LITHIUM AND RARE EARTH ELEMENTS: THE DIRTY BUSINESS OF CLEAN ENERGY

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ABSTRACT

The technological advancement of the modern era is not only impressive but also unbelievable. Today's engineers and innovators have created electric and hybrid vehicles, harnessed the power of wind for energy, and continued to amaze with the incredible rate of ingenuity. While these innovations have countless positive impacts, they are not without cost. Two extremely controversial sources are used to create these modern technologies: lithium and rare earth elements. As engineers are praised for creating lithium-ion batteries for electric vehicles or more efficient gearless wind turbines by using these materials, the world ignores the environmental, geopolitical, and social costs associated with their extraction and production. The mining of lithium in Bolivia has prolonged the exploitation synonymous with this nation's colonized history. In China, where ninety-seven percent of rare earth elements are mined, environmental destruction, illegal mining, and rare earth trading run by gangsters has plagued the country's poorest citizens. Although the world has come to rely on these sources to advance, the lack of transparency and oversight has led to ignorance regarding their damage. In order to truly embrace the modern world, the public must demand the sustainable production of the technologies upon which it relies.

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INTRODUCTION

"We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology."[1]

Within the last decade, the global community has demonstrated a desire to replace environmentally damaging fossil fuels with cleaner, renewable energy sources.[2] It is inarguable that the underlying reason for this shift is the global recognition of climate change. As governments in the developed world seek to reduce their dependence on imported oil, lithium and rare earth elements have become major resources for the battery-powered automobiles. Lithium and rare earths are also contained in wind turbines, laptops, cell phones, and almost every other modern electronic device. While the use of these materials appears to be the greener alternative, their extraction, production and eventual disposal represent complex issues transcending international boundaries. Almost half of the world's lithium is found in the Salar de Uyuni of Bolivia, a country that has experienced 500 years of resource exploitation by foreign governments.[3] In the modern era, the exploitation continues with transnational corporations, which often "[flaunt] environmental concerns and labor protections while employing the poor and indigenous who have little other choice than to pillage and lay waste to their own land in an attempt to maintain their impoverished existence."[4]

Similarly, China maintains dominance over the production and extraction of rare earth elements. However, ignorance of the environmental destruction caused by rare earth mines has resulted in the pollution of local water sources, thereby destroying local farms. Villagers in

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[1] Carl Sagan, *Why We Need To Understand Science*, 14.3 SKEPTICAL INQUIRER,(1990), *available at* http://www.csicop.org/si/show/why_we_need_to_understand_science.
[2] Andrew W. Eichner, *More Precious Than Gold: Limited Access to Rare Elements and Implications for Clean Energy in the United States*, U. ILL. J.L. TECH. & POL'Y 257, 258 (2012).
[3] *Id.* at 324.
[4] *Id.* at 326.

China's prime mining areas have developed cancer and other illnesses from exposure to the acidic byproducts of rare earth mining. Small villages are abandoned when the rare earth supply is exhausted and the villagers are left hopeless in the wake of the damage. Local gangsters, whose illegally operated mines continue to flourish freely without regulation by the Chinese government, also terrorize villagers. Although commended as the basis for the green technology of the future, lithium and rare earth elements pose significant environmental, geopolitical, and social issues. These significant costs leave one lingering question: are these materials the answer?

The first section of this article discusses national efforts to implement clean energy with specific examples of energy policies adopted by the United States and the European Union. Part II addresses the arguments in favor of lithium and rare earth elements as viable substances used to create renewable energies and explains the global locations, extraction, and production. Transnational corporations' exploitation of lithium resources in Bolivia is detailed in part III. Part IV references China's experience with mining rare earth metals. Finally, part V contains recommendations regarding the environmental, geopolitical, and human rights concerns surrounding lithium and rare earth elements, specifically including the implementation of sustainable extraction and production methods, greater transparency in the international trade of rare earth elements, and the operation of recycling plans for used lithium-ion batteries.

I. The Shift Toward Clean Energy

Within the last decade, the recognition of climate change and a shift toward cleaner energy has been the focus of many developed countries' environmental policies, most notably the United States and the states comprising the European Union. In June 2013, President Barack Obama of the United States issued his Climate Action Plan, which echoes the "moral obligation

to future generations to leave them a planet that is not polluted and damaged."[5] The plan seeks to address the threat of climate change and reiterates a previous promise made by President Obama in 2009 to reduce greenhouse gas emissions in the United States to the range of seventeen percent below 2005 levels by the year 2020.[6] The United States intends to lead the international effort in combatting climate change by "deploying clean energy" and "promoting American leadership in renewable energy."[7] In regards to the transportation sector, the Obama Administration emphasized the importance of partnering with the private sector to employ such cleaner fuel sources as advanced batteries and fuel cell technologies.[8]

Similarly, the European Union has set goals to reduce greenhouse gas emissions by twenty percent from 1990 levels by 2020.[9] A noteworthy aspect of the European Union's plan includes a cap and trade system, which limits the total amount of certain greenhouse gases that can be emitted by the factories, power plants, and other installations in the system.[10] Citing road transport as one-fifth of the EU's total emissions of carbon dioxide, the European Union sought to set mandatory emission reduction targets for new cars.[11] In 2009, the European Commission codified its intent to reduce carbon dioxide emissions from vehicles via Regulation No. 443/2009.[12]

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[5] EXEC. OFFICE OF THE PRESIDENT, THE PRESIDENT'S CLIMATE ACTION PLAN 4 (June 2013), *available at* http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.
[6] *Id.*
[7] *Id.* at 6.
[8] *Id.* at 8.
[9] *2020 Climate & Energy Package,* EUROPEAN COMMISSION (July 8, 2015), http://ec.europa.eu/clima/policies/strategies/2020/index_en.htm.
[10] *EU Emissions Trading System (EU ETS)*, EUROPEAN COMMISSION (July 8, 2015), http://ec.europa.eu/clima/policies/ets/index_en.htm.
[11] *Road Transport: Reducing CO2 Emissions from Vehicles*, EUROPEAN COMMISSION (July 8, 2015), http://ec.europa.eu/clima/policies/transport/vehicles/index_en.htm.
[12] Council Regulation 443/2009 on Emission Performance Standards, 2009 O.J. L 140, *available at* http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009R0443-20130508&from=EN.

Both the European Union and the United States emphasize the need for global dialogue and cooperation in order to effectively pursue alternative energy. The President's Climate Action Plan acknowledges the need to address clean energy on an international level with specific reference to President Obama's initiation of the Major Economies Forum on Energy and Climate, a multinational forum that brings together the seventeen countries that represent seventy-five percent of global greenhouse gas emissions.[13] Furthermore, both the European Union and the United States note the importance of working with developing or emerging economies to maintain global commitment to tackling climate change.[14]

The policies of the European Union and the United States echo the sentiments of the international community. The United Nations Summit on Climate Change in New York in September 2014 signified the global agreement to "galvanize and catalyze climate action."[15] One of the most notable achievements of the Summit includes the pledge by many developed countries to help developing countries adopt clean energy and reduce greenhouse gas emissions.[16] The most recent United Nations Conference in Lima in early December 2014 further set negotiations for an international agreement on climate change expected to occur during the United Nations Climate Change Conference in Paris in late 2015.[17] During the Lima Conference, over 190 nations proposed the elements of the forthcoming Paris agreement and set the ground

[13] EXEC. OFFICE OF THE PRESIDENT, *supra* note 5, at 17.
[14] *Id.*
[15] *UN Climate Summit 2014*, UNITED NATIONS (Sept. 23, 2014), http://www.un.org/climatechange/summit/.
[16] Elizabeth Shogren, *3 Key Takeaways From This Week's UN Climate Summit*, NATIONAL GEOGRAPHIC (Sept. 24, 2014, 4:02 PM), http://news.nationalgeographic.com/news/2014/09/140924-united-nations-climate-change-summit-world/.
[17] *Lima Call for Climate Action Puts World on Track to Paris 2015*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, (Dec. 14, 2014), http://newsroom.unfccc.int/lima/lima-call-for-climate-action-puts-world-on-track-to-paris-2015/ [hereinafter *Lima Call for Climate Action*].

rules for the submission of contributions by individual nations.[18] Important outcomes of the Lima Conference included pledges by both developed and developing countries of over $10 billion to the Green Climate Fund, which will provide the necessary endowment required to combat climate change at the international level.[19] An additional outcome was the Lima Ministerial Declaration on Education and Awareness-raising, which calls on governments to integrate climate change issues into school curricula and climate awareness into national development plans.[20] The Lima Conference also acknowledged the need for more countries to accept the Kyoto Protocol Doha Amendment, the international emissions reduction treaty, "in order to provide further momentum for global climate action for the years leading up to 2020."[21] At the time of the Lima Conference, only twenty-one parties had officially accepted the amendment, while 144 parties were required to bring it into force.[22] Finally, the secretariat organized a fair to showcase how nations are taking action against climate change through the implementation of renewable energies and sustainable land use.[23] Although the Lima Conference has been criticized for providing only guidance and not requirements for participating nations, it "represents a fundamental breakthrough in the shape of the global climate regime" and paves the path toward an agreement at the Paris Conference.[24]

II. LITHIUM AND RARE EARTH ELEMENTS IN RENEWABLE ENERGIES: EXTRACTION, PRODUCTION, AND JUSTIFICATIONS

[18] *Id.*
[19] *Id.*; *see also Background*, GREEN CLIMATE FUND, http://www.gcfund.org/about/the-fund.html (last visited Jan. 3, 2015).
[20] *Lima Call for Climate Action*, *supra* note 17.
[21] *Id.*
[22] *Id.*
[23] *Id.*
[24] Michael Jacobs, *Lima Deal Represents a Fundamental Change in Global Climate Regime*, THE GUARDIAN (Dec. 15, 2014, 10:28 AM), http://www.theguardian.com/environment/2014/dec/15/lima-deal-represents-a-fundamental-change-in-global-climate-regime.

Lithium is one of a group of elements called "alkali metals," which are known for being highly reactive.[25] The high level of reactivity can be apparent when alkali metals are exposed to water, which releases heat via an exothermic reaction.[26] Because of its high reactivity, lithium does not occur as a free metal in nature; however, it is found in several large mineral and brine deposits throughout the world.[27] The brine deposits containing lithium are essentially a combination of salt water and varying amounts of dissolved solids.[28] Some of the largest commercially viable brine reserves with actual operations include the Salar de Atacama in Chile, the Salar de Hombre Muerto in Argentina, and Clayton Valley in the United States.[29] After the lithium in these areas has been mined from hard rock or evaporated from brine reserves, a chemical process is applied to process the lithium into a usable form.[30] The world's largest, yet untapped, source of lithium is found in Bolivia's Salar de Uyuni salt flats, which contains an estimated 5.4 of the total 11 million tons of the world's lithium supply.[31]

Because lithium is often combined with rare earth elements for the production of renewable energy sources, such as lithium-ion batteries, the two resources must be discussed together. Rare earth elements are a group of seventeen elements that occur together on the periodic table of elements.[32] The elements are often referred to as "rare earth metals" and are found in an endless list of products including hybrid car batteries, wind turbines, magnets, and a

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[25] Mark Winter, *Lithium: The Essentials*, WEBELEMENTS, http://www.webelements.com/lithium/ (last visited on Jan. 3, 2015).
[26] *Periodic Table: Lithium*, ROYAL SOCIETY OF CHEMISTRY, http://www.rsc.org/periodic-table/element/3/lithium (last visited on Jan. 3, 2015).
[27] *Id.*; *see also* DONALD E. GARRETT, HANDBOOK OF LITHIUM AND NATURAL CALCIUM CHLORIDE 1 (2004).
[28] Erica Gies, *Lithium Producer Chases Tesla's Bold Battery Plan*, N.Y. TIMES, Mar. 16, 2014, http://www.nytimes.com/2014/03/17/business/energy-environment/lithium-producer-chases-teslas-bold-battery-plan.html.
[29] Garrett, *supra* note 27, at 5.
[30] Gies, *supra* note 28.
[31] Anna Hooper, *Recharging Bolivia: Evo Morales' Lithium Dilemma*, 31 HARV. INT'L REV. 9, 9 (2009).
[32] *REE – Rare Earth Elements and Their Uses*, GEOLOGY.COM, http://geology.com/articles/rare-earth-elements/ (last visited Jan. 3, 2015) [hereinafter *REE*].

variety of weapons used by the United States military.[33] They are grouped together on the periodic table because of their chemical similarities; however, each element has starkly different electro-magnetic and optical uses that determine its application to the previously mentioned technologies.[34] For example, the element europium is used in the printing of euro bills in the European Union to deter forgery.[35] When placed under an ultraviolet light, a constellation of blue stars made from europium appears on authentic currency.[36] The most common uses for rare earths are based on their incredible magnetic properties.[37] A magnet made with the element neodymium is ten times as powerful as an iron magnet and can hold up to 1,000 times its own weight.[38] Magnets made from rare earths are essential to laptop hard drives and speakers in cellular phones.[39] Wind turbines similarly rely on the magnetic properties of rare earth elements.[40] Traditionally, wind turbines required huge and mechanically complex gears.[41] However, the complexity of the gears became very expensive in the event of a mechanical failure, so the industry sought to eradicate the use of gears by exploiting the magnetic properties of rare earth elements.[42] Instead of cumbersome mechanical gears, modern wind turbines use a core containing neodymium magnets laced with another rare earth element, dysprosium.[43] The magnets create an electric current by induction when the electrons are moved by the magnetic

[33] Tim Folger, *Rare Earth Elements*, NATIONAL GEOGRAPHIC, June 2011, http://ngm.nationalgeographic.com/2011/06/rare-earth-elements/folger-text/1.
[34] Justin Rowlatt, *Rare Earths, Neither Rare, Nor Earths*, BBC NEWS (Mar. 22, 2014), http://www.bbc.com/news/magazine-26687605.
[35] *Id.*
[36] *Id.*
[37] *Id.*
[38] *Id.*
[39] *Id.*
[40] *Id.*
[41] *Id.*
[42] *Id.*
[43] *Id.*

power of the rare earths.[44] Because of their strength, rare earth magnets generate power at lower speeds and therefore provide a more reliable and less burdensome machine.[45]

These metals are not literally rare; in fact, they have abundance in the Earth's crust that is almost 200 times that of gold.[46] They are rare because of these elements are not found together in high concentrations; therefore, mining is difficult.[47] China is the largest producer of rare earth elements, supplying an estimated ninety-seven percent of the world's rare earth needs.[48] In regards to the automotive industry, Ford Motor Company reports that hybrid electric vehicles with lithium-ion batteries contain about one kilogram of rare earth elements.[49] The automotive industry has proclaimed lithium-ion batteries to be the cleaner alternative to fossil fuel due to the complete eradication of carbon dioxide emissions.[50] In addition to its obvious advantage over fossil fuels, lithium batteries can be recharged safely and efficiently without the release of hydrogen gas, which is a dangerous byproduct of alkaline batteries.[51] Lithium is extremely conductive, which also means it has very high electrical power.[52] As a result, lithium batteries produced for vehicles have significant power. For example, the Model S, manufactured by Tesla

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[44] *Id.*
[45] *Id.*
[46] *REE*, *supra* note 32.
[47] *Id.*
[48] Folger, *supra* note 33.
[49] *Rare Earth Elements*, FORD MOTOR CO., http://corporate.ford.com/microsites/sustainability-report-2012-13/supply-materials-elements.html (last visited Jan. 3, 2015).
[50] *See generally Zero Emission*, NISSAN MOTOR CORP., http://www.nissan-global.com/EN/ZEROEMISSION/ (last visited Jan. 3, 2015); *Model S*, TESLA MOTORS, http://www.teslamotors.com/models (last visited Jan. 3, 2015); *Developing Batteries for EVs and Future Societies*, MITSUBISHI CORP., http://www.mitsubishicorp.com/jp/en/mclibrary/business/vol1/ (last visited Jan. 3, 2015).
[51] Brian Palmer, *Troves of Lithium, Valuable for Batteries, Boost Mood in Bolivia and Afghanistan*, THE WASHINGTON POST (Aug. 31, 2010), http://www.washingtonpost.com/wp-dyn/content/article/2010/08/30/AR2010083003937.html.
[52] Peter Braun, *Don't Look so Smug: Your Tesla Might be Worse for the Environment than a Gas Car*, DIGITAL TRENDS (Nov. 13, 2013), http://www.digitaltrends.com/cars/hold-smugness-tesla-might-just-worse-environment-know/.

Motors, Inc., boasts up to 275 miles of driving on a single charge.[53] Finally, lithium batteries are praised for their future potential, specifically in regards to new developments in battery chemistry and experimentation with lithium-air batteries.[54]

III. CONTINUOUS EXPLOITATION: THE BOLIVIAN EXPERIENCE

Although Bolivia contains the world's largest lithium reserves, it is one of the poorest nations in South America.[55] Due to poor resources and a lack of infrastructure, this nation is unable to take advantage of its own wealth of natural resources located in the remote area of Salar de Uyuni.[56] Even with transnational corporations from France, South Korea, and Japan lining up to invest in Bolivia's lithium, the administration of President Evo Morales has nationalized much of its natural resource industry, thus preventing many foreign companies from investing in Bolivia.[57] Although President Morales has been heavily criticized for closing the doors to Bolivia, the justifications for nationalization are based on a long history of exploitation.[58]

The exploitation of Bolivia dates to its colonization by the Spanish during the sixteenth century.[59] During the colonial period, the Spanish stripped Bolivia of its richness in natural metals such as gold, silver, tin, cadmium, tungsten, iron, lead and antimony.[60] Hardly any of the profits from the extraction of these resources went to the Bolivian people but instead "lined the

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[53] TESLA MOTORS, *supra* note 50.
[54] Andrew W. Eichner, *More Precious Than Gold*: *Limited Access to Rare Elements and Implications for Clean Energy in the United States*, 2012 U. ILL. J.L. TECH. & POL'Y 257*,* 264 (2012).
[55] Alexander S. Farr, Comment, *Bolivia, Batteries, and Bureaucracy,* 17 L. & BUS. REV. AM. 319, 321 (2011).
[56] *Id.* at 322.
[57] Andres Schipani, *Bolivia: the Saudi Arabia of Lithium?*, THE FINANCIAL TIMES (Jan. 7, 2013, 7:27 PM), http://blogs.ft.com/beyond-brics/2013/01/07/bolivia-the-saudi-arabia-of-lithium/.
[58] Farr, *supra* note 55, at 324.
[59] *Id.*
[60] *Id.*

pockets of imperialist Spain for 250 years."[61] The social effects of this exploitation were extreme, including a forced labor system comprising of the indigenous population.[62] The harsh conditions of the mines, specifically in Cerro Rico and Potosi, led to the deaths of "millions of indigenous people who died extracting ore for their colonial masters."[63]

Although the Bolivian people eventually gained independence from the Spanish, they fell to further exploitation by transnational corporations who hoped to take advantage of the newly independent Bolivians and become wealthy from the country's natural resources.[64] Since such corporations were engaged in extractive industries, they brought little development or improvement to the Bolivian people, specifically the native populations.[65] Transnational corporations thrive in poor countries like Bolivia because they have the power to provide industry, foreign exchange and jobs.[66] The incredible bargaining power of transnational corporations leads governments in targeted areas such as Latin America, Asia and Africa to open their doors and ignore the abuses that stem from having these operations.[67] The governments of developing countries are unable to prevent or punish human rights abuses and environmental degradation and instead often "[facilitate] or [collaborate] in the violations."[68]

The contamination of the Desaguadero water system presents a stark example of the desire of governments in the developing world to remain appealing to transnational

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[61] *Id.*
[62] *Id.*
[63] COLONIALISM: AN INTERNATIONAL SOCIAL, CULTURAL, AND POLITICAL ENCYCLOPEDIA 485 (Melvin E. Page ed., 2003).
[64] Farr, *supra* note 55, at 325.
[65] *Id.*
[66] *Id*.
[67] *Id.*
[68] Maria McFarland Sánchez-Moreno & Tracy Higgins, *No Recourse: Transnational Corporations and the Protection of Economic, Social, and Cultural Rights in Bolivia*, 27 FORDHAM INT'L L.J. 1663, 1668 (2004).

corporations.[69] The Bolivian communities dependent on this water system complained as early as the 1980s that the Desaguadero River had become contaminated, most likely because of environmentally irresponsible mining.[70] Non-governmental organizations conducted environmental studies and confirmed that cyanide and high levels of heavy metals contaminated the water source, thus making it inadequate for consumption.[71] The company attributable to the contamination was Empresa Minera Inti Raymi S.A., a Bolivian mining company whose majority shareholder is Newmont Mining Corporation, a transnational corporation headquartered in Denver, Colorado.[72] To make matters worse, in January 2000, a massive oil spill originated from a pipeline owned by Transredes, S.A., a transnational corporation jointly owned by Shell and Enron.[73] An estimated 29,000 barrels of oil spilled into the Desaguadero River; however, "the Bolivian government did virtually nothing in the immediate post-spill period to minimize damage or to protect the interests of the affected communities."[74] As a result, the spill was a clear indicator of the Bolivian government's desire to protect the transnational corporations at the expense of its citizens.

During the last decade, the Bolivian government sought to nationalize its resource sectors, most likely with its history of exploitation in mind. In 2006, Bolivia nationalized hydrocarbons and "required the major oil companies operating in Bolivia (Petrobrás, Repsol, and Total) to relinquish control of their field operations to the country's national oil company, [Yacimientos Petrolíferos Fiscales Bolivianos], and to sustain an increase in taxes on their profits

[69] *Id*. at 1680.
[70] *Id.*
[71] *Id.*
[72] *Id.*
[73] *Id.*
[74] *Id.* at 1681.

to a total of eighty-two percent or to leave the country."[75] Morales's strong stance against transnational corporations and his aggressive assertion over hydrocarbons infiltrated the lithium sector as well. [76] A Bolivian-owned and controlled lithium industry could lead to the economic advancement the country always had the power to create.[77] The current administration of President Evo Morales is "determined to avoid the history of raw material exploitation" when it comes to Bolivia's lithium resources.[78] In 2008, Morales broke ground on a lithium processing plant, with the hope of making batteries in the next year.[79] The Morales administration tapped the mining company Comibol to run the $5.7 million state-owned plant, which represents "a clear intention by the Bolivian Government to nationalize the entire mining industry."[80] Despite President Morales's intentions to make the Bolivian people "the primary beneficiaries of their country's resource wealth," the total lack of a developed infrastructure requires foreign investors to aid in the development of a successful lithium industry.[81]

While the Bolivian lithium industry represents hope for this perpetually exploited nation, it is likely that lithium production will greatly interfere with the fragile ecosystem of the Salar.[82] Bolivia will use brine bed and evaporation ponds, and then re-inject the remaining salt to extract the lithium.[83] This method increases the salinity of the rivers, which the local people in this region use to irrigate their farms.[84] Further environmental concern exists over the processing of

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[75] Farr, *supra* note 55, at 327.
[76] *Id.*
[77] *Id.*
[78] Nancy Postero, *Protecting Mother Earth in Bolivia: Discourse and Deeds in the Morales Administration*, *in* AMAZONIA: ENVIRONMENT AND THE LAW IN AMAZONIA 78, 83 (James M. Cooper & Christine Hunefeldt eds., 2013).
[79] *Id.*
[80] MERIDIAN INT'L RESEARCH, THE TROUBLE WITH LITHIUM 2 (May 29, 2008), *available at* http://www.meridian-int-res.com/Projects/Lithium_Microscope.pdf.
[81] Farr, *supra* note 55, at 328.
[82] Postero, *supra* note 78, at 83, 84.
[83] *Id.* at 84.
[84] *Id.*

lithium, which is most commonly done by mixing magnesium with the lithium and could lead to further contamination.[85] Finally, environmentalists have raised concerns about the unintentional combination of lithium with water, which results in highly corrosive lithium hydroxide.[86] This combination could likely result during the rainy season, when the Salar often floods.[87] The fragile character of the Salar de Uyuni further exacerbates the environmental concerns of lithium extraction in Bolivia.[88] The Salar is recognized as a natural wonder of the world and "to extract enough Lithium to meet even ten percent of global automotive demand would cause irreversible and widespread damage to these environments, that have taken millennia to form."[89]

IV. ENVIRONMENTAL DAMAGE AND ILLEGAL MINES: THE CHINESE EXPERIENCE

Many green energy alternatives such as electric cars, energy efficient light bulbs, and wind turbines are made with rare earth elements and the world's dependence on these materials is rising quickly.[90] China's undoubted monopoly over these resources represents a significant problem since the rare earths are extracted "from some of the most environmentally damaging mines in the country, in an industry dominated by criminal gangs."[91] China's current dominance over the production of rare earth elements coincided with the push for technological innovations, beginning in the 1980s.[92] A global demand for rare earth elements has risen dramatically and simultaneously with the development of new technologies that rely on these materials.[93] During

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[85] *Id.*
[86] *Id.*
[87] *Id.*
[88] MERIDIAN INT'L RESEARCH, *supra* note 80, at 52.
[89] *Id.*
[90] Keith Bradsher, *Earth-Friendly Elements, Mined Destructively*, N.Y. TIMES, Dec. 25, 2009, http://www.nytimes.com/2009/12/26/business/global/26rare.html?pagewanted=1&adxnnl=1&adxnnlx=1416013937-xeBoKGjxeq5UYYq06Dq2Ew.
[91] *Id.*
[92] Ruth Jebe, Don Mayer & Yong-Shik Lee, *China's Export Restrictions of Raw Materials and Rare Earths: A New Balance Between Free Trade and Environmental Protection?*, 44 GEO. WASH. INT'L L. REV. 579, 586-587 (2012).
[93] *Id.* at 586.

this time, China focused its efforts on improving techniques for rare earth production and the Chinese government regulated the industry by prohibiting foreign investors from mining unless in a joint venture with Chinese companies.[94] In the 1990s, the high profitability of rare earths attracted start-up enterprises in China, which resulted in competition and oversupply that pushed the price of rare earths down while the number of rare earth exports increased.[95] Thus, many mines outside of China closed due to the inability to compete with China's low prices.[96] China's dominance continued to grow as it reinvested in better extraction and refining technologies.[97]

The primary method used to extract rare earth elements is the situ mining technique.[98] Ore, or rocks that contain concentrations of the rare earth elements, is first extracted from open pit mines.[99] Holes are then drilled into the ore deposit and a chemical substance, usually ammonium sulfate, leaches or drains through the rock before it is collected through holes drilled at a lower level of the deposit.[100] An estimated ninety percent of rare earths are extracted by leaching the ore with an ammonium or salt-based solution.[101] Although this method is common in rare earth extraction, each rare earth element has "its own unique properties . . . [and] its own unique separation process."[102] After the completion of the separation process, the newly separated elements are dried and processed into metals and alloys.[103] This in situ mining process is considered beneficial because of the ability to leave the ore in the ground, thereby cutting

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[94] PUI-KWAN TSE, U.S. DEP'T OF THE INTERIOR & U.S. GEOLOGICAL SURVEY, CHINA'S RARE EARTH INDUSTRY (2011), *available at* http://pubs.usgs.gov/of/2011/1042/of2011-1042.pdf.
[95] Jebe, Mayer & Lee, *supra* note 92, at 587.
[96] *Id.* at 588.
[97] *Id.*
[98] BRITISH GEOLOGICAL SURVEY, RARE EARTH ELEMENTS 12 (Nov. 2011), *available at* http://www.bgs.ac.uk/research/highlights/2010/rare_earth_elements.html.
[99] *Id.*
[100] *Id.*
[101] *Id.*
[102] Jebe, Mayer & Lee, *supra* note 92, at 590.
[103] *Id.*

extraction costs.[104] However, the injection of chemicals into the ore to separate the rare earth elements leads to concerns of chemicals contaminating water supplies and farmland.[105]

In the community of Guyun Village in southeastern China, the environmental damage is tangible.[106] The mine in this region was exhausted of its rare earth elements in only three years.[107] The acids used to extract the rare earths washed into nearby streams and rivers destroying rice paddies and fish farms and contaminating water supplies.[108] Conditions are significantly worse in the Chinese city of Baotou, which produces half of China's output of rare earths.[109] Here, the world's largest rare earths mine, Tailings Pond, lacks a proper lining and has been seeping its toxins into the groundwater for the last twenty years.[110] At the pond in Baotou, factories dump water containing the chemicals used to process the rare earths.[111] The toxic contents of the pond also "trickl[e] towards the nearby Yellow River, a major drinking water source for much of northern China."[112] In the 1990s, when China's production of rare earths skyrocketed, local farmers in this area saw their livestock die, crops wither, and neighbors develop cancer.[113] The waters of the pond contain an assortment of toxic chemicals, including

[104] *Id.* at 591.
[105] *Id.* at 591.
[106] Bradsher, *supra* note 90.
[107] *Id.*
[108] *Id.*
[109] Jonathan Kaiman, *Rare Earth Mining in China: The Bleak Social and Environmental Costs*, THE GUARDIAN (Mar. 20, 2014, 10:30 AM), http://www.theguardian.com/sustainable-business/rare-earth-mining-china-social-environmental-costs.
[110] *Id.*
[111] *Rare-Earth Mining in China Comes at a Heavy Cost for Local Villages*, THE GUARDIAN (Aug. 7, 2012, 8:59 AM), http://www.theguardian.com/environment/2012/aug/07/china-rare-earth-village-pollution [hereinafter *Rare-Earth Mining*].
[112] Kaiman, *supra* note 109.
[113] *Id.*

radioactive elements such as thorium.[114] Exposure to such toxic chemicals can cause cancers of the pancreas and lungs, and leukemia.[115]

In addition to the obvious environmental pollution that accompanies the government-operated mines, the rush to profit from rare earths resulted in a mining industry consisting of thousands of mines, many operating illegally without government permits.[116] Illegal mines often ignored safety and environmental regulations and smuggled rare earths out of the country in violation of exportation regulations.[117] In the southern region of China, gangsters have taken advantage of the increasing and consistent demand for rare earths, "[reaping] profits that can rival drug money, while leaving pollution and violence in their wake."[118] Because of China's control over the world's supply, "the Chinese government's only effective competitors in producing these valuable commodities are the crime rings within the country's borders."[119] The gangs have silenced villagers who have complained about the environmental destruction that occurs when the illegal mines dump sulfuric acid and other toxic chemicals into streambeds during ore processing.[120] Although government officials have attempted to crackdown on illegal mines by levying heavy fines or seizing equipment, the mines always reopen after a short time.[121]

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[114] *Rare-Earth Mining*, *supra* note 111.
[115] *Id.*
[116] Jebe, Mayer & Lee, *supra* note 92, at 588.
[117] *Id.* at 588-589.
[118] Keith Bradsher, *In China, Illegal Rare Earth Mines Face Crackdown*, N.Y. TIMES, Dec. 29, 2010, http://www.nytimes.com/2010/12/30/business/global/30smuggle.html?pagewanted=all&_r=0.
[119] *Id.*
[120] *Id.*
[121] Keith Bradsher, *Many Victims of Mines Runs by Gangsters are Peasants*, N.Y. TIMES, Dec. 29, 2010, http://www.nytimes.com/2010/12/30/business/global/30smugglebar.html?ref=global.

Illegal mines continue to flourish because it is almost impossible to trace rare earths to the mine where they were produced.[122] This is especially true since legal mines often trade with illegal mines in order to meet production quotas.[123] In addition to the terroristic gangsters in the southern mines, the northern Guangdong refineries that buy from them are also infamous for their viciousness.[124] A particularly grisly example includes a dispute between the refineries and Pacific Ores Metals and Chemicals, a rare earths trading company in Hong Kong.[125] During this $5 million business dispute, someone kidnapped the general manager of Pacific Ores, brought him to the Hong Kong office blindfolded, gagged and bound in duct tape, and then slit his throat with a box cutter.[126]

The Chinese government has used its world dominance over rare earths to its advantage in geopolitical contexts as well. During a territorial dispute with Japan in 2010, the Chinese government enacted an unannounced embargo on all rare earths shipped to Japan for two months.[127] To prove its point, "Chinese customs inspectors even delayed some shipments to Europe and the United States by demanding that buyers prove they would use the rare earths for manufacturing and not resell them to Japan."[128] Such restrictions effectively "[constricted] foreign access to [rare earth elements], while increasing the availability of [rare earth elements] to Chinese downstream processors."[129] In response to China's actions, Japan, the United States, and the European Union filed suit with the World Trade Organization contesting China's export

[122] Bradsher, *supra* note 118.
[123] *Id.*
[124] *Id.*
[125] *Id.*
[126] *Id.*
[127] *Id.*
[128] *Id.*
[129] Jebe, Mayer & Lee, *supra* note 92, at 581.

restrictions on rare earth elements.[130] The complaining states argued that the export restrictions violate China's obligations under the 1994 General Agreement on Tariffs and Trade by "imposing prohibited quantitative restrictions on [rare earth elements]" and administering those restrictions in an unreasonable manner.[131] Ironically, China responded by alleging that the restrictions were based on conservation of its natural resources and an attempt to reduce pollution from mining.[132] The World Trade Organization dispute settlement panel ruled against China finding that China's discriminatory export restraints breached World Trade Organization rules.[133] The World Trade Organization Appellate Body also rejected China's appeal, concluding that China failed to prove its justifications for the restricted export quotas of rare earths.[134]

V. THE NEED FOR GREATER TRANSPARENCY

The environmental, geopolitical, and human rights concerns that surround lithium and rare earth elements demonstrate that this renewable energy comes with a grave price. Further environmental concerns are exacerbated by issues surrounding the eventual disposal of lithium-based batteries since a large amount of energy remains stored even in partially discharged batteries.[135] The United States granted $9.5 million to Toxoco, Inc. for the construction of a

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[130] *Id.* at 580.
[131] *Id.* at 593.
[132] *Dispute Settlement: Dispute DS431, China—Measures Related to the Exportation of Rare Earths, Tungsten and Molybdenum*, WORLD TRADE ORGANIZATION (May 20, 2015), http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds431_e.htm.
[133] *United States Wins Victory in Rare Earths Dispute with China: WTO Report Finds China's Export Restraints Breach WTO Rules*, OFFICE OF THE U.S. TRADE REP. (Mar. 2014), https://ustr.gov/about-us/policy-offices/press-office/press-releases/2014/March/US-wins-victory-in-rare-earths-dispute-with-China.
[134] Tom Miles, *China Loses Appeal of WTO Ruling on Rare Earth Exports*, REUTERS (Aug. 7, 2014, 1:04 PM), http://www.reuters.com/article/2014/08/07/china-wto-rareearths-idUSL6N0QD5T820140807.
[135] James Kanter, *Fancy Batteries in Electric Cars Pose Recycling Challenges*, N.Y. TIMES, Aug. 30, 2011, http://www.nytimes.com/2011/08/31/business/energy-environment/fancy-batteries-in-electric-cars-pose-recycling-challenges.html?adxnnl=1&pagewanted=all&adxnnlx=1416180744-aKAP+qt6Ab/Tg1A0B/VSYA.

recycling plant in Ohio.[136] The German government made a similar move by giving $8.2 million to the Chemetall Group to build a recycling plant in the German state of Lower Saxony.[137] In 2011, the Umicore Group opened a recycling plant outside of Antwerp, Belgium that can recover the elements contained inside electric and hybrid car batteries, including cobalt, nickel, lithium, and neodymium.[138] These plants are demonstrative of the required high costs as well as the necessary specialized process because recycling "yields tree-trunk-size chunks of gnarled metal alloy, some weighing more than 2,000 kilograms."[139] As a result, recycling plans must be in place before industries employ lithium-based batteries in their products.

A tracking system to ensure that rare earths are acquired by legally operated mines that also use sustainable mining practices is necessary to maintain greater transparency within this trade. Although relations between the United States and China have been historically strained, the recent successful meeting between President Barack Obama and President Xi Jinping at the Asian Pacific Economic Cooperation Summit (APEC) demonstrates that these world powers can initiate change. One of the most noteworthy agreements between the United States and China at APEC was the pledge to reduce or limit carbon dioxide emissions, thus signaling to the rest of the world that the two largest world powers are willing to work together to combat climate change.[140] The recent friendly interaction between these two powers shows that further agreements on the sustainable production of rare earth elements is not an impossible feat.

The automotive industry must reconsider its dependence on lithium-based batteries since "the concept of the 'Green Car' is incompatible with the fact that if [lithium-ion] batteries are

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[136] *Id.*
[137] *Id.*
[138] *Id.*
[139] *Id.*
[140] Edward Wong, *China's Climate Change Plan Raises Questions*, N.Y. TIMES (Nov. 12, 2014), http://www.nytimes.com/2014/11/13/world/asia/climate-change-china-xi-jinping-obama-apec.html?_r=0.

used to propel it, it will be produced at the expense . . . of the most fragile and beautiful ecosystems that are left on this planet."[141] Additionally, those car manufacturers integrating lithium batteries in their vehicles must fully weigh the risks inherent with such use. Lithium is highly reactive, which also means it is highly flammable.[142] In the fall of 2013, three separate accidents involving Tesla vehicles caused the cars to catch fire.[143] Because the lithium market is expected to double within the next decade, automakers must diligently test and perfect the use of lithium-ion batteries in order to protect their consumers.[144] Furthermore, a study released by the Environmental Protection Agency links the battery chemistry that uses such rare earths as cobalt and nickel in the production of lithium-ion batteries as having "significant . . . cancer toxicity impact potential."[145] These risks are also exacerbated by the false belief that electric vehicles substantially decrease global warming potential. While electric vehicles may have an improvement on the global warming potential of twenty-four percent, this figure changes dramatically when considering the full life cycle of electric vehicles, from mining to recycling.[146] The initial production of the vehicle and the battery consist of an estimated forty percent of the total carbon footprint of the electric vehicle.[147] Specifically, the energy source used to produce electric vehicles can contribute considerably to global warming potential. The United States derives close to forty-five percent of its electricity from coal.[148] Any electric vehicle that uses

[141] MERIDIAN INT'L RESEARCH, *supra* note 80, at 52.
[142] Braun, *supra* note 52.
[143] Peter Braun, *Another Tesla Blaze Brings the Score to Model S Fires: 3, Other Major EVs: 0—Update*, DIGITAL TRENDS (Nov. 12, 2013), http://www.digitaltrends.com/cars/things-heating-tesla-third-car-fire-six-weeks/.
[144] Braun, *supra* note 52.
[145] ENVTL. PROT. AGENCY, APPLICATION OF THE LIFE-CYCLE ASSESSMENT TO NANOSCALE TECHNOLOGY: LITHIUM-ION BATTERIES FOR ELECTRIC VEHICLES (Apr. 24, 2013), *available at* http://www2.epa.gov/sites/production/files/2014-01/documents/lithium_batteries_lca.pdf.
[146] Braun, *supra* note 52.
[147] *Id.*
[148] *Id.*

coal power for its production will be seventeen to twenty-seven percent worse than diesel or gas engine in terms of global warming potential.[149]

CONCLUSION

It is obvious that lithium and rare earth elements present substantial issues unknown by most of the public. While most have been convinced that these materials represent the key to future green energy alternatives, the materials have significant damaging potential. This damage transcends the environmental arena and elicits geopolitical and social concerns, the effects of which have already been felt around the world. To echo the words of Carl Sagan contained at the beginning of this article, "we live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology." Instead succumbing to blind acceptance, the public needs to be aware of the severe problems caused by the technology that it is dependent upon.

[149] *Id.*