China's Rare Earths in Emerging Green Technologies: An Economic, Environmental, and Social Rationale for Policy

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by

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Written Component: China's Rare Earths in Emerging Green Technologies: An Economic, Environmental and Social Rationale for Policy

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1.0 Introduction

I look to investigate how China's rare earth industry can affect the global energy technology market. Rare earth elements (REE) are used in the manufacturing of a variety of clean energy technologies such as hybrid vehicles and wind turbines. This industry of raw materials plays an important role in the progress of cleantech both domestically in China and elsewhere around the world. The goal is to present how China and the rest of the world are framing the policy debate around REEs, keeping in mind the economic, environmental, and social rationale. This will include an analysis of the industrial mining and political landscape, and provide insight on how technology and policy advancements can shape the global market for clean energy.

REEs are just one small contributor to the manufacturing of cleantech products, but a very important raw material. By delivering a written thesis that critically analyzes how this one specific raw material bounces in the boundaries of the political, economic, and technology landscape, I can provide my recommendation on a professional level through a policy memo, along with a briefing to a person who is active in global discussions regarding REEs.

This topic provides a balance between multiple interests explored throughout my academic career. Through the Liberal Arts and Engineering Studies' interdisciplinary program, I've advanced through courses in environmental engineering, natural resources, international relations, as well as environmental law and policy, all of which can provide a different perspective of the REE industry. This topic is one of many that showcases the interconnectedness and interdependence of countries, which encourages me to take on a global perspective when pursuing my interest in renewable energy. I hope to advocate for environmentally-related issues in a more political avenue, with the goal of one day working on a global platform.

2.0 Deliverables

In addition to the written component, multiple deliverables will be created to serve a particular purpose with an intended audience in mind. Deliverables are as followed:

Research Article -- A composed paper exploring the relationship between REEs and the clean technology industry will provide opportunity to demonstrate the ability to communicate research findings effectively in both a professional and international context. The written thesis/research article will explore the economic, environmental, and social rationale for policies surrounding REEs, as well as analyze technology innovation potential. The objective of this deliverable is to demonstrate a thorough grasp on the topic through critically analyzing and interpreting findings in an original way. The intended audience is all of academia, which promotes a peer-reviewing community, and can further advance knowledge of this topic. This deliverable was selected to better develop the skill set required for future pursuits in graduate school.

Policy Memo: This deliverable will condense the information of the written thesis, while also provide recommendations for a particular audience at regarding the REEs quota system and policy opportunity. In this case, the policy memo will be directed to the task force of Dr. Elizabeth Sherwood-Randall, Deputy Secretary of U.S. Department of Energy due to their active involvement in the country's energy strategy. This deliverable was selected to better understand and practice communication regarding policy among representatives.

3.0 Literature Review

This has become a fairly new topic of discussion over the past five years, especially considering the push for clean technology development. Articles and reports have been put on both a federal and academic level. In terms of literature added already in the scientific community, there have been official briefings put out by the department of energy as well as satellite images by NASA of China mines. Scientific journals have had some publications over the years.

The United Nations came out with a Global Sustainable Development Report in 2013 with rare earth elements as a topic of focus. Using the scientific search engine Scopus, "rare earth metals" and "rare earth elements" was searched. Initially 33,628 articles came up, until subject areas such as chemical engineering and computer engineering were excluded, and social sciences and humanities were the main focus. There were left 533 documents published 1960 onwards, as shown in Figure 1 below. To further find literature relevant for sustainable development, the search for "renewable energy" and "rare earth elements" resulted in 29 articles starting in 2000, with a major increase in articles published in 2011. Peak times were in 2010 and 2013, correlating when global price fluctuations were most vulnerable. As shown in Figure 2 below, the report showed that most literature came from the United States, followed by literature originating in China.

Figure 1. Articles published 1960 and onward

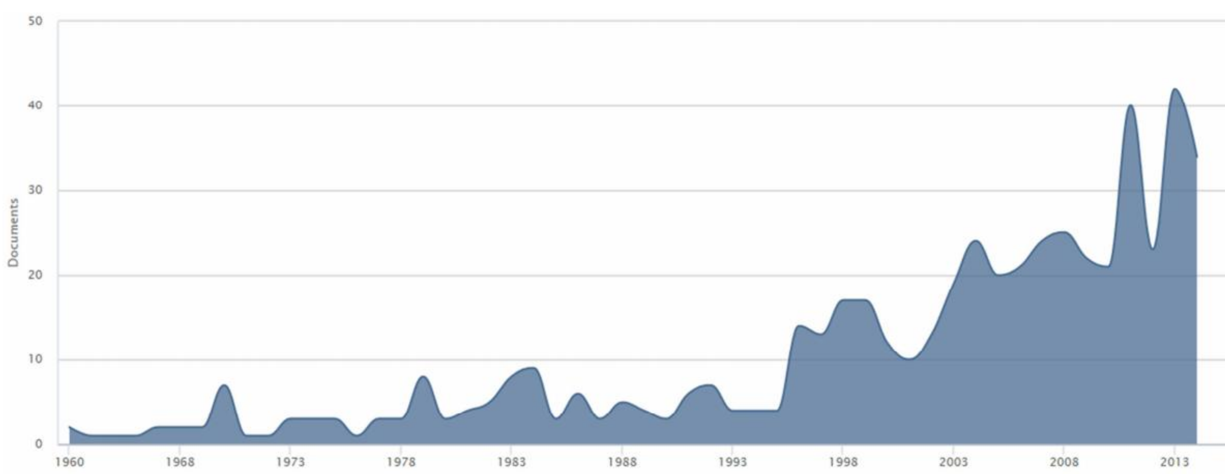
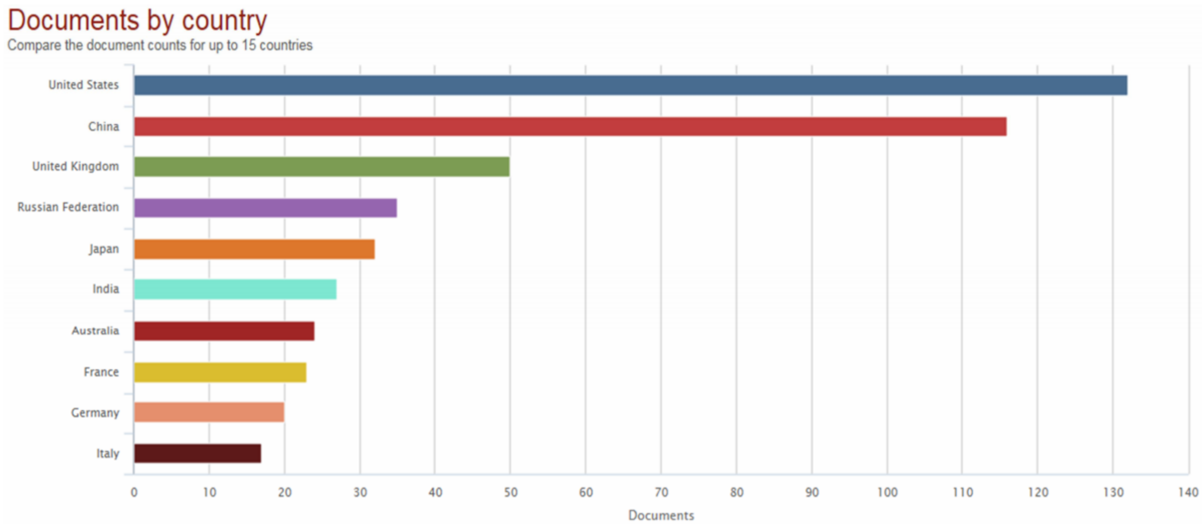


Figure 2. Articles published by country as of 2013



4.0 Overview of Deliverables

Each deliverable is based off a standard used in a professional context, with each depending on its intended audience. The specifications for each deliverable is as followed:

<u>Research Article</u>: Dissertation guidelines in combination with Columbia University's master's program and Cal Poly's master's program will be followed for final submission. This entails required order, page numbering, font, cover page, title page, copyright page, abstract, footnotes, and style. Details can be found below in section 10.0.

<u>Policy Memo:</u> A two-page policy memo will be formed following Cornell University's Policy Memo Guidelines used by fellows that pursue public policy research. Formatting will include organization's seal, proper heading, problem statement, and recommendations. Details can be found below in section 10.0.

5.0 Design

<u>Research Article</u>: I wanted to produce something that gave me practice at what I'd be pursuing in graduate school. I based my research criteria and formatting guidelines based of Columbia University and Cal Poly's master thesis for public policy.

<u>Policy Memo:</u> I based the criteria for the policy memo on Cornell University's policy memo guidelines that student fellows use who go into work experience in D.C. for the public and private sector.

The following timeline was used to complete my senior project:

Date	Task
1/31	Preliminary research, outline creation, contact external sources for interview (Personal China contacts, California Mountain Pass mine, wind turbine manufacture etc)
2/28	Introduction, hard data collection, layman's view
3/22	Send emails to three individuals reviewing/verifying work
	Lots of writing
4/03	Submit human subject form for three individuals reviewing/verifying work
4/30	Working draft of deliverables completes
5/07	Near-final draft of deliverables completed
5/10	Send deliverables to three individuals reviewing/verifying work
5/27	Finalize edits of deliverables
5/31	Final presentation outline complete, practice
6/08	Final presentation

6.0 Analysis and Verification

Graduate-Level Performance
The research article/written thesis deliverable provides a writing sample that can be used for graduate school applications, and will follow graduate-level researching, analyzing, writing, and formatting guidelines. For the matrix, success is determined by B- (80%) and above, which is a total score of 19 of 24

Criteria	Description	Outstanding (4)	Good (3)	Average (2)	Poor (1)
Content	*Raises vital questions or issues, formulating them clearly and precisely*				
	Thinks open-mindedly, recognizing and assessing, as appropriate,				

	assumptions, implications, and/or practical consequences.				
	Provides quantitative data with contextual analysis to support argument				
	Shows an understanding of technological, social, economic, and political implications				
Sources		Bibliography includes 20 sources (15 primary, 5 secondary) at the minimum	Bibliography includes 16 sources (12 primary, 4 secondary) at the minimum	Bibliography includes 12 sources (9 primary, 3 secondary) at the minimum	Bibliography includes less than 12 sources
Formatting	*See attached list*	At least 28/31 formatting guidelines checked off	At least 25/31 formatting guidelines checked off	At least 22/31 formatting guidelines checked off	21 and below

Policy Advocacy
Through a formulated mock policy memo, background information and issues surrounding REEs must be put into condensed form for a representative.

Criteria	Description	Outstanding (4)	Good (3)	Average (2)	Poor (1)
Analysis and Argument	*Counterarguments and alternative policies are effectively rebutted using evidence*				
	Highlights key assumptions and policies				
	Evidence - hard data is effectively used to support				

	analysis and argumentation				
Recommendations	*Recommendations address the problem, and are feasible and action-oriented*				
Format	*Proper header, formalities, and is condensed form no more than 2 pages*				

Due to time constraints, only two of the three individuals could provide feedback and verification of success.

Name	Credentials	Research Article	Policy Memo
Terry Foeke	• Based in Shenzhen, Guangdong, China • Active employee at PCH International (supply chain management) • Environmental Defense Fund, Environmental Protection Agency Background	23/24	19/20
Jeanne Choi	• MS in Environmental and Energy Policy • PhD in International Relations and Affairs • Natural Resource Defense Council Background • Active employee at Clinton Foundation's Climate Initiative	20/24	17/20
Aaron Wolf	• MPA in Public Management • Legislative Assistant for US House of Representatives congresswoman • Active employee at Clinton Foundation's Climate Initiative	--	--

7.0 Social Impact

My contribution will be to the scientific community in attempt of getting my work published. I hope to broaden dissemination to enhance scientific and technological understanding, enhance infrastructure for research and education and promote learning of this topic. My contribution aims to bring awareness to these critical natural resources and all issues associated with it.

8.0 Future Work

After senior project, I will try to get my research article portion of senior project published in a competition and/or small-time scientific journal. Through this project, I have developed skills that will prepare me in my future pursuits at graduate school in a tentatively-planned degree in

Masters of Public Policy. I have the long-term goal of working on a global platform that is addressing environmental issues that will better the livelihoods of people.

9.0 Conclusion

Through research I have studied the mining, refining, and processing of rare earths and learned the technical, economic, environmental, and political importance of it as a natural resource.By studying the dynamic between the United States and China, it has provided insight into multiple dimensions of issues associated with REEs, and how there is potential to shape policy that can support strategic and environmental needs, and well as incubate innovation of green technologies. I have had the opportunity to get a global perspective, along with practicing my research, analytical, and writing skills that will prep me to be an active participant in environmental issues down a politically avenue.

10.0 References

Kuhn, Janne. Rare Earth Elements; from Mineral to Magnet. United Nations Global Sustainable Development Report (2015).

Columbia University Graduate School of Arts and Sciences. Formatting Guidelines. Found at: http://gsas.columbia.edu/content/formatting-guidelines

Cornell College. Policy Memo Guidelines. Found at: http://www.cornellcollege.edu/cornell-fellows/resources-fellows/policy-memo-guidelines.shtml

China's Rare Earths in Emerging Green Technologies: An Economic, Environmental and Social Rationale for Policy

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Abstract

Rare earth elements hold unique properties that are valuable in both current and upcoming markets, with a wide range of industrial and commercial applications including green technologies. With China controlling 95% of the global supply, it will use the industry as a tool of economic statecraft, and will leverage its monopoly by strategically implementing policies that meet its long-term objectives. This report provides a discussion of the major issues and concerns of the global supply chain for REEs, their major end uses, and legislative and other policy proposals that have potential to change the direction of the market.

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List of Acronyms and Abbreviations

CMI - Critical Materials Institute

DOD – Department of Defense

DOE - Department of Energy

GAO - Government Accountability Office

REE - Rare Earth Element

ROW - Rest of the World

USGS - United States Geological Survey

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1.0 Introduction

In a motivated effort to reduce our dependency on fossil fuels as well as greenhouse gas emissions, a variety of clean technologies are emerging. Among these clean technologies, wind turbines, solar cells, and electric vehicles are on a rise and are becoming more recognized by researchers and policymakers.[1] What these high tech products have in common is the use of rare earth elements (REEs)--seventeen metals with unique properties that provide critical functionality to both current and upcoming markets.

The United States has become so reliant on rare earths that a few years ago an intense global power struggle broke out over their free flow. The reason is that one country, China, has a virtual monopoly in which it runs 95% of the mining, refining, and processing and in 2010 it used that power to disrupt the world supply.[2] It was at that time, the United States learned China can use its REE industry as a tool of economic statecraft, and will leverage its monopoly on the industry by aggressively and strategically implementing policies that meet its long-term objectives. China's leaders could use this natural resource to gain high profits and geopolitical leverage.. However, in its effort to make its mark as a global power, China has faced the trade off of negative environmental implications of its REE industry.

2.0 Issues Surrounding Rare Earth Elements

There are a few physical, environmental and regulatory challenges that come with REEs, each that play a role in the processing and distribution of the resource.

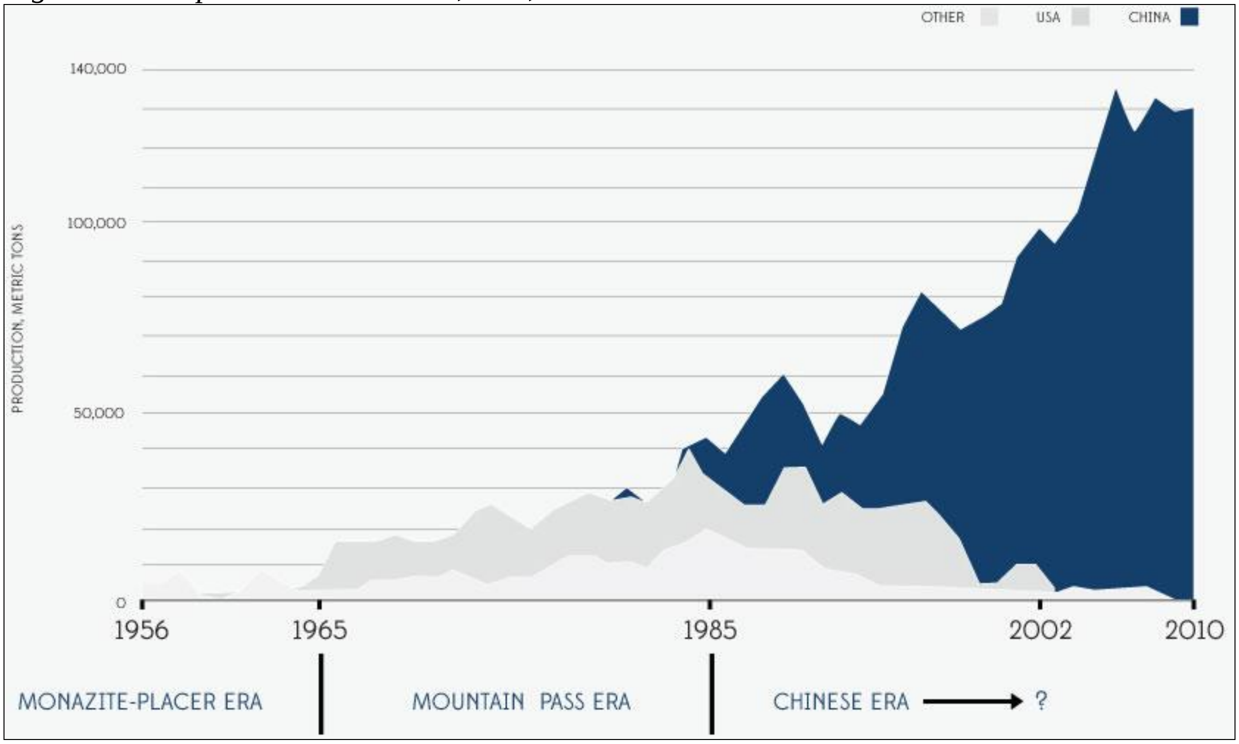
[1] Smith, Robert. China's Rare Earth Policies: Economic Statecraft or Interdependence? *Security Studies (2012): 3: 23-54.*
[2] Long, Keith. The Future of Rare Earth Elements-Will These High-Tech Industry Elements Continue in Short Supply? *United States Geological Survey (2011).*

2.1 Scarcity

The use of *rare* in REEs is actually misleading, considering these elements are widely dispersed in the earth crust. REEs can be found in 200 different minerals, some of which are located in our backyards; however, only a handful of locations on earth have high enough concentration for mining operations to be economically viable.[3] In addition, scarcity has become more amplified since 2002 when the mining of rare earths moved from Mountain Pass, California to China due to environmental damage and high operating costs. Development has been encouraged in China ever since former president, Deng Xiaoping recognized REEs as an important strategic resource when he stated in his little-noticed speech of 1992, "the Middle East has oil and China has rare earth."[4] His foresight on REEs held valuable in the decades to come with the spark of momentous investments in both China's knowledge and technology base.[5] This near-monopoly scenario has led to China's stranglehold on the rest of the world, primarily the United States, as shown in Figure 1 below.

[3] Habib, Komal. Exploring rare earths supply constraints for the emerging clean energy technologies and the role of recycling. *Journal of Cleaner Production*. (2014) 84: 348-359.
[4] Stahl, Lesley. 60 Minutes: Rare Earth Elements: Not So Rare After All. *CBS News.* (March 22, 2015).
[5] Ting, Ming Hwa and Seaman, John. Rare Earths: Future Elements of Conflict in Asia? *The International Politics Asian Studies Review*. (2013). 2: 234-252.

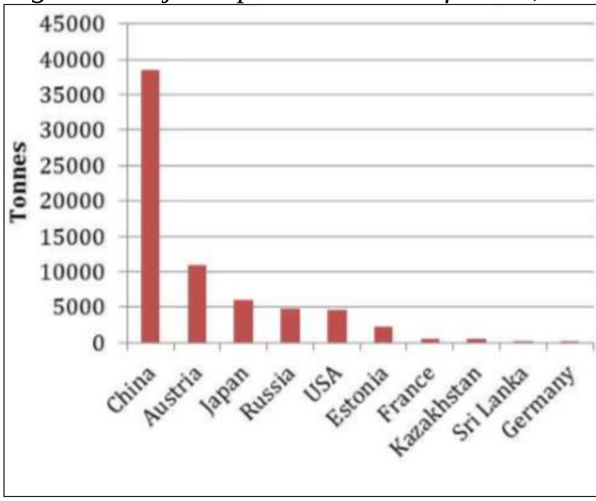
Figure 1. REE production in China, U.S., and ROW

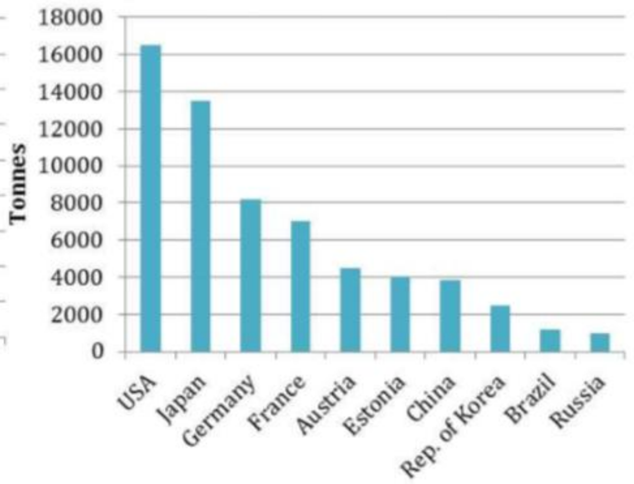


The monopoly-driven scarcity has thus made China the primary existing producer, user, and exporter of REEs. As shown in Figure 3 below, the U.S., Japan, and Germany are the key importer nations of REEs, together using roughly 37,000 tons in 2009, which is roughly equivalent to the tonnage exported by China alone for that same year. The import-dependency for this critical resource is problematic considering how China functions as a country internally and in the global market. China ranks an average score of 35.9/100 on the World Bank's governance scale, which evaluates indicator of voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption.[6] Therefore, reliability on imports is stressed even more by China's current state.

[6] Kaufmann, D., Kraay, A., Mastruzzi, M. The Worldwide Governance Indicators: Methodology and Analytical Issues World Bank: China. (2013).

Figure 2.Major exporter nations of REEs, 2009 *Figure 3.Major importer nations of REEs, 2009*





2.2 No Known Substitute

Secondly, REEs have no known alternative substitutes which ultimately reinforce the power-dependence relationship between China and U.S. There is such great appeal for REEs due to their unparalleled uses in a wide variety of applications that significantly improve energy efficiency.[7] In addition, their high performance levels allow for a reduction in size and weight in many applications, which simultaneously lowers the environmental impact.[8] Today we see many defense systems, mobile devices, and clean technology dependent on REEs, thus translating into the U.S. being dependent on China. For example, rare earths are making our appliances energy efficient through state-of-the-art refrigerators, touch screen thermostats, energy efficient light bulbs, and air conditioning systems.[9] We would not have the advantage of smaller sized technology such as touch-screen phones and laptops without the use of REEs. Much of modern life today, along with the furthering of technology, depends on this critical resource. REEs are

[7] Alonso, Elisa. Evaluating Rare Earth Element Availability: A Case with Revolutionary Demand from Clean Technologies. *Environmental Science and Technology (2012):* 46: 3406-3414.
[8] Habib, Exploring rare earths supply constraints for the emerging clean energy technologies and the role of recycling. 355
[9] Gholz, Eugene. Energy Report: Rare Earth Elements and National Security. *Council on Foreign Relations*. (2014)

key to the emergence of green technology such as the new generation of wind powered turbines, solar cells and plug-in hybrid vehicles.[10]

2.3 Environmental Impact

It is ironic that many green technologies require REEs considering the potential environmental implications of them. It is an energy intensive and polluting process throughout nearly all stages in the production and life of REEs. The U.S. follows strict environmental policies on activities related to mining and processing REEs, whereas China by contrast carries out lax practices that result in a negative environmental impact.[11] This is in fact why the Mountain Pass, California mine was shut down in 1998 in which radioactive water seeped into the surrounding Mojave Desert from an underground pipe, and China then took control of the market.[12] Environmental damage can be looked at from the role that China and the U.S. play as either a producer or consumer in the global market.

Looking at the production and processing component, therefore primarily China's role, any environmental consideration comes with a financial trade off. In an effort to keep their competitive edge, mining companies in China will keep expenses to a minimum instead of channeling money towards environmentally friendly practices. In addition, incentive to meet any type of environmental standard is reduced due to the government owning the land instead of the factories; therefore, producing companies will not invest in machinery or processes that lower damage if it can be easily taken away. The Ministry of Environmental Protection created a standard as of 2009, requiring enterprises to increase investment in protection; however, due to the revenue potential, many REE mines continue to operate illegally, or with little regulation,

[10] Gholz, Energy Report: Rare Earth Elements and National Security.
[11] Hurst, Cindy. The Rare Earth Dilemma: China's Rare Earth Environmental and Safety Nightmare. *The Cutting Edge*. (November 15, 2010).
[12] Stahl, 60 Minutes: Rare Earth Elements: Not So Rare After All.

which in turn has contributed to China's environmental hazards.[13] One of the biggest producers of China's REE supply is the City Bayron, which in Figure 4 and Figure 5 below, shows the mine's growth from 2001 to 2006.[14] The satellite images visually depict vegetation as red, grassland as light brown, rocks as black, and water surfaces as green.

F*igure 4. NASA Satellite Image of Bayon Obo on July 2, 2001*

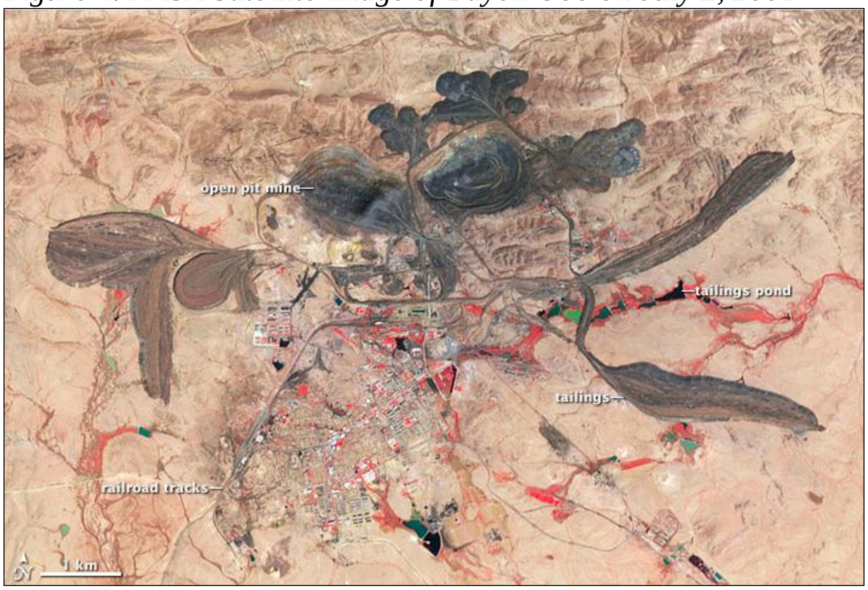
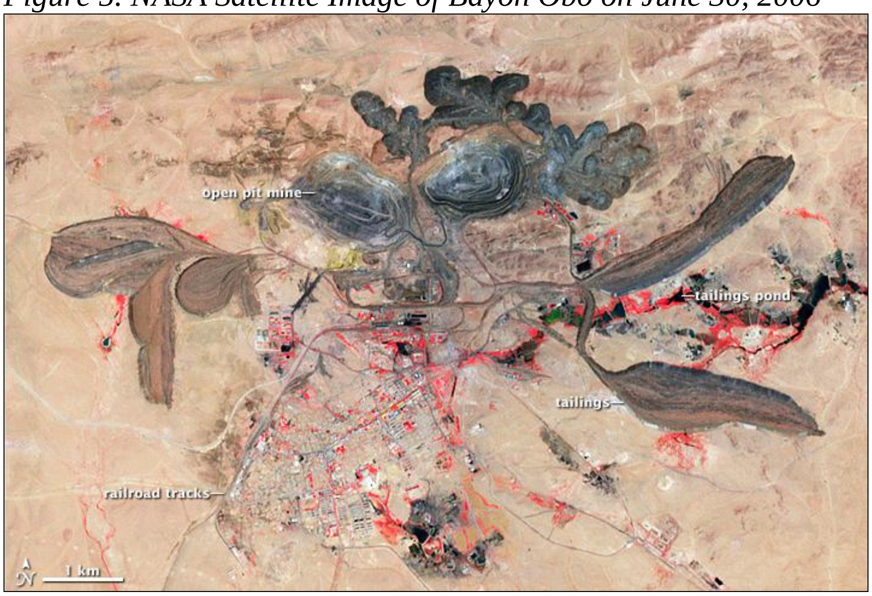


Figure 5. NASA Satellite Image of Bayon Obo on June 30, 2006



[13] Tse, Pui-Kwan. China's Rare Earth Industry. *United States Geological Survey* (2011).
[14] NASA Earth Observatory. Bayan Obo Rare Earth Mines. *NASA* (2001 and 2006).

Such an intensive mining operation has a definite impact on the surrounding environment. According to the Chinese Society of Rare Earths, 60,000 cubic meters of waste gas containing dust, hydrofluoric acid, sulfur dioxide, and sulfuric acid are released with every ton of REEs mined.[15] In addition, 200 cubic meters of acidic wastewater, plus one ton of radioactive waste residue are also produced with one ton.[16] Reagents injected into the ground to extract REEs often contaminate water supplies, making it unusable for drinking or irrigation. In the case of Baotou, one of China's primary rare earth cities, the water pollution poses a serious threat to the Yellow River, the primary source of irrigation and fishing for 150 million downstream users.[17]

2.4 Administrative Difficulties

In the wake of the 2010 episode, the Chinese government discovered how difficult it was to control its domestic suppliers. China's Ministry of Industry and Trade set quotas on the amount of rare earths that can be exported; companies would then try to create loopholes to maximize profits through exportation.[18] For example, since quotas did not apply to alloys, companies would export minimally processed alloys mixed with REEs to get shipments past customs inspectors. In addition, smuggling has posed enforcement difficulties. It is estimated that 20,000 tons of rare earths are smuggled out of China each year, which equates to roughly 50% of legal exports.[19] Japan is predicted to be one of the primary benefactors of illegal trading,

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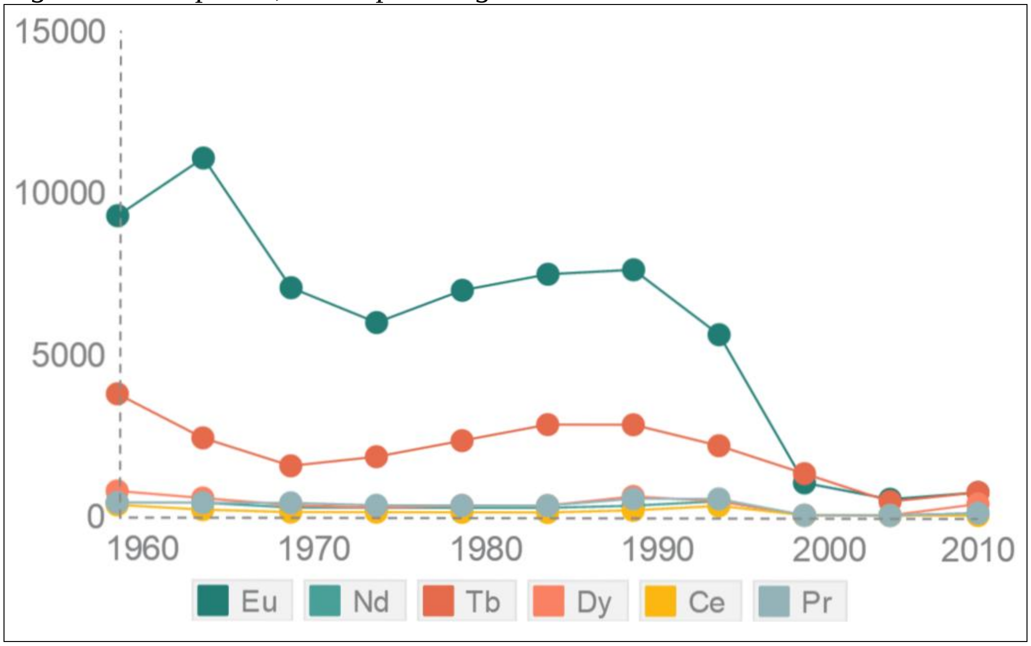
[15] Hurst, Cindy. The Rare Earth Dilemma: China's Rare Earth Environmental and Safety Nightmare. *The Cutting Edge*. (November 15, 2010).
[16] Ibid.
[17] Hurst, Cindy. China's Rare Earth Industry: What Can the West Learn? *Institute for the Analysis of Global Security (2010): 4-6.*
[18] Humphries, Mark. Rare Earth Elements: The Global Supply Chain. *Congressional Research Service*. (2011).
[19] Ting, Ming Hwa and Seaman, John. Rare Earths: Future Elements of Conflict in Asia? *The International Politics-Asian Studies Review*. (2013). 2: 234-252.

obtaining 20% of its rare earth needs from the Chinese black market.[20] Eliminating illegal mining and smuggling practices through administrative processes is fundamental to increasing control over rare earth prices.

3.0 History of Prices

From the late 1950s to the 1970s, prices for REEs declined with the increased supply from the Mountain Pass, California operation. Prices rose during the mid to late 1970s due to a combination of inflation, rising energy costs, and increased demand and stabilized in the 1980s. With the Chinese mines coming into full force during the 1990s, supply quickly outpaced demand, driving prices down significantly. Since REEs cannot be mined individually, over-production of all REEs resulted. Using data provided by the USGS, Figure 6 below provides a visual representation of price trends of six major REEs over the past six decades.[21]

Figure 6. FEE prices, dollar per kilogram



[20] Hurst, China's Rare Earth Industry: What Can the West Learn, 5.
[21] United States Geological Survey. Metal Prices in the United States through 2010: Scientific Investigations Report. *USGS*. (2012).

Since the 2008 global recession, prices again dropped and industries were looking to cut production costs. Prices for most REEs between 2007 and 2009 dropped between 20% and 40%, with terbium (Tb) falling 50% from $750 to $395 per kilogram. By the end of 2011 price instability returned, but this time the average price of rare earths shot up by as much as 750%.[22] This was due to the Chinese government imposing stricter regulations in certain provinces, ultimately slowing down REE supply.[23] Although the price shock faded, the urgency for rare earths still continued.

In 2010, attention regarding the criticalness of REE was brought to the U.S. when there was an incident at sea involving a Chinese fishing boat ramming a Japanese coast guard ship in a territorial dispute.[24] The Japanese seized the captain, and two weeks later China stopped shipping REEs to Japan for 40 days. Although China seemed to earn a victory, it actually achieved very little politically.[25] In addition, this caused prices to go up worldwide as a response.

4.0 Innovation Potential

In the wake of the 2010 rare earth crisis, U.S. government agencies led by the Department of Defense (DOD) and USGS, quietly began to study the risks of dependency on China. As a request by Congress, the Government Accountability Office (GAO) initiated studies that ended up raising concerns regarding potential scenarios. As a result, in 2013, the U.S. Department of Energy (DOE) announced a $120 million grant with the creation of the Critical Materials Institute (CMI), which is designed to find and commercialize ways to reduce the dependence on rare earth metals and other materials critical for U.S. energy security. It would be

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[22] Jones, Nicola. A Scarcity of Rare Metals is Hindering Green Technologies. *Yale Environment 360*. (November 18, 2013).
[23] Jones, A Scarcity of Rare Metals is Hindering Green Technologies.
[24] Bradsher, Keith. *Taking a Risk for Rare Earths,* New York Times (March 8, 2011).
[25] Ibid.

revolutionary to find alternative materials that eliminate the need for so many critical elements, however, challenging since REEs contain unique properties.

Very little of REEs are recycled. In 2011, it was estimated that 3% of REEs were recovered.[26] There is a desperate need to advance recycling technologies for critical resources. Much of which is classified as E-Waste is making its way into landfills, however, similar to extrapolating REEs from rock, it is costly to do so from complex devices.[27] There are some companies, primarily in Europe, that are at the forefront of progressive recycling methods.

More efficient mining processes can increase the recovery of rare earths. One of the current methods for extracting REEs from the ore is through soaking, which allows the minerals to float and can then be skimmed off the surface.[28] The CMI is looking for controlled additives that can better bind molecules to help the REEs afloat and extracted.

It is vital for the U.S. to take a long-term view with the technology it is developing and commercializing. For example, in 1995, China bought the biggest America rare earth magnet company, Manquench, which gave them access to all the patents, equipment, and some employees that were able to teach the Chinese how to make the products.[29] At the time, the U.S. did not understand the strategic importance of keeping that technology in-country. The technology was transferred to China before it was appreciated in the U.S.

5.0 Policy Moving Forward

There requires a furthering of multilateral negotiations on an international level to promote the development of the REE industry. In order to advance a global market in a direction

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[26] Environmental Protection Agency. Rare Earth Elements: A Review of Production, Processing, Recycling, and Associated Environmental Issues. *EPA.* (2012).
[27] Goonan, Thomas. Rare Earth Elements-End Use and Recyclability: Scientific Investigations Report. *United States Geological Survey* (2011).
[28] Ibid.
[29] Humphries, Rare Earth Elements: The Global Supply Chain.

of better trading opportunity, it is vital to transition away from the near-monopoly scenario China currently has over rare earths.

5.1 The Economic Rationale

In the effort to expand non-Chinese supplies, policy needs to take on a view of supply and demand. There is a growing interest among the ROW. Investors in the United States, Japan, and Australia began opening mines and building new processing plants in 2010. By 2013, Molycorp in the U.S. as well as Lynas in Australia and Malaysia started delivering non-Chinese rare earths to global market.[30] As of 2011, $960 million has been invested from enterprises in the U.S. Germany, France, Japan, and a Canada into the rare earth industry.[31] However, production capacity is still limited and market prices must dictate any further expansion. Although supply led by Molycorp and Lynas has helped alleviate overdependence in China, REEs still remain critical and China is still heavily relied upon.

The U.S. government currently provides minimal help when it comes to promoting investment. Incentives such as subsidies and tax breaks that can lure businesses into the market do not exist.[32] China on the other hand can move forward through programs that crack down on illegal mining and smuggling activity in an effort to increase control of prices. A fairly new policy framework offers some progress as it allows rewards up to 3,000 Yuan for individuals who provide information on illegal activity.[33] Between 2006 and 2011, the number of domestic rare earth producers and traders authorized to export REE products decreased from 47 to 22

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[30] Humphries, Rare Earth Elements: The Global Supply Chain.
[31] United Nations Conference on Trade and Development. Commodities at a Glance: Special issue on rare earths. *UNCTD* (2014).
[32] Stahl, 60 Minutes: Rare Earth Elements: Not So Rare After All.
[33] Ibid. Humphries.

producers.[34] When looking at the demand side of things, downstream markets are already adjusting to the ever changing supply picture. To bring change to the industry, the U.S. needs to take a long term view.

5.2 The Environmental Rationale

It is vital for international law and policy to take into account the consequences of a solution while looking through a green lens. Since there are environmental concerns not only throughout the process of mining, refining, and processing, but also among applications and disposal of REE produced products, it is important for countries to take protective measure against any pollution created during the REE life cycle and ultimately hold responsibility. The U.S. demand for rare earths that are primarily supplied by China play a crucial role in the global market. It only makes sense that the U.S. plays an equivalent role in mitigating the environmental effects for which it is both directly and indirectly responsible throughout the REE life cycle.[35] Policy has the power to create incentives to prompt environmentally responsible practices. This can thus prevent a "race to the bottom" by governments willing to mine, process, and dispose of toxic materials.[36]

Although the environmental impacts are clear, as previously stated in Section 2.3, the ROW has strong incentive to downplay any environmental motivations from China. As stated by former American trade official, Alan Wolff, "A panel would emphasize with a genuine environmental objective, but I do not think it would sympathize with cutting off supply disproportionately to foreign users in the name of saving the environment."[37] Looking at a

[34] Ibid. UNCTD.
[35] Kirby, David. Made in China: Our Toxic Imported Air Pollution. *Discover*. (2011).
[36] Winfield, Wilson. The Lurking Costs of Green Technology Metals in a Global Market. *Sustainable Development Law and Policy* (2011): 11.
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multilateral agreement though an environmental lens, it will allow for the integration of oversight on an international level and regulation of the market's supply and demand of REEs. Ultimately, this will keep the environmental impact in check with other multilateral environmental agreements.[38]

5.3 The Social Rationale

REE exploitation in China has shown social and health-related effects. The number of people suffering black lung and pneumoconiosis in Baotou was 5,387 people as of 2011. Occupational poisoning from lead, mercury, benzene, and phosphorus also plague the region. Many health and safety risks are worsened by the Baotou Steel Corporation, the fifth largest steel producer in China, which sees rare earths as an economically irrelevant set of by-products due to their small market size of $ billion, which compares to that or iron ore valued at $962 billion.[39]

Entire villages along the Yellow River that are downstream of Baotou have had to relocate. There are estimated to be more than 450 cancer village in China that are a result of similar environmentally hazardous practices like that of REE processing.[40] A rise in social upheaval occurred in July of 2012 when rural workers protested against the mass amount of environmental pollution in Sichuan, a city of heavy rare earth mining, which then led to the ultimate cancellation of the proposed refinery plant.[41] Policy moving forward for such an environmentally-related issue must have the public in mind given the number of complains to the environmental authority in China as increased 30% per year since 2002, while the number of mass protests has grown annually.[42]

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[38] Ibid, Winfield.
[39] Lee, L. Made in China: Cancer Villages. *Environment* (2010).
[40] Ibid. Lee.
[41] Economist Beijing. Environmental Activism in China. *The Economist*. (July 7, 2012).
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6.0 Conclusion

Rare earths remain a material of interest that should be approached with urgency. The unparallel qualities of REEs make it a vital resource for the advancement of green technologies. Alleviating issues surrounding REEs such as scarcity, resource substitution, environmental impact, and administrative difficulties can be tackled across the entire supply-chain. The power dependent relationship China and the U.S. current has can be approached with domestic opportunities that invite businesses in order to disperse supply and demand globally and thus slowly deteriorate the current monopoly China has over the rest of the world.

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U.S. DEPARTMENT OF ENERGY
Washington, D.C.

June 12, 2015

MEMORANDUM

To: Dr. Elizabeth Sherwood-Randall, Deputy Secretary
From: Gabrielle Amar, Critical Materials Institute Task Force
Topic: WTO Negotiations - U.S. Quota Response

The following memorandum outlines information regarding rare earth elements (REEs) in preparation for negotiations held by the World Trade Organization (WTO), and their major uses as they relate to the U.S. energy strategy. Challenges regarding the quota system leave the U.S. with other policy routes to alleviate market issues in the long term.

China's Quota System

In 1992, the former Chinese president, Deng Xiaoping declared rare earths to be a protected and strategic mineral on behalf of the Chinese government. As a result of this declaration, foreign investors became prohibited from mining REE and are restricted from participating in REE processing-related projects except in joint ventures with Chinese firms.

China's Ministry of Industry and Trade has been responsible for developing plans for meeting production quotas, as well as quotas for individual provinces. Provinces are responsible for managing their allocated quotas and assigning output quotas from individual mining companies. Over-quota production came from miners who worked without proper mining licenses and who used outdated mining technology that caused significant environmental damage (i.e. Guangdong, Jiangxi, and Sichuan).

As of right now China is exporting roughly 40,000 tons of REEs annually, which is almost equivalent to the demand together from U.S., Japan, and Germany annual imports. In 2010, China's Ministry of Industry and Trade set quotas on the amount of rare earths that can be exported; however, companies would try to create loopholes to maximize profits through exportation. For example, since quotas did not apply to alloys, companies would export

minimally processed alloys mixed with REEs to get shipments past customs inspectors. In addition, smuggling has posed enforcement difficulties.

It is estimated that 20,000 tons of rare earths are smuggled out of China each year, which equates to roughly 50% of legal exports previously mentioned. Japan is predicted to be one of the primary benefactors of illegal trading, obtaining 20% of its rare earth needs from the Chinese black market.

Major End Uses and Applications

REEs have unparalleled electrical, magnetic, optical, and catalytic applications that significantly improve energy efficiency. Their high performance levels allow for a reduction in size and weight in many applications, which simultaneously lowers the environmental impact. REEs are found in energy efficient appliances such as state-of-the-art refrigerators, touch screen thermostats, energy efficient light bulbs, and air conditioning systems. In addition, REEs are vital to wind turbines, solar cells, and electric vehicles. For example, 25 pounds of REEs are required for a hybrid vehicle.

Selected Possible Policy Options

The following are proposed methods that the U.S. government can take to alleviate the current quota system:

- *Research and Development* - $120 million for granted to the Critical Materials Institute (CMI), with further funding having potential for renewal in 2015. The objective of CMI is to find and commercialize ways to reduce the dependence on rare earth metals and other materials critical for U.S. energy security.
- *Authorize and Appropriate Funding for USGS Assessment* - Further research can support and encourage greater REE exploration. There is potential in domestic rare earth mines with market opportunities.
- *Establish a Stockpile* - Current stockpiles approved by the U.S. Pentagon located in Montana have stockpiles containing a substantial amount of rare earths enriched material, with high percentages of both heavy and critical rare earth element
- *Support Domestic Businesses* - Incentives such as subsidies and tax breaks that can lure businesses into the market instead of having U.S. market opportunities taken overseas.