, 2011); and Daniel Grushkin, "Alaska's Billion Dollar Mountain," *Bloomberg Businessweek*, October 27, 2011, at *http://www.businessweek.com/magazine/alaskas-billion-dollar-mountain-10272011.html* (October 31, 2011).

[5] Dorothy Kosich, "Molycorp, Daido, Mitsubishi Form Next Generation Rare Earth Magnets JV," Mineweb, November 29, 2011, at *http://www.mineweb.com/mineweb/view/mineweb/en/page72102?oid=140588&sn=Detail&pid=102055* (December 2, 2011).

[6] Yu Xi, "Prices of Rare-earth Metals Drop in July," Global Times, July 7, 2011, at *http://www.globaltimes.cn/NEWS/tabid/99/ID/665156/Prices-of-rare-earth-metals-drop-in-July.aspx* (October 31, 2011).

[7] "Cerium Metal Prices, News, and Information," Metal-Pages, December 1, 2011, at *http://www.metal-pages.com/metals/cerium/metal-prices-news-information/* (December 2, 2011).

important than the fact that it ultimately *should* happen: ECE prices *should* rise when market forces drive them in that direction. Without scarcity and high prices, responsive research and innovation will not occur and technological stagnation will ensue, perpetuating the very conditions that prompted concerns over ECEs.

Are ECEs Different?

In this way, government intervention is typically self-defeating. It prevents the market from clearing away problems used to justify intervention in the first place (for example, the temporary lack of substitutes for scarce REEs). There are, of course, those who believe the government should act whenever prices are high or low—in natural resources, houses, farm goods, health care, stocks, and so on. The outcome is always that the vast majority end up subsidizing a very small group.

In addition, there are more sophisticated claims that market principles should not apply to ECEs, as they are thought to be exceptional. These claims do not stand up well to scrutiny.

Certain ECEs are important to the U.S. military, but most are not. Further, within the group that is important, some materials have long life cycles and no supply shortage is anticipated.[8] It is misleading to insist that an assured supply of ECEs is vital for national security without demonstrating shortfalls that rely both on known resources and on specific forecasts of military demand. Otherwise, the potential national security importance of a small subset of ECEs will be used to justify much broader, harmful government interference.

The other feature of ECEs, and REEs in particular, often cited to support government action is Chinese supply dominance. This dominance is not important in American trade figures. Raw and refined REEs do not fit seamlessly into existing trade categories, but the U.S. spent at most $1.4 billion on their import in 2010 (fish imports from China were almost $2 billion).[9] At that level, the cost of imported REEs cannot be important either in the defense budget or in commercial energy.

In terms of production, China is said to account for more than 90 percent of REEs, though this figure may now be declining. The reason for a possible decline is also a reason for worry: The Chinese government and its state-owned enterprises have consistently behaved in predatory fashion with respect to REEs. The first phase of this behavior was actually sharp reductions in prices that drove competitors out of business.[10] This occurred for most of the past decade and gave China its leading position.

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[8] B. R. Arvidson, "The Many Uses of Rare-Earth Magnetic Separators for Heavy Mineral Sands Processing," International Heavy Minerals Conference, June 2001, at *http://www.outokumputechnology.com/files/Technology/Documents/Physical%20Separation/Technical%20Papers/ManyusesofREBA.pdf* (October 31, 2011), and Jack Lifton, "Heavy Rare Earths In America, Crystal Balls & Brass Balls," Technology Metals Research, August 4, 2011, at *http://www.techmetalsresearch.com/2011/08/heavy-rare-earths-in-america-crystal-balls-brass-balls/* (October 31, 2011).

[9] U.S. Census Bureau, "U.S. International Trade Statistics," at *http://censtats.census.gov/naic3_6/naics3_6.shtml* (December 2, 2011).

[10] Jack Dini, "China's Monopoly on Rare Earth Metals," Canada Free Press, October 30, 2011, at *http://www.canadafreepress.com/index.php/article/41856* (December 2, 2011).

When Beijing stopped undercutting the market, prices rose sharply and the global hunt for alternatives began, which is now bringing prices down. China's response to the ongoing price decline has been to cut supply further.[11] This has reintroduced some fear of shortage but is also a further spur to global market development. Indeed, the PRC has been cutting supply to no avail throughout the period during which prices have been dropping. Chinese production dominance in REEs is unfortunate, but it is also unstable.

The PRC's share of reserves is also unstable. While the viability of deposits varies with market prices, the U.S. Geological Survey claims that China has over one-third of known REE reserves. The share falls when all ECEs are considered and, even for REEs, will fall as exploration continues.[12] As with all other mineral resources when prices rise, there are likely vast sources of ECEs yet to be discovered. If prices remain high, and with them the incentive to explore, the size and distribution of known reserves will change considerably.[13]

An aspect of the functioning of markets that is often omitted in discussing ECEs, therefore, is that Chinese dominance can last only as long as Beijing is willing to sell REEs at below-market prices. Because alternative suppliers can freely enter when prices are high, the market can adjust to any Chinese predation.

Further, REEs will not always be as important as they are seen to be now. The uses of REEs are not timeless; they arose in the 1970s from a private-sector response to unreliable supply of strategic minerals from southern Africa.[14] Nor was the prominence of REEs anticipated: Some environmentalists who opposed Molycorp's mine a decade ago now call for REE subsidies for environmental equipment. China's price cuts actually spurred mass use of REEs and many assume REEs will grow further in importance. But if conditions are reversed so that prices are high and it is REE supply that is unreliable, other ECEs will again arise as substitutes.

What To Do...

In light of these facts, the House must first decide the extent of any true national interest that might justify government intervention. Examining market developments and the nature of ECEs show no broad national-interest justification right now (although there may be a national interest

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[11] Shivom Seth, "More Rare Earth Companies in China Suspending Production as Prices Slide," Mineweb.com, October 27, 2011, at *http://www.mineweb.com/mineweb/view/mineweb/en/page72102?oid=138362&sn=Detail&pid=102055* (November 30, 2011), and "Baotou Rare Earth Shares Plunge After Decision to Halt Production," Xinhuanet, October 19, 2011, at *http://news.xinhuanet.com/english2010/china/2011-10/19/c_131200285.htm* (November 30, 2011).

[12] U.S. Geological Survey, "Mineral Commodity Summaries," January 2011, at *http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/mcs-2011-raree.pdf* (October 31, 2011).

[13] Geology.com, "REE: Rare Earth Elements and Their Uses," at *http://geology.com/articles/rare-earth-elements/* (March 18, 2011); Abhishek Shah, "Toshiba Leads Japanese Search for Rare Earth in Mongolia, Kazakhstan and Uranium Processing," GreenWorldInvestor.com, November 29, 2010, at *http://greenworldinvestor.com/2010/11/29/toshiba-leads-japanese-search-for-rare-earth-in-mongoliakazakhstan-and-uranium-processing/* (December 2, 2011).

[14] Aaron Sichel, "The Story of Neodymium: Motors, Materials, and the Search for Supply Security," Chorus Motors, Autumn 2008, at *http://www.choruscars.com/Chorus_NEO_WhitePaper.pdf* (December 2, 2011).

concerning a small subset of ECEs used by the military). The ensuing question is whether future government intervention might be justified.

In seeking to address this question, the House has multiple options, ranging from research to recycling to retread industrial policy. When the market is working properly, as it is now, the most helpful government policy is to extend the size of the market through deregulation. An obvious way to inhibit Chinese or any other monopoly position in ECEs is for the U.S. to make more of its own resources available. To this end, modifications of federal restrictions on land use should be studied.

A second core government role is information provision. Pursuant to the committee's instruction to testify regarding H.R. 2090, The Energy Critical Advancement Act of 2011, the resolution correctly acts to fulfill this role. One clear government responsibility is to ensure that U.S. military equipment demand is not affected by surprise ECE market shifts, and information relevant to these specific requirements should be compiled on a regular basis.

In energy, the dynamic exploration and production processes in REEs in particular are altering the distribution of American and global production and reserves. This information is very difficult for a private actor to compile and update, making it a government responsibility to do so, one rightly taken up in H.R. 2090. A number of other proposals also do this, offering different mechanisms and different priorities.

Beyond information provision, government can be involved in basic research, as H.R. 2090 indicates. Basic research should be focused on areas of clear government responsibility, and all opportunities to shift work to the private sector should be examined.

...And What Not To Do

In contrast, active interference in a functioning market is self-defeating. Some proposals and actions concerning ECEs pick out seemingly important materials for what is unavoidably long-term action on the basis of short-term conditions. Supporting ECEs in light of current use risks warping research incentives and generating inferior technology. Supporting individual companies risks elevating the inefficient over superior present or future competitors. A combination of weak firms and inflexible technology kills any industry. Picking winners, including technological winners, in a rapidly developing market increases the odds of a losing industry in the future.

A brief description of certain Department of Energy programs that utilize ECEs provides examples of market-distorting practices with no national-interest justification.

- The Advanced Research Projects Agency–Energy (ARPA–E) intends to "bridge the gap between basic energy research and development/industrial innovation." This is a bridge between work that might help the private sector and work which binds needed private-sector innovation to government initiative. ARPA–E tops its goals with "To bring a freshness, excitement, and sense of mission to energy research," straining the notion of national interest.[15]

- The Vehicle Technology Program is "strongly committed to partnerships to help ensure the eventual market acceptance of the technologies being developed." Ensuring market acceptance of technology is exactly what the government should not do; it pushes private actors toward the government's preferred path, limiting flexibility and assuring lower capability and higher cost.

- The Advanced Manufacturing Office is similarly looking to deploy technologies rather than just initiate research.

- The Wind Program's goals lead with job creation and rural economic development, far removed from a national interest in energy.[16]

The government should generally not participate in applied research, as this biases the technology path. While the line between basic and applied research is often blurry, one difference is that research focused on exploiting current technology is applied and not a proper activity for government. Also, government research should not be done in cooperation with only one commercial entity or focused on technology utilized by only one commercial entity. These are essentially subsidies supporting inefficient production and should be avoided entirely.

Recipients of subsidies often claim the mantle of representing the national interest. These claims are incompatible with all legislation seeking the correct goal of a competitive ECE market. It is competition that ensures superior firms and the best technology will emerge over time. In a competitive market, no single firm or technology is important enough to merit government support. Government interference to support a particular firm or technology inherently bars formation of a competitive ECE market and assures higher costs and slower development.

In this vein, it should be recognized that the heavier cost of subsidies is not financial, but rather their distorting effect on markets. Loan guarantees are thus only a minor improvement over grants. The direct cost to the taxpayer is lower, but they still work at odds with the creation of competitive markets, emergence of superior firms, and dynamic technological development.

The defense of loan guarantees and other subsidies is that they are necessary to ensure ECE supply. However, the market is already doing an excellent job of ensuring ECE supply, and prices are falling as a result. Government action to ensure supply might mean lower prices, but this has little value given that REE imports in particular cost so little. Far more important is that below-market prices discourage conservation, substitution, and innovation.

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[15] U.S. Department of Energy, Advanced Research Projects Agency, "About," at *http://arpa-e.energy.gov/About/About.aspx* (December 2, 2011).

[16] U.S. Department of Energy, Vehicle Technologies Program, "Financial Opportunities," September 29, 2011, at *http://www1.eere.energy.gov/vehiclesandfuels/financial/index.html* (December 2, 2011), U.S. Department of Energy, Advanced Manufacturing Office, "About," November 30, 2011, at *http://www1.eere.energy.gov/industry/about/index.html* (December 2, 2011) and U.S. Department of Energy, Wind Program, "About the Program," September 22, 2011, at *http://www1.eere.energy.gov/wind/about.html* (December 2, 2011).

The various proposals for action are also subject to simple arithmetic. A single guaranteed loan, outright subsidy, or applied research program is probably a bad idea, but it is a limited one. Many such programs or subsidies make it certain the government will make multiple incorrect choices, picking elements, companies, and especially technologies that ruin market development. Finally, any proposals that mandate both multiple subsidies and many other activities immediately fail even to identify and prioritize a critical task that justifies government attention.

Conclusion

In sum:

1. The House should consider opening more land to ECE-related assessment and exploration.

2. The House should strongly consider immediately devoting more resources to gathering information on ECEs on a regular basis.

3. The House absolutely should not subsidize ECE mining, production, or refinement, including with loan guarantees. This will reverse progress being made by the market.

4. The House should consider supporting basic research on ECE's. Applied research is often tantamount to subsidy, carries the same risks, and should be strictly limited.

Because prices may go up as well as down, the U.S. government should gather information on possible market shifts. For the same reason, demands for further government intervention in ECEs are being made on the basis of conditions that would no longer apply when the intervention became effective. In contrast, global market adjustment has been rapid and thorough. Let the market continue to work.

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Chairman HARRIS. That is okay. Thank you very, very much.

I now recognize our third witnesses, Dr. Robert Jaffe of MIT.

DR. ROBERT JAFFE, JANE AND OTTO MORNINGSTAR PROFESSOR OF PHYSICS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. JAFFE. Mr. Chairman and members of the Committee, thank you for the opportunity to testify today.

As Mr. Harris mentioned, I recently chaired a study of energy-critical elements sponsored by the American Physical Society and the Material Research Society. Today I will highlight a few of our key findings and recommendations.

Despite calls to the contrary, the sky is not falling. We will not run out of any chemical element any time soon. Nevertheless, the problem of availability of certain key elements is serious and very real. While rare earths are the flavor of the month, or perhaps the flavor of last month, a host of other elements are poised to present problems in the future. We are in this for the long term.

If appropriate steps aren't taken, we may face disruptive short-term constraints on supply of some elements that are not presently mined or refined or traded in large quantities but are critical to the deployment of potentially game-changing technologies. Casualties might range from important petroleum refinery catalysts to state-of-the-art wind turbines. Constraints on the availability of ECEs would limit the competitiveness of both U.S. industries and the domestic scientific enterprise, disrupting both innovation and investment.

I describe five types of constraints in my written testimony. Let me mention just two now. First are geopolitical constraints. Some ECEs exist only in one or two large or rich deposits in the world which are not in the United States. In other cases, economic or political forces have allowed one or few countries with particularly rich or abundant ECE resources to manipulate the market, as we have just heard.

A second constraint is the risk associated with joint production. Some ECEs are only recovered as byproducts in extraction of more common metals. While they are in low demand, these ECEs may be abnormally cheap only to become far more expensive when by-product production is exhausted.

The study I chaired recommends a comprehensive approach to the ECE problem based on information, research and recycling. It is our view that with careful stewardship by the government coupled with the imagination of fundamental research and the initiative of U.S. Government, the problem of ECEs can be managed for the foreseeable future.

In developing our recommendations, we took a lesson from industry. General Electric had for many years tracked the market for an exceptionally rare metal, rhenium, which is critical to its advanced turbines in modern natural gas-fired power plants. In 2005, GE predicted a demand for rhenium that would soon outpace worldwide supply. Instead of stockpiling, GE reduced its immediate need for new rhenium by a wide-ranging recycling program and a multi-year research program aimed at developing an alternative alloy. By 2010, they had found, tested and certified several low-rhenium alloys. Meanwhile, the price of rhenium had jumped tenfold to over $10,000 a kilogram. GE succeeded, but smaller U.S. companies, universities and national labs, one, don't have the information-gathering network needed to recognize an impending supply disruption; two, can't afford to carry out substitutional research; and three, can't engage in extensive recycling. Consequently, in general, we recommend the following:

First, the government should gather, analyze, and disseminate information on ECEs across the lifecycle supply chain including resources, production, use, trade, disposal and recycling. Accurate information about availability will allow scientists, entrepreneurs and investors to see beyond the price spikes and plan for the future.

Second, the government should promote fundamental research aimed at the twin goals of increasing supplies and decreasing our dependence on ECEs. It is especially important to support fundamental research on earth-abundant substitutes for ECEs.

Third, cell phones and iPods end up discarded at the back of sock drawers, yet often they contain ECEs in concentrations that exceed all but the richest ores. We need to develop technology and awareness to promote recycling of these elements that are often and truly more precious than gold. Here again, both government and industry have a role to play. I believe our report's recommendations can be implemented with a budget-limited approach that respects the distinction between activities that belong in the private sector and those that fall to government.

You have asked me to comment on the *Energy Critical Elements Advancement Act of 2011* introduced by Representative Hultgren. The Hultgren bill, which shares many features with Mr. Miller's bill, has provisions on the full triad that we recommend: information, research and recycling. It also reflects our view that these important actions can be addressed in a budget-limited or, in some cases, a budget-neutral manner. The Hultgren bill recognizes the need for careful stewardship by the government without unnecessary overreach. It couples the imagination of fundamental research and the initiative of U.S. industry so that the problem of ECE availability can be managed for the foreseeable future.

Thank you very much for the opportunity to testify, and sorry for running over.

[The prepared statement of Mr. Jaffe follows:]

PREPARED STATEMENT OF DR. ROBERT JAFFE, JANE AND OTTO MORNINGSTAR PROFESSOR OF PHYSICS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Mr. Chairman and members of the committee, thank you for the opportunity to testify today on *"Energy Critical Elements: Identifying Research Needs and Strategic Priorities"* and comment on legislation before you. I am a professor of physics at MIT and recently chaired a study of *Energy Critical Elements* sponsored by the Panel on Public Affairs (POPA) of the American Physical Society (APS) and by the Materials Research Society (MRS). I enclose a full copy of the report for the record, but this morning I'll simply highlight a few key findings and recommendations.

THE ROLE OF ECEs

Although we are not going to run out of any chemical element anytime soon, the problem of availability of certain key elements is serious and very real. While rare earths are the "flavor of the month", a host of other elements are poised to present problems in the future.

Recently a colleague of mine had to lay-off a post-doc due a spike in the price of helium he needed to sustain the research program. A minor event? But multiplied over and over in scientific research, business, and industry throughout America, serious disruptions in innovation and investment occur when the price and availability of critical elements fluctuate wildly over a few months time.

If appropriate steps are not taken, we face potentially disruptive short-term constraints on supply of some elements that are not presently mined, refined, or traded in large quantities, but are critical to the deployment of potentially game-changing energy technologies. Casualties might range from key petroleum refinery catalysts to state-of-the-art wind turbines or market competitive solar panels. I refer to these elements as ECEs -- **Energy-Critical Elements**.

I enclose a page identifying several ECEs and their role in our nation's energy future.

CONSTRAINTS ON AVAILABILITY

Constraints on availability of ECEs would threaten the competitiveness of both U.S. industries and the domestic scientific enterprise. I'll briefly mention each of the constraints along with an example from the list of ECEs:

1) Low Abundance or Concentration
Though not intrinsically rare, some ECEs are not mineralized efficiently by geological processes, and do not occur in viable ores.
EXAMPLE: Although nearly as abundant as tin, germanium has limited use because it is not found in rich ores.

2) Geopolitical Risks
By chance, in some cases, ECEs exist in only one or two large or rich deposits in the world. In other cases, complex economics and politics have led to dominance of a single or small number of countries that have particular ECEs, allowing those countries to manipulate the market.
EXAMPLE: China has limited the export of rare earth elements.

3) Risks of Joint Production
Some ECEs are only recovered as by-products in extraction of more common metals. This links their availability to the economics of the primary metal. While in low demand, these ECEs may be abnormally cheap, only to become far more expensive when by-production is exhausted.
EXAMPLE: Nearly all tellurium is a by-product of copper refining.

4) Environmental Concerns
Some countries in the developed world will not accept environmental disruption associated with extraction of particular ECEs, while other countries are willing to tolerate environmental degradation for short-term gain. Rising environmental standards and/or social unrest can disrupt supplies.
EXAMPLE: The extraction of certain rare earth elements in South China is notoriously damaging to the environment.

5) Response times in production & utilization
It takes 5-15 years to bring new sources online and/or research and develop substitutes.
EXAMPLE: The supply of lithium is uncertain due to time delays in production.

APS POPA/MRS RECOMMENDATIONS
The panel I chaired made recommendations to address constraints on element availability. We focused intensely on elements critical to new technologies that have the capacity to transform the way we harvest, transport, store, or use energy. (Please note that we did not consider defense-related issues.)

It is our view that with careful stewardship by the government, coupled with the imagination of fundamental research and the initiative of U.S. industry, the problem of ECE availability can be managed for the foreseeable future.

To accomplish that, we recommend a three-component approach based on information, research, and recycling.

But first, let me say a few words about what we don't recommend.

The U.S. can't mine its way to ECE independence. Yes, we should certainly pursue domestic mining when economically and environmentally appropriate – but not with the expectation that mining alone will solve the problem. Many ECEs are simply not found here in economically viable deposits, and others are produced more efficiently – for a variety of reasons – by other countries. Free international trade with a diverse set of suppliers works to everyone's advantage.

We can't rely on stockpiling either. We found that stockpiling is a disincentive to innovation because it anchors us to the status quo. Stockpiles have proved a poor way for governments to try to moderate price fluctuations and stabilize markets, often with unintended negative consequences. (Note, however, that we did not consider defense stockpiles, which may be motivated by other considerations.)

In developing our recommendations for the most effective way to address this issue, we took a lesson from industry.

> **CASE STUDY**: General Electric has for many years tracked the market for an exceptionally rare metal, rhenium, which is critical to its advanced turbines used both in jet engines and modern natural-gas fired power plants. In 2005, General Electric projected that demand for rhenium would outpace worldwide supply within a few years. Instead of stockpiling, GE reduced its immediate need for new rhenium by a wide-ranging recycling program, and began an intensive, multiyear research program to develop an alternative alloy. By 2010 they had found, tested, and certified several new alloys that use less rhenium. Meanwhile the price of rhenium had risen 10-fold to over $10,000/kg.
>
> **LESSON**: GE succeeded, but many smaller U.S. companies and university & national labs: 1) do not have the information gathering network needed to recognize an impending supply disruption; 2) can't afford to carry out substitutional research; and, 3) can't engage in extensive recycling.

Consequently, in general, we recommend the following:

1) The government should gather, analyze, and disseminate information on ECEs worldwide across the life-cycle supply chain, including resources, production, use, trade, disposal and recycling. Accurate information about availability will allow the scientific enterprise as well as investors to see beyond the price spikes and plan for the

future. This can be achieved by, among other things, elevating the federal information gathering entity to a "Principal Statistical Agency" similar to the Bureau of Labor Statistics and the Energy Information Administration.

2) The government should promote fundamental research aimed at the twin goals of increasing supplies and decreasing our dependence on ECEs. It is especially important to support fundamental research on earth-abundant substitutes for ECEs. The goal should be a broad understanding of the advantages and disadvantage of technologies based on alternative materials, in order to enable U.S. manufacturers or lab researchers to more smoothly shift to a substitute material or alternative technology in advance of supply disruptions.

3) Cell phones and iPods end up discarded in the back of sock drawers, yet they often contain ECEs in concentrations that exceed the richest ores. Those dispersed products could be gathered into a resource – an urban mine – so the ECEs can be extracted for reuse. There are various paths to achieve this: government could help increase recycling by enabling greater consumer awareness and industry could stimulate it by providing consumer incentives.

THE ENERGY CRITICAL ELEMENTS ADVANCEMENT ACT OF 2011

I believe that our report's recommendations can be implemented with a budget-limited approach that respects the distinction between activities that belong in the private sector and those that fall to government. As a result, I'm delighted to testify today along with a Research Fellow at the Heritage Foundation.

Several House bills have been introduced to address the minerals availability issue. I'll speak to one in particular: HR 2090 -- the Energy Critical Elements Advancement Act of 2011, introduced by Representative Hultgren.

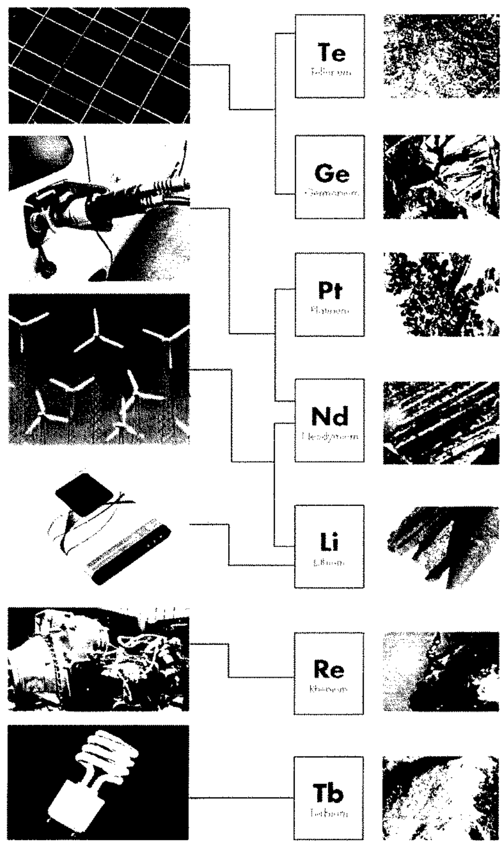
The Hultgren bill has provisions on the full triad that we recommend: information, research, and recycling. It is also closely aligned with our view that these important actions can be addressed in a budget-limited – or even in some cases a budget-neutral – manner.

The Hultgren bill is comprehensive and recognizes the need for careful stewardship by the government without unnecessary overreach. It couples the imagination of fundamental research and the initiative of U.S. industry so that the problem of ECE availability can be managed for the foreseeable future.

Thank you for the opportunity to testify.

Energy Critical Elements: Powering Our High-Tech World

Energy Critical Elements (ECEs) are found in a myriad of high-tech, environmental and military equipment. From smart phones to solar panels to jet engine parts, ECEs play crucial roles in products affecting our daily lives.



TELLURIUM—brittle, silvery-white metallic element used in solar panels

GERMANIUM— hard, grayish-white element with metallic luster; used in solar panels

PLATINUM—silvery-white, lustrous, ductile and malleable; used in pollution control devices for cars, and in fuel cells

NEODYMIUM—bright, silvery rare-earth metal element; used in wind turbines and hybrid cars

LITHIUM—a soft, silver-white metallic element; used in wind turbines and lithium-ion batteries in hybrid cars

RHENIUM—silvery-white metal with one of the highest melting points of all elements; used to make advanced turbines and jet engine parts

TERBIUM—a soft, silvery-white rare earth metal; used along with its fellow rare earth europium in compact fluorescent light bulbs to provide an acceptable color balance

Energy critical element images obtained from: *http://images-of-elements.com*

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One Physics Ellipse,
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529 14th Street, NW, Suite 1050
Washington, DC 20045

Chairman HARRIS. No, thank you, Dr. Jaffe.

I now recognize our fourth witness, Dr. Karl Gschneidner of the Ames National Laboratory.

STATEMENT OF DR. KARL GSCHNEIDNER, SENIOR MATERIALS SCIENTIST, AMES NATIONAL LABORATORY

Dr. GSCHNEIDNER. Thank you very much for giving me the opportunity to speak this morning in testimony. I also want to thank the Hon. Mr. Harris and the Hon. Mr. Miller for the very nice introduction to my talk. I can probably cut out half of it, but I won't. And also, the other speakers were a very nice preface.

The rare earth elements comprising scandium, yttrium and the 15 lanthanides are vitally critical to both our military and energy securities. In the military sector, all of our weapons systems are especially dependent on rare earths, and permanent magnets, which are utilized in electric motors, computers, guidance systems, etc., sensors, capacitors, resistors, phosphors for optical displays, lasers, aircraft engines, communication devices such as filters, tuners, phase shifters, radar antenna and optical devices, camera lenses and fiber.

In the energy sector, we are especially dependent on rare earths in permanent magnets for electric motors, cars, trucks, wind turbines, nickel-metal-hydride batteries, petroleum refining catalysts, fluorescent and LED lighting, oxygen and electrical sensors to control combustion in automobiles, to improve fuel consumption and reduce pollution, and high-temperature alloys for turbines for generating electricity.

The Ames Laboratory has a long tradition of research on rare earth-related elements going back to World War II when Ames Laboratory developed a low-cost process for preparing uranium metal for the first atomic nuclear fusion reactor in Chicago. Subsequently, they developed the ion exchange process for separating and purifying the rare earth elements which is still utilized today to produce the highest purity individual elements. They also contributed together with other Department of Energy laboratories to commercialize the liquid-liquid solvent extraction process, which is used today for separating the rare earths on a large scale.

From 1950 through the 1970s, the Ames Laboratory scientists prepared high-purity metals and studied the magnetic, physical and chemical properties, discovered many new compounds and measured their fundamental properties. Much of this new information contributed to the eventual discovery of the lanthanum nickel hydrogen battery, the giant magnetorestrictive material, Terfenol-D, and the samarium-cobalt neodymium-iron permanent magnets.

Currently, most of the research on rare earth carried out at the Ames Laboratory is funded by the U.S. Department of Energy's Office of Basic Energy Sciences, BES, some lesser support from the Energy Efficiency and Renewable Energy, EERE, and Advanced Research Projects Agency-Energy, ARPA–E. Other research is supported by CRADAs and work for industry.

The BES research involves both experimental and theoretical studies on novel materials, which is the giant magnetocaloric effect, colossal magnetoresistance and giant magnetorestriction and also correlated electron systems. The ARPA–E and the EERE research includes studies on the anisotropic sintered permanent magnets for automobile traction motors. Rare earth CRADA and work for industry efforts include magnetic refrigeration materials, recycling and development of low-cost processes for making metal.

Most of the critical needs in the future research for us are: One, improving high-temperature magnetic strength of the neodymium iron-boron permanent magnets. Two, new host materials for phosphors and reduced amounts of europium and terbium activators for most efficient lighting. Three, designing of recycling processes recovering the metallic elements without converting them to chemicals and then back to metals and improving recovery techniques for rare earth phosphors. Four, improve the effectiveness of rare earths and stabilize zeolite cracking catalysts and designing new catalysts and catalytic processes for bond cleavage and bond formation of hydrocarbons. And five, a more vigorous investment in new advanced energy technology including fuel cells and magnetic refrigeration.

These goals cannot be accomplished without replacing the rare earth intellectual capital. It is imperative to educate and train the next generation of engineers, scientists and technical managers. This can be best accomplished through the National Research Center for Rare Earths and Energy established. Finally, our country will fail if we do not rebuild the rare earth industry especially beyond mining.

Thank you very much for giving me the opportunity to testify on this vitally critical topic.

[The prepared statement of Dr. Gschneidner follows:]

PREPARED STATEMENT OF DR. KARL GSCHNEIDNER, SENIOR MATERIALS SCIENTIST, AMES NATIONAL LABORATORY

Introduction

The rare earth elements, comprising of scandium (Sc), yttrium (Y), and the lanthanides [the most important ones regarding this theme are: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), erbium (Er), ytterbium (Yb), and lutetium (Lu)], are vitally critical to both our military and energy securities.

In the military sector, all of our weapon systems are especially dependent on: Nd, Pr, Sm and Dy in permanent magnets which are utilized in electric motors, computers, guidance systems, etc.; Y, Ce, and Nd in sensors, electronic materials, e.g. capacitors, resistors; Y, La, Nd, Eu, Tb, and Dy in phosphors for optical displays and lasers, etc.; Y and Gd in aircraft engines and turbines; Y and Gd in communication devices such as filters, tuners, phase shifters, radar antennas; and Y, La, Gd, and Lu in optical devices, camera lenses, fiber optics.

In the energy sector: Nd, Pr, Sm, and Dy are used in permanent magnets for electric motors (cars, trucks, wind turbines); La and mischmetal in nickel-metal-hydride batteries; Ce, La, and mixed rare earths in petroleum refining catalysts; Y, Ce, Eu, Tb, and Dy in fluorescent and LED lighting; Y, Ce, and Nd in oxygen and electrical sensors to control combustion in automobiles to improve the efficiencies of fuel consumption and reduce the environmental pollution; Y, La, and Ce in high temperature alloys for turbines for generating electricity; and Gd as a nuclear reactor moderator.

Rare Earth Research at the Ames Laboratory

HISTORY

The Ames Laboratory has a long tradition of research on the rare earth related elements, going back to World War II when the Ames Laboratory developed a low cost process for preparing uranium (U) metal for the first atomic nuclear fusion reactor in Chicago. The process is still being used today. The Ames Laboratory also supplied two tons of U (1/3 of the fuel needed) for the reactor to be self sustaining. Subsequently scientists at the Ames Laboratory developed the ion exchange process for separating and purifying the rare earth elements, which is still utilized today to produce the highest purity individual elements. They also contributed together with other Department of Energy laboratories to the commercialization of the liquid-liquid solvent extraction processes which are used today for separating the rare earth elements on a large scale; tens of thousands of tons per year per mine, or about 140,000 tons in 2010 worldwide, 90% coming from China. In the late 1940s to early 1950s Ames Laboratory scientists developed processes for making pure rare earths by the metallothermic process, and during the 1950s through 1970s developed new processes for purifying the metals from 99 to 99.99 wt.% pure by casting, zoning, sublimination, distillation and solid state electrolysis methods. During this same period they studied the fundamental properties of the elementary metals—magnetic, electrical, thermal, elastic, mechanical, chemical, etc.—and prepared and discovered many new intermetallic, inorganic and organic compounds. Much of this new information contributed to the eventual discovery of the electrical properties of the LaNi5Hx battery electrode; the magnetic behaviors of Terfenol-D (Tb0.3Dy0.7Fe1.9) a giant magnetostrictive material; the magnetically very strong Sm_2Co_{17}, $SmCo_5$, $Nd_2Fe_{14}B$ and $Pr_2Fe_{14}B$ permanent magnets; and the electrical conductivity of yttria-stabilized zirconia $(Zr_{1-x}Y_x)O_2$ electrical sensors. One of the co-discoverers of the Nd2Fe14B permanent magnets carried out his Ph.D. graduate research at the Ames Laboratory.

Analytical chemists devised new schemes, techniques and procedures for analyzing the purity of individual rare earth elements for other rare earths, and also non-rare earth impurities. Modifications of these methods are still utilized today.

CURRENT RESEARCH ACTIVITIES

Most of the research on rare earth carried out at the Ames Laboratory is funded by the U.S. Department of Energy through the Office of Basic Energy Sciences (BES), with some lesser support from Energy Efficiency and Renewable Energy (EERE), and Advanced Research Projects Agency-Energy (ARPA-E). Other research is supported by CRADAs (Cooperative Research and Development Agreements) and work for industry.

The BES research includes several projects (7) and these are as follows. (1) Extraordinary Responsive Magnetic Rare Earth Materials, such as $R_5(Si_1\text{-}xGex)_4$, RAl_2, and RCo_2, which exhibit unusual magnetic, electric, thermal, and elastic behaviors when stimulated by external changes of temperature, applied magnetic fields, or pressure. These include the giant magnetocaloric effect, colossal magnetoresistance and giant magnetostriction (Pecharsky and Gschneidner). (2) Novel Materials Preparation and Processing Methodologies research includes quasicrystals ($Cd_{84}Yb_{16}$), $RFeAsO_{1\text{-}x}$ superconductors (polycrystalline and single crystals), reactive metal crystal growth (GdNi)(Lograsso, McCallum, Anderson and Jones). (3) Work in the Innovative and Complex Metal-Rich Materials Project has a small rare earth component, which includes (R,M)-M'X giant multiply endohedral clusters (Miller and Corbett). (4) Complex States, Emergent Phenomena and Superconductivity in Intermetallic and Metal-like Compounds research involves correlated electron systems (Yb-based materials), superconductors (RNi_2B_2C, RFeAsO), and ferromagnets ($Nd_2Fe_{14}B$, $CeAgSb_2$) (Canfield and Prozorov). (5) Research in the Correlations and Competition between Lattice, Electrons and Magnetism Project involves X-ray and neutron scattering of various materials including $Gd_5(Si_{2\text{-}x}Gex)_4$, RNi_2B_2C, GdBiPt, and RFeAsO (McQueeney, Kreyssig, Goldman). (6) The Magnetic Materials Discovery research on $LaNi_2Ge_2$ and $LaNi_2P_2$ mixtures, RV_4O_8, and EuM_2Sb_2 (M = Pd, Rh) was carried out in this Project by David Johnston. (7) In addition to these experimental efforts there is a considerable amount of theoretical work going on overlapping several of the condensed matter physics research projects tying this research together (Harmon, Duane Johnson).

The EERE-Vehicle Technologies research project includes studies of anisotropic bonded and sintered $R_2Fe_{14}B$ (R=Nd+Y+Dy) permanent magnets with high temperature stability for automotive traction motors with little or no Dy content. Also this research was expanded to include scientists and engineers from University of Nebraska-Lincoln, University of Maryland, Brown University, Oak Ridge National Laboratory, and Arnold Magnetic Technologies to enable a fully coupled theoretical and experimental effort to develop non-rare-earth magnets for advanced traction motors (Anderson, McCallum, Kramer).

There is one funded ARPA-E project which involves developing high energy permanent magnets for hybrid vehicles and alternative energy. The lead organization for this effort is the University of Delaware (G.C. Hadjipanayis). The Ames Laboratory's research is headed by McCallum.

A new ARPA-E project on Ce-based permanent magnets for automotive traction motors was funded to begin in FY2012. The Ames Laboratory is the lead organization and there are three industrial partners—Molycorp Minerals, General Motors and Nova Torque. McCallum is the lead project manager and is joined by his Ames Laboratory colleagues Antropov, Gschneidner, Johnson, Kramer and Pecharsky.

CRADA rare earth related research is concerned with recycling magnetic materials and developing new low cost processes for making rare earth metals for various industrial uses. A work for other project involves research on magnetic refrigerant materials.

MATERIALS PREPARATION CENTER (MPC)

The MPC was established in the 1970s to provide high purity rare earth metals, intermetallic compounds, inorganic compounds, alloys, etc. to research scientists, not only at the Ames Laboratory but also all over the world to promote and assist scientific investigations, both basic and applied; and under certain conditions to assist the commercialization of certain materials. In addition to supplying polycrystalline materials, they also grow single crystals and directional preferred oriented polycrystals of many of these materials, and also make very high purity rare earth and related metals by advanced metallurgical processing techniques. The MPC is a world-renowned national resource treasure. The MPC works on a cost recovery basis.

Future Research and Other Needs

(not just the Ames Laboratory but the entire USA)
Magnets – $Nd_2Fe_{14}B$

- Reduce the amount of Dy
- Improve the high temperature magnetic strength
- Improve the processing technology
- Lower cost Nd, Pr metals
- Reduce the rare earth content
- Non-rare earth magnets – new, improved existing ones

Phosphors

- Improved, lower cost, more efficient separation technologies
- New host materials – more efficient light emitting phosphors
- Reduce amount of activators (Eu, Tb) for same lumen output
- Development of up-conversion phosphors

Production and Separation

- New improved extractants and complexing reagents
- Design of better separation techniques, and/or equipment
- New advanced chemistries – combinational and biometric

Catalysts

- Improve the effectiveness of the rare earths in stabilizing the zeolite cracking catalysts
- New catalysts and catalytic processes – for bond-cleavage and for bond-formation of hydrocarbons
- New diesel exhaust catalysts

Recycling

- Design processes for recovering the metallic materials and placing them directly in production schemes as metallic materials without converting them to chemicals (oxides or halides), separating the rare earths, then reducing them to the metals and finally alloying; especially important for magnets, battery and metallic alloying agents.
- Better recovery techniques for rare earth phosphors from CFC (compact fluorescent lamps), long tubes, color TVs and monitors, color display units
- Design phosphor applications for reusing recycled, but unseparated rare earth phosphors
- Recovery of rare earths from cracking catalysts, especially the heavy lanthanides Tb and Dy
- Develop value-based lifecycle models

Sustainability

- Improve manufacturing efficiency—reduce waste.
- Design end-of-life products to easily recover the rare earth materials
- Develop green chemistry and environmentally friendly processing technologies

New Advanced Energy Technologies

- Fuel cells
- Magnetic refrigeration

Rare-earth Information Center (RIC)

- Re-establish RIC to help promote rare earth research and technology, and commercialization of these elements via the RIC News and RIC Insight, respectively, the quarterly and monthly RIC newsletters; and answering information inquiries.

Rebuilding the Rare-Earth Industry Beyond Mining

- Loan guarantees for small mining companies, producers of intermediate products (metals, magnets, phosphors, catalysts, etc.) and OEMs (Original Equipment Manufacturers) who manufacture hard drives, electric motors, cell phones, i-pods, CFLs, wind turbines, sensors, etc.
- Tax incentives for same.

Replacing Rare Earth Intellectual Capital - It's Imperative to Educate and Train the Next Generation of Engineers, Scientists and Technical Business Managers

- Requires 60 to 110 Ph.D., M.S., and B.S. degree students per year for the next ten years
- Promote rare earth courses at educational institutions—via distance learning; semester long courses, short courses
- Research projects funded by NSF, DOE, DoD, NIST
- National scholarships
- Establish a National Research Center of Rare Earths and Energy

Chairman HARRIS. Thank you very much.

I now recognize our final witness, Mr. Luka Erceg of Simbol Materials.

STATEMENT OF MR. LUKA ERCEG, PRESIDENT AND CEO, SIMBOL MATERIALS

Mr. ERCEG. Good morning, Chairman Harris, Ranking Member Miller and members of the Subcommittee. Thank you for the opportunity to testify today regarding the important legislation before you. I would also like to thank our Congressman, Mr. McNerney, for his support and leadership on these important issues.

My name is Luka Erceg and I am the President and CEO of Simbol Materials, a California-based producer of critical materials. It is exciting that this Committee has taken up energy-critical materials, broadening the discussion to more than just rare earth elements. Critical materials are the backbone to U.S. innovation, supporting job creation and competitiveness in clean technology, defense, agriculture and many other industry segments.

Simbol is commercializing an innovative and sustainable process to produce the critical materials lithium, manganese and zinc domestically that are being currently produced from a demonstration plant in California. We are permitting our first facility, and when complete, we will, one, be the only U.S. producer of certain manganese compounds, and two, we will double U.S. lithium production in 2013. This will continue to create high-value jobs.

We believe the U.S. Government can drive investment and job creation by establishing a clear policy for critical materials through a well-coordinated and consistent effort. Without prescription, the definition of critical materials should be based on strategic importance and domestic production that supports policy objectives, ensuring consistency across all federal agencies. Definitions of critical materials should recognize the elemental, compound and derivative forms as appropriate.

Lithium has been recognized as critical in the proposed legislation. Its compounds and derivatives are a critical component in advanced batteries for electric vehicles and other energy storage applications. Due to a lack of domestic production, the U.S. imports approximately 76 percent of its lithium needs.

Manganese, however, has not been recognized as critical in the proposed legislation, while it too supports strategic energy and defense priorities, and the lack of U.S.-based production is substantial. Manganese metal is essential for producing specialty steels for defense applications and manganese dioxide is critical to advanced batteries for electric vehicles. The U.S. is 100 percent reliant on foreign sources of manganese and 95 percent of the world's manganese metal production comes from China. Two federal entities have demonstrated the importance of manganese to U.S. policy initiatives. The Defense Logistics Agency has classified manganese metal as a critical material and the Department of Commerce has protected domestic manganese dioxide production against unfair Chinese and Australian trading practices.

The preceding illustrates that without a clear definition, a critical element such as manganese can be inadvertently overlooked. This demonstrates the need for clarity and policies and definitions of critical materials across the U.S. Government. Critical materials should not be viewed through only an end-use lens. Critical materials themselves are an important industry. The interagency process led by OSTP has led to a greater focus on the whole of critical materials but work remains and a whole of government approach is required.

Underlying a consistent policy for critical materials is federal support for R&D, which is a powerful driver for private investment into this important industry. Federal support in R&D helps to de-risk new technologies coupled with commercial sector investments that send loud market signals and encourage follow-on investing in areas of policy interest. These signals lead to job creation. For example, in 2009, the DOE's Geothermal Technologies Program announced a $3 million grant to Simbol to demonstrate its processes, building on our relationship with the Lawrence Livermore National Laboratory. Following the grant announcement, Simbol raised a further $35 million in capital prior to ever receiving the first federal grant dollar. The government's validation of Simbol sent a clear signal to the market that stimulated commercial investments 14 times the grant itself. With this support, we have grown our workforce from 16 to 62 and will reach 80 or more by yearend 2012, and we will continue job creation through further expansion.

Small companies are the economic growth engine of America, and as such, grant dollars and R&D support should be targeted to small, innovative and disruptive companies, creating greater leverage for job creation than through support of larger corporations. When a market does not exist, government funding can encourage the development of one. R&D also creates opportunities for universities to train the next generation of scientists and engineers needed to reduce the six to nine months we are experiencing in trying to find qualified candidates. The lack of a domestic critical materials supply chain and industry has resulted in the erosion of our talent pool and the departure and decline of important industries to countries such as but not limited to China. Supporting critical materials closes the loop on education, R&D and commercialization in this important area, and we hope that our testimony will help you improve upon the important legislation before you.

Thank you for the opportunity to testify, and I look forward to your questions.

[The prepared statement of Mr. Erceg follows:]

PREPARED STATEMENT OF MR. LUKA ERCEG, PRESIDENT AND CEO, SIMBOL MATERIALS

Chairman Harris, Ranking Member Miller, and Members of the Subcommittee, my name is Luka Erceg, and I am the President and CEO of Simbol Materials. Thank you for the opportunity to testify today about research needs and priorities related to critical materials.

Simbol is commercializing innovative, sustainable processes for the domestic production of lithium (Li), manganese (Mn) and zinc (Zn). We currently operate a demonstration plant in the Salton Sea region of California, where we co-produce minerals from geothermal brines at an existing geothermal power plant. Following power production, we "borrow" the brine for about 90 minutes to selectively extract the targeted minerals. The brine is then re-injected into the ground. This process has a smaller environmental footprint and cost profile than any other method for producing these materials.

We anticipate groundbreaking of our initial commercial lithium plant in the spring of 2012. Each full-scale lithium facility will produce approximately 16,000 tons per year of lithium carbonate equivalent, and 19,000 tons per year of manganese metal. Each of Simbol's lithium plants will increase global supply by approximately 10-15% over today's production volumes. There is sufficient capacity in the Salton Sea region to construct several facilities.

A domestic supply chain for critical materials will spur domestic manufacturing and innovation

While the development of a domestic supply chain for critical materials will reduce the risk of supply disruption and mitigate exposure to price spikes, the greatest benefit of developing a domestic supply chain is bolstering our nation's competitive position in innovative industrial sectors.

At every point in a supply chain, manufacturing drives innovation. As a supply chain lengthens, each step is strengthened through industry collaboration—which creates a more competitive overall domestic industry. In the case of electric vehicles and grid storage applications, critical materials are the cornerstone of the supply chain. It is important to realize that production processes to convert raw materials to usable products for downstream markets are highly technology-intensive. At Simbol, we have approximately 9 PhDs and 4 MS degrees on staff (representing about 25% of our current workforce)—all with backgrounds in chemical engineering, electrochemistry and chemistry. Our growth to date and future hiring is almost exclusively in the areas of skilled trades and technical functions. Our scientists and engineers are consistently finding innovative ways to improve the quality of materials and to develop the next generation of products.

We believe that further domestic innovation in critical materials will drive workforce growth throughout our entire industry. Because domestic production of these materials largely ended in the 1970s, today it is inordinately difficult to hire individuals with experience in Mn and Li processing. In fact, it is taking us up to nine months to find qualified candidates for key positions at Simbol. This is a direct result of the absence of university programs: no U.S. universities offer geothermal energy degrees. While DOE has been making targeted investments in university coursework, in order to jump-start significant growth in this sector, strong university programs are an imperative. We believe that market growth in the production and processing of critical materials will lead to increased training of students in these fields, and subsequent technology advancements through our university system.

Federal research and development funding drives private sector investment in critical materials

We strongly support legislative initiatives to develop research, development and deployment activities for critical materials. These programs will jump-start the development of a domestic supply chain for clean energy, defense and other strategic sectors in the face of aggressive policy and financial support for entrenched foreign producers.

The establishment of a new industry is inherently risky, and requires a concerted effort by both the public and private sectors. We believe that federal support for basic research remains essential to advancing America's position in the clean energy economy. The Advanced Research Project Agency – Energy (ARPA–E) plays a critical role in driving cutting-edge, game-changing technologies. The Department of Energy (DOE) and other federal agencies play an important function in supporting R&D efforts to develop and demonstrate technologies that lower operating costs, allow access to new resources, and improve quality and environmental performance.

Federal R&D support that assists the private sector—including small businesses like Simbol Materials—in de-risking innovative technologies, when coupled with commercial sector investments, send loud signals to the market that encourage follow-on investment. In the critical materials space, these federal R&D commitments are power drivers of private investment, and directly support the development of a competitive domestic supply chain for next generation energy and defense technologies.

For example, in 2009, DOE's Geothermal Technologies Program (GTP) announced its intent to award Simbol a $3 million grant to demonstrate its processes for the competitive production of lithium, manganese and zinc chemicals for energy storage applications. Since being awarded the grant, we have grown our workforce from 16 to 62, and will reach approximately 80 by the end of next year. We also have leveraged those federal funds to raise approximately $43 million in further capital. The majority of these funds were committed prior to the actual delivery of the first grant dollar, demonstrating the investment signal provided by the government's technology validation.

Financing risk remains the greatest barrier to commercialization of critical materials production and processing facilities

While basic R&D support is essential to restoring U.S. leadership in mineral production technology, the federal government also has a critical role in helping overcome commercialization risk. While Simbol has been highly successful in raising private capital, the investment required for a full-scale plant is significant. Private investors require a demonstrated market for our product, but the reality is that—at least here in the U.S.—we are selling into a nascent industry. While growth projections for advanced batteries (and associated Li and Mn consumption) are high, investors continue to hold back, awaiting the emergence of downstream industry consumption for electric vehicles and grid storage. Furthermore, the absence of a federal strategy for the development of supply chains to support priority policy areas causes confusion in the marketplace regarding the importance of critical materials.

Federal support for commercialization will help us bridge this so-called "valley of death." In the same way that our GTP grant attracted an initial round of private capital, we anticipate that federal commercialization assistance would stimulate private investment for the full-scale production facility. It is important to note that mineral production facilities do not qualify for assistance under existing commercialization programs. For example, neither the Section 1703 loan guarantee program nor the Section 48(c) advanced energy manufacturing tax credit reaches sufficiently far back in the supply chain to support mineral production or processing activities. Current legislative proposals would be strengthened by adding provisions to expand eligibility.

Absence of policy clarity stunts private investment in critical materials.

The United States does not have a national policy on critical materials. Even the R&D investments we are discussing today are not explicitly focused on critical materials. Instead, nascent critical materials policies and investments are packaged in disparate programs and agencies based on end use technology. Let me give you two examples. First, Simbol received our DOE grant—not because we are helping build a domestic critical materials supply chain—but because we offer benefits to geothermal power production. On the other hand, we were excluded from consideration for a loan under the DOE Advanced Technology Vehicle Manufacturing Program because we could not prove that our lithium would be used only for electric vehicle batteries. This stove-piped focus on end use technology conceals the important critical materials policy efforts being undertaken in different parts of the DOE.

This issue magnifies itself across the federal agencies. Different agencies approach critical materials from different end use perspectives, often resulting in divergent perspectives on criticality.

Let me give you an example from Simbol's vantage point. By any objective measure, both Li and Mn should be considered "critical." As is the case with rare earth metals, this designation is not due to scarcity in global supply, but rather due to the lack of U.S. production. Li is an essential component of advanced batteries for electric vehicle and grid storage applications. The U.S. is approximately 76% import dependent on Li, with most global production from salt flat evaporation in South America and growing supply in China. While some government studies—including the Department of Energy's 2010 critical materials strategy—have labeled lithium as "critical," other assessments have not included it.

Electrolytic manganese metal (EMM) is a fundamental input for specialty steels for defense and commercial applications, and Mn dioxide increasingly is emerging as one of the leading metal components for electric vehicle battery cathode powders.

The U.S. is 100% import dependent on foreign sources of manganese ore, as well as electrolytic manganese metal—95% of which is produced in China. Signaling U.S. concern with foreign production and trade patterns, the U.S. issued anti-dumping orders penalizing Chinese and Australian Mn producers. Despite this, Mn was not included in DOE's 2010 strategy, although in April of this year the Defense Logistics Agency identified it as one of the Department of Defense's top ten shortfall materials.

These examples are not intended to serve as a criticism, but rather as a demonstration of the need for clarity across the U.S. government in defining what makes a material "critical."

This lack of consistency and policy clarity has stunted private sector investment. In the absence of a clear, consistent signal that the U.S. government is committed to developing domestic critical materials resources, private investors place their money elsewhere. On November 21, Reuters reported that Beijing plans to dedicate $1.7 trillion to "strategic sectors" over the next five years. This builds on the $500 billion in Chinese public and private investment in lithium production since 2000. Similarly, South Korea announced approximately $300 million in public dollars for lithium production, and the Japanese government has been providing substantial public dollars through various loan guarantee and grant programs for lithium and other critical materials. In every instance, government involvement has led to substantial investment by private industry in the critical materials sector.

A coordinated critical materials effort is needed across the Executive Branch.

We recognize and applaud the Obama Administration for taking a focused approach to critical materials issues. The interagency working group led by the Office of Science and Technology Policy has been effective in bringing diverse agencies together to consider these issues. Efforts like the "Materials Genome Initiative" have placed high-level attention on materials science. Important activities are taking place at individual agencies, including DOE, where Mr. Sandalow's team is doing excellent work in developing and updating a critical materials strategy for energy production. But these efforts should be coordinated through federal policies and programs that are responsive to market conditions and support domestic critical materials production regardless of end use.

Critical materials policy recommendations

We applaud Representative Hultgren and other members of this Committee for introducing legislation focused on the development of critical materials. Given the urgent need for clear policy signals, and the commitment to this issue on both sides of the aisle and the Capitol, it is our hope that critical materials legislation can be advanced this Congress. As the various proposals continue to move through the legislative process, I urge you to consider the following policy recommendations:

- *Establish whole-of-government critical materials policy:* Current initiatives are scattered at various agencies and masked within programs focused on end-use technologies. It is essential to formalize and improve coordination efforts to create a whole-of-government critical materials policy agenda.
- *Utilize self-classifying definitions:* Rather than stipulating a list of qualifying materials or delegating broadly to federal agencies, we recommend a self-classifying definition, which could be based on 1) use of specific materials in industries that support strategic or policy priorities and 2) the level of U.S. production and processing. Such a definition should apply across the entire federal government. This will ensure that the government is not picking winners and losers at a given moment in time, but rather structuring programs based on the realities of the rapidly changing global marketplace. A straightforward, clear definition will immediately communicate to the market that designated materials are critical to U.S. policy goals. This will rapidly drive private investment to strategic federal priorities.
- *Invest in materials science going back to the beginning of the supply chain.* At every point in the supply chain, manufacturing drives innovation. Developing a domestic supply chain for critical materials will bolster our nation's competitive position in innovative and industrial sectors. This also will serve as a force for rebuilding our university programs in materials science and engineering, which have languished since the 1970s, following the downturn in U.S. critical materials production.
- *Streamline methods for licensing technology from national laboratories.* We recognize that there have been a broad set of efforts to create a more consistent licensing process for technology commercialization from our national labora-

tories. However, there remains substantial variance within the laboratory system. We need to advance a more effective process that gets technology out of the labs and into the commercial sector, in order to drive technology growth and create opportunities for further innovative research.

- *Small-dollar government investments in research yield significant returns.* Small businesses employ approximately 50% of the private sector workforce in the U.S., and they are able to move technology along the S-curve of innovation faster than other entities. In this time of downward pressure on federal budgets, it is essential to continue to support the small companies and innovative technologies that drive growth throughout our economy. We believe that the federal government will be best served by diversifying its investments and providing small research grants to a wide variety of promising technologies in strategic sectors. This limits the government's exposure and enables it to serve as a catalyst for growth industries. In Simbol's case, a $3 million federal investment leveraged approximately $43 million in private sector financing.

Thank you for the opportunity to testify, and I look forward to your questions.

Chairman HARRIS. Thank you very much, Mr. Erceg. I want to thank the panel for their testimony, reminding members Committee rules limit questioning to five minutes, and the Chair at this point will open the round of questions. I recognize myself for five minutes.

Mr. Sandalow, your testimony notes that, and I think you mentioned that DOE is updating its critical materials strategy, I think you said next month, due to "the rapidly changing market," and that is kind of the issue. Given how quickly the market has reacted to current supply constraints, how would the government be best positioned, because, you know, the government isn't usually very flexible on how it works, and how would it be best positioned to position itself with regards to rare earths? Shouldn't its efforts be focused as has been suggested on, you know, gathering information, doing only basic research, not necessarily applied technology solutions and recycling? And is that the direction you think this report is going to go or is it going to be more expansive than has been suggested, and I think as the bill suggests, that we focus on information, basic research and recycling?

Hon. SANDALOW. Well, thank you for your question, Mr. Chairman. It is a very important one. And DOE's 2011 Critical Materials Strategy will be released this month, and in that report, we have analyzed about 16 critical materials. We have looked at their role in the clean energy economy and we have looked at supply over the years ahead, and we have criticality assessments. We are updating the announcement that we did last year, and we hope it will be informative to the community that is working on these issues.

With respect to your question about the role of government, I think you identified, and others have as well, some central roles. Certainly, collecting information is central, and government plays an extremely important role in that. Government also plays an important role in supporting research. I would be careful about artificial distinctions between basic and applied research in this area. I think research across what are sometimes called technology readiness levels of different numbers are important, and I would just highlight one example in a different area along these lines.

In the 1980s, the Department of Energy supported work in what was then not widely known technology called hydraulic fracturing and horizontal drilling. It is a technology used to extract shale gas. And it was by any definition applied research that the Department of Energy was doing, partnering with companies in order to further develop this technology. Well, that work was picked up by companies and today we have a shale gas revolution here in the United States, which is revolutionizing our power markets and is spreading around the world. So I don't think we would have wanted to be limited at that time by any artificial distinction. I think we should be careful of it now. So I think government's role there is important.

There is one other principle I want to highlight in terms of government's work on this, since you asked about it, Mr. Chairman, is interagency coordination. I am keenly aware sitting at the Department of Energy that we only work on a part of this issue, the critical materials issue. So it is very important that we coordinate across the Federal Government. We are doing that now within the Administration led by OSTP.

Chairman HARRIS. No, I appreciate that, you know, since you mentioned hydraulic fracturing, which is kind of a favorite topic for the Committee at some times. You know, the problem is that, you know, when you go again to applied technology, then you do pick winners and losers, and right now the Department of Energy and the Environmental Protection Agency are picking hydraulic fracturing as a loser. They are not doing innovative research in it, even though it is one of the most promising, and I guess that is my problem with that.

But Mr. Erceg, you know, you bring up an important point. Obviously, there is the imprimatur of somebody having like the Federal Government agency having reviewed a proposal and said yeah, this has merit, is obviously important. But your point that, you know, you even made the point that the government grant was for $3 million for your company but it leveraged into $42 million of private capital, venture capital, I take it. Obviously, that means that the venture capitalists weren't looking at the government's investment per se, the $3 million, because that is a drop in the bucket compared to what it is going to cost to develop your technology, but merely the fact it had been reviewed and it was felt to be a useful, potentially useful process, and I think your process was more along the lines of applied technology and the basic research similar to Solyndra was applied technology, not basic research. Is in fact the importance of what the government can do as reviewing these proposals and the amount of dollars to it is maybe not as important, that it has gone through a third-party outside, you know, substantive review?

Mr. ERCEG. Thank you, Chairman Harris. I certainly would agree with that. If you look at the history of Simbol, when we were seeking our first round of funding, there were in fact next to no private industry experts in this field, and that actually led us to senior scientists at the Lawrence Livermore National Laboratory, and so what you actually had was a confluence of activities. What we saw was government was deciding that electric vehicles was one of the key policy initiatives for the Department of Energy to pursue that. In addition to that, Department of Energy has been a long-term supporter of geothermal technologies programs. You know, we have had a decline in the availability of technical talent in this country in these areas. In fact, you know, all the investment that has gone on through the last couple of years has been to build a U.S. industry around electric vehicles. We have had a decline in addition to that in technical talent for geothermal. So when it came time to validate the approach the technologies that we were doing, the DOE had a very, very important role. The geothermal side of the DOE was able to essentially say yes, this has a lot of benefit to geothermal producers, not every one of them but certainly it has a benefit to promote geothermal investment and development, and then secondarily coupled with the policy initiative that producing these materials from a brine could satisfy other important policy areas as well, that $3 million became an enormous signal to the market that this was an area that government and the United States was committed to.

Chairman HARRIS. And again, because you seem to suggest at the beginning of your answer, it is not as much the value of the dollars but that a collection of experts had looked at it and said this is valuable?

Mr. ERCEG. That is correct.

Chairman HARRIS. Thank you very much.

Mr. Miller.

Mr. MILLER. Thank you. I think Dr. Scissors and I agree that government should not rush to solve problems that the market will solve on its own. I think we differ on how long we are willing to wait for that to happen. A source that I know is not revered at Heritage said that in the long run, we are all dead, and in this case, I think waiting for the market to solve its own problem will be a very long wait when there are massive barriers to entry, massive investment required to compete with the Chinese, who we know will use predatory pricing, have in the past, will again, and have very deep pockets to wait out any potential competitors.

Dr. Jaffe, I was struck by your using the term "fundamental research." It appeared to me that you were trying to skate over that distinction between basic and applied, wanting to avoid that argument. It appears that we do—there is some picking of winners and losers about what research is done, what research is funded by the majority. The losers are called applied, the winners are called basic. There is not a clear distinction. There is no bell that goes off when basic research crosses over into applied, and it appears that most of what we are talking here would meet the usual definitions of applied and yet it seems that most of us think we need to do it.

Is there a useful distinction there? What should the distinction be between what kind of research in this area we support and what isn't? If you say let us not do basic—let us not do applied but let us do basic, what is your definition? How are you defining that? Let us start with you, Dr. Jaffe. Which is fundamental research is applied, which of your fundamental research is basic?

Dr. JAFFE. Thank you for the question. I think we did choose that word "fundamental" quite carefully. There are picking of winners and losers when any research task is presented, whether it is at the very basic level or at the applied level. The distinction that seems most meaningful to me is time scale. It seems that private enterprise shies away from making investments in research that have very long payoff time scales, and that—those kinds of efforts usually fall to government or foundation-sponsored research, whether it is in the area of very abstract research like I do or whether it is in the more practical areas of research like recycling or lifecycle analysis.

When I listed those areas of research ranging from characterization of resources all the way through to recycling and resource analysis, it seems to me that that spans a spectrum more identified by the time scale than it was by the character of the individual investigation.

Mr. MILLER. Anyone want to answer this question in 15 seconds?

Dr. SCISSORS. I will take a shot. It is the market view, it is not the science view, which is when there is a single firm or single technology, it is very difficult to see how you are not moving—a firm, not a research center—how you are not moving into applied research.

Mr. MILLER. Anyone else, a very quick answer? Okay.

One of the differences between the bill that I have introduced and Mr. Hultgren's bill, and I think a weakness of the Hultgren bill, is that it gives significant responsibility, coordinating responsibility, to an agency that exists only by Executive Order. So we could get statutory authority to an agency that might not be there if this President or another President changes that Executive Order. But everyone seems to agree that there should be coordination between agencies. The Department of Defense has national security needs. Department of Energy obviously has energy needs. The Interior Department historically has kept records in this area, has a role as well. Who do you think should be in the position of—Dr. Holdren, I think, I said in June that OSTP was taking the lead in coordinating across agencies. What—Mr. Sandalow, perhaps you could start. What agency do you think should have that coordinated role going forward?

Hon. SANDALOW. Well, thank you for the question, Congressman. I am not in a position to comment on the specifics of legislation and the different proposals that are out there, but just two thoughts in response to your question. First, today, the Office of Science and Technology Policy is coordinating our work within the Executive Branch, and that is working very well. They are convening regular meetings on this, making sure that the different experts are talking to each other and that policy is coordinated. And I guess I would just add, you know, more broadly, from looking—I have had the opportunity in the past week or so to look at the different bills that are out there, and I think, as someone said, we have about 10 or 12 bills, and I see in those bills a lot more similarities than I see differences. And so this may be an opportunity where different sides can come together and really enact something that would be good for the American people, good for American business and move us forward in this—on this topic.

Mr. MILLER. Dr. Gschneidner, you testified before the I&O Subcommittee in 2010, just last year, and you emphasized the need to attract young people to research in this area and to build a workforce in this area. What provisions should we make for educating a workforce in legislation or otherwise?

Dr. GSCHNEIDNER. Well, as I noted in my testimony at that time and also in the testimony today, I think a national center for rare earth research and energy would be a very good step in the right direction where the center would be located, as far as rare earths are concerned, at a university which has a long background of history, and that would be the major thing, but there would be other satellites at other universities which contribute their expertise which is not found in the main thing—and I think the other thing is scholarships in addition to stipends to attract students into this area.

Mr. MILLER. Thank you, Mr. Chairman.

Chairman HARRIS. Thank you very much.

I recognize the gentlelady from Illinois, Ms. Biggert.

Mrs. BIGGERT. Thank you, Mr. Chairman, and thank you for holding this hearing.

This question is for Dr. Sandalow and others if they care to respond. Recognizing that critical materials are the foundation for batteries and much of the focus of battery improvement, how would you characterize critical materials from a supply perspective as it relates to acquiring these materials for battery production?

Hon. SANDALOW. Well, thank you, Congresswoman, and let me recognize in answer to your question the really superb cutting-edge work done by Argonne National Laboratory in the topic you were asking about. Argonne has really been a leader in battery research for many years.

Last year in the Department of Energy's Critical Materials Strategy, we identified a number of materials that are important for batteries and assess their criticality, as we said. We looked at lithium and concluded that lithium—there are issues with respect to lithium supply, particularly with lithium ion batteries. We didn't classify them as the most critical, as one of the most critical elements in terms of overall supply. We found that there are likely to be adequate supplies of lithium going forward. Other batteries, nickel-metal-hydride batteries, have other elements that are important, and actually sitting to my left are some of the world's experts in the chemistries of nickel-metal-hydride batteries and so with them sitting at the table, with your permission, we will pass the microphone to them.

Mrs. BIGGERT. Well, first, let me just continue with this question and then we will do that, because, you know, obviously Argonne is doing a lot of research on the work on batteries, and I am always focused on taking that technology from the lab to the marketplace. Would you consider the supply issue critical at that point, taking it out of the labs to the marketplace, or is it something to monitor for the time being?

Hon. SANDALOW. Just maybe two pieces of that question. First, in terms of our progress overall on batteries and battery research, this is an extremely important area for the U.S. transportation sector. Right now, we have electric vehicles that are on the roads for the first time. They are starting to make a difference and they will make a big difference, particularly if the cost of these lithium-ion batteries can be reduced, and research in this area is so important for reducing our oil dependence, for reducing our dependence on foreign oil, and it is important that we move those batteries to the marketplace.

In doing that, we need to pay attention to the material inputs for those batteries. Obviously, that includes lithium. Our analysis and the analysis of others concludes that lithium is not among those materials that is most critical in terms of supply, that there are adequate supplies of lithium out there. There are other materials that are important as well.

Mrs. BIGGERT. All right. Would somebody else like to address that? Yes.

Mr. ERCEG. Congresswoman Biggert, I would like to just address this question of lithium supply and even the supply of critical materials. First off, as has been noted on this panel, we are not running out of any of these raw materials in the earth. What we are lacking here in this country is the ability to produce these materials and process them. That requires a highly skilled and trained workforce. It requires research and development. But it also requires paying attention to the entire supply chain from how that material works its way from a company like ours where I can assure you the technology in producing a high-end lithium carbonate or lithium hydroxide for use in a battery is as complex as producing a cathode power, okay? And when you move these materials through the supply chain, if elements of that supply chain do not exist, there are no bonds for innovation. You lose the ability to innovate throughout the industry, and that is, I think, what is critical to understand is that critical materials support innovation and we need to foster that innovation.

Mrs. BIGGERT. Thank you.

And then Mr. Sandalow again, as our country faces the fiscal constraints and our economy is facing some pretty strong headwinds, we are making progress but it isn't enough, and as such, we in the Federal Government need to do our part to cancel or at least rein in those programs that are not delivering the value for the money to our taxpayers, and in terms of program management, what research and development milestones or goals will teams competing for the critical materials energy innovation hub need to meet so that we can better evaluate our return on the investment?

Hon. SANDALOW. Thank you for the question, Congresswoman. It is extremely important, and let me note that a couple of years ago when I had the privilege of first coming into this job, I looked around the Department of Energy and realized that there was no coordination across the many parts of the Department of Energy or very little coordination with respect to our research in this area. That is one of the reasons that we pulled together our team within the diverse parts of the Department of Energy to coordinate to be sure that we weren't duplicating efforts in this area, and that internal coordination I think has paid a lot of dividends for the department and I hope for the taxpayers.

The exact question that you are speaking about in terms of our R&D plan is one that we are going to be addressing more specifically in the Critical Materials Strategy that we are releasing this month and so if you are interested, we would be delighted to send that up to you.

Mrs. BIGGERT. That would be great. I appreciate that. Thank you.

Yield back.

Chairman HARRIS. Thank you very much.

I now recognize the gentleman from California, Mr. McNerney.

Mr. MCNERNEY. Thank you, Mr. Chairman.

Mr. Erceg, as a business from my district, I would like to—and I am really thrilled to welcome you here today and have you share the story of your success with us. Can you expand a little bit on the grant you received from the Department of Energy and how that helped you and your company create jobs?

Mr. ERCEG. Certainly. Thank you, Congressman McNerney. So we in 2009 had received a $3 million grant from the Department of Energy's Geothermal Technologies program, and the grant had arisen to foster the commercialization or in testing of the extraction of materials from geothermal binds and to validate that technology. So at the time we had 16 employees, and we had done a lot of applied research in our own laboratory efforts, building on some of the work and understanding that had been gained from working with Lawrence Livermore, and then the $3 million that was granted to us was actually—actually paid for the salaries of many of the employees that helped us run these processes in a commercial-like environment. So we raised additional capital, continued to invest our own capital to put in the hard assets and equipment and then the $3 million grant was predominantly used for the salaries necessary to operate this facility in a 24 by 7 basis so that we could replicate and demonstrate that the technologies had matured to a point where you could now build a commercial-scale facility.

In addition to that, the capital has also fostered additional R&D opportunities with universities and with national labs where we continue to work on programs for extracting other materials. The interesting thing is, is that this signal also led the State of California as itself to provide us with substantial opportunities such as matching grant dollars and then in addition to that sales tax exemptions that were provided for acquiring commercial-scale equipment and building our facilities.

Mr. MCNERNEY. Would you say that regulations have stifled business and growth in your case or in general?

Mr. ERCEG. So regulation is always tough, and I don't opine on whether we should have regulation or not. We respect the fact that the regulations exist and that we have to adhere to the laws of the country. In our instance, actually regulation had an interesting effect, is that it actually fostered more innovation. So it actually drove us into a more sustainable process. The net result of that was that we could be more sustainable in the form of production that we use to produce lithium compounds than our competitors can while at the same time being able to compete with the lowest-cost producers. So in that respect, it had a very positive outcome.

Our concern with regulation is just simply timing. You know, as long as we know that there is timing transparency and consistency, I am confident that, you know, American innovation can adhere and be competitive.

Mr. MCNERNEY. Thank you.

Mr. Scissors, it seemed to me that you were saying to trust the market and hope for the best, and, you know, I don't think the Chinese use that model, and I bet you they are hoping that we continue to use that model but I just can't abide with that approach. The market is not a free market. We need some participation and guidance from other sources than just the market itself.

Dr. SCISSORS. Would you like me to reply, sir?

Mr. MCNERNEY. I threw the first stone. Throw it back if you want.

Dr. SCISSORS. Okay. It is not just trust the market and hope for the best. Rare earths exist because of the market. You know, we are just not hoping for something, we have evidence that the market works. We have evidence from the beginning of private sector innovation. We have evidence in the last year when the Chinese, as you are absolutely right, tried to play on the market and they failed. They haven't failed forever. I agree with both comments.

Mr. MCNERNEY. You said they tried to——

Dr. SCISSORS. They tried to drive up prices and now they are failing. That is the whole point of trying to take over a market so you can drive up prices and control the process and that——

Mr. MCNERNEY. That drove up market prices pretty significantly.

Dr. SCISSORS. Absolutely, and I don't mean to imply that because——

Mr. MCNERNEY. They made a lot of money in the process, and our companies have paid the price for that.

Dr. SCISSORS. And now they are losing a lot of money, and my point is not that they are not going to try again. They are going to try again. The point about whether the market works is whether other firms can enter, whether consumers can respond, and they can and they have. I am not relying on the Chinese to do anything nice. I have studied the Chinese economy for 20 years. They are going to be predatory. Is it possible—I will stop in a second, I am sorry—for market participants to respond, and we have seen evidence that it is.

Mr. MCNERNEY. All right. I think I will yield back.

Chairman HARRIS. I recognize the gentleman from—I didn't see you sitting over there—the gentleman from California, Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, and I am sorry, I was here a little bit late. This is December 7th, and there is a group of Pearl Harbor survivors downstairs who I was meeting with, which sort of fits in with what we are talking about today, doesn't it? The fact is that American security can be attacked whether through economy and economic means or through military means, and certainly what we are talking about today, Mr. Chairman, goes directly to the security of our country because we realize that many of the materials that we are talking about today and the elements that are necessary to have a modern society are at risk, and we are vulnerable to what is a government that is the world's worst human-rights abuser, perhaps like Pearl Harbor where the Japanese militarists at that time were actually the greatest expansionary power along with their Nazi allies. Today, the Chinese communist regime has leverage over the West that it should not have, and if we are to make sure that it does not, we have to look at this from many different directions, and I will read your testimony, and I appreciate—I am sorry that I was not here. I was down with the Pearl Harbor survivors.

But just a few thoughts, and that is—and maybe your reaction. If I am saying something repetitive, please feel free of not commenting. But if we are to have the security we need in these materials, we of course need research and development that will make sure we have alternatives, but we also need to make sure that the regulatory policies of the government will permit our people to do what is necessary to meet the challenge, but also we need to make sure that we have a policy at the Bureau of Land Management and the Department of Interior that will permit us when we have these materials available domestically that will permit us to actually let our people to do their job in getting us those materials and processing them. We should take this very seriously because China is taking it seriously, not only in manipulating the market, as the gentleman just said, but in going around the world making alliances with other horrendous gangster regimes, whether it is Burma or whether it is African countries and Sudan, et cetera, in order to have this quest of having control of these very necessary materials for modern-type equipment.

So with that said, I just thought I would put that into the record. Maybe some of you have any comment on that. Please feel free. I am sorry if it was repetitive. Yes, sir.

Dr. SCISSORS. I will just briefly comment on your land management issues because I brought that up quickly in my testimony. I agree. I suspect we don't agree on everything but I agree with you there, and I said that there is a commercial return available. We have, in my opinion, a properly functioning market. When you expand the size of a market, you get wealth from that. I am not arguing to the committee that there are no other considerations and I am not arguing that I know a lot about those considerations. There are lots of considerations. I just want to put it on the record that in addition to the national security aspect that you are referring to, there is a commercial return to expanding the land available for ECE exploration. There may be countervailing factors but there is a positive one to think about.

Mr. ROHRABACHER. Well, let us just note that something as heralded as solar energy has been dramatically hampered by the Bureau of Land Management. I mean, it wasn't until this year that after prodding, after years and years of putting pressure on the Bureau of Land Management that they were willing to give any contracts or any approvals for solar energy sites in America's deserts. I mean, there was, I think, over 200 applications and not one of them had received an approval from the Bureau of Land Management, and it wasn't until Congressional pressure—I wrote the legislation and submitted it—was exerted that they ended up permitting, and that is something as easy to understand as putting out solar panels, and sometimes the people who work for government will get distracted and in this case I think it was the habitat of the little lizards and the insects that were more important than the well being of the American people that prevented us from making those kind of decisions.

Let us make sure that doesn't happen in something with these vital materials because we are not going to have the industrial and the modern society that makes our standard of living unless we do take care of this challenge.

Thank you very much for holding this hearing, Mr. Chairman.

Chairman HARRIS. Thank you.

I recognize the gentleman from New York, Mr. Tonko.

Mr. TONKO. Thank you, Mr. Chair.

Assistant Secretary Sandalow, I am encouraged by your reports that efforts are underway to increase our supply of energy-critical materials. While that is good news, especially for some companies in my district that are manufacturing products that require these elements, but I would ask if DOE has responded to this barrier to retaining and expanding manufacturing by creating—by doing more if we want firms to manufacture, like a question to you would be, is DOE's effort linked with a broader strategy to put the manufacturing model and link it to these efforts, and is OSTP or the Commerce Department part of a broader strategy to encourage domestic manufacturing, not just a reliable supply of energy-critical materials?

Hon. SANDALOW. We are, Congressman, and thank you very much for that important question, because U.S. manufacturing is so vital for economic growth, for job creation, and the President has proposed extending the manufacturing tax credit known as 48(c) and a variety of other policies that are central and really beyond the scope of the particular issue that we are talking about in this hearing. I know in your district there is a company called Tonko, I believe, which is doing terrific work in this area, and within the Department of Energy, we are looking at this issue as part of a holistic package within the Administration, coordinating with the Office of Science and Technology Policy and the critical-materials aspect and other parts of the government on manufacturing policy.

Mr. TONKO. And Dr. Jaffe, in your testimony, you suggest there may be a significant amount of energy-critical materials contained in discarded cell phones and other electronic devices, things we now refer to as e-waste. Do we have processes for collecting and recovering these materials for recycling?

Dr. JAFFE. For some of them, yes. For others, it is a subject of future research.

Mr. TONKO. Well, with the number of manufacturers that have moved their facilities to China to gain access to their supply of ECEs, do we have enough demand here to make recycling an economically viable option?

Dr. JAFFE. At the present time, recycling couldn't possibly satisfy the need for new supplies of these critical elements simply because the demand is growing so rapidly, the amount in present use is not sufficient. There are other economic puzzles and scientific puzzles, one of them being that cell phones seem to migrate down the economic world and end up when they are finally discarded in countries where obtaining a stream of recycling is very difficult.

Mr. TONKO. Thank you.

And Dr. Gschneidner, you provide a list of research needs in this area. Are any of these underway at DOE or are they being funded by the department at this time?

Dr. GSCHNEIDNER. There is some work being done at various DOE laboratories but I don't think they are coming out of regular projects. I mean, they are sort of diverting funds, you might say, into that direction.

One of the problems I want to comment on, on rare earths, is that the amount of rare earths in a cell phone is insignificant. It is .1 weight percent, which makes recycling very difficult. Of course, if you recycle it for the gold, the platinum and the copper and co-mine it, that makes it move in the direction you want to go. But as Dr. Jaffe says, a lot of this material is being shipped overseas. The recycling problem for the rare earths is difficult because the amount of rare earths in most applications is pretty small except the wind turbines, but there are not very many of them that are ready to be recycled anyway. So it is a difficult challenge on the rare earth side.

Mr. TONKO. Thank you. Thank you very much.

Mr. Chair, I yield back.

Chairman HARRIS. Thank you very much.

I recognize the gentleman from Illinois, the sponsor of H.R. 2090 and a member of the full Committee, Mr. Hultgren.

Mr. HULTGREN. Thank you, Mr. Chairman. I want to thank you for letting me join the Subcommittee today.

Thank you all very much. This is a very important discussion and I am so grateful for the important work that all of you are doing and getting ready for the next steps that we need to take as Members of Congress here.

I want to start with Assistant Secretary, a quick question for you, Assistant Secretary Sandalow. I know you can't give your opinion on my bill but I wondered if you could share your thoughts on Dr. Jaffe's recommendations in his report.

Hon. SANDALOW. Well, broadly, we think the report is a really important contribution to the discussion here. I don't want to comment on every specific recommendation in there but it really is a very important piece of work. We thank Dr. Jaffe and the whole committee that worked so hard on it.

Mr. HULTGREN. Thank you.

Expanding my question to the rest of you and specifically the strategy for critical materials, kind of a long question here, but I wonder if you could comment on this. What are your perspectives on the December 2010 DOE Critical Materials Strategy? Specifically, what input can you offer on the three key points that are outlined in the report including the need for a diversified supply chain, the development of substitutes and increases in recycling and overall efficiency? I wondered also if we have time if you can mention your opinion, what is the appropriate proportion of the amount of effort expended towards each one of these items and how might a focus on development of substitutes and on recycling and efficiency improvements impact the overall industry? So starting with Dr. Scissors, I wonder if you would have some comments.

Dr. SCISSORS. Okay. I am going to give again the market view as opposed to the science view, and the market view is, we already are diversifying supply and we already are substituting, and that is best handled by the market because the market responds to prices and prices are what cause supply diversification and demand substitution. If the government orchestrates that, they are going to get it wrong. They are going to substitute the wrong things, they are going to diversify into the wrong things because ultimately what we are trying to satisfy is market demand, not government demand. So the government steps in. We are going to get a mismatch between demand and supply.

Where I would see a government role is recycling simply because environmental protection is part of the government mandate. That is a public good. It is an appropriate government role. We have heard from my colleagues challenges in this area and make it a disincentive for the private sector to recycle because the commercial return is low due to content and because we are relocating our waste overseas, which is also a proper government role. So I would stress the recycling side for the government, not because the other two points aren't important but because they are properly handled by the private sector.

Dr. JAFFE. If I might respond, I think there are three different timescales involved here. The diversified supply chain recognizes the present reality that these elements are found all over the world and in all kinds of different circumstances and that in order to maintain the present supply we have to cultivate supplies wherever they occur. The research efforts adjust over a somewhat longer time scale looking for substitutes, looking for new ways of identifying resources. And finally, I think the recycling efforts are an investment in the longest term. I think the public simply doesn't appreciate the preciousness of these materials. Many of them are literally less abundant than gold on the surface of the earth and they should be regarded as the same way you would regard your discarded diamond rings or fillings from your teeth.

Dr. GSCHNEIDNER. May I make a comment? I agree with Dr. Scissors in part in that the market situation has developed so that the Molycorp now is a U.S. producer. They are going to produce about 5,000 to 6,000 tons this year, 12,000 next year and 40,000 probably by the end of 2013, beginning of 2014. The problem is—I think that part of the problem—I said there are three parts to the rare earth crisis, and that is the first one. The second one and the third one, which are the most serious ones which we need to really consider is what happens after Molycorp mines this stuff. They are going to make metals and then they are going to make magnets. What are we going to do with them? Are we going to ship them back to China to make all these things? We have to build up our infrastructure at that point, and I think maybe at that point guaranteed loans and tax incentives for the manufacturers that make the products out of the magnets, out of the phosphors and so forth, and I think we need to support.

And then the final thing, as I mentioned earlier before, is the education. We have got to train people, and it is a long term. It is ten years down the road before these—maybe five plus before a Ph.D. becomes really productive. It takes four years to get if he is lucky, and maybe five years. And so by the time he really becomes productive, it is a long-term investment. So we—and the government has to do that. I think there is just no doubt about that, that we have to do that. And we see that. It is already occurring. As a matter of fact, next year one of my colleagues is going to be teaching a rare earth course, a three hour credit. It is going to be distance learning for anybody available in the whole world. And Colorado School of Mines is also working on some of these things.

So I think things are moving but we do need some help in certain aspects of these things down the road from the Federal Government. Thank you.

Mr. HULTGREN. Thank you.

Mr. Chairman, can I see if Mr. Erceg has any quick comments? Do we have time?

Chairman HARRIS. Sure you can, and we will have a round, a three minute round of questions follow-up if you would like, but you can——

Mr. HULTGREN. Just quickly, Mr. Erceg.

Mr. ERCEG. Thank you. I would just note that diversity of supply, substitutes and recycling form a circle, and this circle is linked through R&D and education, and if we focus on diversity of supplies being more than just a shovel in the ground and that it includes processes and downstream production, as you build those processes up, R&D and research will continue as substitutes, but when we do get to the question of recycling, the existence of manufacturing here in the United States will also enable recycling, and it is very important to not lose sight of the coordination that occurs in the market if all elements of the supply chain exist.

Mr. HULTGREN. Again, thank you all.

Thank you, Mr. Chairman. Yield back.

Chairman HARRIS. Thank you very much, and as I said, I know some members have additional questions. We are going to have just limited three minute round of questions, and I will start.

Dr. Scissors, let me ask you a question. You are kind of a policy person. As we go to authorize these things, one thing I personally wouldn't want to see is an authorization of something that would lead to another Solyndra where we authorize a program that really isn't basic research, that really does attempt to pick a winner and loser, and isn't—you know, the function of basic research in my mind should be not to necessarily project exactly where things are going to go in the future but to set open the array of options that science and scientific development could present. How do we do that with regards to this? How do we do this in this legislation so that—again, you know, we have seen this with, for instance, coal energy research where the Administration has decided, you know, it is just going to do carbon sequestration is the answer. Now, I will tell you what is going to happen. It is not going to be the answer and we will have lost valuable years where we could have done basic research on, for instance, developing the metallurgy to develop the high-efficiency carbon, high-efficiency coal generation facility for instance. How do you think we do this in the legislative structure?

Dr. SCISSORS. My incomplete but I think valuable as part of the answer is, you can't—you know, Solyndra. You can't involve particular companies. You can't identify a company or a technology. The government has to be working, if it is going to do this, with multiple companies and multiple technologies. If you pick one, first of all, it is at odds with the whole idea of a competitive market. I think everybody in this room wants a competitive market in rare earth but the government picking out a company is immediately at odds with that.

And second, partly going back to the ranking member's comment, you are setting up a giant target for our deep-pocketed competitor to destroy. It is much harder to respond to basic research and progress on a wide variety of fronts than it is to say this is the company that is getting U.S. money. So it is not a good tactic, you know, as somebody who works in markets, it is not a good tactic to pick out a single company or single technology. It is also going to end up biasing the technological development and causing inefficiency in the industry. So I have an incomplete answer for you but the start of the answer is, if you are looking at one technology and one company the government is making a mistake.

Chairman HARRIS. Dr. Jaffe, let me ask you, because I think the study that you are involved in made recommendations on that. I mean, how do we—and you noted that big companies can do it. GE can do this on their own but it is the small innovative companies that maybe can't. how do we protect ourselves from placing those wrong bets?

Dr. JAFFE. Well, I frankly, I think it is impossible to prescribe the rules of basic research in detail in legislation. I think that creating a constituency for basic research and then trusting the imagination and creativity of the world of higher education, national laboratories and industry to arrive at research topics through peer review is the way to go. But I would still warn you that 75 percent or more of the research activities that are undertaken now come a cropper, and the creative part that comes from the remaining 25 may end up being something that you didn't imagine in the first place at all.

Chairman HARRIS. Thank you very much. I know that is true in medical research. That is for certain.

I recognize the gentleman from New York for three minutes.

Mr. TONKO. Assistant Secretary, when DOE does respond to a need out there for the Nation, does it look to an array of companies, an array of technologies, or do you determine a single source and single solution?

Hon. SANDALOW. Congressman Tonko, thank you for your question. We look at an array of companies, and this is an important question so I am glad this Committee is talking about it, and, you know, I would say this. Governments around the world are deeply involved in energy markets today, and they have been for decades, and so the people of the United States acting through their government are standing up for their businesses or helping their businesses succeed in the global marketplace. That is an extremely important role. Now, as we do that, we absolutely, as you say, Congressman, are looking at a broad range of businesses, and the one that is here is a great success story about creating jobs and making a difference for Americans today using funding from the American people and through the Federal Government.

Mr. TONKO. And to the panel at large, compared to other commodities, how transparent is the global market and how sensitive is this market to uncertainties and volatility?

Dr. SCISSORS. That is something I know a lot about. At present, it is very sensitive and not transparent, and that is exactly as you would expect. We have a currently dominant producer. Even though its market share is shrinking, it is still dominant by any measure, and the only thing they are transparent about is bragging about their predatory pricing, that they are going to drive people out of the market and raise the prices. So I guess in some sense, they are providing us a service by being so transparent. It certainly makes the WTO case easier. But, you know, reserve—we are just at the beginning of figuring out what we should be looking for, what are the critical elements here. They are changing. Where are they? You know, we see this in the United States, which is far more transparent than China is. We don't really know where the deposits are yet. So this is the early stages of a market, and I would argue the market is moving very rapidly but I agree with your point that compared to other important commodities in energy, we don't know as much as we do elsewhere.

Mr. TONKO. Mr. Erceg?

Mr. ERCEG. Thank you, Congressman Tonko. You know, being a market participant, I can tell you that in the context of critical materials, there is very, very little transparency, and what ends up happening is, there seems to be a fair amount of transparency in the earliest part of the supply chain, where are deposits, what does it cost to bring a shovel of material out of the ground. The moment you start separating these materials and defining them as compounds and derivatives, you lose complete visibility into the markets. It just becomes so clouded because the number of players becomes more and more fragmented and reduced as you move through the various components.

We can throw the term "lithium" around very, very easily but, you know, I not being scientifically trained could bore you for an hour with a list of compounds and derivatives that come out of lithium and I can point to the fact that there might be only one producer or two producers in each instance. So it is very important that the research that goes on sponsored by the government in terms of understanding the markets such as what Mr. Sandalow's office is doing and goes on at the DOD and other places because that offers us visibility into what are our key policy initiatives and then the market can determine, all right, well, which compounds and derivatives are critical to meeting those components and then you can have a market response, which is what happened in Simbol's case. But we really have to focus on the fact that to create a competitive economy, and a competitive response in this area, we need more players here in the United States as well and only in that way can we ensure that our Nation has market signals as well.

Mr. TONKO. Thank you.

Chairman HARRIS. Dr. Jaffe.

Dr. JAFFE. Thank you. I just wanted to add briefly, I certainly agree that the absence of transparent and robust markets is a serious issue, and that was the motivation behind our recommendation for a higher level of information gathering and dissemination. The Energy Information Administration does a remarkable job of gathering and making available facts about energy from production through consumption for countries all over the world, and we don't have any similar way of gauging the availability and life of these materials that are becoming so critical.

Chairman HARRIS. Thank you very much.

I recognize the gentleman from California, Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, and again, I missed the opening here. I was down with our Pearl Harbor survivors, so I am sorry if this is repetitive but perhaps it again fits in with this whole idea. This is December 7th. We were attacked at Pearl Harbor and we lost 3,000, basically 3,000 lives of our military personnel there in Pearl Harbor and the battleship sunk our ability to defend ourselves was immediately changed for the worse and put us in a very desperate situation for the first year of that war. What type of danger are we in now in terms of these critical materials? I mean, there is not going to be a sneak attack where bombs will be dropped but what if—and we already know the Chinese are willing to attack us economically. They have already tried that to a limited degree of success and maybe long-term failure, according to our Heritage Foundation witness.

So what danger are we in? Are we in danger of the American people's standard of living being impacted if we don't pay attention to this rare earth issue and what we are talking about today? Could our economy be severely damaged and American people's standard of living actually go down unless we do something dramatic about this? Maybe everyone could have a little—whoever wants to do it.

Dr. GSCHNEIDNER. May I make a comment, please, on the China situation? The China situation has changed considerably in the past few years, as we know, but I think a lot of things that people don't appreciate. The Chinese economy is growing so fast that the Chinese philosophy now is, we are not going to send our rare earth materials, which are very precious, to the rest of the world, we are going to keep them ourselves, as a matter of fact, they are going to compete with us for other supplies from other countries and so forth.

The other thing is on the Chinese situation, the ore supplies. They have found out—you know, they had found this one rich deposit of the heavies, which is where most of the critical elements come from, is going to run out in five or ten years, and they realize that, and there are no other sources in China for this that have this rich deposit, and so that is changing a good part of their philosophy.

The second thing is that, I have talked to—there was a conference in Hong Kong just a couple, few weeks ago, and I was there, and there was about 300 companies from all over the world that had, quote, rare earth deposits. Many of them are not. And they are looking into this business. The market forces are moving things in this direction.

Mr. ROHRABACHER. And if we don't succeed, is that——

Dr. GSCHNEIDNER. No, I think——

Mr. ROHRABACHER. If we don't——

Dr. GSCHNEIDNER. If we don't succeed—-

Mr. ROHRABACHER. What can we face as a people and what will we see here as a people if we do not succeed on this issue?

Dr. GSCHNEIDNER. Well, the places where we won't succeed is we have to have these companies that come in after the mining and the manufacturing and Molycorp comes. I think the supply situation is going to be basically more or less solved in a couple more years. But it is after these materials are available that we don't have the infrastructure and the commercial companies to do it and so we are still going to have to depend on the Chinese.

Mr. ROHRABACHER. And what will the impact be on the average American's life?

Dr. GSCHNEIDNER. Well, it is a little bit hard to say but you will have to put up with some other difficulties.

Mr. ROHRABACHER. Maybe one of your other panelists can tell us.

Dr. JAFFE. At a meeting preparatory for our report, we had a Korean representative who said that the past was the Stone Age, the Bronze Age, the Iron Age, the age of metals, and the future is the age of the rest of the periodic table. But looking forward to the next century, the engagement of these other elements which we haven't paid much attention to in the past will become pervasive in the economy. It will be everywhere. They may play minor roles in this element, in this object or this manufacturing process, but they are with us for the future and we need to take a long-term viewpoint. To ask what the individual effect on an American would be like asking in the 18th century what the effect on Americans would be of the absence of molybdenum, which is now a crucial ingredient in fabricating high-performance steels. We use it everywhere.

Dr. SCISSORS. Well, being a resident of Washington, I will, you know, make up stuff. After my colleagues pointed out that there is no way to do this, I will do it anyway, but not because I think I am right, just because we are in Washington and that is what we do.

Mr. ROHRABACHER. Educated guesses.

Dr. SCISSORS. Right. Just one element of context. Total amount of rare earths that we imported from China last year was $1.4 billion worth. We imported $2 billion of fish. This is not a cost issue. So when you are talking about pocketbook or coming out of Americans' pocketbooks, it is not a threat. When you are talking about future technologies, that is a different story, but coming out of American pocketbooks is not a threat. By that, I mean in terms of surprise on the defense side, you have looked at the DOD reports, I am sure. They don't see a short-term problem. So when you are talking about what we can do concretely for the short term, I agree with my colleague. This is not an issue. It is not something to worry about. There is no sneak attack that is going to cost us a lot.

We don't know about the long term, and that is where learning more, providing more information, addressing transparency issues, we don't want to be surprised as we were as you referred to on December 7th.

Chairman HARRIS. Thank you very much.

Let me recognize the gentlelady from California.

Ms. LOFGREN. Thank you very much. I think this is an important hearing, and one of the reasons among many it is important is to let the American people know that despite the name rare earth, the elements aren't actually rare, and this is something that we can get ahead of except we need to get organized to get ahead of it.

I would like to just ask a—I was at a hearing in the Judiciary Committee, which is why I am late, and we had the head of the FTC and the Department of Justice antitrust division, and one of the issues that we talked about was the interplay of patent law, which is exclusive, a grant of a monopoly, and antitrust, which is breaking up monopolies, and I noticed that Hitachi has refused to license its patent for high-grade permanent magnets, and there may be other instances where we are out of luck because of a license issue. Have we, Mr. Sandalow, as a department consulted with DOJ and with the FTC on whether this does in fact meet the obligations of these patent holders not to engage in monopolistic activities?

Hon. SANDALOW. I am not aware that we have, Congresswoman, and it is something that I will follow up on. Your question highlights an extremely important broader point and one that we were talking about before, which is the importance of developing intellectual capital in this area. This is not just about mines, it is also about minds. It is about making sure that Americans have the expertise to develop intellectual property in this area so we have the patents in the future.

Ms. LOFGREN. Yes, but if the patent is being held now by a monopoly that refuses unreasonably to license it to the detriment of our country as well as our industry, something can be done about that. So if you wouldn't mind getting back to me on your response to that, I would very much appreciate it.

Mr. Erceg, you mentioned—your testimony, as I understand it, was that in some cases regulations can actually spur innovation, although there needs to be transparency and the timing does matter. Can you expound on that for me so I fully understand your point?

Mr. ERCEG. Well, thank you Congresswoman, for the question. You know, I think it is no secret in saying that California ranks as one of the most stringent regulatory regimes for any type of materials-based processing, and I would just use as an example that, you know, we were limited. The fact of natural resources is, we don't really choose where we find them, and in this instance, the natural resource being the salt and sea brine is located squarely in the State of California. So we knew that going in as a business model and understood that there was going to be a lot of regulation as to how you work with and process materials. Knowing that in advance, we knew that we had to develop our processes in such a way that, one, we could meet the needs of the regulatory authorities, but secondarily, before we could raise investment dollars, we had to be able to demonstrate that even with meeting those regulatory obligations, we could be competitive in the marketplace.

So what ended up happening was, we had, you know, a brilliant team of scientists and engineers who represent the applied nature and then the actual tactical nature of our business came together and said oh, well, if we do this, this will allow you to do X, Y and Z, and that ended up, for instance, allowing us to reduce the CO_2 emissions out of a geothermal power plant and reincorporate them in the carbonation step of our plants, and that is the example I would give as spurring innovation.

I will say that, you know, regulation ultimately affects timing, you know, and that is a substantial concern. You know, when we look to competitors around the world, you know, their regulations are oftentimes more lax than ours, and I don't propose in any regard that we should reduce the regulatory burdens that are out there but we have to be conscious of the impact on time and what it does in allowing a company to reach a commercial point and built that plant going through the number of regulatory steps necessary. So, you know, I would just, you know, hope that we can take a balanced approach in society on this issue.

Ms. LOFGREN. If I may, Mr. Chairman, you can't breathe the air in Beijing today. You can in San Josén. So there is a reason for this but I think if we—if I am hearing you correctly, if the standards are set out in advance and you can look to them, that that is very helpful. Would that be accurate?

Mr. ERCEG. That is certainly accurate, ensuring that especially in areas of policy initiatives, if we can provide companies the opportunity to move rapidly through these processes, that too could be very beneficial, and that is not—again, that is not a statement to say that we should lower the standard, just allow us to move through it much quicker, and as industry participants, we will rise to the challenge and innovation will help us.

Ms. LOFGREN. Thank you very much.

Chairman HARRIS. Thank you.

And before we adjourn, Assistant Secretary Sandalow, I think you wanted to answer the Congressman from California, who subsequently left, but if you want, I will give you 30 seconds or a minute to address the issue of what if we don't.

Hon. SANDALOW. Well, thank you, Mr. Chairman. I did. I appreciate that very much. I just wanted to say, first, it is an important question that the Congressman was asking, I think and I agree with much of what was said here. I think if we don't address this set of issues, we are going to face problems in terms of the availability of certain products, potentially problems in terms of the cost of certain products, and problems in terms of job creation and technology development, and those are all important, you know, very important issues. At DOE, we haven't done the kind of overall economic analysis, so I don't mean to be speaking to an overall economic analysis, but there is no question that there are serious issues here. I mainly wanted to make the point that these are issues that we can solve. These are issues we can address. We have done that in the past, by pulling together, by smart policy, by the right types of investments, by following policies like finding new sources of supply, developing substitutes and recycling. We have overcome challenges like that, and I believe we can do that again.

Chairman HARRIS. Thank you, and I share your optimism. I think we will have a bipartisan product of the Committee that will address that.

I want to thank the witnesses for their valuable testimony and the members for their questions. The members of the Subcommittee may have additional questions for the witnesses, and we will ask you to respond to those in writing. The record will remain open for two weeks for additional comments from members.

The witnesses are excused and the hearing is adjourned.

[Whereupon, at 11:43 a.m., the Subcommittee was adjourned.]

Appendix

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by The Honorable David Sandalow,
Assistant Secretary for Policy and International Affairs,
Department of Energy

Questions Submitted by Chairman Andy Harris

Q1. Mr. Erceg noted in his testimony that after DOE announced its intention to award Simbol Materials a $3 million grant to demonstrate its technology, the company was able to raise $43 million in additional private sector capital, and that this private funding was committed before DOE actually delivered its grant funding, illustrating that the government "seal of approval" implicit in the award -- and not the actual dollars backing it -- triggered the private investment.

This seems to suggest that DOE efforts such as this to catalyze private investment could be undertaken much more cheaply, specifically by simply having the government signal its endorsement, or seal of approval, of a particular project rather than giving companies millions of dollars. Has DOE considered the potential benefits of such an approach? If not, will it do so?

A1. DOE is always interested in considering ways to deliver value to taxpayers at less cost. At present, DOE undertakes technical merit reviews pursuant to specific authorities assigned to the agency as part of a screening process to help inform decisions about whether to allocate limited resources to any given technology research, development, demonstration or commercialization project. DOE does not conduct merit reviews of technology development proposals as a public service to private sector investors. Generally, absent specific statutory authority to promote products, services or enterprises, an employee of DOE may not use or permit the use of the employee's Government position or title or any authority associated with the employee's public office for that purpose.

DOE is aware that a finding of potential merit in technical review of innovative technologies may translate to some value to applicants and potential investors and has taken steps to leverage its efforts in technical review to realize additional value from R&D program activity. For example, the Advanced Research Projects Agency-Energy (ARPA-E) has received over 5,000 applications since its first funding opportunity announcement in 2009. To economize on the effort of all involved, ARPA-E reviews all preliminary proposals before inviting a fraction of them to prepare full proposals. In order to realize the full value of the DOE investment in the technical review of the preliminary proposals, ARPA-E allows applicants who are invited to prepare a full proposal to choose to be listed on the ARPA-E website, even if they are not selected for award negotiations. However, DOE notes that the public acknowledgment of ARPA-E's expression of interest in receiving a full proposal does not constitute a DOE certification of technical merit or an endorsement of the entity or its technology.

QUESTION FROM REPRESENTATIVE HARRIS

Q2. The Department of Energy's 2010 Critical Materials Strategy identifies three pillars to address the challenges associated with critical materials in the clean energy economy. The first of these pillars states that substitutes must be developed. However, there are examples in which private industry proactively developed substitutes to preemptively limit the economic impact of fluctuation in material supply and price. How does DOE ensure its R&D prioritizes and is limited to longer-term efforts that industry is unable and unlikely to pursue by itself? Would a more robust dissemination of information better enable market responsiveness?

A2. One of the reasons DOE developed its first Critical Materials Strategy in 2010 was to better prioritize research, taking into account activities in the private sector and elsewhere. The Advanced Research Projects Agency- Energy (ARPA-E), the Office of Energy Efficiency and Renewable Energy, and the Office of Science each target their investments related to substitute research to avoid duplication with the private sector and with each other. The combination of investments helps build national capabilities both to meet future national energy policy goals and also to participate in the global clean energy market. Other countries are pursuing materials strategies of their own, including investing in substitute R&D. DOE R&D investments help the U.S. to compete with other nations.

QUESTION FROM REPRESENTATIVE HARRIS

Q3. Your testimony highlighted numerous programs throughout DOE that are supporting critical materials R&D, specifically 14 ARPA-E projects pursuing rare earth substitutes for electric vehicles and wind generators: and funding solicitations from the Wind Energy, Vehicle Technologies and Small Business Innovation Programs. How does DOE determine priorities and focus areas for these efforts and ensure R&D funded by the numerous programs does not duplicate efforts?

A3. We share the goal of making sure DOE uses resources efficiently and effectively to address critical materials challenges. That's one of the reasons DOE developed its first Critical Materials Strategy in 2010. Over the past two years, DOE has convened cross-departmental discussions on critical materials research priorities. The multiple offices are supporting complementary work. The Advanced Research Projects Agency-Energy (ARPA-E) is supporting highly transformative, innovative projects to develop alternative technologies with little or no critical materials content. The Office of Energy Efficiency and Renewable Energy focuses its work on using critical materials more efficiently and effectively in specific technologies such as those supported by the Vehicle Technologies Program and the Wind & Hydropower Technologies Program. The Office of Science funds basic research activities on the fundamental properties of materials, particularly through the Basic Energy Sciences Office. For DOE's 2011 Critical Materials Strategy, the Department developed an R&D plan that integrates the complementary work of the multiple DOE offices and identifies potential gaps that may be opportunities for future investment. Incorporating the input across several offices has made the research agenda much more comprehensive than it would be if it were housed in a single office.

QUESTION FROM REPRESENTATIVE HARRIS

Q4. General Electric's research begun in 2005 is often cited as an example of a company proactively responding to potential supply shortages for critical materials. Is there reason to believe a similar course would not be pursued by other affected industries, such as the automobile or wind turbine industries?

A4. According to reports, General Electric's proactive approach to potential material shortages has been very successful. However, individual proprietary company-level analyses and strategies are not a substitute for a national engagement for several reasons. First, not all companies have the resources to perform the same level of analysis and then use the analysis to inform R&D investments. Second, publicly available national or global analyses of supply, demand, prices and material criticality can contribute to market transparency. Finally, some research topics cut across companies and even industries. For example, both the automobile and wind turbine industries use neodymium magnets. In this case, it is beneficial both to understand combined material demand across industries and also to support precompetitive magnet substitute research that could benefit both industries.

QUESTION FROM REPRESENTATIVE HARRIS

Q5. Unfortunately, one of the major impediments to market stability in energy critical elements is the monopolistic tendencies of Chinese trade policy and a demonstrated willingness to leverage their monopoly position for geopolitical advantage and drive American companies out of business. As such, what other policy actions (WTO, currency legislation, stockpiling, etc.) should the congress consider to mitigate the impact of these actions?

A5. Any trade actions are under the purview of the U.S. Trade Representative's Office and the Department of Commerce. DOE supports a strategic response to help diversify supply, reduce use of newly mined minerals through recycling, and enable use of alternatives and more efficient use of critical materials in general. DOE has created an R&D plan for critical materials in order to address these issues. DOE appreciates the support of the critical materials R&D plan and the Critical Materials Energy Innovation Hub to address substitutes, recycling and diversity of supply.

QUESTION FROM REPRESENTATIVE HARRIS

Q6. Energy Critical Elements are well-known to be of significant importance to certain defense applications such as jet engines and weapons systems. How is the Department of Defense working to address potential national security-related challenges, and how Should (or are) these efforts coordinated with those supported by DOE?

A6. Since March 2010 OSTP, in close coordination with the National Economic Council, the Office of the U.S. Trade Representative and the National Security Council, has been convening an interagency working group that addresses critical materials issues through the full supply chain. This workgroup has been examining issues such as market risk (short- and long-term), the importance of critical materials for emerging high-growth industries, and opportunities for long-term impact through innovation. DOE and DOD have been working closely together as co-chairs of a workgroup subgroup addressing critical materials criteria and prioritization.

QUESTION FROM REPRESENTATIVE HARRIS

Q7. The testimony from the hearing included multiple references to the rapidly changing rare earth marketplace, which seems to be evolving at a pace that makes government research or policy changes difficult to keep up with. How long is the process from which DOE makes a funding opportunity announcement, through the selection process, and finally selecting awardees and spending the money? Is it plausible that by the time the application process is completed, an award is announced, and funds are actually spent, the rapidly changing market conditions will render the research irrelevant or no longer critical?

A7. The DOE process from issuing a funding opportunity announcement to making an award, at which point a successful applicant can begin spending funds, generally takes 5-8 months.

Technology innovation in the production and use of critical materials is not outpacing the process of making research grants at the Department of Energy. R&D objectives relating to critical materials can help stimulate more fundamental materials science and energy technology innovations that will have a lasting impact by ultimately broadening the array of available energy technologies.

QUESTION FROM REPRESENTATIVE HARRIS

Q8. The proposed "Critical Materials Energy Innovation Hub" received funding as part of DOE's fiscal year 2012 budget. Please describe the selection process and provide the criteria it will employ to determine an awardee. How is DOE ensuring the selection process will be fully competitive and conducted in an open and transparent manner, and that key U.S. stakeholders that are not explicitly part of the Hub collaboration will benefit from its work? What milestones or research and development goals will the awardee be required to meet? How does DOE plan to ensure that work funded through the Hub is limited to technology areas that industry is unable and unlikely to pursue by itself?

A8. On December 23, 2011, President Obama signed the Consolidated Appropriations Act, 2012, through which $20,000,000 is provided for the Energy Innovation Hub for Critical Materials. The DOE Energy Innovation Hubs aim to foster innovation through a unique approach, where scientists and engineers from many disciplines work together to overcome the scientific barriers to cutting-edge energy technologies in specific topic areas. In this environment, the researchers can accomplish greater feats more quickly than they would separately.

DOE expects to solicit proposals for the Critical Materials Hub through a Funding Opportunity Announcement (FOA). A FOA would target research areas foundational to manufacturing advances that lead to increased availability of and/or reduced use of critical materials in energy efficiency and renewable energy systems and that industry is unlikely to pursue on its own. The applications would be evaluated by a peer review panel with criteria such as scientific/technical merit, appropriateness of the approach, expertise/experience of personnel, appropriateness of budget, integration of R&D, soundness of management plan, and potential market for the proposed technologies. The required milestones would be developed by the applicant; their appropriateness would be judged by the peer reviewers. In post-award management of the hub, DOE would ensure that the milestones are met. Cost share with industry and/or state government would be required. The large hub team size and its interdisciplinary makeup will encourage multidisciplinary diffusion of innovation into the broader scientific and technical community.

Responses by Dr. Derek Scissors,
Research Fellow, Heritage Foundation

Questions Submitted by Chairman Andy Harris

Q1. General Electric's research begun in 2005 is often cited as an example of a company proactively responding to potential supply shortages for critical materials. Is there reason to believe a similar course would not be pursued by other affected industries, such as the automobile or wind turbine industries?

A1. This course is already being pursued. Companies such as Umicore are altering their research paths in response to changing prices. In wind turbines, for example, Boulder Wind Power has developed a technology using more readily available neodymium rather than dysprosium. In autos, Toyota and General Motors are improving induction motors that reduce the use of critical elements. And so on.

More broadly, recall that rare earths became commercially valuable materials in the 1970's, when GM and Sumitomo responded to supply disruptions of then-strategic minerals. What we now consider critical materials are not timeless and irreplaceable. Their role is the result of powerful and long-term private sector innovation. That innovation will inevitably continue to change what is deemed critical, unless the government gives in to short-term concerns and chills natural technological progress.

Q2. Unfortunately, one of the major impediments to market stability in energy critical elements is the monopolistic tendencies of Chinese trade policy and a demonstrated willingness to leverage their monopoly position for geopolitical advantage and drive American companies out of business. As such, what other policy actions (WTO, currency legislation, stockpiling, etc.) should the Congress consider to mitigate the impact of these actions?

A2. With regard to a stockpile, Chinese predatory behavior is one factor in the decision. The US should absolutely consider supplies from the PRC to be at risk. However, stockpiling is only effective if the correct elements are available when needed. For ECE's, this assessment must frequently be redone, as supply and demand rapidly shift. A traditional stockpile, as in oil, would not be useful.

The most obvious recommendation is to pursue a WTO case concerning restrictions on rare earth exports. Given blatant violations of WTO principles by Chinese state firms, this case should be easy to win. While full implementation of WTO decisions is a lengthy process, the initial favorable decision would permit the US to retaliate, perhaps on China-made goods using rare earths. This will discourage Chinese predation to some extent. One hopeful note: Chinese measures often backfire. The PRC did not even fill its export quota for rare earths in 2011 as demand for Chinese output weakened.

Beyond the WTO case, a complex but vital trade issue concerns subsidies. Large Chinese rare earth miners are all state-owned and receive heavy subsidies. The most relevant such subsidy is protection from competition, with the central government explicitly driving non-state producers out of the market. The first step in responding to these subsidies is a comprehensive assessment of their size and any harm inflicted on the U.S. To mitigate actions based on China's near-monopoly position, the US must document and counter the tools through which this position was established. Suppression of competition in the Chinese domestic market tops the list.

The other way to fundamentally undermine the Chinese position is to permit the American market to expand. This can be most quickly and efficiently started by permitting more land to be surveyed for possible ECE deposits. As with stockpiles, Chinese behavior is only one factor in this decision.

Q3. Energy Critical Elements are well-known to be of significant importance to certain defense applications such as jet engines and weapons systems. How is the Department of Defense working to address potential national security-related challenges, and how should (or are) these efforts coordinated with those supported by DOE?

A3. I am not the best person to assess DOD efforts or DOD-DOE coordination. True national security requirements should take priority over market imperatives while industrial policy should not, so it may not be possible to effectively coordinate DOD and DOE initiatives. A guiding objective for DOD should be to try to project military demand for ECE's against supply projections, to avoid surprises. DOD should not simply treat all ECE's as critical to future military equipment.

Q4. Dr. Scissors, you note your support for targeted government resource assessments and information gathering associated with Energy Critical Elements. What specific information is most important for the federal government to provide to energy critical element market participants?

A4. The ECE market involves, both at home and overseas, information concerning land and resources that can only be provided by national governments. The market is also shifting rapidly. As a result, the most valuable information at present is quite basic in nature. It is important that this information be provided reliably and repeatedly.

The definition of ECE should be broad and flexible, anticipating change. For all classified ECE's, the government should initially work to provide the most recent information concerning:

1. Total world output and output change
2. Output and change in output by country
3. Total world demand and demand change
4. Demand and change in demand by country
5. Demand and change in demand by industry
6. Total world known deposits and change in known deposits
7. Total world estimated deposits and change in estimated deposits
8. Known deposits and change in known deposits by country
9. Estimated deposits and change in estimated deposits by country
10. Price trend using a standardized measure and benchmark

Responses by Dr. Robert Jaffe,
Jane and Otto Morningstar Professor of Physics,
Massachusetts Institute of Technology

Questions Submitted by Chairman Andy Harris

Q1. General Electrics research begun in 2005 is often cited as an example of a company proactively responding to potential supply shortages for critical materials. Is there reason to believe a similar course would not be pursued by other affected industries, such as the automobile or wind turbine industries?

A1. I believe that GE's situation was unusual, almost unique: it had appreciated for many years the importance of rhenium to its turbine business and made it a high priority to gather information on U.S. and world production and reserves. Because of the proprietary value that individual companies would place on this kind of information and on their research, it seems quite unlikely that "industries" would respond collaboratively as your question suggests. Instead a few big players might have the long term perspective, the vision, and the resources to commit to a similar strategy, while most would not. Entrepreneurial startups and small businesses would be at a particular disadvantage.

I should mention that the number of individual chemical elements that might be important to a given emerging technology would likely be quite large. Instead of tracking one element, rhenium, as described in the GE case, a company might be confronted with the daunting task of tracking many.

This is the kind of information gathering activity that has typically been recognized as a legitimate function of the Federal Government, as illustrated by the Bureau of Labor Statistics or the Energy Information Administration.

Q2. Unfortunately, one of the major impediments to market stability in energy critical elements is the monopolistic tendencies of Chinese trade policy and a demonstrated willingness to leverage their monopoly position for geopolitical advantage and drive American companies out of business. As such, what other policy actions (WTO, currency legislation, stockpiling, etc.) should the Congress consider to mitigate the impact of these actions?

A2. The APS/MRS study focused primarily on medium to long-term approaches to ECE problems, so my perspective on these issues is somewhat limited. Our committee did agree that the U.S. should take all appropriate actions under bilateral and multilateral trade agreements and through the WTO. We observed, however, that the time scale for addressing issues in these forums is often too long to have an impact on the crisis of the moment (one more reason for taking a longer term perspective). We advocated for free international trade in general, but did not discuss currency manipulation. Finally, we recommended against federal stockpiling for economic reasons1 for several reasons. First it often has unintended and unforeseeable economic consequences; second, it interferes with free markets in a particularly crude way; and third, individual companies have the capacity to stockpile according to their own needs.

Our report recommended a triad of information, research, and recycling to anticipate problems before they become critical. Unfortunately, by the time an individual event has reached the proportion of the "rare earth crisis", the government's arsenal is rather limited.

Responses by Dr. Karl Gschneidner,
Senior Materials Scientist,
Ames National Laboratory

Questions Submitted by Chairman Andy Harris

Q1. Unfortunately, one of the major impediments to market stability in energy critical elements is the monopolistic tendencies of Chinese trade policy and a demonstrated willingness to leverage their monopoly position for geopolitical advantage and drive American companies out of business. As such, what other policy actions (WTO, currency legislation, stockpiling, etc.) should the Congress consider to mitigate the impact of these actions?

A1. Yes, there are some other actions Congress should carry out. But before I present my suggestions we need to understand the Chinese strategy regarding rare earths.

The supply of the basic rare earth materials in the Rest of the World (ROW) is close to being ameliorated with Molycorp (in the USA), Lynas (Australia) and other smaller mining operations in the USA, Canada and South Africa in (or coming into) operation. The post-mining manufacturers and related infrastructure is practically non-existent in the ROW, Japan is probably ahead of the USA and Europe in this regard. We need to re-establish this portion of the rare earth industry. It is absolutely necessary to do so from both a military and energy security posture. But if we can build up this manufacturing capability to supply computers, magnetic devices, electric motors, cell phones, i-pods, etc. for the general public the money will be spent in the USA and not sent to China.

My first three recommendations are: (1) that we make government guarantee loans available to these companies to become established; (2) make favorable tax incentives at the federal, state and local levels; and (3) place import restrictions (quotas, taxes, etc.) on rare earth containing products coming from China.

In order to re-establish the USA's rare earth intellectual capital and keep us competitive, it is imperative to educate and train the next generation of scientists, engineers, technical business managers for our rare earth industry, especially the post mining manufacturers. This requires 60 to 110 Ph.D., M.S. and B.S. degree students per year for the next 10 years. In order to carry this out: educational institutions need to teach semester long courses and short courses on various aspects of the rare earths both locally and via distance learning; federal government research organizations, such as NSF, DOE, DoD, and NIST, need to fund research projects involving rare earth science and technology; and a National scholarship program needs to be established to assist students to obtain and complete their education.

My fourth recommendation is: the establishment of national rare earth scholarships to be administered by the Energy Innovation Hub on Critical Materials authorized by Congress on December 2, 2011.

The Chinese are restricting the supply of the basic rare earth materials (concentrates, metals, magnets, etc.) to the Rest of the World (ROW), but not the commodities (i-phones, TVs, audio systems, cell phones, components which go into automobiles, computers, lighting, etc.) which utilize the rare earths. The Chinese want to sell the high value products (i-phones, TVs, etc.) and therefore, will continue to supply them to consumers in ROW and also internally in China itself.

However, I foresee real problems further down the road, five to ten years from now, when we have rebuilt the post-mining manufacturing infrastructure. Putting the manufactured electronic products, magnets, electric motors, CFL and LED lamps, computers, etc. in the consumer market will be in direct competition with the equivalent products from China. China is not going to let these markets slip out of their hands—they will do most anything to retain them and earn hard currency, which could include cutting prices below their costs and thus dumping these products in the marketplace. This will be the next battlefield—it will be a very competitive period, and we cannot fail, we cannot let them drive our companies out of business. From military and energy security needs we need these US manufacturers in the time of military conflict—who would produce the various devices that the country needs in a reasonable time scale?

How can we compete with the Chinese with their low labor costs and centrally controlled economy? Automate-Automate-Automate our manufacturing processes; maintain our intellectual and patent rights, and our trade and corporate secrets; and finally send our components to South and Central American countries to be assembled into the final products taking advantage of the lower labor costs in these nations.

Responses by Mr. Luka Erceg,
President and CEO, Simbol Materials

Questions Submitted by Chairman Andy Harris

Q1. Unfortunately, one of the major impediments to market stability in energy critical elements is the monopolistic tendencies of Chinese trade policy and a demonstrated willingness to leverage their monopoly position for geopolitical advantage and drive American companies out of business. As such, what other policy actions (WTO, currency legislation, stockpiling, etc.) should the Congress consider to mitigate the impact of these actions?

A1-a. **Free trade practices must be paired with support for strategic domestic industries**

The U.S. has long been the leader in fostering free-trade throughout the world, and simultaneously, our companies have exported many technologies. Our policies have now come full circle—we have invested abroad in countries with a comparative advantage in many resources (labor, natural resources, etc.). Those countries have now rapidly increased their standards of living for their citizens and have developed industries in areas where the U.S. previously exerted leadership, taking jobs from U.S. Citizens. Employment in the chemical and mining industries, for example, is down by more than 30% the past 20 years. Critical aspects of the U.S. industrial commons—the skills shared by a large, interlocking group of supply-chains, universities, and government that has been central to U.S. technological leadership—has lost its vitality as materials suppliers and production factories have moved abroad. The issue is significant as many of the advanced technologies, such as electric vehicles, solar, wind, LED lighting, rely on materials that are increasingly complex and produced overseas.

The answer, however, is not one of protectionism. Rather, it is to demand respect of the WTO standards and to make far greater use of the WTO Agreement to rebuild our domestic industries. The United States along with its partners in Japan and the European Union should vigorously pursue WTO dispute settlement. Congress should appropriate all funds necessary for the Office of the United States Trade Representative and the newly created Trade Enforcement Unit to litigate against distortive export quotas and export duties that constitute an implicit assistance to domestic producers and downstream processors, providing them with an unfair competitive advantage. Unless we take measures that permit U.S. industries to rebuild, we will continue to be a nation of importers.

We must stop the altruism of sacrificing our industries and jobs for the sake of free trade, rather, we must take up "fair trade." American ingenuity stands toe-to-toe with the best in the world. All that is needed is a level playing field.

A1-b. **Monopolistic tendencies of Chinese trade policies**

Unfortunately, monopolistic tendencies are not limited to just China, although it does provide ample evidence. The issue really is whether the monopolistic tendencies are actually a "wrongful act." Unfortunately, due to our reliance on the WTO, it is far too easy to argue pursuant to the WTO's conservation provisions, such as found in Article XX of the WTO Agreement, which provide ample protection for countries such as China. Even if their acts are wrongful, the time it takes to bring a WTO case is such that American industries will suffer inordinately.

Pursuant to Article XIX of the WTO Agreement, the U.S. government could take emergency action to safeguard domestic industry. Let us take manganese or rare earths as an example. The U.S, the European Union, and Mexico in their formal request to the WTO for dispute settlement noted that Chinese export restraints on raw materials significantly distort the international market and provide preferential conditions for Chinese industries that use these raw materials. The U.S. Government could implement import duties pursuant to Article XIX to protect U.S. Industries. However, who would that really help? The irony is that many of the customers of these products are located abroad, and in fact could be U.S. Customers. So the question next becomes to which products do you apply duties —the raw materials or the finished goods? Neither are produced in the U.S. today. In the case of manganese, duties will work because there is a domestic industry for refined chemical products. However, there is not for manganese ore or manganese metal.

My recommendation would be to take a position of supporting critical industries and making use of treaty safeguards and laws as necessary. Should domestic production be revived, the United States antidumping and countervailing duty laws could be used to combat a repeat of underselling by Chinese producers. However, the underlying problem is that we do not encourage enough manufacturing in the U.S. This is consequently causing shortages of talented persons.

A1-c. **Manufacturing (not stockpiling) will provide us with innovation bonds and long-term competitiveness**

It is my opinion that stockpiling of materials is akin to the early failures of aid to under-developed nations. In the past, we provided food aid which was a short-term stimulus to those in need, but once the food was gone the situation reversed itself. Aid was most successful when we taught under-developed nations to grow their own food — it is time to teach the U.S. how to manufacture and support those endeavors. This century we saw U.S. leadership in the production of raw materials fall and shift to other nations. This was driven by taxation and permitting.

We next saw U.S. manufacturing leadership fall and shift overseas — notably following raw material production. This occurred because of anticompetitive trade policies of nations such as China that required that raw materials be processed into finished products in their countries. In the U.S., such tied relationships are considered in violation of our competition laws and are illegal. Why do we tolerate them with trading partners? This was driven by high labor costs and taxation. Once manufacturing left, so too did innovation.

Manufacturing and innovation are intimately related. The erosion of our economy is abundantly clear — loss of raw material production, led to loss of specialty materials, led to loss of manufacturing. Without jobs, students do not enroll in university programs as there is no gainful employment for them in this country; hence they shift to other studies. Only 15.6 percent of U.S. bachelor's degrees were awarded in science technology and engineering (STEM) during 2010. Once the education system stops offering courses, educators stop conducting research and thus innovation begins to wane. China now leads the world in materials science publications, overtaking Japan and the U.S., and currently challenging the combined output of the EU-15 group of well-established European research economies While the demand for innovation has increased, government sponsored research has actually declined as a share of GDP. In one generation, we lost tremendous headway in multiple disciplines. It is perhaps not surprising that many emerging industries, such as solar-panels, and LED-lighting industries that have their roots in the U.S. semiconductor materials commons, are now mostly based in Asia. The erosion must stop.

Approximately 20 years ago, lithium-ion battery technology was invented in the United States. Today, the U.S. is not consequential to the world market for lithium-ion technologies. Some of the battery related investments made through ARRA funds were deployed for end-use assembly of battery and their components. We missed the opportunity to invest in materials capability that is at the head of the innovation supply-chain and the foundation for a competitive industrial base. This is not a criticism, rather an example of how much more we must do to foster education, innovation, and manufacturing in the United States.

Today, the U.S. falls woefully short in its ability to produce raw materials and to manufacture specialty / critical materials. U.S. companies must be given an opportunity to be competitive. Today, we face the highest labor costs, the most difficult permitting regimes, strictest environmental standards, the highest taxes, and lack of sufficient training in industries of strategic importance to the U.S. economy. Any one of the impediments aforementioned is daunting to overcome, let alone all. In no way do I suggest that environmental standards be lessened, or an elimination of permits. Rather, our governance slows the ability of U.S. Industry to act and respond, rather than encouraging it. Permitting must be transparent and rapid for manufacturing. Environmental standards must be predictable. Being competitive is not about lowering the pay of U.S. workers, rather, being competitive is about productivity. We need to encourage the optimization of labor, capital, and natural resources—the basic implements to the economy. That is manufacturing, and manufacturing of critical materials.

We suffer from a tax regime that has encouraged off-shoring of manufacturing and many other jobs. There is evidence that without such tax benefits related to repatriation of income, there would be no incentive to off-shore jobs. It is further worth noting that the research tax subsidy in the United States is only about half of that available in such technology strongholds as Japan. It is imperative to support the development of manufacturing supply chains in the U.S. But, merely providing acute stimuli will do little as we do not address the underlying problems. History has shown that nations are strongest when they manufacture. This has the advantage of reducing imports, or alternatively increasing exports to balance trade. Strengthening in our trade position improves the strength of the U.S. dollar. Only support of manufacturing will provide the solution.

Critical materials play a special role in our economy. Critical and specialty materials are the building blocks to advanced technologies, even such as solar panels, EV batteries, magnets for wind turbines, handheld consumer electronics, etc. Material innovation will lead to substantial R&D, innovation, commercialization, and job creation.

I respectfully submit to the committee, that without reducing taxes, providing incentives for manufacturing in general and more specifically to specialty materials producers, and supporting education, we cannot counter the monopolistic tendencies of other nations. By providing the incentive to increase U.S. based manufacturing, we will encourage companies to invest in training and collaboration with educational and research institutions. This will then foster more technical developments that will strengthen our ability to compete and lead.

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