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CRITICAL MINERALS AND MATERIALS LEGISLATION

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

ON

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S. 1133

JUNE 9, 2011

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JEFF BINGAMAN and LISA MURKOWSKI are Ex Officio Members of the Subcommittee

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CRITICAL MINERALS AND MATERIALS LEGISLATION

THURSDAY, JUNE 9, 2011

U.S. SENATE,
SUBCOMMITTEE ON ENERGY,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:31 p.m. in room SD–366, Dirksen Senate Office Building, Hon. Maria Cantwell presiding.

OPENING STATEMENT OF HON. MARIA CANTWELL, U.S. SENATOR FROM WASHINGTON

Senator CANTWELL. [presiding] Good afternoon.

The Energy Subcommittee of the Energy Committee will come to order. In hearing today is to receive testimony on several bills relating to critical minerals and materials legislation, those bills being S. 383, S. 421 and S. 1113. I know my colleagues are coming back from a floor vote we just had, but I'm going to go ahead and get started.

We are here this afternoon to discuss the issue of critical minerals and materials which are essential components of many of the technologies that are part of our modern economy. Under the leadership of Chairman Bingaman and Ranking Member Murkowski, the full Committee has spent considerable time this Congress discussing and developing legislation to address our nation's many energy challenges. We have considered legislation to support the development of conventional and alternative fuels and technologies, options for low carbon electricity generation, and efforts to catalyze America's innovation in private sector investment needed to achieve cleaner and more diverse energy future.

But we must not lose sight of the fact that our energy economy also depends on a stable, reliable, materials supply chain. When it comes to cleaner, alternative energy sources rare Earth elements and key mineral resources are essential ingredients in technologies as diverse as solar cells, wind turbines, energy storage technologies, efficient LED lighting and SMART grid electronics. Infinia, a company that makes innovative, high performance, solar power systems in Richland, Washington, said when we had the last hearing on this topic, "Access to commercial supply of rare Earth metals is of critical importance to Infinia and our suppliers and customers."

It's not just rare Earth metals. Other critical materials such as platinum, lithium, palladium are used in a broad array of essential modern technologies ranging from batteries to electronics to pollution control technologies. Just looking around the room I see dozens of ways these critical materials are being used already.

However, as last year's subcommittee hearing established while America was once sufficient in supplying the materials and finished product used in high tech manufacturing today. We now are more reliant on imports from other nations. As Assistant Secretary Sandalow points out in his testimony, in the next 5 years we could face supply disruptions in the materials needed to produce clean energy technologies.

To my mind the situation we find ourselves in when it comes to critical materials has many similarities and parallels to the situation we face in transitioning to a cleaner, more diverse, energy source in general. Not too long ago, the United States was the world's largest producer of rare earth elements. Not too long ago, we were inventing and manufacturing the world's wind turbines and solar panels.

But somewhere along the way, that changed. 97 percent of the world's rare Earth elements are now produced in China, which also has some of the world's largest endowments of rare Earth and critical minerals. At the same time China's renewable energy investment is up 39 percent. China is now the world's largest manufacturer of wind turbines and solar modules.

China has now overtaken the United States in terms of installed, renewable, electricity capacity. There are reports that provide evidence that China is using its strategic endowments to constrain global supply of selected rare Earth elements and critical materials. They are using these resources to monopolize the manufacturing of advanced and efficient clean energy technologies. The Associated Press reported on Wednesday that China is consolidating its rare Earth production industry such that a single company will have a monopoly on rare Earth production in China's main rare Earth producing region.

The reality is that we can no longer afford to ignore this problem or to continue to drift without a national energy strategy, we must have predictable policies in this area. In many ways the challenges and solutions to critical materials in energy production shortages are the same. We need to establish a national plan and priorities, to invest in R and D, to provide the private sector with certainty and predictability and to figure out ways to make sure that those efforts are being undertaken.

Most of all we need to make sure our efforts are leveraging America's innovative spirit of free market entrepreneurship so that we can make sure that we catch up again. We cannot risk having enormous exposure to supply chain shortages of strategic commodities. To that end I commend and thank my colleagues who have put 3 bills out for consideration today, Senator Hagan, Senator Udall and Senator Murkowski.

So I will defer to them now to explain those bills. My hope is that given the broad range of co-sponsorship and stakeholder support for these measures and with on the help of our expert witnesses today, we will be able to come up with bipartisan legislation to address this important national problem.

When my colleagues arrive, if they wish to make any opening statements we will allow them to do so. The ranking member, Senator Risch, I believe is on his way. The full committee ranking member, Senator Murkowski. We've been joined by Senator Bingaman, the full committee chair.

Senator Bingaman, would you like to make any statement today?

OK, if not, then I'm going to proceed to Senator Hagan and allow her to make a statement about her bill—Senator Murkowski, would you like to make any statement? We're now allowing the subcommittee and full committeechairs to make opening statements.

STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

Senator MURKOWSKI. I appreciate that, Madame Chair. I apologize that I am late. I apologized to my Chairman. I was late for the hearing this morning and just my day.

Thank you to those who have joined us and——

Senator CANTWELL. I—just to give you a second. I have made a statement and then when you're finished or if Senator Risch arrives in time we'll allow him to make a statement and then we'll go to our witnesses, Senator Hagan, who also has introduced legislation today. Then we'll go to our full panel of witnesses.

Senator MURKOWSKI. Thank you, Madame Chairman. I appreciate the opportunity to speak on the legislation that we have in front of us. One of which I am introducing relating to critical minerals in the supply chain.

We've got a real problem on our hands. Minerals are the building blocks of our nation's economy. From rare Earth elements to Mendelevium, we rely on our minerals for the smallest computer chips to the tallest skyscrapers.

Minerals make it possible for us to innovate and invent and in the process they shape our daily lives, our standard of living and our ability to prosper. There's no question that a stable and affordable supply of minerals is critical to America's future competitiveness. Yet despite all that, our mineral related capabilities have been slipping for decades. Rare Earth elements garner most of the headlines, but the U.S. remains 100 percent dependent on foreign suppliers for 17 other minerals and more than 50 percent dependent on foreign sources for some 25 more.

To revitalize the domestic, critical mineral supply chain, I've introduced one of the measures that we have before us today. It's the Critical Minerals Policy Act. I've got 17 co-sponsors including 8 of my Democratic and 9 of my Republican colleagues. I thank them all for that support.

The bill provides clear programmatic direction to keep the U.S. competitive. Will ensure that the Federal Government's mineral policies, some of which have not been updated since the 1980s are brought here into the 21st century here. The legislation requires that USGS generate a list of minerals critical to the U.S. economy, outlines a comprehensive set of policies that will bolster the production of these critical minerals, expands manufacturing and promotes recycling and alternatives all while maintaining strong, environmental standards.

What sets this bill apart is not only a more comprehensive look at the various minerals, but also its attention to the broader supply chain including the permitting process for domestic critical mineral production. The U.S. ranks dead last in the world in terms of the amount of time it takes to get to a yes or no answer to permit applicants. It's our responsibility here in this Energy Committee to understand why this is the case. If there's any real purpose for these delays. If not, what we can do about them.

The U.S. has some of the strongest standards in the world for environmental protection. Mining operations are subject to no less than 30 Federal, State and local regulatory programs. As a country we should be proud and maintain the commitment that we've displayed over generations to being good stewards of our natural environment.

We set standards as a result of these laws, standards for air emissions, waste storage, ground water supplies. I believe that if operators are capable with complying with these standards they should be allowed to produce the minerals. If they're not, then I don't want them doing business here in the United States.

What we should not do, however, and particularly in the case of minerals critical to our global competitiveness and our national security is purposely or unwittingly subject these projects to an unnecessarily long permitting process. Delaying projects, standing capital and allowing bureaucratic intransigence is not a strategy for environmental protection. To the contrary it is disingenuous—thank you, disingenuous, and a dangerous thing for us to do as the U.S. struggles to create private sector jobs and attract long term investments.

There's no question we know that mining has an environmental impact. It's a process that involves digging holes in the ground. It's just as simple as that. But we have to acknowledge that national interests served by reducing our reliance on foreign, critical mineral supplies and understand that these projects can be pursued in a more modern and a more responsible way here at home than abroad.

I've gone to great lengths to take measured inquiry based steps to address the permitting process in my bill. I think it's reflected in the broad, bipartisan support that it's attracted. I do hope, Madame Chairman, that we will be able to continue to improve, not only on the proposals that we have before us, but working together to ensure that the significance of our critical mineral supply chain is recognized and helped to advance.

So I appreciate, again, your support and having the hearing today.

Senator CANTWELL. Thank you, Senator Murkowski. We're now going to turn to Senator Hagan, who has joined us. Thank you for being here today to talk about S. 421, your legislation, Powering America's Lithium Production Act.

Senator Hagan.

STATEMENT OF HON. KAY R. HAGAN, U.S. SENATOR FROM NORTH CAROLINA

Senator HAGAN. Thank you, madame chairman and your Ranking Member Risch, I really do appreciate you inviting me here today to join this Subcommittee to discuss the need to secure a stable supply of rare Earth and other critical materials. I'll certainly want to thank Chairman Bingaman and Ranking Member Murkowski also. As members of the subcommittee well know the topic of today's hearing is vitally important to our Nation's ability to out innovate and out compete our global competitors.

Chairman Cantwell, you mentioned this and Senator Murkowski, how important this is. Critical materials are the building blocks of next generation manufacturing and are essential components of everything from windmills to IPods to solar panels to the navigation system of an Abrams tank. As the Chair of the Senate Armed Services Emerging Threats Subcommittee, I can tell you that many of these materials are essential to our national security and our ability to equip our men and women on the battlefield.

That's why I am encouraged that this Subcommittee is working together in a bipartisan way to put in place a strategy that will help ensure reliable and affordable access to critical minerals well into our future. In particular I want to thank the chairman and the ranking member for bringing this to the Subcommittee today this legislation that I introduced in late February, the Powering of America's Lithium Production Act. Lithium is the material of choice for rechargeable batteries, also known as lithium-ion batteries. It's a crucial component of clean energy products such as electric vehicles and our SMART grid of the future.

As demand for electric vehicles continues to grow it is conservatively estimated that global lithium demand will grow by 20 percent annually through the end of this decade. Through the Recovery Act, Congress recognized the growing demand for lithium-ion batteries by making an unprecedented investment in our ability to manufacture advanced batteries here in the United States. Recovery Act investments included billions of dollars in loans and grants to support more than 30 electric vehicle battery and component manufacturing plants. Without a doubt these investments will enhance our energy security and will allow U.S. battery manufacturers to supply our growing electric vehicle market.

But while we've made significant progress in assembling the infrastructure needed to manufacture these critical lithium-ion batteries domestically, we have yet to make similar investments in the production of the materials found inside these batteries. Currently the battery grade lithium used to power the next generation of lithium batteries is supplied almost exclusively from foreign sources. Even though 2 of the 3 global manufacturers capable of producing battery grade lithium are headquartered in the United States, most of their current production actually occurs overseas close to the major battery manufacturers in Asia.

So instead of simply encouraging these manufacturers to replicate their overseas facilities here at home, we really should be encouraging them to improve on these technologies to give our domestic battery manufacturers a competitive edge. The Powering America's Lithium Production Act would do just that. It will enable these manufacturers to keep pace with escalating demand and will encourage them to invest innovation here at home in the United States.

To do so, it provides grants to support the developments and commercialization of technologies that will enhance domestic lithium production for use in advanced batteries. When you combine that with our expanded domestic battery capacity, breakthroughs in lithium production will help put the U.S. at the forefront of electric vehicle innovation and manufacturing. As today's sky high gas prices teach us, dependence on foreign energy sources leaves our Nation less safe and less competitive in the global economy. We must not repeat this pattern with our critical mineral supply.

The strength of the American economy depends on investment in clean energy technologies such as lithium-ion batteries that will bolster our national security, reduce our dependence on foreign oil, protect our environment and to me, most importantly, it will create jobs. The Powering America's Lithium Production Act is an important part of this broader effort. I encourage this Subcommittee to consider this bill carefully.

Madame Chairman, I thank you for the opportunity to be with you here today and Ranking Member Risch. I look forward to continuing to work with the Subcommittee to address this important issue. Thank you.

Senator CANTWELL. Thank you, Senator Hagan. Does anybody have any questions for our colleague before we let her go?

If not, thank you, Senator Hagan, for introducing this legislation and for your interest in such a critical issue.

Senator Risch, would you like to make an opening statement before——

Senator RISCH. No, I'll pass. Thank you.

Senator CANTWELL. Thank you.

Let's call up the second panel then.

Dr. David Sandalow, Assistant Secretary for Policy and International Affairs from the U.S. Department of Energy.

Ms. Marcilynn Burke, Deputy Director of the Bureau of Land Management for the U.S. Department of Interior.

Welcome to both of you. Mr. Sandalow, thank you for being here the second time to talk about this issue and to brief the Committee on the Department of Energy's efforts in this area. So we'll give you a few minutes to get situated. I know you're also going to be accompanied by Mr. Jeff Doebrich, who is the Program Coordinator and Acting Mineral Resource—for Mineral Resources from the U.S. Geological Survey. So welcome, to you as well.

My understanding is you're not going to give testimony but are here to answer any questions that committee members may have. Is that correct? Yes.

Thank you.

Before we do the second panel, I should have recognized Senator Udall, who has also introduced legislation. So Senator Udall, would you like to take a few minutes to talk about S. 383?

STATEMENT OF HON. MARK UDALL, U.S. SENATOR FROM COLORADO

Senator UDALL. I would, Madame Chair. Thank you for recognizing me. I apologize in advance for circulating between this Committee and the Intelligence Committee which I serve on and is holding a hearing now as well.

It's a nice confluence. It's a challenging confluence. Because of what we know about our capabilities on the Intelligence Committee and what rare Earth materials and minerals offer to us in the long run.

So I want to thank you and Ranking Member Risch for holding the hearing. I want to acknowledge the work of the Committee Ranking Member Murkowski, who in many ways is walking in the same steps that I did early this year in introducing legislation on critical material supplies. I came to see that she picked up and included many of the provisions from my bill in her bill. I think it's positive that we agree on many of the steps that we need to take moving forward.

We've already heard from Senator Hagan. We will hear from the witnesses about how important critical material supplies are for our national security and our economic well being. I should also mention that I became aware of this during my service as well in the Armed Services Committee in the Senate.

We used to dominate, the United States did, the world's supply chain, not just because we had the mines, but because we developed the know how as to how to process the minerals and put them into advanced technology. We sold that technology, however. The intellectual property rights went to countries like China and Japan and now we no longer have the manufacturing capabilities nor a skilled work force at the level that we need to have it or want in this country.

So even if we were to open and I know we will, more rare Earth mines in the United States, we currently then have to ship the products of those mines to China to be processed into useful materials. That's, in part, my motivation for having introduced my bill at the beginning of the year to bring back our capacity to process the raw materials here in the U.S. Then to ensure that we can produce products along the entire supply chain.

So I want to thank the chairman's staff, who is here as well, for working closely with me. Now that we have at least 2 separate bills, I think we have some work to do to make sure our policies are aligned. I do have some concerns about some of the sections in the Ranking Member's bill, mainly the mining permitting piece and some of the mineral specific provisions.

But the Energy Committee is known for its focus on working through differences between individual members. I know that Senator Murkowski and I can do that. I know the hearing will give us an opportunity to highlight the differences and the similarities and to move forward ultimately in the committee with a unified voice in ways in which we can better compete as a country and win the global economic race. We so much depend on these important natural resources to be able to do so.

So, Madame Chair, I thank you for the opportunity to comment. I look forward to working with my friend from Alaska.

Senator CANTWELL. Thank you. Thank you, Senator Udall for introducing S. 383 and for your comments today. We'll look forward to working with you on that legislation as several pieces have been introduced. The Committee, obviously, has great interest in this.

So now we're going to turn to our panel. I've already introduced them. So I'm going to let them just make their statements. But welcome to this Committee and thank you for your input.

So, Mr. Sandalow, welcome.

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

Mr. SANDALOW. Thank you, Madame Chairwoman, Ranking Member Risch, members of the subcommittee. It's good to be before you again. Thank you for the opportunity to testify today on critical minerals and materials.

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 produce at an annual rate of about 19,000 tons of rare earth by the end of next year 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 of Energy shares the goal of establishing a stable, sustainable and domestic supply of critical minerals. We look forward to discussions with the Congress on ways to address this issue as we move forward.

Madame Chair, the world is on the cusp of a clean energy revolution. Here in the U.S. we're making historic investments in clean energy. The American Recovery 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 of Recovery Act funds in electric vehicles, battery and advanced energy storage, a smarter and more reliable electric grid, wind and solar technologies among many other areas.

Other countries, importantly, are also seizing this opportunity. The market for clean energy technologies is growing rapidly around the world. For example, the Chinese government is launching programs to deploy electric cars in over 25 major cities while building huge wind farms, ultra super critical advanced coal plants and ultra high voltage, long distance transmission lines. India has launched an ambitious national solar mission. In Europe strong public policies are driving sustained investments in clean energy.

In recognition of the importance of certain materials in the transition to clean energy, the Department of Energy is working to address the use of critical materials in clean energy components, products and processes. As a first step, DOE released its critical materials strategy last December. The report found that 4 clean energy technologies: wind turbines, electric vehicles, photovoltaic cells and fluorescent lighting use materials at risk of supply disruptions in the next 5 years.

In the report 5 rare earth elements: Dysprosium, neodymium, terbium, europium, yttrium along with indium were assessed as most critical in the short term. For this purpose criticality was defined as a measure that combined the importance to the clean energy economy and the risk of supply disruptions. The critical materials strategy highlighted 3 pillars to address the challenges associated with critical materials.

First, substitutes must be developed.

Second, recycling, reuse and more efficient use can significantly lower global demand for newly extracted materials.

Finally, diversified global supply chains are essential. Within global supply chains domestic supply is the most important. That means encouraging Nations to expedite alternative supplies and exploring potential sources of materials such as existing mine tailings and coal ash in addition to facilitating environmentally sound extraction and processing here in the United States.

This year DOE will update its analysis in light of rapidly changing market conditions. DOE is analyzing the use of critical materials in petroleum refineries and other applications not addressed in last year's report. In addition DOE may identify specific strategies from materials identified as critical including strategies with respect to substitution, recycling and more efficient use.

In support of this year's analysis we issued a request for information that focused on critical material content of certain technologies and other topics. That RFI, as we call it, closed last month. We received nearly 500 pages of responses from 30 organizations including manufacturers, miners, universities and national labs. Many organizations shared proprietary data and material usage that will help us develop a clearer picture of current and future market conditions. We are in the process of analyzing that data as we speak.

Madame chair, the administration is currently reviewing the bills before you today, S. 383, S. 421 and S. 1113. DOE has no comments on the specific content of those 3 bills at this time. We share the goal of establishing a secure supply of critical minerals and very much look forward to discussions with the Congress on ways to address any issues as we move forward.

One last thing we've learned through experience is that supply constraints aren't static. As a society we've dealt with these types of issues before. Working together, being smart and serious, we can do so again.

Thank you.

[The prepared statement of Mr. Sandalow follows:]

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

Chairwoman Cantwell, Ranking Member Risch, and Members of the Subcommittee, thank you for the opportunity to testify today and discuss three bills under consideration by this committee: S. 383, S. 421, and S. 1113. I would also like to speak about the critical minerals that underpin the transition to a clean energy economy and the Department of Energy's ongoing work on this topic.

Additionally, significant industry efforts are underway 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 produce at an annual rate 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 the Department of Energy (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 aim to double our renewable energy generation and manufacturing capacities by 2012. We are working to deploy hundreds of thousands of electric vehicles and charging infrastructure to power them, weatherize at least half 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, the Chinese government is launching programs to deploy electric cars in over 25 major cities. They are connecting urban centers with highspeed rail and building huge wind farms, ultrasupercritical advanced coal plants and ultra-highvoltage 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.

In Europe, strong public policies are driving sustained investments in clean energy. Denmark earns more than $4 billion each year in the wind turbine industry. Germany and Spain are the world's top installers of solar photovoltaic panels, accounting for nearly three-quarters of a global market worth $37 billion in 2009. Around the world, investments in clean energy 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

In recognition of the importance of certain materials in the transition to clean energy, DOE has begun to address the use of critical materials in clean energy components, products and processes. As a first step, DOE released its Critical Materials Strategy last December. 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 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 (such as existing mine tailings or coal ash) in addition to facilitating environmentally sound extraction and processing here in the United States. 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.

This year, DOE will update its analysis in light of rapidly-changing market conditions. DOE is analyzing the use of critical materials in petroleum refineries and other applications not addressed in last year's report. In addition, DOE may identify specific strategies for materials identified as critical, including strategies with respect to substitution, recycling and more efficient use. 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. The RFI closed last month. 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.

Within this larger context, we do intend to address domestic production of critical materials in our 2011 report. Production within the United States is important for at least three reasons. First, domestic production is the most secure. Second, the

United States' considerable reserves of some critical materials could add significantly to total global production and to greater diversity in the global supply of these materials. Third, U.S. technology and best practices developed during mine operations can help promote safe and responsible mining in other countries, further contributing to supply diversity and the sustainable development of resources. With regard to mining in the United States, it is important to point out that permits are not the only requirements that can extend the time required to open a mine. The required accumulation of hundreds of millions of dollars of capital for mine development can also lead to delay.

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 research and development (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. We are already closely working with our interagency partners to address these important issues.

S. 383, S. 421, and S. 1113

The Administration is currently reviewing S. 383, S. 421, and S. 1113, and the DOE has no comments on the specific content of these three bills at this time. We share the goal of establishing a secure supply of critical minerals, and 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.

Senator CANTWELL. Thank you, Mr. Sandalow. We'll look forward to asking you questions.

Ms. Burke, thank you for being here.

STATEMENT OF MARCILYNN BURKE, DEPUTY DIRECTOR, BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR ACCOMPANIED BY JEFF DOEBRICH, PROGRAM COORDINATOR, ACTING MINERAL RESOURCES PROGRAM, U.S.GEOLOGICAL SURVEY

Ms. BURKE. Good afternoon. Thank you for this opportunity to discuss S. 383, the Critical Minerals and Materials Promotion Act and S. 1113, the Critical Minerals Policy Act. These bills direct the Secretary's of Energy and the Interior to perform a number of activities intended to support and promote the production of domestic critical minerals and to enhance the Nation's critical minerals supply chain.

In this statement I will address the provisions relevant to the Department of the Interior. As Madame Chair has acknowledged, with me today is Jeff Doebrich and he's the Acting Minerals Program Coordinator at the U.S. Geological Survey. He will answer questions about the USGS's role.

The Department of the Interior supports the goal of facilitating the development of critical minerals on Federal lands in an environmentally responsible manner. Global demand for critical mineral commodities is on the rise with increasing applications in consumer products, computers, automobiles, aircraft and other advanced technology products. Much of this growth in demand is driven by new technologies that increase energy efficiency and decrease reliance on fossil fuels. To begin the process of understanding the potential sources of critical minerals the USGS has recently completed an inventory of known domestic, rare Earth reserves and resources.

S. 383 directs the Secretary of the Interior acting through USGS to establish a research and development program for undiscovered and discovered resources of critical minerals and materials in the United States and abroad. These actions are already underway at the USGS. The USGS continuously collects, analyzes and disseminates data and information on domestic and global rare Earth and other critical mineral reserves and resources as well as production, consumption and use.

S. 1113, the Critical Minerals Policy Act of 2011 directs the Secretary of Interior through the USGS to perform a number of actions that build upon the current capabilities including this recent rare Earth inventory. The bill directs the USGS to develop a rigorous methodology for determining which minerals are critical and then to designate them as such. It also calls for a comprehensive, national resource assessment within 4 years of the bills enactment of each mineral designated as critical under section 101 of the bill.

Section 104 calls for the establishment of a high level working group whose members would come from 9 departments and agencies as well as a designee from the Office of the President. The working group would review, assess and evaluate the permitting process for exploration and development of domestic critical minerals while maintaining our environmental standards. Section 104 requires the working group to submit a report of its findings to the President and Congress. The Department would like to work with the Committee to clarify and focus the duties of this working group. The Department is also concerned that the bill provides insufficient time to carry out both the duties of the working group and to report to Congress.

Section 105 addresses new, critical mineral manufacturing facilities and seeks to facilitate the permitting processes for them for all Federal agencies as well as improve coordination and consideration of permit applications that are under State review. In this permitting process the BLM sometimes reviews and analyzes one category of critical mineral manufacturing as defined in the bill if it is to occur on BLM lands. Often times, however, these and other manufacturing operations are located on non-Federal lands. We are concerned about other portions of section 105 and those are discussed further in our written statement.

The USGS stands ready to fulfill its role as the Federal provider of unbiased research, unknown mineral resources, assessment of undiscovered mineral resources and information on domestic and global mineral resources for use in global critical mineral supply chain analyses. Similarly the BLM welcomes the opportunity to work with the Committee toward the goal of improving the coordination and efficiency of the mining permitting process while maintaining our environmental standards.

Thank you again for this opportunity to present our views on these bills. We'd be happy to answer any questions.

[The prepared statement of Ms. Burke follows:]

STATEMENT OF MARCILYNN BURKE, DEPUTY DIRECTOR, BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR

ON S. 383

Good afternoon, Madam Chairwoman and Members of the Subcommittee. Thank you for the opportunity to discuss S. 383, the Critical Minerals and Materials Promotion Act of 2011. The bill directs the Secretaries of Energy and of the Interior to perform a number of activities intended to promote the domestic production of critical minerals and materials. In this statement, we will address the provisions relevant to the Department of the Interior. The Department of the Interior supports the goals of this bill, although we note that the Departmental activities called for in S. 383 are within the scope of existing Department of the Interior authorities.

The U.S. Geological Survey (USGS) is responsible for conducting research and collecting data on a wide variety of nonfuel mineral resources. Research is conducted to understand the geologic processes that concentrated known mineral resources at specific localities in the Earth's crust and to estimate (or assess) quantities, qualities, and areas of undiscovered mineral resources, or potential future supply. USGS scientists also conduct research on the interactions of mineral resources with the environment, both natural and as a result of resource extraction, to better predict the degree of impact that resource development may have on human and ecosystem health. USGS mineral commodity specialists collect, analyze, and disseminate data and information that document current production and consumption for about 100 mineral commodities, both domestically and internationally for 180 countries. This full spectrum of mineral resource science allows for a comprehensive understanding of the complete life cycle of mineral resources and materials—resource formation, discovery, production, consumption, use, recycling, and reuse—and allows for an understanding of environmental issues of concern throughout the life cycle.

Global demand for critical mineral commodities is on the rise with increasing applications in consumer products, computers, automobiles, aircraft, and other advanced technology products. Much of this demand growth is driven by new technologies that increase energy efficiency and decrease reliance on fossil fuels. To begin the process of understanding potential sources of critical mineral commodities, the USGS has recently completed an inventory of known domestic rare-earth reserves and resources (Long and others, 2010). This study restates basic geologic facts about rare earths relevant to assessing domestic security of supply and reviews current U.S. consumption and imports of rare earths, current knowledge of domestic resources, and possibilities for future domestic production. The report also includes an overview of known global rare-earth resources and discusses the reliability of alternative foreign sources of rare earths.

Though rare earth elements are currently of most concern to many, including the Department of Defense, which funded the inventory, it should be noted that in 2010 the United States was 100 percent dependent on foreign suppliers for 18 mineral commodities and more than 50 percent dependent on foreign sources for 43 mineral commodities. Import partners include Brazil, Canada, China, France, Germany, Japan, Mexico, Russia, and Venezuela. In 2008, a National Research Council committee, funded largely by the USGS, developed a "criticality matrix" that combines supply risk with importance of use as a first step toward determining which mineral commodities are essential to the Nation's economic and national security (National Research Council, 2008).

S. 383

S. 383 directs the Secretary of the Interior, acting through the USGS, to establish a research and development program to (1) provide data and scientific analyses for research on, and assessments of the potential for, undiscovered and discovered resources of critical minerals and materials in the United States and other countries; (2) analyze and assess current and future critical minerals and materials supply chains; and (3) if appropriate, cooperate with international partners to ensure that the research and assessment programs provide analyses of the global supply chain of critical minerals and materials.

These actions are within the scope of existing authorities, and already underway at the USGS. The USGS continuously collects, analyzes, and disseminates data and information on domestic and global rare-earth and other critical mineral reserves and resources, production, consumption, and use. This information is published annually in the USGS Mineral Commodity Summaries (USGS, 2011) and includes a description of current events, trends, and issues related to supply and demand.

The USGS stands ready to fulfill its role as the federal provider of unbiased research on known mineral resources, assessment of undiscovered mineral resources, and information on domestic and global production and consumption of mineral resources for use in global critical-mineral supply chain analysis. Any study conducted to fulfill the objectives of the bill would require substantial resources and would need to compete for funding with other Administration priorities.

Thank you for the opportunity to present the views of the Department on S. 383. We are happy to answer any questions you or the other Members may have.

ON S. 1113

Good afternoon and thank you for the opportunity to discuss S. 1113, the Critical Minerals Policy Act of 2011. The bill directs the Secretaries of Energy and of the Interior to perform a large number of activities intended to support and enhance the Nation's critical mineral supply chain, beginning with developing a methodology to determine which minerals are critical to the Nation's economy. In this statement, we will address the provisions relevant to the Department of the Interior.

The Department of the Interior supports the goal of facilitating the development of critical minerals in an environmentally responsible manner. We note that many of the activities called for in S. 1113 are within the scope of existing Department of the Interior authorities. We would like to work with the Committee toward the goal of improving the coordination and efficiency of the mining permitting process while maintaining environmental standards.

Background

The U.S. Geological Survey (USGS) is responsible for conducting research and collecting data on a wide variety of nonfuel mineral resources. Research is conducted to understand the geologic processes that concentrated known mineral resources at specific localities in the Earth's crust and to estimate (or assess) quantities, qualities, and areas of undiscovered mineral resources, or potential future supply. USGS scientists also conduct research on the interactions of mineral resources with the environment, both natural and as a result of resource extraction, to better predict the degree of impact that resource development may have on human and ecosystem health. USGS mineral commodity specialists collect, analyze, and disseminate data and information that document current production and consumption for about 100 mineral commodities, both domestically and internationally for 180 countries. This full spectrum of mineral resource science allows for a comprehensive understanding of the complete life cycle of mineral resources and materials-resource formation, discovery, production, consumption, use, recycling, and reuse-and allows for an understanding of environmental issues of concern throughout the life cycle.

Global demand for critical mineral commodities is on the rise with increasing applications in consumer products, computers, automobiles, aircraft, and other advanced technology products. Much of this demand growth is driven by new technologies that increase energy efficiency and decrease reliance on fossil fuels. To begin the process of understanding potential sources of critical mineral commodities, the USGS has recently completed an inventory of known domestic rare-earth reserves and resources (Long and others, 2010). This study restates basic geologic facts about rare earths relevant to assessing domestic security of supply and reviews current U.S. consumption and imports of rare earths, current knowledge of domestic resources, and possibilities for future domestic production. The report also includes an overview of known global rare-earth resources and discusses the reliability of alternative foreign sources of rare earths.

Though rare earth elements are currently of most concern to many, including the Department of Defense, which funded the inventory, it should be noted that in 2010 the United States was 100 percent dependent on foreign suppliers for 18 mineral commodities and more than 50 percent dependent on foreign sources for 43 mineral commodities. Import partners include Brazil, Canada, China, France, Germany, Japan, Mexico, Russia, and Venezuela. In 2008, a National Research Council committee, funded largely by the USGS, developed a "criticality matrix" that combines supply risk with importance of use as a first step toward determining which mineral commodities are essential to the Nation's economic and national security (National Research Council, 2008).

S. 1113

S. 1113, the Critical Minerals Policy Act of 2011, directs the Secretary of the Interior, through the Director of the USGS, to perform a number of actions that build on current USGS activities and capabilities, including the recent rare-earths inventory. The bill directs the USGS to develop a rigorous methodology for determining which minerals are critical, and then to use that methodology to designate critical minerals. It calls for a comprehensive national mineral resource assessment within four years of the bill's enactment for each mineral designated as critical under Sec. 101, and it authorizes field work for the assessment, as well as technical and financial assistance for States and Indian tribes. The bill establishes a collaborative effort between USGS and the U.S. Energy Information Administration for annual reviews of domestic mineral trends as well as forward-looking analyses of critical mineral production, consumption, and recycling patterns. The bill repeals the National Critical Minerals Act of 1984 and parts of the National Materials and Minerals Policy, Research, and Development Act of 1980 but retains Sections 1604(e) and (f) of the 1980 Act, which authorize the mineral information tracking and analysis activities of the USGS.

Sec. 104 calls for the establishment of a high-level Working Group whose members would be the Secretaries (or designees) of the Interior, Energy, Agriculture, Defense, Commerce, and State, the U.S. Trade Representative, the Administrator of the U.S. Environmental Protection Agency, and the Chief of Engineers of the Army Corps of Engineers, as well as a designee from the Executive Office of the President. The Working Group would review, assess, and evaluate the permitting process for exploration and development of domestic, critical minerals, while maintaining environmental standards. Sec. 104 requires the Working Group to submit a report to the President and Congress on the Working Group's findings. The Department would like to work with the Committee to clarify and focus the duties of this Working Group. We are also concerned that the bill provides insufficient time to both carry out the duties of the Working Group and to report back to Congress.

Section 104 also calls for the development of a performance metric. The Department of the Interior issued its FY 2011-2016 Strategic Plan in January 2011. As part of developing this plan, the Department developed performance metrics. Throughout the process, and in accordance with the Government Performance and Results Act (GPRA), the Department sought public input into the plan, goals, and performance measures selected. Within the Department's Strategic Plan framework, the BLM already measures and reports in its Budget Justifications information regarding non-energy mineral (which include critical minerals) exploration and development leases, permits, and licenses.

Sec. 105 addresses new "critical mineral manufacturing facilities" and seeks to facilitate the permitting processes for them for all Federal agencies as well as facilitate coordination and consideration of permit applications that are under state review. The bill defines one category of "critical mineral manufacturing" to include "the production, processing, refining, alloying, separation, concentration, magnetic sintering, melting, or beneficiation of critical minerals within the United States" (Sec. 2(4)(A)). In its permitting processes, the BLM sometimes reviews and analyzes such operations if they are to occur on BLM lands. Oftentimes, however, these and other manufacturing operations are located on non-Federal lands.

Sec. 105 of the bill also lists several activities that the President may undertake in cooperative agreements with states regarding the processing of critical mineral mining permits, including memoranda of agreement for the coordination and concurrent review of state and Federal permit applications. The bill also provides for use of consolidated permit applications for all Federal authorizations and memoranda of agreement between Federal agencies to coordinate review of permit applications. The Department supports the goals of optimizing efficiencies in the review of permit applications and would welcome the opportunity to explore with the Committee the circumstances under which a consolidated application for all permits required by the Federal government would be efficient and effective, bearing in mind the diverse missions and authorities of the Federal agencies involved. The Department also supports the goal of coordinating consideration of mining operations across Federal agencies and is working on many levels to improve interagency cooperation.

With respect to concurrent Federal and state review of permit applications (Sec. 105(b)(3)), while the Department supports the idea of sharing information and coordinating with states to the extent practicable, we must remain mindful of the multiple authorities governing the authorization of mineral development, including those delegated to the states to regulate in certain areas such as the Clean Air Act and the Clean Water Act.

Conclusion

The Department maintains a workforce of geoscientists (geologists, geochemist, geophysicists, and resource specialists) with expertise in critical minerals and materials. The Department continuously collects, analyzes, and disseminates data and information on domestic and global rare-earth and other critical mineral reserves and resources, production, consumption, and use. This information is published annually in the USGS Mineral Commodity Summaries (USGS, 2011) and includes a description of current events, trends, and issues related to supply and demand.

The Department, through the USGS, stands ready to fulfill its role as the federal provider of unbiased research on known mineral resources, assessment of undiscovered mineral resources, and information on domestic and global production and consumption of mineral resources for use in global critical-mineral supply chain analysis.

Similarly, we welcome the opportunity to work with the Committee toward the goal of improving the coordination and efficiency of the mining permitting process while maintaining environmental standards

We note, however, that many of the activities called for in S. 1113 are already authorized by existing authorities. Any activities conducted to fulfill the objectives of the bill would require substantial resources and would need to compete for funding with other priorities.

Thank you for the opportunity to present the views of the Department on S. 1113. We will be happy to answer any questions.

Senator CANTWELL. Thank you, Ms. Burke. Again, thank you, to all the witnesses for being here today.

I'm going to start with you, Mr. Sandalow. You touched on the issue of substitutes. It seems to me that there is no amount of mining that is going to fully address this issue.

You know, I've read some information about the University of Nebraska developing a permanent magnet that does not require rare Earth elements at all. The University of Delaware is trying to create a nano composite magnet. If successful, this could result in a huge, reduction in rare earth minerals demand as much as 30 to 40 percent. Japan is working on Ferrite magnets that don't need rare Earth.

So could you elaborate on your point about substitutes for rare Earths and what it will take to bring those products to the marketplace?

Mr. SANDALOW. Thank you for the question, Madame Chairwoman. It's an extremely important area. You're exactly right in saying that substitutes are critical to our work in this area.

We, at the Department of Energy, are supporting work in developing substitutes. The ARPA–E program, for example, has a funding opportunity announcement looking at exactly this topic. Our energy efficiency and renewable energy program is looking at exactly the same types of issues.

In areas, you know, including not only for magnets but lighting and other areas, we have the potential to develop substitutes but it's going to require government partnering with industry in ways that are productive going forward. I think the basic research and development that needs to be done in this area is essential. Then government working with industry can make the steps that will really make a difference.

Senator CANTWELL. The legislation that we have before us today doesn't do a lot in the area of substitutes. Is that correct?

Mr. SANDALOW. I would look to the sponsors. I do think it's important that we do develop substitutes and that we work, you know, productively in that area.

Senator CANTWELL. OK. Mr. Sandalow, do our scientists and engineers have enough data now to evaluate what our domestic resource base is with respect to critical minerals or is there more work to be done there?

Mr. SANDALOW. For mineral assessment I would defer to Department of Interior and USGS. But, you know, in general data collection is an extremely important function of government. It's one that needs to be funded adequately for the sake of our companies and our competitiveness.

Senator CANTWELL. What about work force? Do we have the work force there?

Mr. SANDALOW. It's such an important issue. Thank you for asking. We do not.

Education and training is a huge—very, very important issue in this area, Madame Chair. The educational resources that have gone into this area in other countries swamp those that have gone into those in our own country. It's extremely important that we develop the trained work force to take on this issue.

Senator CANTWELL. Could you elaborate on that? What kind of investment has China or other countries made in the necessary skills? Because I would assume it'd be similar to mining in general or no?

Mr. SANDALOW. It's also in chemistry and in a variety of technical including engineering expertises that are essential to developing products in this area. You know, at the Department of Energy there has been expertise at the Ames National Lab in this area for many, many years. But that type of expertise needs to be multiplied if this country is going to be fully competitive in this area in the years ahead.

Senator CANTWELL. OK. Thank you.

Ms. Burke, obviously there are many of us here who have been seeking an update to the 1872 mining law. I'm certainly one of them. We have royalties for oil and gas and coal. Should there also be royalties on these minerals?

Ms. BURKE. Madame Chairman, as you're aware that we have proposed legislation as part of the budget to take several minerals out of the mining law, gold, copper, those sorts of elements. But we have not looked at what sort of royalty would be appropriate, if any, on rare Earth or other critical minerals.

Senator CANTWELL. OK. How do you look at this inventory issue that we were just discussing? Do we have a good assessment of what the domestic resources are with respect to critical minerals and materials?

Ms. BURKE. I'll defer to Mr. Doebrich.

Senator CANTWELL. OK.

Mr. DOEBRICH. Madame Chairwoman.

Senator CANTWELL. Thank God there's not a fourth witness because you might defer to them. But anyway.

Mr. DOEBRICH. That's true.

Senator CANTWELL. Go ahead.

Mr. DOEBRICH. The only minerals or elements or metals that have been systematically assessed on a national basis are gold, silver, copper, lead and zinc. So rare Earths and other minerals that are considered as critical have yet to be assessed nationally in a systematic way. That's what we're preparing to do in the coming years.

Senator CANTWELL. What does that mean we're preparing to do? So we have a plan. We have the resources. We have a deadline. How long would it take? That.

Mr. DOEBRICH. Yes. We are in the process of updating our national data bases, in the process of updating our deposit models that are required to do these assessments. One of the things that we've been involved with heavily over the last 10 years is a global assessment for a copper, pot ash and platinum development.

So we are waiting for the completion of that which is happening at the end of this fiscal year before we have human resources available then to embark on a new national assessment.

Senator CANTWELL. OK. I think I'll come back to this in a second round. Senator Murkowski, would you like to ask questions?

Senator MURKOWSKI. Thank you for your attendance here today and for working with us on these issues. You mentioned, Ms. Burke, in your testimony that you welcome the opportunity to work with the Committee toward the goal of improving the coordination and the efficiency of the mining permitting process while maintaining the environmental standards. We've got to work on the efficiency side.

Recognizing, again, as I stated in my opening comments, that we're dead last when it comes to this permitting process and how long it takes, anywhere from 7 to 10 years. So we do want to work with you on that. We do want to try to gain some efficiencies within the process itself.

Let me ask both of you. The Critical Materials Strategy Report that came out in December, I understand that sometime before the end of this year there's going to be a new version or an update to that report. As good as the report was, as important as it was, I think there were some concerns that it didn't—there wasn't a lot of interagency coordination as you worked to identify problems and potential solutions.

I—we say in the report that we're dead last. Acknowledge that. But what have we identified in terms of what the solution is to that. Other than just saying, well, that's kind of the responsibility of the Department of the Interior.

So since we've got both agencies today I guess I would ask you to commit to working more collaboratively on this next report that's coming out so that we can hopefully have some more specific proposals than we saw with the last report. You're both nodding your heads. So I take it you agree that this is a good approach.

Mr. SANDALOW. We'd be delighted to do that, Senator. Thank you for the question and the suggestion. I would add that just yesterday there was a meeting convened by the Office of Science and Technology policy among all the major Federal agencies on this topic. There's been very active interagency conversation in the prior months. I know that's the plan going forward.

So completely agree and thank you very much for the suggestion.

Senator MURKOWSKI. OK. Good.

Also to both of you when I released my discussion draft of the Critical Mineral Policies Act for comment, we got a number of comments back to that advocating for the designation of certain USGS offices as principle statistical agencies. I'm wondering if either one of you would care to comment or react to this suggestion. As I understand it would represent a fairly significant reorganization of the minerals information, functions at USGS and would allow the Federal Government to compel the provision of information that in the past has just been made voluntarily.

Is this something that the Administration would support? Is this a good idea? Bad idea?

Mr. DOEBRICH. We'd actually like to better understand what the full ramifications of that designation would mean because we really don't at this moment. So we'd like to actually answer that for the record.

However, I will say that our current collection of production and consumption information, that is done voluntarily and has been done for many years. Through that process we've generated a tremendous amount of trust with the industry and in the production, those who produce and provide materials in the minerals industry. We are, by law, required should the supplier have the information request to keep this information proprietary and so this is OMB guidance and OMB regulations.

So far it's worked very well. We've had very good response using the voluntary method. Again this is through many, many years of doing this and generating a tremendous amount of trust with our partners out there.

Senator MURKOWSKI. So you'll communicate with us in terms of where you might come down one way or another on that? I'd appreciate that. OK.

Let me ask about the Federal, State and local regulatory programs that I mentioned. I think there were 30, no less than 30 different regulatory programs that mining operations are subject to. In looking at the legislation that I've put forward can you tell us whether or not it amends, weakens or in any way modifies any existing, environmental regulatory program?

Ms. Burke.

Ms. BURKE. When we reviewed the bill we did not look at that specific question. But on its face it does not appear to amend any of those laws or regulations.

Senator MURKOWSKI. OK. Good. Thank you.

Thank you, Madame Chair.

Senator CANTWELL. Thank you.

Senator Bingaman.

The CHAIRMAN. Thank you very much. Thanks for chairing the hearing. Let me ask, Mr. Sandalow, I happened to be in Japan last fall when the problem arose with the Chinese cutting off access to rare Earth shipments to the Japanese. Now they claim they didn't do that. But the Japanese think they did.

I was visiting with the Japanese Minister of Economy, Trade and Industry. It was his strong opinion and I shared his opinion that there had been an effort by China to systematically undersell other producers in the world and thereby to drive a bunch of people out of business. Therefore, the Chinese remained the sole remaining source for these rare earth elements.

That was the problem. We needed to find a way to cause the production of these elements to occur again in the United States, as they had in the past, and this—I saw you visited this mine in California. They're gearing up now, I think, because the price of these elements has gone up again. They find it profitable to go back into the business in a more serious way as I understand it.

So, sort of starting from the general proposition that unless we diagnose the problem correctly, we're not likely to fix it. I don't really believe, based on what I've seen that the problem, the core problem here is the permitting process. I think my colleague Senator Murkowski referred to bureaucratic intransigence as the reason why we do not have a production of these rare earth elements.

I don't doubt that there's bureaucratic intransigence. It is everywhere I've ever seen, acknowledge that.

But the main problem here is it hasn't been profitable for U.S. farms to produce these minerals. We have the minerals. We have the rare Earth elements. It hasn't been profitable.

So what we need to do is to find a way to not only—it's now profitable again because the prices are up. But to ensure that there's going to be a reasonable price for these minerals going forward in the world market. I guess my other concern, I'll just add this before I finish my soliloquy here is I'm told that the Chinese have now shifted to a deal where they're consolidating their production of rare Earth elements in a single company. That to me is a little bit concerning as well in that it makes it a lot easier to ensure that the supply and the price is what you in fact want it to be for purposes of the world market.

So what's your reaction to all of this? I'm just wondering if we charge off here and change the permitting process and do all these things. The price of these elements may still drop through the floor here one of these months. Everyone in the U.S. who is in this business will shut down in a hurry. They will in my State.

Mr. SANDALOW. Thank you, Senator, for those very thoughtful comments. I would respond as follows. I think your comments highlight the problem whenever any resource is produced at levels of 90 percent or more from one country. That is going to be a problem when there's a global supply chain for those minerals.

So it is essential that we find a way to globalize the supply chain, including domestic production right here in the United States. As part of that strategy essential that we also find substitutes and that we find ways to minimize the use. That we do so, as your question suggests, on an economically sustainable basis.

That's going to take government and industry working together in partnership. I think it's something that, I know it's something that we can achieve if we work together and do it right.

The CHAIRMAN. Has the Administration considered the possibility? I mean, we have a buy America provisions at the Department of Defense operates under where we would give some preference to products that incorporate rare Earth elements that are produced in this country to the extent that they're available. Going forward, is there any thought of doing something to that effect?

Mr. SANDALOW. That's not been part of discussions that I'm aware of, Senator, but certainly something that we could look at.

The CHAIRMAN. Thank you very much.

Senator CANTWELL. Next is Senator Heller.

Senator HELLER. Thank you, Madame Chairwoman.

I've actually come here for the next panel, but I'm very interested in the discussion that we've had in the last few minutes. So it has produced some questions in my own mind. So I appreciate you giving me a few minutes.

One of the—you brought up the issue of mining reforms and perhaps changing the royalty formulas on some of the hard rock minerals that we mine in this country. I don't know a lot about the history here in the Senate. But I can tell you somewhat of the history in the House and why some of those reforms were difficult to pass was because usually most of the products that came out of the House probably did more to discourage mining production that it did encourage mining production.

So I guess my only point or argument is I'd certainly like to be part of that discussion as you move forward. Because I think we can come to an agreement with something that does in fact encourage mining production as opposed to something that may be too onerous for the industry to go forward. So anyway thanks for your comments. I'd certainly like to be involved to what extent maybe.

I want to also follow up on what Senator Bingaman was saying talking about the permitting process. That is an issue of contention in my State. Exploration is one thing. The many years it takes, obviously, to explore claims and to put it to a point of production. But at that point, that process for permitting may take 7 to 10 years.

When I talk about mining production in Nevada, our State has very high unemployment. Those counties that have high mining production, the unemployment in those counties are half what it is in the rest of the State. So mining works very well and plays well in our State.

So the question that I have is with all the time it takes to do the exploration, all the time it takes for the permitting process and in this case, generally 7 to 10 years. I guess my question for Ms. Burke would be given your knowledge of the importance of developing these resources how do you propose, how would you propose to improve this permitting process, particularly while we wait for current legislation efforts to become law?

Ms. BURKE. Thank you for the question, Senator. Before I launch, headlong, into our proposals for how we might improve the process. I just wanted to clarify that the 7 to 10 years is the time it takes from discovery to go into production. The BLM's permitting process on average for a large mine takes 4 years.

So there are obviously other permits from State and local officials, that sort of thing, that can add additional time. But the BLM's permitting process, on average, takes 4 years.

Just last week or 2 weeks ago, our Director, Bob Abbey, was in your great State of Nevada.

Senator HELLER. He's from Nevada.

Ms. BURKE. Meeting with the Governor and industry and others to discuss this very, very issue. As you may be aware, our office in Nevada is sort of, a pilot if you will, having put in place some efforts to try to streamline or facilitate the more efficient processing of permits. While it is still very early on in this, sort of, new process to tell, I believe that folks are optimistic that the sorts of things that Nevada is trying to do will in fact garner the types of results that we're all seeking.

Senator HELLER. OK. I appreciate your comments. Because I share with the Governor and have had this discussion with both Mr. Abbey and the Governor, obviously, on this process and the impact that it has on the State of Nevada.

So anyway, I thank you for your comments and look forward to working with you down the road as we try to iron out some of these issues.

Thank you, Madame Chairwoman.

Senator CANTWELL. Thank you, Senator Heller.

Senator Franken.

Senator FRANKEN. Thank you, Madame Chair.

This is for anyone. Many electronics have rare Earth elements and other critical materials in them. Senator Bingaman was talking about the Japanese. They have taken up something called urban mining, which means they take old electronics and they reuse or recycle the critical elements that they contain.

Best Buy which is headquartered in my great State of Minnesota, Ms. Burke, has an electronic recycling program where they recycle many kinds of electronics that people bring in for free. Is this something that we can promote? I know that costs are high to recycle, to make widespread recycling of critical materials feasible. But can we somehow reduce the price?

Also if you don't recycle these materials very often they end up being very toxic. So I was wondering what role reprocessing of electronics could play in making sure that we have these rare Earth elements and recycle them and other critical materials?

Mr. SANDALOW. Thank you for the question, Senator. It's an important one. The answer is yes, this is an area that we must look into and that we are looking into.

There are tremendous opportunities with respect to the recycling of rare Earth metals. I think you're going to hear some more about that on the next panel from some of the leaders in this area.

Senator FRANKEN. OK.

Mr. SANDALOW. One of the challenges has been that these rare Earth metals in particular are often found in very trace amounts in the products in which they are located. So separating them and then reusing them can be a challenge for that reason. But that underscores, I think, the opportunity in doing research into new designs that might facilitate the removal of these at the end of the product's life.

That's an area of great interest at the Department of Energy. I think it's one that some of the companies you're going to hear from are working on as well.

Senator FRANKEN. Now very often these old things, these old electronics are exported and end up in, you know, in countries that where they end up being toxic to the environment. I think that's something that we need to try to avoid.

On the permitting process, I do want to make—understand this distinction because I kept hearing this 7 to 10 year thing. Senator

Heller was—it sounded like he was saying that once the exploration has been done then it takes 7 to t10. We have a mine, a potential mine up in Northern Minnesota that has some of these rare metals.

What's slowed it down is they did an environmental impact study and it didn't quite cut mustard. But they're doing it again. I'm confident that eventually they will be able to figure out how to do this mining without harming the water table.

But, I mean, which is it? Is it 7 to 10? Is it—what—run it down for me? Give me some kind of idea of what is a typical process.

Ms. BURKE. The 4 years that I was speaking of is from the time that an operator files a plan of operation or an application with the BLM to the point that we reach a final decision about whether or not the mining operation can go forward and under what conditions.

Senator FRANKEN. But you couldn't permit it before that anyway, I mean, right?

Ms. BURKE. Before the discovery and exploratory work? That's correct.

Senator FRANKEN. OK. So what is the 7 to 10, exactly?

Ms. BURKE. That is taking into account the discovery and exploration and even beyond the time that is necessary for the BLM to process the application.

Senator FRANKEN. But the plan of operation—what is it? It's 4 years from when?

Ms. BURKE. From when the industry files the plan of operation which is in essence an application with the BLM.

Senator FRANKEN. OK. So I don't see how anything could be permitted before there is a plan of operation.

Ms. BURKE. That's correct.

Senator FRANKEN. OK. So then why is this number for the permitting process 7 to 9 years? I mean, wouldn't it be 4 years?

I mean, in other words, I don't want to argue over semantics. But it seems to be misleading to say it's 7 to 10 years if, you know, the permitting process is what I would call the permitting process in which you process the permit. Right?

So that would only happen once someone asked for a permit.

Ms. BURKE. That is correct.

Senator FRANKEN. OK. I just want to make that clear. Thank you, Madame Chair.

Senator CANTWELL. Thank you.

Senator Barrasso.

Senator BARRASSO. Thank you very much, Madame Chairman. Very clear. I appreciate it.

[Laughter.]

Senator FRANKEN. Good.

Senator BARRASSO. They call that 7 to 9 years the Al Franken decade.

[Laughter.]

Senator BARRASSO. The—I want to thank Senator Murkowski for her continued leadership on this critical mineral issue. It's—I'm an original co-sponsor of her Critical Minerals Policy Act 2011. It's an important piece of legislation to reduce U.S. dependence on foreign sources of critical minerals.

You know, in Wyoming we have a company that is looking to open a rare Earth mine. It's an exciting project. It could help address some of the rare Earth supply chain issues. But they have a long way to go before it becomes a reality.

China now controls an estimated 97 percent of the global production of rare Earth elements. China's critical minerals strategy is clear. It wants to give itself a competitive advantage in manufacturing and in other industries. Rare Earth elements are an essential part of wind turbines, solar panels and with control of a key aspect of the supply chain, China then has a clear advantage in manufacturing wind turbines and solar panels.

Last year the Department announced a plan for speeding the permitting for solar projects on public lands to so called solar zones and also announced a process to streamline the permitting for wind projects. It highlights a problem that exists across the board. Permitting any kind of project in this country is a major challenge.

Burdensome regulations, cumbersome bureaucracy stand in the way of American energy and mining. The Murkowski bill includes an examination of the inefficiencies in the permitting process and provisions to help Federal and State coordination. These provisions are important because permitting can be a major hurdle, especially when Federal land is involved. So more needs to be done to address this.

So my question, Mr. Sandalow is in your testimony you mention recycling and alternative sources of material as ways to address shortages in rare Earths and the negative impact on solar and wind energy of those concerns. You specifically referenced coal ash as a potential source of material. The EPA, you know, is currently considering regulating coal ash as a hazardous waste which will hurt the beneficial reuse of coal ash.

So the market for beneficial reuse of coal ash is already cratered because of uncertainty over the threat from the EPA of these additional regulations. So we have an Administration that's promoting a strategy to use coal ash to meet our critical mineral needs. But at the same time, the Administration through the EPA is considering regulations that will serve as a major impediment to what is to here, today, the Administration's strategy. I've, you know, memos from the Department of Energy and all that I know you're familiar with.

So if EPA regulating coal ash is a hazardous waste that's going to undercut the DOE strategy for promoting critical minerals. What's going on now between the Department of Energy, EPA? They're submitting comments regarding coal ash regulations and the potential impact on our critical mineral strategy.

Mr. SANDALOW. Thanks for the question, Senator. I believe we can and we must find ways to accomplish both the goals that are identified in your question. That is, addressing the environmental implications of the disposal of coal ash and finding ways to beneficially reuse that product for American industry. We can do that.

Working together between the EPA and DOE then as well between government and industry, we can find ways to achieve both those goals.

Senator BARRASSO. So have you been communicating specifically with the EPA or where are we along the process? Could you kind of just outline that a little bit for the Committee?

Mr. SANDALOW. That I would have to take back for the record, Senator. DOE and EPA are always talking about these and other issues on a regular basis. But——

Senator BARRASSO. But things are actually ongoing with this?

Mr. SANDALOW. Yes.

Senator BARRASSO. Sometimes we've had different people from different—oh, yes, we're working on it. Then you say, well what are you doing? Find out it's not going as well as we would like.

Mr. SANDALOW. I'm not personally familiar with the details of those conversations, Senator. But I'd be happy to take that for the record and let you know.

Senator BARRASSO. Alright. I'd really like to hear back because I think it's an important issue and it's going to have a major impact on this. Thank you.

We are engaging in relevant policy and technical discussions with EPA and other interagency partners to identify and pursue opportunities to beneficially reclaim rare earths while simultaneously addressing any environmental implications with regards to coal ash. It should be noted that research is still at the early stages for extraction of rare earth elements (REE) from coal ash. If this source of rare earth elements turns out to be economically and technically viable, we would be interested in innovative approaches that both utilize the resource and protect human health and the environment. One approach would be to extract REE's and other materials as part of a treatment process, where treatment changes the physical, chemical, or biological character of a waste to make it less of an environmental threat.

Senator BARRASSO. Thank you, Madame Chairman.

Senator CANTWELL. Thank you. I'd like to move on to the second panel. I know Senator Murkowski had a quick question she wanted to ask one of the witnesses before we did that.

Senator Murkowski.

Senator MURKOWSKI. I thank you, Madame Chair. I will attempt to be brief. We're talking about critical minerals. Of course the question is is how are we defining critical?

Mr. Sandalow, I had to go back to your written testimony because you had stated that within the critical minerals strategy, the report that was released, you say for this purpose criticality was a measure that combined importance to the clean energy economy and the risk of supply disruption. In my bill, we do include—we include the component about risk to supply and the disruption. But also not just importance to the clean energy economy but also defense, health care related applications.

I'm assuming you don't disagree that that should also not be what we look at when we define what is critical?

Mr. SANDALOW. Yes. Our report coming out of the Department of Energy was focused in particular on energy related applications. I think more broadly speaking the term criticality would refer to a broader set of issues.

Senator MURKOWSKI. OK. I just wanted to check.

Thank you, Madame Chair.

Senator CANTWELL. Thank you. Again, thank you to the witnesses for your involvement and testimony on this issue. I'm sure we'll work with you as we continue to move forward on legislation.

We're going to go to the second, or actually third panel, technically, and have them come up and join us at the Dias.

That is, Dr. Jonathan G. Price, State Geologist and Director from the Nevada Bureau of Mines and Geology.

Mr. Luka Erceg, President and CEO of Simbol Materials in Pleasanton, California.

Dr. Steve Duclos, who is Chief Scientist at GE Global Research.

Mr. Mark Caffarey, who is with—who is Executive Vice President of Umicore in Raleigh, North Carolina.

I know Senator Heller you have a connection here. Did you want a few comments of further introduction of Mr.—of Dr. Price?

Senator HELLER. If I may, please.

Senator CANTWELL. Yes, go right ahead.

Senator HELLER. Thank you, Madame Chairman.

It is my pleasure to welcome Dr. Jonathan Price to the Energy and Natural Resources Committee, Subcommittee on Energy, to discuss the minerals bill before us today. Dr. Price is Nevada's State Geologist and Director of the Nevada Bureau of Mines and Geology, which is Nevada's research, public information and geological survey unit housed out of the University of Nevada, Reno. He's also a tenured professor at the Mackay School of Earth Sciences in Engineering, one of the premier mining schools in the nation.

Mining is an integral—is integral to Nevada's history. We have a proud tradition of leading the Nation on mining and minerals research. Mining provides more than 60,000 direct and indirect jobs in Nevada, is responsible for over $204 million in tax revenue and contributes $9.5 billion in economic activities in 2009. Nevada currently has the highest unemployment rate in the country. However, in the areas of my State that rely on mining, such as the Elko area, the unemployment rate is nearly half the State's average because of the economic activities associated with mining.

Not only is mining the backbone of Nevada's rural economy, without mining we couldn't even produce the products we consume every day nor could we get them to market. From microwaves to medical devices to smart phones and the trucks that deliver goods to market, none of it would be possible without mining. Traditional and emerging industries, our national defense systems and national security requires elements and minerals that would not be available without mining.

Mining is critical to our economy and national defense. Our country should have a policy that promotes mining rather than discourages it. I am so pleased that Dr. Price is here to share his perspective with us. His vast achievements, research, honors, awards and publications speak for themselves and I know we're all eager to benefit from his expertise on the subject matter before us.

Again, Chairman Cantwell, thank you for having Dr. Price here with us today.

Senator CANTWELL. Thank you, Senator Heller. With that introduction, Dr. Price, we're going to let you go first and then we'll here from the rest of the witnesses.

Thank you all for being here this afternoon.

Dr. Price.

STATEMENT OF JONATHAN G. PRICE, STATE GEOLOGIST AND DIRECTOR, NEVADA BUREAU OF MINES AND GEOLOGY, RENO, NV

Mr. PRICE. Thank you. My name is John Price. I'm testifying today from my perspective as Nevada State Geologist and as Co-Chair of a 2011 study on energy critical elements by the American Physical Society and the Materials Research Society. A copy of this study is appended to my written testimony. By the way, there's a paragraph in there that addresses this issue that was discussed earlier about the timing for exploration verses development.

Thank you for this opportunity to comment on the importance of your work in addressing the national issues regarding critical minerals. Graphs at the end of my written testimony provide some context for the issues.

Firstly, global demand for nearly every mineral and energy commodity is rising in part because global population is rising and in part because average standard of living is also rising.

Second, China's dominance in the minerals arena presents challenges, threats and opportunities. The world isn't running out of mineral resources. Long term demand will likely be met by supplies from a global free market. The resources are, however, unevenly distributed geologically and geographically such that short term supplies of raw materials and value added manufactured products can be interrupted leading to price increases that can be significant concerns for the U.S. economy.

Energy critical elements or ECEs as we call them in the report, are a class of chemical elements that are 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. The report identifies 3 primary areas of potential actions by the United States to ensure the availability of ECEs.

One, information collection, analysis and dissemination.

Two, research development and work force enhancement.

Three, recycling.

Recognizing that the Department of Defense is responding to the 2008 National Academy of Science's report on managing materials for a 21st century military, the ECE report did not address defense stockpile issues. Did not recommend stockpiles for purely economic reasons. The bills currently pending in the Senate do an excellent job of addressing many of the recommendations made in the ECE report.

The following changes could make the legislation even more effective. Two of the bills have sections covering information collection, analysis and dissemination. The ECE report, as well as the 2008 National Academy of Science's report on critical minerals recommended that the USGS be given more authority and elevate it to a principle statistical agency as is the Energy Information Administration.

All the bills establish R and D programs. However the ECE report recommended a somewhat broader research spectrum. In our view the Federal Government should establish an R and D effort focused on ECE's and possible substitutes that can enhance vital aspects of the supply chain including geologic deposit modeling, mineral extraction and processing, material characterization and substitution, utilization, manufacturing, recycling and life cycle analysis.

The ECE report made an additional recommendation regarding recycling. Steps should be taken to approve rates of post consumer collection of industrial and consumer products containing ECEs beginning with an examination of the numerous methods explored and implemented in various States and countries.

Allow me to conclude with some personal comments. The State Geological Surveys have critical mineral data, geological samples available for research and expertise that are not easily accessible to the USGS. For example, New Mexico has data on rare Earth elements tellurium and beryllium and Alaska makes its new information about domestic mineral resources readily available for follow up by industry.

In Nevada currently the U.S.'s only lithium producer, our State Geological Survey houses considerable information on the geological framework for lithium deposits. It would be appropriate for the bill that deals with permitting issues to specifically identify State regulators as stakeholders within the Federal critical minerals working group should consult. In many States, including Nevada, State and Federal regulators try to work together to speed up the process but the slowness of permitting, particularly on federally managed lands continues to be a major deterrent to domestic exploration and production.

Finally, I believe that authorization levels are too low for the tasks assigned. Given the number of chemical elements that are likely to be considered critical, the USGS's Mineral Resources Program would need at least twice the amount of funding allocated. In addition, the funding for R and D seems low by a factor of 5. These issues could be addressed by reprogram or resources within the USGS and DOE.

Thank you.

[The prepared statement of Mr. Price follows:]

PREPARED STATEMENT OF JONATHAN G. PRICE, STATE GEOLOGIST AND DIRECTOR, NEVADA BUREAU OF MINES AND GEOLOGY, RENO, NV

My name is Jonathan G. Price. I am the Nevada State Geologist and Director of the Nevada Bureau of Mines and Geology, which is the state geological survey and a research and public service unit of the Nevada System of Higher Education at the University of Nevada, Reno. I am testifying today from my perspectives as State Geologist and as the Co-Chair of a 2011 study on Energy Critical Elements: Securing Materials for Emerging Technologies by the American Physical Society's Panel on Public Affairs and the Materials Research Society. A copy of this study is appended to my testimony.

Thank you for this opportunity to comment on the issues of critical minerals and the three bills that you are considering.

Four graphs at the end of this testimony provide some context for the issues. Global demand for nearly every mineral and energy commodity is rising, in part because global population is rising and in part because average standard of living is also rising. Neither copper nor iron are considered critical minerals in most discussions today, because their resources are widely distributed geographically, and markets for them are well established, but they help provide context on the rising demand for the minerals that are considered critical or strategic. The continuing historical rise in demand for copper, an example of a mineral commodity needed for modern society, is documented in Figure 1.* To meet global demand, the world needs to mine the equivalent of one huge copper deposit each year and find a new one to replace the depleted reserves. Although conservation and recycling can lessen the demand for newly mined copper, the increases in both global population and average standard of living require more mining.

Domestic resources for most, but not all, mineral commodities occur in the United States, where they are mined using the world's best practices for environmental stewardship and health and safety for workers and the public. The Federal government (specifically through the U.S. Geological Survey in the Department of Interior for most mineral resources and through the Department of Energy for some of the energy resources) has a vital role in documenting domestic production and reserves and in assessing the likelihood of future discoveries that will add to the mineral and energy resources of our country.

Global iron-ore production and, by that measure, the rise of China as a major economic power, is shown in Figure 2. The dominance of China as a producer of mineral and energy commodities today is illustrated in Figures 3* and 4*. These graphs use critical data collected and reported by the USGS. China's dominance in the minerals arena presents challenges, threats, and opportunities for the United States.

The world isn't running out of mineral resources; long-term demand will likely be met by supplies from a global free market. The resources are, however, unevenly distributed geologically and geographically, such that short-term supplies of raw materials and value-added manufactured products can be and have been interrupted, leading to price increases that can be significant concerns for the U.S. economy and the economies of other, less mineral-rich countries.

The report on Energy Critical Elements: Securing Materials for Emerging Technologies (the ECE report) surveys potential constraints on the availability of these elements. Energy-critical elements (ECEs) are 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. The report addresses elements that have not been widely extracted, traded, or utilized in the past, and are therefore not the focus of well-established and relatively stable markets. The report discusses a number of constraints on the availability of ECEs for the U.S. and world markets:

(a) Crustal abundance, concentration, and distribution. Whereas exploration benefits from well-tested geological models of ore deposits for the more common metals, such understanding is lacking for many of the less common elements.

(b) Geopolitical risk. The production of some ECEs is dominated by one or a few countries.

(c) Risk of joint production. Tellurium and selenium are good examples of ECEs that are produced as byproducts of a more common metal—copper. There is little incentive to increase the production of these byproduct metals, as long as their prices remain low relative to their abundances.

(d) Environmental and social concerns. As countries that now have lax environmental, safety, health, and social impact standards embrace higher standards, the price and availability of ECEs may be significantly affected.

(e) Response times in production and utilization. The time period from exploration to production is commonly 5 to 15 years or longer, and there are similarly long timeframes, sometimes decades, for bringing a new technology, such as a new choice of elements for photovoltaics, to market.

The report identifies five specific areas of potential action by the United States to insure the availability of ECEs:

(1) Federal agency coordination;
(2) information collection, analysis, and dissemination;
(3) research, development, and workforce enhancement;
(4) efficient use of materials; and
(5) market interventions.

Recognizing that the Department of Defense is responding to the 2008 National Academy of Sciences report on Managing Materials for a Twenty-first Century Military, the ECE report did not address military/defense stockpile issues, and apart

*Figures 1–4 have been retained in subcommittee files.

from helium, which has special physical and geological properties, did not recommend stockpiles of ECEs for purely economic reasons.

The bills currently pending in the Senate—S. 383, S.421, and S.1113—do an excellent job of addressing many of the recommendations made in the ECE report, but some changes, following recommendations in the ECE report, could make the legislation even more effective. Specifically:

(1) S.383 and S.1113 have sections covering information collection, analysis, and dissemination. The ECE report, as well as a 2008 National Academy of Sciences report on Minerals, Critical Minerals, and the U.S. Economy, recommended that the USGS (or whatever agency is given the primary responsibility for mineral-resource data collection and analysis) be given more authority and elevated to a "Principal Statistical Agency," as is the Energy Information Administration in the Department of Energy. This designation could be added to S.1113 (Sec. 103-Resource Assessment or Sec. 107-Analysis and Forecasting) or S.383 (Sec. 3).

(2) All the bills establish research and development programs, and S.383 and S.1113 address workforce issues. However, the ECE report recommended a somewhat broader research spectrum than the bills that have been introduced. In our view,

> the Federal government should establish an R&D effort focused on ECEs and possible substitutes that can enhance vital aspects of the supply chain, including geological deposit modeling, mineral extraction and processing, material characterization and substitution, utilization, manufacturing, recycling, and life-cycle analysis.

(3) S.383 and S.1113 include sections dealing with research on efficient use of materials (recycling, substitutions, etc.). The ECE report included an additional recommendation regarding recycling:

> Steps should be taken to improve rates of postconsumer collection of industrial and consumer products containing ECEs, beginning with an examination of the numerous methods explored and implemented in various states and countries."

S.1113 appropriately recognizes the value of having the USGS and DOE work with State geological surveys on resource assessments (Sec. 103). The State geological surveys often have critical-mineral data, geological samples available for research, and expertise that are not easily accessible to the USGS. For example, Peter Scholle, the New Mexico State Geologist, and Virginia McLemore, economic geologist on their staff, informed me about New Mexico's data on rare earth elements, tellurium, beryllium, and other resources, and Robert Swenson, the Alaska State Geologist, noted that their efforts have made new information about Alaskan resources, including platinum-group elements, readily available for follow-up by industry. In Nevada, currently the U.S.'s only lithium producer, our State geological survey houses considerable information on the geologic framework for lithium deposits. At the University of Nevada's Mackay School of Earth Sciences and Engineering, in a joint project with the USGS, we are using samples from the Mackay-Stanford Ore Deposits Collection to begin to understand the distribution of tellurium and selenium in both domestic and international copper deposits. The coastal Atlantic States, from Florida to Maine, have data on offshore and near-shore resources of heavy mineral sands, which need to be included as long-term resources for rare earth elements, titanium, zirconium, and other potentially critical minerals.

It would be appropriate for Section 104 of S.1113, which deals with permitting issues, to specifically identify State regulators as stakeholders with whom the Federal Critical Minerals Working Group should consult. In many states, including Nevada, State and Federal regulators try to work together to speed up the permitting process, but the slowness of permitting, particularly on Federally managed lands, continues to be a major deterrent for domestic exploration and production.

Section 102 (Policy) of S.1113 encourages "Federal agencies to facilitate the availability, development, and environmentally responsible production of domestic resources to meet national critical minerals needs." This wording is consistent with the June 2011 statement by the Society for Mining, Metallurgy, and Exploration concerning rare earth elements:

> It is critical to establish a domestic rare earths minerals production industry to help secure the Nation's clean energy future, reduce the U.S. vulnerability to material shortages related to national defense, and to maintain our global technical and economic competitiveness. Given that the Chinese dominance of the rare earths market has adversely impacted supply stability and endangers the United States and its allies' assured access to

> key materials, rare earths should qualify as materials either strategic or critical to national security. Further, the U.S. government should facilitate the reintroduction of a globally competitive rare earth industry in the U.S.

It is important to emphasize the globally competitive phrase, because the U.S. industries must be economically viable in the global economy. For some mineral commodities, the U.S. may not have sufficient resources that are of high enough grade or large enough to be competitive in today's market. S.383 (Sec. 3) and S.1113 (Sec. 107 and 109) emphasize analyzing U.S. known and undiscovered, potential supplies in context with global supplies. The policy section (Sec. 6) of S.383 appropriately uses the term economically sound in its emphasis on domestic supplies: "promote and encourage private enterprise in the development of economically sound and stable domestic critical minerals and materials supply chains."

Section 303 (Authorization of Appropriations) of S.1113 authorizes levels that are, in my opinion, too low for the tasks assigned in Sections 103 (Resource Assessment), 106 (R&D), and 107 (Analysis and Forecasting). Sections 103 and 107 fall within the charge of the USGS's Mineral Resources Program. Given the number of chemical elements that are likely to be considered critical, including those identified in the ECE report, the USGS's Mineral Resources Program would probably need at least twice the amount of funding allocated for Section 103 ($40 million rather than $20 million). In addition, the funding for R&D seems low by a factor of five ($7.5 million per year rather than $1.5 million per year for the five-year period). These issues could be addressed by reprogramming resources within the USGS and DOE.

Thank you, again, for this opportunity to comment on the importance of your work in addressing the national issues regarding critical minerals.

Senator CANTWELL. Thank you, Dr. Price, for your testimony and for being specific about each of the pieces of legislation before us. We'll get a chance to ask you questions in a few minutes.

Mr. Erceg, thank you.

STATEMENT OF LUKA ERCEG, PRESIDENT AND CEO, SIMBOL MATERIALS, PLEASANTON, CA

Mr. ERCEG. Yes, Senator.

Senator CANTWELL. OK. Thank you very much for being here. Go ahead with your testimony.

Mr. ERCEG. Good afternoon. My name is Luka Erceg. I am President and CEO of Simbol Materials. I'd like to thank you for the opportunity to testify today regarding the important legislation before this committee. Simbol supports these 3 bills and we believe that they will drive innovation, job creation and American competitiveness in the global economy.

Simbol is today commercializing an innovative and sustainable process to produce lithium, manganese and zinc domestically and currently operates a demonstration plant co-producing these critical materials from the affluent brines of geothermal power plants. We're currently permitting our first commercial facility and when complete we will be the only U.S. producer of manganese and electrolytic manganese metal, also known as EMM.

Second, we will double the U.S. lithium production by the end of 2012.

We firmly believe the U.S. Government can drive investment by establishing a clear definition for critical minerals and materials. We believe that lithium and manganese should be considered critical due to the lack of U.S. based production.

Lithium is critical because it is an essential component in advanced batteries for electric vehicles and other energy storage applications. The U.S. imports upwards of 80 percent of its current needs.

Manganese is critical because the EMM compound is essential for producing specialty steels for defense applications and the manganese dioxide compound is a key metal also used in electric vehicle batteries. However the U.S. is 100 percent reliant on foreign sources of manganese ore. 95 percent of the world's EMM today is produced in China. None is produced in the United States. Despite this reliance only the Defense Logistics Agency is classified manganese or EMM as critical materials.

Now these are not criticisms of any agency. Rather, they demonstrate the need for clarity in the definition of critical materials across the U.S. Government. We're concerned that the current legislative proposals may result in a rear view mirror effect through the study and review provisions. As such we would ask the Committee to consider a self classifying definition that's based upon first, the use of specific materials in industries that support strategic or policy priorities and secondarily, the level of U.S. production and processing. These self classifying definitions would provide real time signals to markets and to industry prompting investments. Agencies could still focus on materials of interest to them without government picking winners or losers.

Now Federal support for R and D is a powerful driver for private investment into critical materials production. We firmly support R and D and deployment activities in the proposed legislation as it will jump start a supply chain for domestic material production. Now Federal R and D support to de-risk new technologies when it's coupled with commercial sector investments, sends inordinately large market signals that encourage follow on investing in areas of policy interest. These signals will lead to job creation.

I'd like to give you an example that in 2009, the Department of Energy's Geothermal Technologies Program announced a $3 million grant to Simbol to demonstrate our processes. Following the grant announcement Simbol raised a further $43 million in capital, prior to even receiving the first Federal grant dollar. The government's validation of Simbol sent a clear signal to the market that stimulated commercial investments 12 times the grant itself.

With this support we grew our work force from 16 to 40. We will reach 60 by year end and we'll continue further job creation through construction and operations of our facilities in the near future. These R and D opportunities create opportunities for universities to train the next generation of scientists and engineers. Critical, because it is inordinately difficult to hire individuals with experience in critical minerals and materials processing. It is taking us upwards of 9 months to find qualified candidates for key positions. The lack of a domestic supply chain has resulted in the erosion of our talent pool.

Financing also remains a great barrier to commercialization of production of processing facilities. The lack of a Federal strategy for the development of material supply chains clouds the importance of critical materials creating reluctance in the part of investors. Financing new commercial facilities is difficult for producers such as ours because it is unlikely that we will secure off take agreements to reduce financing risk. Investors and lenders require market visibility for our products, but many of the end use markets that we would sell into are still nascent in the United States such as electric vehicles and other clean energy initiatives.

Existing commercialization programs such as section 1703 Loan Guarantee or the section 48C Advanced Manufacturing Tax Credit did not help as neither contemplated the production of critical materials as components for clean energy technologies. We would ask that this committee consider strengthening the legislative proposals to expand eligibility for component material production under existing commercialization programs.

With that, thank you very much for the opportunity to testify here today.

[The prepared statement of Mr. Erceg follows:]

PREPARED STATEMENT OF LUKA ERCEG, PRESIDENT AND CEO, SIMBOL MATERIALS, PLEASANTON, CA

ON S.383, S.421, AND S.1113

Good afternoon. My name is Luka Erceg, and I am the President and CEO of Simbol Materials. Thank you for the opportunity to speak with you today regarding the important legislation under consideration by this Committee. Simbol supports these three bills, which will drive innovation, support job creation, and advance America's competitiveness in the global clean energy economy.

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 reinjected into the ground. This process has a smaller environmental footprint and cost profile than any other method for producing these materials.

We are currently in the permitting process for the construction of a full-scale production and processing facility. Upon completion, we will be the only U.S. producer of manganese and electrolytic manganese metal. We also expect to double U.S. production of lithium by 2012.

The U.S. government can drive investment by establishing a clear definition for "critical" minerals and materials.

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 (DOE) 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. Congress three years ago passed anti-dumping legislation penalizing Chinese and Australian Mn producers. Despite this, Mn was not included in the DOE's 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 of any agency, but rather as a demonstration of the need for clarity across the U.S. government in defining what makes a material "critical."

The current legislative proposals delegate the activity of defining a set of critical materials to specific federal agencies, with an opportunity for review and updating. We are concerned that this structure will force the government to evaluate a globally competitive market through the rearview mirror. Any assessment that follows this structure will reflect market conditions as they existed several years ago, rather than market conditions today. Instead, a self-classifying definition, which could be based on 1) use of specific materials in industries that support strategic or policy priorities (e.g. advanced batteries, wind turbines and specialty steels) and 2) the level of U.S. production and processing, would provide real-time signals to industry. 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 self-classifying definition would allow market participants to quickly determine policy-makers' priorities without waiting potentially years for agency review and update. 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.

Federal support for research and development (R&D) is a powerful driver of private investment in critical materials.

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

The establishment of a new industry is inherently risky, and it requires a concerted effort by both the public and private sectors. We believe that federal support for basic research remains essential to advancing our country's competitive 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. In addition, the DOE and other 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 firms in de-risking new technologies, when coupled with commercial sector investments, send loud signals to the market that encourage follow-on investing in areas of policy interest. In the critical materials arena, these federal R&D commitments are powerful drivers of private investment, and they support the development of a competitive domestic supply chain for electric vehicles and materials for defense applications.

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 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 40, and we will reach 60 by year-end. We also have leveraged those federal funds to raise approximately $43 million in further capital—the majority of which was committed prior to the actual delivery of the first grant dollar, strongly demonstrating the investment signal provided by the government's technology validation.

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

While basic R&D support is essential to restoring U.S. leadership in mineral production technology, the most significant role for the federal government is in helping overcome commercialization risk. This Committee has heard a series of testimony in recent weeks and months regarding the challenges associated with financing first commercial facilities throughout the clean energy sector. This risk is arguably even more pronounced for mineral producers like Simbol, which are not able to secure offtake agreements to reduce financing 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.

The current legislative proposals would be strengthened by adding provisions to expand eligibility.

Building a domestic supply chain for critical materials will spur domestic manufacturing and innovation throughout the clean energy sector.

The development of a domestic supply chain for critical materials will reduce the risk of supply disruption and mitigate exposure to price spikes. (For example, Mn dependence has exposed DoD to price spikes of up to 350% over 2003 levels.) However, the greatest benefit of developing a domestic supply chain is bolstering our nation's competitive position throughout the entire clean energy sector.

At every point in the 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 8 PhDs and 3 MS degrees on staff (representing 25% of our current workforce), all with backgrounds in chemical engineering, electrochemistry and chemistry. Our scientists and engineers are consistently finding innovative ways to improve the quality of materials and to develop the next generation of products. This is the case throughout the entire critical materials industry, where highly skilled teams are consistently developing and improving materials—to the benefit of our nation's clean energy, defense, and industrial sectors.

Domestic innovation in critical materials also will drive workforce growth. 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 9 months to find qualified candidates for key positions at Simbol. 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.

Conclusion

The development of an industry for critical materials production and processing is essential to the growth of our domestic clean energy economy and our nation's energy security. I appreciate the Committee's attention to this important set of issues, and I look forward to your questions.

Senator CANTWELL. Thank you very much for your testimony.

Next is Dr. Duclos. Thank you very much for joining us this afternoon.

STATEMENT OF STEVEN J. DUCLOS, CHIEF SCIENTIST AND MANAGER, MATERIAL SUSTAINABILITY, GE GLOBAL RESEARCH, NISKAYUNA, NY

Mr. DUCLOS. Madame Chair Cantwell and Ranking Member Risch, and members of the committee, it's a privilege to share with you GE's thoughts on how we manage shortages of materials critical to our manufacturing and what steps the government can take to help industry minimize the risk associated with these shortages. This hearing addresses an issue that is critical to the future well being of U.S. manufacturing for large and small businesses alike. Without development of new supplies and focused research in materials and manufacturing such supply challenges could undermine efforts to meet the Nation's future needs in energy, health care and transportation.

I'll focus on my remarks today on GE's critical mineral and materials strategy and outline recommendations for how the government can strengthen its support of industry in this area. The materials in GE's products are comprised of 70 of the first 83 elements in the periodic table. Thousands of GE manufacturing jobs are associated with products incorporating rare Earth elements including energy efficient fluorescent lighting, permanent magnets in wind turbines, compressor motors for oil and gas, medical imaging equipment and encodings for aviation engines and electrical generating gas turbines. As Chief Scientist and Manager of Materials Sustainability of GE Global Research, it's my job to understand the latest trends in materials and to work with our businesses to manage our material needs in a sustainable way.

To evaluate risk associated with materials shortages GE uses a modification of the assessment tool developed by the National Research Council in 2008. Risks are quantified by element in 2 categories, price and supply risk and impact of restricted supply to GE. These elements—those elements deemed to have a high risk in both categories are identified as materials needing further study and a detailed plan to mitigate supply risks. For this analysis we use in house knowledge as well as data from the U.S. Geological Survey.

There is a broad spectrum of solutions that can be implemented to minimize the risk of those elements identified as being at high risk. Those include No. 1, improvements in the global supply chain including the development of alternate sources and mines and for manufacturer's long term agreements in development of strategic inventory of materials.

No. 2, improvements in material utilization in manufacturing and reduction of manufacturing waste.

No. 3, development of recycling technologies that extract at risk elements from both end of life products and manufacturing end loss. This includes the design of products that are more easily recycled and serviced.

No. 4, development of materials and systems technology that either greatly reduce the use of at risk elements or eliminates the need for the element all together.

Several examples of these are discussed in my written testimony where GE has successfully taken this approach. These include the replacement of helium with boron in neutron detectors. The reduction by a factor of 2 of the Rhenium content is super alloys for our jet engines, a development that leveraged past research programs supported by DARPA, the Air Force, Navy and NASA.

Finally No. 5, reassessment of the entire system. Often more than one technology can address a customer's need. Each will use a different subset of the Periodic Table. An example is the development of energy efficient LED lighting technologies as supported by the Department of Energy that offer a 70 times reduction in the use of rare Earth elements for lighting.

Attention needs to be played—paid to all of these mitigation strategies. The shorter term sourcing and manufacturing solutions are critical to bide time for the more optimal recycling and material substitution solutions that tend to be longer term, higher risk and require risk mitigation strategies involving parallel paths. The government can help by enabling public/private collaboration that provides both materials understanding and resources that enable these material substitution approaches.

Anticipated growth in the use of critical materials for efficient energy and transportation technologies mandates that we develop a comprehensive systems strategy in mitigating risk to our domestic manufacturing sector. Accordingly I advocate 3 aspects within Federal policy regarding critical minerals and materials.

First, enhance our Nation's ability to monitor, assess and coordinate a response to identify critical minerals and materials issues.

Second, support innovations in material substitutions and manufacturing. Collaborative and precompetitive efforts between academia, government laboratories and industry will help ensure that manufacturing compatible solutions are available to avert disruptions in U.S. manufacturing.

Third, adopt a comprehensive approach to developing mitigation strategies outlined in this testimony: new material sources, recycling technologies, manufacturing efficiencies, alternate materials and new systems solutions.

Madame Chair Cantwell and members of the committee, thank you. I look forward to answering your questions.

[The prepared statement of Mr. Duclos follows:]

PREPARED STATEMENT OF STEVEN J. DUCLOS, CHIEF SCIENTIST AND MANAGER, MATERIAL SUSTAINABILITY, GE GLOBAL RESEARCH, NISKAYUNA, NY

Introduction

Chairman Cantwell, ranking member Risch, and members of the Subcommittee, it is a privilege to share with you General Electric'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 associated with these shortages.

Background

GE is an advanced technology, services, and finance company taking on the world's toughest challenges. Operating in more than 100 countries with more than 300,000 employees, we are driving advanced technology and product solutions in key industries such as energy, water, transportation, aviation, and healthcare 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, GE uses rare earth minerals in the production of energy efficient fluorescent lighting, in permanent magnets for generators in our most advanced wind turbines, in compressor motors for our Oil and Gas business, in our medical imaging technologies, and in coatings for aircraft engines and power generation turbines.

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 materials needs in a sustainable way.

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. GE's strategy to address its materials needs could easily serve as a framework for how the Federal government can strengthen its support of academia, government, and industry in this area.

GE's Evaluation of Material Risks

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, and similar to an assessment recently completed by the Department of Energy to evaluate critical materials for energy technologies. In the GE analysis, 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. We continue to work with researchers at Yale University who are developing a more rigorous methodology for assessing the criticality of metals.

Minimization of Material Risks

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, including the support of new mines. Manufacturers can also develop 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 shortterm 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. An example of this is the development of near-net-shape manufacturing technologies that produce parts and products by maximizing material utilization.

Another solution is the recycling of end-of-life products and optimizing product design to enable such recycling. In addition, development of recycling technology for the re-use of manufacturing scrap can generate an important source of raw materials. Currently, commodity elements such as Aluminum and Copper are extensively recycled—extending this to critical materials can generate an important source of these raw materials.

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 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. GE recently completed construction of a facility in Twinsburg, Ohio to manufacture Boron-10 neutron detection modules for use in Radiation Portal Monitors and other neutron detection systems.

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 onehalf 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. 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 forecasting 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 components 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 technological approach can address a customer's need. Each of these approaches 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-seventieth 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 should 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. One such solution would be the development of permanent magnet materials that use significantly less rare earth. GE is currently working on novel magnet processing techniques using nano technology that could reduce rare earth concentrations in permanent magnets by up to 80% in a project supported by the Department of Energy's ARPA–E.

Recommendations

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 and reuse/recycling. 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) 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) Federal government support of materials, manufacturing, and systems research will be critical to laying the foundation upon which solutions are developed when risks to supplies of critical minerals and materials are identified. These complex problems will require collaborative involvement of academic and government laboratories with direct involvement of industry to ensure solutions are manufacturable. This includes educational and workforce development that will be critical to building industry's capability in these areas.

3) With global economic growth resulting in increased pressure on material stocks, along with increased complexity of the needed resolutions, it is imperative that comprehensive action be taken on the solutions discussed in this testimony: developing new materials sources, manufacturing efficiency, recycling technologies, development of alternate materials, and new systems solutions. This will require investment in long-term and precompetitive research and development—and the Federal government's support of these will be of increasing criticality as the demand for raw materials grows globally.

Comments on S.383, S.421, and S.1113

GE believes legislation on the critical materials issue needs to be comprehensive, and cover the source, manufacturing, recycling, and R&D solutions discussed above. S.383 and S.1113 offer the most comprehensive legislation to assess critical material needs, to reinvigorate the domestic mining supply chain, manufacturing, and research and development to mitigate risks arising from insufficient or uncertain sources of supply. It is also critical to bolster education within the mining, separations, engineering, and manufacturing workforce. GE believes it is critical to emphasize long-term innovation, as opposed to short-term stockpiling, in the critical materials policy and strategy.

Conclusion

In closing, we believe that a comprehensive 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 Cantwell and members of the subcommittee, thank you for your time and the opportunity to provide our comments and recommendations.

Senator CANTWELL. Thank you, Dr. Duclos. Thank you very much for your testimony.

Mr. Caffarey, thank you for being here as well. After you finish then we'll go to questions. Thank you very much for your testimony.

STATEMENT OF MARK CAFFAREY, EXECUTIVE VICE PRESIDENT, UMICORE USA, INC., RALEIGH, NC

Mr. CAFFAREY. Thank you, Madame Chair.

Madame Chair Cantwell, Ranking Member Risch and members of the Committee, my name is Mark Caffarey and I'm Executive Vice President of Umicore USA in Raleigh, North Carolina. Thank you for the opportunity to testify before you today.

Umicore is a global materials technology company whose annual sales of some $15 billion. Founded over 200 years ago, Umicore has a long history in mining and metal smelting. In the last 15 years alone we have transformed our operations by developing a closed loop business model that provides more than 50 percent of the metals we transform into materials from our own recycling, many of which qualify as critical materials in the U.S. and other countries.

As the world's leading recycler of precious metals in 2010 alone Umicore recovered approximately $6 and a half billion in metal values from discarded, end of life products and industrial by-products. Because Umicore knows that in principle metals can be infinitely recycled without losing any of their properties. A key component of our business strategy is to further increase the range of materials we derive from recycling.

The 3 bills before the committee today all call upon the Department of Energy to launch programs in the recycling of critical materials. Because we at Umicore believe the recycling of products containing critical materials is a central strategy to securing access to those materials for the U.S., we support these efforts and the focus in all 3 bills on research and development. I will highlight 3 main points in my testimony today.

First, the U.S. likely has the largest cache of critical materials in the world. They can and should be recycled to assure secure and ready access to the critical materials needed for defense and civilian high tech products. Umicore supports Federal efforts to achieve this through recycling.

Second, recovering metals from production scrap and waste and from end of life products is much more efficient and needs much less energy than production from primary resources. In terms of productivity consider that for every ton of ore containing the platinum group metals, mining will yield approximately 5 grams of PGMs per ton. But by recycling automotive catalysts we can harvest 2,000 grams PGMs per ton, 400 times more.

Our plant in North Carolina is already reclaiming over 2 million grams of PGMs from approximately one million recycled automobiles every year. Our main recycling refining facility is recovering 17 different metals from its varied feed. Aluminum recycling achieves 90–95 percent energy savings which is certainly something to aim for in critical materials. Recycling is by far the more efficient energy way to produce critical materials as long as the appropriate process flows are used.

Third, the economic growth benefits our domestic commitment to the recycling of critical materials could be enormous. Umicore itself employs 14,400 people worldwide with 1,500 highly skilled, highly paid employees at our precious metal and battery recycling facility. The employment potential of a U.S. critical materials recycling industry is significant in terms of new job creation and job availability at varying skill levels. The 4 stages of the recycling process are: collection, dismantling, pre-treatment and refining of the pretreated materials into the final critical materials products which is done at Umicore's recycling plants.

The economic growth potential is enormous. The recycling of critical materials is an entire industry. One the U.S. has yet to even begin building domestically.

These 3 bills call upon the Secretary of Energy to develop an R and D program that includes recycling. Umicore believes that the government support included in these bills is for fundamental, precompetitive research and development of critical materials is appropriate and necessary. The bills focused on R and D will be especially important in the subset of critical materials known as rare Earths. Umicore is now performing research on the possibility of recycling rare Earths from various sources of end of life materials and evaluating the possibility of stepping into funded projects where this can be further addressed.

But proven technologies already exist to recycle many critical materials beyond the rare Earth subset. Umicore has the technology and expertise to do so. With respect to these critical materials it is important for the U.S. to support the development of a critical materials recycling industry built upon those existing and proven technology.

Umicore believes that this committee should consider provisions to require the Secretary to study and make recommendations to the Congress on how to development of such an industry could catalyze by demonstration, deployment and financing programs in the Department of Energy or other Federal agencies in any bill it advances to the Senate floor. Such a study would contemplate how Federal policies could support the development of private sector infrastructure for each of the 4 stages in the recycling process. So that the American system for recycling critical materials is as robust as it should be. Such a study could be a vital first step to achieving the significant national security, energy efficiency and economic growth benefits previously described.

Thank you for the opportunity to testify. I look forward to answering any questions you may have.

[The prepared statement of Mr. Caffarey follows:]

PREPARED STATEMENT OF MARK CAFFAREY, EXECUTIVE VICE PRESIDENT OF UMICORE USA, INC., RALEIGH, NC

Madam Chairman, Mr. Ranking Member, and Members of the Committee, my name is Mark Caffarey, and I am an Executive Vice President at Umicore USA. Thank you for the opportunity to testify before you today.

Umicore is a global materials technology company, with annual sales of some $15 billion. We focus on areas where we can best use our expertise in materials science, chemistry, metallurgy, and recycling. We produce metals-based materials for: rechargeable batteries for laptops, mobile phones and electric cars; emission control catalysts for passenger cars; photovoltaic systems; and fuel cells. We are also the world's leading recycler of precious metals.

The three bills before the Committee today—S. 383. S. 421, and S. 1113—all call upon the Department of Energy to launch programs in the recycling of critical materials. I am testifying today to offer Umicore's support for those programs, because we at Umicore believe the recycling of products containing critical materials is a central strategy to securing access to critical materials for the United States.

Our belief is not based on theory, but rather on practice—our own business experience. Umicore is more than 200 years old, with a history in mining and metals smelting. In the last fifteen years we have transformed our operations by developing a closed loop business model, allowing us to secure from our recycling more than 50% of the metals we transform into materials. Among those are three highlighted by DOE as critical for clean energy technologies (indium, gallium, tellurium from US DOE's Critical Materials Strategy, 2010) as well as Platinum Group Metals added to the list of critical materials in other parts of the world. In 2010 Umicore recovered approximately $6.5 billion in metals value from discarded end-of-life products and industrial by-products. Because Umicore knows that, in principle, metals can be infinitely recycled without losing any of their properties, a key component of our business strategy is to increase even further the range of materials we derive from recycling.

As you consider the legislation before you, we urge to contemplate the benefits of recycling in achieving the common objectives of these three bills. First and most importantly, these bills all seek to ensure that the United States has secure, ready, domestic access to critical materials required for defense and civilian hightechnology products. If the United States committed itself to meeting its critical materials needs in large part through recycling, there is no nation on earth that could match American resources. The United States has the largest "aboveground" mines of critical materials in the world, in the sense that this country's supply of industrial scrap and end-of-life automobiles, electronics, and electronic appliances—whether they are in wreckers' yards, land-fills, or Americans' basements and attics—can't be matched by any other nation. In essence, these "above-ground mines" make the United States the Saudi Arabia of critical materials. A well-developed recycling system could tap these mines for U.S. critical materials security without limit.

Second, recovering metals from production scrap and waste and from end-of-life products is much more efficient and needs much less energy than production from primary resources. In terms of productivity, consider that for every ton of gold-containing ore taken from the ground through mining, approximately 5 grams of gold can be recovered. Likewise for ore containing platinum group metals that is mined, approximately 5 grams of PGM's can be recovered. (Platinum Group Metals = Platinum, Palladium, Rhodium, Ruthenium, Osmium, and Iridium) On the other hand, for every ton of mobile phones recycled, we can harvest 300-350 grams of gold, or more than 70 times the yield from mining. And for every ton of automobile catalysts recycled, we can harvest 2,000 grams of PGMs—more than 400 times the yield from mining. Each year in Maxton, North Carolina, Umicore Autocatalyst Recycling (UAR) reclaims over 2 million grams of PGMs from approximately 1 million recycled automobiles. The spent automotive catalyst is de-canned and sampled in the North Carolina facility.

In terms of energy savings, take the production of aluminum, for example. Recycling uses only 5-10% of the energy that would be required for virgin aluminum production, representing a 90-95% energy savings. For the precious metals (i.e. gold, silver and the the platinum group metals) and for metals such as cobalt, indium or tellurium, the energy savings achieved by state-of-the-art recycling are also significant. An exact calculation of energy efficiency per metal is difficult to achieve due to the heterogeneous nature of our feed and the numerous metals extracted from the Umicore flowsheet. Our initial work indicates that the annual production of metals from our recycling/refining facility creates in total about 1/5th the CO2 emissions compared to producing those same 17 metals via the primary route. Recycling is by far the more energy efficient way to produce critical materials—as long as the appropriate process chains are used.

Take an example of these energy efficiency savings from our own organization. Umicore Battery Recycling has evaluated its recycling process for rechargeable battery materials versus primary production of these materials. Umicore's process avoids the mining of virgin materials (at high energy cost), requires no additional energy-consuming processing to achieve quality in the materials because of the high purity of the materials in the used batteries, and finishes with a highly energy-efficient recycling (smelter) technology. Umicore estimates that the energy savings achieved by its battery recycling process amounts to 50-70% compared to production from ores (depending on the battery composition). Umicore's rechargeable battery recycling plant will soon have a capacity for 7,000 tons of rechargeable batteries (equivalent to 150,000 automobiles or 250 million mobile devices).

Likewise, Umicore's recycling process for precious metals containing industrial by-products and End of Life materials avoids the mining of virgin materials (at high energy cost) and allows the recovery of 17 metals in all—two of them from the critical list published by DOE: indium and tellurium. The rare earth elements present in the automotive catalysts would be extremely difficult to recover due to the chemical nature of those catalysts.

Third, and finally, the economic growth benefits of a domestic commitment to the recycling of critical materials could be enormous. Umicore itself employs 14,400 people world-wide, with 1500 highly-skilled, highly paid employees at our largest plant, the precious metals and battery recycling plant. The employment potential of a robust U.S. critical materials recycling industry is significant, involving not only many, many jobs but also jobs of varying skill levels at each of four stages of the recycling process: (1) the collection of discarded end-of-life products and scrap; (2) the dismantling and sorting of products and the separation of components; (3) the pre-treatment of the separated components; and (4) the refining of the pre-treated materials into the final critical material products, which is what we do at our recycling plants. Finally, there is all the indirect employment that can be associated with the recycling industry—IT, engineering, transportation, sales, administration, as well as research at universities and research centers. The economic growth potential is enormous, because the recycling of critical materials is an entire industry, and the United States has not begun yet to build one domestically.

The three bills before you call upon the Secretary of Energy to develop a research and development program that includes recycling. Again, Umicore's own experience offers testimony to the wisdom of those provisions, having gone from a company obtaining metals from mining to one obtaining metals mainly from industrial by-products and end-of-life products using highly energy efficient, clean recycling technologies. This strategic business decision has resulted in high levels of innovation within the company and has stimulated research and innovation via collaboration with many university partners and in-house R&D centers. So Umicore believes that government support for fundamental, precompetitive research and development for critical materials—as contemplated in the three bills before you today—is appropriate and necessary.

The focus on research and development in the three bills will be especially important in the subset of critical materials known as the "rare earths." Umicore is now performing research on the possibility of recycling rare earths from various sources of end-of-life materials and is evaluating the possibility of stepping into funded projects where this can be further addressed.

But we also note that there are existing, proven technologies to recycle many critical materials beyond the rare earth subset. So with respect to these critical materials, we can focus now on how the nation should support the development of a critical-materials recycling industry built upon those existing, proven technologies like Umicore's..

To that end, I note that Umicore has provided comments (attached) to the Secretary of Energy on the proposed strategic plan for the department to the effect that there should be a department-wide effort to determine how DoE programs can support the development of such a critical materials recycling industry.

But perhaps this Committee should also consider including in any bill it forwards to the floor provisions that require the Secretary to study and make recommendations to the Congress on how the development of such an industry could be catalyzed by demonstration, deployment, and financing programs in the Department of Energy or other federal agencies. As noted above, the recycling process includes four critical stages: collection, dismantling, pre-treatment, and then refining. Such a study would contemplate how federal policies could support the development of private-sector infrastructure for each of these stages so that the American system for recycling critical materials is as robust as it should be. Such a study could be a vital first step to achieving the significant national security, energy-efficiency, and economic growth benefits described above.

Thank you for the opportunity to testify before you today, and I stand ready to answer any questions you may have.

Senator CANTWELL. Thank you very much, Mr. Caffarey.

I'm going to start with you because you've just finished your testimony here about, you know, the amount of domestic resources and recycling. If we considered the above ground mines, as you call them, then we are certainly endowed with a lot of resource.

What do you think the barriers are to developing that supply chain? Do you think that it's different than, what we're doing with aluminum and gold recycling?

Mr. CAFFAREY. I believe I've tried to illustrate that the whole recycling process has 4 parts to it. So definitely we're very weak on the collection side. We're very weak on the pre-treatment side.

The last step where we recover the different elements do exist. We have systems in place for that already. But to get the materials to those different facilities is the weak link in the whole recycling process.

Senator CANTWELL. What would you suggest as strategies to try to deal with that barrier?

Mr. CAFFAREY. I believe that would be a study by the DOE or the other Federal agencies to look as to what is the best way to get to collect these products and keep them together and pre-treat them the right way. Today we do not have the solution as we concentrate on the efficient recycling of the different end of life products.

Senator CANTWELL. But I'm assuming there's no incentive either in many of these recycling markets that have failed to materialize so far because the collection is so disperse or no one's come up with an economic model to benefit that recycler, or because sometimes distance and transportation costs make it uneconomical. So do you think that this is about incenting recycling?

Mr. CAFFAREY. There are different ways to go about it. But I think it's also a question of a lack of information. I believe the automotive recyclers are well organized. But do they know exactly all the different elements that an automobile contains?

We mentioned rare Earth permanent magnets. The automobile is a perfect example of containing a wide variety of permanent magnets. But who exactly knows where they are or what is the best way to collect them before the automotive is—an automobile is shredded. Because once it's shredded and goes to the steel in the streets the different elements are lost.

Senator CANTWELL. OK. Mr. Duclos, you talked about the combination approach, some efficiency, some new materials research and recycling. I know that there are global companies in my State like Boeing and others who are looking at these markets. Which of the approaches do you support looking at, when you look at this legislation, you know, reducing as someone who is a manufacturer needing this material? What do you like in those strategies?

Mr. DUCLOS. Yes. It's a—thanks for the question because this is really a key part of the challenge. The fact is is that the solution will be a mix of these 5 solutions and which one in particular is chosen, which set of these solutions is chosen depends on the element and it depends on the use of that element.

There may be some cases where material substitution is more easily done. In that case that's a fairly clean answer to the question, involves doing some research in order to develop those material substitutions. But in other cases material substitutions may not be at all possible. In those cases you would look to the recycling and the manufacturing efficiency to make sure that we're being as efficient as possible in the use of the material.

So it's really a mix.

Senator CANTWELL. How important are we in this equation. By that I mean, government. We asked the previous panel about an assessment of where we are with these various materials. It's clear we need to get more information from them.

Is this something the private sector can handle on its own?

Mr. DUCLOS. These challenges before us are great. When we face an issue with the material we face having to choose among those solutions. The fact is that there can be oftentimes parallel paths. The real challenges at the beginning of this process to do that, sort of, fundamental, precompetitive understanding of materials and what materials, properties, can give—what in a product, can help definitely lead to, you know, which direction to go. That's where the Federal Government can help.

In addition I think it's really important in terms of Federal Government's help in collecting information. You know, we will not publicly say, you know, which materials we think are critical. However, we would be willing to give that information in a proprietary sense.

We have with the Department of Energy, for example, in their assessment. I think that's a really important thing that the government can do is collect that information. So we can see around corners and anticipate these challenges before they happen so that we can implement this series of solutions.

Senator CANTWELL. Thank you.

Mr. Price and Mr. Erceg, you both talked about this work force issue which we heard on the previous panel as part of this issue and in the manufacturing area or, you know, getting people prepared because we've seen a decline in qualified people that is critical for minerals materials. How might we encourage people in this particular area? What do you think is missing?

Mr. PRICE. In the university systems what stimulates bringing people into the work force is typically the research opportunities that are there to fund the graduate students and the post-docs to work in those arenas. Those research opportunities, I think, are one of the main ways of taking a look at it. In that energy critical elements report we also talked about having some centers of excellence in things like rare Earth processing, element by element on the most critical minerals that we're talking about.

Those kinds of centers are also a good way of approaching a problem. So it would be a combination of research opportunities that would help to train the graduate students and post-docs and then these centers of excellence.

Senator CANTWELL. Is——

Mr. PRICE. I believe the Department of Energy is moving in that direction on the processing side of things. It really falls more on the shoulders of the USGS on the geological aspects.

Senator CANTWELL. Interesting.

OK, Mr. Erceg?

Mr. ERCEG. Thank you, Senator. I would also add that when, you know, through R and D collaborations such as the DOE grant programs, ARPA–E's innovation programs. Those are fantastic programs that create collaborative opportunities for commercial enterprises to work with universities. This has been a key function of our grant program as well.

Once you can go to the universities and say, look, we've got this grant opportunity. This is the commercial aspects we see. It draws students to them.

You know, fortunately we've all been students before. It's difficult to, you know, look at your career and say, wow, there's no career opportunities if I study this. So it's a fantastic window to show, you know, our great students and science and engineering, you know, a path to commercialization.

Senator CANTWELL. Thank you.

Senator Risch.

Senator RISCH. Thank you, Madame Chairman.

Mr. Caffarey, I am interested in the recycling aspects of this and is it your testimony that the economics are such that the economics aren't an incentive to the industry to recycle the products?

Mr. CAFFAREY. My testimony—thank you for the question, Senator.

My testimony is to say that there is a mine that's readily available and we're not organized to collect the different materials because we have processes that can efficiently recover critical elements. We have years of experience in recovering the precious metals out of catalytic converter. We have experience recovering precious metals and other metals out of electronic scrap which is a large feed of our process.

We're looking into how to contribute to the rare Earth question now a day with some new R and D in recycling. But I believe the question is always how do we get the material together.

Senator RISCH. That's the question I was focusing on is the financial aspects of it. Because, you know, we Americans are really, really motivated when there's a profit involved. I don't know how familiar you are with the automobile dismantling business.

But I've got some friends in that business. I've watched it done. I'm telling you they take everything out of there that they can and separate it out that will make them more money. So I'm a little surprised to hear you say that it's not being done.

Mr. CAFFAREY. I didn't say it's not being done. But maybe not everybody has the information. What's not essential when we talk about magnets, not everybody knows that it contains rare Earth. Maybe there's also a contribution to education, to educate the industry, to educate the people that are involved today at that level and maybe they will have ideas to, well, before we shred it maybe we should be removing this part.

Then they can also contribute to say, well, you know, it's very difficult. Maybe the automotive design should be done to make it easier to recover. So then we're also talking about the design for recycling to make it easier to be able to recover those parts at end of life.

Senator RISCH. That's why I was interested in the economics of it. My experience is that the marketplace, if there's dollars and cents involved, always figure it out before the government does. Not only that, but they figure it out a whole lot better.

That's why I was wondering about the economics of this whether or not it's just simply that there isn't enough money in it to motivate people to extricate these parts out of an end of life product.

Mr. CAFFAREY. I can only share the experience that we have and for all the materials that we process it's economical.

Senator RISCH. Thank you. Thank you, Madame Chair.

Senator CANTWELL. Senator Udall.

Senator UDALL. Thank you, Madame Chair. Thank you to the panel for taking the time. This is fascinating and important both.

Mr. Caffarey, I'd like to turn to you initially. You point out that the U.S. has, I think as you put it, the largest above ground mines of critical——

Mr. CAFFAREY. Correct.

Senator UDALL. Materials. That's an interesting way to think of what you're doing. That our landfills make us the Saudi Arabia of critical materials. This is interesting.

In addition, in light of the fact that I think a Chinese official has been reported as saying, the Middle East has oil and China has rare earths, what can we do and I know you've talked a little bit about this up to this point to develop the critical materials recycling industry in our country? Would you just, if you would, think about what kind of job creation potential it might hold.

Mr. CAFFAREY. At the 4 different stages of recycling you have different levels of skills that are required. If you take the collection point, that would be the lowest level, the lowest skill level that's required. Then when you're doing the final step where the transformation and recovery and recycling, that's where you need the highest skill, the metallurgy knowledge, the chemistry knowledge, the engineering.

But then after collection you have the pre-treatment of the different materials. As far as trying to give as an example, the automotive, we try, not be the best, but there are different parts. The mobile phone is also a very complex item where you have different elements.

If you want to recover selenium or tellurium out of the telephone you're not going to be doing that just for that. You have to have a system in place that allows you to gather the mobile phones together and then have a process that will recover all the different elements. It's, if you take one metal as an individual example that might not justify the whole recycling process. But when you put them all together then that will justify the process.

So on the job level I can see definitely a greater number of employment opportunities on the collection, people working at the different State or even county or city levels and then gathering a most efficient stream. The industry has still to be created. There are some that are very economical or very beneficial and that get cherry picked. We have to have a system that can take care of all end of life materials.

Senator UDALL. Did I read recently that tellurium has some 100 times the value per volume that the similar amount of gold would have or am I not remembering correctly where I read that? In other words the tellurium is quite valuable given its rarity.

Mr. CAFFAREY. The tellurium has gained in value, yes. It's not at the level of gold yet.

Senator UDALL. OK.

Mr. CAFFAREY. But——

Senator UDALL. Somebody was thinking in a wishful manner.

Mr. CAFFAREY. I believe so, yes.

Senator UDALL. Let me continue the line of questioning directed to you. You said that recovering metals from scrap and waste is much more efficient and requires less energy than getting them from ore. I think that's the thrust of what you've been saying. I find that your example of the platinum group metal is amazing that you get 400 times the yield from recycling automotive catalysts than yield from mining those same platinum group metals.

As you may know we've had a hearing in this Committee on energy efficiency. Do you think that if more companies pursued recycling from their material needs that we could reduce, significantly perhaps, our manufacturing energy needs in our country?

Mr. CAFFAREY. Yes, we're convinced of that.

Senator UDALL. You are convinced?

Mr. CAFFAREY. We have recently started up at an industrial level the recycling of rechargeable batteries. We have done life cycle analysis to help us evaluate, well, what is the value, what is the contribution. Using the elements that we recover from recycling have reduced the need for energy by 70 percent. So comparing the use of recycled materials verses the use of mined materials it requires less and it requires 70 percent less energy.

There's also a difference in the total CO_2 emissions that is also a factor and that goes together with that. So there's less CO_2 emissions when using the recycled materials verses using the mined materials.

Senator UDALL. Those are powerful statistics. I know the Chairwoman has a keen interest in this as well. It's in part why she scheduled this hearing. But there's enormous opportunity.

My time is beginning to expire. But I know we've talked a lot about manufacturing in our country and the concerns that we have that we're losing our manufacturing base. It strikes me that what you've talked about and others on the panel when it comes to recycling. It's a form of manufacturing, maybe a form of, I don't know what the simple term would be, reverse manufacturing or—but, I mean, this offers another way in which we can take advantage of all the skill sets that Americans have.

Mr. CAFFAREY. Definitely.

Senator UDALL. I don't know if you would rebut that way of thinking about what you're doing and others are doing, but it strikes me that this is a form of manufacturing.

Mr. CAFFAREY. Yes. Your raw material is just nothing that you get out of the ground. Yes. Above ground mine like you mentioned.

Senator UDALL. Yes, there was one keen observer of our energy policy who said, if you want to find more oil you ought to drill below Detroit. The point that was being made was by creating more efficient automobiles and providing that option to the American public to buy more efficient automobiles you're in fact finding more oil.

It's a concept, I think, we can apply to a lot of other areas in America. As we become more lean, more efficient with our use of energy and therefore, I think, more secure.

Madame Chair, thank you for, again, holding the hearing on this very, very important topic.

Senator CANTWELL. Thank you, Senator Udall. Thanks for introducing your legislation.

I just had one follow up. Dr. Price, you talked about Centers of Excellence. Are there any centers that exist now and where would you see that kind of collaboration? How would that manifest itself?

Mr. PRICE. As Mr. Sandalow said in his testimony or in response, there is a rare Earth element center of excellence at Ames, Iowa. That's the only one that I'm aware of that really focuses on a specific group of elements. They've been doing research for many years on the processing of rare Earth elements.

That stands as an example of what our committee was recommending.

Senator CANTWELL. Processing. Processing, meaning?

Mr. PRICE. The big problem with rare Earths is that they're chemically very similar. To separate them for the individual uses, if you want neodymium, you have to separate it from the other rare Earth elements. The process for doing that is an area fertile for continued research.

When it gets into the recycling issues, separating then the rare Earth from the other materials, if you wanted to separate the neodymium from iron, neodymium boron magnets, there's research that's needed to do that.

Senator CANTWELL. How do you think we should look at this right now in the context of that particular center? The challenge that's in front of us? Particularly this, you know, relationship between, you know, centers of excellence in my mind are a combination with a little government resource of academia and the private sector business enterprise working together on joint collaborative—on a collaborative approach for solutions.

Given the challenge that we're facing in becoming more aggressive, pursuing centers of excellence around particular areas of rare Earth minerals? Is Ames enough? What else do we need to do?

Mr. PRICE. Ames is a good start on the rare Earth side of things. They do not, however, focus very much on the geological aspects of it. Their part of it is looking at the, more of the, downstream processing and supply sides of things.

NSF has very good models of centers that are competitive in a peer reviewed manner. DOE is talking about various hubs of excellence and this could easily fall under their approach to that problem.

Senator CANTWELL. I'm not sure I'm following you.

Mr. PRICE. That by having programs that are peer reviewed by the scientific community such that we're getting the very best of the research opportunities is generally the best way to go with these sorts of centers.

Senator CANTWELL. OK. But again, you mean on this specific materials and their usage.

Mr. PRICE. Yes.

Senator CANTWELL. Or potential usage.

Mr. PRICE. Yes.

Senator CANTWELL. When you said geological earlier, obviously the dynamics are changing, they're constantly changing. In the Northwest, these are big aerospace manufacturer and they consider composites. They consider alloys. They consider future materials back and forth. You know, these are big decisions.

So before we go opening up mining all over again, we obviously want a lot of expertise on where the future is going with these materials. So I would think that if we needed more centers of excellence it would be more in that area, less in the geological area. So that's what I'm trying to have you help me understand your point.

Mr. PRICE. Yes. Rare Earth is a great example. There are only 2 really big deposits in the world that have been contributing a whole lot to the rare Earth supply, one big deposit in China and then the Mountain Pass deposit in California. There are a number of other rare Earth deposits throughout the world none of which have been supplying material at the levels that those 2 had.

There's a lot of opportunity for understanding how to extract the rare Earth elements from those different types of deposits. They occur in different minerals. The one in California and the one in China are both in rare Earth fluorocarbonates that have been relatively easy to process. But some of the other rare Earth deposits throughout the world are in different minerals that have challenges in terms of extraction.

The fact that there are so few deposits really is a fertile area for the geological aspects. We can easily ask the question why aren't we finding more? There may well be other rare Earth deposits that are out there that need to be looked at seriously.

The USGS did its assessment. It was sort of off from the basic literature that's out there. They looked at what the rare Earth situation is like in the U.S. But they actually missed a number of deposits that we know about that could be the long term resources. But they're in some cases, different minerals that haven't been looked at all that seriously.

So it would require then a combination of that sort of geological knowledge of what's out there, what some of these potential resources may be, then working with the process engineers, metallurgists, extract the metallurgists to try to figure out how do we best get those rare Earths out of those minerals. Then the further downstream aspect certainly the recycling part of it is a big piece as well.

So it's a combination of——

Senator CANTWELL. Thank you. That's helpful.

So what is an example of someplace where we haven't been looking on another rare Earth or I mean another extraction that we haven't been looking at?

Mr. PRICE. A good example there might be tellurium. Right now the world's supply of tellurium is coming primarily from a certain way of processing copper ores. We actually don't know all that well where all the tellurium is in those copper ores. So there's research that's beginning to look into those issues.

But we do know that certain types of or certain processes are extracting the tellurium. It comes, these days, from the sulfide ores that are characteristic of the big copper deposits in Chile and Peru and Arizona. Utah is another big producer.

Those copper ores have the tellurium, presumably, in with the copper minerals themselves. That's where it's being collected today. In Arizona we process a lot of those copper minerals today using a different technique that is basically getting none of the tellurium.

So there's a big issue of well, we know there's tellurium in those deposits. We're not extracting it. Can we do more to understand how to extract it from that process?

Senator CANTWELL. Just for the record, what would we do with tellurium? What's its use?

Mr. PRICE. The big issue with tellurium these days in this energy critical arena has been that it's one of the preferred elements used in thin film photovoltaics. Cadmium telluride turns out to be one of the best approaches to thin film photovoltaics for solar panels.

Senator CANTWELL. This would be a key part of that manufacturing process?

Mr. PRICE. That's correct.

Senator CANTWELL. Thank you.

Thank you all. I'm sure we could go on with this expertise of the panel. We thank you for your testimony today. I'm sure that if members have questions we'll follow up for the record.

Again, we'll keep consulting with you as we move forward on this legislative process. Thank you all very much. The hearing is adjourned.

[Whereupon, at 4:28 p.m., the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Questions

RESPONSE OF JONATHAN G. PRICE TO QUESTION FROM SENATOR BINGAMAN

Question 1. The most fundamental question to consider today is how we should go about determining exactly which minerals and materials are critical? The National Academy of Science recommended a method in their 2008 study whereby that determination can be made-this seems like a good starting point, but can we make a more focused definition of which materials are critical for energy technologies? How can we make sure that every mineral or material under the sun is not considered to be "critical"?

Answer. The 2011 study on Energy Critical Elements: Securing Materials for Emerging Technologies by the American Physical Society's Panel on Public Affairs and the Materials Research Society, which is available at http://www.aps.org/policy/reports/popa-reports/loader.cfm?csModule=security/getfile&PageID=236337 , defined the term "energy-critical element" (ECE) 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. We reserve the term ECE for chemical elements that have not been widely extracted, traded, or utilized in the past and are, therefore, not the focus of well-established and relatively stable markets." The study identifies several elements that we consider "possible" ECEs. Although our list of ECEs is not exhaustive, and others could justifiably be added, this approach is good to follow in setting priorities for data collection, analysis, research, development, and workforce building by the federal government.

The 2008 National Academy of Sciences report offered an additional approach that can further narrow the list of priority elements. That study did not focus on energy technologies; using that approach alone could yield a larger number of elements needing study than would result from a combined approach that also focused on ECEs.

The 2011 American Physical Society report did recommend that "the federal government should regularly survey emerging energy technologies and the supply chain for elements throughout the periodic table with the aim of identifying critical applications, as well as potential shortfalls." This should help the United States be prepared for potential shortfalls in availability. As an example, beryllium, which is not currently considered an ECE, but is critical for many defense-and space-related technologies, in recent years has been produced from only one mine in the United States. That mine supplies much of the beryllium used throughout the world, such that other countries consider beryllium a critical element. Our federal government should be evaluating the domestic and global availability of beryllium on a regular basis. The U.S. Geological Survey (USGS) produced a fine document in 1973, titled United States Mineral Resources (USGS Professional Paper 820, 722 pages), which briefly evaluated the potential for domestic as well as international supplies of many of the elements in the periodic table. An update of that document is long overdue. In my opinion, it should be updated at least every ten years, with more focus paid to those elements that are considered critical for energy technologies, defense, and domestic economic development.

RESPONSES OF JONATHAN G. PRICE TO QUESTIONS FROM SENATOR COONS

Question 1. As the state geologist of Nevada, one of the most resource-rich states in the country, how would you characterize the existing state of geological knowledge about critical materials such as REE deposits compared to better understood deposit types such as porphyry Cu or epithermal Au?

Answer. Because there have been far fewer scientific studies of rare earth element deposits (and many of the other critical minerals) than of the types of deposits that host major resources for copper and gold, we lack the understanding that is needed to explore for the new types of resources that will surely be found in the future. We need descriptive studies of known deposits as well as process-oriented studies on the geochemistry and mineralogy of the critical elements, so that we can predict the occurrence of new types of deposits that currently are not recognized in today's mineral-resource assessments. There are many examples of how lack of knowledge of new deposit types (e.g., Carlin-type gold deposits and Olympic Dam-type iron oxide-copper-gold deposits) leads to gross underestimation of resource potential.

Question 2. Is geologic mapping adequately supported in the USA to allow accurate estimates of resource availability?

Answer. No. The National Cooperative Geologic Mapping Program (in the Department of Interior-USGS budget) is funded well below the level that the Senate and House have authorized. The STATEMAP portion of the program leverages federal and state dollars, as does the EDMAP portion of the program, which supports training of the next generation of geologic mappers. These maps are integral to not only resource assessment but also to conscientious, environmentally responsible development of those resources.

Question 3. How could state geologists contribute to federal efforts to better understand and develop deposits of critical minerals and materials?

Answer. There are several opportunities for state geological surveys to work with the federal government in this regard. The USGS has four programs that are particularly relevant: (1) the external grants portion of the USGS Minerals Program, (2) the National Cooperative Geologic Mapping Program, (3) the National Geological and Geophysical Data Preservation Program, and (4) Minerals Information. As the Department of Energy focuses on specific energy-critical elements, there also will be opportunities for DOE to work with state geological surveys.

Because the USGS does not have the breadth of expertise that is needed to understand the processes that form the wide variety of ore deposits or to assess the potential for new discoveries both domestically and internationally, the USGS Minerals Program needs to engage the knowledge of experts in state geological surveys, universities, and industry in this work. A significant external grants program (on the order of 20% of the Minerals Program budget, as is the case in the USGS Earthquake Hazards Program) would greatly improve the effectiveness of the Minerals Program.

The National Cooperative Geologic Mapping Program is an excellent approach to engaging state geological surveys in providing the geological framework necessary for both discovery and development of mineral deposits. Geologic maps are needed to determine how the mineral deposits within a given area formed, where undiscovered deposits are most likely to occur, what environmental consequences there may be to development of the deposits, how best to protect groundwater and other resources during development, and how to ensure effective reclamation and post-mining land use.

The National Geological and Geophysical Data Preservation Program in the USGS got a modest start in response to a 2002 National Academy of Sciences study on the need for geoscience data preservation (Geoscience Data and Collections—National Resources in Peril). This program includes information on how to gain access to samples that are curated by state geological surveys. Much more could be done to improve the information that the USGS needs for its assessments of domestic mineral resources. Many state geological surveys have archives of samples and data from drilling of water wells, mineral-exploration wells, and energy-exploration wells, all of which are relevant to mineral-resource assessments and future development.

The responsibility of monitoring mineral production in the U.S., in the context of worldwide production, was moved to the USGS when the U.S. Bureau of Mines was closed in 1996. Although memoranda of understanding continue to be signed by state geological surveys and the USGS for collaboration on collection of statistics, there is no longer funding to assure that the best data are collected by the federal government. The U.S. Bureau of Mines formerly had officers stationed in major mineral-producing states and foreign countries, but that funding disappeared shortly before the responsibility of collecting mineral information was given to the USGS.

The Department of Energy is currently working with state geological surveys on building a National Geothermal Data System. The states are formatting their geothermal-relevant data in a nationally consistent manner. Some of these data sets are also relevant to mineral resources, and a similar DOE-state cooperative effort could be undertaken with a focus on energy-critical elements. Coordination between the USGS Minerals Program, the USGS's National Geological and Geophysical Data Preservation Program, and DOE's work is essential to avoid duplication of effort. The states are often in a good position to facilitate coordination among federal agencies that share interests in maintaining high-quality data on mineral and energy resources within the states.

RESPONSE OF LUKA ERCEG TO QUESTION FROM SENATOR BINGAMAN

Question 1. The most fundamental question to consider today is how we should go about determining exactly which minerals and materials are critical? The National Academy of Science recommended a method in their 2008 study whereby that determination can be made-this seems like a good starting point, but can we make a more focused definition of which materials are critical for energy technologies? How can we make sure that every mineral or material under the sun is not considered to be "critical"?

Answer. Mr. Chairman, you have pinpointed the most fundamental issue in this debate. The National Academy of Science (NAS) defines criticality based on two parameters: importance in use and exposure to supply disruption. While we believe that the NAS report is the most comprehensive government examination of these issues to date and we largely agree with these parameters, we are concerned that they fail to sufficiently capture the fundamental importance of U.S. production. Building a domestic supply chain for critical materials not only alleviates potential supply disruptions, but it also supports domestic innovation and job creation.

As I stated in my testimony, manufacturing drives innovation at every point in the supply chain. 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. Developing domestic production and processing capabilities will not only drive job creation in those industries but also will drive innovation and increase competitiveness throughout the entire supply chain.

For this reason, the concept of domestic production should be built into the definition of critical materials. To avoid the issue you appropriately raise of potentially designating an inordinate number of materials as "critical," we should only consider criticality for materials that support strategic energy and defense priorities.

RESPONSES OF LUKA ERCEG TO QUESTIONS FROM SENATOR UDALL

Question 1. In your testimony you mention a "self-classifying" definition for criticality. Can you explain this more? What does this mean and how would it work?

Answer. The market for critical materials is dynamic and vibrant, changing and evolving constantly. Investment decisions are being made in real time. While current legislative proposals establish thoughtful structures for federal agencies to determine what materials are "critical," these processes are inherently backward-looking, examining a market that existed months or years previously.

Although these processes are useful, the federal government can more directly and quickly drive private investment in priority mineral production and processing activities by establishing a clear, self-classifying definition. By establishing a clear definition that can immediately be interpreted by the marketplace, Congress will accelerate the development of critical mineral and material resources.

We recommend a definition that considers two factors: 1) importance for strategic energy and defense priorities and 2) degree of U.S. import reliance for ore and processed materials.

Question 2. It looks as though you would include the level of U.S. production as criteria for criticality. As you know there are several mineral resources that we do not have in the U.S. and we are 100% reliant on imports. Does this mean those materials would be deemed critical under the self-classification even if they have stable supply chains? In other words, would U.S. resources be necessary to keep a mineral off the list of critical minerals under the self-classifying type of definition?

Answer. Yes, we believe that if the U.S. is 100% import reliant on a mineral and it is used in an area of strategic energy and defense priorities, it should be deemed critical.

We believe that two criteria should be considered in determining criticality: 1) importance for strategic energy and defense priorities and 2) degree of U.S. import reliance for ore and processed materials.

This definition recognizes the importance of building a domestic supply chain in support of driving domestic innovation and competitiveness throughout the electric vehicle and grid storage industries.

RESPONSE OF STEVEN J. DUCLOS TO QUESTION FROM SENATOR BINGAMAN

Question 1. The most fundamental question to consider today is how we should go about determining exactly which minerals and materials are critical? The National Academy of Science recommended a method in their 2008 study whereby that determination can be made-this seems like a good starting point, but can we make a more focused definition of which materials are critical for energy technologies? How can we make sure that every mineral or material under the sun is not considered to be "critical"?

Answer. It is important to prioritize the criticality of raw materials and the elements contained in those raw materials, in order to focus risk mitigation efforts on those materials and elements that are most at risk. To this end GE has used a methodology similar to that developed by the National Academy of Sciences, which quantitatively assesses the "Supply and Demand Risk" and the "Importance to GE". If an element is found to be high on both scales it is considered to be "critical" and in need of a detailed plan for mitigation of supply risks. This approach can be modified for a certain area of concern, such as "energy technologies" by modifying the assessment of the second factor to "Importance to Energy Technologies". The "Supply and Demand Risk" factor can be made quantitative by following either the Academy of Sciences approach, or with the approach being developed by Prof. Thomas Graedel at Yale University, which uses established economic and geopolitical indices to evaluate this parameter. As an example, the criticality to energy technologies can be quantified by the amount of usage in energy technologies and an assessment of the criticality of the usage in those technologies. The Department of Energy has done such an analysis in late 2010 which determined that 5 rare earth elements (Y, Dy, Nd, Tb, and Eu) and 1 non-rare earth element (In) were critical to renewable energy technologies. This number of at risk elements is consistent with the analysis that GE did across its business segments. These examples demonstrate that methodologies do exist that quantify, prioritize, and reduce the number of elements that need further attention.

RESPONSE OF STEVEN J. DUCLOS TO QUESTION FROM SENATOR COONS

Question 1. GE is known for its innovative utilization of rhenium. A recent large discovery of molybdenum and rhenium in Australia (Merlin zone of Mt. Dore deposit, Queensland) may dramatically change the economic and resource picture for rhenium. How does GE stay abreast of such geologic developments and how would dramatic changes in rhenium availability change your business model?

Answer. Advancement of materials technology is a key part of continued improvement in advanced gas turbine engines for aviation and ground-based energy production. Rhenium has been one of the important elements in GE achieving progress in engine technology since it is a strengthener of nickel-based superalloys. GE recognizes the importance of Rhenium, which is why it has been our policy to conserve this material. Therefore, GE has continued to seek alternatives for future product development and application.

GE stays abreast of developments in Rhenium in a variety of ways. First, we constantly seek information on Rhenium and other materials through a variety of publications and outlets. The news of new Rhenium discoveries has been quickly publicized, and we are alert to the quantity and availability of the newly discovered resources. Second, GE attempts to create and maintain relationships with mining, processing, and researchers in the materials industry for all materials including Rhenium. Third, GE maintains an independent in-house materials research organization to identify and assess new materials for our aviation and energy products. All of this information is used to help develop our strategy on the application of advanced materials to our products.

Dramatic increases in the availability of Re supply can reduce cost and increase design flexibility of some aviation products while dramatic decreases in availability could not only raise cost but decrease design flexibility of some aviation products. We believe that Re is an important element and that we should not consume any more of it than absolutely needed. GE has developed alloys with reduced Re and no Re that have been used to replace existing products with higher Re containing alloys in current applications. In addition, GE reclaims Re from chip grindings and recycles Re-containing alloys as a key part of our strategy. GE will continue to conduct research on advanced materials that require little or no Rhenium to ensure that we have the most overall effective solutions to our future advanced engine products.

RESPONSE OF MARK CAFFAREY TO QUESTION FROM SENATOR BINGAMAN

Question 1. The most fundamental question to consider today is how we should go about determining exactly which minerals and materials are critical? The National Academy of Science recommended a method in their 2008 study whereby that determination can be made-this seems like a good starting point, but can we make a more focused definition of which materials are critical for energy technologies? How can we make sure that every mineral or material under the sun is not considered to be "critical"?

Answer. There have been a number of studies on what constitutes a "critical material" beginning with the NSF study in 2008 that is referenced by Senator Bingaman. Additional work has been done by others, including methodology studies and proposals shown in "Critical raw materials for the EU" [1]published June 2010 by the European Commission's Directorate General Enterprise and Industry. While their work was directed at the European situation and to non-energy materials, it offers another outlook on assessment. Their three "indicators" for criticality were economic importance, supply risk and environmental country risk. Included in the assessments are the extent to which a material can be substituted and how much of the material demand can be met by recycling.

The same general categories of assessment are used in "Energy Critical Elements: Securing Materials for Emerging Technologies"[2] wherein sufficient supply is of utmost importance and demand is still to be determined as R&D and markets move forward.

From this very brief summary it is clear that most approaches are, in principle, similar. And in looking at the findings of the various reports mentioned here, whether for energy or non-energy applications, there are many overlaps in the materials found to be critical. Differences seem to come less from different methodological approaches than from different frame conditions/priorities in the country which conducted the ssessment. Therefore Umicore cannot recommend any specific methodology but proposes to simply start from the good work that already is available.

In any event, the list of critical materials is not a static one but one that will change, grow, shrink depending on a number of factors. There will be new and evolving technologies to consider. Is the material readily available and easily mined? Is it present underground but also in urban mines and landfills? Is it a by-product of other metal(s) and what is its concentration in that metal? Can it be extracted in that case in an economically appropriate way? Are there end products containing the material that are being collected and recycled? What is the concentration of the material in those end products and is it easily extracted?

The provisions in S.1113 and S.383 for tracking of critical materials supply and performing R&D to strengthen supply of those materials through recycling and more efficient use are a step in the right direction. Supporting the work of DOE and USGS is necessary in this context.

RESPONSES OF MARK CAFFAREY TO QUESTIONS FROM SENATOR UDALL

Question 1. You mentioned that for the last 15 years your company has been working on a "closed loop business" model, meaning you used recycled base materials. What drove your company to pursue this business model? What were the biggest incentives and what were the biggest obstacles to reaching your goals in this area?

Answer.

- Drivers for Umicore to follow closed loop model:

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[1] "Critical raw materials for the EU" published June 2010 by the European Commission's Directorate General Enterprise and Industry, Raw Materials Supply Group. Technical input: Fraunhofer Institute, Bio Intelligence. http://ec.europa.eu/enterprise/policies/rawmaterials/ documents/index—en.htm

[2] "Energy Critical Elements: Securing Materials for Emerging Technologies" published March 2011 by APS (American Physical Society) and MRS (Materials Research Society).

—Business driven—Based on our long and deep expertise in metallurgy, chemistry and metal markets/application areas, we knew we could build on key strengths which make us very competitive in the recycling field. In fact, our recycling activities are in a Business Group that is a profit center within Umicore. Umicore has proven that sophisticated recycling technology provides not only ecological advantages but is a profitable business if conducted in the right way.

—Strategic—In the 1990s Umicore decided to transform itself from a mining and metallurgy company to a materials technology company and in the years since we have achieved that, developing downstream activities into leading global positions (both by internal growth and acquisition). The closed loop approach for us is hence an important way to secure our own raw material supply and get access to the precious and special metals we need to manufacture our products. It shows that vertical integration to secure the supply base cannot only be achieved by investing in mining activities but also in pushing the recycling. Furthermore, the closed loop approach allows us closer relationships with many of our customers to whom we supply our products and for whom we recycle later on, either for return of more product to them or for payment of metal content.

- Incentives—The strategic fit in Umicore's sustainability objectives and the business opportunities.
- Obstacles—Transforming a traditional mining company into a sustainability focused material technologies company is not an easy move and is not achieved overnight.

Internally it means adapting operational and functional structures and adjusting the mindsets of our workforce. Externally we are often confronted with difficult conditions in the recycling business, meaning that not all companies/countries are able to compete equally. Issues in this context are illegal exports of end-of-life materials, (environmentally) substandard treatment processes at some market participants, possible preferential treatment of imports and exports in some places and often poor general transparency in recycling markets.

Question 2. You mentioned in your testimony that there are 4 major steps in the recycling process: collection, dismantling, pretreatment and refinement. I have been told steps 1 and 2 occur more in the European Union than here in the United States. If this is the case, how was that capability built up? How do collection and dismantling in the EU?

Answer. Steps 1-3 (collection, dismantling, pretreatment) occur both in the United States and in Europe. Europe, however, has developed regulations that have lead to higher volumes of electronic scrap, automotive catalysts and batteries being collected than is the case in the U.S. This comes from legislative direction on targeted volumes for collection and recycling. One example is the EU Battery Directive* which requires that by 2012, 25% of all batteries sold in the European Union must be collected and recycled. That percentage increases to 45% by 2016.

Without collection in significant volumes, steps 2, 3 and 4 in the recycling process may not provide an economically viable business.

By comparison, in North America, the Rechargeable Battery Recycling Corporation (a non-profit set up by battery manufacturers and suppliers into North America) is the only nationwide collection organization for the consumer batteries of all types. A sorting and preparation step allows the organization to direct the different battery chemistries to the most effective recycling tool, whether in North America or Europe. Even with an extensive network of over 30,000 collection points, RBRC collects just over 10% of the batteries sold into this market.

Typically the first three steps in the recycling process should take place in the region where the materials arrive at their end of life. Dismantling and pretreatment are usually combined at the same facility and can include various combinations of manual and mechanical processes. These can differ by materials involved but also by operators or regional traditions. There are cases of the scrap being exported to countries where less sophisticated dismantling and pretreatment methods are used. It is often the case in those circumstances that yield is very poor and workers' health and safety are compromised. As long as the end-of-life products stay in the recycling chain that can recover the most critical materials and recover them most efficiently and with the least environmental impact, the value chain is maximized.

For complex, precious metal bearing materials such as circuit boards, automotive catalysts or mobile phones, the refining is driven by economics (technical sophistica-

* This information has been retained in subcommittee files.

tion and economies of scale). Umicore is a leading refiner and plays a significant role not only in Europe, but globally. The principal recycling chain in Europe for precious metals containing products is described in the attached article.[3] Please note that while the basic information in this article continues to be accurate, the article was written in 2006 and some of the quantities shown have since grown.

Our precious metals refinery as well as our rechargeable battery recycling facility receive feed from all parts of the world, including North America, Australia and Asia, in order to achieve economies of scale.

One more example for the current situation in North America: End-of-life (EOL) automotive catalytic converters are collected by a variety of small to medium size companies in cooperation with the local scrap yards and automotive dismantling facilities. Despite the high content of Platinum Group Metals (PGMs), only 50% are recycled. One impediment to a larger percentage is the export of used automobiles to markets outside the U.S. and Canada. Others are:

- Lack of knowledge that there are valuable metals contained in those catalytic converters (as well as in other parts of the car)
- Poor dismantling practices that capture only a portion of the metals-containing parts of the automobile
- Separation not done in a way to capture all the value that is present.

When looking at a way to make the recycling of electronic waste most immediately interesting and profitable, it can make sense to focus on the quality of recycling and not solely on quantity, For example, collection of end-of-life products containing valuable materials (examples: laptops and mobile phones) should be actively promoted and supported.

In the U.S. it is a fact that landfilling competes with recycling in the electronic waste and battery worlds. If there is no incentive for society to recycle their electronics and rechargeable batteries, if there is no education to show them (or the collectors) how valuable the metals contained can be, if there is no legislation in place that compels society to recycle, how can we move to the step of making recycling the norm? If nothing else, can we encourage people to put electronics inside a plastic bag that can then be put into their recycling bin? Then it will be up to the collectors to funnel the electronics to dismantlers or to other, specialized, collectors.

There is another aspect within the recycling chain to consider when it comes to availability of critical materials and that is the possibility to return the materials themselves to the suppliers that use them and have generated the scrap in the first place. Umicore often uses this tool for its automotive catalyst recycling, for example.

And let's move beyond the immediate practicalities to encourage companies (and our design and engineering students) to design their next generation devices, automobiles, batteries in a way that allows easy dismantling and access to those parts containing critical materials. It will make recycling that much simpler and the economics of collection that much more attractive.

SENATOR RISCH—ADDITIONAL INFORMATION IN RESPONSE TO SENATOR RISCH'S VERBAL QUESTION FOLLOWING ORAL TESTIMONY ON JUNE 9, 2011

The market failure in the system that could produce high-value recycled materials is very much like a chicken-and-egg problem—which comes first, the chicken or the egg? The problem is most acute with respect to end-of-life goods—electronics and small devices—held by American households.

First, the chicken. We do not have an infrastructure in place to collect a significant volume of household end-of-life goods; there is no easy, convenient way for most Americans to dispose of those goods for recycling. Where electronic waste recycling does occur in the U.S., it's mainly by varying local mandates, or voluntary collection drives, producing a hodge-podge, fragmented, low-volume approach. As a result, almost all Americans store their end-of-life electronics—like old personal computers—in their basements or attics, and they end up simply throwing in the garbage end-of-life small devices—like cell phones and mobile phones. The same is true for rechargeable batteries. Consequently, these goods are not collected in central locations where a market player could purchase them for recycling. They are instead landfilled, with environmental ramifications and loss of valuable critical materials that could have remained in the supply chain.

Second, the egg. We also do not have in the United States the plants that use best available technology to process end-of-life goods through the full recycling

[3] "Recycling of Electronic Scrap at Umicore's Integrated Metals Smelter and Refinery" Author: Christian Hagelukenken, Umicore. Published in "World of Metallurgy"—ERZMETALL 59 (2006) No. 3

chain, to achieve the end result of new materials from the discarded goods. Without these plants, there are few market purchasers for end-of-life goods that could drive the systematic collection of such goods.

So which comes first, the chicken or the egg? Actually, the question is better framed as, "How do we get both the chicken and the egg in the United States?" Let's look at the European Union for one possible answer.

We know that in Europe there are plants operating today that use best available technology to process end-of-life goods for recycling and produce new materials from the discarded goods. We also know that the raw materials for their process—the endof-life goods—are collected systematically and are available to these plants to purchase for their recycling processes. There are discussions going on in Europe to set separate collection targets for those products that contain the most valuable critical materials, to be certain those come into the recycling cycle.

The market works in these regions because the end-of-life goods are collected in significant volumes and within those volumes, higher value recyclables are targeted specifically as well. The end-of-life goods are then available for purchase and become the feedstock for these recycling process plants.

These facts from Europe would suggest that (1) we can replicate these recycling process plants in the U.S. (companies like Umicore could be interested in opening new plants) if (2) we encourage the systematic collection of end-of-life goods in the U.S. to be among the raw materials for these plants. Finding a way to jumpstart an infrastructure to collect end-of-life goods in the U.S. could be the key to unleashing the market dynamic that would create a supply of raw materials that would in turn lure recycling plants to the country. Thereafter, the market would likely grow significantly on its own.

We will be pleased to answer any additional questions that may arise after reading these responses.

RESPONSES OF DAVID SANDALOW TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. The most fundamental question to consider today is how we should go about determining exactly which minerals and materials are critical? The National Academy of Science recommended a method in their 2008 study whereby that determination can be made—this seems like a good starting point, but can we make a more focused definition of which materials are critical for energy technologies? How can we make sure that every mineral or material under the sun is not considered to be "critical"?

Answer. As part of the DOE Critical Materials Strategy, DOE assessed the criticality of various materials used in four clean energy technologies (electric drive vehicles, wind turbines, solar photovoltaic cells and fluorescent lighting phosphors). In conducting the criticality assessment, DOE adapted the National Academy of Sciences (NAS) methodology cited above, which uses two assessment dimensions. To address critical materials in clean energy technologies, DOE slightly modified NAS's "Supply Risk" dimension and replaced NAS's "Impact of Supply Disruption" dimension with "Importance to Clean Energy". Assessment scores for each dimension were based on a combination of qualitative and quantitative analyses.

DOE's assessment considered nine rare earth elements and five other elements used in clean energy technologies. In the short term, only six of the fourteen elements assessed were deemed as critical (dysprosium, europium, indium, terbium, neodymium, and yttrium) for clean energy technologies. The detailed assessment criteria and scores are given in Chapter 8 and Appendix A the DOE Critical Materials Strategy, which is available at http://energy.Rovisites/prod/files/piprod/documents/cms__dec__17__full__web.pdf.

Question 2. In the hearing, we discussed that there are real global market uncertainties surrounding critical mineral supplies—what risks would the domestic mining industry face in light of the fact that there are more broad global supply chain risks? In other words, how does the global uncertainty in the critical materials markets affect the US's ability to reconstruct a full domestic supply chain for these minerals and materials?

Answer. Uncertainty in critical materials markets can create challenges for U.S. businesses and make it more difficult to reconstruct a full domestic supply chain for these materials. There are both supply and demand strategies that reduce these difficulties and support a robust domestic supply chain. The difficulties are minimized when supply chains are globalized (instead of concentrated in single countries), substitutes are developed, and materials are used more efficiently. Better global markets and open trade policies can also play a role in helping to manage risks. Around the world, governments are working closely with businesses in their countries to address challenges and seize opportunities associated with critical materials markets. Recognizing the U.S. government's important role in working with U.S. businesses can help strengthen American competitiveness in this area and others.

RESPONSES OF DAVID SANDALOW TO QUESTIONS FROM SENATOR MURKOWSKI

INTERAGENCY COORDINATION ON REPORTS

In December of last year, the Energy Department published a very useful report on its "Critical Materials Strategy." It is my understanding that, before the end of this year, the department plans to release a new version of this report. As good as that first version of the DOE strategy was, I had some concerns that it did not demonstrate as much interagency coordination as it could have, and felt that some more specific solutions to the problems identified might have been helpful. For example, the report explained that the U.S. ranks dead last in permit processing, but merely stated that such activities were the Interior Department's responsibility.

Question 1. Can the Department of Energy commit to working in a more collaborative way on the next iteration of this Critical Materials Strategy, and perhaps publishing the next version jointly and with more specific proposals—under legal authorities you already have or need to see advanced by Congress—to solve some of the problems we face?

Answer. DOE is committed to working collaboratively with relevant agencies (Commerce, DOD, EPA, Interior, State) and components of the Executive Office of the President (OSTP, CEQ, USTR) in generating its Critical Materials Strategy. Throughout the preparation of the 2010 Strategy, DOE provided updates to and sought inputs from other relevant agencies both directly and through meetings of the EOP Interagency Working Group on Critical Mineral Supply Chains led by the White House Office of Science and Technology Policy (OSTP). For this year's updated Strategy, DOE envisions a deepened working relationship with relevant agencies based on last year's collaboration. The interagency working group will provide DOE and other agencies additional opportunities to collaborate on a range of topics, including establishing an economy-wide definition for criticality, identifying and prioritizing materials critical to our economy and national security, and identifying potential strategies for ameliorating the criticality of these materials. Building on close collaboration with USGS last year, DOE envisions working closely with USGS as well as DOUBLM this year to ensure application of the best available data and information pertaining to rare earth mining in DOE's 2011 Critical Materials Strategy.

DEADLINES

Question 2a. S. 1113 contains several deadlines, reporting requirements, and other activities that would be conducted pursuant to a deadline if the bill is enacted.

Please review all applicable deadlines contained in S. 1113 and provide an assessment of the Department's ability to meet them in a timely manner.

Answer. Section 106 contains a DOE reporting requirement on R&D programs for recycling and alternatives. Reports summarizing activities, findings and progress are required within 2 years of the passage of the act and then every 5 years afterwards. Assuming adequate resources, this timeline is reasonable, if it is understood that a first report would mainly focus on activities and progress, as R&D may take several years to produce findings. Assuming adequate resources, the timeline for the report requested in Section 210 is also reasonable.

Question 2b. S. 1113 contains several deadlines, reporting requirements, and other activities that would be conducted pursuant to a deadline if the bill is enacted.

If the Department feels it will be unable to meet any of the applicable deadlines contained in S. 1113, please provide an alternative timeframe that would be more workable from the agency's perspective.

Answer. For the report required in Section 202, detailed findings from R&D would likely take longer than 2 years because R&D may take several years to produce findings, similar to the R&D described in Section 106. Four or five years would be more reasonable.

COST ESTIMATES and EXISTING AUTHORIZATIONS

Question 3a. S. 1113 contains several authorizations to conduct research and development, develop methodologies, and engage in other activities not accounted for in existing budgets..

Please provide an estimate of the time and funds necessary to undertake such activities, assuming such provisions were fully implemented.

Answer. R&D programs required by sections 106, 202, 204, 205 and 206 of S. 1113 could build on R&D conducted by DOE's Office of Energy Efficiency and Renewable Energy, as well as other offices within DOE. The estimation of time and funds necessary to undertake such activities would be determined through budgetary deliberations.

Question 3b. S. 1113 contains several authorizations to conduct research and development, develop methodologies, and engage in other activities not accounted for in existing budgets.

If the department is able to conduct research and development, develop methodologies, and engage in any other of the aforementioned activities, under existing authorizations, please provide a comprehensive list of those authorizations cross-referenced to the relevant sections of S. 1113.

Answer. A number of existing DOE authorities could be read to authorize the types of research and development activities listed in S. 1113. However, none of these provisions expressly calls for the activities described in Titles I and II of 5.1113. Much of the specific R&D activity in S.1113 is authorized under the Energy Independence and Security Act (EISA) of 2007 (Public Law 110-140). Under section 452 of EISA, the Department of Energy is authorized to establish a program to "support, research, develop, and promote the use of new materials processes, technologies, and techniques to optimize energy efficiency and the economic competitiveness" of energy intensive industries. (42 U.S.C. 17111) Section 452 includes authority for efforts related to "flexible sources of feedstock" and "recycling, reuse, and improved industrial materials". Section 641 of EISA 2007 authorizes DOE to develop advanced storage methods. (42 U.S.C. § 17231). Advanced materials for renewable energy are also addressed in section 656 of EISA 2007 (42 U.S.C. § 17244). Research into alternative materials specifically for vehicle light-weighting applications are authorized under section 651 of EISA 2007. (42 U.S.C. § 17241) Additionally, other existing statutes could be read to allow the Department to engage in research, development, demonstration, commercialization, and technical and economic assessment activities for materials considered critical to domestic clean energy technology and the domestic clean energy industry, specifically 42 U.S.C. sections 5555, 5901 et seq., 9204, 12001 et seq., 16231, and 16272.

The authority in the 21st Century Competitiveness Act (Public Law 110-69), as amended, (codified at 42 U.S.C. § 16538) would allow ARPA–E to participate in many of the activities contemplated in S. 1113 sections 106, 109, 202, 204, 205, 206 and 210.

Response of David Sandalow to Question From Senator Udall

Question 1. We heard testimony from General Electric and Umicore on how their respective companies use and have developed recycling processes for critical materials. What is DOE doing in the area of R&D for recycling of critical materials? What is DOE doing in the area of post-consumer collection and other logistical challenges to recycling of critical materials?

Answer. The Department of Energy (DOE) has pursued electric vehicle battery recycling research for some time. For example, Argonne National Laboratory has, for a number of years, done work evaluating the potential for recycling of lithium-ion batteries in order to develop improved processes and maximize material recovery. DOE has also supported some recycling infrastructure. In 2009, the Department supported TOXCO to expand their current battery recycling operations in Lancaster, Ohio.

Research into recycling of materials identified as critical in last year's Critical Material Strategy is an increasing focus for DOE, with the intent of pursuing R&D that has the best potential to contribute to an economical supply of critical materials. For example, the proposed Critical Materials Hub will pursue separation technologies that can be economically applied to both mined ores and recycled product streams.

While DOE intends to pursue recycling as part of a strategy to address material criticality, it is important to keep in mind that post-consumer collection and logistics is primarily in the domain of other federal and state agencies. Furthermore, there may be opportunities to recycle from industrial waste streams.

Responses of David Sandalow to Questions From Senator Hoeven

Question 1. Why, in your estimation, has China been able to effectively develop its critical minerals program?

Answer. As part of its RE industrial policy, China has been investing in RE R&D since the 1950s. China has two key national research programs and four state laboratories on REs that house a total of around 3,000 scientists.

In the early 1990s, China entered the international rare earth market and quickly drove down global rare earth prices due to policies that encouraged production and exports. China's share of global RE production rose rapidly in the 1990s, and oversupply contributed to the closure of mines in the United States and other countries by 2001. Some experts have pointed to the lack of environmental controls as a factor contributing to low cost Chinese production.

Since the early 2000's, China's policies have moved toward a comprehensive industrial policy of directing production, restricting exports and encouraging domestic production in downstream RE-consuming industries. China has used export restraints and foreign investment policies on rare earths to develop domestic downstream manufacturing sectors, such as magnet and battery producers, and drive foreign manufacturers of high-technology products to relocate to China. Some have linked the Chinese government's efforts to enhance domestic production of higher value-added RE outputs to employment generation and the building of a vertically integrated RE industry. Outside of the rare earth industry, China is pursuing similar policies of export restraints with respect to indium and other metals and minerals.

Question 2. If China continues to develop its critical minerals program, how long until China has cornered the critical mineral development through either low cost production or mineral allocations? If they do corner the market, what is the implication for our national security?

Answer. China already dominates the market in certain materials, especially rare earth elements and indium. This dominance has been achieved through favorable resource endowments of these minerals as well as low labor costs, and industrial policies designed to maximize market share. With regard to rare earths, for instance, China has been the world's leading rare earth producer since 1996, and rapidly grew its share of global RE production when it entered the global market with high-volume, low-cost minerals in the 1990s. This affected the economic viability of deposits elsewhere. As a result of these developments, China currently produces more than 95 percent of global rare earth elements. Additionally, current economic reserves of indium are heavily concentrated in China, which accounts for about 73% of global reserves and half of indium refining.

China's dominance in certain critical material markets has implications for U.S. economic, energy, and defense objectives. In part, due to tightening export quotas imposed by China on all rare earth elements, prices of certain elements have risen by 300-2500% between 2009 and 2011. Sustained price increases could limit the ability of U.S. manufacturers to procure the material inputs necessary for production or, in some cases, impact the price of finished components and end products. Additionally, severe supply restrictions of critical materials due to tightened quotas could create shortages of certain technologies or dependence on foreign suppliers.

Response of David Sandalow to Question From Senator Coons

Question 1. How will the proposed innovation hub for critical materials differ from ongoing research programs at DOE, USGS, and the AMES national lab? Will there be opportunities for collaboration between the proposed innovation hub and existing researchers at universities and other national labs?

Answer. The proposed Critical Materials Hub will focus on flexible and adaptable materials processing, efficient separation techniques, and other novel approaches to reducing dependencies on critical materials. For example, the Hub will address industrial processes that are sufficiently adaptable to enable adjustment of process outputs to the changing economic and demand profiles of input critical materials. The understanding gained from these processing improvements will aid in optimizing critical materials use in existing components. Also, innovations in separations of chemically similar rare earth elements could promote increased, sustainable production of critical materials by significantly decreasing the time and cost of materials processing and reducing the environmental footprint of these processes. The Critical Materials Hub will pursue separation technologies that can be economically applied to both mined ores and recycled product streams. The R&D pursued by the Hub will complement the current DOE critical materials R&D portfolio.

This current DOE R&D portfolio includes work supported by the Office of Energy Efficiency and Renewable Energy (EERE) and ARPA–E that focuses on technology and product alternatives that reduce or eliminate dependence on critical materials. Current activities in EERE are centered on reduction or elimination of rare earths in electric drive motors, batteries, and magnesium alloys for vehicles. ARPA–E has recently issued a solicitation to fund 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. Several current ARPA–

E projects also focus on new magnet and battery technologies with reduction or elimination of rare earth elements as a goal.

The current DOE R&D portfolio also includes work supported by the Basic Energy Sciences (BES) program within DOE's Office of Science to elucidate the fundamental properties of lanthanides and actinides, including separation science relevant to advanced nuclear fuels. The Office of Science also supports work to investigate the atomic basis of materials properties and behavior and to improve materials performance, with an emphasis on magnetic materials containing rare earth additions.

The Hub will complement the existing efforts supported by DOE by addressing processing and separation challenges at multiple stages of the supply chain. The scope of the proposed Hub will be distinct from the current work on critical materials at the USGS and the DOE-supported work at Ames Laboratory. The USGS collects, analyzes, and disseminates information on the domestic and international supply of and demand for minerals and materials essential to the U.S. economy and national security. USGS also provides assessments of undiscovered mineral resources in the United States and around the world. The Hub will not conduct these types of analyses. Ames Laboratory, which is a DOE research facility run by Iowa State University, is a leader in rare earth research, with a focus on the synthesis of highest quality polycrystals and single crystals, advanced characterization methods, and first principles modeling and does not focus on the processing challenges the Hub will address.

Following the model of the existing Energy Innovation Hubs, the Critical Materials Hub will be competitively awarded to a self-assembled team of experts that may include members from academia, industry, and the national laboratories. The Hub model will drive these scientists and engineers to accelerate solutions to the most pressing critical materials problems and promptly transfer the knowledge to industrial partners who will be able to incorporate those solutions into the market.

RESPONSES OF MARCILYNN BURKE TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. Presently there is a lack of information on which critical minerals are present on public lands and what their present value might be. Do you have any estimates of the value of any of these minerals? What would you need to do to get an estimate of the present value of these mineral deposits?

Answer. The first step to get a full understanding of potential value of mineral resources on public lands is to inventory known reserves and resources and then conduct an assessment of undiscovered resources. The USGS recently completed an inventory of known principal rare-earth-element reserves and resources in the United States. Of these, approximately half are located on public lands. The next step is to define a list of other critical minerals that are important for the country's economic and national security and conduct an inventory of those reserves and resources. Once the inventories are complete, and proper geologic and grade-tonnage models are constructed for the critical minerals in question, then an assessment of undiscovered critical mineral resources may be conducted. By combining known resources with estimates of undiscovered resources, a more comprehensive understanding of resource endowment on public lands can be realized. The value of the mineral resources depends on many variables, including the cost of exploration and development, as well as market prices, all of which can fluctuate greatly during the time leading up to development.

Question 2a. The public gets a royalty for the extraction of other minerals, such as oil, gas, and coal mined from federal lands. Shouldn't a royalty be paid for critical minerals as well?

Answer. At this time, the BLM does not have a position with respect to royalty collection for strategic minerals. The Administration has proposed a gross royalty on some of the most valuable hard rock minerals (gold, silver, lead, zinc, copper, uranium, and molybdenum) produced from Federal lands by shifting these minerals to a leasing system.

Question 2b. How can we make sure that the American taxpayer gets a return on their investment in public lands where these mineral deposits are opened to mining?

Answer. Generally the BLM tries to secure a fair return for the American people for the use of their public land resources. However, the 1872 Mining Law does not authorize that a royalty be paid for the removal of locatable hardrock minerals. In order to ensure a better return to the taxpayer, the Administration has proposed a gross royalty on some of the most valuable hardrock minerals produced from Federal lands by shifting these minerals to a leasing system. This proposal does not currently include critical minerals. [Note: Minerals covered by the BLM/DOI hardrock legislative proposal are gold, silver, lead, zinc, copper, uranium, and molybdenum.]

Question 3. As you know, the disposition of hardrock minerals on public lands is governed by the antiquated Mining Law of 1872, which allows miners to locate claims and exclude other uses and mining developers. Some believe that these claims can be held for speculative purposes. Wouldn't it help ensure that critical minerals are developed diligently and in a more orderly fashion if a leasing system were put in place?

Answer. To date, industry has demonstrated little interest in developing critical minerals on public lands through the filing of notices of exploration and plans of operation. The Administration has proposed moving certain hardrock commodities into the existing leasing system. Permitting requirements for other Federal, state, and local authorizations would remain unchanged.

Question 4. At present, how many plans have been submitted to the BLM that are seeking to open a mine that would extract "critical minerals" from public lands? These "critical minerals" could include any of the minerals or elements as identified by the National Academy of Science in their "Minerals, Critical Minerals, and the US Economy" report or the DOE strategic plan on the same topic. If there are none pending, can you provide a history of any submitted plans within the past 10 years.

Answer. The BLM has not approved any mining plans of operations for critical minerals or rare earth elements during the past 10 years. Presently, none are pending; however the BLM expects to receive two plans of operations for proposals to commence mining minerals and elements from the NAS critical elements list. Both projects are located in Nevada.

- Lithium—proposed by Western Lithium in Kings Valley, Nevada. The plan of operations is expected to be submitted by third quarter 2011.
- Vanadium—proposed mine known as the Gibellini Project, south of Eureka, Nevada. The company is expected to file a plan of operations in 2011.

Question 5a. Can you describe the process that a potential owner/operator of a new mine has to go through to open a new mine?

Answer. The process of mining locatable minerals on public lands generally consists of the following steps, as broadly described in Geological Survey Scientific Investigations Report 2010-5220:

1) Proving the deposit (locating a mining claim, exploring the deposit, providing a financial guarantee or bond);

2) Mining and metallurgical planning (submitting a mining plan of operations to develop the deposit, compliance with the National Environmental Policy Act (NEPA));

3) Permitting the mine-BLM, other Federal agencies and the State (approval of plan of operations, seeking permits from Corps of Engineers, applying for a mine identification number and obtaining any needed plan approvals from the Mine Safety and Health Administration (MSHA), state and related agencies, providing a bond);

4) Construction of mine and plant (inspections of mine development, approvals from state for construction plans, periodic bond adequacy review);

5) Operation (mining, periodic safety and health inspections and monitoring by MSHA and possibly other federal and state regulatory agencies, periodic bond adequacy review);

6) Reclamation and closure (inspections of reclamation, bond release, closure of mining project in accordance with other federal and state regulatory agencies rules and regulations).

The steps listed above do not, for purposes of this answer, include capital formation and acquisition of project financing.

Question 5b. How many regulatory programs oversee any given mine operation, from concept design to the startup of commercial production-including all applicable environmental standards?

Answer. On Federally-owned lands, two regulatory programs-administered by the Forest Service (FS) (36 CFR 228) and the BLM (43 CFR 3809)-oversee a given mine operation.

In addition, mines on Federally-owned lands must also comply with all applicable state, Federal, and local permitting requirements. At the state level, there are often multiple permitting programs, largely focused on air and water quality, ground water protection, mining reclamation and mine safety matters. In most states, permitting programs to implement Federal environmental laws have been delegated to states by the Federal government, such as implementation of the Clean Air Act and Clean Water Act. State and local governments in some states may establish additional permitting requirements. Gold mines are also subject to air toxics regulation under the Clean Air Act.

Question 5c. Are these different from the regulatory programs that have oversight and enforcement authority over the mines during their operation?

Answer. Mining regulators with direct responsibility for oversight and enforcement of mines include the Federal land management agencies (BLM and FS), the Mine Safety and Health Administration (U.S. Department of Labor), and state mine inspectors as well as state mine permitting and reclamation agencies.

These agencies are distinct from the Federal and state agencies charged with regulating the various aspects of environmental laws. Generally, the environmental regulators are focused on a single resource such as air, water, or wildlife.

Question 5d. Can you describe each of these programs, their intent, and at what level of government they reside?

Answer. These programs are numerous. In 1999, the National Research Council provided sample descriptions of these programs in a report titled "Hardrock Mining on Federal Lands." The details of these descriptions are found in Appendix C of that report, which is copied and attached as Attachment 1 to these Questions for the Record.

The full report is available in Acrobat format from the National Academy Press Web site. (http://www.nap.edu/catalog.php?record__id=9682). The states may have modified, extended, or improved their regulatory programs; however, the BLM does not track closely this kind of information.

Question 6a. Is there any report that you are aware of that indicates that the US is last in permitting times?

Answer. The position of "last in permitting times" is derived from the 2011 edition of an annual report prepared by a mining consultancy, the Behre Dolbear Group, called "Ranking of Countries for Mining Investment, Where Not to Invest." The report is available on the company Web site, www.dolbear.com.

The same report lists the U.S. as No. 6 among the 25 nations evaluated in its favorability toward mining enterprises when taking into account six other rating factors in addition to mining delays.

Question 6b. How does the US permitting regime compare to other nations in the approval process and permitting of new mines?

Answer. The BLM has not conducted any surveys of mine permitting times generally. The Behre Dolbear survey gives the United States a one out of 10 possible points. The highest score was awarded to Australia, which received an eight out of 10 points.

Question 6c. Is this different for the reopening of old mines?

Answer. The BLM has done no surveys in this area, and the Behre Dolbear survey appears to make no differentiation between new mines and mines being reopened.

Question 7a. What exact role does the BLM play in the actual permitting process?

Answer. For mines on public lands, BLM:

- acknowledges Notices for exploration as specified by the 43 CFR 3809 regulations;
- approves Plans of Operations for mining operations and exploration as specified by the 43 CFR 3809 regulations;
- accepts and approves financial guarantees for both Notice-and Plan-level activities.

The BLM's approval of Plans of Operation requires environmental analysis under NEPA. Because of this requirement, the BLM generally serves as the lead agency for the environmental analysis and many of the other Federal and state permitting agencies become cooperators in that process.

Question 7b. Does the BLM issue permits? If not permits, then what?

Answer. The BLM does not issue permits. The BLM acknowledges notice level exploration, approves plans of operations, and approves financial guarantees.

Question 8. The most fundamental question to consider today is how we should go about determining exactly which minerals and materials are critical? The National Academy of Science recommended a method in their 2008 study whereby that determination can be made-this seems like a good starting point, but can we make a more focused definition of which materials are critical for energy technologies? How can we make sure that every mineral or material under the sun is not considered to be "critical"?

Answer. The 2008 National Academy of Sciences study was largely funded by the USGS and provides a good conceptual framework of how to consider the criticality of mineral commodities. With the NAS criticality concept as a foundation, the USGS is making progress on a more quantitative approach, whereby mineral commodities can be quantified in terms of risk of supply. Quantifying importance of use must be approached with specific industries in mind and involves an analysis of what mineral commodities have important applications in each of the energy, defense, transportation, health care, and agricultural industries, for example.

RESPONSES OF MARCILYNN BURKE TO QUESTIONS FROM SENATOR MURKOWSKI

PRINCIPAL STATISTICAL AGENCY—On April 15th, I released a discussion draft of the Critical Minerals Policy Act for comment. In reviewing those comments, I was struck by the number advocating for the designation of the minerals information offices at USGS as a "Principal Statistical Agency."

Question 1a. Please describe the logistical, managerial, functional, budgetary, and other differences between the current status of these offices and how they would be treated if designated as a Principal Statistical Agency.

Answer. In a 1997 Order Providing for the Confidentiality of Statistical Information, OMB established "a uniform policy for the principal statistical agencies" but appears to have used the term principal statistical agency informally. The Order lists twelve agencies under the heading "Designated Statistical Agencies or Units". These agencies were determined by OMB to be subject to the 1997 Order and thus obliged to implement certain policies on confidentiality of information (Federal Register, v. 62, No. 124, p. 35044-35050)[1]. The USGS is not included as one of the twelve agencies listed in the 1997 Order.

The Confidentiality Information Protection and Statistical Efficiency Act of 2002 (CIPSEA) defines a statistical agency or unit as "an agency or organizational unit of the executive branch whose activities are predominantly the collection, compilation, processing, or analysis of information for statistical purposes"[2]. OMB, which coordinates the implementation of CIPSEA, recognized 14 statistical organizational units as statistical agencies or units for the purposes of CIPSEA in its 2007 guidance on implementing the Act[3]. Neither the USGS as a whole, nor any part of USGS, is designated as a statistical agency or unit under CIPSEA.

The designation of an agency or unit as a statistical agency or unit for the purposes of CIPSEA subjects the agency to different confidentiality standards. CIPSEA statistical agencies or units must implement higher standards to protect data confidentiality than other statistical units. This involves increased physical and IT security measures, confidentiality training for all personnel, additional record keeping, informing respondents about the confidentiality protection and use of information, ensuring that information is used only for statistical purposes, ensuring that identifiable information is not disseminated, and supervising and controlling agents who have access to confidential information. CIPSEA does not convey specific authority to an agency. Rather, each agency's authority is defined in the statutes governing that agency. For example, some CIPSEA statistical agencies have mandatory data collection authority. In addition, there are differences in how the agencies are funded.

If a unit within USGS, such as the National Minerals Information Center, were to be designated as a statistical unit under the provisions of CIPSEA, that unit would have to implement additional IT and administrative security measures, increase personnel training, and meet additional reporting requirements to comply with the required higher confidentiality standards. The confidentiality of data collected by the National Minerals Information Center is currently governed by subsection (f) of the National Materials and Minerals Policy, Research, and Development Act of 1980 (30 U.S.C. 1604(f)).

Question 1b. Does the Administration support making this "Principal Statistical Agency" designation?

Answer. The Administration has not yet developed a position on the designation of the National Minerals Information Center as a Principal Statistical Agency. The Administration is in favor of a well supported and robust nonfuel mineral data collection and analysis function to provide timely information on nonfuel mineral supply and demand statistics and forecasts.

The mission of the USGS National Minerals Information Center (formerly the Minerals Information Team) is to col≥lect, analyze, and disseminate information on

[1] Order roviding for the Confidentiality of Statistical Information http://www.gpo.gov/fdsys/pkg/FR-1997-06-27/pdf/97-16934.pdf

[2] Confidential Information Protection and Statistical Efficiency Act of 2002 P.L. 107-347, title V http://www.gpo.gov/fdsys/pkg/PLAW-107publ347/pdf/PLAW-107publ347.pdf

[3] Implementation Guidance for Title V of the E-Government Act, Confidential Information Protection and Statistical Efficiency Act of 2002 (CIPSEA) http://www.gpo.gov/fdsys/pkg/FR-2007-06-15/pdf/E7-11542.pdf

the domestic and international supply of and demand for minerals and mineral materials essential to the U.S. economy and national security.

The Center's goal is to provide decision makers with the information required to ensure that the Nation has an adequate and dependable supply of minerals and materials to meet its defense and economic needs at acceptable costs related to environment, energy, and economics.

The USGS does not anticipate designation of the national Minerals Information Center as s Principal Statistical Agency will improve our ability to meet this goal.

Question 1c. Are there benefits to making such a designation, in terms of gathering information that is not currently available, or downsides, in terms of the relationships already established with those providing minerals information on a voluntary basis?

Answer. The USGS believes that such a designation would have little impact on the quantity and quality of data currently collected through a long-standing trust-based voluntary system. The public and private sectors rely on USGS minerals information to understand better the use of materials and the ultimate disposition of materials in the economy, to use national resources efficiently, and to forecast future supply and demand for minerals.

The National Minerals Information Center canvasses the nonfuel mining and mineral-processing industry in the United States for data on mineral production, consumption, recycling, stocks, and shipments. More than 140 surveys are conducted annually on commodities-from abrasive materials to zirconium. Aggregated U.S. statistics are published because individual company data are proprietary and are not released. More than 18,000 producer and consumer establishments voluntarily complete about 40,000 survey forms annually. The USGS has cooperative agreements with the U.S. State governments to exchange data. In addition, the Center reports U.S. trade data collected by the U.S. Department of Commerce.

International minerals information is directly obtained through questionnaires and exchanges from approximately 100 countries annually.

Question 1d. Are there any other issues that the Senate Energy and Natural Resources Committee should consider or be aware of in deciding whether or not such a designation should be made?

Answer. Designation of USGS's nonfuel mineral data collection effort as a statistical agency or unit under the provisions of CIPSEA would result in a requirement for increased documentation, increased administrative and IT security measures, and increased staff to implement the increased confidentiality measures. We do not anticipate that such a designation would improve our ability to provide decision makers with the information required to ensure that the Nation has an adequate and dependable supply of minerals and materials to meet its defense and economic needs at acceptable costs related to environment, energy, and economics.

Question 2. In reviewing my legislation, S. 1113, can you tell us whether it amends, weakens, or in any way modifies existing regulatory programs meant to ensure environmentally-responsible conduct?

Answer. The language of the bill does not appear to directly affect the BLM's existing regulatory programs.

PACE OF PERMITTING—Behre Dolbear's most recent "Where Not to Invest" report states that "permitting delays in the United States are the most significant risk to mining projects. the United States is ranked lowest, at a 1 due to the average 7-to 10-year period required before mine development can begin."

Question 3. Would you describe the Administration as satisfied or dissatisfied with the fact that the United States is last in the world when it comes to mine permitting?

Answer. The BLM on average takes four years to approve a mining plan of operations for a large mine (more than 1,000 acres) on public lands. A number of factors contribute to the duration of this approval period, including the BLM's NEPA obligations and its responsibility in reviewing a proposed mining plan of operations on public lands to ensure that prospective mine operators address environmental protections for water, air quality, and other natural resources in compliance with the laws of the United States. We continuously strive to improve the efficiency of our process. In addition, a number of factors outside the BLM's control contribute to the duration of the period before mine development begins, including the filing of mining plan modifications by the operator, delays by the operator in the posting of bonds, and litigation by third parties.

Factors contributing to mine plan approvals that require longer than four years include litigation and appeals, state and local permitting, and other federal state, and local authorizations. These longer time periods before mine approval may also include time the operator spends exploring the site under a notice, before filing a mine plan of operations to the BLM.

DUPLICATIVE AUTHORITIES—The Department's written testimony asserted that "many of the activities called for in S. 1113 are already authorized by existing authorities."

Question 4. Please provide a detailed list, cross-referencing those authorities contained in S. 1113 that the department feels are duplicative with relevant sections of the U.S. Code, including full citations and naming of the relevant, underlying statute(s) noted.

Answer.

S. 1113 Provision	Existing Authority
Secs. 101, 103, 107, 203, 207, 208, 209, 211	Organic Act of March 3, 1879; 43 U.S.C. 31 et seq.. Strategic and Critical Materials Stock Piling Act of 1946, 50 U.S.C. 98g. National Mining and Minerals Policy Act of 1970; 30 U.S.C. 21a. National Materials and Minerals Policy, Research and Development Act of 1980; 30 U.S.C. 1601 et seq., especially 1604(e) and (f)..

DEADLINES—S. 1113 contains several deadlines, reporting requirements, and other activities that would be conducted pursuant to a deadline if the bill is enacted.

Question 5a. Please review all applicable deadlines contained in S. 1113 and provide an assessment of the Department's ability to meet them in a timely manner.

Question 5b. If the Department feels it will be unable to meet any of the applicable deadlines contained in S. 1113, please provide an alternative timeframe that would be more workable from the agency's perspective.

Answer. The BLM believes that the deadline imposed by the reporting requirement at Sec. 104 (d) would be difficult to meet, due to the size and nature of the request. Such a task would require data calls from multiple agencies and stakeholders. It would require the redirecting of staff resources from other priority work since much of this data is not centrally located and would require manual extraction from case records which would then need to be collected and analyzed. It is unknown if any of the Department's databases would be adequate to collect and analyze the collected data. The ability of other agencies within the Department of Interior to meet these deadlines is unknown.

The USGS recommends the following:

S. 1113 Provision Deadline	Deadline Recommended
Sec. 101 (a): 30 days	90 days. It will take time to realign staff and projects to position ourselves to begin conducting the activities called for in this bill..

S. 1113 Provision Deadline	Deadline Recommended
Sec. 101 (c): 120 days	240 days. It is estimated that the draft methodology will be available for comment on the federal register for 30 days (120 days from enactment). An additional 30 days will be required to review public comments and revise the draft methodology accordingly (150 days from enactment). Establishing a National Academy committee and the time required for the committee to review the methodology is expected to be an additional 90 days (240 days from enactment)..
Sec. 101 (d): 150 days	270 days. Reviewing the National Academy committee's recommendations and revising the methodology accordingly is estimated to require 30 days (270 days from enactment)..
Sec. 101 (e): 150 days	360 days. It is estimated that the final methodology will be available for comment on the federal register for 30 days (300 days from enactment). Final determination of critical minerals using this methodology will require an additional 60 days (360 days from enactment)..
Sec. 103 (a): 4 years	As provided..
Sec. 104 (e), (f)(2): 4 years	5 years. One year from time of completion of assessment activities will be required to compile, synthesize, report , and publish final assessment results..
Sec. 211 (a): 21 months	24 months. This will be the time required if only an inventory of identified resources for these mineral commodities is called for and not an assessment of undiscovered resources. No previous national assessments of these mineral commodities exist, so updating assessments is not applicable..
Sec. 211 (d): 2 years	30 months. An additional 6 months from completion of inventory will be required to analyze, compile a report, and publish results..

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COST ESTIMATES and EXISTING AUTHORIZATIONS—S. 1113 contains several authorizations to conduct research and development, develop methodologies, and engage in other activities not accounted for in existing budgets.

Question 6a. Please provide an estimate of the time and funds necessary to undertake such activities, assuming such provisions were fully implemented.

Answer. From the BLM's perspective, the extensive nature of this request would require an expenditure of no less than $1 million with additional funding needed for a database. The primary cost would be data collection, which must be done manually. The BLM does not have personnel available to collect this data and a third-party contractor would likely be needed. In addition, the modification of an existing database or a creation of new database to collect, store, and analyze the requested data would be necessary.

Question 6b. If the department is able to conduct research and development, develop methodologies, and engage in any other of the aforementioned activities, under existing authorizations, please provide a comprehensive list of those authorizations cross-referenced to the relevant sections of S. 1113.

Answer.

S. 1113 Provision	Time required	Funds Required	Existing Authorizations
Sec. 101	1 yr	$1M	Strategic and Critical Materials Stock Piling Act of 1946; 50 U.S.C. 98(g).
Sec. 103 (a); (d)	4yrs; 5 yrs	$20M	Organic Act of March 3, 1879; 43 U.S.C. 31 et seq.. Mineral resource assessment work on certain public lands is authorized under the Wilderness Act of 1964; 16 U.S.C. 1133; the Federal Land Policy and Management Act of 1976; 43 U.S.C. 1711, 1782.; the Alaska National Interest Lands Conservation Act of 1980; 16 U.S.C. 3150.
Sec. 107	6 yrs	$8M	National Materials and Minerals Policy, Research and Development Act of 1980; 30 U.S.C. 1601 et seq., especially 1604(e) and (f)..
Sec. 211 (a) (d)	24 months (if inventory of identified resources and not assessment of undiscovered resources); 30 months	$5M	Organic Act of March 3, 1879; 43 U.S.C. 31 et seq..

RESPONSES OF MARCILYNN BURKE TO QUESTIONS FROM SENATOR COONS

Question 1. Are geologic occurrence models adequate to effectively explore for REE?

Answer. The USGS is currently updating existing mineral deposit models for the important rare earth element (REE) bearing mineral deposit types. These models provide the fundamental geologic framework in which to understand why such deposits form and why they formed where they have in the earth's crust. This information is used to predict where undiscovered deposits are likely to be found. Once these geologic models are complete, they will be adequate to explore for and assess undiscovered REE deposits.

Question 2. Are geologic occurrence models adequate to effectively estimate endowments of REE for the USA, China, and less well-known parts of the world like Afghanistan?

Answer. To understand an endowment requires an inventory of known reserves and resources and an assessment of undiscovered resources. An assessment of undiscovered resources requires up-to-date global grade-and-tonnage models for each specific type of REE-bearing deposit. Currently the grade-and-tonnage models for the important REE-bearing mineral deposits are inadequate and in need of updating. The USGS recently completed an inventory of known principal REE reserves and resources in the United States. An estimate of domestic undiscovered REE resources cannot be made until grade-and-tonnage models are adequately updated and constructed. This also applies to estimating endowment for areas outside the United States.

APPENDIX II

Additional Material Submitted for the Record

STATEMENTS OF UMICORE

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE) UPDATE

The European Commission adopted its draft proposal for a revised directive on WEEE in December 2008 following a public consultation and impact assessment. The revision aims to improve implementation and compliance, in particular through addressing the low collection rate of WEEE, diverging requirements for producers, sub-standard treatment in the EU and illegal exports of outside the EU.

The proposal is now in the legislative decision-making process, when the European Parliament and the Council (Member States) amend and then adopt the proposal. As the Council (Member States) and the European Parliament had different views on several provisions, a first reading agreement could not been reached (the European Parliament voted in first reading in November 2010 and the Member States reached political agreement in May 2011). As such, the directive will enter the second reading procedure, which means a final agreement could be reached by end of this year or early next year.

Revised/new provisions

Scope: the directive should apply to EEE falling under the following ten categories: large household appliances, small household appliances, IT and telecommunications equipment, consumer equipment, lighting equipment, tools, toys, leisure and sports equipment, medical devices, monitoring and controlling instruments and automatic dispensers. *Note* that the final agreement could refer to an open scope, which would include all EEE with a few exceptions (the European Parliament and several Member States support an open scope).

Product design—measures to promote the design and production of EEE in view of facilitating re-use, dismantling and recovery should be promoted.

Collection target—the revision proposes a new collection target of 65% of the average weight of EEE placed on the market of each Member State in the two previous years to be achieved annually by producers or third parties acting on their behalf starting in 2016. The objective is to further boost collection while taking into account the variations in EEE consumption in each Member State (the current "one size fits all" target of 4kg per inhabitant per year of WEEE from households has led to sub-optimal targets for some countries and too ambitious for others). The proposal foresees several flexibilities such as possible transitional measures for Member States and a reexamination of the rate later on by the European Parliament and Council.

Separate collection—the disposal of untreated separately collected WEEE is prohibited and the collection and transport of separately collected WEEE should be carried out in a way which optimizes re-use and recycling and the confinement of hazardous substances. Cooling and freezing equipment containing ozone depleting substances and fluorinated greenhouse gases are considered priority products for which a high level of separate collection is to be targeted.

Recovery and Recycling targets—the existing recovery and recycling targets set per product category are increased with 5%. Also, in order to encourage the re-use of whole WEEE, the revision proposes to include re-use of whole appliances in the increased target for recycling combined with re-use (one target for recycling and re-use). These targets are calculated for each category as weight percentage of separately collected WEEE that is sent to recovery facilities.

Treatment requirements—Member States should ensure that all separately collected WEEE undergoes proper treatment. *The European Parliament and the Council amended the Commission proposal calling for the development of standards for treatment, including recovery, recycling and preparing for re-use.*

Financing WEEE from private households—calls for Member States to encourage producers to finance all the cost occurring for collection facilities for WEEE from private households.

Information for users—producers are allowed to show purchasers a visible fee at the time of sell of new products for the costs of collection, treatment and disposal

Producer Registration—the revision proposes the harmonisation of the registration and reporting obligations for producers between the national producer registers, including making the registers inter-operational, with the view to reduce the administrative burden related to WEEE implementation.

Enforcement—in order to strengthen the enforcement of the WEEE Directive, in particular to distinguish between EEE and WEEE in the case of shipments of used EEE, minimum monitoring requirements for shipments of WEEE are proposed. Such requirements include: a copy of the invoice and contract relating to the sale and/or transfer of ownership of the EEE which states that the equipment is for direct re-use and fully functional, evidence of evaluation or testing of the EEE and sufficient packaging to protect the shipped products from damage during transportation, loading and unloading.

In response to Item "5—Crosscutting Questions" of the Department of Energy Quadrennial Technology Review Framing Document, Umicore has the following comments:

2) How do we balance international competitiveness against international cooperation?

There is an example Umicore recognizes from its own experience, where international collaboration is the core of the projects covered. That is the European Commission FP7 research programs. The Seventh Framework Programme (FP7) bundles all researchrelated EU initiatives together under a common roof to reach the goals of growth, competitiveness and employment. Further details available at http://cordis.europa.eu/fp7/home_en.html. Umicore is actively committed to several of such programs, which broaden the scope of work and collect expertise from different viewpoints. We find this a very enriching experience.

Collaboration can also be at a national level; e.g. in Germany where Umicore is a member of the Development Plan for Electric Mobility. The Plan intends to speed up research and development for battery electric vehicles as well as the market preparation and introduction for those vehicles. Ultimate target: 1 million EV's on the road by 2020.

Programs such as these assist Umicore in defining its own materials development.

3) What principles should the Department follow for allocating resources among technologies of disparate maturity and potential time to impact?

Put in place across the board a defining strategy that integrates both materials development and recycling. This "closed loop" model ensures that whatever the level of maturity, the resources will be put to the best use.

d) What are useful metrics to guide DOE technology activities?

- Increased energy efficiency
- Lower environmental impact

Wherever possible, use quantitative metrics that clearly link to the objectives of the programs as well as to general sustainable development principles. These metrics should measure the progress made relative to the starting point and can have their origins in engineering sciences. These could be energy efficiency and environmental impact metrics; for example, the categories used inLife Cycle Analysis:

- Green house gas potential
- Emission of hazardous substances—Recycling of waste streams (e.g. recycling of wastes from the production of energy materials or technologies or recycling of process water)
- Or amount of waste that cannot be recycled.

Furthermore a combination of different metrics will be necessary to cover all aspects of technology performance.

An example from our own organization: Umicore Battery Recycling has evaluated its recycling process for battery materials versus primary production of battery materials by using exergy as a metric (besides other metrics in the technology development phase), to express preservation of material quality as well as the lower use of energy resources. The two items are linked as the recycling of batteries preserves the material so it can be used for new batteries, it avoids the mining of virgin materials (at high energy cost) and it preserves the efforts (energy) invested in the battery material during mining and processing in its first life cycle. Furthermore the high purity of the materials in the used batteries means that less effort (energy) is necessary to obtain high-quality materials again. Umicore combined this with a highly energy-efficient recycling (smelter) technology, which uses as little energy as possible. See "The global life cycle of rechargeable Lithium ion batteries: what natural resource savings can be gained through recycling?"—Jo Dewulf, Ghent University together with Umicore http://www.batteryrecycling.umicore.com/download/show_LCM2009CapetownJoDewulf.pdf

7) Have we correctly identified and structured these six strategies?

A critical component that we do not see incorporated here is acknowledging the role of the supply of materials in achieving the goals of the strategies, and as a consequence the energy needed to mine, refine, manufacture (= supply) the materials is not taken into account. The demands for energy and materials are closely interlinked as it takes energy to produce the materials that can enable the clean energy future. Recycling of metals requires much less energy than their primary production, hence recycling is a core technology in achieving a clean energy society.

Recovering metals from production scrap and waste and from end-of-life products needs much less energy than production from primary resources. For aluminum for example, recycling uses only 25% of the energy demand for virgin aluminum production, hence produces also 1/4th of the CO_2 emissions. For the more noble metals such as cobalt, the platinum group metals and metals such as indium, tellurium or selenium the energy savings made by recycling the metals can be even larger. Therefore recycling is a core energy technology. Producing metals via responsible recycling means that the industry will emit less CO_2 and the possibilities for new recycling industry and associated manufacturing industry in the U.S. can increase. The energy demand in the industrial sector will be lower as well. In addition, further advancements (innovation) in the energy efficiency of the recycling processes can drive down the energy consumption further, resulting in a "double gain" in the field of energy savings.

This leads Umicore to recommend that the DOE include in all its R&D programs, across the six strategies:

1) the notion that recycling of materials/products and energy-efficient production of metals and materials reduce the demand for energy, thereby serving as the underpinning of a sustainable long-term policy around clean energy technology research

2) a life cycle and systems approach to the evaluation of the reduction in energy usage over time

3) the notion that the materials, devices and/or technologies developed need to be designed from the beginning as recyclable, making certain the energy footprint of recycling is low. Or more generally, that the new technology is performing better than the current technology in all aspects—holistically, in terms of energy and material usage and from the environmental perspective

4) appropriate metrics be used that support the evaluation of the performance from an energy and materials sustainability point of view

5) recycling and materials sustainability should be demonstrated.

To support the implementation of the above we suggest assigning a dedicated person who can take the lead on recycling and materials efficiency, and is responsible for embedding this underpinning and cross-cutting theme throughout the six strategies. Although this may sound huge and a near-impossible transformation, Umicore, as a global company, is proof that such a transformation is possible. Umicore has transitioned from a company active in metals production from mining to a company that produces materials for clean technologies, and produces these metals mainly from industrial by-products and end-oflife products using highly energy efficient, clean recycling technologies. This strategic business decision has resulted in high levels of innovation within the company and has stimulated research and innovation via collaboration with many university partners and inhouse R&D centers. It has created high-tech manufacturing and industry jobs. Including recycling and the concept of energy-efficient materials supply into the program offers the United States also the possibility to stimulate innovation and contribute to national and global sustainability, as well as (partly) de-coupling itself from fossil fuels and dependence on other countries for metals supplies. The end-of-life products necessary for recycling are, in many cases, already located within the United States.

Please see also our response to item 8 for examples of how Umicore is already working within the six strategies.

8) We welcome comment on the selection of these technologies and sources, as well as suggestions of alternate technologies and sources, and updated technology, cost and forecast data, particularly in rapidly-moving fields.

Umicore's concerns about the need for energy efficient materials production and recycling are indicated in the items above. There are direct and indirect relations between the materials and processes in which we are involved and we see value in developing a kind of network structure among all the different players in the industry: a byproduct or waste from one can easily be the raw material for another, for example. So rather than keep each entity within one box of the Six Strategies structure, we'd prefer diagonal lines connecting wherever possible.

Specifically on 6.1.1.1—Transport—Increase Vehicle Efficiency—Light-weight materials

DOE mentions the stimulation of the use of light weight metals like aluminum, magnesium and other materials to reduce the vehicle weight. Further supporting our comments in section 7, we like to use this as a specific case. Despite the fact that most of the vehicle energy consumption takes place in the use phase of the vehicle, it will be important to also look at the energy investments made into the light weight materials. This implies looking at the energy efficiency of the light metal primary production process as well as stimulating recycling of the light weight materials.

Recycling of the light weight materials is not straightforward however, as the connection of the light weight material to other materials, coatings etc. influences the effectiveness of the recycling process and the material losses incurred. This is where the initial design comes in and can facilitate recycling of the materials later on. In addition, the appropriate recycling strategies and technologies need to be developed and/or improved. Furthermore, recycling lowers the energy demand of the metals manufacturing industry hence has a direct link to Strategy 6.2.1—Building and Industrial Efficiency. All of this allows for additional opportunities for innovation and clean technology developments.

Appropriate metrics to evaluate are necessary. In this regard we can suggest reading the following in the area of magnesium and metrics:

1) "Coated magnesium—Designed for sustainability" by C.E.M. Meskers, PhD thesis Delft University of Technology, 2008.

2) C.E.M. Meskers, M.A. Reuter, U. Boin and A. Kvithyld. "A fundamental metric for recycling applied to coated magnesium" metallurgical and materials transactions B vol 39, no 3 pp 500-517, 2008

3) C.E.M. Meskers, Y. Xiao, R. Boom, U. Boin and M.A. Reuter. "evaluation of the recycling of coated magnesium using exergy analysis" Minerals Engineering vol 20 no 9 pp 913-925, 2007.

Specifically on 6.1.2.1—Transport—Progressive Electrification of the Vehicle Fleet—Batteries

Umicore has done extensive work in this field that can support deployment of one million EV's by 2015. Based on its "closed loop" business model (strategy that integrates materials development and recycling), Umicore develops material designs and materials solutions for the battery and OEM customers that contribute both to better quality and to cost reduction (lower US$/kWh) while also developing a unique recycling process for rechargeable batteries. Work is focused in the following areas—often based on funding provided by Belgian, other European, and South Korean programs.

1. Operating a state of the art industrial recycling plant while at the same time continuing to improve its processes
2. Development of next generation Li Ion cathode materials (with capacity, safety, recyclability and cost as main drivers)
3. Development of new Li Ion anode materials (same targets)
4. Exploring the limits of Li Ion chemistry by combining both cathode and anode materials to make the best Li Ion battery possible
5. Further improving the driving range of EV's with post Li Ion battery systems, while contributing to better cost/performance
6. Providing a material solution to the customer through collaboration with other battery component suppliers (eg. Electrolytes, binders)
7. Performing safe dismantling of used batteries and providing suggestions for more optimized designs

Research and development is the cornerstone to realize these successfully and the pilot production of batteries is key and available. In the case of Umicore, the R&D is both applied and fundamental. It is related to product and process innovation. The innovation is based on a profound knowledge of the application and a high quality network within the academic and industrial worlds.

Metrics for battery materials are related to the US$/kWh ratio by the use of less expensive and future recycled base materials and by the improvements in their capacity on both cell and system levels.

THE BATTERY DIRECTIVE SUMMARY

The directive aims at minimising the negative impacts of batteries and accumulators on the environment. This should be achieved by reducing the use of hazardous substances in batteries and accumulators (in particular, mercury, cadmium and lead) and by treating and recycling the amounts of used substances.

It applies to all types of batteries and accumulators, including (H)EVs (exception: batteries used in equipment to protect Member States' security or for military purposes, or in equipment designed to be sent into space).

In order to ensure that a high proportion of spent batteries and accumulators are recycled, the directive sets out collection and recycling targets. As such, Member States must establish collection schemes to promote and maximise separate waste collections and prevent batteries and accumulators being thrown away as unsorted municipal waste. Collection rates of at least 25% and 45% based on annual sales have to be reached by September 2012 and September 2016 respectively. Furthermore, as batteries and accumulators need to be easily removed, Member States should ensure that manufacturers design their appliances accordingly.

The directive also foresees that treatment and recycling are performed using the best available techniques and establishes minimum recycling efficiencies, focused on the output of the recycling process. The recycling process of lead-acid batteries should recover all the lead and 65% of the average weight of those batteries. The recycling process of nickel-cadmium batteries should recover all the cadmium and at least 75% of the average weight of those batteries. For other batteries, the recycling process should recover 55% of the average weight. Treatment and recycling may be performed outside the EU provided it fulfills similar requirements to those in the EU. The methodology to calculate the recycling efficiencies as well as the criteria for assessment of similar conditions for treatment and recycling outside the EU need to be further developed by the European Commission.

The producers have to bear the cost of collecting, treating and recycling batteries and accumulators, as well as the costs of campaigns to inform the public of these arrangements.

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