Written Statement of

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Before the
Committee on Energy and Natural Resources
United States Senate

"Critical Minerals Policy Act of 2013"

January 28, 2014

Introduction

Chairman Wyden, Ranking Member Murkowski, and Members of the Committee, thank you for the opportunity to testify today on the important role that critical minerals play in moving the U.S. towards a clean energy economy and the U.S. Department of Energy's (DOE) ongoing work related to this topic.

Many domestically-manufactured products rely on critical materials, or materials that are important in their use and subject to supply restrictions. The energy industry is heavily reliant on critical materials and could be significantly affected by supply disruptions and resulting price increases and fluctuations. These critical materials are found in many traditional, new, and emerging energy applications, as well as key ingredients in lighting, solar photovoltaics and batteries, and many other applications. Technologies using critical materials are poised to make even more significant contributions to national energy, environmental, and economic goals.

The Department is currently reviewing S. 1600, the Critical Minerals Policy Act of 2013, and has no specific comments on the legislation at this time. However, the Department believes in the importance of ensuring a stable, sustainable, domestic supply of critical minerals. We look forward to continuing our discussions with Congress on ways to: monitor and identify critical materials as they potentially impact the energy economy; address the production, use, and recycling of critical minerals throughout the supply chain; as well as develop alternatives to critical minerals moving forward.

The Department has been moving swiftly on multiple fronts to address challenges across the lifecycle of critical elements, while also exploring alternatives to those that are hardest to obtain. These efforts are informed by the Department's *Critical Materials Strategy* developed in 2010 and 2011, which I will be happy to discuss with you today. I will also describe the Critical Materials Institute, an Energy Innovation Hub established by my office last year, and devoted to finding solutions in response to the scarcity of these elements that are critical to U.S. manufacturing and the expansion of clean energy technologies.

DOE is pursuing an all-of-the-above approach to developing every source of American energy. I represent the Office of Energy Efficiency and Renewable Energy (EERE), which leads DOE's efforts to help build a strong clean energy economy, a strategy that is aimed at reducing our reliance on foreign oil, saving families and businesses money, creating jobs, and reducing pollution. We support some of America's best innovators and businesses to research, develop, and demonstrate cutting-edge technologies, and work to break down market barriers in the EERE portfolio's three sectors: 1) sustainable transportation (vehicles, biofuels, hydrogen and fuel cells); 2) energy efficiency (energy-saving homes, buildings, and manufacturing); and 3) renewable electricity generation (solar, geothermal, hydrogen and fuel cells, wind and water).

Our nation stands at a critical point in time regarding the competitive opportunity for clean energy. In 2013, $254 billion was invested globally in clean energy, just over 360 percent increase since 2004; trillions more will be invested in the years ahead.[1] In the decades-long transition to a clean energy economy, the United States faces a stark choice: the clean energy technologies of today and tomorrow can be invented and manufactured in America, or we can surrender global leadership and import these technologies from other countries.

DOE's *Critical Materials Strategy*

Many of today's clean energy technologies rely on the use of materials with certain essential properties, such as efficient light emission or strong magnetism. Many of those critical materials are essential to producing products that EERE is also investing in, and in order to address this reliance, in both 2010 and

[1] See: Bloomberg, "Global Trends in Renewable Energy Investment, Fact Pack as of Q4 2013" (Jan. 2014): http://about.bnef.com/files/2014/01/BNEF_PR_FactPack_Q4_CleanEnergyInvestment_2014-01-15.pdf

2011, DOE issued *Critical Materials Strategy* reports that defined and assessed critical materials by analyzing two dimensions: importance to the clean energy industry, and supply risk. The Department's 2010 and 2011 *Critical Materials Strategy* reports identified five rare earth materials – neodymium, europium, terbium, dysprosium, and yttrium – as critical materials currently essential for America's transition to cost-competitive clean energy technologies, like wind turbines, electric vehicles, and energy efficient lighting. The Strategy reports also identified two additional elements, lithium and tellurium, as "near-critical" materials. Identifying and addressing near-critical element challenges is crucial as both the clean energy industry and critical materials market dynamics change. These particular non-rare earth materials play, at this time, an indispensable role in batteries for hybrid and electric vehicles and commercial photovoltaic thin films, and represent the next-highest criticality in terms of importance to the clean energy industry and risk of supply disruption.

The Department's *Critical Materials Strategy* reports identified three pillars to address critical materials challenges: 1) diversifying supply of critical materials, 2) developing alternatives to critical materials, and 3) driving recycling, reuse, and more efficient use of critical materials. I will address these in turn: First, diversified global supply chains are essential. To manage supply risk, multiple sources of materials are required. This means taking steps to facilitate the extraction, processing, and manufacturing of critical materials here in the United States, as well as encouraging other nations to expedite alternative supplies. In all cases, extraction, separation, processing, and manufacturing must be done in an environmentally sound manner. Second, substitutes must be developed. Research leading to material and technology substitutes will improve flexibility, decrease demand for critical materials, and help meet the materials needs of the clean energy economy. Third, recycling, reuse and more efficient use of critical materials could significantly lower world demand for newly extracted materials. Research into recycling processes coupled with well-designed policies will help make recycling economically viable over time. Addressing these three pillars is a moving target, as critical materials challenges change over time. Ongoing assessments are necessary to identify the status of current and emerging critical materials; as new technology develops and markets respond to supply risk, the criticality of materials will also shift.

DOE R&D Organizations

Several entities within the Department contribute to the critical materials research and development (R&D) effort. The Basic Energy Sciences program in the Office of Science supports broad-based, fundamental materials research. The Advanced Research Projects Agency - Energy (ARPA-E) invests in high-potential, high-impact energy technologies that are likely too early for private-sector investment. Within EERE, investment in research related to critical materials occurs within the Vehicle Technologies Office (VTO), the Wind Power Technologies Office, the Solar Energy Technologies Office (SETO), the Geothermal Technologies Office (GTO), and the Advanced Manufacturing Office (AMO).

DOE national laboratories are also integral to this R&D effort. The national laboratory system includes the nation's historic leader in rare earth materials research, the Ames Laboratory in Ames, Iowa. While Ames Laboratory has a core-competency in rare earth materials, many other national laboratories also contribute significantly to R&D aimed at reducing the criticality of critical materials. For example, Argonne National Laboratory, Brookhaven National Laboratory, Pacific Northwest National Laboratory, Sandia National Laboratories, and Lawrence Berkeley National Laboratory have complementary efforts spanning from basic and applied research to development and demonstration.

In response to the *Critical Materials Strategy* reports, the Department of Energy launched a national competition for an Energy Innovation Hub. Early in 2013, DOE announced the Critical Materials Institute (CMI), led by Ames National Laboratory. CMI is the nation's premier research, development and analysis institute dedicated to finding innovative solutions and developing creative, transformational paths to eliminating the criticality of rare earth and other materials.

CMI began operations in June of 2013. CMI has brought together leading researchers from academia, four Department of Energy national laboratories, as well as the private sector to develop solutions to the domestic shortages of rare earth metals and other materials critical for U.S. energy security. CMI addresses materials criticality problems by developing technologies spanning the supply chain for the rare earth (plus lithium and tellurium) elements, as well as providing research infrastructure to address any emergent challenges related to materials criticality.

CMI faces a formidable task: developing solutions to potential supply chain risks across the lifecycle of several different materials. The solutions will not be the same for different kinds of materials or applications. For example, technologies to improve separation and processing of rare earth elements from domestic deposits may increase the supply of neodymium (for magnets) but not europium (for lighting) due to the ore composition.

The Institute has focused its efforts around the three pillars of the *Critical Materials Strategy*. For example, to diversify supply, researchers are studying new, lower cost ways to extract, separate and process rare earth metals from ores and recycled materials. To develop substitutes, Institute researchers, in partnership with private sector partners, are searching for substitutes for rare earth phosphors. Energy-efficient lighting phosphors currently need europium, terbium, and yttrium, and this group is searching for alternatives using materials such as manganese. To improve reuse and recycling, CMI's R&D in this area is focused on two major areas: first, improving the cost- and energy-efficiency of separating the rare earth containing components from end-of-life products like light bulbs, hard drives and motors; and second, developing new technologies to extract rare earth elements from these end-of-life components to produce new materials. If successful, the technologies proposed by CMI could reduce loss of critical rare earths within domestic manufacturing by 50 percent and reduce critical rare earths elements going to domestic landfills by 35 percent.

In its first year of operations, the team is off to a fast start. Key start-up and management operations have been put in place. About 35 projects across the Institute are up and running. All of these projects involve multiple partners, often three or four partners collaborating to achieve the best solutions under CMI's mission. EERE is pleased to report that CMI researchers filed seven intellectual property invention disclosures. While there is tremendous work still to be done by the Institute, that is a great sign of things to come.

R&D Progress by DOE Programs

In my office and across the Department, we have an obligation to research issues relevant to supporting manufacturing as it relates to energy. Increasing U.S. manufacturing competiveness relies on thinking broadly about addressing challenges across the supply chain and across various industrial applications in our R&D investments. By stepping up research related to critical materials, DOE will help ensure clean energy technologies will be invented and manufactured in America. EERE's R&D investments are directly aligned with the aforementioned three pillars of the *Critical Materials Strategy* and coordinated among the program offices across the Department.

Regarding the first pillar -- diversifying supply -- some of the key research challenges in separations and processing of rare earth elements have been addressed historically at a small scale within the research portfolios of the Basic Energy Sciences program in the Office of Science, Laboratory Directed Research and Development, Small Business Innovation Research, and Small Business Technology Transfer. EERE has also invested in technologies to improve domestic lithium production. Through the American Recovery and Reinvestment Act of 2009, VTO supported a project to expand lithium carbonate and lithium hydroxide production to supply the domestic battery industry as well as a project to recycle lithium batteries for resale of lithium carbonate. The EERE Geothermal Technologies Office has funded the development of technologies to cost effectively extract minerals such as lithium, manganese and zinc from geothermal brines – to improve domestic production at reduced costs and to increase the overall value of geothermal electricity generation.

For substitutes, DOE has made significant investments, specifically toward rare earth permanent magnets for motors and generators. For instance, both EERE (through VTO and the Wind Power Technologies Office) and ARPA-E have significant efforts related to addressing rare earth materials criticality in these areas through the development of alternative motor and generator topologies which do not require rare earth permanent magnets. VTO has also invested in optimizing the use of rare earth materials in permanent magnets – focusing on magnet processing, composition, and improving high temperature performance with reduced rare earth content. In addition, VTO supported researchers are working to develop rare earth-free permanent magnets for advanced traction motors. For example, they are modifying aluminum, nickel and cobalt (alnico) magnets for improved performance in these new motors and developing new iron-cobalt based alloys to replace rare earth permanent magnets. ARPA-E's "Rare Earth Alternatives in Critical Technologies" program focuses on early-stage alternative technologies that reduce or eliminate the need for rare earths by developing substitutes in two key areas: electric vehicle motors and wind generators. Technological advances that utilize low-cost and abundant alternatives such as manganese and nickel will become increasingly vital to our national economic and energy security. The projects funded by ARPA-E must aim to meet or exceed the performance of their rare earth predecessors while remaining cost-competitive.

EERE's Wind Power Technologies Office supports several next-generation drive train technology projects. One of the key goals for these projects is reduction in the cost of wind energy. Although not a stated requirement for the program, many of these innovative technologies would also reduce or eliminate the use of permanent magnets containing rare earth materials, particularly for next-generation direct-drive wind turbines. For example, innovative superconducting direct-drive generators and new processes to make these materials on a cost-competitive basis for large wind turbines are being investigated.

The Department is also addressing substitutes for near-critical materials. DOE's *2011 Critical Materials Strategy* classified lithium as "near-critical." R&D efforts continue across the Department to develop alternatives to this material. In December 2012, the Joint Center for Energy Storage Research (JCESR), which is the Energy Innovation Hub for Battery and Energy Storage, began operations. JCESR is managed out of DOE's Office of Science and is led by Argonne National Laboratory. The mission of JCESR is to develop new battery chemistries beyond lithium-ion, and its goal is to deliver electrical energy storage with less or no lithium, five times the energy density, and at one-fifth the cost of today's commercial batteries within five years.

Additionally, in the *2011 Critical Materials Strategy*, tellurium was also assessed as near-critical. It is a material used in solar cells being deployed in the United States today. EERE's Solar Energy Technologies Office has supported a large number of projects to develop new technologies that focus on earth abundant materials as alternate, inexpensive materials in solar photovoltaics. For example, in September 2011, DOE awarded funding to 23 projects ($24.5 million) through the Next Generation Photovoltaics II solicitation, many of which incorporated earth-abundant materials such as copper, iron, and tin. Improving the recycling and reuse of critical materials – the third pillar – has, until recently, had limited DOE R&D investment. However, with the startup of the Critical Materials Institute and its work in this area, DOE is primed to make strides in this arena of R&D.

Interagency Coordination

Finally, the Department would also like to underscore the importance of continued interagency coordination and collaboration on the topic of critical materials. Issues related to critical materials and minerals touch on the missions of many federal agencies, and the full interagency perspective can help us proactively address critical materials issues. DOE co-chairs the National Science and Technology Council's Subcommittee on Critical and Strategic Mineral Supply Chains, which was established in

December 2010. This Subcommittee facilitates a strong, coordinated effort across federal agencies to identify and address important policy implications arising from strategic minerals supply issues. Areas of focus for the Subcommittee include identifying emerging critical materials, improving depth of information, and identifying R&D priorities. The Subcommittee also informally reviews and examines domestic and global policies that affect the supply of critical materials, such as permitting, export restrictions, recycling, and stockpiling.

Conclusion

The work being done across the Department, including at the Critical Materials Institute, shows that DOE is taking steps to address the global demand for critical materials that underpin clean energy technologies. The United States intends to be a world leader in clean energy technologies. To this end, we must ensure a sustainable domestic supply chain for our clean energy economy. We look forward to working with Congress on addressing critical materials challenges.