S. HRG. 111–750

# RARE EARTHS

## HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

TO

EXAMINE THE ROLE OF STRATEGIC MINERALS IN CLEAN ENERGY TECHNOLOGIES AND OTHER APPLICATIONS, AS WELL AS LEGISLATION TO ADDRESS THE ISSUE, INCLUDING S. 3521, THE RARE EARTHS SUPPLY TECHNOLOGY AND RESOURCES TRANSFORMATION ACT OF 2010

SEPTEMBER 30, 2010

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## STATEMENTS

**THURSDAY, SEPTEMBER 30, 2010**

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

The subcommittee met, pursuant to notice, at 10:05 a.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. Good morning. The Subcommittee on Energy of the Energy and Natural Resources Committee will come to order.

I thank everyone for being here today.

The purpose of this hearing is to explore the role of rare minerals in clean energy technologies and other applications. It is also to understand the ramifications and vulnerabilities of U.S. dependence on overseas sources of these materials and what kind of corrective policies are appropriate.

When people think of strategic minerals for modern technology, they are also thinking of the so-called rare earth elements, 17 elements on the periodic table with strange names like samarium, promethium, and europium. Rare earths are employed in a wide range of high-tech products that are increasingly essential to our modern lifestyles and our future economic growth and national security.

Rare earth elements undergird our daily lives. They are used in the catalytic converters in cars we drove here today. They are the catalysts that petroleum refiners use to make gasoline that went into the cars. They are found in televisions that we watched this morning and in the BlackBerries that some people in the audience are using right now.

They are essential to our national security. They are used in defense applications, including jet fighter engines, missile guidance systems, anti-missile defense, and communications satellites.

Then there is the particular emphasis of today's hearing: clean energy technology.

Here too, rare earth elements are finding wide application, particularly in the most efficient, cutting-edge applications, including rechargeable batters for electric vehicles, generators for wind turbines, and glass for solar panels.

Beyond the official rare earths are numerous other strategic minerals that also play a critical role in modern clean energy technologies. They include copper, lithium, indium, gallium, selenium, cadmium, cobalt, and others.

While not all of these are rare, the United States is increasingly dependent on foreign providers for many of them. We are not just dependent for the ore; we are dependent on others for many of the refining steps in the supply chain process.

With such wide-ranging applications for these minerals in such critical technologies, the issue of ensuring a secure supply of strategic minerals is paramount.

Fifteen years ago, the United States was the world's largest producer of rare earth elements. Since then our country has become almost entirely dependent on imports from China. Unfortunately, the Chinese industry is on track to absorb all Chinese rare earth production as soon as 2012. In July, China's Ministry of Commerce announced that China would cut its export quota for rare earth minerals by 72 percent, raising concerns around the world about supply disruptions.

With the country pushing to increase its production of wind, solar panels, consumer electronics, and other products, the demand for rare earths is soaring. There is evidence that China plans to use their exclusive access to rare earths as a competitive advantage in clean energy products. As China's former President Deng Xiaoping reportedly said in 1992, "There is oil in the Middle East and there is rare earth in China."

Fortunately, most rare earths and other strategic minerals are fairly widely dispersed around the world. According to research compiled by the Congressional Research Service, China holds 36 percent of the world's reserves and the U.S. holds about 13, and the rest is distributed in other countries.

Experts expect capacity to be developed in the United States, Australia, and Canada within the next 2 to 5 years. Due to long lead times between discovery of deposits and producing elements, supply constraints are likely in the next few years.

Then there is the fact that rare earth mining, like all hard rock mining, raises a host of environmental concerns. The last major rare earth mine in the United States was closed in 2002, and there are a variety of reasons for that closure, but according to the New York Times, environmental contamination played a role.

So as we are considering the prospects of resuming rare earth mining in this country, we must make sure we are doing all that we can to make sure it is done in a responsible way.

It is also important that we look at the entire supply chain for rare earths and other strategic materials, not just mining. A major issue for the United States is the lack of refining, alloying, and the metal fabrication capacity to process any rare earths that we might produce. Even if we were to increase rare earth mining in the United States, we still have to send much of that extracted material overseas to China for its processing.

So today's hearing is to discuss all of that, and I want to thank our witnesses for being here.

First, we are going to hear from Secretary Sandalow, and in the second panel, we are going to hear from Dr. Roderick Eggert, who is Professor and Division Director of the Division of Economics and Business at Colorado School of Mines from Golden. Thank you for being here. Mr. Preston Rufe—I am not sure I am pronouncing that right. Maybe my colleague will help us on that. Mr. Peter Brehm who is from Infinia technology in Kennewick, Washington. So we appreciate all of you being here.

I am going to turn to my colleague, the ranking member, Senator Risch, for his opening statement, and again thank him for being here so we can hold this important hearing.

[The prepared statement of Senator Murkowski follows:]

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

Thank you, Chairwoman Cantwell, for holding this important hearing and for allowing me to submit my written statement to its Record. I especially appreciate this Subcommittee's attention to S. 3521, the Rare Earths Supply Technology and Resources Transformation Act of 2010, which I introduced this past June along with five co-sponsors.

From experience, we know that clean energy technologies face a range of obstacles. The credit crunch has slowed capital investment, disputes have arisen over which lands are suitable for infrastructure, and the electric grid has sometimes proved incapable of handling new generation. Most alternative and renewable resources are still much more expensive than their conventional counterparts, and many are also intermittent or unreliable in nature.

Over the long run, however, our most difficult challenge may be our most fundamental: ensuring a stable supply of the raw materials needed to manufacture clean energy technologies in the first place. According to the U.S. Geological Survey, our nation's reliance on foreign minerals has "grown significantly" over the past several decades. In 2009, we imported more than 50 percent of our supply of 38 different minerals and materials, and we were 100 percent dependent on foreign countries for some 19 of those commodities. That's up significantly from just seven mineral commodities in 1978.

This growing dependence is important because minerals offer our best chance to harness the potential of clean energy. Even now, we import 100 percent of the quartz crystal used in photovoltaic panels, the indium used in LED lighting, and the rare earth elements used in advanced vehicle batteries and permanent magnets. The large quantities of minerals required for clean energy technologies only add to the scale of our needs. A large wind turbine can contain more than one ton of rare earth elements—in addition to more than 300 tons of steel, nearly five tons of copper, and three tons of aluminum.

Taken together, recent trends in our nation's mineral consumption signal a little-known, yet rather worrisome, trend: as our demand for minerals has risen, so too has our dependence on foreign nations for their supply. And even though clean energy technologies currently account for a fraction of worldwide mineral consumption, we're already seeing strains in global supplies.

Many countries have undertaken a 50-year, or longer, view of the world and continue to lock down long-term supply arrangements through investments in Africa, Australia, South America, and other resource-rich locales. These actions will help emerging economies meet their burgeoning demand for raw materials, but it could leave our nation out in the cold at the very moment we realize we most need these minerals.

Just as we've seen with our reliance on foreign oil, the United States' total reliance on foreign sources of rare earths puts us in a perilous situation. China currently accounts for 97 percent of global production of these incredibly important metals and has repeatedly followed through on plans to decrease export of them. Some have compared China to a one-nation OPEC for rare earths—and China's recent actions signal that they are well aware of their immense power over the supply of this sought-after commodity.

By cutting rare earth exports, China is seeking to ensure the manufacture of clean technologies within its own borders. But the implications for energy security and job creation in America are also apparent: we risk a future in which wind turbines, solar panels, advanced batteries, and geothermal steam turbines are not made in the USA, but somewhere else.

Further, what's worse is that some minerals are now being used as a weapon to strike back against vulnerable countries who have failed or who are unable to meet their own needs with domestic production. The latest evidence comes in the form of China's decision to halt rare earth exports to Japan, after Japan arrested a Chinese fishing boat captain involved in a collision with Japanese Coast Guard vessels.

Some experts contend that the lack of a cap-and-trade system is at the root of this emerging crisis. I disagree—a price on carbon would do little to promote mineral production in the United States, and could actually hurt it. Instead, I believe that one of the main reasons why our nation is on the verge of falling behind in the development of clean energy technologies is that we have slowly but surely surrendered the front end of the clean energy supply chain.

We're left with quite a paradox. Even as many of America's political leaders take steps to limit mining, a reliable supply of minerals has become essential to the manufacture of nascent energy technologies. If allowed to continue, we will simply trade our current dependence on foreign oil for an equally devastating dependence on foreign minerals.

Even our environmental goals could be jeopardized. The widespread deployment of clean energy technologies is not only contingent upon breakthroughs in research and development but also the affordability of the raw materials used in them. If prices spike because the supply of raw materials is insufficient, entire technologies could fail.

The good news is that the United States has, within its borders, abundant reserves of many critical minerals that we currently choose to import. These reserves represent an opportunity to create many new American jobs, and their production would help facilitate a robust clean technology manufacturing sector. Particularly in these tough economic times, we should recognize that mining jobs pay well and provide an excellent career path for those who pursue them.

Understanding that we could soon face a global supply crunch, and that we have significant mineral reserves here at home ready to be developed, I introduced the Rare Earths Supply Technology and Resources Transformation (RESTART) Act on June 22nd, 2010. Senators Barrasso and Enzi of Wyoming, Senators Crapo and Risch of Idaho, and Senator Vitter of Louisiana have joined me as co-sponsors of this legislation, which would address a number of hurdles standing in the way of a resurgent rare earths industry.

Specifically, the RESTART Act would:

- Promote investment in, exploration for, and development of rare earths as U.S. policy;
- Establish a task force to reform permitting and regulation of rare earth production;
- Require an assessment of rare earth supply chain vulnerabilities;
- Seek agency recommendations on procuring and stockpiling critical rare earths;
- Provide loan guarantees for rare earth production, processing and manufacturing;
- Seek a review of rare earth projects related to national defense capabilities;
- Prioritize funding of innovation and job training in the rare earth industry; and
- Subject the sale of assets supported by taxpayer dollars to Secretarial approval.

In my view, the most important issue for Congress to address is the bureaucratic delays faced by those who wish to develop our domestic production capabilities. In country rankings, the United States ranks dead last in permitting delays. This is a problem that must be fixed, and we can do so in a way that maintains the environmental protections that we rightfully demand.

I understand that many people do not want public lands to be used for mineral extraction or any other form of energy development. The truth, however, is that those views are both short-sighted and counterproductive. Our standard of living requires us to generate and consume a significant amount of energy, and that energy must be produced somewhere. All resources carry some cost to the environment, whether in carbon content or the raw materials and physical area needed to tap their potential. We will not see significant progress on clean energy technologies until we are serious about the production of the minerals used to produce them.

Albert Einstein once wrote that "in the middle of difficulty lies opportunity." Our nation faces a great challenge in the form clean energy technology deployment. But as we struggle to find our way forward, we'll also be presented with new opportunities to strengthen our economy and our security.

Rare earth production is one of those opportunities. As this Subcommitee continues to consider ways to promote clean energy, I would encourage you to take the long view—and to recognize that greater domestic production of rare earths and other mineral commodities is vital to the future of our energy supply, our economic wellbeing, and the integrity of the environment.

## STATEMENT OF HON. JAMES E. RISCH, U.S. SENATOR FROM IDAHO

Senator RISCH. Thank you, Madam Chairman, for holding this meeting. This is truly an important meeting.

Most people in America do not know what a rare earth is, and if you did a quiz on 100 people walking down the street, you would find maybe one who could even remotely describe what a rare earth was. But as you pointed out, the rare earths are absolutely critical elements in the production of many different products that we use today.

One of the things that interests me is this is truly a national security issue. Rare earths, although a lot of the things that they are used for in national security uses we cannot talk about here, are things that are absolutely necessary for the defense of this country.

As you point out, the United States has only 13 percent of the known reserves, but that only tells part of the picture. It paints only part of the picture. Although we have 13 percent, it is very, very difficult for entrepreneurs and miners to go out and extract that 13 percent because of the environmental restrictions in this country.

A good example is the cobalt mining that has taken place in Idaho, and I have asked a witness here today who is going to describe an enterprise that is taking place in Idaho today. When I was Governor, I went and looked at and had a good tour of the cobalt mine that we anticipate will be opening quite soon in Idaho. The environmental challenges to opening that mine were absolutely stunning, and Formation Capital needs to be complimented for, No. 1, even taking this on to begin with. When I looked at it, it surprised me that people were willing to expend capital on it.

However, as happens in a free market, the rewards as a result of the risks are going to be substantial for Formation Capital. They will contribute greatly to the national security of the United States and also help us with the challenges that the United States faces getting rare earths.

As you pointed out, China is very, very aggressive on rare earths. The fact that they have the largest deposits of rare earths on the face of the planet is certainly a concern to us, but also of concern are the political issues that happen in China. A good example of that is that recently China got in a dust-up with Japan over the arrest of a fishing boat captain, and that trickled all the way down to the rare earths exports to Japan and the Chinese cutoff the exports of rare earths to Japan. China denies it, but Japan, who had been importing rare earths, can no longer get rare earths out of China.

So these are the kind of things that cause us no end of concern. We are going to hear a little bit about that today.

With that, again, thank you, Madam Chairman, for holding this hearing.

Senator CANTWELL. Thank you.

Senator Barrasso, did you wish to make an opening statement?

Senator BARRASSO. Thank you very much, Madam Chairman. I will wait for the questioning.

Senator CANTWELL. Thank you very much.

We are going to hear from the Assistant Secretary of Policy and International Affairs for the U.S. Department of Energy, the Honorable David Sandalow. Thank you very much for being here. We look forward to your testimony.

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

Mr. SANDALOW. Thank you, Chairwoman Cantwell, Ranking Member Risch, members of the subcommittee.

I am here today to talk about rare earth metals, their importance to clean energy technologies, and the Department of Energy's recent work on this topic. This is an important issue, as both of you have just highlighted, one that needs priority attention in the months and years ahead.

The administration has been focused on this issue for some time. At the Department of Energy, we are working to develop a strategy on rare earths, as I announced earlier this year. The administration is continuing to review S. 3521. We share the goal of establishing a secure supply of rare earth metals, and we look forward to discussions with the Congress on ways to address this issue as we move forward.

Rare earth metals have many desirable properties, including the ability to form unusually strong, light-weight magnetic materials which make them valuable to a number of clean energy technologies. For example, neodymium is used in magnets for electric generators found in wind turbines.

Ironically, rare earth metals are not, in fact, rare. They are found in many places on earth, including the United States, Australia, and Canada. In fact, the United States was the world leader in production of rare earths as recently as the late 1980s. However, these rare earth metals are often difficult to extract in profitable quantities. This and other factors have led to geographically concentrated production.

Today more than 95 percent of global production of rare earths comes from China. This concentration of production creates serious concerns, especially in light of recent events. While China holds 37 percent of known reserves and the United States holds 13 percent and there are significant reserves in other countries, development of new rare earth mines will require significant investment and time.

It goes without saying that diversified sources of supply are important for any valuable material. Development of substitutes and policies for reuse, recycling, and more efficient use are also important. We must pursue these strategies.

The recent maritime dispute between China and Japan in which there were unconfirmed reports that China threatened or adopted a de facto ban on such exports to Japan underscore the geopolitical risks associated with these issues.

Madam Chairwoman, the world is on the cusp of a clean energy revolution. Other countries are seizing this opportunity and the market for clean energy technologies is growing rapidly all over the world. Around the world, investments in clean energy technologies are growing, helping create jobs, promoting economic growth, and fighting climate change. Here in the United States, we are making historic investments in clean energy. The American Recovery and Reinvestment Act was the largest one-time investment in clean energy in our Nation's history, more than $90 billion. At DOE, we are investing $35 billion in Recovery Act funds in electric vehicles, battery and advanced energy storage, a smarter and more reliable electric grid, wind and solar technologies, among other areas.

In recognition of the importance of rare earth elements in the transition to clean energy, DOE is developing a strategic plan for addressing the role of rare earth metals and other critical materials in clean energy components, products, and processes. As a first step in the development of that plan, we released a public request for information this past May. We received over 1,000 pages of information from about 35 organizations, including manufacturers, mining companies, industrial associations, and national labs. Many organizations shared proprietary data that have helped us to develop a clearer picture of current and future demand.

Based on these responses and analyses being conducted throughout the Department, our strategy is nearing completion. It focuses on four core technologies that will be crucial to our transition to a clean energy economy. Those are permanent magnets, batteries, photovoltaic thin films, and phosphors. A public draft of the strategy will be available later this fall.

To proactively address the availability of rare earths and other important materials, we must take action in three categories. First, we must globalize supply chains for these materials. Second, we must develop substitutes for these materials. Doing so will improve our flexibility as we address the materials demand of the clean energy economy. Third, we must explore opportunities to promote recycling, reuse, and more efficient use of strategic materials in order to gain more economic value from each ton extracted. With all three of these approaches, we must consider all stages of the supply chain.

In conclusion, Madam Chair, there is no reason to panic but every reason to be smart and serious as we plan for a growing global demand for products that contain rare earth metals. Recent events underscore this. The United States intends to be a world leader in clean energy technologies. Toward that end, we are shaping policies and approaches to help prevent disruptions and supply of critical materials. With focused attention and working together, we can meet these challenges.

Thank you.

[The prepared statement of Mr. Sandalow follows:]

PREPARED STATEMENT OF DAVID SANDALOW, ASSISTANT SECRETARY, 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.

I am here today to speak about rare earth metals, their importance to clean energy technologies, and the Department of Energy's recent work on this topic. This is an important issue—one that needs priority attention in the months and years ahead. The Administration has been focused on this issue for some time. The Department is working to develop a strategy on rare earths that I announced earlier this year and the Administration is continuing to review S. 3521. We share the goal of establishing a secure supply of rare earth metals, and we look forward to discussions with the Congress on ways to address this issue as we move forward.

Rare earth metals have many desirable properties, including the ability to form unusually strong, lightweight magnetic materials. They also have valuable optical properties including fluorescence and emission of coherent light. These properties and others have made rare earth metals valuable in a number of clean energy technologies, among other important applications. For example, lanthanum is used in batteries for hybrid cars. Neodymium is used in magnets for electric generators found in wind turbines, and europium is used in colored phosphors for energy-efficient lighting.

Ironically, "rare earth" metals are not in fact rare. They are found in many places on Earth, including the United States, Canada and Australia. In fact, the United States was the world leader in production of rare earth metals as recently as the late 1980s. However, rare earth metals are often difficult to extract in profitable quantities. This and other factors have led to geographically concentrated production. Today, more than 95 percent of global production of rare earths comes from China. This concentration of production creates serious concerns. While China holds 37 percent of known reserves and the United States holds 13 percent, and there are significant reserves in other countries, development of new rare earth mines will require significant investment, and it can take years before new sources yield significant production.

It goes without saying that diversified sources of supply are important for any valuable material. Development of substitute materials and policies for re-use, recycling and more efficient use are also important. If rare earth metals are going to play an increasing role in a clean energy economy, we need to pursue such strategies. The recent maritime dispute between China and Japan, in which there were unconfirmed reports that China threatened or adopted a de facto ban on such exports to Japan, underscores the geopolitical risks associated with these issues.

GLOBAL CLEAN ENERGY ECONOMY

This transition to a clean energy economy is already well underway. The world is on the cusp of a clean energy revolution. Other countries are seizing this opportunity, and the market for clean energy technologies is growing rapidly all over the world.

Today, the Chinese government is launching programs to deploy electric cars in over 20 major cities. They are connecting urban centers with high-speed rail and building huge wind farms, ultrasupercritical advanced coal plants and ultra-high-voltage long-distance transmission lines.

India has launched an ambitious National Solar Mission, with the goal of reaching 20 gigawatts of installed solar capacity by 2020.

In Europe, strong public policies are driving sustained investments in clean energy. Denmark is the world's leading producer of wind turbines, earning more than $4 billion each year in that 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 last year. 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.

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 will also 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.

DOE STRATEGY

In recognition of the importance of rare earth elements in the transition to clean energy, DOE is developing a strategic plan for addressing the role of rare earth metals and other materials in clean energy components, products and processes. As a first step in the development of the plan, we released a public Request for Information (RFI) this past May soliciting information from stakeholders on rare earth metals and other materials used in the energy sector. The request focused not only on rare earths, but also on other elements including lithium, cobalt, indium, and tellurium.

We received over 1,000 pages from about 35 organizations, including Original Equipment Manufacturers (OEMs), mining companies, industrial associations, and national labs. Responses addressed supply, demand, technology applications, costs, substitutes, recycling, intellectual property, and research needs. Many organizations shared proprietary data on material usage that have helped us develop a clearer picture of current and future demand.

Based on these responses and analyses being conducted throughout the Department, the strategy is nearing completion. It focuses on four core technologies that will be crucial to our transition to a clean energy economy: permanent magnets, batteries, photovoltaic thin films, and phosphors. A public draft of the strategy is expected to be available later this fall.

I can broadly outline the approach we are taking to proactively address the availability of rare earths and other important materials required to support and expand clean energy development.

First, we must globalize supply chains for these materials. To manage supply risk, we need multiple, distributed sources of clean energy materials in the years ahead. This means taking steps to facilitate extraction, refining and manufacturing here in the United States, as well as encouraging our trading partners to expedite the environmentally-sound creation of alternative supplies.

Second, we must develop substitutes for these materials. Doing so will improve our flexibility as we address the materials demands of the clean energy economy. In order to meet this objective, we will need to invest in R&D to develop transformational magnet, battery electrodes and other technologies that reduce our dependence on rare earths. DOE's Office of Science, Office of Energy Efficiency and Renewable Energy, and the ARPA–E program are currently conducting research along these tracks.

Third, we must explore opportunities to promote recycling, re-use and more efficient use of strategic materials in order to gain more economic value out of each ton of ore extracted and refined. Widespread recycling and re-use could significantly lower world demand for newly extracted rare earths and other materials of interest. For example, we could develop a process to recycle terbium and europium in the phosphors of compact and conventional fluorescent light bulbs. Neodymium could be recycled from hybrid and electric vehicles. Additionally, recycling and re-use could reduce the lifecycle environmental footprint of these materials, another critical priority.

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.

Managing supply chain risks is by no means simple for a company, much less a country. At DOE, we focus on the research and development angle. From our perspective, we must think broadly about addressing the supply chain in our R&D investments, from extraction of materials through product manufacture and eventual recycling. It is also important to think about multiple technology options, rather than picking winners and losers. We work with other federal agencies to address other issues, such as trade, labor and workforce, and environmental impacts. We are already closely working with our interagency partners to address these important issues.

## 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 rare earth metals. Recent events underscore this. 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. Senator Risch is amazed at your precise ending of your testimony at 5 minutes.

Senator RISCH. Somebody called it a world book record.

[Laughter.]

Mr. SANDALOW. Thank you, Senator.

Senator CANTWELL. Mr. Sandalow, your position and title as it relates to this—obviously, trade is an important aspect of this issue and keeping markets open and functioning. So what degree are you involved in that? What other parts of our executive branch are taking the role and responsibility in shaping that, and will that be part of this report and recommendation?

Mr. SANDALOW. Thank you, Chairwoman.

Within the executive branch, the U.S. Trade Representative's Office has the lead on trade issues, and the Commerce Department plays a very significant role as well. The Department of Energy is involved in our discussions of these issues and we participate in interagency discussions on trade matters when they involve clean energy, and both the U.S. Trade Representative's Office and the Department of Commerce look to the Department of Energy, for example, for expert information on these topics. But those two Departments or agencies would be in the lead on trade issues.

Senator CANTWELL. So by your first recommendation, you are calling for globalization of supply chains. What do you think are the actions that we would be taking as a Government to help in the globalization of the supply chain?

Mr. SANDALOW. That is part of the interagency discussion on these topics, as well as our own review within the Department of Energy. They could include diplomatic discussions. They could include additional investments here in the United States.

About a century ago, Winston Churchill said that security depends upon variety and variety alone in the supply of oil, and he was talking about making sure that we have supply from all over the world. The same principle applies to critical materials today.

Senator CANTWELL. In your recommendation, you are talking about ARPA–E programs. What is the magnitude or what are some of the areas of R&D that you think we need to be involved in?

Mr. SANDALOW. At the Department of Energy today, we have a total of approximately $15 million being invested in research and development in these areas. That includes the ARPA–E program, as you just mentioned. It includes our science program. It includes our energy efficiency and renewable energy program. The areas that have been the primary focus so far have been in magnets and looking at the alternatives and more efficient use of these materials in magnets. There are a variety of other important applications and ways that research and development can make a difference here, and as part of our strategic review, we are looking at how to best prioritize our research and development in this area.

Senator CANTWELL. Not to steal from Dr. Eggert's testimony, because we want to hear it, but he does make recommendations similar to EIA and getting information into the markets. Do you agree with that? I do not know if it is the market is not collecting enough data or it is not a primary market function, so that just like with oil, although I would personally say that EIA needs to do a lot more aggressive job given the potential manipulation of markets to collect even more data, but it is certainly a model. So do you agree with that assessment?

Mr. SANDALOW. Senator, I do strongly agree that we need more and better information on this topic. We learned a lot within the Department of Energy from this response to the request for information that we issued last spring. So I think we need to find better ways to make sure that we are gathering the important information on this topic. As it escalates in importance, I am hearing on a bipartisan basis everybody believes it is a very important issue, and we need to have the best information on it.

Senator CANTWELL. But I think he is recommending—and we will hear from him, but I think his point is that without this kind of information about what truly is happening in the marketplace, it is hard to understand the functioning of these markets or shortages or supply issues. Will that be part of the recommendation, what kind of organization and the types of information? You know, we just recently upgraded what EIA should be responsible for in collecting. So it would be great if the agency would make a recommendation to us on the kinds of structure of this information and data collection.

Mr. SANDALOW. Thank you, Senator. It has certainly been one of the topics we are discussing, and I appreciate your input on this and we will reflect that as we move forward on the strategy.

Senator CANTWELL. Thank you.

Senator Risch.

Senator RISCH. Thank you, Madam Chairman.

Mr. Sandalow, I am truly impressed with the sensitivity and the Department's stance on this issue of how important it is. What I want to focus on is what America can do. How do we resolve this? So I have a few questions in that regard.

The first one is do you believe that the State Department and Defense Department share your sensitivity, the Department of Energy's sensitivity, to this issue and the full comport of the seriousness of the situation?

Mr. SANDALOW. Senator, needless to say, I do not want to speak for my colleagues, but we have had a number of interagency discussions on this and they are coming to the table very engaged on this issue.

Senator RISCH. I appreciate that.

The next area of inquiry I would have would be what are you doing as far as coordinating with other agencies when there is an opportunity to go get these rare earths. I would suspect that probably you are aware of instances where people who are mining or companies that want to mine face the regulatory challenges of going and getting this material. Understandably we have to be sensitive to the environment. On the other hand, there has got to be a way to do this and balance both of those so that we can have a market in these rare earths. Are you coordinating? Is your agency coordinating with the EPA, with the Forest Service, with the BLM, with the agencies that are on the ground that should be making these things work?

Mr. SANDALOW. Yes, Senator, we are. The Executive Office of the President has coordinated interagency discussions on this topic and, in particular, the Office of Science and Technology Policy. There has been a regular process looking at these issues, including the set of issues you just identified. This has certainly been an issue of growing attention in the time that I have been in Government service in about the past year and a half, and certainly, I think recent events underscore the importance of even greater attention to it.

Senator RISCH. I agree with that. I think greater attention needs to be given to it. I would say this. I appreciate the three points that you made, for instance, the global supply chain, and I also appreciate the remarks of the chairman regarding market-making. But there really is no market. I mean, there is a monopoly today, and until we can actually produce some of the material, we cannot make a market.

So I think the focus needs to be at this time how do we go get this. How do we encourage miners to go get this? How do we get the free market system to go out there and go get these materials and bring them into the marketplace so that indeed we can have a global supply? So I would encourage the focus to be in that regard at this point, and that is, working with the various agencies that license, that monitor, that regulate this industry.

Thank you very much. Thank you, Madam Chair.

Senator CANTWELL. Thank you.

Senator UDALL. Thank you, Madam Chair.

Good morning, Mr. Secretary.

Let me move to the downstream manufacturing supply chain. We are paying a lot of attention to the access we need to the rare earth resources in their raw forms, but we also need to look at the supply chain, the oxides and metals and alloys and magnets. What do you see as the DOE's role in helping to rebuild those phases in the supply chain?

Mr. SANDALOW. It is a very important question, Senator. So thank you for asking it.

This issue is not just about mining. This issue is about the entire supply chain from mining and refining to incorporation of these metals into components and then into final products that go to consumers.

At the Department of Energy, we are paying a lot of sustained attention to the clean energy technology supply chain from the beginning to the end. Our role in this, I believe, is critical going forward. We are looking in our strategic review not just at the mining and extracting side of this issue, but at the entire supply chain. So we are looking at policies that will help to rebuild this type of capability within the United States and believe it is of utmost importance.

Senator UDALL. Do you think that, similar to what China is doing, if we developed a rare earth supply chain, that we then would be able to attract more manufacturing interests like China is doing? Perhaps we would do it in a different, more American free market with open arms way, but it is an intriguing thought, given the way that China is using this to gain advantage.

Mr. SANDALOW. I think this is an important part of building up the new clean energy technology which is going to create jobs for Americans. It is already creating tens and hundreds of thousands of jobs around this country. I think in order to do that, we need to look at the entire supply chain. It is critical in magnets that go into motors and generators. It is critical in phosphors for lighting.

It is critical for batteries and a variety of areas. It is absolutely central.

Senator UDALL. Something to really keep in mind I believe.

Let me turn to Colorado. I want to thank you for your work with Molycorp which is based in Colorado. They are looking to apply to the loan guarantee program for advancing their prospects into the second phase.

Other than the loan guarantee program, what other mechanisms and approaches have you identified that would help support the development of the rare earths supply chain in the U.S.? If so, what are some examples? If you have not, have you begun to identify ways that the DOE can increase its assistance?

Mr. SANDALOW. Thank you for the question, Senator.

One category is research and development, and the Department of Energy has a budget in these areas and extraordinary expertise, some of the best scientists in the country within our national lab system. So we are looking at how to prioritize that research and development and how to right-size it and make sure that this issue receives the priority that it deserves.

Another category of tools is one that Chairwoman Cantwell pointed to, which is information gathering and how do we make sure that we have the best information on these issues.

A third category are financial instruments. You identified one, which is the loan guarantee program. There are potentially others that might be possible in order to support the development of this industry.

So I think we need to look at all of these going forward.

Senator UDALL. Yes, I think it is important to note that at this point Molycorp, although there might be others would disagree, appropriately so, really is on the leading edge of this, and it speaks to the fact that we do not have much underway right now and we need to accelerate that.

That leads to my final question. I think you have spoken to this in your testimony, and it is really why we are here and why it is important that the chairwoman and the ranking member convened this hearing.

If we lose access to rare earth materials, what does that do to our broader energy policy objectives? What contingency plans are you developing, if any?

Mr. SANDALOW. Let me answer that question. I want to just mention a fourth very important category of policies that occur to me, Senator, which is education and training. One of the issues that we have here is that the work force of the United States has not been fully developed in order to work on these issues. I know the Colorado School of Mines is one of the leading institutions in this whole area and building up the expertise through institutions like the Colorado School of Mines I think is an extremely important set policies.

In terms of the implications, I think they are potentially very serious. I think if we lose access to these, it could interrupt the development of clean energy technologies. It could interrupt commerce. I think that we need to be sure that we proceed along the strategy that we have been talking about, globalizing supply chains, developing substitutes, and more efficient reuse and recycling.

Senator UDALL. In other words, losing access is just not acceptable and would be very, very detrimental to the 21st century American energy economy, as well as all the other applications.

Thank you, Madam Chairwoman.

Senator CANTWELL. Thank you.

Senator BARRASSO. Thank you very much, Madam Chairman.

It is good to see you again. Thank you for being here today.

There is a rare earth project under development in Wyoming. It is an exciting project. It has the potential to create jobs. It will help reduce our dependence on China for strategic minerals.

Rare earth elements are an essential part of wind turbines, critical for the batteries and the magnets used in hybrids and electric vehicles, as you know. To me this is also a national security issue. Rare earth elements are used in jet fighter engines, in missile defense, and in satellites. The United States is 100 percent reliant on imports right now of rare earth elements, and strategic minerals are an important but often overlooked part of the energy debate.

The rare earth project in Wyoming is primarily located on Federal land. Not surprisingly, the permitting process has become a big hurdle. Litigation, Government red tape, those things discourage investment in mining operations throughout the West. Today the Western Caucus, which several of us are members of, released a report called The War on Western Jobs. It details the Government regulations that are undercutting jobs in the West.

So I wanted to talk a little bit about domestic production. From an economic and a national security standpoint, how important is it to have domestic extraction and refining capacity for strategic metals?

Mr. SANDALOW. Domestic production is very important, Senator. I think it is a critical part of our overall strategy for globalizing supply chains, and we need to have this production capacity here in the United States.

Senator BARRASSO. In the testimony, you mentioned steps to facilitate extraction, refining, and manufacturing here in the United States. Could you give us a little of the specifics in terms of what steps you suggest?

Mr. SANDALOW. Senator, we have a strategy under development at the Department of Energy. It is not yet final, and so I do not want to prejudge what my boss will ultimately decide it ought to include. But I think the topics that we have been focusing on include research and development strategy of the Department of Energy, which is central. It includes education and training. It includes information, and it includes different possible financial instruments.

Senator BARRASSO. Can you include in that list considering streamlining the permitting process to promote American production of rare earth elements?

Mr. SANDALOW. Senator, the regulations that you were referring to earlier are not—if I understand correctly what they were, they are not within the regulatory jurisdiction of the Department of Energy. So that would not be part of our strategy per se, although we are involved in discussions with interagency colleagues on these issues.

Senator BARRASSO. You mentioned recycling a bit. I do not know what our current capacity is to recycle some of the rare earth elements. Can you talk a little bit about that and how feasible it is to really do that sort of on the larger scale?

Mr. SANDALOW. Currently our capacity is low. Products are, in general, not designed to facilitate the recycling and the capture, and markets are not structured in order to do that. But potentially this could contribute greatly to our security if we were able to redesign these products in a way to do that and then recapture the rare earth metals. It is an important area of research.

Senator BARRASSO. Great.

I think last time you were here with this committee, you testified about electric vehicles to some degree. I think you mentioned driving to work every day in a plug-in electric hybrid and noted the importance of electric vehicles in overall reducing our dependence on foreign oil.

So as far as the amount of rare earth elements that are used, how do traditional gas-powered cars compare to electric and hybrids, do you know?

Mr. SANDALOW. In electric motors and batteries of the type that are found in plug-in electric vehicles, there are rare earth metals that are critical that would not be found in a traditional internal combustion engine. There are rare earth metals and other critical materials used in internal combustion engines and in the refinery processes for petroleum, as has already been mentioned in this hearing. But there is an additional increment that is used in electric vehicles.

Senator BARRASSO. I mean, I know that like a Prius has about 10 pounds of one specific rare earth element and I did not know if the Department had done some calculations about how many pounds overall of rare earth elements you would need to try to replace all of the gas-powered cars on the road today with electric or with hybrids. It just seems it is a big volume.

Mr. SANDALOW. That is the type of analysis we have underway, Senator. I do not have those numbers right now at the tip of my tongue, but that is exactly the type of question that we are looking at as part of our strategy.

Senator BARRASSO. Thank you.

Thank you, Madam Chairman.

Senator CANTWELL. Thank you.

We are going to move to the next panel, but Mr. Sandalow, my colleague, Senator Udall, mentioned the loan guarantee program, and I should have mentioned earlier that part of this hearing is Senator Murkowski's bill, S. 3521. I do not know if you have any views that you want to give us on that. Part of that is, I think, qualifying for the loan guarantee program. That might be the main focus of that legislation. But do you have any comments on her bill that has been before us today?

Mr. SANDALOW. The administration is continuing to review that bill. We strongly support the goal of securing a supply of rare earth metals, which is reflected in that bill. Currently the loan guarantee program does not provide authority for loans purely on the mining and extracting of rare earth metals. So it is an important issue and it is part of the discussion internally at the Department of Energy and within the administration.

Senator CANTWELL. OK, thank you. Thank you very much for your testimony. Unless anybody has any other questions, thank you.

We will move to our second panel, and I would like to welcome Dr. Roderick Eggert. As I said earlier, he is Professor and Division Director of the Division of Economics and Business at Colorado School of Mines in Golden, Colorado. Mr. Preston Rufe, Environmental Manager at Formation Capital Corporation from Salmon, Idaho. Mr. Peter Brehm, Vice President, Business Development for Infinia, Kennewick, Washington.

Thank you all very much for being here today and for your testimony. We have copies of your testimony. So if you could keep your remarks to 5 minutes, that would be much appreciated. So welcome and thank you for being here.

Mr. Eggert, we are going to start with you.

**STATEMENT OF RODERICK G. EGGERT, PROFESSOR AND DIVISION DIRECTOR, DIVISION OF ECONOMICS AND BUSINESS, COLORADO SCHOOL OF MINES, GOLDEN, CO**

Mr. EGGERT. Good morning, Madam Chairman and members of the committee. My name is Rod Eggert. I am a mineral economist from Colorado School of Mines. As you noted, I provided written testimony. In my oral remarks, let me highlight two aspects of that testimony.

First, a National Research Council study that was published in 2008 called Critical Minerals and the U.S. Economy. I chaired the committee that prepared this report. It provides a broad context for current concerns. Of particular note, let me draw your attention to the conceptual framework in this analysis. It is a framework for assessing criticality. It talks about how to measure and evaluate the degree of supply risk associated with a particular element or mineral. It also talks about the importance in use or the difficulty of substituting away from an element should its supply be constrained.

This document also prepared a preliminary assessment of the criticality, quote/unquote, of 11 potential critical minerals. We did not assess the entire periodic table. We only looked at 11 possible critical elements at that time, which was about 3 years ago. At this point, we identified indium, manganese, niobium, platinum group metals, and the rare earth elements from among the 11 that were more rather than less critical, in other words, more difficult to substitute away from and subject to a greater degree of supply risk.

I might note that earlier this year the European Commission, using a very similar methodology to ours, identified 15 critical raw materials from the perspective of the European Community, and the European Commission named many of the elements that we have heard so far today.

My written testimony also contains my personal views which are contained in a paper that was published earlier this year in the National Academies Issues in Science and Technology. Let me emphasize two of several points among my personal views.

First of all, although markets are not panaceas, I think it is important that we do not forget that markets provide significant incentives for managing supply risks, although on the supply side and on the demand side—and on the demand side, I am thinking about the incentives that users face to, in effect, provide their own insurance against the supply risk over the longer term, figuring out and studying ways to substitute away from elements subject to supply risk.

Let me also highlight that my paper argues, nevertheless, there are useful and important roles for Government and I identify four areas in which I suggest concentrating Government activities.

The first area, encouraging undistorted international trade when there are trade restrictions, export restrictions imposed by exporting countries.

Second, I support improving the regulatory approval processes for domestic resource development. Let me be clear, however, that I am really not in favor of special treatment for a particular resource or a particular element. So I would not give special treatment to rare earths, for example. I think it is a broader issue, one that deals with domestic resource development generally and also relates to, I think even more broadly, developments throughout the economy and the difficulty of siting and permitting new developments.

My third and fourth areas for policy recommendation focus on the Government's role in facilitating the provision of the information, something Dr. Sandalow mentioned, information which provides the basis for decisions by both private and public participants. Also the Government has an important role to play in facilitating research and development throughout the supply chain, in other words, from mine through disposal and importantly recycling.

Thank you very much. I would be happy to answer questions when that opportunity arises.

[The prepared statement of Mr. Eggert follows:]

PREPARED STATEMENT OF RODERICK G. EGGERT, PROFESSOR AND DIVISION DIRECTOR, DIVISION OF ECONOMICS AND BUSINESS, COLORADO SCHOOL OF MINES, GOLDEN, CO

Good morning, Madam Chairman and members of the Committee. My name is Rod Eggert. I am Professor of Economics and Business at Colorado School of Mines. My area of expertise is the economics of mineral resources. I begin my testimony by describing the context for current concerns about critical minerals and clean energy technologies. I then present perspectives on these concerns from two published documents: a 2008 study of the National Research Council (NRC)[1] on critical minerals (I chaired the committee that prepared this report), and a 2010 paper with my personal views on critical minerals, published in the National Academies' Issues in Science and Technology. Finally, I briefly describe the activities of a panel on which I serve now, organized under the auspices of the American Physical Society. This panel's work focuses on critical elements for emerging energy technologies.

CONTEXT

Mineral-based materials are becoming increasingly complex. In its computer chips, Intel used 11 mineral-derived elements in the 1980s and 15 elements in the 1990s; it may use up to 60 elements in the future. General Electric uses some 70 of the first 83 elements of the periodic table in its products. Moreover, new tech-

[1] The National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology.

nologies and engineered materials create the potential for rapid increases in demand for some elements used previously and even now in relatively small quantities. The most prominent examples are gallium, indium and tellurium in photovoltaic solar cells; lithium in automotive batteries; and rare-earth elements in permanent magnets for wind turbines and hybrid vehicles, as well as in compact-fluorescent light bulbs.

These technological developments raise two concerns. First, there are fears that supply will not keep up with the explosion of demand due to the time lags involved in bringing new production capacity online or more fundamentally the basic geologic scarcity of certain elements. Second, there are fears that supplies of some elements are insecure due to, for example, U.S. import dependence, export restrictions on primary raw materials by some nations, and industry concentration. In both cases, mineral availability—or more precisely, unavailability—has emerged as a potential constraint on the development and deployment of emerging energy technologies.

MINERALS, CRITICAL MINERALS, AND THE U.S. ECONOMY[2]

It was in this light that the standing Committee on Earth Resources of the National Research Council initiated a study and established an ad hoc committee, which I chaired, to examine the evolving role of nonfuel minerals in the U.S. economy and the potential impediments to the supplies of these minerals to domestic users. The U.S. Geological Survey (USGS) and the National Mining Association sponsored the study, the findings of which appear in the volume Minerals, Critical Minerals, and the U.S. Economy (National Academies Press, 2008).

The report provides a broad context for current discussions and concerns. It defines a "critical" mineral as one that is both essential in use (difficult to substitute away from) and subject to some degree of supply risk. The degree to which a specific mineral is critical can be illustrated with the help of a figure (Figure 1).* The vertical axis represents the impact of a supply restriction should it occur, which increases from bottom to top. The impact of a restriction relates directly to the ease or difficulty of substituting away from the mineral in question. The more difficult substitution is, the greater the impact of a restriction (and vice versa). The impact of a supply restriction can take two possible forms: higher costs for users (and potentially lower profitability), or physical unavailability (and a "no-build" situation for users).[3]

The horizontal axis represents supply risk, which increases from left to right. Supply risk reflects a variety of factors including: concentration of production in a small number of mines, companies, or nations; market size (the smaller the existing market, the more vulnerable a market is to being overwhelmed by a rapid increase in demand); and reliance on byproduct production of a mineral (the supply of a byproduct is determined largely by the economic attractiveness of the associated main product). Import dependence, by itself, is a poor indicator of supply risk; rather it is import dependence combined with concentrated production that leads to supply risk. In Figure 1, the hypothetical Mineral A is more critical than Mineral B.

Taking the perspective of the U.S. economy overall in the short to medium term (up to about a decade), the committee evaluated eleven minerals or mineral families. It did not assess the criticality of all important nonfuel minerals due to limits on time and resources. Figure 2 summarizes the committee's evaluations. Those minerals deemed most critical at the time of the study—that is, they plotted in the upper-right portion of the diagram—were indium, manganese, niobium, platinum-group metals, and rare-earth elements.[4]

Any list of critical minerals reflects conditions at a specific point in time. Criticality is dynamic. A critical mineral today may become less critical either because

[2] This section of my testimony draws on testimony Steven Freiman and I prepared (and Dr. Freiman delivered) for the hearing before the Subcommittee on Investigations and Oversight of the House Committee on Science and Technology, "Rare Earth Minerals and 21st Century Industry," March 16, 2010.

* Figures 1 and 2 have been retained in subcommittee files.

[3] When considering security of petroleum supplies, rather than minerals, the primary concern is costs and resulting impacts on the macroeconomy (the level of economic output). The mineral and mineral-using sectors, in contrast, are much smaller, and thus we are not concerned about macroeconomic effects of restricted mineral supplies. Rather the concern is both about higher input costs for mineral users and, in some cases, physical unavailability of an important input.

[4] Earlier this year, using a very similar analytical framework and definition of "critical" minerals, the European Commission identified fourteen critical raw materials from the perspective of European users: antimony, beryllium, cobalt, fluorspar, gallium, germanium, graphite, indium, magnesium, niobium, platinum-group metals, rare earths, tantalum, and tungsten (Critical raw materials for the EU, report of the Ad-hoc Working Group on defining critical raw materials, Brussels, European Commission, June 2010).

substitutes or new sources of supply are developed. Conversely, a less-critical mineral today may become more critical in the future because of a new use or a change in supply risk.

Although the study did not make explicit policy recommendations, it made three policy-relevant recommendations, which I quote below:

> 1. The federal government should enhance the types of data and information it collects, disseminates, and analyzes on minerals and mineral products, especially as these data and information relate to minerals and mineral products that are or may become critical.
>
> 2. The federal government should continue to carry out the necessary function of collecting, disseminating, and analyzing mineral data and information. The USGS Minerals Information Team, or whatever federal unit might later be assigned these responsibilities, should have greater authority and autonomy than at present. It also should have sufficient resources to carry out its mandate, which would be broader than the Minerals Information Team's current mandate if the committee's recommendations are adopted. It should establish formal mechanisms for communicating with users, government and nongovernmental organizations or institutes, and the private sector on the types and quality of data and information it collects, disseminates, and analyzes. It should be organized to have the flexibility to collect, disseminate, and analyze additional, nonbasic data and information, in consultation with users, as specific minerals and mineral products become relatively more critical over time (and vice versa).
>
> 3. Federal agencies, including the National Science Foundation, Department of the Interior (including the USGS), Department of Defense, Department of Energy, and Department of Commerce, should develop and fund activities, including basic science and policy research, to encourage U.S. innovation in the area of critical minerals and materials and to enhance understanding of global mineral availability and use.

### "CRITICAL MINERALS AND EMERGING TECHNOLOGIES"[5]

In this recent paper, I examine the concerns about (un)availability of mineral-derived elements as a constraint on the development and diffusion of emerging technologies. I make four major points.

First, we are not running out of mineral resources, at least any time soon. The world generally has been successful in replenishing mineral reserves in response to depletion of existing reserves and growing demand for mineral resources. Reserves are a subset of all mineral resources in the earth's crust. Reserves are known to exist and both technically and commercially feasible to produce. Reserves change over time. They decline as a result of mining. They increase as a result of successful mineral exploration and development and technological advancements in mineral exploration, mining, and mineral processing. Over time, reserve additions generally have at least offset depletion for essentially all mineral resources.

Second, rather than focusing on running out of mineral resources, it is more useful to consider the constraints imposed on emerging technologies by the costs, geographic locations, and time frames associated with mineral production. Costs are important because over time production tends to move to lower-quality mineral deposits—those that are less rich in mineral, deeper below the surface, in more remote locations, or more difficult to process. The result is higher costs for users, unless technological improvements are sufficient to offset these cost increases. Thus the constraint that mineral availability sometimes imposes on users is one of higher costs rather than physical unavailability.

Geographic location of production also is important. Other things being equal, supply risks are greater, the more concentrated production is in a small number of mines, companies, or companies. Concentrated production leaves users vulnerable to opportunistic behavior by producers, either in the form of higher prices or physical unavailability of an essential raw material. I have been careful not to say that import dependence is a risk factor. In fact, import dependence can be good if foreign sources of a mineral are available at lower costs than domestic sources. Rather it is the lack of diversified supply, domestic or foreign, that leads to supply risk, especially if a foreign source leaves us vulnerable to geopolitical risks.

[5] Roderick G. Eggert, "Critical Minerals and Emerging Technologies," Issues in Science and Technology, volume XXVI, number 4, 2010, pp. 49-58. The paper discusses minerals for national defense as well as for emerging energy technologies. In this testimony, I do not discuss military or defense issues.

Time frames are important in understanding supply risks. In the short to medium term (one or a few years, up to about a decade), supply risks are determined by the characteristics of existing sources of supply or new facilities that are sufficiently far along that they are reasonably certain of coming into production within a few years—are they diversified or concentrated, are there geopolitical risks, how important is byproduct production (which responds only weakly to changes in the price of the byproduct), is there excess or idled capacity that could be restarted quickly, is there low-grade material or scrap from which an element could be recovered?

Over the longer term (beyond a decade), mineral availability is largely a function of geologic, technical, and environmental factors. Does a resource exist in a geologic sense or in scrap that could be recycled? Do technologies exist to recover and use the resource? Can users recover a resource in ways that society considers environmentally and socially acceptable?

Third, although markets are not panaceas, they provide effective incentives for dealing with concerns about reliability and availability of mineral resources. Markets provide incentives for investments that re-invigorate supply and reduce supply risk. There are minor manias now in exploration for mineral deposits containing rare-earth elements and, separately, lithium. Markets encourage users of mineral-based elements to obtain "insurance" against mineral supply risks. Users have the incentive to manage supply risks in the short to medium term by, for example, maintaining stockpiles, diversifying sources of supply, developing joint-sharing arrangements with other users, or developing tighter relations with producers. Over the longer term, users might invest in new mines in exchange for secure supplies or, undertake research and development to substitute away from those elements subject to supply risks.

Fourth, despite the power of markets, there are useful and important roles for governments. To ensure mineral availability over the longer term and reliability of supplies over the short to medium term, I recommend that government activities focus on:

- Encouraging undistorted international trade. The U.S. government should fight policies of exporting nations that restrict raw-material exports to the detriment of U.S. users of these materials.
- Improving regulatory approval for domestic resource development. Although foreign sources of supply are not necessarily more risky than domestic sources, when foreign sources are risky, domestic production can help offset the risks associated with unreliable foreign sources. Developing a new mine in the United States appropriately requires a pre-production approval process that allows for public participation and consideration of the potential environmental and social effects of the proposed mine. This process is costly and time consuming—arguably excessively so, not just for mines but for developments in all sectors of the economy. I am not suggesting that mines be given preferential treatment, rather that attention be focused on developing better ways to balance the various commercial, environmental, and social considerations of project development.
- Facilitating the provision of information and analysis. Echoing the recommendation of the 2008 NRC report on critical minerals cited earlier, I support enhancing the types of data and information the federal government collects, disseminates and analyzes. Sound decision making requires good information, and government plays an important role in ensuring that sufficient information exists. In particular, I (and the 2008 NRC committee) recommend (a) enhanced focus on those parts of the mineral life cycle that are under-represented at present including: reserves and subeconomic resources, byproduct and coproduct primary production, stocks and flows of materials available for recycling, in-use stocks, material flows, and materials embodied in internationally traded goods and (b) periodic analysis of mineral criticality over a range of minerals. In addition, we suggest that the Federal government consider the Energy Information Administration, which has status as a principal statistical agency, as a potential model for minerals information, dissemination, and analysis. Whatever agency or unit is responsible for minerals information, it needs greater autonomy and authority than at present.
- Facilitating research and development. Again echoing the NRC report on critical minerals, I recommend that federal agencies develop and fund pre-commercial activities that are likely to be underfunded by the private sector acting alone because their benefits are diffuse, difficult to capture, risky and far in the future. Over the longer term, science and technology are key to responding to concerns about the adequacy and reliability of mineral resources—innovation that both enhances our understanding of mineral resources and mineral-based materials and improves our ability to recycle essential, scarce elements and sub-

stitute away from these elements. In particular, I (and the NRC committee) recommend funding scientific, technical, and social-scientific research on the entire mineral life cycle. We recommend cooperative programs involving academic organizations, industry, and government to enhance education and applied research.

To sum up my personal views, the current situation with critical minerals and emerging energy technologies deserves attention but not panic. By undertaking sensible actions today, there is no reason to expect that the nation will be in crisis anytime soon. But I also am aware that without a sense of panic, we may not undertake these sensible actions.

AMERICAN PHYSICAL SOCIETY STUDY

Finally, the issues of interest to this Committee are also of interest to the members of the American Physical Society (APS), a leading professional society of physicists. APS, through its Panel on Public Affairs, established a panel of experts a year ago to prepare a discussion paper on Critical Elements for New Energy Technologies. The panel, on which I serve, will issue its paper and recommendations later this year. The study is a joint activity of APS and the Materials Research Society, with additional support from the Energy Initiative at the Massachusetts Institute of Technology.

Thank you for the opportunity to testify today. I would be happy to address any questions the subcommittee may have.

Senator CANTWELL. I am getting coaching here from my colleague from Idaho. Mr. Rufe, thank you very much for being here.

## STATEMENT OF PRESTON F. RUFE, FORMATION CAPITAL CORPORATION, SALMON, ID

Mr. RUFE. Good morning. Thank you. Thank you for the opportunity to come speak to you this morning about the role of strategic minerals in clean energy technologies and more specifically the role of cobalt in clean energy technologies, as well as other strategic applications.

The importance of a sound policy regarding the domestic production of these materials is underscored, as you have already heard, by the recent events that occurred between China and Japan, spurred by the reported incident involving a Chinese fishing boat—threatens China to use their role as either the current major provider or emerging major provider of strategic minerals in the world to leverage that role to influence or in the form of political power. So any energy policy we adopt must address the development and production, the responsible development and production, of domestic sources.

Current policies like the Department of Energy's loan guarantee program are successful in jump-starting the manufacturing of clean energy technologies like rechargeable batteries, such as those plants that are being started up there in Michigan and Tennessee, Kentucky, and others. But they do not address, again, the supply for the base materials. Any policy that fails to address the supply for the base materials will hamstring any manufacturing efforts.

The Western Governors Association recognized this and they adopted a policy resolution regarding the adoption of a national minerals policy urging the legislature to adopt a policy on national minerals, which is essentially to effect the supply of domestic sources through responsible mining and refining.

Strategic minerals, specifically cobalt, are ubiquitous in the technologies we rely on day to day. The fastest growing use of cobalt is in rechargeable batteries, specifically chemistries like nickel metal hydride and lithium ion which are found in our portable electronics. Telephones, portable computers, hybrid electric vehicles, all electric vehicles all rely on those chemistries. Those chemistries rely on cobalt for their function. In fact, virtually all rechargeable battery chemistries currently in production rely on cobalt for their function.

Cobalt is also largely used for super-alloy production. Super-alloys are those products that are alloy metals that are exposed to extremely high pressures and temperatures such as turbine engines, jet turbine engines, gas turbines for land-based power generation. It is used extensively as a catalyst for coal to liquid technologies, gas to liquid technologies, fuel desulfurization, thereby cleaning our air.

Permanent magnets like those named for their primary rare earth element constituents also rely on cobalt for their function, particularly reliant on the cobalt for retaining their magnetic properties in high-temperature environments.

There is a promising new technology being researched at MIT, and it has to do with storing solar energy for use of solar power during nighttime hours.

But despite all these uses, we have currently no production capability in the U.S. That is to say, that the U.S. consumes 20 percent of the world's supply of cobalt and produces none. Moreover, the U.S. consumes 60 percent of the world's supply of high purity cobalt. There is a very limited supply left in our strategic reserve.

Cobalt is primarily produced as a byproduct from copper and nickel mining. Two of the greatest sources exist in the Democratic Republic of Congo and Zambia. As we already heard, China is emerging as one of the major controllers of the element cobalt also. Our supply is essentially controlled by entities that are either unfriendly to the U.S. or politically unstable. As I mentioned that reliance on high purity cobalt—it is estimated that approximately 80 percent of the world's supply of high purity cobalt is controlled by a single foreign company.

However, there is a domestic source here in the United States that is in the process of being developed in Idaho. That is the Idaho Cobalt Project which involves both an underground mine and a high purity refining capability. When in production, this project will be the only U.S. domestic source.

We must reenergize effective policies regarding the exploration, development, and production of strategic minerals to effect U.S. security and eliminate this precarious state of dependency.

Thank you.

[The prepared statement of Mr. Rufe follows:]

PREPARED STATEMENT OF PRESTON F. RUFE, FORMATION CAPITAL CORPORATION, SALMON, ID

While you will hear a lot of testimony today regarding the Rare Earth Elements (REEs), this testimony focuses on another strategic mineral absolutely essential to the successful deployment of clean energy technologies and other strategic applications like national defense and energy security; this strategic mineral is the essential element, cobalt. This testimony includes a discussion on current and projected uses of cobalt, cobalt supply and demand, and the need to re-energize U.S. strategic mineral policy. Recently, Formation Capital Corporation, U.S., responded to a Request for Information from the U.S. Department of Energy regarding REEs and other materials used in energy technologies. Given the similarity in subject matter, our response to that RFI is enclosed with this testimony for your review.*

CURRENT AND PROJECTED USES

The fastest growing use of cobalt is in the production of rechargeable batteries. Virtually all mainstream battery chemistries require significant amounts of cobalt. Both hybrid electric vehicles (HEVs) and all electric vehicles (EVs) rely on electrical storage capacity to function. In addition to HEVs and EVs, electronics such as computers, cell phones, portable tools, and power supply backups also rely on NiMH or Li-Ion technology for their rechargeable batteries. The rechargeable battery demand in the U.S. is growing and has already overtaken other cobalt applications in terms of percentage of use.

Cobalt is also the essential element needed in almost every form of clean energy production technology being developed today. Gas to liquid (GTL), coal to liquid (CTL), clean coal, oil desulfurization, photovoltaic cells (or solar panels), wind turbines, gas turbines, and fuel cell technologies all require cobalt. As a catalyst, cobalt is essential for cleaning traditional carbon-based energy sources as well as reducing dependence on foreign sources of carbon-based energy sources through leveraging domestic sources available in coal, gas-shales, and oil-shales. Cobalt catalysts are responsible for cleaning our current automobile fuel, through removal of sulfur, thereby keeping our air cleaner.

Super-alloy is a general term for alloy metals that are used in elevated temperature and/or elevated pressure environments and are used extensively in the aerospace sector. The U.S. national defense, as well as our robust civil air transportation backbone, relies on cobalt to provide reliable, safe, and efficient jet propulsion. Needed to construct evermore light and powerful jet engines operating at higher and higher temperatures, cobalt is the essential element used in turbine blades to retain their structural integrity while being subjected to torturous corrosion, temperatures and pressures. Typically, a high bypass, turbofan jet engine of the 40,000 lb. thrust class requires 110 to 132 pounds of cobalt in each finished engine. Major users of high-purity cobalt include General Electric, Boeing, Pratt & Whitney, Rolls Royce, and other aerospace companies. Today, super-alloys account for almost half the U.S. annual consumption of cobalt.

Cobalt is not a competitor or replacement for other strategic minerals like REEs. On the contrary, it is the symbiotic relationship that cobalt and other minerals share that makes so many technologies effective. A great example of this relationship is that of cobalt and certain REEs in the production of permanent magnets. Permanent magnets are needed to make wind turbines and other land based clean energy production technologies. Cobalt's extremely high Curie temperature allows these permanent magnets to maintain their magnetic properties at high temperatures. While some permanent magnets contain cobalt as a primary constituent, other magnets often named for their REE primary constituents also rely on cobalt in their production. While some permanent magnets are finished in the U.S. for enduse, they are largely manufactured overseas in Asian markets.

Research being conducted at MIT shows an exciting projected use of cobalt in synthesizing photosynthesis to produce carbon-free energy by separating hydrogen and oxygen for use in fuel cells. This process, which uses dissolved cobalt and phosphate to split the water molecule, can be coupled with solar and wind power generation technologies to provide power storage during periods of darkness or no wind thereby making clean, carbon-free energy available 24 hours a day.

SUPPLY & DEMAND

With no current domestic primary production (i.e., mining and refining) of cobalt in the U.S. and stockpiled supplies available in the strategic reserve dwindling, the U.S. is completely dependent on foreign supplies; although, a very small fraction of production does occur as a by-product of other metal production and recycling. As of December, 2009, the strategic reserve contained only 293 tonnes of cobalt. With the U.S annual demand for cobalt accounting for nearly 20% of the world's annual supply of approximately 60,000 tonnes, the remaining strategic reserve is insignificant.

Most cobalt production comes as a by-product of other metal production such as nickel and copper. Many of the largest producers of cobalt as a by-product are located in countries that are either unstable or unfriendly to the U.S. Two of the largest cobalt by-product producers are the Democratic Republic of Congo and Zambia. With on-going political and civil strife in the regions, the mines are sometimes

*Documents have been retained in subcommittee files.

forced to shut down and, once shuttered, these operations can take years to re-open. China has rapidly become the world's largest producer of refined cobalt and is growing into the world's largest consumer. China has the potential to become the virtual OPEC of cobalt refining, potentially controlling major producers both domestically in China as well as Africa. China's latest move to potentially limit REE exports to Japan is further evidence of this monopoly.

According to the Cobalt Development Institute (CDI), the demand for portable electronic device rechargeable batteries has doubled over the past several years. Increasing numbers of HEVs and EVs drives the demand for rechargeable batteries ever higher. The deployment of more and more clean energy production technologies further swell demand. In fact, the growing demand for cobalt in battery and catalyst use has surpassed super-alloys as the primary demand for cobalt. Furthermore, the demand in the battery and catalyst sectors has shifted from the U.S. and Europe to Asia and is evidenced by the battery and catalyst production in Asian countries. This shift, however, may reverse as large-scale battery production operations in the U.S. take hold, such as those starting up in Michigan and Tennessee.

The rapid growth of the Chinese industrial and consumer base, along with increasing competition for cobalt in the emerging clean energy sector, further strains the U.S. already tenuous position of foreign dependency. Moreover, it is estimated that approximately 80% of the high-purity cobalt market, that is the purity of cobalt needed in super-alloys and many high-tech applications, is controlled by a single foreign company. With U.S. demand for high-purity cobalt at 60% of the world's supply and no currently operating domestic sources or refineries, we are completely dependent on other countries for our supply of high-purity cobalt.

There is, however, at least one primary source of high-purity cobalt in the U.S. being developed in Idaho. The Idaho Cobalt Project includes development of an underground mine and refinery. Cobalt was formerly mined in this area from the early 1900's until the 1970's. When in production, the Idaho Cobalt Project mine and refinery will be the only U.S. domestic, primary source of high purity cobalt.

### POLICY

The importance of re-energizing effective policies regarding the exploration, development, and production of strategic minerals in support of clean energy technology development is underscored by the U.S.' precarious position of dependency. The Western Governors Association (WGA) recently adopted policy resolution 10-16, titled "National Minerals Policy." This policy resolution states, "WGA urges the federal government to fund an effort by the U.S. Geological Survey and state geological surveys to identify potential, domestic REE deposits and other critical minerals for alternative energy technologies." As you now know, the U.S. demand for strategic minerals and REEs for clean energy technologies, as well as other uses, vastly outpaces the limited or non-existent production in the United States today.

The challenge of permitting a new mine in the U.S. must be weighed by companies exploring or trying to develop strategic mineral deposits domestically. Additionally, uncertainties regarding policies towards mining can further hamper efforts to develop domestic sources. A vital component of effective energy policy must include the development of the essential minerals required to effect U.S. energy security.

Cobalt is essential for the future of the U.S.' national defense and energy security. While demand for cobalt increases globally, the supply continues to be controlled by an exclusive group of countries or foreign companies that may not be friendly to the U.S. or are politically unstable. The U.S.' cobalt dependency can only be remedied through effective application of policy that makes the domestic production of cobalt, via environmentally sustainable mining and refining, a priority.

Senator CANTWELL. Thank you very much for your testimony.

Mr. Peter Brehm, thank you very much for being here. We look forward to your testimony.

## STATEMENT OF PETER BREHM, VICE PRESIDENT OF BUSINESS DEVELOPMENT AND GOVERNMENT RELATIONS, INFINIA CORPORATION, KENNEWICK, WA

Mr. BREHM. Thank you, Madam Chairman and Ranking Member Risch and members of the subcommittee. I am Peter Brehm, the Vice President of Business Development and Government Relations for Infinia Corporation. We are headquartered in the State of Washington and we have operations in New Mexico, Michigan, and

California, as well as Spain, India, and Japan. We have over 130 employees, 100 of whom are based at our headquarters in the Tri-Cities in Washington State. Notably being nearby, we have several key business partners, supplies, and consultants in and from Idaho. It is an honor to appear before you and testify on behalf of Infinia.

First, let me tell you a little bit about our firm. Infinia has developed and manufactures the PowerDish, a unique, high-performance solar power system that uses a Stirling engine and a parabolic mirror to convert sunlight into heat and resulting heat into electricity. Our system is not PV- or solar panel-based, but instead a unique U.S.-developed and manufactured concentrating solar power system. Each PowerDish produces 3 kilowatts of power. Our systems do not consume water which is in short supply in the West, nor do they need flat or graded ground to operate. Through scalability, we can size our projects to fit within existing transmission and distribution constraints.

Notably, we manufacture here in the United States, and at a time when the auto industry is facing historic difficulties, our technology is perfectly suited to being manufactured on automotive supplier assembly lines. In fact, virtually our entire supply chain is the automobile industry suppliers, most of which are based in the hard-hit Midwest, including Michigan, Ohio, Indiana, and Iowa, but notably a major supplier in Utah.

Although our primary focus is the commercialization of the PowerDish solar power system, we are actually a very diversified renewable and alternative energy technology developer and manufacturer. In addition to our solar power system, we have over a dozen renewable and alternative energy development programs in such diverse areas as tactical and remote power systems, combined heat and power, coolers, and cryocoolers.

With significant interest in investment in such a broad range of renewable energy and alternative energy technologies, Infinia brings a rather unique perspective to this hearing. Not only do we use rare earth metals in our core technology, but many of our customers also use rare earth metals or closely related materials.

As technical background, Infinia's core technology are Stirling Cycle devices, including Stirling engines which convert heat into electricity and Stirling coolers and cryocoolers which convert electricity into cooling. The key component of all of the above-described Stirling Cycle devices is a linear alternator, and this is where rare earth metals come into play.

The linear alternators use what are known as permanent magnets and the most powerful and compact permanent magnets use rare earth metals. In our case, we currently use neodymium magnets. Additionally, we also use some small samarium-cobalt magnets.

Rare earth magnets in our linear motors or alternators are a critical part of all Stirling engines, cryocoolers, heat pumps, and air conditioners we are currently developing. Neodymium-based magnets provide the highest possible energy product and represent Infinia's major need for rare earth metals. Samarium magnets are also required for some applications. Samarium-cobalt magnets are also the only possible alternative to neodymium-iron-boron magnets. These have reduced but acceptable performance but still use rare earth metals. Any other alternatives will increase system size and weight and reduce power and efficiency to levels that are not viable for practical applications.

Access to and a commercial supply of rare earth metals is of critical importance to Infinia, our suppliers, and customers. Policies to ensure this supply are of great interest. It should be noted that in spite of the impression, as other panelists have made given by their names, rare earth metals are reasonably available and we have never had an issue securing neodymium or samarium. The potential problem is the supply is concentrated and apparently, considering recent events, subject to political disruption.

The loss or disruption of the rare earth metals supply would be catastrophic to Infinia in terms of price spikes, production volume, and related supply chain disruptions that would drastically limit our ability to develop and manufacture our products. Weight and efficiency are insurmountable hurdles with respect to alternative materials. Rare earth metals are simply a necessity for development, manufacturing, and advancement of Infinia's technology, as well as many other modern essentials.

Infinia strongly supports efforts such as S. 3521 to help ensure the supply of rare earth metals. However, we are concerned that one aspect of this proposed legislation is to extend the DOE loan guarantee program to domestic rare earth metals production. While we conceptually strongly support broadening the DOE loan guarantee program to encompass a domestic rare earth metals supply, we are troubled that this may jeopardize loans needed by other renewable energy projects. Recent testimony by the DOE's loan guarantee program management appears to indicate that DOE does not have adequate funding to support the existing pipeline of renewable energy-related DOE loan guarantee projects and proposals, much less an expanded pipeline that might result from S. 3521 or similar legislative or regulatory proposals.

As the committee is keenly aware, funding representing over half of the DOE loan guarantee program has already been reallocated on two separate occasions. The DOE loan guarantee program and adequate funding for this program is of great import to Infinia and our renewable energy industry colleagues.

On a related note, we would also like to bring to the attention of the committee that there are promising U.S.-invented and developed technologies, namely high temperature superconducting motors and generators, that require virtually no rare earth metals and are direct substitutes for similar traditional motors requiring rare earth metals. The irony is that we do have the world's leading high temperature superconducting industry here, and based on recent budget direction, it appears that DOE is looking to slowly terminate that program.

Thank you.

[The prepared statement of Mr. Brehm follows:]

PREPARED STATEMENT OF PETER BREHM, VICE PRESIDENT OF BUSINESS DEVELOPMENT AND GOVERNMENT RELATIONS, INFINIA CORPORATION, KENNEWICK, WA

Madam Chairman, Ranking Member Risch and Members of the Subcommittee, I am Peter Brehm, the Vice President of Business Development & Government Relations for Infinia Corporation. We are headquartered in the State of Washington, and we have operations in New Mexico, Michigan and California, as well as Spain, India and Japan. We have over 130 employees, 100 of whom are based at our headquarters in the Tri-Cities in Washington State. Notably, being nearby, we also have several key business partners, suppliers and consultants in and/or from Idaho. It is an honor to appear before you and testify on behalf of Infinia.

Let me first tell you a bit about my firm. Infinia has developed and manufactures the PowerDish™, a unique, high-performance solar power system that uses a Stirling engine and a parabolic mirror to convert sunlight, which is free, into electric power, which is valuable. Our system is not a PV or solar panel-based system, but instead a unique U.S.-developed and manufactured Concentrating Solar Power system. Each PowerDish™ produces 3 kW of grid-quality AC electricity. Our systems do not consume water—which is in short supply in the West—nor do they need flat or graded ground to operate. And through scalability, we can size our projects to fit within existing transmission and distribution system constraints.

Notably, we manufacture here in the United States and, at a time when the auto industry is facing historic difficulties, our technology is perfectly suited to being manufactured on automotive supplier assembly lines. In fact, virtually our entire supply chain is automobile industry suppliers, most of which are based in the hard-hit Midwest including, Michigan, Ohio, Indiana and Iowa.

Although our primary focus is the commercialization of the PowerDish™ solar power system, we are actually a very diversified renewable and alternative energy technology developer and manufacturer. In addition to our solar power system, we have over a dozen renewable and alternative energy development programs funded by the Department of Defense (DOD), Department of Energy (DOE) and commercial partners in such diverse areas as tactical power systems, remote power systems, combined heat & power systems, coolers, cryocoolers and air conditioners.

With such a diverse portfolio of technologies, Infinia is a member of several renewable and alternative energy related trade associations. We are a member of, and I represent Infinia on the Board of Directors for the Solar Energy Industries Association (SEIA) and the Commercial Coalition for the Application of Superconductors (CCAS). Infinia is also a member of the United States Clean Heat & Power Association, the Clean Technology and Sustainable Industries Association, the Washington State Clean Technology Alliance and the Large-Scale Solar Association among others. On a related note, I was appointed by Governor Christine Gregoire in 2009 to the Washington State Clean Energy Leadership Council, which advises Washington State's Governor and Legislature on Clean Energy Policy.

With significant interest and investment in such a broad range of renewable and alternative energy technologies, Infinia brings a somewhat unique perspective to this hearing. Not only do we use Rare Earth Metals (REM) in our core technology, but many of our customers also use Rare Earth or closely related materials.

As technical background, Infinia's core technology are Stirling Cycle devices including Stirling engines which covert heat into electricity and Stirling coolers, cryocoolers, heat pumps and air conditioners which convert electricity into heat, cooling and cryocooling. The key component of all of the above described Stirling Cycle devices is a linear alternator.

This is where the Rare Earth Metals come into play. The linear alternators use what are known as permanent magnets and the most powerful and compact permanent magnets use REM's. In our case, we currently use Neodymium magnets which are made of the REM Neodymium. Additionally, we also use some small Samarium-cobalt magnets which use the REM Samarium.

As an example, the tables and pictures* below describe the REM used by Infinia's PowerDish™. As the slides indicate REM's are vital to our products.

Rare earth magnets in our linear motors or alternators are a critical part of all Stirling engines, cryocoolers and heat pumps/air conditioners being developed or commercialized by Infinia. Neodymium based magnets provide the highest possible energy product and represent Infinia's dominant need for rare earth elements. Samarium is required for some applications with magnets that operate at significantly elevated temperatures. Samarium/cobalt magnets are the only possible alternative to the neodymium/iron/boron magnets. These have reduced but acceptable performance, but they still use a rare earth element. Any other alternatives such as Alnico magnets will increase system size and weight and reduce power and efficiency to levels that are not viable for practical applications.

Access to and a commercial supply of REM's is clearly of critical importance to Infinia, our suppliers and our customers. Policies to ensure this supply are of great interest. It should be noted that, in spite of the impression one might get from their name, REM's are reasonably available and we (and to the best of our knowledge, our vendors) have never had an issue securing the Neodymium or Samarium. The

* Tables and graphics have been retained in subcommittee files.

problem is the supply is concentrated and apparently, considering recent events, subject to political disruption.

The loss or disruption of the REM supply would be catastrophic to Infinia in terms of price spikes, production volume and related supply chain disruptions that would drastically limit our ability to develop and manufacture our products. Weight and efficiency are insurmountable hurdles when alternatives are assessed for Infinia's Stirling cycle devices. REM's are simply a necessity for the development, manufacturing and advancement of Infinia's technology, as well as many other modern essentials.

Infinia strongly supports efforts such as S.3521 to help ensure the supply of REM's. However, we are concerned that one aspect of this proposed legislation is to extend the DOE Loan Guarantee Program to domestic REM production. While we conceptually support broadening the DOE Loan Guarantee Program to encompass a domestic REM supply chain, we are troubled that this may jeopardize loans needed by other renewable projects. Recent testimony by the DOE's Loan Guarantee Program management appears to indicate that DOE does not have adequate funding to support the existing pipeline of renewable energy related DOE loan guarantee projects and proposals, much less an expanded pipeline that might result from S.3521 or similar legislative or regulatory proposals.

As the committee is keenly aware, funding representing over half of the authorization for the DOE's Loan Guarantee Program has already been reallocated on two separate occasions apparently leaving the DOE's Loan Guarantee Program insufficient funding to support its existing backlog of projects and proposals—one of which is a proposal by Infinia to invest in our automotive industry supply chain in Washington State, Utah, Michigan, Indiana and several other states. The DOE Loan Guarantee Program and adequate funding for this program is of great import to Infinia and our renewable energy industry colleagues.

On a related note, we would also like to bring to the attention of the committee that there are promising U.S. invented and developed technologies, namely High Temperature Superconducting (HTS) motors and generators, that require virtually no REM's and are direct substitutes for similar traditional motors and generators requiring large quantities of REM's. The development and commercialization of these and other HTS applications would significantly reduce the demand for REM's, which would lessen the threat and/or effect of supply disruptions.

Despite the value of HTS technologies, the DOE appears to be in the process of winding down and ultimately terminating the HTS program. We would respectfully like to suggest, especially considering the recent disruptions to the supply of REM's, that the committee strongly encourage the DOE to rethink their apparent decision to wind down and/or terminate the DOE's High Temperature Superconducting program.

Thank you for the opportunity to testify on behalf of Infinia and our renewable energy industry colleagues.

Senator CANTWELL. Thank you for your testimony.

We are going to start with you, Dr. Eggert, if we could. On this issue in your testimony, you talked about a USGS mineral information team, or whatever group would be assigned for this information gathering, should have greater authority and autonomy than at present. What are you thinking about? What are we trying to capture by giving them greater authority and autonomy?

Mr. EGGERT. The National Research Council report and the committee that I chaired recommended that the minerals information function have the designation of, it is either, primary or principal statistical agency which gives it the authority to require the submission of data that it requests. At present, the minerals information function is hampered by the voluntary nature of their requests or responding to their requests. In some cases, particularly with very small markets like many of the rare elements, not just rare earths, but the rare elements more generally, that is a significant issue, and there is a lack of transparency in these markets generally.

Senator CANTWELL. So collecting all the information and requiring that so we can have a clear idea about the markets and the possible shortages.

Mr. EGGERT. The supply risks from a policy perspective.

Senator CANTWELL. The supply risks.

Mr. EGGERT. That is right, yes.

Senator CANTWELL. You also talked about pre-commercial activities by the Federal Government in R&D. Are there particular areas there that you think we need to focus on?

Mr. EGGERT. There are areas both on the supply side and the demand side. I think on the supply side, research and development especially related to recycling is important. Earlier in the supply chain, research and development related to the processing of rare earth, if we are talking about rare earths, rare earth ores and concentrates, is where the principal challenge occurs at present in the production of rare earths. On the demand side, it would be research related to primarily material substitution, material science sort of research.

Senator CANTWELL. Is cobalt the key area there, or where do you think we need to be looking at substitution possibilities?

Mr. EGGERT. It potentially could be in any of the elements that satisfy two conditions, subject to a high degree of supply risk and also at present very difficult to substitute away from without losing functionality in the product. I mean, I would include rare earths in that. I would include cobalt in that list. I do not have a comprehensive list of elements in my mind, but it certainly would include both rare earths and cobalt and probably some others.

Senator CANTWELL. Then just last on the foreign policy question, I mean, you obviously want us to be aggressive about making sure we have a level playing field. But you also talk about the lack of a diversified supply base domestically and foreign supply. Are there other things that we should be doing to encourage the larger global supply in addition to what we would do here to stabilize—is that what you meant by "rather it is a lack of diversified supply, domestic and foreign, that leads to the supply risk"?

Mr. EGGERT. I guess that was part of my main point that import dependence by itself need not be subject to supply risk, but it can be when there is geopolitical risk or a concentrated supply. I think our primary responsibility certainly should be thinking about the domestic possibilities for production, but there may be opportunities for diplomatic initiatives associated with international developments. I guess I am not thinking about our investing public funds overseas.

Senator CANTWELL. No, and I was not suggesting that either. I was just interested in where you thought, obviously, you could balance out because the challenge in the next few years to deal with this from a supply chain perspective takes time. So I did not know if there were other things that we could be doing in the short term to balance out the clout or the issues with China.

Thank you.

Senator RISCH. Thank you, Madam Chairman.

Mr. Eggert, you made one comment that I want to test a little bit here. You indicated that you were opposed to special treatment when it comes to mining or processing or what have you of certain of the rare earths. I understand that that is probably a politically correct position to take.

But assume for theoretical purposes and general purposes—and for obvious reasons we are going to have to talk in theoretical purposes—we find a rare earth that is necessary for our nuclear arsenal or, for that matter, for modern conventional weapons for the smart weapons that we have and the only place we can get it here is in the United States. Would you have any difficulty with a policy of the Government that did treat the extraction and processing of the mineral differently than maybe other things due to the important national security of that particular rare earth?

Mr. EGGERT. Certainly if there were a specific circumstance where the impact of not having supply was sufficiently large, then sure, in theory one could imagine relaxing environmental standards in that specific situation.

Senator RISCH. Let us move past the theory. Are you aware of any of those rare earths that we have a need for now that are very important to our national security?

Mr. EGGERT. I have to say I am not an expert on defense applications. My impression from what I have read is that there are a number of defense systems that do depend critically on some of the rare earths.

Senator RISCH. Your reading is correct.

Mr. Rufe, could you describe for the committee, please—give us the executive summary, but perhaps you could describe the regulatory challenges that you faced and still face in bringing this cobalt project into production.

Mr. RUFE. Thank you, Senator Risch. That is an excellent point to discuss.

The timeframe it takes a project to go from its exploration phase into production averages somewhere between 6 and 7 years in the United States. That is quite a contrast to other countries where it might take in the timeframe of a few years.

The biggest hurdle that companies face in developing projects today is regulatory uncertainty. Because of the timeframe it takes to go from start to finish, so to speak, the environment is changing and not environment in the literal sense so much as the environmental regulatory environment, if you will, is changing rapidly. So not knowing what you are going to have to deal with when you actually get the project into production at day one is leading companies to great concern about the investing into projects in the United States.

Some of the greatest issues—the most important issues that mining companies deal with as far as developing mining projects is in water quality, largely water quality. By changing water quality regulations and standards, as we are able to detect lower and lower levels of constituents in water, we see a moving bar on what the standard is. It does not necessarily equate to better, cleaner, or more environmentally friendly conditions. It just means there are lower numbers, and that makes it very difficult and very challenging for projects to move forward, constantly adapting technologies, new technologies, to counter these requirements as they grow into place.

Senator RISCH. Thank you very much. As I noted, when I was Governor, I visited that site and went over the challenges that you people were facing there. I am truly amazed that you have gotten to the point that you have gotten, and you are to be congratulated.

The last challenge I heard was that one of the Federal agencies had thrown a huge bond requirement at you. Have you gotten past—after all the things that you got, finally at the very end they put a bar that you could not cross. Have you resolved that?

Mr. RUFE. Senator, unfortunately, we have not yet resolved that issue, and I appreciate you bringing that up because that is the greatest issue that we still are faced with prior to moving into construction. In fact, there is a move out there under the CRCLA Act, section 108, I think it is section B to promulgate additional financial assurance requirements for mining projects. In many cases, it is either duplicative, redundant sort of financial assurance requirements that are already required by Federal land management agencies like the Forest Service, the Bureau of Land Management, and other State agencies. That too presents a tremendous risk for future projects. So we have not yet resolved that. It is actually an issue that is kind of bouncing back and forth between the Washington office of the Forest Service and now back to the Salmon office where we are working with the local representatives there to resolve. But the point is that projects that are facing massive financial assurance requirements is detrimental to the economics of these projects.

Senator RISCH. Thank you. I wish we had more time to spend on that.

Can I ask one more question please, Madam Chairman, of Mr. Brehm?

Senator CANTWELL. Yes.

Senator RISCH. Briefly, could you tell us—you have heard our discussion today about the brouhaha between China and Japan and how Japan got cutoff from the rare earths. If that same thing happened between the United States and China—for instance, if we got in a row over the currency or the Dalai Lama or one of those things, and they cut us off—what is that going to do to your business, to Infinia's business?

Mr. BREHM. We really have no alternatives to samarium, cobalt, and the neodymium magnets. So if we would lose the supply, we could not produce while that supply was not available.

Senator RISCH. Thank you for your indulgence, Madam Chairman.

Senator CANTWELL. Thank you.

Senator UDALL. Thank you, Madam Chairman.

I would draw attention for my friend from Idaho to an article yesterday: Pentagon Losing Control of Bombs to China, Neodymium Monopoly. I will get a copy of this to you.

Senator RISCH. Thank you. I think I have read it already.

Senator UDALL. You are always ahead of me, but I think your points about the DOD and their involvement are very, very important ones.

Senator McCain is here. He and I both sit on the Armed Services Committee, and this may be something that we need to also consider in the Armed Services Committee.

Let me follow up on Senator Risch's questioning. I come at this truly with an open mind, and I did, Mr. Rufe, develop some concerns as you talked about the long processes involved, particularly on the financial side and the guarantees.

I have heard from Molycorp—I mentioned Molycorp as a Colorado-based company—that they believe the environmental regulations that are in place are appropriate, are balanced, and that they can develop rare earths and adhere to the permitting and environmental regulations that are in place. Maybe each one of you could comment in turn about proposals to relax environmental regulations. I think it is important, of course, to maintain clean air and clean water and the things that we value, particularly in the West, but all over our country. If you would, if you would each comment.

We will start with Mr. Eggert. By the way, welcome. It is always nice to have a Coloradan here in Washington, D.C.

Mr. EGGERT. Thank you very much. It is my pleasure to be here.

I would distinguish between relaxing environmental standards and making the approval process more efficient. What I would emphasize is improving the efficiency of the process rather than relaxing the standards.

Mr. RUFE. To piggyback on Mr. Eggert's comments, the relaxation of regulatory requirements I do not believe is the appropriate response. Rather, it is establishing some certainty as far as what those regulations will be today and 5 to 10 years into the future. That is the greatest risk that we face. Eliminating redundancy, streamlining, as Mr. Eggert said, streamlining that process, reducing the duplicity that we are seeing. One of those, as I mentioned, is the potential redundancy of financial assurance requirements through the multiple Federal agencies involved in a mining process.

Senator UDALL. Fair enough.

Mr. Brehm.

Mr. BREHM. Of course, I am not an expert on environmental regulations as they apply to mining. But I would echo both Mr. Rufe and Mr. Eggert's point, that businesses like certainty. I do not think they are really saying anything negative about the regulatory regime. It is just it is a moving target and difficult to hit. We all want clean water. We do not want a situation, for example, in Senator Risch's home State—I am a big fan of northern Idaho and Lake Pend Oreille. There are still signs up there you cannot eat the fish because of mercury left over from mining in the 1800s. So I think really more certainty would do everything for you, I would assume.

Senator UDALL. Thank you for those concise and insightful comments.

Mr. Eggert, let me turn back to you. We hear often that rare earths are not actually that rare, but that they occur naturally everywhere. What is rare about them, though, is finding them in a concentration high enough and large enough to mine economically. At current prices, what do you believe is an ore grade that can be mined economically? How high would prices have to go before lower grade deposits become economical? If you want to take that for the record, too, we would be happy to provide you with that.

Mr. EGGERT. Let me say I am not a mining engineer, and even though my undergraduate degree is in geology, I cannot comment on ore grades in rare earth deposits.

I would also say that at present, prices for most rare earths have spiked. I think they have increased something like 700 percent over the last 8 or 9 months, but those are likely to be temporary, although how temporary one cannot be sure.

I think the biggest issue at present is that the Chinese rare earth deposits are of sufficient quality that they potentially could supply most world demand at prices below what would be necessary for at least many other potential rare earth mines. So I think the conundrum facing many private investors in rare earths is the fact that the prices could fall if Chinese producers decided to, all of a sudden, relax the export restrictions and flood the market.

Senator UDALL. I see my time has expired. Let me end with a comment which will lead to a question for you all for the record, which is I understand China has more than 6,000 scientists and researchers devoted to rare earth research and development and applications. We only have one institution of higher learning in our country that offers a course in rare earths. That is at the Colorado School of Mines. To be fair, I think you all just announced plans to offer that course just a couple of weeks ago. So it is clear we have got a lot of work to do. I will direct a question for the record to all of you on that in that vein.

Senator CANTWELL. Thank you.

Senator MCCAIN. Thank you, Madam Chairman, and thank you for holding this hearing because it comes in light of some interesting international events that have taken place. Obviously, I am referring to the Chinese restriction of rare earth materials to Japan in light of the confrontation that just took place between China and Japan. 97 percent—is that correct, Mr. Eggert—of the rare earth products come from China?

Mr. EGGERT. Approximately 97 percent of the raw material comes from China, yes.

Senator MCCAIN. Yet there is some evidence that some of the rare earth materials are in the United States of America. To wit, I specifically point out the Painted Desert. There is information that some of that rare earth material may be there, as well as other places in the country. Is that true? Do you know, Mr. Eggert?

Mr. EGGERT. Yes. There are a number of rare earth-bearing mineral deposits in the United States and a number of other countries.

Senator MCCAIN. Is that your view, Mr. Rufe and Mr. Brehm?

Mr. RUFE. Yes, Senator, it is.

Mr. BREHM. I believe we probably have the second largest deposits after China.

Senator MCCAIN. So we have the second largest deposit, and yet there is virtually no production.

This molybdenum—I am not in an area of my total expertise, but there is a little bit of production in the United States. Is that true, Mr. Eggert?

Mr. EGGERT. Molybdenum.

Senator MCCAIN. Yes.

Mr. EGGERT. Yes, there is quite a bit of molybdenum production in the United States.

Senator MCCAIN. Is that the only one of rare earths that is a significant production?

Mr. EGGERT. Molybdenum, I think strictly speaking, is not considered a response element. It is in a different part of the periodic table.

Senator MCCAIN. OK. Then I will retract my question.

So you said that there would be a situation where the Chinese might dump on the market and that would reduce the costs, but from their recent action, it may be more likely that they would certainly hold back to keep the cost of rare earths high. Certainly they are doing that to the Japanese right now. If trade conflicts escalate between the United States and China, to wit, the House acting just yesterday on the situation of currency imbalance, you could see further restraints on the part of the Chinese.

So that leads me to the important part of our conversation. What do we need to do in order to stimulate—and I understand it takes a number of years, if we started today, to get some of this rare earth materials in production. What do we need to do? Suppose you had a magic wand and said, OK, this is the environment we need to create to have the United States play a role in rare earth materials and resources if only to satisfy our defense needs which, as you know, require some of these materials. Mr. Eggert?

Mr. EGGERT. My written testimony covers this issue generally. I would emphasize, in response to your question, the importance of education and training because we really have a deficit in terms of the work force and the intellectual infrastructure——

Senator MCCAIN. Yes, but that does not start production.

Mr. EGGERT. You are right. You are right.

I also am in favor of improving the regulatory environment and the regulatory process through which new mines are permitted. But as I also said, I am really not in favor of special—under most circumstances, in favor of special treatment for specific elements.

Senator MCCAIN. Mr. Rufe.

Mr. RUFE. I can speak specifically, Senator, to the Idaho Cobalt Project, Formation Capital's effort in Salmon, Idaho. We are able to produce cobalt at the low end of the cost spectrum across the world's supply of cobalt. We are able to produce there. But if there was a magic wand, as you put it, I think it would have to be in the financial area to provide the, for example, loan guarantees to finance these efforts.

Senator MCCAIN. Is that not a chicken or egg thing? Because financial backing is not going to come unless they see a clear path toward return on their investment, which right now, at least the people I talk to, is impeded—maybe Mr. Brehm has a view—by the vast regulatory thicket they have to go through and congressional action sometimes blocking specific projects from moving forward. We have that case of a copper mine in Arizona. Go ahead.

Mr. RUFE. Yes, sir. No doubt that that may be the case. Certainly in instances of our national security, the return on investment is not necessarily measured in terms of dollars. So interpreting your question in that manner, that is why I answered the way I did.

Senator MCCAIN. We do not expect the Federal Government to get into the mining business, but we hope to create an environment where businesses and enterprises can go in and get into that business and provide us with much needed strategic materials.

Mr. BREHM. Again, Senator, we are a customer of the material, not so much a supplier.

But I think this hearing is a great first step. Personally and from Infinia's point of view, what we really appreciate about this hearing is that there have been a number of questions that indicate you Senators are looking at the entire supply chain, and we think that is very important.

As I mentioned earlier, certainly we are actually conceptually very supportive of expanding the loan guarantee program to include mining of this material so long as there is an increase in the authorization because recently the loan guarantee program has been going the other way.

But again, from just a core business concept, regulatory certainty I think would go a long way. So for the investors in Mr. Rufe's project, if they knew—like many industries, if you had a road map and you knew exactly when and what it would cost you to get the mine permitted, I think the return would be—it is the uncertainty of the return cost by the regulatory uncertainty, I would assume.

Senator MCCAIN. I thank you.

I thank you, Madam Chairman. As Senator Udall pointed out, I think we need to look at this issue from a national security standpoint clearly since there are materials that go into the production that are vital in the production of many of our weapons systems. Clearly the numbers indicate that these materials are going to become scarcer and scarcer, not to mention the possibility that we would have China take action such as they just took against Japan. It could have significant impact.

So I thank you for holding the hearing, Madam Chairman, and I do not think this issue is going away for a while.

Senator CANTWELL. Nor do I. Thank you, Senator McCain. I thank you and Senator Udall, actually all my colleagues from the West participating in this hearing this morning. It is an important issue, and I am sure we will continue to dialog about it both from a national security and clean energy perspective.

I wanted to go back to the recycling issue for a second. Mr. Eggert, is there any number, idea, concept about the recycling end of this and the potential for materials from recycling?

Mr. EGGERT. The potential is large, but up until now, there has been very little recycling of rare earth elements and most of the rare elements in the lists of elements in this category that one sees, largely because these elements are used in small quantities in much larger and bulkier products, and it is technically quite difficult to separate the rare earth element, for example, from the product in many cases. So there needs to be work to improve the technical efficiency of recycling rare elements from products and back at the product design stage in really designing for recycling.

Senator CANTWELL. So what do we need to do to get a sense of how big that potential or opportunity is?

Mr. EGGERT. I guess it would start with information and look at the degree to which there are rare earths and other rare elements in our waste dumps, and I think at present we do not really know.

Senator CANTWELL. Mr. Rufe, the Molycorp at Mountain Pass in California had some substantial environmental issues. I mean, they had leaks from a waste pipe into their evaporative ponds. They broke the wastewater pipe when they were trying to clean out the mineral scale inside the pipe. The scale had above average levels of radioactivity from participating minerals, resulting in environmental contamination when the pipe burst. I mean, to make matters worse, they were on public lands. So this mine was closed in 2002 in part due to the environmental issues, the fact the mine had reached its capacity as well on wastewater ponds, and since that time, the operator has had to address these and other environmental and safety issues.

How are the cobalt mine operations differing from the mining of rare earths, and how can we be assured that cobalt that you are hoping to produce will not cause the same environmental damage?

Mr. RUFE. To start, the cobalt is not a radioactive element, nor is it found with a predominant quantity of radioactive elements. So that is not largely a concern.

The major issues that have occurred in the past on historic mining properties where there is legacy contamination and ongoing cleanup are directly attributable to historic mining practices. For example, waste management is largely the greatest concern or the greatest cause of contamination today at these legacy sites. That was essentially because the removal of rock and the management of waste was nearly indiscriminate in its placement. It was a matter of convenience, whereas today's mining practices use very deliberate geochemical testing and monitoring programs along with placement in specially engineered facilities to prevent those type of situations from occurring. Specifically, the Idaho Cobalt Project incorporates a series of different mitigation measures to mitigate against those sorts of risks, and those largely are in the modern design of the facility.

Senator CANTWELL. What about other rare earths and mining practices?

Mr. RUFE. Largely the same issues exist as far as the management of the mine wastes, where they are placed, how they are handled, and I cannot speak specifically to some of the rare earth production facilities. I am not familiar with some of the extraction techniques that are used to concentrate those ores, but largely it is focused in waste management for most mine operations.

Senator CANTWELL. I just was discussing with my colleagues here. Obviously, updating the 1872 Mining Law I think could be very helpful in making sure that we have good practices on the books.

Mr. Eggert or Mr. Brehm, any other comments about mining practices and environmental safety?

Mr. BREHM. Again, we are a consumer.

Senator CANTWELL. Thank you.

My colleague, Senator Risch, do you have any more questions?

Senator RISCH. Just briefly, Madam Chairman. You would be very impressed with the plan that the Cobalt Project has in Idaho, and as Mr. Rufe has indicated, they were saddled with having to pick up not only a plan that took care of their waste management, but as he pointed out, there was a legacy there that had to be dealt with and done by people who were not bad people. They were just people who handled things differently than we do today and did what they did at the time. As a result of that, they have had to pick up part of that. So the fact is their operation there is going to make the environment better than were they not there and the legacy contamination just stayed.

So having said that, thanks again for holding this—well, I guess jointly holding this hearing. I think that we have just scratched the surface here. I think this is a really—as has been pointed out, my large concern is national security, but this is an issue that is something that deserves the attention of the U.S. Congress, and certainly the agencies of the executive branch need to focus on this and be a facilitator as opposed to a prohibitor of mining these rare earths. This is only going to get more critical as time goes on and particularly as manufacturing continues to mature in the clean energy area and, for that matter, a lot of other areas. So we will continue to monitor it and I think this hearing has been very helpful in helping raise the level of the understanding of the challenges that we face. Thank you, Madam Chair.

Senator CANTWELL. Thank you, Senator Risch, and thank you for being here and allowing us to get this hearing done. It is important that we continue to have a discussion on this issue, and clearly this committee plays an important role. While this policy has many ramifications and many issues, as our colleagues from the Armed Services Committee pointed out, and obviously issues of the administration's foreign policy, I do think the impetus of this hearing originally was Senator Murkowski's bill, 3521, and there is some discussion there that we have received testimony on today.

But ultimately I think it starts with information. Information is power and having more accurate information about these markets and these minerals and where we are today and where we can go in the future is critical and is the jurisdiction of this committee. So clearly, whether it is EIA or other organizations, getting that responsibility, as Mr. Eggert said, is not just a voluntary function, but getting accurate information, and making sure that we have that I think is going to be critical.

So we will have many more opportunities to move forward on this legislation. Hopefully, we can do so in a bipartisan fashion and show results for making sure that the United States has the access to these materials that it needs.

So with that, the hearing is adjourned.

[Whereupon, at 11:25 a.m., the hearing was adjourned.]

# APPENDIXES

## APPENDIX I

## Responses to Additional Questions

RESPONSES OF DAVID SANDALOW TO QUESTIONS FROM SENATOR CANTWELL

*Question 1.* In Mr. Brehm's testimony he mentions that for some clean energy technologies that rely on rare earths there are potential substitutes that do not require, or require significantly lower quantities of, rare earths.

According to a report recently published by the U.S. Geological Survey, there is research going on in this area of substitutes.

The report cites research at the University of Nebraska that has the goal of developing a permanent magnet that does not require rare earths at all.

It also mentions researchers at the University of Delaware that are trying to create a new magnetic material based on "nano-composite" magnets. If successful, this process could slash the use of rare earths in magnets by 30 or 40 percent.

And according to recent press reports, Japan's New Energy and Industrial Technology Development Organization (NEDO) and Hokkaido University have developed a hybrid vehicle motor using only inexpensive ferrite magnets that don't need rare earths.

Can you please elaborate on this idea of substitutes for rare earths? Do you think that non-rare earth alternatives can be as effective as technologies that use rare earths?

Answer. Substitutes for rare earths can occur at different steps in the manufacturing supply chain. In some cases, it may be possible for manufacturers to replace a rare earth element with a different material (or other rare earth) that provides the same functional properties but is cheaper or more abundant. An example of this type of substitution occurs in NiMH batteries, which are used in most Hybrid-Electric vehicles. Battery manufacturers substitute less expensive mischmetal (a rare earth alloy of cerium, lanthanum, praseodymium and neodymium in varying proportions) in place of more expensive pure lanthanum with little sacrifice of battery performance. In other cases, manufactures could substitute entire parts of components containing rare earths with other technologies. Examples of this type of substitution could include substituting rare earth permanent magnet motors in electric vehicles with other types of motors, or substituting lithium-ion batteries, which contain no rare earth elements, for NiMH batteries in vehicles. Still another option is substitution of the entire end use application. An example of this type of substitution would be the replacement of fluorescent light bulbs containing rare earth phosphors with light emitting diodes that use little or no rare earth elements. Through the EERE Solid State Lighting program, DOE has taken national leadership in support of new technologies with the potential to develop LED and OLED alternatives to phosphor based fluorescent lighting. One critical area for these future technologies is advanced crystal growth for LEDs. In its inaugural round of funding, ARPA-E supported an advanced ammonothermal crystal growth project which if successful, would substantially improve the efficiency and quality of white LED bulbs.

The effectiveness of substitutes varies by individual technologies. Effectiveness must also be judged against a number of different criteria, including both the cost and functionality of the substitutes. Timeframe is also important, since substitution may involve significant changes to product designs and manufacturing production lines. For example, substitution of a rare earth magnet motor in an electric vehicle with a different type of motor would likely require substantial vehicle redesign, new suppliers and changes to assembly lines. However, automakers already make these types of changes periodically when they update existing car models. In the long run, DOE believes that cost-effective substitution is possible for most energy applications that use rare earths.

*Question 2.* Do you see substitutes as a truly preferential option, or merely tolerable as a "next best" option to rare earths?

Answer. DOE believes that substitution is possible for most energy applications that use rare earths given sufficient time to develop new technologies. This may include substitution of base materials, components or the entire end-use application. The decision to substitute for rare-earth content must ultimately be based on how the substitution affects the overall cost and performance of the end-use application. This calculation should also take into account the supply risks associated with all of the materials used in the system, not just rare earth elements. Therefore, the potential for substitution will vary over time and for each technology.

*Question 3.* Are there certain types of technologies or applications that have greater potential for having effective substitutes without rare earths than others?

Answer. Energy related technologies and applications with the greatest potential for effective substitutes are those where the substitutes are likely to provide substantial cost and performance improvements beyond the simple fact that they use less rare earth elements. One example is the potential substitution of lithiumion (Li-ion) batteries for nickel metal hydride (NiMH) batteries (which contain lanthanum, praseodymium and neodymium) in electric-drive vehicles. Li-ion batteries are currently more expensive than NiMH, but potentially offer superior energy density, cold-weather performance, abuse tolerance, and recharging rates. Another example is the substitution of light emitting diodes (LEDs) for fluorescent light bulbs. LEDs contain a fraction of the rare earth phosphor content of fluorescent bulbs, and they also have the potential for greater efficiency and longer life. Both substitute technologies—Li-ion batteries and LED light bulbs—are already likely to grow in market share based purely on their performance advantages. The fact that they use little or no rare earths would serve only to accelerate the substitution process.

*Question 4.* Is there particular research that you can think of that would be helpful for DOE to pursue or support when it comes to developing rare earth substitutes?

Answer. DOE has identified a number of research priorities related to both finding rare earth substitutes and reducing the amount of rare earth required for a given application. Research priorities for substitutes include:

- Magnets and motors: Advanced power electronics which enable induction motors with superior performance to permanent magnet motors.
- Phosphors and lighting: Research into alternative phosphor materials, including the use of quantum dots. Also, research into Organic LEDs that use no rare earths, with improvements to luminous efficacy, cost, and color rendering.
- Batteries: Research into lithium-ion and other battery chemistries, as well as over the horizon battery technologies which would utilize only earth abundant materials such as iron or zinc, and have performance/cost ratios which are 5-10 times better than Li-ion batteries.

Research priorities for reducing rare earth content include:

- Magnets and motors: Research into opportunities to get the same performance with less rare earth content. This includes the development of high-flux soft magnets and nano-structured permanent magnets, including core-shell structures and composites.
- Phosphors and lighting: Research into non-organic LEDs, which use significantly less phosphors than fluorescent bulbs.

*Question 5.* Mr. Sandalow, in my view and experience, any time there are constraints on the supply of a commodity the conditions are ripe for excessive market speculation and sometimes manipulation. We have seen this in recent years in the markets for oil, electricity, natural gas, and other commodities. I am concerned about the possibility for the same issues to arise in the market for rare earths.

For example, is it possible that the Chinese could deliberately withhold rare earths supply from the global market today, prompting the U.S. and other countries to invest billions of dollars in developing alternative sources of supply, only to flood the market with cheaper product in the future, and put U.S. projects out of business? I'm concerned this type of manipulation is possible.

One powerful antidote to market manipulation is transparency and the promulgation of good information about the market. When market participants have good information about prices, producers, production rates, stockpiles, etc., they are able to plan and make sound decisions. Bubbles and shortages are far less likely to develop because it is much harder to manipulate a market that is exposed to the light of day.

Can you comment on the current level of transparency in the markets for rare earths and strategic minerals? How confident are we in our knowledge of the details of all aspects of the supply chains for strategic minerals?

Answer. The current level of transparency in markets for rare earths is very low. Rare earths are not traded on any global metal exchanges, such as the New York Mercantile Exchange (NYMEX) or London Metal Exchange (LME). Instead, bilateral agreements negotiated directly between producers and consumers are the standard. Reference prices for rare earths are mainly reported by the trade press with varying reliability. While we are confident in our general knowledge of the supply chain, our knowledge of specific details is limited. We would benefit from increasing the amount of detailed information about the supply chain.

*Question 6.* What is the current extent of DOE's market intelligence gathering efforts? Does the EIA follow the markets for rare earths and other strategic minerals closely? How reliable is their information?

Answer. DOE's current market intelligence on critical minerals is mainly limited to open source reporting from industry, academia, and other research organizations. Most rare, precious, minor, and specialty metals and their alloys are traded through bilateral contracts based on negotiated pricing between parties. Certain elements such as rare earths, gallium, tellurium, indium, and lithium are not traded on major exchanges such as the London Metal Exchange, which means there is no spot or futures market. The result is a fragmented market with information principally derived from producers, consumers, and traders. The nature of the process limits price disclosure in these markets and the prices of specialty metals quoted by traders and consultants vary widely in their reliability.

*Question 7.* Because of their strategic importance do you think it would be worthwhile to expand EIA's data collecting and processing capacity for these materials? Do you believe additional information gathering would be helpful?

Answer. This question has been referred to the U.S. Energy Information Administration (EIA) for response. EIA's mission is to collect, analyze, and disseminate independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment. EIA currently aids in the understanding of energy-related demand for rare earth minerals by collecting data and developing projections and scenarios that provide insight into the future demand for energy technologies that use these materials, such as wind turbines and electric vehicles. While EIA does conduct some equipment surveys, detailed data on material inputs are not currently a part of these surveys.

While rare earth minerals are used in conventional energy activities such as petroleum refining as well as in emerging "clean energy" technologies, they are also used extensively outside the energy sector. For example, while neodymium permanent magnets are used in both wind turbines and electric vehicles, they also are used in glass coloring applications, fertilizers, and permanent magnets for non-energy products such as microphones, speakers, and headphones. To that end, any energy-related analysis or data collection that EIA might pursue would only address a limited segment of the demand for rare earths.

The United States Geological Survey (USGS) has ongoing data collection responsibilities and professional expertise in assessing and reporting supply and demand data for nonfuel minerals, including the rare earths. In addition, several programs in the Department of Commerce are engaged in tracking and projecting developments within individual industries, including non-energy sectors that are significant users of rare earths. It would seem important to draw on relevant expertise throughout the government by pursuing increased data collection and analysis efforts related to the supply and aggregate markets for rare earth minerals. EIA would focus its contributions on issues concerning energy-related uses of rare earths and the possible implications of rare earth supply issues for our energy future.

*Question 8.* Mr. Sandalow, I was pleased that you mentioned the importance of reuse and recycling in your testimony. According to the Environmental Protection Agency, ewaste—composed of consumer electronics like TVs, video equipment, computers, audio equipment, and phones—makes up almost 2% of the municipal solid waste stream.

Although electronics compose a small percentage of municipal waste, the quantity of electronic waste is steadily increasing. In 1998, the National Safety Council Study estimated about 20 million computers became obsolete in one year. By 2007, EPA estimated that that number had more than doubled.

From 1999 through 2005, the recycling rate for consumer electronics was about 15%. For 2006-2007, the recycling rate increased slightly, to 18%, possibly because several states started mandatory collection and recycling programs for electronics.

The trend is in the right direction, but it still leaves 82% of obsolete consumer electronics going into landfills.

The Mining and Minerals Policy Act of 1970 declared that it is in the national interest of the United States to foster the development of the domestic mining industry ". . .including the use of recycling and scrap."

Can you please elaborate on the potential for reuse and recycling of rare earths and other strategic minerals from products that have reached the end of their useful life (whether consumer products or industrial products)? How significant could this be as a source of these materials?

Answer. There are several factors that drive the viability of reuse and recycling. First is the value of the component material. Second is the ease of disassembly or separation. Third is the quantity of material that can be gathered easily from a logistical perspective. These factors play out differently for various elements and applications. For example, relatively high value rare earth phosphors could be recycled from existing streams of fluorescent lights that are currently collected due to their mercury content. This recycling could potentially meet a significant fraction of current demand. However, where the demand is now ramping up, recycling cannot meet current demand. For example, the increasing use of neodymium magnets in wind turbines and electric vehicles means that wind turbines and vehicles currently at the end of their useful life will not contain the quantities of neodymium required for today's wind turbines and vehicles. Today's vehicles and wind turbines can be designed for future recycling, however.

*Question 9.* Do you plan to address the issue of reuse and recycling in your strategic plan? Do you plan to develop recommendations for how to increase the rates of reuse and recycling? Are there any lessons to be learned from efforts to recycle strategic minerals in other countries?

Answer. Recycling and reuse will be addressed in DOE's Strategy, including both research and policy.

*Question 10.* Mr. Sandalow, in your testimony you highlighted the effort, currently underway, of your team at DOE to develop a strategic plan for addressing the role of rare earths and other materials in clean energy components, products, and processes.

I am aware that other parts of the Administration have been working on other studies as well, including the Energy Information Administration and the President's Task Force on rare earths being hosted by the Office of Science and Technology Policy.

Could you please elaborate on where you are in the process of developing your strategic plan and what types of issues you are addressing?

Answer. DOE is developing an agency-wide Critical Materials Strategy addressing rare earth elements and other materials important for a clean energy economy, with a late 2010 release expected. The Strategy will discuss goals and key technologies to advance clean energy, the supply chain perspective (including intellectual property issues), current DOE research investments, and historical supply and demand of materials of interest. Approaches to proactively address the availability of rare earths include globalizing supply chains, developing substitutes, and improving material use efficiency (including recycling).

*Question 11.* How will your plan fit into the work being conducted by the President's Task Force?

Answer. DOE is actively participating in the OSTP-led working group with other key interagency players, including the Departments of Defense, Commerce, Interior, State, Justice and the EPA. This working group meets regularly and will help align strategies and programs on this issue. DOE's work has already benefitted from these interagency discussions, particularly with DOD and USGS. DOD is currently working on an assessment of rare earths in defense applications. USGS has been an invaluable source of data and information.

*Question 12.* Will the strategic plan apply to additional critical minerals beyond rare earths, such as cobalt or copper, that are also vital to the success of clean energy technologies?

Answer. Yes, the Strategy will not only address rare earth elements, but other materials important to a clean energy economy. Specifically, the Strategy will focus primarily on elements such as indium, gallium, and tellurium, which are used in solar photovoltaic thin films, as well as cobalt and lithium, which are used in batteries for electric vehicles.

*Question 13.* Can you give us any kind of preview of what recommendations might be in the plan? Do you envision some of your recommendations requiring federal legislation to enact?

Answer. In general, the Strategy will consider three approaches: globalizing supply chains; developing substitutes; and reusing, recycling, and improving material use efficiency.

*Question 14.* Mr. Sandalow, you made only passing reference to Senator Murkowski's bill, S. 3521 in your testimony. I would be very interested in hearing your views and the position of DOE on this legislation.

As I'm sure you know, the bill would establish a strategic task force, composed primarily of cabinet level officials, to streamline efforts to increase rare earth production in the United States.

It also calls for the Secretary of Energy to issue guidance to the rare earth industry on how to obtain DOE loan guarantees for projects to re-establish the domestic rare earths supply chain.

What are your views on these and other provisions in the bill?

Answer. The Administration is continuing to review S. 3521. We share the goal of establishing a secure supply of rare earth metals, and we look forward to discussions with the Congress on ways to address this issue as we move forward.

*Question 15.* Do you agree with the bill's emphasis on domestic production as the best way to alleviate our rare earths supply concerns?

Answer. In our view, a three-pronged approach of globalizing supply chain, developing substitutes, and promoting recycling, reuse and more efficient use is necessary to address our rare earth supply concerns. Rebuilding U.S. capacity to produce rare earths contributes to globalizing supply sources of rare earths which reduces supply risks, as would continuous diplomatic efforts to better ensure supply. At the same time, research labs within the government and in the private sector can develop ways to substitute for, recycle, and/or reduce use of rare earths. Some inroads have already been made from such investments on both the government and industry sides in R&D.

*Question 16.* Do you agree that increasing domestic production of rare earths constitutes a national security imperative such that it should be streamlined and receive Federal financial support through mechanisms such as loan guarantees?

Answer. To alleviate potential supply disruptions of rare earths, it is advisable to increase domestic production of rare earths. It is estimated that the U.S. has the world's third largest reserve of rare earths. The U.S. also has some of the most advanced requirements for environmental safeguards and community rights over mining. However, it takes about seven years or longer in the U.S. to complete the permit process from exploration to mine operation.[1] Permitting times vary around this timeframe depending on whether the mine is situated on Federal lands or private lands and depending on state and local regulations. This is very long compared to most countries; the process takes one to two years in Australia, for instance. It is worth exploring how to simplify the permitting process of rare earth mines in the U.S. without compromising the environmental review process.

*Question 17.* Mr. Sandalow, I understand that in your role as Assistant Secretary of the international office at DOE, you have visited China many times and visited with many energy officials and scientists during these trips.

During any of these visits, did you sit down with senior government official to discuss the issues you brought up in your testimony related to rare earths and other critical minerals?

Answer. Yes, on several occasions.

*Question 18.* The July decision by the Chinese government to further reduce exports quotas for rare earths certainly gives policy makers cause for concern.

In your opinion, do you think the Chinese will continue to ratchet down their exports to other countries, both exports of raw rare earths and processed rare earths for industrial applications?

Answer. Chinese Foreign Minister Yang Jiechi recently told Secretary of State Hillary Clinton that China intends to be a "reliable supplier" of rare earth metals. This is welcome. I believe the United States government must be prepared for a wide range of scenarios in this area in the years ahead. The United States is interested in working with like-minded trading partners to determine the best way forward to ensure reliable supplies of rare earths from all sources. We are prepared to work bilaterally and multilaterally (at the G20, APEC, the WTO and other fora) to seek progress on the issue. Our goal is to support the rules-based global trading system, and make sure that industries that need rare earths in their production processes have an open and reliable marketplace from which to procure them.

*Question 19.* What do you think their rationale is for putting such trade restrictions in place?

[1] GAO, "Rare Earth Materials in the Defense Supply Chain," April 1, 2010; Robert Matthews, "Permits Drag on U.S. Mining Projects," Wall Street Journal, February 8, 2010.

Answer. I would prefer not to speculate on Chinese government motivations. As stated above, I believe it would be prudent for the United States to be prepared for a wide range of scenarios in this area in the years ahead.

*Question 20.* Do you have any confidence that bilateral negotiations might result in the easing of export restrictions in the short term?

Answer. Chinese Foreign Minister Yang Jiechi recently told Secretary of State Hillary Clinton that China intends to be a "reliable supplier" of rare earth metals. The U.S. government welcomes that statement. Whether this will involve easing of current export restrictions is uncertain, and we continue to urge China to ensure that its policies on rare earths are transparent and consistent with its international obligations.

*Question 21.* Mr. Sandalow, I noted that several times in your written testimony you referred to the importance of "environmentally sound" extraction of rare earth materials. You mentioned it once in reference to domestic projects, and again in the context of encouraging our international trading partners to develop "environmentally sound" sources of supply.

In reading about rare earths mining operations, it has not impressed me as an "environmentally sound" process. The Mountain Pass mine in California closed in 2002, in part for environmental reasons. According to a recent article on the mine[2], when it was in full operation it used to routinely dump wastewater in the desert.

In China practices seem to be even worse, with the Economist magazine reporting that "Horror stories abound about poisoned water supplies and miners."[3]

I'd like to understand better what you, and the DOE, are thinking of when you refer to "environmentally sound" extraction. What does that really mean? Is it actually possible? To what degree can extraction of rare earths be made "environmentally sound"?

Answer. We should be pursuing mining practices and processes that conserve resources and prevent pollution to the air, water and land. This will improve worker health and safety; improve air quality and water quality; reduce the need for handling and disposal of radioactive substances; and reduce soil and groundwater contamination. Preventing pollution can also save money over the long run. U.S. technology and know-how gained from mine operations can help promote safe and responsible mining in other countries, further contributing to diversity of supply.

*Question 22.* How do you suggest we encourage the use of environmentally sensitive extraction methods, whether in the U.S. or overseas?

Answer. This is primarily a role for EPA and/or the Department of the Interior, through their permitting processes.

*Question 23.* Is DOE engaged in any research that could lead improved environmental practices at rare earths mines? Would DOE consider such a line of research to fall within its purview, considering the importance of these minerals to clean energy technology development?

Answer. DOE is not currently engaged in rare earth mining research.

*Question 24.* Mr. Sandalow, in your testimony you outline, in broad strokes, the approach DOE is taking to address the availability of rare earths and other important materials to support and expand clean energy development. One of the components of DOE's approach is to develop substitutes for these materials. You argue that to develop substitutes, we will need to invest in R&D to develop transformational magnets, battery electrodes, and other technologies.

Yet the U.S. Geological Survey, in its most recent Mineral Commodity Summaries, indicates that while substitutes to rare earths are available for many applications, they are generally less effective.

However, According to recent press reports, Japan's New Energy and Industrial Technology Development Organization (NEDO) and Hokkaido University have developed a hybrid vehicle motor using only inexpensive ferrite magnets that don't need rare earths.

Can you be more specific about the potential you see for developing substitutes for rare earths?

Answer. Substitutes for rare earths can occur at different scales. In some cases, it may be possible for manufacturers to replace a rare earth element with a different material (or other rare earth) that provides the same functional properties but is cheaper or more abundant. An example of this type of substitution occurs in NiMH batteries, which are used in most Hybrid-Electric vehicles. Battery manufacturers substitute less expensive mischmetal (a rare earth alloy of cerium, lanthanum, praseodymium and neodymium in varying proportions) in place of more expensive pure

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[2] http://www.eenews.net/Landletter/2010/07/22/archive/1?terms=mining+rush+on+for+rare+earths

[3] http://www.economist.com/node/16944034?story—id=16944034

lanthanum and still achieve adequate battery performance. In other cases, manufacturers could substitute entire parts of components containing rare earths with other technologies. Examples of this type of substitution could include substituting rare earth permanent magnet motors in electric vehicles with other types of motors, or substituting lithium-ion, iron or zinc batteries, which contain no rare earth elements, for NiMH batteries in vehicles. Still another option is substitution of the entire end use application. An example of this type of substitution would be the replacement of fluorescent light bulbs containing rare earth phosphors with light emitting diodes that use little or no rare earth elements. The effectiveness of substitutes varies by individual technologies. Effectiveness must also be judged against a number of different criteria, including both the cost and functionality of the substitutes. Timeframe is also important, since substitution may involve significant changes to product designs and manufacturing production lines. In the long run, DOE believes that cost-effective substitution is possible for most energy applications that use rare earths, though it is important to keep in mind that substitutes for rare earths could also have supply risks of their own.

*Question 25.* You indicate that research to develop substitutes for rare earths and other critical minerals is being pursued at DOE's Office of Science, the Energy Efficiency and Renewable Energy Program, and ARPA-E. Can you please discuss these efforts more detail? How much support are these programs receiving? Have they shown any results yet? If so, for what applications?

Answer. While there have been a number of relevant individual projects supported by the Office of Science, EERE, and ARPA-E, these have not been part of a unified DOE Strategy. This is one reason DOE launched the process to develop a Critical Materials Strategy earlier this year. More information on these topics will be included in DOE's Strategy when released soon. In the near term, these offices are working together to engage the scientific and business communities in the U.S. and abroad regarding rare earth technology development opportunities through workshops, direct discussions and public forums. The goal is to identify the highest priority R&D opportunities to ensure a long-range U.S. competitiveness in energy sectors, especially those which may currently be dependent on foreign resources for rare earths and related critical materials.

*Question 26.* Other than trying to develop substitutes, is DOE pursuing any other research tracks involving rare earths?

Answer. The Office of Science supports fundamental research related to the structure and properties of materials containing rare earth additions. These studies include research on both known and new magnetic materials, superconducting materials, and other materials that are relevant to energy applications. The research focuses on the synthesis of highest quality materials, often in single crystal form; advanced characterization methods, especially neutron and magnetic x-ray scattering; and theory/modeling. The ultimate goal of the research is to understand and control the materials functionality at atomic length scales. The detailed theoretical understanding is used to identify new materials with optimal properties.

*Question 27.* Who owns the intellectual property for rare earth processing? (i.e. Who benefits from licensing this technology to new mining operations like Molycorp's?)

Answer. The landscape of intellectual property for rare earth processing is complex and changing. While much of the intellectual property (IP) is held overseas at this time, this may change as R&D leads to processing innovation.

*Question 28.* Is this U.S. technology, or must it be acquired from overseas? Is the IP for processing rare earths unique, or is it common to processing other hard rock minerals?

Answer. The landscape of intellectual property for rare earth processing is complex and changing. While much of the IP is held overseas at this time, this may change as R&D leads to processing innovation.

*Question 29.* Are there active efforts underway to improve rare earth processing technologies? Is this an area that would benefit from additional R&D?

Answer. Yes, at DOE national labs, universities, and in private companies. Yes, this area would benefit from additional R&D.

RESPONSE OF DAVID SANDALOW TO QUESTION FROM SENATORS MURKOWSKI, BARRASSO, AND RISCH

*Question 1.* In June 2010, you testified before the Senate Energy & Natural Resources Committee about S. 3495, legislation to promote the deployment of electric vehicles. A similar measure was introduced less than a month before that hearing, and the actual bill we focused on was introduced exactly one week prior to it. At the time, we greatly appreciated your submission of testimony that clearly articulated the Department of Energy's views and positions on many of the programs that S. 3495 would create.

By contrast, your testimony at a hearing on September 30, 2010 related to the rare earths supply chain and S. 3521, which we introduced to address issues associated with that supply chain, failed entirely to articulate the Department's views and positions on the measure. The aforementioned hearing on S. 3495 was noticed exactly one week in advance, while the hearing on S. 3521 was noticed a full two weeks in advance and our bill was introduced over 3 months ago. We would also note that S. 3521 is just 15 pages in length, while the electric vehicle bill you testified on in June spans 74 pages.

Your Department had considerable time and notice to review S. 3521. You also had much less text to review. Despite this, your written testimony said virtually nothing about the legislation. Even when pressed by the Subcommittee Chairwoman to make a statement about the bill during the hearing, you merely responded that DOE is continuing to review it. This lack of feedback not only impairs our Committee's ability to refine S. 3521; it also makes it more difficult to believe that DOE, and the Administration as a whole, are making progress on a coherent Strategy to address the challenges we face regarding the rare earth supply chain.

Could you please explain why, exactly, the Department failed to provide any feedback on our legislation? Is it a result of insufficient staff, a lack of Departmental understanding about these issues, or something else? To the extent that you have had an opportunity to review S. 3521 since the hearing, can you more fully articulate the Department's views on the measure?

Answer. With respect to S.3521, my September 30 testimony stated that the Administration shares "the goal of establishing a secure supply of rare earth metals, and we look forward to discussions with Congress on ways to address this issue as we move forward." I believe this is a topic with substantial potential for bipartisan cooperation to advance U.S. interests and look forward to working with Congress as it considers this and any related legislation in the months ahead.

RESPONSES OF DAVID SANDALOW TO QUESTIONS FROM SENATOR STABENOW

*Question 1.* Whether it's manipulating its currency or illegally subsidizing its clean energy industry, China is ignoring the rules. I know USTR filed a case against China on its export restrictions of raw materials, but WTO cases take time. I've seen the process play out with the auto parts case. While waiting for the WTO process to play out, 6 companies when out of business. Unfortunately, on this issue of rare earths, we don't have time. We're in a race. With China having imposed an even harsher export quota on its Rare Earth Elements, what are we doing to hold China accountable? How can DOE help USTR?

Answer. The U.S. Trade Representative is currently investigating claims by the United Steelworkers that China's rare earth export restraints disadvantage U.S. clean energy companies. The USTR will decide whether to launch a formal WTO challenge against China on these and other claims no later than January 13, 2011. DOE staff are assisting USTR with technical aspects of the investigation. Chinese Foreign Minister Yang Jiechi recently told Secretary of State Hillary Clinton that China intends to be a "reliable supplier" of rare earth metals. The U.S. government welcomes that statement. Other U.S. government officials have discussed these issues with Chinese government officials as well.

*Question 2.* China shrewdly recognized the need to invest in the mining and production of these rare earths. Like I said, we're in a race now playing catch-up. What is the Department of Energy doing to find more domestic sources of these rare earths as well as alternatives that do not rely on these materials?

Answer. DOE's work on rare earth metals includes research on alternatives. This work is a growing priority, with considerable attention devoted to development of DOE's first-ever Critical Materials Strategy, to be released soon. DOE does not have regulatory jurisdiction over mining activities.

*Question 3.* Mr. Brehm, of Infinia Corporation, mentions in his testimony that alternatives to rare earth elements are expensive and not as effective. However, he then proceeds to say that a technology called the "High Temperature Superconductor" can be used in motors and generators that require virtually no rare earth elements. However, despite these qualities DOE is not continuing to help develop and commercialize this technology.

Can you speak to this and explain why DOE is not pursuing this sort of alternative that does not rely on rare earth elements? Is DOE looking at other technologies that would be less dependent on rare earth elements?

Answer. With the FY 2011 budget request, the Department's Office of Electricity Delivery and Energy Reliability (OE) is winding down its involvement in high temperature superconductivity (HTS) wire research. The Department continues to see a role for superconductivity technology in the modernization of the grid. However, after investing over $600 million over the past 20 years, the Department believes that the HTS wire research has reached a point that provides meaningful technical value and that second generation HTS wire technology can be successfully transitioned to the U.S. manufacturing base. While OE's investment in HTS wire research is ending, the Department believes superconductivity technology holds promise in energy applications. For example, ARPA-E recently competitively awarded a HTS Superconducting Magnet Energy Storage System project under its grid-scale storage program. DOE is also supporting research into other kinds of technologies using less or no rare earths, including lithium ion batteries as a substitute for NiMH or LED's as a substitute for fluorescent lamps.

RESPONSES OF DAVID SANDALOW TO QUESTIONS FROM SENATOR BENNETT

*Question 1.* Mr. Sandalow, you mentioned that steps need to be taken "to facilitate extraction, refining, and manufacturing here in the United States." I wholeheartedly agree.

What specific steps are being taken by the Administration to facilitate these goals and promote new domestic mining and mineral development?

*Question 2.* What is the Administration doing to reduce the regulatory burden on current and prospective mining operations?

*Question 3.* What is the Administration doing to expedite new mineral development applications?

*Question 4.* What is the Administration doing to make federal land available to new mineral leases?

Answers 1–4. Domestic mining and mineral development is a subject under the jurisdiction of the Department of the Interior. The Department of the Interior has noted that balance and coordination are two important requirements for successful mineral development. We need a balanced approach to reforming the Mining Law of 1872 that will generate a fair return to the American taxpayer, and ensure that development occurs in a manner consistent with the need for mineral resources and the protection of the public, public lands and water resources. Coordination between relevant government agencies is also a key requirement. The USGS provides land managers, including BLM and the U.S. Forest Service, with scientific information that serves as a foundation for decision making and that enables managers to ensure that an appropriate balance is maintained between the public expectation of protection of Federal lands and the public desire for economic growth based on resource extraction and energy independence.

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RESPONSE OF PRESTON F. RUFE TO QUESTION FROM SENATOR UDALL

*Question 1.* China has more than 6,000 scientists and researchers devoted to rare earth research, development and applications. In this country, only one institution of higher learning offers a course in the rare earths—that is at the Colorado School of Mines. Clearly, we need to restore both our production capability as well as our information and knowledge base in rare earth RD&D. What suggestions do you have in this regard?

Answer. Loan guarantees and grants are effective tools for the stimulation of developing domestic capabilities; however, of the two, loan guarantees present the lowest cost to the taxpayer. Currently, loan guarantee programs, such as those offered through the U.S. Department of Energy, are available for the development of clean energy technologies manufacturing but are not available for the production of requisite raw materials (i.e., mining and refining). Loan guarantees and grants will greatly assist in energizing the responsible development of strategic mineral sources.

Education programs at institutions of higher learning are largely influenced by the respective demand for their programs. Targeted scholarship, internship, co-ops fellowships, and work programs that focus on strategic elements and clean energy technologies will provide incentives to students considering studies in those fields. The U.S. Department of Energy currently offers such programs in other fields such as nuclear science, why not in areas related to clean energy technology and strategic minerals? Moreover, targeted private industry-university research partnerships could further expand our domestic knowledge base.

RESPONSES OF PRESTON F. RUFE TO QUESTIONS FROM SENATOR CANTWELL

RECYCLING AND REUSE

Shifting gears a bit, I would like to take a moment to focus on reuse and recycling of critical minerals. It seems that many, if not most, critical minerals can be recycled from waste industrial and commercial technologies once the life of the product is complete.

*Question 1.* Do you know of any opportunities where we can convert existing industrial manufacturing facilities into facilities that can be utilized for the processing of rare earths for clean energy technology (e.g. batteries, magnets, etc) or for recycling programs for the recovery of the critical minerals that we have discussed here today?

Answer. Formation Capital Corporation, U.S. is the final steps of financing to construct the Idaho Cobalt Project (i.e., cobalt mine) and retrofit/refurbishment to establish a cobalt processing facility (i.e., refinery), both located in the State of Idaho. The refinery, located in Kellogg, Idaho, was formerly used in the processing of silver-copper-antimony ore concentrate. The refinery is a zero-liquid discharge facility that uses a much more environmentally friendly process than traditional smelting and pyrometallurgical refining methods. This facility can and will be converted to produce super alloy-grade cobalt from the ore mined and concentrated at the Idaho Cobalt Project. Plans to expand the facility's capabilities to include recycling rechargeable batteries are also being considered. The author is unaware of any other existing hydrometallurgical facilities in the U.S. capable of conversion to produce high-purity cobalt.

Domestic, cobalt recycling capabilities are limited but do currently exist. Although published in 1998, the USGS Open File Report 02-299, Cobalt Recycling in the United States in 1998, by K. B. Shedd (Shedd, 1998) presents a valid and comprehensive view of the various aspects of cobalt recycling. Domestic, cobalt recycling capacity primarily consists of alloy scrap and battery recycling. For more information on the specifics of cobalt recycling, the reader is directed to (Shedd, 1998).

*Question 2.* How can the U.S. best go about developing a domestic rare earth recycling program? Are incentives or grant programs needed to jumpstart such a program?

Answer. The economic viability of a metals recycling program is predominantly controlled by the price of the new commodity and the cost of recycling. To some extent, environmental regulations that require the diversion of a particular item or material from landfills (e.g., nickel-cadmium batteries) facilitate some viable recycling efforts. Instituting laws or at least incentives, that require ethical raw material sourcing from responsible mines and countries with established, strong environmental laws; and requiring mandatory product "end of life recycling" would help provide for long-term stability and availability of raw materials.

With no domestic source currently in production, recycling foreign produced cobalt provides the only domestic cobalt supply, almost entirely in chemical forms. However, when in production, the Idaho Cobalt Project will supply approximately three million pounds (3,000,000 lbs) of super-alloy grade cobalt, annually. Once again, loan guarantee programs would certainly aid in jumpstarting opportunities for the domestic production of raw materials.

*Question 3.* Do you see particular challenges associated with recycling rare earths and other critical minerals? If so, could these be overcome? What would have to be done to do so?

Answer. Recycling cobalt is technologically feasible and is a proven process. Cobalt is a high value metal and has been recycled extensively since the early 1980's. The problem is that there are no large quantities of scrap to be recycled and, according to The U.S. Geological Survey, Mineral Commodity Summaries, January 2010, in 2009, recycled scrap accounted for only 24% of U.S. reported consumption.

ALTERNATIVES TO RARE EARTHS

*Question 4.* In Mr. Brehm's testimony he mentions that for some clean energy technologies that rely on rare earths there are potential substitutes that do not require, or require significantly lower quantities of, rare earths.

According to a report recently published by the U.S. Geological Survey, there is research going on in this area of substitutes.

The report cites research at the University of Nebraska that has the goal of developing a permanent magnet that does not require rare earths at all.

It also mentions researchers at the University of Delaware that are trying to create a new magnetic material based on "nano-composite" magnets. If successful, this process could slash the use of rare earths in magnets by 30 or 40 percent.

And according to recent press reports, Japan's New Energy and Industrial Technology Development Organization (NEDO) and Hokkaido University have developed a hybrid vehicle motor using only inexpensive ferrite magnets that don't need rare earths.

Can you please elaborate on this idea of substitutes for rare earths? Do you think that non-rare earth alternatives can be as effective as technologies that use rare earths?

Answer. Although not one of the 17 so-called rare earth elements, current substitutes for cobalt generally result in decreased performance. Known as "Curie temperature", cobalt is an essential metal for alloying as it maintains its magnetism at a higher temperature than all other ferromagnetic elements, along with its corrosion and wear resistance. Therefore, unless the process temperatures are reduced where these alloys are employed, such as turbines and permanent magnets, substitutes for Questions for Mr. Rufe Senate Energy Subcommittee cobalt yield metals with lower or decreased functionality. Unfortunately, decreasing the temperature that some processes operate at can be counterproductive and yield lower efficiencies (e.g., jet turbine engines). However, all technologies continue to evolve and composite materials that do not contain metals (i.e., ceramics) may hold promise for future substitutions, where possible.

*Question 5.* Do you see substitutes as a truly preferential option, or merely tolerable as a "next best" option to rare earths?

Answer. Regarding substitutes for cobalt, in most applications there is a major loss of efficiency and reliability for those areas where substitution is possible. The U.S. Geological Survey, Mineral Commodity Summaries, January 2010 also points out that substitutions for cobalt often result in degraded performance; however, the Summary goes on to list several applications where substitutions are possible. In applications such as jet engines there are no current acceptable substitutes known.

Research since the early 1980's focused on reducing the quantity of cobalt required for a particular application or product, with the easiest substitutions already completed. For example, consider lithium ion (Li-Ion) rechargeable batteries: In 1995 a good-quality Li-Ion battery contained approximately 60% cobalt by weight; the very best still do, however many applications can now efficiently utilize newer battery chemistries that contain between 10-20% cobalt, by weight. Although current chemistries contain less cobalt per weight of battery, the current challenge facing the global cobalt supply is producing these batteries in the massive quantities needed to support clean energy development.

*Question 6.* Are there certain types of technologies or applications that have greater potential for having effective substitutes without rare earths than others?

Answer. Regarding cobalt, the most likely candidates for substitute materials is in the rechargeable battery sector. New and evolving battery chemistries are still being explored. Future research may yield rechargeable batteries that do not require as much or any cobalt yet exceed current discharge capacities and stability in various applications; however, this is less likely to occur as previous research has resulted in demonstrating that cobalt is in-fact needed to maximize efficiency and dependability.

*Question 7.* Is there particular research that you can think of that would be helpful for DOE to pursue or support when it comes to developing rare earth substitutes?

Answer. Once again regarding cobalt, the science surrounding construction of rechargeable batteries is well understood; however, there are many innovative energy storage technologies that are just now emerging through research. For example, research conducted at Massachusetts Institute of Technology demonstrated a functional energy storage technology that does not require rechargeable batteries nor any rare earth elements for energy storage and can operate at non-toxic or benign environmental conditions. Capable of storing energy produced from solar photovoltaic systems, the technology relies on cobalt and phosphate to catalyze the hydrolysis of water. The hydrogen and oxygen produced is subsequently re-combined using proven fuel-cell technology to produce power during hours of darkness. Additional support for researching novel energy storage technologies would be helpful to develop alternative energy storage techniques.

### S. 3521 AND LOAN GUARANTEES FOR RARE EARTHS

*Question 8.* One of the purposes of today's hearing is to consider Senator Murkowski's bill S. 3521, the Rare Earths Supply Technology and Resources Transformation Act.

As I'm sure you know, this bill would formally establish a national policy of promoting investment in, exploration for, and development of rare earths.

To that end, it would establish a cabinet-level task force to help expedite permitting and regulation of rare earth production.

It also calls for the Secretary of Energy to issue guidance to the rare earth industry on how to obtain loan guarantees for projects to re-establish the domestic rare earths supply chain.

Can you please comment on the bill in general. Do you support it? Do you believe it would be effective in rebuilding a rare earths supply chain in the U.S.? How do you think the bill could be improved?

Answer. The Bill, in general, focuses on REEs, however, virtually all REE applications require other constituents to function. Focusing on REEs is important and vital; however, is too singular in its view of what are truly strategic minerals. A more comprehensive approach, such as that suggested by the Western Governors Association, that addresses a National Minerals Policy is needed to effectively address building or re-building the U.S. critical mineral supply chain.

We believe that cobalt, indium, gallium and other strategic and critical metals should also be included in the bill. Including other strategic minerals would help to ensure a functioning industry is built-up without missing key components that would become the new problem metals without domestic production. In short, including other strategic and critical metals would avoid swapping one problem for another.

[*this appears to be a typo*] easons. In your testimony you state very clearly that the United States' dependence on imports is not necessarily bad, unless there is a lack of diversified supply, domestic or foreign, that leads to supply risk, especially if a foreign source leaves us vulnerable to geopolitical risks.

The current situation with China seems to illustrate precisely the kind of risk you refer to. You go on to state that the government and policy makers should encourage undistorted international trade, while at the same time fighting policies of exporting nations that restrict raw-material exports to the detriment of US consumers of these materials.

*Question 9.* Do you have suggestions as to how we can go about pursuing this goal?

Answer. The subject matter of this question is outside of my expertise.

*Question 10.* Do you, or other economists, anticipate that the Chinese rare earth production or export could slow further in the near term for any reason—for example, strengthened environmental regulations?

Answer. The subject matter of this question is outside of my expertise.

*Question 11.* Do you think that the US can build refining or other value-added production infrastructure in a timeframe to compete with existing infrastructure in China?

Answer. The average timeframe required to develop a new mine in the U.S. is 6 to 7 years after discovery of an economic ore body. The exploration, discovery and initial engineering to establish an economic ore body can take many more years. Usually multiple sites need to be explored before an ore body gets discovered. Historically, only around one prospect in 1,000 actually hosts an economic ore body. Providing adequate funding to U.S. and State geological surveys could accelerate the exploration process.

## GLOBAL SUPPLY CHAIN ISSUES/COBALT

*Question 12.* In your testimony you discuss the specific importance of cobalt to US national security in two fronts: clean energy and energy security, and national defense. Some illustrative examples that you noted in these two categories were cobalt's use in clean energy technologies such as solar panels, wind turbines and fuel cells, but also its use in high-performance jet engines for light, advanced aircraft.

You were also very clear in your testimony to single out the uses and needs of cobalt from the other rare earths.

Do you recommend cobalt management and procurement policies separate from those for other rare earths?

Answer. The U.S. needs a comprehensive policy that encompasses strategic minerals like cobalt, the rare earth elements, and others. For example, the Western Governors Association policy resolution 10-16, titled "National Minerals Policy." This policy must seek to evaluate current risks associated with the supply chain and then focus efforts on minerals of strategic importance to enable responsible development of domestic sources. The policy must establish regulatory certainty and eliminate redundant financial assurance obligations that improperly burden responsible development. Policies that focus exclusively on the rare earth elements, and not including cobalt and other strategic minerals, are excessively narrow in focus.

Policies that do not take a comprehensive approach will yield situations where foreign dependency continues to constrain the supply chain of the multiple strategic minerals essential to support successful clean energy and other manufacturing endeavors.

*Question 13.* Which element of US national security would suffer most in the face of prospective cobalt shortages, domestic clean energy deployment or national defense?

Answer. Dependence on foreign sources for strategic minerals jeopardizes both the national defense and energy security of the U.S. Cobalt is a strategic mineral, so designated by the Defense Logistics Agency (DLA). The remaining cobalt stockpile in the strategic reserve managed by the DLA is waning. With only a nominal reserve available, any supply disruptions threaten national defense applications, particularly super-alloy grade applications such as jet engine production.

However, as noted in my testimony, the fastest growing use of cobalt is in rechargeable battery manufacturing. Rechargeable batteries are the essential energy storage component of clean energy technologies like solar and wind, as well as hybrid electric, all electric vehicles, and a plethora of portable electronic devices (e.g., cellular phones). These clean energy technologies rely on rechargeable batteries and virtually all battery chemistries in production rely on cobalt for their function. Thus, given the rapidly expanding use of cobalt in clean energy technology manufacturing, continued expansion will be adversely constrained by a prospective cobalt supply shortage.

*Question 14.* Do you recommend that the U.S. seek to secure the entire rare earth supply chain, including manufacturing, for national security, and to protect the emerging domestic clean-tech industry? Or do you recommend the U.S. re-establish strategic, global rare earth dominance? Or Both?

Answer. The U.S. should seek to increase, or in some cases create, a productive domestic supply chain of strategic minerals such as cobalt and the rare earth elements. The first step in promoting such a policy must include the identification and development of domestic resources. This can be influenced by funding U.S. and State geological surveys to conduct preliminary exploration and locate domestic sources, as suggested by the Western Governors Association Policy Resolution 10-16.

Ensuring a minimum percentage of U.S. requirements are met from domestic production, refining and processing will make sure that basic supplies can be met during periods of crisis, be it political, economic, environmental or other. Moreover, this policy must also seek to leverage existing capabilities of countries friendly to U.S. interests to supplement some percentage of U.S. requirements from primary domestic production. Additionally, re-furbishing, re-establishing, or creating national stockpiles for strategic minerals should also require a minimum percentage of domestic, ethically sourced material.

U.S. RARE EARTHS SUPPLY CHAIN REVITALIZATION

*Question 15.* You have all testified to the importance domestic rare earth supply chain revitalization, given our current dependence on Chinese imports and the strategic importance of these materials.

It is worth noting, as you have in your testimony, that the U.S. was once a leading producer of rare earths, but that our domestic rare earth supply chain has become dormant in the face of lower-cost production overseas. [Please note that much of the "lower cost production" of cobalt results from foreign suppliers not being subjected to the same regulatory scrutiny and environmental compliance laws that exist in the U.S. Moreover, these major foreign cobalt suppliers are not equally burdened with financial assurance obligations for end-of-project reclamation. This is not to suggest that the U.S. should lower the standard but rather streamline the process, remove red tape and define a realistic, fair system for determining reclamation financial assurances that do not unfairly penalize a domestic producer.]

It is clear that U.S. dependence on the small group of foreign nations which currently make up the global rare earth supply chain is not ideal from the point of view of our domestic manufacturing capabilities, or our national security.

As you have noted, re-establishing a robust US rare earth supply chain is a cogent solution to this problem. However, bringing on-line the extraction, refining, alloying and other processing capabilities necessary for domestic rare earth production, not to mention hiring and training personnel with the necessary expertise, are not tasks that can be accomplished overnight.

It may be several years before a US rare earths supply chain can begin to meet our domestic demands. Therefore, we must continue consider the impact of continued rare earths imports, or even shortages, in the near term.

Which US industries / strategic interests do you think will suffer most in near-term, assuming projected shortages materialize?

Answer. As discussed above, national defense and energy security will likely suffer the most in near-term, should projected shortages materialize.

*Question 16.* Which aspects of a US rare earth supply chain can be brought back online most quickly (mining, refining, alloying, etc.) and are all of the stages of the rare earth supply chain necessary to have here in the US?

Answer. Developing new mines on public lands in the U.S. is a 6-7 year process and involves a host of permitting challenges that must be overcome in order to obtain the necessary permissions to start a new mining operation. The magnitude of the ordeal further complicates efforts to finance startup operations. Refining and manufacturing, on the other hand, often take place outside public lands and do not necessarily require the same timeframe for startup.

There are existing facilities in the U.S. that, with significant improvement, could be adapted or retrofitted to process other materials. For example, the hydrometallurgical facility that will be used by the Idaho Cobalt Project to refine super-alloy grade cobalt was previously used as a silver-copper-antimony refinery. Although significant retrofit is required, much of the existing infrastructure will be used in processing cobalt and may also be capable of processing REE's.

*Question 17.* Further, is a domestic production necessary to secure the critical minerals supply chain?

Answer. Domestic production is preferable to foreign production for the many reasons outlined above. However, the primary concern with strategic minerals like cobalt and the rare earth elements is that they are currently or becoming dominantly controlled by entities that may not be friendly to U.S. interests. According to the U.S. Geological Survey, in addition to rare earth elements, China is also currently the largest supplier of cobalt to the U.S.

Clearly, at least a minimum percentage of U.S. requirements being met by domestic production would be superior to total dependence on foreign sources to ensure U.S. national security and to carry out U.S. energy policies.

*Question 18.* Are federal financial incentives or legislation required to expedite the redevelopment of production and refining of rare earths domestically?

Answer. The ongoing state of economic depression presents a very challenging financing climate for companies seeking financing for new operations. This is even more pronounced for unique commodities such as cobalt and REE's as they are not among the typical "bank financed" metals, such as gold, silver and copper. Expanding financial incentives in the form of loan guarantees for mining, refining, and other operations, in addition to manufacturing, that are related to critical minerals could greatly expedite the redevelopment of domestic capacity.

*Question 19.* If the U.S. does re-establish its rare earth mining capacity, how can we be confident that the domestic manufacturing capability will also be available to use those minerals?

Answer. Once again, a comprehensive approach must be employed. The entire supply chain must be energized to promote a productive domestic strategic minerals manufacturing capacity. A comprehensive approach should include all strategic metals required: from the mining process, to initial processing, to refining, and to manufacturing.

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RESPONSE OF RODERICK G. EGGERT TO QUESTION FROM SENATOR UDALL

*Question 1.* China has more than 6,000 scientists and researchers devoted to rare earth research, development and applications. In this country, only one institution of higher learning offers a course in the rare earths—that is at the Colorado School of Mines. Clearly, we need to restore both our production capability as well as our information and knowledge base in rare earth RD&D. What suggestions do you have in this regard?

Answer. My four general suggestions for public policy in this area are: (1) work toward undistorted international trade, (2) improve the efficiency of the preproduction approval process for domestic mineral production, (3) facilitate the collection, publication, and analysis of information on rare earth and other essential elements, and (4) facilitate research and development (R&D) activities throughout the supply chain for rare earths, including recycling, as well as for materials R&D on possible substitutions away from rare earths and other critical elements.

Domestic production capability: I would not focus narrowly on domestic production capabilities but rather emphasize more-diversified, global production capabilities in "friendly" countries (i.e., those nations that we consider secure and reliable trading partners). With mines such as Mountain Pass (California), the United States would become part of a more-diversified global supply chain.

Information and knowledge: The United States has lost its leadership role in developing intellectual and human capital related not only to rare earths but more generally in minerals and materials throughout the entire supply chain (geology, mining, metallurgy, materials science, recycling). In re-invigorating the intellectual infrastructure in this area, the federal government plays an important role through funding for research and related educational activities. Faculty and students follow the funding. For both basic and applied research, two specific types of partnerships are worth considering: between universities and the national labs, and between universities and private companies.

RESPONSES OF RODERICK G. EGGERT TO QUESTIONS FROM SENATOR CANTWELL

China has recently shown its willingness to restrict exports of rare earth elements for foreign policy reasons. In your testimony you state very clearly that the United States' dependence on imports is not necessarily bad, unless there is a lack of diversified supply, domestic or foreign, that leads to supply risk, especially if a foreign source leaves us vulnerable to geopolitical risks.

The current situation with China seems to illustrate precisely the kind of risk you refer to. You go on to state that the government and policy makers should encourage undistorted international trade, while at the same time fighting policies of exporting nations that restrict raw-material exports to the detriment of US consumers of these materials.

*Question 1.* Do you have suggestions as to how we can go about pursuing this goal?

Answer. I think joining with the Japanese, Europeans and perhaps other nations through the World Trade Organization is the appropriate vehicle for working to eliminate trade distortions.

*Question 2.* Do you, or other economists, anticipate that the Chinese rare earth production or export could slow further in the near term for any reason—for example, strengthened environmental regulations?

Answer. I think there is a lack of information, at least outside of China, on this issue. A number of credible observers state that two developments are possible over the next decade or so: (a) growth in Chinese domestic use of rare earths will make China a net importer of rare earths even if existing levels of Chinese rare-earth production stay the same, and (b) Chinese adoption of western-style environmental and worker-health-and-safety regulations will lead to less Chinese production. In addition, there were reports in the press this week that Chinese rare-earth deposits may be depleted in the next 10-15 years but I do not have an opinion about the credibility of these reports.

*Question 3.* Do you think that the US can build refining or other value-added production infrastructure in a timeframe to compete with existing infrastructure in China?

Answer. It will be several years before the United States becomes a significant producer of rare-earth metals. Molycorp's Mountain Pass mine could be operating at full capacity in less than five years. My understanding is that, initially at least, Mountain Pass will (a) mine the ore containing rare earths, (b) separate the various rare earths from one another and produce rare-earth concentrates, and (c) ship the concentrates to China for conversion to rare-earth oxides and, in turn, rare-earth metals that can be used in magnets and other applications. In other words, Molycorp does not now have the capability (including the intellectual property) to convert concentrates into rare-earth oxides and then metals. Molycorp's long-term goal, however, is to produce oxides, metals, and even rare-earth magnets.

Any US rare-earth mines other than Mountain Pass will take longer than five years to come into full production.

*Question 4.* Which element of US national security would suffer most in the face of prospective cobalt shortages, domestic clean energy deployment or national defense?

Answer. I am not an expert on cobalt. My impression is that it is relatively more important in military (national defense) applications than in clean-energy technologies.

*Question 5.* Do you recommend that the U.S. seek to secure the entire rare earth supply chain, including manufacturing, for national security, and to protect the emerging domestic clean-tech industry? Or do you recommend the U.S. re-establish strategic, global rare earth dominance? Or Both?

Answer. I think a secure rare-earth supply chain is important, even essential. Not all parts of this supply chain need to be physically located in the United States. We should develop those domestic mineral deposits that have a comparative advantage over foreign deposits. We should strive to develop the human capital and intellectual property that allows us to innovate at all stages of the supply chain.

CULTIVATING BETTER MARKET DATA ON CRITICAL MINERALS

*Question 6.* Dr. Eggert, in my view and experience, any time there are constraints on the supply of a commodity the conditions are ripe for excessive market speculation and sometimes manipulation. We have seen this in recent years in the markets for oil, electricity, natural gas, and other commodities. I am concerned about the possibility for the same issues to arise in the market for rare earths.

For example, is it possible that the Chinese could deliberately withhold rare earths supply from the global market today, prompting the U.S. and other countries to invest billions of dollars in developing alternative sources of supply, only to flood the market with cheaper product in the future, and put U.S. projects out of business? I'm concerned this type of manipulation is possible.

What you suggest, Chinese flooding the market, is a possibility at least conceptually and is a fear that, I believe, is discouraging the financing of investment in rare-earth mines outside of China. However, I am not sure that we have a good idea about the sustainability of low-cost Chinese production, especially if Chinese officials implement environmental and worker-health-and-safety rules similar to ours.

One powerful antidote to market manipulation is transparency and the promulgation of good information about the market. When market participants have good information about prices, producers, production rates, stockpiles, etc., they are able to plan and make sound decisions. Bubbles and shortages are far less likely to develop because it is much harder to manipulate a market that is exposed to the light of day.

Can you comment on the current level of transparency in the markets for rare earths and strategic minerals? How confident are we in our knowledge of the details of the market?

Answer. Markets for rare earths and some other rare metals are not transparent at the moment. The number of participants (buyers and sellers) is small. As a result, each participant tends to view information as a source of competitive advantage and tries to keep information confidential. We are not confident in our knowledge of details of the market.

*Question 7.* Do you think it would be worthwhile and useful to expand our capacity to collecting and process data on the markets for these materials?

Answer. Yes. I think it is important not only to expand our capabilities with respect to market data (production, consumption, prices, etc.) but also data and information on subeconomic resources, material flows over the lifecycle of a product, and resources embodied in goods that potentially could be recycled.

PERMITTING MINING OPERATIONS

*Question 8.* You have both testified that the process by which mines can be permitted and opened should be cleaner and more straightforward. I do note that you were careful to state that these permits should not be fast-tracked and that all environmental regulations must be complied with in the permitting process.

Exactly what parts of the process are you referring to in your testimony?

Answer. I am not an expert on permitting. But the process typically takes too long and involves an un-necessarily large number of administrative agencies.

*Question 9.* In either of your opinions, how can this process be improved?

Answer. I am not sure. Some changes may require legislation but others may be possible at the initiative of the relevant agencies.

U.S. RARE EARTHS SUPPLY CHAIN REVITALIZATION

*Question 10.* You have all testified to the importance domestic rare earth supply chain revitalization, given our current dependence on Chinese imports and the strategic importance of these materials.

It is worth noting, as you have in your testimony, that the U.S. was once a leading producer of rare earths, but that our domestic rare earth supply chain has become dormant in the face of lower-cost production overseas.

It is clear that U.S. dependence on the small group of foreign nations which currently make up the global rare earth supply chain is not ideal from the point of view of our domestic manufacturing capabilities, or our national security.

As you have noted, re-establishing a robust US rare earth supply chain is a cogent solution to this problem. However, bringing on-line the extraction, refining, alloying and other processing capabilities necessary for domestic rare earth production, not to mention hiring and training personnel with the necessary expertise, are not tasks that can be accomplished overnight.

It may be several years before a US rare earths supply chain can begin to meet our domestic demands. Therefore, we must continue consider the impact of continued rare earths imports, or even shortages, in the near term.

Which US industries / strategic interests do you think will suffer most in near-term, assuming projected shortages materialize?

Answer. The near-term risks are greater for defense/military sector.

*Question 11.* Which aspects of a US rare earth supply chain can be brought back online most quickly (mining, refining, alloying, etc.) and are all of the stages of the rare earth supply chain necessary to have here in the US?

Answer. Mining (re-opening of the Mountain Pass Mine). Subsequent stages in the supply chain will take longer.

*Question 12.* Further, is a domestic production necessary to secure the critical minerals supply chain?

Answer. Domestic production is one way to achieve security of supply. For rare earths, what is critical is a more-diversified global supply that does not depend on a limited number of sources in one country—in this case, China. Having said this, the United States has several promising mineral deposits containing rare-earth elements, and these deposits could serve as the starting point for domestic production of rare-earth oxides, metals, and permanent magnets and other products.

*Question 13.* Are federal financial incentives or legislation required to expedite the redevelopment of production and refining of rare earths domestically?

Answer. Eventually the Mountain Pass Mine is likely to re-open and operate at full capacity on its own, without federal financial incentives. However, lenders still are recovering from the financial crisis and are reluctant to lend to projects to such as Mountain Pass without including a substantial risk premium in the interest rate charged to borrowers. Thus progress toward re-opening Mountain Pass has stalled due to the mine owner's reluctance to borrow money at a steep interest rate. Federal loan guarantees would significantly lower the interest rate at which Mountain Pass could borrow money and likely speed up the process of mine re-opening.

*Question 14.* If the U.S. does re-establish its rare earth mining capacity, how can we be confident that the domestic manufacturing capability will also be available to use those minerals?

Answer. As the question implies, a mineral resource by itself does not create competitiveness in those activities using the mineral resource as an input—in this case, the production of oxides, metals, magnets, and other products. The other important inputs in this case include intellectual property and human resources for using rare earths, both of which are lacking in the United States at present.

RECYCLING AND REUSE

*Question 15.* Shifting gears a bit, I would like to take a moment to focus on reuse and recycling of critical minerals. It seems that many, if not most, critical minerals can be recycled from waste industrial and commercial technologies once the life of the product is complete.

Do you know of any opportunities where we can convert existing industrial manufacturing facilities into facilities that can be utilized for the processing of rare earths for clean energy technology (e.g. batteries, magnets, etc) or for recycling programs for the recovery of the critical minerals that we have discussed here today?

Answer. Recycling of post-consumer scrap containing rare earths is an important potential source of rare-earth supply. But at present it is not carried out to any large degree due to technical challenges that need to be overcome. Small amounts of rare earths are reportedly being recovered from some permanent magnet scrap (U.S. Geological Survey).

*Question 16.* How can the U.S. best go about developing a domestic rare earth recycling program? Are incentives or grant programs needed to jumpstart such a program?

Answer. Funding for research and development programs, probably through joint work involving universities, national (federal) research labs, and the private sector.

*Question 17.* Do you see particular challenges associated with recycling rare earths and other critical minerals? If so, could these be overcome? What would have to be done to do so?

Answer. The important challenges are technical and economic. The technical challenges relate to the difficulty of separating and recovering very small amounts of an element (the rare earth or other critical mineral) that are incorporated into and part of modern engineered materials. It is useful to think of two types of recycling of post-consumer scrap: functional, in which the recycled element is re-used to take advantage of the same chemical or physical property as in its original application (e.g., rare earths used again in permanent magnets); and non-functional, in which the recycled element or material is used in a different, lower-valued applications (e.g., plastic from beverage containers used in outdoor decks or road material). Both types of recycling are valuable. Functional recycling is typically more difficult to achieve than non-functional recycling. Research is necessary to overcome the technical challenges.

The economic challenge is to carry out recycling for a profit. The initial technological breakthrough often works only at a bench (or laboratory) scale and is expensive. Usually it is only through experience that costs are reduced and the scale of operation increased.

ALTERNATIVES TO RARE EARTHS

*Question 18.* In Mr. Brehm's testimony he mentions that for some clean energy technologies that rely on rare earths there are potential substitutes that do not require, or require significantly lower quantities of, rare earths.

According to a report recently published by the U.S. Geological Survey, there is research going on in this area of substitutes.

The report cites research at the University of Nebraska that has the goal of developing a permanent magnet that does not require rare earths at all.

It also mentions researchers at the University of Delaware that are trying to create a new magnetic material based on "nano-composite" magnets. If successful, this process could slash the use of rare earths in magnets by 30 or 40 percent.

And according to recent press reports, Japan's New Energy and Industrial Technology Development Organization (NEDO) and Hokkaido University have developed a hybrid vehicle motor using only inexpensive ferrite magnets that don't need rare earths.

Can you please elaborate on this idea of substitutes for rare earths? Do you think that non-rare earth alternatives can be as effective as technologies that use rare earths?

Answer. Substitution comes in two basic forms. The first is material-for-material or element-for-element (e.g., aluminum for steel in cans, palladium for platinum in catalytic converters). Typically, this type of substitution changes both the costs and performance of the engineered material. By "performance," I mean the chemical or physical properties of the material, such as strength, corrosion resistance, electrical conductivity, ability to operate at high temperatures, etc. Some substitutions result in a small loss of performance but a big reduction in costs. Others result in improved performance at about the same costs. Only rarely is material-for-material as simple as directly substituting one material or element for another with no other changes to the material; rather, substituting one material or element for another requires also modifying other aspects of the material or product.

The second type of substitution is resource-saving—using less of a material or element in an application but achieving the same performance (e.g., thinner-walled aluminum cans made possible by improved aluminum-rolling capabilites, less indium per flat-panel display because of improvements in manufacturing efficiencies and reductions in the amount of indium being wasted).

Both types of substitution are important to consider when thinking about rare earths.

*Question 19.* Do you see substitutes as a truly preferential option, or merely tolerable as a "next best" option to rare earths?

Answer. I think substitution is one of several important options to consider.

*Question 20.* Are there certain types of technologies or applications that have greater potential for having effective substitutes without rare earths than others?

Answer. This question is outside my area of expertise.

Is there particular research that you can think of that would be helpful for DOE to pursue or support when it comes to developing rare earth substitutes?

All aspects of the supply chain are important, including social-science research on material flows and life-cycle costs.

S. 3521 AND LOAN GUARANTEES FOR RARE EARTHS

*Question 21.* One of the purposes of today's hearing is to consider Senator Murkowski's bill S. 3521, the Rare Earths Supply Technology and Resources Transformation Act.

As I'm sure you know, this bill would formally establish a national policy of promoting investment in, exploration for, and development of rare earths.

To that end, it would establish a cabinet-level task force to help expedite permitting and regulation of rare earth production.

It also calls for the Secretary of Energy to issue guidance to the rare earth industry on how to obtain loan guarantees for projects to re-establish the domestic rare earths supply chain.

Can you please comment on the bill in general. Do you support it? Do you believe it would be effective in rebuilding a rare earths supply chain in the U.S.? How do you think the bill could be improved?

Answer. As I noted in my written testimony, domestic production is one of several responses to supply risks and increased demand, and this bill would work toward re-establishing domestic production. It likely would be effective, at least in part. Government by itself will not re-establish a domestic supply chain.

I offer the following specific comments on the bill, including suggestions for improvement:

—Philosophy: De-emphasize the priority given to self-sufficiency in rare-earths production. What is critical for rare-earth users, including the military and developers of clean-energy technologies, is a more-globalized and diverse supply chain for rare earths than exists at present.

—Scope: Broaden the focus of the bill, including the mandate of the Task Force, to include not just rare earths but other elements that are critical to military and emerging clean-energy technologies, such as gallium, indium, platinum-group elements, tellurium, and others. I support the idea of a Task Force, but have no view on which departmental Secretary should chair the Task Force.

—Expedited Permitting: I do recommend that rare-earth deposits be given special treatment in permitting. Rather, I support efforts to make the permitting process more efficient for all types of mineral production in the United States.

—Stockpiles: I do not support economic stockpiles—that is, those that might be funded or maintained by the federal government on behalf of private-sector users. Private users (manufacturers) have sufficient incentive to maintain their own stockpiles if they believe stockpiles are the best way to deal with supply risks. As for national-defense (or military) stockpiles, I think it is appropriate to require the Department of Defense to assess whether stockpiles are the best way to deal with their supply risks.

—Loan Guarantees: I commented on this issue below.

—Innovation, Training, Workforce Development (Section 7): A key part of the bill, which I support. I know my support for these provisions could be interpreted as self serving, as I am a university professor and potentially could benefit from these provisions. I strongly believe, nevertheless, that innovation, training, and workforce development all represent what economists call "public goods," which markets by themselves will under-supply from the perspective of society as a whole—because the benefits of public goods are diffuse, difficult for private individuals and organizations to fully capture, risky, and far in the future.

*Question 22.* Could you please comment on the Loan Guarantee provisions in particular? Is this provision necessary? If rare earths are in such high demand, why is it necessary, or appropriate, for the Federal government to subsidize investment in rare earths projects?

Answer. I repeat here an answer I gave to a previous question: "Eventually the Mountain Pass Mine is likely to re-open and operate at full capacity on its own, without federal financial incentives. However, lenders still are recovering from the financial crisis and are reluctant to lend to projects to such as Mountain Pass without including a substantial risk premium in the interest rate charged to borrowers. Thus progress toward re-opening Mountain Pass has stalled due to the mine owner's reluctance to borrow money at a steep interest rate. Federal loan guarantees would significantly lower the interest rate at which Mountain Pass could borrow money and likely speed up the process of mine re-opening."

More broadly, and considering the processing of rare-earth ores subsequent to mining, I believe there is a strong case for loan guarantees to encourage investment in new and relatively untested technologies associated with processing of rare-earth ores. But I believe loan guarantees for this purpose already are possible without new legislation.

If we think of loan guarantees as a form of national insurance against future supply disruptions, then they are a relatively low-cost form of insurance.

Finally, let me say that I am sympathetic to the implication of the question—that is, that markets will go a long way toward taking care of the problem. As I emphasized in my written testimony, markets provide powerful incentives for producers and users to respond to increased demand as well as supply risks. The areas that public policy should emphasize are those in which markets have problems—that is, international trade, inefficient domestic processes for regulatory approval, information, and research and development.

INTELLECTUAL PROPERTY

*Question 23.* According to a July article on rare earths mining in the Land Letter, "reviving Mountain Pass will require more than a half-billion dollars to retool the mine's aging separation plants, build a new gas-fired power generator and water recycling units, and acquire expensive technology licenses to convert the rare earth minerals into usable metals, alloys and magnets."

Who owns the intellectual property for rare earth processing? (i.e. Who benefits from licensing this technology to new mining operations like Molycorp's?)

Answer. My impression is that Chinese interests hold much of the intellectual property but I am not an expert in this area.

*Question 24.* Is this U.S. technology, or must it be acquired from overseas? Is the IP for processing rare earths unique, or is it common to processing other hard rock minerals?

Answer. See answer to previous question. A significant portion of the intellectual property for processing rare earths is unique, or at least represents a significant modification to more-common methods for other minerals.

*Question 25.* Are there active efforts underway to improve rare earth processing technologies? Is this an area that would benefit from additional R&D?

Answer. This is a very important area for additional R&D. There is relatively little (some might say 'essentially no') R&D occurring in this area in the United States today.

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RESPONSE OF PETER BREHM TO QUESTION FROM SENATOR UDALL

*Question 1.* China has more than 6,000 scientists and researchers devoted to rare earth research, development and applications. In this country, only one institution of higher learning offers a course in the rare earths—that is at the Colorado School of Mines. Clearly, we need to restore both our production capability as well as our information and knowledge base in rare earth RD&D. What suggestions do you have in this regard?

Answer. Public and private investment in technical education and research is both appropriate and desirable, as well as good public policy. Targeted public and private investment in strategic research is equally appropriate and desirable. A combination of Federal, State, local and commercial investment and collaboration in rare earth RD&D should be encouraged and adequately funded.

RESPONSES OF PETER BREHM TO QUESTIONS FROM SENATOR CANTWELL

RECYCLING AND REUSE

*Question 1.* Shifting gears a bit, I would like to take a moment to focus on reuse and recycling of critical minerals. It seems that many, if not most, critical minerals can be recycled from waste industrial and commercial technologies once the life of the product is complete.

Do you know of any opportunities where we can convert existing industrial manufacturing facilities into facilities that can be utilized for the processing of rare earths for clean energy technology (e.g. batteries, magnets, etc) or for recycling programs for the recovery of the critical minerals that we have discussed here today?

Answer. Many applications of rare earth materials use only very small amounts, which will make recycling challenging. The obvious exceptions are batteries and magnets, as highlighted in the Senator's question.

Infinia is a consumer of rare earths primarily through the permanent magnets used to make the linear alternators for our Stirling engine and coolers. We are not familiar with any opportunities to convert existing industrial facilities into rare earth processing or recycling facilities, but we believe it is likely such facilities do exist and that such recycling initiatives are worthwhile pursuing.

*Question 2.* How can the U.S. best go about developing a domestic rare earth recycling program? Are incentives or grant programs needed to jumpstart such a program?

Answer. Most recycling programs will require public policy support to start-up and become self-sustaining. It would be appropriate and desirable to establish policies, such as incentives and grants, to encourage rare earth and critical mineral recycling.

*Question 3.* Do you see particular challenges associated with recycling rare earths and other critical minerals? If so, could these be overcome? What would have to be done to do so?

Answer. As mentioned above, the major challenge will be that only small quantities of rare earths and critical minerals are used in many applications, particularly those related to electronics. Recycling of rare earths and critical minerals from batteries and magnets should be more straightforward and feasible.

ALTERNATIVES TO RARE EARTHS

*Question 4.* In Mr. Brehm's testimony he mentions that for some clean energy technologies that rely on rare earths there are potential substitutes that do not require, or require significantly lower quantities of, rare earths.

According to a report recently published by the U.S. Geological Survey, there is research going on in this area of substitutes.

The report cites research at the University of Nebraska that has the goal of developing a permanent magnet that does not require rare earths at all.

It also mentions researchers at the University of Delaware that are trying to create a new magnetic material based on "nano-composite" magnets. If successful, this process could slash the use of rare earths in magnets by 30 or 40 percent.

And according to recent press reports, Japan's New Energy and Industrial Technology Development Organization (NEDO) and Hokkaido University have developed a hybrid vehicle motor using only inexpensive ferrite magnets that don't need rare earths.

Can you please elaborate on this idea of substitutes for rare earths? Do you think that non-rare earth alternatives can be as effective as technologies that use rare earths?

Answer. Research in this arena is promising and our developing nanotechnology capabilities show great promise. It is certainly feasible and perhaps even likely that non-rare earth alternatives can be developed that will be as effective as technologies that use rare earth. Scarcity and supply constraints routinely lead to technological innovation. However, the timeline is uncertain.

*Question 5.* Do you see substitutes as a truly preferential option, or merely tolerable as a "next best" option to rare earths?

Answer. There is rarely a "silver bullet" as alternatives are likely to come with their own set of issues. However, it is certainly reasonable to be optimistic that substitutes will eventually be at least viable and perhaps even preferred for the reasons mentioned in the answer to the previous question.

*Question 6.* Are there certain types of technologies or applications that have greater potential for having effective substitutes without rare earths than others?

Answer. We do not have expertise in this area, but it would be reasonable to expect that applications using larger quantities of rare earths and critical minerals, such as magnets and batteries, would have greater potential for having effective substitutes.

*Question 7.* Is there particular research that you can think of that would be helpful for DOE to pursue or support when it comes to developing rare earth substitutes?

Answer. High Temperature Superconducting (HTS) technologies tend to use dramatically less (1/100th to 1/1000th the amount of) rare earth materials as compared to conventional technologies. For example, a HTS wind turbine or hydro-power generator would use 1/1000th as much rare earth material as a permanent magnet wind turbine or hydropower generator. Unfortunately, it appears the DOE is winding down its HTS program in FY-2011 with plans to end the DOE HTS program by FY-2012.

S. 3521 AND LOAN GUARANTEES FOR RARE EARTHS

*Question 8.* One of the purposes of today's hearing is to consider Senator Murkowski's bill S. 3521, the Rare Earths Supply Technology and Resources Transformation Act.

As I'm sure you know, this bill would formally establish a national policy of promoting investment in, exploration for, and development of rare earths.

To that end, it would establish a cabinet-level task force to help expedite permitting and regulation of rare earth production.

It also calls for the Secretary of Energy to issue guidance to the rare earth industry on how to obtain loan guarantees for projects to re-establish the domestic rare earths supply chain.

Can you please comment on the bill in general. Do you support it? Do you believe it would be effective in rebuilding a rare earths supply chain in the U.S.? How do you think the bill could be improved?

Answer. Infinia does support Senator Murkowski's initiative, and we do believe it would be effective in rebuilding a rare earth supply chain in the U.S. As mentioned in our original testimony, our major concern is that the DOE Loan Guarantee Program (LGP) has recently lost a considerable amount of its appropriations and is inadequately funded for existing programs. While we support inclusion of the rare supply chain in the DOE LGP program, we strongly encourage additional funding authorization and appropriations.

RESPONSES OF PETER BREHM TO QUESTIONS FROM SENATOR STABENOW

*Question 1.* While China holds most of the commercial supply of rare earth materials, I also realize that China is in a race with American companies to manufacturing clean energy technologies such as wind, solar and advanced batteries. I am sure that Infinia and other solar companies face enormous pressure from companies in China.

Could China use its supply of rare earth materials to attract manufacturers to China? Does the location of the supply and factor in to your long-term plans at all?

Answer. Yes. Based on recent events, China clearly sees political value in their near monopoly position in the supply of rare earth metals. The next logical step is to use this potential monopoly to create downstream industries surrounding these materials and develop internally and/or attract manufacturers of products that use these rare earth materials in China.

For example, this has happened with respect to oil in Saudi Arabia. The Saudi's have wisely used their enormous supply of oil to dramatically grow their refining and petrochemical industries. Developing countries do not just want to export raw materials; they want to do value added manufacturing.

*Question 2.* Infinia is a rather unique supply chain for a solar and renewable technology manufacturer and I applaud your efforts to help to diversify our automotive supply chain with a clean energy industry. Can you please tell us what the impact on your supply chain would be if access to these rare earth metals would be limited for political or other supply disruptions?

Answer. No current commercially viable alternative exists for our components that utilize these rare earth metals. Should supply of these metals be disrupted for political or other reasons, it would severely impact Infinia and our supply chain.

# APPENDIX II

## Additional Material Submitted for the Record

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

#### INTRODUCTION

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

#### BACKGROUND

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

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

A) GE Lighting utilizes Cerium, Terbium, and Europium in synthesizing efficient phosphors for fluorescent lamp products, which are critical in the Department of Energy's transition from inefficient incandescent lamps.

B) GE Energy uses Neodymium, Samarium, Dysprosium, and Terbium in permanent magnets for compact and efficient generators in GE's most advanced 2.5 MW wind turbines.

C) GE also uses permanent magnets in technology prototypes for traction motors for our hybrid locomotives, high-speed motors and generators for aviation applications, high speed motors for turbo-expanders, high power density motors for PHEVs and EVs, ultra high-efficiency industrial motors, as well as compressor motors for GE Oil and Gas business.

D) GE Healthcare uses rare earth materials for scintillators in both Computed Tomography (CT scan) and Positron Emission Tomography (PET scan) health imaging technologies.

E) GE Aviation uses small quantities of rare earth permanent magnet materials for defense technologies in guidance systems.

F) Small amounts of rare earths are used in materials and coatings in 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 needs in a sustainable way.

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

UNDERSTANDING 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. Risks are quantified element by element in two categories: "Price and Supply Risk", and "Impact of a Restricted Supply on GE". Those elements deemed to have high risk in both categories are identified as materials needing further study and a detailed plan to mitigate supply risks. The "Price and Supply Risk" category includes an assessment of demand and supply dynamics, price volatility, geopolitics, and co-production. Here we extensively use data from the US Geological Survey's Minerals Information Team, as well as in-house knowledge of supply dynamics and current and future uses of the element. The "Impact to GE" category includes an assessment of our volume of usage compared to the world supply, criticality to products, and impact on revenue of products containing the element. While we find this approach adequate at present, we are working with researchers at Yale University who are in the process of developing a more rigorous methodology for assessing the criticality of metals. Through these collaborations, we anticipate being able to predict with much greater confidence the level of criticality of particular elements for GE's uses.

STRATEGIES TO MINIMIZE 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. There is a broad spectrum of strategies that can be implemented to minimize the risk of those elements identified as being at high risk. These include:

1) Improvements in the global supply chain can involve the development of alternate sources, as well as the development of long-term supply agreements that allow suppliers a better understanding of our future needs. In addition, for elements that are environmentally stable, we can inventory materials in order to mitigate short-term supply issues. To enable a diversified supply chain for US industry, the federal government can play an important role in strengthening the domestic rare earth supply chain. Without a domestic supply chain, US industry, including clean energy technologies and defense technologies, are dependent on global suppliers and subject to market decisions made by global suppliers.

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

3) An optimal solution is to develop technology that either greatly reduces the use of the atrisk 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 two illustrative recent examples.

a. The first involves Helium-3, a gaseous isotope of Helium used by GE Energy's Reuter Stokes business in building neutron sensors for detecting special nuclear materials at the nation's ports and borders. The supply of

Helium-3 has been diminishing since 2001 due to a simultaneous increase in need for neutron detection for security, and reduced availability as Helium-3 production has dwindled. GE has addressed this problem in two ways. The first was to develop the capability to recover, purify and reuse the Helium-3 from detectors removed from decommissioned equipment. The second was the accelerated development of Boron-10 based detectors that eliminate the need for Helium-3 in Radiation Portal Monitors.

b. 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 multiyear research programs to develop the capability of recycling manufacturing scrap and end-of-life components. A significant materials development effort was also undertaken to develop and certify new alloys that require only one-half the amount of Rhenium, as well as no Rhenium at all. This development leveraged past research and development programs supported by DARPA, the Air Force, the Navy, and NASA. The Department of Defense supported qualification of our reduced Rhenium engine components for their applications.

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

4) Another approach to minimizing the use of an element over the long term is to develop recycling technologies that extract at-risk elements from both end-of-life products and manufacturing yield loss. Related to this is developing technologies that 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.

5) A complete solution often requires a reassessment of the entire system that uses a raw material that is at risk. Often, more than one technology can address a customer's need. Each of these technologies will use a certain subset of the periodic table—and the solution to the raw material constraint may involve using a new or alternate technology. Efficient lighting systems provide an excellent example of this type of approach. Linear fluorescent lamps use several rare earth elements. In fact, they are one of the largest users of Terbium, a rare earth element. Light emitting diodes (LEDs) use 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 must also be considered. This example shows how a systems approach can minimize the risk of raw materials constraints.

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

1) Early identification of the issue—technical development of a complete solution can be hampered by not having the time required to develop some of the longer term solutions.

2) Material understanding is critical—with a focus on those elements identified as being at risk, the understanding of materials and chemical sciences enable acceleration of the most complete solutions around substitution. Focused

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

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

RECOMMENDATIONS FOR THE FEDERAL GOVERNMENT AND COMMENTS ON S.3521

Based on GE's broad experience in commercial applications that utilize rare earth materials, our experience conducting materials supply risk assessment, and developing innovative solutions to mitigate supply risk, GE offers the comments and recommendations below to improve S. 3521.

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. GE is supportive of Federal government efforts to reinvigorate the domestic supply chain of rare earth materials in the US. A bolstered domestic rare earth supply chain would diversify suppliers for US industry, reduce reliance on global suppliers, and would have a positive direct impact on domestic employment. Furthermore, we believe the Senate and House versions of the RESTART bill favorably complement H.R. 6160 "Rare Earths and Critical Materials Revitalization Act." We believe this legislation should address the following general recommendations:

1) Appoint a lead agency with ownership of early assessment and authority to fund solutions—given the need for early identification of future issues, we recommend that the government enhance its ability to monitor and assess industrial materials supply, both short term and long term, as well as coordinate a response to identified issues. Collaborative efforts between academia, government laboratories, and industry will help ensure that manufacturing compatible solutions are available to industry in time to avert disruptions in US manufacturing.

2) Sustained funding for research focusing on material substitutions—Federal government support of materials research will be critical to laying the foundation upon which solutions are developed when materials supplies become strained. These complex problems will require collaborative involvement of academic and government laboratories with direct involvement of industry to ensure solutions are manufacturable.

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

GE offers the following specific comments regarding S.3521. 1) In Section 6, in addition to revitalizing the domestic rare earth supply chain, it is recommended that the bill explicitly incorporate the need to revitalize US manufacturing capability. 2) In Section 7, we also recommend that the bill encourage rare earth conservation and innovative technology development by supporting applied research aimed at rare earth recycling and reduction technologies, support for development of rare earth replacement materials, and support for development of systems that replace or minimize rare earth elements.

CONCLUSION

In closing, we believe that a more coordinated approach and sustained level of investment from the Federal government to support the domestic rare earth supply chain, 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 Bingaman and members of the committee, thank you for your time and the opportunity to provide our comments and recommendations.

## Statement of Mark A. Smith, Chief Executive Officer, Molycorp Minerals, LLC

### INTRODUCTION

Chairwoman Cantwell, Ranking Member Risch and Members of the Subcommittee, thank you for the opportunity to share my observations, experiences, and insights on the subject of rare earths; on global supply and demand; on the work we are doing at our facility at Mountain Pass, California; and on the latest regarding our plan to deliver to America a complete rare earth "Mine-to-Magnets" manufacturing supply chain in the next two years.

I'm the Chief Executive Officer of Molycorp, Inc., a rare earths technology company that serves as the Western Hemisphere's only producer of rare earths. Molycorp owns the rare earth mine and processing facility at Mountain Pass, California, one of the richest rare earth deposits in the world. I have worked with Molycorp and its former parent companies, Unocal and Chevron, for over 25 years, and have watched closely the evolution of this industry over the past decades.

It has been remarkable to watch the applications for rare earths explode—particularly in the clean energy and clean-tech sectors. The U.S. invented rare earth processing and manufacturing technology. But as rare earth-based technologies have become more and more essential to our modern standard of living, America has become almost completely dependent on China for access to rare earth oxides, metals, alloys and permanent magnets that, in many ways, form the heartbeat of high-tech.

Fortunately, our nation is on the cusp of effectively reversing our near-total dependence on foreign nations for rare earths.

Molycorp has produced rare earths for nearly 58 years. We are engaged now in modernizing and re-building our rare earth separations and processing facilities at Mountain Pass so that we can dramatically increase production of American rare earths in the fastest time frame possible. We are executing a "Mine to Magnets" strategy to rebuild the rare earth oxide, metal, alloy, and magnet manufacturing capabilities that our country has lost in the past decade. This effort will help to address rare earth access concerns as well as help to catalyze clean tech manufacturing job creation in the U.S.

### FREQUENTLY ASKED QUESTIONS

I am frequently asked several questions from policymakers at both the state and federal level regarding rare earths and Molycorp's plans. Those questions are:

1. How large is the rare earth resource at Mountain Pass?
2. Is Mountain Pass producing rare earth materials right now and, if so, can you increase production in the near-term?
3. Will Molycorp be able to produce sufficient rare earths to place America in a position of effective rare earth independence?
4. What types of rare earths and rare earth products are you going to produce?
5. Do you plan to manufacture critical rare earth products like permanent rare earth magnets in this country?
6. How quickly can you make all of this happen?

Let me provide answers to each of these important questions on the occasion of the Subcommittee's hearing.

First, the rare earth ore deposit at Mountain Pass is one of the richest in the world, both in terms of its size and its richness of rare earth content, or "ore grade." While we have secured a 30-year operating permit from the State of California, we expect to be producing American rare earths for many years beyond that. In short, America is blessed with a huge abundance of rare earths at Mountain Pass.

Second, in terms of current rare earth production, Molycorp is now producing 3,000 tons per year of rare earths materials at Mountain Pass. That level of production positions us—and the U.S.—as the second largest commercial producer of rare earths in the world, behind China. Our 3,000 tons may be a far cry from the more than 100,000 tons per year now produced in China. But those 3,000 tons per year of American rare earths are coming at a time when China's export policies are creating actual shortages of rare earth. Rare earth dependent industries in the U.S. and elsewhere are scrambling now for every ton of product they can find. Molycorp is doing all that it can to help supply rare earths to as many customers in the United States and abroad as we can.

While Molycorp will be heavily engaged over the next two years in constructing a new, state-of-the-art rare earth separations facility at Mountain Pass, we plan to continue to produce rare earths from our large supply of previously mined ore in our stockpile. And, we are working hard to increase that production even as we focus on building our new facility. The way we see it, continued production of American rare earths is, quite simply, an imperative for America, both in terms of clean energy technology development and our national defense.

Third, is Molycorp capable of producing sufficient rare earths to place America in a position of virtual rare earth independence? The answer is yes—with a caveat.

Our new production facility will be producing at a rate of 20,000 tons per year of rare earth oxide equivalent by the end of 2012. Current U.S. consumption is estimated to be about 15,000 tons per year of REO equivalent. So, while we continue to stress that rare earthdependent industries should seek, as much as possible, to maintain multiple sources of supply, Molycorp's production will effectively reverse America's near-total dependence on foreign rare earths. We will help America accomplish this in only two years.

The caveat I will add is this: global demand for rare earths is projected to grow dramatically in the next five years, from the current 124,000 tons per year to an estimated 225,000 tons per year in 2015.

However, those growth projections do not, in our view, fully take into account the potentially explosive rise in demand that will be driven by two technology sectors in particular: permanent magnet generator wind turbines and hybrid vehicles (including hybrids, plug-in hybrid and all-electric vehicles). Those technologies have the potential to drive demand to entirely new levels, which is going to require both Molycorp to increase production as well as other non-Chinese producers around the world.

The good news from the perspective of U.S. production capacity is that Molycorp has the ability, under our current operating permits, to double our 20,000 tons per year of production to 40,000 tons per year. Our new facility has been designed to allow for modular expansion, which means that, depending upon market conditions and with sufficient additional capital investment, we will be able to achieve a doubling of our production within only 12-18 months.

Can we produce even more than 40,000 tons per year? Absolutely, although it would require securing new operating permits to allow that level of production. And, again, increasing our production is dependent upon market conditions and on the economics associated with the increased investment that is required.

Four: what types of rare earths will Molycorp produce?

We will produce all nine of the most commercially significant rare earths, including lanthanum, cerium, neodymium, praseodymium, samarium, europium, gadolinium, dysprosium, and terbium.

But let me also help the Members of the Subcommittee dispel a common misperception about the production of rare earths from different ore bodies. It is sometimes claimed—or promoted—that some rare earth ore bodies can produce only certain types of rare earths and not others.

The simply geologic fact is this: all significant rare earth deposits contain all 15 of the rare earths in the lanthanide series—light rare earths, medium rare earths, and heavy rare earths. The proportional distribution of each rare earth can vary slightly in each ore body, but all rich ore bodies, such as Mountain Pass, can produce all of the rare earths.

The key to producing different rare earths is dependent upon three factors:

1) The total amount, or "richness," of rare earths in the ore body, expressed as a percentage and known as "ore grade. We have found, after more than half a century of doing the highly challenging chemical separations of rare earths, that ores with a two percent or less ore grade are highly unlikely to ever be economically separated into individual rare earths.

2) The physical characteristics of the rare earth ore. Some ore bodies are more conducive to physical separation of individual rare earth elements, while others are not. There are ore deposits being discussed today that will probably stay in the ground because they will be found to be too difficult or expensive to process and separate.

3) In today's economic and political environment, successful chemical separation of rare earths requires high recovery rates, high process efficiencies, and environmental superiority in performance.

Fortunately, Molycorp excels in all three areas.

1) We have a rare earth resource at Mountain Pass with a very high ore grade—an average of 8.25 percent. This is one of the highest average ore grades in the world for a deposit this size. By contrast, China's largest producing mines average in the 4-6 percent range for ore grade.

2) Our ore has physical characteristics that allow us to achieve exceptionally efficient chemical separation of individual rare earths.

3) The new separations technologies we are deploying at Mountain Pass will cut our production costs so much that we will be able to produce rare earth oxides at about one-half of the cost of the Chinese—all while we dramatically shrink the environmental footprint of U.S. rare earth production.

Finally, we get asked often if we plan to deploy in the U.S. the full rare earth magnet manufacturing supply chain. The answer here is simple: yes.

By the end of 2012, Molycorp will have manufacturing operations on U.S. soil that include production of high-purity rare earth oxides; rare earth metals; rare earth alloys; and rare earth permanent magnets. A graphic representation* of the rare earth manufacturing supply that Molycorp is building is seen below.

### FINANCING OUR "MINING TO MAGNETS" STRATEGY

With a total project cost of $511 million through the alloy production phase, the capital intensity of a project of this size and scope is substantial, particularly in a climate where credit markets are contracting and interest rates remain largely prohibitive for a project like this.

We successfully overcame the first critical financing hurdle when, on July 29th of this year, Molycorp completed a highly successful Initial Public Offering (IPO) of stock to the capital markets. We raised a total of $379 million in that effort. While this does not cover the entire cost of our project, it has provided Molycorp with the resources necessary to accelerate our hiring and begin execution of the project.

To raise the remaining funds necessary to complete the "mining to magnets" strategy, Molycorp is pursuing several forms of potential debt financing to fully fund the project, including vendor financing for certain essential equipment and traditional project financing. Because the latter involves financing terms that remain relatively prohibitive, we have submitted an application to the U.S. Department of Energy's Loan Guarantee Program. With interest rates through that program of three to four percent and far more reasonable payback terms than traditional debt, this is the preferred source of financing for our project. It will do much to help us maintain the accelerated timeline that is critical given the global supply challenges ahead. We submitted our DOE application on June 24th, and we were informed in July that we had cleared the initial review. We are now engaged in the second phase of the process, and will submit our second phase application by December 31, 2010.

### ENVIRONMENTAL STEWARDSHIP AS A DRIVER OF COST-COMPETITIVENESS

Many industry observers question how a U.S. producer of rare earths can ever compete with the Chinese, when the possibility always lingers that the Chinese could flood the market and dramatically depress rare earth prices, a practice they have demonstrated previously. While we believe that such a path by China is highly unlikely to occur again—given China's everincreasing consumption of its own production—we have spent the better part of the past eight years preparing to weather any such storm.

In a nutshell, we changed the orientation of our thinking and discovered that, by focusing principally on energy and resource efficiency, we could make major improvements in our cost competitiveness while at the same time advance our environmental stewardship.

Our scientists have developed several groundbreaking new technologies and applications that will dramatically shrink the environmental footprint of rare earth production at Mountain Pass. These technologies will:

- Cut in half the amount of raw ore needed to produce the same amount of rare earth oxides that we have produced historically. This effectively doubles the life of the ore body and further minimizes the mine's footprint;
- Increase the processing facility's rare earth recovery rates to 95% (up from 60-65%) and decrease the amount of reagents needed by over 30%;
- Recycle our reagents. By doing so we effectively eliminate waste water, the need for traditional evaporation ponds, and the need for daily truckloads of reagent deliveries to our facility (a significant carbon reduction).
- Our new water recycling and treatment processes reduce the mine's fresh water usage from 850 gallons per minute (gpm) to less than 50 gpm—a 94% reduction;
- Finally, the construction of a Combined Heat and Power (CHP) plant—fueled by natural gas—will eliminate usage of fuel oil and propane. This will signifi-

* All graphics have been retained in subcommittee files.

cantly reduce the facility's carbon emissions, reduce electricity costs by 50%, and improve electricity reliability.

These process improvements fundamentally reverse the conventional wisdom that superior environmental stewardship increases production costs. Quite simply, our commitment to energy and resource efficiencywill enable us to beat China on price. These improvements result in major reductions to our operating costs, and based on current cost data, we will be able to produce rare earths at an average of $1.27 per pound of REO and the Chinese price is $2.54 per pound, half the cost of the Chinese product.

At the same time, we significantly distinguish ourselves from the Chinese rare earth industry, which has been plagued by a history of significant environmental degradation. China is just beginning to recognize and rectify their environmental issues and, combined with rising wages in China, it will contribute to further upward pressure on their pricing.

RESPECT FOR INTELLECTUAL PROPERTY

The processes of rare earth alloy production and permanent magnet manufacture are covered by U.S. patents that are held by foreign corporations, some of which do not expire until after 2020. That means that any U.S. company that intends to produce rare earth alloys and magnets need to acquire licenses or enter into joint ventures with those who have access to these patents. This is precisely what Molycorp is doing. We have several letters of intent to form joint ventures in these areas, and we fully anticipate executing agreements that will allow us to conduct these operations on U.S. soil by 2012.

RARE EARTHS AS A CATALYST FOR JOB CREATION

Access to rare earths is obviously essential. But without rebuilding each phase of the supply chain and reestablishing the manufacturing capacity to produce rare earth metals, alloys, and magnets, the U.S. will find itself in a continued dependence on China for key technological building blocks.

Viewed through this lens and as evidenced above, the domestic development of rare earth resources and manufacturing capabilities is not only a strategic necessity but also a potential catalyst for job growth in the clean energy and advanced technology manufacturing sectors. If these resources and capabilities were built up domestically, it could have a multiplier effect on downstream, value added manufacturing. Consider China's experience. It has to create 10-15 million jobs a year just to accommodate new entrants into its job market, and it has viewed the rare earths industry as a "magnet" for jobs. China repeatedly attracted high-tech manufacturers to move to its shores in exchange for access to rare earths among other enticements. We believe, and we are seeing already, that the U.S. can experience a similar jobs boost by rebuilding the rare earths supply chain within its borders, and utilize it to attract manufacturing opportunities down the value chain.

LEGISLATIVE RECOMMENDATIONS

We applaud Sen. Murkowski's effort to raise the government's awareness and understanding of rare earths and the supply challenges ahead, and the effort to address a variety of near-term concerns, including interagency coordination, vulnerability assessments, and stockpiling. While there is much in the legislation that we agree with, we would like to make the following recommendations:

- Establish the "Rare Earth Policy Task Force" (REPTF) at the White House Office of Science and Technology Policy (OSTP): Molycorp recommends that the REPTF outlined in Sec. 3 of the legislation be centered at OSTP. Not only is this task force already underway at OSTP (bolstered in part by existing, but underutilized, policy that puts OSTP in charge of critical minerals oversight), it is arguably the most effective agency to manage the REPTF's work, particularly given the breadth of rare earth applications across advanced technologies and the resulting issues that cut widely across numerous agencies. As currently drafted, the legislation establishes a focus for the REPTF that is too narrow, and it underutilizes the potential of the REPTF. Mining is obviously a part of rare earth production, but the vast majority of the rare earths supply chain has more to do with chemistry, technology, and manufacturing than mining. While the REPTF can help to improve the efficiency of government efforts to bring new projects on-line, it should understand the broader, emerging trends in the industry, paying particular attention to supply forecasting, current and emerging applications, recycling, substitution/minimization, workforce issues, and technological advancements throughout the supply chain and how it impacts the federal government's work across the represented agencies. To this end, annual reports should also be issued to the House Science and Technology Committee and the Senate Commerce, Science and Transportation Committee

- Do not relax the required permitting or regulatory process for rare earth projects: While Molycorp supports efforts to ensure that permitting and regulatory processes move forward smoothly and efficiently, it does not support any efforts to reduce or eliminate the environmental protections necessary for project approval. The environmental degradation at the rare earth mines in China is not reflective of what is possible in the rare earths industry. Environmental permitting and attention to sustainability are necessary for the long term health of the industry. Through its focused attention to energy and resource efficiency and environmental stewardship, Molycorp is proving that rare earth operations can be both environmentally superior and globally cost competitive.
- Enhance the research and development (R&D) and education elements of the legislation: We support Sec. 7 of the legislation and its effort to direct agency resources and attention to rare earth R&D and workforce development, but we think this is an area of the legislation that could go even further. While most of the legislation addresses the nation's near-term challenges related to rare earths, Sec. 7 is what will help to create and sustain a viable rare earths industry in the U.S and ensure a stable supply of talented engineers, scientists, chemists, etc., that will help the U.S. regain its once dominant position in the industry. We encourage the Committee to work with industry, academics, researchers, and non-profit organizations to identify additional ways that the federal government can support and accelerate technological advancements and educational opportunities in this area. We also encourage the Committee to collaborate with the House Science and Technology Committee, which recently moved similar legislation on rare earth R&D and education.
- Specify how the Defense Production Act (DPA) can be utilized to support rare earth projects: Currently, Sec. 6 of the bill calls for the DoD to describe past, present and future rare earth-related projects under the DPA authority, and provide a justification to Congress if there are none. Rather than stopping there, the bill should instruct DoD to provide a description/analysis of how academic institutions, researchers, private industry, etc., can utilize the DPA to provide support for rare earth projects. Given current DoD study already underway, Congress should use those findings to conclusively determine the support that can be achieved under current law.

## CONCLUSION

Thank you for the opportunity to submit this testimony. We are available to any Member of the Committee, or of the full Senate, to answer any additional questions you may have. Molycorp looks forward to working with the Committee, and with the Congress and the Administration, as we move America toward a position of greater rare earth independence over the next two years.

Thank you very much.

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