U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Investigations & Oversight

HEARING CHARTER

"The Federal Perspective on a National Critical Materials Strategy"

Tuesday, June 14, 2011
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

Purpose

On June 14, 2011, the Subcommittee on Investigations and Oversight has invited officials from the Administration to discuss the federal perspective on a national critical materials strategy. This includes rare earth elements as well as other critical materials.

Background

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

Located primarily around the center of the Periodic table (*Appendix 2*), there are several reasons why these elements may be considered critical beyond the role they play in electronics and advanced technologies such as electric cars, wind turbines and photovoltaic cells. The joint APS and MRS study explains elements may be critical because they might be "intrinsically rare in Earth's crust, poorly concentrated by natural processes, or currently unavailable in the United States."[2] While many energy critical elements also play important roles in national defense, this hearing is primarily focused on the commercial and energy applications of these materials.

Within the definition of energy critical elements are a group of seventeen chemical elements that are commonly found together, and referred to as the *rare earth elements*. On the Periodic table, fifteen of these elements are located in the Lanthanide series (*see below*), which make up a row of elements with atomic numbers in ascending order from 57 to 71. The other two are Yttrium (atomic number 39) and Scandium (atomic number 21). A list of the rare earth elements below, and their common end uses, is available in *Appendix 3*.

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[1] "*Energy Critical Elements: Securing Materials for Emerging Technologies*," a report by the American Physical Society and the Materials Research Society, February 2011, available at: http://www.aps.org/policy/reports/popa-reports/loader.cfm?csModule=security/getfile&PageID=236337 (hereinafter APS/MRS Report)
[2] Ibid.

Lanthanide Series*	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	La	**Ce**	**Pr**	**Nd**	**Pm**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
	138.9	140.1	140.9	144.2	(145)	150.4	152.0	157.2	158.9	162.5	164.9	167.3	168.9	173.0	

Rare earths share similar - yet unique - chemical and physical properties that make them critical components of advanced technologies such as high powered magnets, petroleum refining catalysts, batteries, and lasers among others. Like other critical elements, rare earths are important components of everyday items such as cell phones, blackberries, hybrid cars, etc.

Rare earths are further classified into two categories – light and heavy. The lighter elements – basically the first half of the Lanthanide series – are more abundant and have a larger market. The heavier elements – the second half of the Lanthanide series – are scarcer, but equally, if not more critical, even with a smaller market share.

Despite the terminology, rare earths are actually abundant in the Earth's crust. They are however, expensive and difficult to mine, as the process of separating and isolating each individual rare earth element is highly complex and cumbersome – both financially as well as logistically. When initially extracted from the ground as an ore, rare earths are mixed together. The mixed rare earths have to be chemically extracted from the ore concentrates, and further chemically separated from any other metals that exist in the ore. The remaining mix of rare earths then undergoes an additional process to isolate each individual rare earth in a "separation plant."[3] These are expensive facilities to build, and can "easily involve hundreds of repetitive steps taking up to a month to finish a single batch of material, and although batches can be run almost continuously the size of the plant must reflect the optimum large batch size for producing enough volume to make a profit, by selling the resulting commercially pure separated chemical compounds."[4]

International Production

China

From the 1960s to the 1980s, the United States was the dominant producer in the world of rare earths. But the intensive nature of rare earths mining ultimately led to the demise of this industry. The process of mining and separating rare earth elements presents environmental challenges. It creates "hundreds of gallons of salty wastewater per minute, consuming huge amounts of electricity, requiring toxic materials for the refining process and occasionally unearthing dirt that is radioactive."[5] Combined with China's lower environmental standards, labor costs, and government backing of an industry of interest to that nation, the U.S. couldn't remain competitive, and ultimately ceded authority of this industry to the Chinese. The result is

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[3] Jack Lifton, "*In Xanadu Did Goldman Sachs Decree A Rare Earths Surplus For All To See*," Technology Metals Research, May 6, 2011, available at: http://www.techmetalsresearch.com/2011/05/in-xanadu-did-goldman-sachs-decree-a-rare-earths-surplus-for-all-to-see/

[4] Ibid.

[5] Tiffany Hsu, "*High-tech's Ace in the Hole*," Los Angeles Times, February 20, 2011, available at: http://articles.latimes.com/2011/feb/20/business/la-fi-rare-earth-20110220/3 (hereinafter Hsu Article)

that today, China produces about 97% of the world's rare earth oxides - demonstrating the success of a vision eloquently encapsulated in the following 1992 quote by Deng Xiaoping, the architect of China's economic transformation, "There is oil in the Middle East; there is rare earth in China."[6]

But as China's interest in the industry has expanded, so too has its control. Since 2006, "the Chinese Commerce Ministry has been reducing export quotas, as well as limiting and cutting the number of firms that are allowed to export rare earths in their raw form. In 2006, 47 Chinese companies had permits to export rare earths, but by 2010, only 22 companies were allowed to do so."[7]

Understandably, with a reduction in permits has come a reduction in exports. According to the U.S. Chamber of Commerce, "Last year, China slashed exports by 72%, and then by another 35% for the first half of 2011."[8]

Moreover, as of 2007, China has established export taxes on rare earths. "Originally set at between 15 percent to 25 percent, depending on the oxide or concentrate being exported, the rates on many more rare earth products are expected to be raised by 25 percent in 2011."[9]

China claims these measures are necessary to protect its environment from rogue mining operators, and to sustain its rare earths industry. To that end, China issued guidelines earlier this year that lifts rare earth elements to the level of national strategic reserves. Additionally, existing mines are forbidden from expanding capacity, China is setting up a strategic stockpile system for rare earth metals, and it aims to concentrate 80 percent of the country's heavy rare earth mining assets in the hands of its three largest companies over the next couple of years.[10]

China's actions have created tense relations with American technology and renewable energy industries, leading the U.S. Trade Representative's office to say that "if China continues to rebuff requests to ease export limits on rare earths, it may take the dispute to the World Trade Organization."[11] And, an analyst at the Heritage Foundation had the following to say:

> *"Beijing already faces a losing case at the World Trade Organization (WTO) for its rare earth export quotas. A Chinese embargo would take at least a few months to have an effect and would trigger WTO sanctioned retaliation that would match or exceed the dollar value of rare earth exports. Trade disruptions from that point would harm the PRC far more than the U.S., given the much greater volume of Chinese shipments to America and the jobs associated with them."*[12]

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[6] Paul Krugman, "*Rare and Foolish*," New York Times, October 17, 2010, available at: http://www.nytimes.com/2010/10/18/opinion/18krugman.html

[7] Ming Hwa Ting, "*China's Rare Earth Motives*," The Diplomat, June 5, 2011, available at: http://the-diplomat.com/new-leaders-forum/2011/06/05/chinas-rare-earth-motives/ (hereinafter Ting Article)

[8] Bill Kovacs, "Rare Earth Elements and our Clean Energy Future," ChamberPost, April 19, 2011, available at: http://www.chamberpost.com/2011/04/rare-earth-elements-and-our-clean-energy-future/

[9] Ting Article, *supra*, note 7

[10] Tony Zhu, "*China Tightens Control of Rare Earth Industry*," Business China, May 20, 2011, available at: http://en.21cbh.com/HTML/2011-5-20/wNMjMyXzIxMDIwNA.html

[11] Hsu Article, *supra*, note 5

[12] Derek Scissors, "*Rare Earths: The U.S. Government Should not Manage Supply*," Heritage Foundation Web Memo No. 3201, March 21, 2011, available at: http://thf_media.s3.amazonaws.com/2011/pdf/wm3201.pdf

Japan

China's willingness to take advantage of its near monopoly on rare earth elements isn't restricted to export quotas and taxes, nor are its policies directed solely to the United States. While China is the world's largest producer of rare earth elements, Japan conducts a great deal of the world's rare earth processing, and is therefore vulnerable to Chinese export restrictions. Last year, China suspended exports of rare earths to Japan in retaliation for Japan's detention of a Chinese fishing boat captain accused of deliberately ramming two Japanese patrol boats in disputed waters.[13] While Japan kept custody of the fisherman during its investigation, the Chinese government kept raising diplomatic stakes in demanding his freedom, leading to an increasingly tense stand-off between the two nations. Japan eventually relented, and let the Chinese captain go, claiming that the negative impact on the Japan-China relationship wasn't worth the cost. China, meanwhile, denied any embargo on rare earth shipments to Japan – even though it took almost two months before shipment of the minerals resumed.[14]

Australia

Prior to the Japanese incident, in 2009, China sought to expand its influence in other countries. Flush with the cash flow of a bustling economy, the Chinese made multiple unsuccessful bids to purchase significant shares of several companies in Australia's resource industry:

- A $400 million bid for a controlling stake in a rare earths miner fell through;
- For national security reasons, Australia's Defense Department intervened in a proposed joint venture between an Australian subsidiary of a Chinese company and an Australian outback mining venture;
- In a separate deal, again for national security reasons, Australian Treasurer Wayne Swan rejected Minmetals' (a Chinese state-owned firm) $2.6 billion offer for OZ Minerals;
- A $19.5 billion discussion between Chinese-owned metals firm Chinalco and Rio Tinto broke down after Rio backed away from the deal; and
- China Nonferrous Metal Mining (Group) Company ended negotiations to purchase Lynas Corporation because Australia's Foreign Investment Review Board required the Chinese company's ownership stake to be below 50% while maintaining a minority of board seats on Lynas.[15]

The Lynas negotiation attracted a great deal of attention given the leverage the Chinese would have had in a company that owns significant deposits of undeveloped rare earths. Had China been successful in this endeavor, it would have further tilted the playing field in its favor, despite the 97 percent control it already enjoys in the production of rare earth oxides.

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[13] Keith Bradsher, "*Amid Tension, China Blocks Crucial Exports to Japan*," New York Times, September 22, 2010, available at: http://www.nytimes.com/2010/09/24/business/global/24rare.html
[14] Keith Bradsher, "*China Restarts Rare Earth Shipments to Japan*," New York Times, November 19, 2010, available at: http://www.nytimes.com/2010/11/20/business/global/20rare.html
[15] Rob Taylor, "*China Drops Lynas Bid; Further Strains Australia-China Relations*," Mineweb, September 24, 2009, available at: http://mineweb.com/mineweb/view/mineweb/en/page72068?oid=89761&sn=Detail

Domestic Production

The combination of China's aggressive actions - strong-arming Japan, aggressive purchase bids in Australia, reducing the number of rare earth export permits and quotas, and increasing taxes on these exports - has prompted numerous countries to call for a more diversified rare earths market and greater domestic exploration and production. As China's economy and industry grows, its own need for these rare earth materials is increasing. Because of this, it is possible that China could cease rare earth exports, or become a rare earth importer at some point in the future.

These circumstances have led to a renewed interest in domestic production of rare earth elements. Although "[r]are earth element reserves and resources are found in Colorado, Idaho, Montana, Missouri, Utah, and Wyoming…[t]here is no rare earth mine production in the United States."[16] The company best positioned to reconstitute domestic production is Molycorp Minerals, LLC. Based in Colorado, the company owns a mine in Mountain Pass, California, a site that once allowed Molycorp to hold the title of largest producer of rare earths in the world. But the mine shut down in 2002, as a result of low priced Chinese imports, strict environment regulations in the U.S., and liabilities associated with environmental contamination.[17] Nevertheless, proving its value, China has attempted to buy the mine three times after it shut down in 2002.[18]

In his testimony before this Subcommittee last year, Mark Smith, Molycorp's Chief Executive Officer, outlined the company's approach toward restarting the mine, and establishing itself as a competitive business. According to Mr. Smith:

> *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. We have spent the better part of the past 8 years developing the answer to this question. 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.*
>
> *We will incorporate a wide variety of manufacturing processes that are new to the rare earth industry, which will increase resource efficiency, improve environmental performance, and reduce carbon emissions. Specifically:*
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> - *Our overall processing improvements will almost 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;*

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[16] Marc Humphries, *Rare Earth Elements: The Global Supply Chain*, CRS, September 30, 2010, available at http://www.crs.gov/Products/R/PDF/R41347.pdf (hereinafter Humphries/CRS Report)

[17] Keith Bradsher, "*Challenging China in Rare Earth Mining*," New York Times, April 21, 2010, available at: http://www.nytimes.com/2010/04/22/business/energy-environment/22rare.html

[18] Ibid.

- *Our extraction improvements will 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%;*
- *Our reagent recycling, through proprietary technology that Molycorp has developed, could lead to even greater decreases in reagent use;*
- *Our new water recycling and treatment processes reduce the mine's fresh water usage from 850 gallons per minute (gpm) to 30 gpm — a 96% 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 significantly 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. At the same time, we significantly distinguish ourselves from the Chinese rare earth industry that has been plagued by a history of significant environmental degradation, one that it is just beginning to recognize and rectify.*[19]

From a financial perspective, Molycorp's efforts are receiving favorable marks thus far. By the end of last year, Molycorp claimed it had secured all the permits it needed to begin mining ore this year.[20] Molycorp is spending over $500 million on its 2,200-acre facility, and by 2014, plans to dig about 40,000 tons of dirt a year, compared to its current 3,000 tons.[21]

Moreover, as part of its 'mine-to-magnets' strategy, Molycorp and Hitachi Metals Ltd. agreed to "form a joint venture to produce rare-earth alloys and magnets, moving Molycorp a step closer to establishing a rare-earth manufacturing chain in the U.S."[22] This deal would expand Molycorp's business beyond just mining. Hitachi owns a host of patents on neodymium iron boron (NdFeB) permanent magnets, which advances Molycorp's 'mine-to-magnets' strategy. These powerful magnets have played an essential role in miniaturizing consumer electronics (cell phones), and are key components of lightweight, high-power motors and generators (wind turbines, hybrid and electric vehicles.)

From Japan's perspective, where Hitachi is based, this venture would provide the country with some place other than China for a supply of rare earths. Separately, Molycorp also struck a deal with Sumitomo Corporation, another Japanese company, which "agreed to buy $100 million, or more than 3%, of Molycorp's shares and provide $30 million in financing as part of a seven-year rare-earth supply agreement."[23]

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[19] Mark A. Smith, CEO, Molycorp Minerals, LLC, Testimony, House Science and Technology Subcommittee on Investigations and Oversight, March 16, 2010 (hereinafter Smith Testimony)

[20] "*Update 1 – Rare Earth Producer Molycorp Wins OK for Mine*," Reuters, December 13, 2010, available at: http://af.reuters.com/article/metalsNews/idAFN1321376420101213

[21] Hsu Article, *supra*, note 5

[22] Tess Stynes, "*Molycorp, Hitachi Metals Reach Rare Earth Deal*," Wall Street Journal, December 21, 2010, available at: http://online.wsj.com/article/SB10001424052748703581204576033382079826492.html

[23] Ibid.

Interagency Working Group

Since March 2010, OSTP, in coordination with the National Economic Council and the National Security Council, has been hosting an interagency working group on critical and strategic mineral supply chains, which includes the topic of supply constraints on rare earth elements. The group is initially focusing on four areas:

- Defining, screening and prioritizing critical materials;
- Prioritizing federal research and development;
- Review of domestic and global policies that affect the supply of critical and strategic minerals (e.g., permitting, export restrictions, recycling, stockpiling, etc.) and consideration of methods to mitigate risks through industrial or diplomatic processes; and
- Transparency of resource supply and demand information.

Participants in this group include: Department of Energy, Department of Defense, U.S. Geological Survey, Department of Commerce, Environmental Protection Agency, Department of Justice, Department of State, and the U.S. Trade Representative.

At this time, there are no plans to develop a collaborative report or document to reflect the dialogue and/or exchange of ideas between the participating agencies.

Last December, DOE officials published the "*Critical Materials Strategy*" report, and indicated that they plan to release an update at the end of this year. The 2010 report examined the role of rare earths and other materials in the clean energy economy. In the report, DOE describes plans to:

(i) *develop its first integrated research agenda addressing critical materials;*
(ii) *strengthen its capacity for information-gathering on this topic; and*
(iii) *work closely with international partners, including Japan and Europe, to reduce vulnerability to supply disruptions and address critical material needs.*[24]

With respect to its critical materials strategy, the DOE report identifies three points:

- *First, diversified global supply chains are essential;*
- *Second, substitutes must be developed;*
- *Third, recycling, reuse and more efficient use could significantly lower world demand for newly extracted materials.*[25]

The follow-up report "will include additional analysis of rapidly-changing market conditions. It will analyze the use of critical materials in other technologies, such as fluid cracking catalysts in petroleum refineries. Finally, the updated strategy will identify specific steps forward for substitution, recycling and more efficient use of materials identified as critical."[26]

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[24] *Critical Materials Strategy*, U.S. Department of Energy, December 15, 2010, available at: http://www.energy.gov/news/documents/criticalmaterialsstrategy.pdf (hereinafter DOE Report)
[25] Ibid.
[26] *DOE Announces Second RFI on Rare Earth Metals*, March 22, 2011, available at: http://www.energy.gov/news/10193.htm

There is a need for data on recycling efforts by industry, as well as understanding the potential for substitute materials. Stories such as Toyota's plans to switch from rare earths to a special induction motor in its Prius,[27] and GE's success in developing a new alloy to replace Rhenium, a critical material in its turbine engines, are encouraging.[28]

It would also be beneficial to Congress and private industry if the Administration would address the issue of mining permits. Highlighting the seriousness of this subject, during testimony before a House Natural Resources Subcommittee on Energy and Mineral Resources hearing on May 24, Mr. Hal Quinn, President and CEO of the National Mining Association, made the following observation:

> *"Regulatory costs can slowly drown an enterprise. But the uncertainties and delays in obtaining permits to commence operations can crush the mining enterprise before it even gets in the dirt. Permit delays pose the highest hurdle for domestic mining with necessary government authorizations now taking close to 10 years to secure. If commodity cycles are historically 20 years in duration, the 10-years it takes to obtain permits leaves U.S. mining still in the starting blocks with the race half way over."*[29]

Funding Streams

Funding for rare earths and critical materials R&D is spread throughout several DOE programs, making it difficult to isolate specific budget numbers. The following is a list of programs and sub-programs from which funds may be used relative to rare earths and critical materials projects: Office of Energy Efficiency and Renewable Energy; Advanced Research Projects Agency-Energy; Industrial Technologies Program; Next Generation Materials Program; Next Generation Manufacturing Processes; Manufacturing Energy Systems Program; Energy Efficiency Partnership; and Industrial Technical Assistance Program.

Additionally, the USGS Mineral Resources Program supports funding for the collection, analysis, and dissemination of minerals information in the U.S. and around the world.

For examples of rare earths and critical material budget details, please see *Appendix 4*, which includes selected information from DOE's 2010 "*Critical Materials Strategy*" Report.

Statutory History

Thirty years ago, the National Materials and Minerals Policy, Research and Development Act was enacted because:

[27] Hsu Article, *supra*, note 5
[28] APS/MRS Report, *supra*, note 1
[29] Hal Quinn, President and CEO, National Mining Association, Testimony, House Natural Resources Subcommittee on Energy and Mineral Resources, May 24, , available 2011 at: http://naturalresources.house.gov/UploadedFiles/QuinnTestimony05.24.11.pdf

> *…[T]he United States lacks a coherent national materials policy and a coordinated program to assure the availability of materials critical for national economic well-being, national defense, and industrial production, including interstate commerce and foreign trade….*[30]

The Congress declared it the President's responsibility to coordinate a plan of research and other actions that would "…promote an adequate and stable supply of materials necessary to maintain national security, economic well-being and industrial production with appropriate attention to a long-term balance between resource production, energy use, a healthy environment, natural resources conservation, and social needs."[31] Our current situation with rare earth minerals indicates that successive Administrations failed to carry out this policy.

The 1980 Act directed development of a plan that would, among other outcomes, produce continuing assessments of demand for minerals and materials in the economy; conduct a "vigorous" research and development effort; collect, analyze and disseminate information; and cooperate with the private sector and other nations.[32]

Four years later, dissatisfied with the inaction to the 1980 law, Congress decided in the National Critical Materials Act of 1984 to establish a National Critical Materials Council in the Executive Office of the President to serve as the focal point for critical materials policy. The Council was tasked to assist the President in carrying out the requirements of the 1980 Act.[33] In 1993, through Executive Order 12881,[34] the National Critical Materials Council was terminated, and its responsibilities transferred to the National Science and Technology Council, located within the Office of Science and Technology Policy.

In 1995 and 1996, the NSTC published reports on the Federal Research and Development Program in Materials Science and Technology. No equivalent report has been produced since, however, nor has OSTP produced the "long-range assessments of materials needs related to scientific and technological concerns" or "scientific and technical changes over the next five years" whose annual preparation the statute requires.[35]

Somewhere along the way, there appears to have been a failure in communication between the two branches of government given that multiple Administrations have disregarded responsibilities assigned by Congress in the 1980 Act.

During its hearing on rare earths last March, this Subcommittee revisited policy issues it thought had been settled decades ago to determine how to avoid finding ourselves in similar straits in the future. The full Committee on Science and Technology even held a mark-up in September on H.R. 6160, the Rare Earths and Critical Materials Revitalization Act of 2010, introduced by Rep.

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[30] 30 USC 1601(a) (6)
[31] 30 USC 1602
[32] 30 USC 1603
[33] 30 USC Chapter 30
[34] Ex. Ord. 12881, "Establishment of the National Science and Technology Council," November 23, 1993; 58 *Fed. Reg*. 62491. Dr. Gibbons tied the reorganization both to President Clinton's decision to reduce staff within the White House and to the National Performance Review conducted by Vice President Gore. Bill Loveless, "*Gibbons to Propose Formation of Science and Tech Council*," Federal Technology Report, September 2, 1993; p. 1
[35] 30 USC 1604(b) (2) and (3)

Kathleen Dahlkemper a day before the mark-up. Among its provisions, Rep. Dahlkemper's bill repealed the National Critical Materials Act of 1984, and amended parts of the National Materials and Minerals Policy, Research and Development Act of 1980. On September 29, the House approved the bill by a vote of 325-98.

This year, a number of Members have introduced legislation regarding rare earths and critical materials, with at least two of them repealing the 1984 Act. (*See Appendix 1*.)

Issues

R&D Portfolio

The federal government funds a number of research and development programs related to rare earths and critical materials. Recent reports recommend establishing research and development efforts focused on geological deposit modeling, mineral extraction and processing, material characterization and substitution, manufacturing, recycling, and life-cycle analysis. The private sector has a strong incentive to conduct this research as well; however, its focus is primarily on applied research rather than basic or fundamental research. In times of fiscal austerity, some have suggested prioritizing research and development activities in such a manner that precludes duplication, and prevents the crowding-out of private sector work. In other words, the federal government should not only identify what research needs to be conducted to enhance the critical element supply chain, but also what research is actually appropriate for government support versus private sector investment.

Information

Another recommendation for the U.S. government involves improving information related to discovered and potential resources, production, use, trade, disposal, and recycling. Currently, USGS provides the majority of data on element and mineral supplies; however, the agency has very little information on current and future demands. DOE projects the potential demand for energy critical elements, but not for all applications. In order to gather, analyze, and disseminate information on both supply and demand, reports have recommended that a "Principal Statistical Agency" should be tasked with regularly surveying emerging technologies and the supply chain throughout the Periodic table, with an aim of identifying critical applications, as well as potential shortfalls.

Loan Guarantees

A number of federal incentives were proposed to address shortfalls in domestic rare earth element production, most notably loan guarantees. Because access to capital was limited after the financial downturn, potential rare earth producers applied for DOE loan guarantees, and several legislative proposals sought to expand similar programs for rare earth elements. Despite the limited access to capital, concerns have been raised about the necessity of such incentives, given the high demand for rare earth elements.

Stockpiling

Recent proposals direct the federal government to stockpile certain rare earth elements and critical materials, especially those vital to national security and defense. The Defense National Stockpile maintains and manages strategic and critical materials, but proposals have suggested similar non-defense stockpiling efforts in addition to this effort. Conversely, other proposals have suggested that stockpiling is not necessary for non-defense related purposes other than helium.

Permitting

Arguments have been made for a streamlined permitting process for miners of rare earths and critical materials, as it can take as long as ten years to obtain the necessary approval. Any effort to revitalize a domestic rare earth industry that can compete with China is contingent upon minimizing administrative burdens. Ensuring that the permitting process is expedited in a manner that respects public health and safety, and the environment, is key to the industry's long term viability.

Witnesses:

Dr. John P. Holdren, Director, Office of Science & Technology Policy (OSTP)

> Dr. Holdren has been invited to talk about the interagency working group on critical and strategic mineral supply chains, which is comprised of OSTP, National Economic Council and the National Security Council. Dr. Holdren will describe the group and its objectives, especially with respect to any research and development plans relative to rare earths and critical materials.

Mr. David Sandalow, Assistant Secretary for Policy and International Affairs, U.S. Department of Energy (DOE)

> Mr. Sandalow will discuss DOE's participation in the above-mentioned interagency working group, and address DOE's activities relative to rare earths and critical materials, especially with respect to any research and development plans.

Mr. Jeff L. Doebrich, Program Coordinator (Acting), Mineral Resources Program, U.S. Geological Survey (USGS)

> Mr. Doebrich will explain USGS' participation in the interagency working group, and provide an overview of USGS' research activities relative to rare earths and critical materials.

APPENDIX 1

HOUSE BILLS

- **Rep. Leonard Boswell -** H.R.618, *Rare Earths and Critical Materials Revitalization Act of 2011*, introduced February 10, 2011:

  Establishes in the DOE a research, development, and commercial application program.

  Directs the Secretary of Energy to:

  > (1) support new or significantly improved processes and technologies (as compared to those currently in use in the rare earth materials industry),
  > (2) encourage multidisciplinary collaborations and opportunities for students at institutions of higher education, and
  > (3) submit an implementation plan to Congress.

  Amends the Energy Policy Act of 2005 to authorize the Secretary to make loan guarantee commitments for the commercial application of new or significantly improved technologies for specified projects.

  Amends the National Materials and Minerals Policy, Research and Development Act of 1980 to:

  > (1) instruct the Director of the Office of Science and Technology Policy to coordinate federal materials research and development through the National Science and Technology Council (instead of, as currently required, the Federal Coordinating Council for Science, Engineering, and Technology, which is now defunct);
  > (2) modify the duties of the Secretary of Commerce regarding critical needs assessment; and
  > (3) repeal specified reporting and other duties of the Secretaries of Defense and of the Interior.

  Repeals the National Critical Materials Act of 1984.

- **Rep. Brad Miller -** H.R.952, *Energy Critical Elements Renewal Act of 2011*, introduced March 8, 2011:

  Establishes in the Department of Energy (DOE) a research, development, and commercial application program.

  Directs the Secretary of Energy to:

  > (1) support new or significantly improved processes and technologies (as compared to those currently in use in the energy critical elements industry);
  > (2) encourage multidisciplinary collaborations and opportunities for students at institutions of higher education;

(3) collaborate with the relevant agencies of foreign countries with interests relating to energy critical elements;
(4) establish a Research and Development Information Center to catalogue, disseminate, and archive information on energy critical elements; and
(5) submit an implementation plan to Congress.

Directs the President, acting through the Office of Science and Technology Policy, to coordinate the actions of federal agencies to:

(1) promote an adequate and stable supply of energy critical elements;
(2) identify energy critical elements and establish early warning systems for supply problems;
(3) establish a mechanism for the coordination and evaluation of federal programs with energy critical element needs; and
(4) encourage private enterprise in the development of an economically sound and stable domestic energy critical elements supply chain.

Amends the Energy Policy Act of 2005 to authorize the Secretary to make loan guarantee commitments for the commercial application of new or significantly improved technologies for specified rare earth materials projects.

Amends the National Materials and Minerals Policy, Research and Development Act of 1980 to:

(1) instruct the Director of the Office of Science and Technology Policy to coordinate federal materials research and development through the National Science and Technology Council (instead of, as currently required, the Federal Coordinating Council for Science, Engineering, and Technology, which is now defunct);
(2) modify the duties of the Secretary of Commerce regarding critical needs assessment; and
(3) repeal specified duties of the Secretaries of Defense and of the Interior.

Repeals the National Critical Materials Act of 1984.

- **Rep. Henry C. "Hank" Johnson, Jr -** H.R.1314, *RARE Act of 2011*, introduced April 1, 2011:

  Directs the Secretary of the Interior, through the Director of the USGS, to submit a comprehensive report on global rare earth element resources and the potential future global supply of such resources.

  Requires the report to include recommendations on areas of need for future geologic research related to rare earth elements and other minerals that are critical based on the impact of a potential supply restriction and the likelihood of one.

- **Rep. Mike Coffman -** H.R.1388, *Rare Earths Supply Chain Technology and Resources Transformation Act of 2011*, introduced April 6, 2011:

Establishes in the Department of the Interior a task force which shall report to the President through the Secretary of the Interior. The task force will be composed of Secretaries or their designees from the following agencies: Interior, Energy, Agriculture, Defense, Commerce, State, OMB, the Chairman (or designee) of the Council on Environmental Quality, and other members the Secretary of Interior considers appropriate.

The Task Force will review and report on ways for federal agencies to expedite the permitting process and reduce barriers to investment and development of the domestic rare earth industry. The Task Force shall then submit this report to the President, the Senate Committee on Energy and Natural Resources, the House Committee on Energy and Commerce, and the House Committee on Natural Resources.

Using funds from the sale of excess materials in the National Defense Stockpile, the President, acting through the Secretary of Defense, shall establish a neodymium iron boron magnet alloy and dysprosium iron alloy inventory to be managed by the Administrator of the Defense Logistics Agency Strategic Materials. The Secretary of Defense shall encourage domestic neodymium iron boron magnet manufacturing capability by seeking to enter into a long-term supply contract with such producer of such magnets and ensure that a sintered neodymium iron boron magnet producer who is awarded any such long-term contract establishes manufacturing capability for only military-use magnets for sale to the National Defense Stockpile.

- **Rep. Doug Lamborn** – H.R.2011, *National Strategic and Critical Minerals Policy Act of 2011*, introduced May 26, 2011:

  Directs the Secretary of the Interior to coordinate a government wide assessment of the Nation's mineral resources and availability to meet current and future strategic and critical mineral needs.

  Requires the Secretary of the Interior to evaluate factors impacting domestic mineral development, including workforce, access, permitting and duplicative regulatory requirements as well as identify areas for improvement.

  Directs the Interior Department to assemble the report within six months.

  Requires an annual progress report, beginning one year after the date of enactment of the Act for the following two years, outlining the progress made in reaching the policy goals described in the bill.

- **Rep. Randy Hultgren -** H.R. 2090**,** *to improve assessments of and research about energy critical elements, and for other purposes*, introduced June 2, 2011:

  Instructs the Secretary of the Interior and Secretary of Energy (acting through the Energy Information Administration) to improve assessments of energy critical elements that covers discovered and potential resources, production, use, trade, disposal and recycling. This entity will be designated a "principal statistical agency" and will make this information available to the public.

Directs the Secretary of Energy in coordination with the Secretary of Interior to establish a research program to advance basic research and enable expanded availability of energy critical elements. Requires the National Science and Technology Council to submit a report to the Science committee on the status of these endeavors.

<u>SENATE BILLS</u>

- **Sen. Mark Udall -** S.383, *Critical Minerals and Materials Promotion Act of 2011*, introduced February 17, 2011:

  Directs the Secretary of the Interior, acting through the USGS, to establish a research and development program to:

  > (1) provide data and scientific analyses for research on, and assessments of the potential for, undiscovered and discovered resources of critical minerals and materials in the United States and other countries;
  > (2) analyze and assess current and future critical minerals and materials supply chains; and
  > (3) cooperate with international partners to ensure that the research and assessment programs provide analyses of the global supply chain of critical minerals and materials.

  Directs the Secretary of Energy to conduct a research, development, and demonstration program to strengthen the domestic critical minerals and materials supply chain for clean energy technologies, and to ensure the long-term, secure, and sustainable supply of critical minerals and materials sufficient to strengthen the national security and meet the clean energy production needs of the United States.

  Directs the Secretary of Energy to promote the development of the critical minerals and materials industry workforce in the United States by supporting:

  > (1) critical minerals and materials education by providing undergraduate and graduate scholarships and fellowships at institutions of higher education, including technical and community colleges;
  > (2) partnerships between industry and institutions of higher education, including technical and community colleges, to provide onsite job training; and
  > (3) development of courses and curricula on critical minerals and materials.

  Expresses the policy of the United States to promote an adequate and stable supply of critical minerals and materials necessary to maintain national security, economic well-being, and industrial production with appropriate attention to a long-term balance between resource production, energy use, a healthy environment, natural resources conservation, and social needs. Directs the President take specified steps to implement such policy.

- **Sen. Kay Hagan -** S.421, *Powering America's Lithium Production Act of 2011*, introduced February 28, 2011:

  Amends the Energy Independence and Security Act of 2007 to require the Secretary of Energy (DOE) to provide grants to eligible entities for research, development, demonstration, and commercial application of domestic industrial processes that are designed to enhance domestic lithium production for use in advanced battery technologies.

  Defines an "eligible entity" as:

  > (1) a private partnership or other entity that is organized in accordance with federal law and engaged in lithium production for use in advanced battery technologies;
  > (2) a public entity, such as a state, tribal, or local governmental entity; or
  > (3) a consortium of such entities.

  Requires such eligible entities to use such grants to develop or enhance:

  > (1) domestic industrial processes that increase lithium production, processing, or recycling for use in advanced lithium batteries; or
  > (2) industrial process associated with new formulations of lithium feedstock for use in such batteries.

- **Sen. Lisa Murkowski -** S.1113, *Critical Minerals Policy Act*, introduced May 26, 2011:

  The bill provides clear programmatic direction to help keep the U.S. competitive and will ensure that the federal government's mineral policies – some of which have not been updated since the 1980s – are brought into the 21st century.

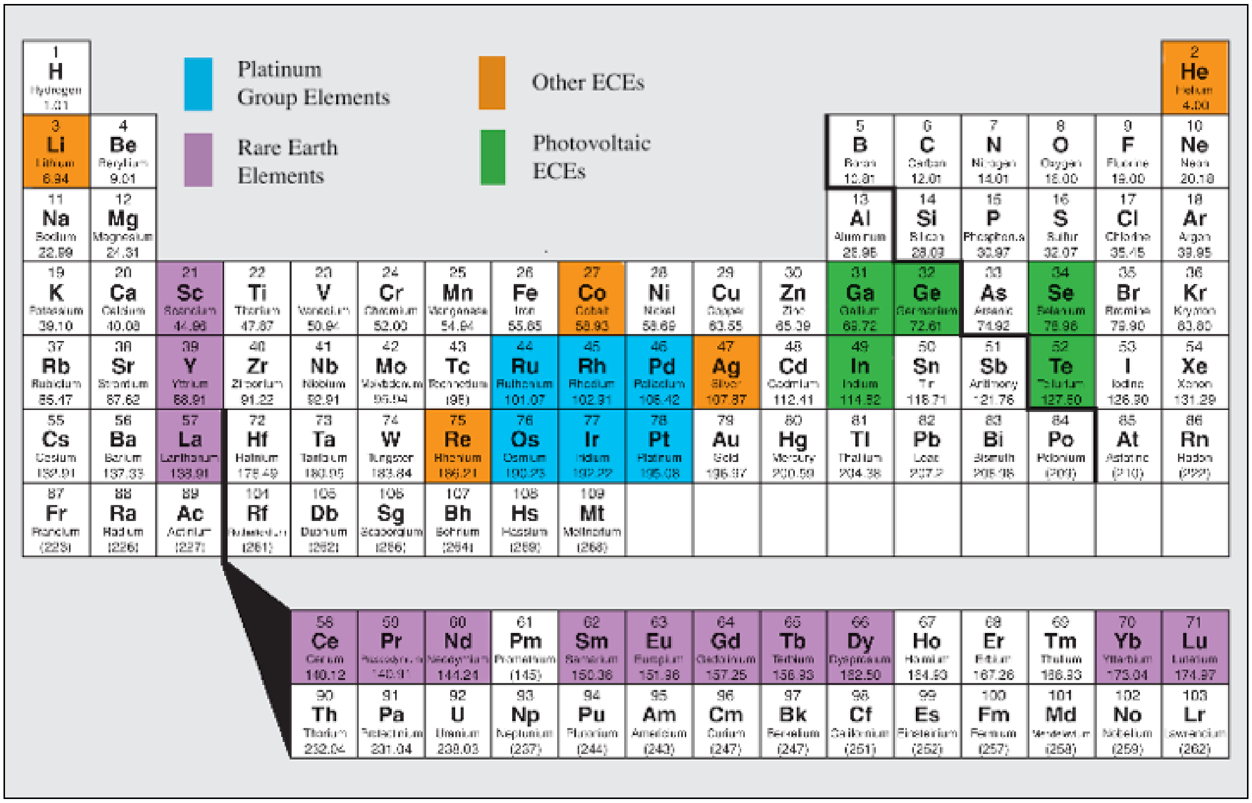
  The legislation starts by directing USGS to establish a list of minerals critical to the U.S. economy and, pursuant to those designations, outlines a comprehensive set of policies that will bolster critical mineral production, expand manufacturing, and promote recycling and alternatives – all while maintaining strong environmental protections.

  To avoid the duplication of authorities related to critical minerals, two previous Acts of Congress are repealed, in whole or in part: the National Critical Minerals Act of 1984 and the National Materials and Minerals Policy, Research, and Development Act of 1980.

  A savings clause to clarify that nothing in this Act displaces the authorizations included under "Geological Survey" of the first section of the Organic Act of March 3, 1879.

  Authorizes a total of $106 million for the various activities, programs, authorizations, and requirements of the Act.

APPENDIX 2[36]



Possible Energy-Critical Elements (ECEs) are highlighted on the periodic table. The rare earth elements (REEs) include lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Tb), and lutetium (Lu). The closely related elements scandium (Sc) and yttrium (Y) are often included as well. The REEs are considered as a family, although Pm is unstable, and Ho, Er, and Tm have no energy-critical uses at present and are omitted from our list. Y together with the Tb—Lu form the heavy rare earth elements (HREE), and Sc plus Ce—Gd constitute the light rare earths (LREE). The platinum group elements (PGEs) include ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir), and platinum (Pt). Additional ECE candidates include gallium (Ga), germanium (Ge), selenium (Se), indium (In), and tellurium (Te), all semiconductors with applications in photovoltaics. Cobalt (Co), helium (He), lithium (Li), rhenium (Re) and silver (Ag) round out the list.

36 APS/MRS Report, *supra*, note 1

APPENDIX 3[37]

Rare Earth Elements (Lanthanides)
Selected End Uses

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

[37] Humphries/CRS Report, *supra*, note 16

<u>**APPENDIX 4**</u>

<u>**Rare Earth Elements and Critical Material Funding**</u>

<u>Department of Energy</u>

The following information is from Chapter 4 of DOE's 2010 "*Critical Materials Strategy*" report:

> *Several U.S. Department of Energy (DOE) data and information programs, research and development (R&D) programs and financial instruments address rare earths and other key materials. Current programs focus on the component and end-use technology stages of the supply chain and address both the economic and the innovation dimensions of the clean energy sector.*
>
> *DOE also supports R&D addressing specific materials and alternatives across the supply chain. In Fiscal Year (FY) 2010, the Office of Science, the Office of Energy Efficiency and Renewable Energy (EERE) and the Advanced Research Projects Agency-Energy (ARPA-E) together provided approximately $15 million for research on rare earth materials and possible substitutes for magnets. An additional $35 million was spent by ARPA-E on next generation battery technologies that don't require rare earths.*
>
> *At the basic science end of the pipeline, the Materials Sciences and Engineering (MSE) Division of the Office of Basic Energy Sciences supports broad-based, fundamental materials research. MSE seeks to illuminate the atomic basis of materials properties and behavior and improve materials performance at acceptable costs through innovative design, synthesis and processing. This research was funded at a level of about $5 million/year in FY2010.*
>
> *Most of the supported work has been performed at Ames Laboratory. A key component of the Ames Laboratory program is the Materials Preparation Center (MPC). The MPC was established in 1981 to provide high purity metals (including the rare earths, uranium, thorium, vanadium, chromium); and intermetallics, refractory, inorganic compounds and specialty alloys; none of which are available commercially in the required purity or form/shape needed by the requestor on a cost recovery basis.*
>
> *Moving along the pipeline to applied research via feasibility research, technology development and demonstration, ARPA-E supports two initial projects totaling $6.6 million specifically targeted to developing substitutes for rare earth magnets. The goal of this $4.4 million project is to develop materials to allow the United States to fabricate the next generation of permanent magnets (PMs) with magnetic energy density (maximum energy product) up to two times higher than the current value of the strongest commercially available neodymium-iron-boron (Nd-Fe-B) magnets. If successful, this*

project will lead to cheaper, more energy-efficient, more power-dense magnets for deployment in a wide range of clean energy technologies.

In another ARPA-E project, General Electric Global Research (GE) is developing next-generation permanent magnets with a lower content of critical rare earth materials. For the $2.2 million project, GE is developing bulk nanostructured magnetic materials with a dramatic increase in performance relative to state-of-the-art magnets. These new magnets will increase the efficiency and power density of electric machines while decreasing dependence on rare earth minerals.

Addressing the challenge of rare-earth and critical-materials-containing batteries, particularly in the emerging hybrid and electric vehicle transportation sectors, the Batteries for Electric Energy Storage in Transportation (BEEST) program invested $35 million in first-of-kind demonstration of new batteries and storage chemistries, structures and technologies.

The Office of Energy Efficiency and Renewable Energy (EERE) is supporting an applied magnet research project valued at $2 million (FY 2010) at Ames Laboratory. This project is focused on fabricating high-performance, cost-effective PMs that can be used for traction motors with an internal PM rotor design.

In addition to the magnet material research, EERE's Vehicle Technologies Program supports two projects valued at a total of $1.4 million (FY2010) at Oak Ridge National Laboratory investigating alternative motor designs that do not use rare earth PMs.

In addition, in 2009, the Vehicle Technologies Program awarded $9.5 million to Toxco, to expand an existing battery recycling facility in Ohio and become the first U.S. facility to recycle lithium-ion vehicle batteries.

For wind power applications, reducing magnet size by developing higher flux density magnets is more important than consistent properties at elevated temperatures. EERE's Wind and Water Technologies Program is supporting QM Power, Inc., with to develop a higher flux density PM generator. There are also much larger investments within EERE in battery, PV and lighting R&D that have key materials use implications.

The Loan Guarantee Program (LGP) was established under Title XVII of the Energy Policy Act (EPAct) of 2005. The LGP is authorized to provide loan guarantees to support domestic manufacturing of component technologies that use critical materials if those technologies meet the statutory tests. Projects supported by the program have the potential to affect market demand for key materials.

The Advanced Technology Vehicles Manufacturing (ATVM) Loan Program provides loans to automobile and automobile part manufacturers to re-equip, expand or establish manufacturing facilities in the United States to produce advanced technology vehicles or qualified components, and for the associated engineering integration costs. Vehicles with efficiency standards that will contribute to a clean energy economy are included in the

> *definition of advanced technology vehicles. The ATVM lacks authority to directly support extraction and production of key materials. However, the ATVM issued loans to companies for projects that may affect the market demand of nickel metal hydride (NiMH) or Lithium ion batteries and NdFeB permanent magnet motors. These companies include Ford Motor Company ($5.9 billion), Nissan North America ($1.6 billion), Tesla Motors ($465 million) and Fisker Automotive ($529 million).*[38]

Since this report was published, there have been two notable additions according to DOE congressional affairs staff:

- ARPA-E issued a $30 million funding announcement for projects on rare earth alternatives in green technologies being funded out of the FY 2011 appropriations; and
- A $20 million request to create a critical materials innovation hub in the FY 2012 appropriations request.

US Geological Survey

According to USGS congressional liaison office, USGS' FY 2012 request of $44.2 million for its Mineral Resources Program represents "about an 18 percent reduction from the FY 2010 enacted level of $53.8 million. As a result, [USGS] will eliminate collection, analysis, and dissemination of minerals information for about 180 other countries; domestic minerals information activities will continue. This is the information that goes into the Mineral Commodity Summaries and Volume III-Area Report: International, of the Minerals Yearbook. In addition, [USGS] will eliminate mineral resources research and field studies in Alaska and will eliminate about 50 scientific and technical positions [out of a total of about 350] across the United States."

[38] DOE Report, *supra*, note 24