Testimony before

The Subcommittee on Investigations and Oversight of the House Committee on Science and Technology

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Introduction

Chairman Miller and members of the Committee, it is a privilege to share with you GE's thoughts on how we manage shortages of precious materials and commodities critical to our manufacturing operations and what steps the Federal government can take to help industry minimize the risks and issues associated with these shortages.

Background

GE is a diversified global infrastructure, finance, and media company that provides a wide array of products to meet the world's essential needs. From energy and water to transportation and healthcare, we are driving advanced technology and product solutions in key industries central to providing a cleaner, more sustainable future for our nation and the world.

At the core of every GE product are the materials that make up that product. To put GE's material usage in perspective, we use at least 70 of the first 83 elements listed in the Periodic Table of Elements. In actual dollars, we spend $40 billion annually on materials. 10% of this is for the direct purchase of metals and alloys. In the specific case of the rare earth elements, we use these elements in our Healthcare, Lighting, Energy, Motors, and Transportation products.

Nowhere in the company is our understanding of materials more evident than at GE Global Research, the hub of technology development for all of GE's businesses. Located just outside of Albany NY, GE scientists and engineers have been responsible for major material breakthroughs throughout our 110-year history. One of GE's earliest research pioneers, William Coolidge, discovered a new filament material, based on ductile tungsten, in 1909, which enabled us to bring the light bulb to every home. Just four years later, he developed a safe x-ray tube design for medical imaging. In 1953, GE scientist Daniel Fox developed LEXAN plastic, which is used in today's CDs and DVDs. It was even used in the helmets that US astronauts Neil Armstrong and Buzz Aldrin wore when they walked on the moon. More recently, GE scientists created a unique scintillator material, called Gemstone, which is the key component in GE Healthcare's newest High-Definition Computed Tomography (CT) medical imaging scanner that enables faster and higher resolution imaging.

Because materials are so fundamental to everything we do as a company, we are constantly watching, evaluating, and anticipating supply changes with respect to materials that are vital to GE's business interests. On the proactive side, we invest a great deal of time and resources to develop new materials and processes that help reduce our dependence on any given material and increase our flexibility in product design choices.

We have more than 35,000 scientists and engineers working for GE in the US and around the globe, with extensive expertise in materials development, system design, and manufacturing. As Chief Scientist and Manager of Material Sustainability at GE Global Research, it's my job to understand the latest trends in materials and to help identify and support new R&D projects with our businesses to manage our needs in a sustainable way.

Chairman Miller, I commend you for convening this hearing to discuss an issue that is vital to the future well being of US manufacturing. Without development of new supplies and more focused research in materials and manufacturing, such supply challenges could seriously undermine efforts to meet the nation's future needs in energy, healthcare, and transportation. What I would like to do now is share with you GE's strategy to address its materials needs, as well as outline a series of recommendations and indeed, a framework, for how the Federal government can strengthen its support of academia, government, and industry in this area.

Comments and Recommendations

The process that GE uses to evaluate the risks associated with material shortages is a modification of an assessment tool developed by the National Research Council in 2008. Risks are quantified element by element in two categories: "Price and Supply Risk", and "Impact of a Restricted Supply on GE". Those elements deemed to have high risk in both categories are identified as materials needing further study and a detailed plan to mitigate supply risks. The "Price and Supply Risk" category includes an assessment of demand and supply dynamics, price volatility, geopolitics, and co-production. Here we extensively use data from the US

Geological Survey's Minerals Information Team, as well as in-house knowledge of supply dynamics and current and future uses of the element. The "Impact to GE" category includes an assessment of our volume of usage compared to the world supply, criticality to products, and impact on revenue of products containing the element. While we find this approach adequate at present, we are working with researchers at Yale University who are in the process of developing a more rigorous methodology for assessing the criticality of metals. Through these collaborations, we anticipate being able to predict with much greater confidence the level of criticality of particular elements for GE's uses.

Once an element is identified as high risk, a comprehensive strategy is developed to reduce this risk. Such a strategy can include improvements in the supply chain, improvements in manufacturing efficiency, as well as research and development into new materials and recycling opportunities. Often, a combination of several of these may need to be implemented.

Improvements in the global supply chain can involve the development of alternate sources, as well as the development of long-term supply agreements that allow suppliers a better understanding of our future needs. In addition, for elements that are environmentally stable, we can inventory materials in order to mitigate short-term supply issues.

Improvements in manufacturing technologies can also be developed. In many cases where a manufacturing process was designed during a time when the availability of a raw material was not a concern, alternate processes can be developed and implemented that greatly improve its material utilization. Development of near-net-shape manufacturing technologies and implementation of recycling programs to recover waste materials from a manufacturing line are two examples of improvements than can be made in material utilization.

An optimal solution is to develop technology that either greatly reduces the use of the at-risk element or eliminates the need for the element altogether. While there are cases where the properties imparted by the element are uniquely suitable to a particular application, I can cite many examples where GE has been able to invent alternate materials, or use already existing alternate materials to greatly minimize our risk. At times this may require a redesign of the system utilizing the material to compensate for the modified properties of the substitute material. Let's look at a few illustrative recent examples.

The first involves Helium-3, a gaseous isotope of Helium used by GE Energy's Reuter Stokes business in building neutron sensors for detecting special nuclear materials at the nation's ports and borders. The supply of Helium-3 has been diminishing since 2001 due to a simultaneous increase in need for neutron detection for security, and reduced availability as Helium-3 production has dwindled. GE has addressed this problem in two ways. The first was to develop the capability to recover, purify and reuse the Helium-3 from detectors removed from decommissioned equipment. The second was the accelerated development of Boron-10 based detectors that eliminate the need for Helium-3 in Radiation Portal Monitors. DNDO and the Pacific Northwest National Lab are currently evaluating these new detectors.

A second example involves Rhenium, an element used at several percent in super alloys for high efficiency aircraft engines and electricity generating turbines. Faced with a six-fold price increase during a three-year stretch from 2005 to 2008 and concerns that its supply would limit our ability to produce our engines, GE embarked on multi-year research programs to develop the capability of recycling manufacturing scrap and end-of-life components. A significant materials development effort was also undertaken to develop and certify new alloys that require only one-half the amount of Rhenium, as well as no Rhenium at all. This development leveraged past research and development programs supported by DARPA, the Air Force, the Navy, and NASA. The Department of Defense supported qualification of our reduced Rhenium engine components for their applications.

By developing alternate materials, we created greater design flexibility that can be critical to overcoming material availability constraints. But pursuing this path is not easy and presents significant challenges that need to be addressed. Because the materials development and certification process takes several years, executing these solutions requires advanced warning of impending problems. For this reason, having shorter term sourcing and manufacturing solutions is critical in order to “buy time” for the longer term solutions to come to fruition. In addition, such material development projects tend to be higher risk and require risk mitigation strategies and parallel paths. The Federal Government can help by enabling public-private collaborations that provide both the materials understanding and the resources to attempt higher risk approaches. Both are required to increase our chances of success in minimizing the use of a given element.

Another approach to minimizing the use of an element over the long term is to assure that as much life as possible is obtained from the parts and systems that contain these materials. Designing in serviceability of such parts reduces the need for additional material for replacement parts. The basic understanding of life-limiting materials degradation mechanisms can be critical to extending the useful life of parts, particularly those exposed to extreme conditions. It is these parts that tend to be made of the most sophisticated materials, often times containing scarce raw materials.

A complete solution often requires a reassessment of the entire system that uses a raw material that is at risk. Often, more than one technology can address a customer's need. Each of these technologies will use a certain subset of the periodic table – and the solution to the raw material constraint may involve using a new or alternate technology. Efficient lighting systems provide an excellent example of this type of approach. Linear fluorescent lamps use several rare earth elements. In fact, they are one of the largest consumers of Terbium, a rare earth element that along with Dysprosium is also used to improve the performance of high-strength permanent magnets. Light emitting diodes (LEDs), a new lighting technology whose development is being supported by the Department of Energy, uses roughly one-hundredth the amount of rare earth material per unit of luminosity, and no Terbium. Organic light emitting diodes (OLEDs), an even more advanced lighting technology, promises to use no rare earth elements at all. In order to "buy time" for the LED and OLED technologies to mature, optimization of rare earth usage in current fluorescent lamps can also be considered. This example shows how a systems approach can minimize the risk of raw materials constraints.

In addition to high efficiency lighting, GE uses rare earth elements in our medical imaging systems and in wind turbine generators. Rare earth permanent magnets are a key technology in high power density motors. These motors are vital to the nation's vision for the electrification of transportation, including automobiles, aircraft, locomotives, and large off-road vehicles. The anticipated growth in the use of permanent magnets and other rare earth based materials for efficient energy technologies mandates that we develop a broad base solution to possible raw material shortages. These solutions require the development of the sourcing, manufacturing efficiency, recycling, and material substitution approaches outlined above.

Based on our past experience I would like to emphasize the following aspects that are important to consider when addressing material constraints:

1) Early identification of the issue – technical development of a complete solution can be hampered by not having the time required to develop some of the longer term solutions.
2) Material understanding is critical – with a focus on those elements identified as being at risk, the understanding of materials and chemical sciences enable acceleration of the

most complete solutions around substitution. Focused research on viable approaches to substitution and usage minimization greatly increases the suite of options from which solutions can be selected.

3) Each element is different and some problems are easier to solve than others – typically a unique solution will be needed for each element and each use of that element. While basic understanding provides a foundation from which solutions can be developed, it is important that each solution be compatible with real life manufacturing and system design. A specific elemental restriction can be easier to solve if it involves few applications and has a greater flexibility of supply. Future raw materials issues will likely have increased complexity as they become based on global shortages of minerals that are more broadly used throughout society.

Given increasing challenges around the sustainability of materials, it will be critical for the Federal government to strengthen its support of efforts to minimize the risks and issues associated with material shortages. Based on the discussion above, we make the following recommendations for the Federal government:

1) Appoint a lead agency with ownership of early assessment and authority to fund solutions - given the need for early identification of future issues, we recommend that the government enhance its ability to monitor and assess industrial materials supply, both short term and long term, as well as coordinate a response to identified issues.

Collaborative efforts between academia, government laboratories, and industry will help ensure that manufacturing compatible solutions are available to industry in time to avert disruptions in US manufacturing.

2) Sustained funding for research focusing on material substitutions – Federal government support of materials research will be critical to laying the foundation upon which solutions are developed when materials supplies become strained. These complex problems will require collaborative involvement of academic and government laboratories with direct involvement of industry to ensure solutions are manufacturable.
3) With global economic growth resulting in increased pressure on material stocks, along with increased complexity of the needed resolutions, it is imperative that the solutions discussed in this testimony: recycling technologies, development of alternate materials, new systems solutions, and manufacturing efficiency have sustained support. This will require investment in long-term and high-risk research and development – and the Federal government's support of these will be of increasing criticality as material usage grows globally.

Conclusion

In closing, we believe that a more coordinated approach and sustained level of investment from the Federal government in materials science and manufacturing technologies is required to accelerate new material breakthroughs that provide businesses with more flexibility and make us less vulnerable to material shortages. Chairman Miller and members of the committee, thank you for your time and the opportunity to provide our comments and recommendations.

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Steven Duclos is a Chief Scientist at the General Electric Global Research Center in Niskayuna, New York, and manages GE's Material Sustainability Initiative. The Material Sustainability initiative addresses GE's risks in the availability and sustainability of the company's raw material supply, by developing technologies that reduce the use, support the recycling, and enable substitution of lower-risk materials.

From 2000 to 2008 Dr. Duclos managed the Optical Materials Laboratory, also at GE GRC. The laboratory is responsible for development of advanced materials for a broad spectrum of GE businesses, including its Lighting and Healthcare businesses. From 1994 to 2004 Dr. Duclos served on the Executive Committee of the New York State Section of the American Physical Society. Prior to joining the GE Global Research Center in 1991 he was a post-doc at AT&T Bell Laboratories in Murray Hill, New Jersey.

Dr. Duclos received his B.S. degree in Physics in 1984 from Washington University in St. Louis, M.S. degree in Physics from Cornell University in Ithaca, New York in 1987, and Ph.D. in Physics from Cornell in 1990. He is the recipient of an AT&T Bell Laboratories Pre-doctoral Fellowship and the 1997 Albert W. Hull Award, GE Global Research's highest award for early career achievement.