CHINA'S RARE EARTH SUBSIDIES AND STRUCTURAL ADVANTAGES

A Comprehensive List of China's Advantages That Must Be Overcome
for Any U.S. or Allied Rare Earth Project's Success

This Document Was Prepared for:

U.S. House Caucus on Critical Materials
U.S. House and Senate Natural Resource Committees
U.S. House and Senate Armed Services Committees
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and
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Foreword By Guillaume Pitron:
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"The energy transition has barely begun and the U.S. finds itself increasingly dependent on China for rare earths and other critical materials...

Today's U.S. and Allied dependency upon the foreign production of these metals, mostly controlled by China, is reminiscent of the OPEC-imposed energy crisis of the 1970s…

Let's face it: the Chinese-U.S./allied tensions over rare earths are not simply an economic war; they reflect, more profoundly, a rift between two opposed governance models.

This is why this report is highly necessary: not only does it help us face uncomfortable truths, but it also can act as a powerful wake-up call for the U.S. and the West to defend their own values."

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PART 1 - BACKGROUND

China has worldwide monopolistic control over the production of separated heavy rare earth elements (HREE)[13] and the production of standard and high-operating-temperature[14] rare earth (REE) NdFeB[15] (Neodymium (Nd), Iron (Fe), Boron (B)) magnets.[16] These magnets are currently irreplaceable components critical in the manufacture of cell phones, advanced robotics, electric vehicles (EV)[17], hybrid vehicles(HV), large and offshore wind turbines ("Wind") and military defense systems. China also controls access to other REE metals, alloys, and garnets used in U.S. defense systems, medical treatments, nuclear reactors, and consumer, commercial, and industrial products. This REE monopoly provides China a dangerous point of leverage against the economic and national security interests of the U.S. and Allied nations.

This comprehensive report ("Document") addresses the root causes that have created the present critical material disadvantages for the U.S. and its Allies by detailing historical factors that triggered the rise of China's REE industry and the failed historical attempts to reverse the imbalance. This Document examines the many advantages employed to sustain this monopoly and demonstrates that the monopoly is designed to maximize China's geopolitical advantage, not profits. Finally, with knowledge of China's goals and advantages, this Document proffers strategies and methods the U.S. Government may implement[18] to counter these economic imbalances.

A Brief History of China's REE Industry

- China first entered the REE market in 1980 with mining and limited ore processing capabilities; this coincides with NRC / IAEA regulatory changes[19] that trigger China's ascendance
- By 1985 China had established the largest REE research facility in the world[20]
- By 1990 China had mastered the separation of REEs[21] and had mapped a strategy of capturing and controlling the downstream production of REE value added products
- By 1995 China had begun negotiating the acquisition of U.S. REE magnet and metal powder technology[22]
- By 2005 China made its first attempt to acquire a non-Chinese REE mining property[23]
- By 2008 China's proportion of global REE production reached 97%[24]
- By 2010 China had total monopoly control over all aspects of the rare earth value chain [see 105, 137] and briefly halted REE shipments to Japan[25] resulting in a REE price bubble[26]
- By 2015 China had bankrupted Molycorp[27] and Lynas[28] after "*losing*" 2014 World Trade Organization (WTO) case on REE export restrictions by flooding the market with Light Rare Earth Elements (LREE) [29]
- By 2016 it was apparent that[30] China's moving-forward strategy was to off-shore its resource needs and to leverage-up control over the downstream production of REE metals and magnets[31]
- By 2022 China had outsourced close to 40 percent of its REE mining requirements, but retained or even bolstered its control over the production of "new" REE metals and magnets.[32]

Over this 43-year period the U.S. has not successfully challenged China's dominance in the REEs production in any material way.[33]

All efforts to break China's monopolistic advantage in production of REEs by the U.S. (and Allied) finance industry, members of the U.S. Congress, the Executive branch, the U.S. Departments of Energy ("DoE") and Defense ("DoD"), and U.S. economic allies continue to fail based on lack of proper due diligence. Without an in-depth analysis of China's top-down, sovereign-monopoly, how could any other outcome be expected?

Historically, the finance industry and the U.S. government have narrowly focused on REE mining, one of the many steps in the REE value chain, with only a recent limited focus on refining.[34] There has been little attention paid to the economic importance of the other critical REE value chain steps which include, but are not limited to: mineral concentration, mineral separation,[35] metallic conversion,[36] heat-tolerant magnet-chemistry application requirements,[37] and the fabrication of magnets.[38]

To the extent that these challenges and risks have been discussed within academic, U.S. policy, and finance arenas, the discussions were typically limited to only the most superficial issues. In fact, searching academic literature, policy papers and the formal business plans of Molycorp, Lynas, MP and other public REE ventures, there is not a single analysis that interrogates China's monopoly, including any evaluation of China's many advantages detailed in this document, or assessments of its compounding affects across the full REEs value chain.

China does not hide what it is doing nor how it uses subsidies and structural advantages to win in this space. The obfuscation of risk and lack of diligence have become accepted practice of U.S. and Allied projects seeking funding and of the entities making investment decisions.[39]

The purpose of this Document is to identify and describe China's many advantages in the REE sector gained through massive Chinese government investment into the industry and all related sciences, the acquisition of technology, the ongoing consolidation of industry participants, and the prudent application of monopoly practices. This Document is also intended to serve as a comprehensive checklist for U.S. and Allied governments, the finance industry, and emerging projects to engineer economically viable solutions.[40] This Document also makes policy recommendations designed to level the playing field.

PART 2 - INTRODUCTION

China's monopoly is widely acknowledged, but there has not been a single, comprehensive analysis to fully evaluate and dissect its various parts, to understand how and why each part works, to analyze its multiple defensive contingency structures, and to probe the monopoly for any possible weaknesses.[41]

This Document will demonstrate that many of the current and historical investment decisions have been based on insufficient due diligence, including unrealistic assessments of factors as basic as REE mineralogy and ore body geochemistry,[42] limited assessment of domestic refining and separation capabilities, and the chemistry requirements for electric vehicles (EVs), hybrid vehicles (HVs), Wind, and military grade magnets.[43]

More importantly, this Document's primary objective is to point to the larger challenges and risks posed by China's geopolitically motivated national industrial and defense policies to achieve hegemonic control over critical materials and subsequently, over technology markets.

Why is an assessment necessary? For the last two decades, all applied and/or attempted U.S. solutions have assumed that China's actions and intentions were primarily economic in nature.[44] A thorough examination of China's monopolistic structure, unprecedented investment into the sector by nearly every national leader since Deng Xiaoping[45] and formal policy statements from China's top leadership [(see 49)] shows that it is not. All these data points were repeatedly ignored. Consequently, U.S. and Allied "attempted solutions" have inevitably failed[46] while China's hegemonic power over critical resources and technology continues to grow beyond the point of impairing the U.S. defense industry and national security.

China views control over REEs and other critical materials[47] as the new battlefield in a worldwide geopolitical struggle. China's motivations are not merely economic in the traditional sense. Rather, these mineral resources are being leveraged as a geopolitical fulcrum for China's economic advantage and technological domination of downstream technologies and related industries (e.g., Made in China 2025).[48] If U.S. and Allied countries want to remain technologically and economically competitive, they must adjust their strategies to this new battlefield environment.

This Document outlines China's hard and soft subsidies and over 40 significant Chinese structural advantages that must be overcome if the U.S. and its Allied partners intend to successfully develop a REE value chain that is not subject to Chinese manipulation or control.

China currently enjoys monopolistic advantages in the separation and metallic conversion[49] of REEs based on at least three levels: hard subsidies, soft subsidies, and structural advantages. These advantages are embedded into China's 40-year program of National Industrial and Defense Policy.[50] These policies are geopolitical in nature, not economic. The attempted U.S. or Allied government solutions currently employed cannot overcome China's advantages without acknowledging and adapting to the fundamental truths outlined in this Document.[51]

The cost of ignoring China's geocentric strategies can be observed in the significant change in the respective shares of global output that China and the United States held in advanced industries from 1995 to date.[52] China's top-down objectives are nationalistic; the U.S. and its Allies' objectives are not. Traditional "capitalist" and "free market" solutions are not working[53] and will continue to fail until U.S. investment and policy adapt to the reality that is China. New U.S. strategies with long-term domestic or allied-centric objectives must be developed and employed.[54]

2.1 Hard Subsidies:

The primary hard subsidy is a thirteen percent (13%) value added tax (VAT) which acts as a rebate for shipping finished magnets and correspondingly a tax for shipping REE oxides, metals or alloys.[55] This VAT is a subsidy for the preferential export of Chinese post-metallic REE magnets and magnetic dependent component assemblies, such as REE magnet motors. This VAT burden is reflected in global pricing, as global REE pricing is set by China and reflects China's VAT. This VAT locks global trade pricing in pre-magnetic REEs on-par with China's export tax penalty, thereby creating an incentive for high value separated oxides to remain in China until converted into magnets. It also creates a powerful incentive for upstream non-Chinese producers of REE concentrates and oxides to sell into China. This also assures a fixed cost disadvantage for all non-Chinese producers of REE metallics and/or magnets produced from Chinese oxides or Chinese pre-magnetic metallic powders.[56] In fact, the VAT penalty is universally adopted by all non-Chinese REE producers and is passed on to downstream consumers, so any trade in REE products between non-Chinese companies reflects China's VAT premium.

To quote an unnamed expert and anonymous contributor:[57]

> *"In China rare earths as well as practically all raw materials are subject to trade manipulation using the VAT refund upon export as a manipulation tool. Raw materials are ring-fenced in China to keep domestic industry oversupplied with cheap resources, so that the value-added products, downstream, have a cost advantage vis-à-vis foreign markets. Without the ring-fencing price and availability, markets would inevitably equalize through international trade. Denying VAT refund upon export for raw materials is this fence."*

This person notes that the VAT is legal under World Trade Organization (WTO) rules, so technically, it is not a subsidy.

The influential capacity of China's VAT cannot be overstated. It is a powerful weapon and all non-Chinese upstream producers have embraced it as a way to attract financing and to boost profits.

To quote another unnamed expert and anonymous contributor:

> *"China's VAT is ultimately a trap for non-Chinese upstream producers. To calculate an IRR (Internal Rate of Return), the western world upstream projects need to use values for market prices for their products, be they concentrates or separated oxides. The only published indices are in China, and these include VAT. Hence the oxide producer calculates an inflated IRR and raises funding based on that figure. Now they are stuck (and find they can only sell to niche markets as the downstream metals, alloy and magnet makers cannot compete in bulk markets). In time there will be a realization that the true market price for oxides (and all pre-magnetic materials) are overstated (probably by around 17-18% once Provincial subsidies are added to the Chinese VAT rebates). Then all China needs to do, at the*

opportune time, is manipulate market price downward (e.g., eliminate the VAT premium and provincial subsidies) and all the non-Chinese upstream projects go under."

Of course, if/when this happens, be assured that the U.S. and WTO will celebrate China's decision to eliminate the VAT, much like the U.S. and WTO celebrated their 2014 WTO victory over China's export restrictions. [see 82] The outcome will be much the same. [see 28] The WTO victory significantly contributed to the 2015 bankruptcy of Molycorp [see 26, 32] and 2016 near-bankruptcy of Lynas. [see 27]

This hard subsidy advantage is effective because China controls more than 85% of the world's REE separation capabilities and approximately 90% of the world's NdFeB magnet alloy production from virgin REE material.[58] All of this is managed through four coordinated State Owned Enterprises ("SOE") and a dozen or more State controlled administrative bodies.

In addition, the respective 15% and 10% balances of global REE separation and magnet production remain largely dependent on China for high purity separated Neodymium (Nd) [(See 13 for REE elements)] and Praseodymium (Pr) and wholly dependent on China for separated Terbium (Tb) and Dysprosium (Dy). Currently, no one can make a high-operating-temperature NdFeB magnet[59] without Chinese controlled inputs of separated Tb and Dy – and there are no substitutes for these elements. This is a major distinction. Standard NdFeB magnets, without Tb or Dy, cannot be used in high-temperature applications such as EV critical components (drive motors and braking systems), Wind, or weapons systems.[60] If any country/company wants to produce high-value pre-magnetic REE alloys, they must purchase separated Tb and Dy oxides from China with the associated 13% VAT markup.[61] Current mining byproduct resources capable of producing the heavy rare earths Tb and Dy could rapidly come on line if Congress would address the thorium / source material problem which is detailed later in this Document. Other alternatives could become available if a REE magnet production tax credit becomes available.[62]

Relatively speaking, China's primary hard subsidy may seem insignificant when compared to the collective advantages of its many soft subsidies and its other structural advantages. However, because China's domestic NdFeB magnet maker's margins are single digit percentages, the ability to influence price and the absence of a double-digit VAT refund upon export is significant for everyone who wants to compete with China in NdFeB magnet production.

2.2 Soft Subsidies:

Labor Costs:

1. Lower cost of labor.

Educational Advantage:

1. Superior vocational
2. Technical
3. Advanced degree training specific to REEs.[63]

Environmental Costs:[64]

1. Lower environmental costs.[65]

Permit/License Costs:

1. Lower mine and factory permitting
2. Lower licensing costs and timelines.[66]

Tax and Quota Advantages for Importing:

1. Chinese REE companies that import REEs from outside China are not subject to China's official internal quota system on the production and distribution of the REEs. This is a significant incentive for "private" Chinese REE companies to develop non-Chinese resources (independent of China's official programs like One Belt One Road). These developed and imported REE concentrates subsequently can sell below the official "market price" and the environmental consequences as well as resource depletion happens outside of China.

China's One Belt One Road Program:

1. China uses its One Belt One Road Program ("OBOR") to develop new resource partners for its REE and Critical Materials industries. (Note: Supply partners developed under OBOR tend to have even lower environmental and labor costs and standards than China[67]).

Discounts on REE Resources:

1. China can secure discounts from non-Chinese producers selling REE concentrates (they have nowhere else to go). Official "market value" for REE concentrates and mixed oxides may be elusive for outsider vendors.[68]
2. Chinese firms enjoy even greater discounts on black-market materials that are being produced above official quotas or have been mined illegally. Some materials are mined in China and re-routed via another country back into China (suspected to represent a large portion of the Myanmar trade).
3. There are indications that aligned Chinese REE companies have advantageous internal trade/transfer pricing relationships.[69]

Government Sponsored Research:

1. The Chinese REE industry benefits from massive Chinese government subsidies in basic science, material science and applied science. The Chinese government operates the world's largest REE research and development program comprised of at least four large-scale national laboratories (the U.S. does not have a single national lab dedicated exclusively to REEs). The Chinese government's consolidated REE national lab program dwarfs the world's combined research efforts (both public and private).

Technology Procurement:

1. All REE-dependent technology developed in the U.S., by industry[70] or national labs, is eventually transferred and commercialized inside China (for access to REEs and/or enhanced profits).[71]
2. Chinese nationals working inside or hacking U.S. universities, national labs and the defense industry regularly transfer basic science, material science, applied science, R&D, trade secrets and commercial/defense applications to China.[72]

2.3 Structural Advantages:

Orchestrated Action Across State-Owned Enterprises

1. The four leading Chinese REE companies are SOE's.
2. These companies are, in effect, an extension of the state. Through economic manipulation China can leverage these SOEs to act as China's de facto *Federal Reserve of Rare Earths*. They have the ability to influence the price of REEs through centralized supply decisions and public statements [see 106] much like the U.S. Federal Reserve influences interest rates. Challengers / suppliers such as MP Materials Corp. ("MP"), in California and Lynas Rare Earth Ltd ("Lynas"), in Australia, operate in China's shadow and their profitability and viability can be largely influenced by Chinese supply manipulation and pricing policy.
3. Due to the unique configuration of China's monopoly structure, by operating multiple SOEs against each other, they create a sort of faux-free-market capitalism – resulting in hyper-competitive productivity. This is the opposite of U.S. / Allied experiences with monopolies. Traditionally monopolies are inefficient and tend to undersupply to assure high prices. China pits the SOEs into fierce competition against each other, resulting in high efficiency, oversupply, and low prices. At the same time China fully sponsors the equivalent of many Bell Laboratory research facilities (AT&T's Bell Labs was the single most important research facility in the world), running a dozen or more REE-dedicated research facilities.

Massive Overcapacity:

1. China's massive overcapacity and technical capabilities in refining and the ability to manage actinides (radioactive elements) present in some REE ores, like thorium, assures the vast majority of the world's REEs (+85%) are refined in China. For example, most of China's heavy REEs are imported from Myanmar, Brazil, Africa, and Southeast Asia. Light REEs are imported from MP and Lynas. All REE ores mined in Myanmar, Brazil, Africa, southeast Asia, and the United States (43,000 tons in 2021) are sent to China for elemental separation.[73] The only material exceptions are the REE mined in Australia by Lynas. These concentrates are further refined and partially separated at Lynas' Malaysian facility. However, all Europium (Eu), Samarium (Sm) and Gadolinium (Gd), and tiny amounts of Dy and Tb, are sent to China for full separation. Significantly, the Malaysian facility is now facing closure as a result of its failure to comply with Malaysian government requirements specific to the ongoing production and accumulation of thorium.[74]

2. China’s massive overcapacity and technical expertise in REE separation assures that the majority of the world’s high value REEs (Nd, Pr, Tb and Dy) are separated in China. Building and maintaining overcapacity has been a long Chinese tradition. During a visit to Ganzhou in 2013, it was noted that the total capacity for separating heavy REEs in the Ganzhou region was 65,000 tons per year, or more than four times China’s (and therefore the world’s) total output that year.
3. China’s massive overcapacity in metallic conversion, when combined with its hard and soft subsidies, can produce REE metallic and pre-magnetic[75] material far below the cost of what is possible outside of China. The typical Chinese margin, from separated elements to metallics, is about 5%. This strongly suggests that there are other unknown subsidies at play.[76]

Cost of Capital:

1. Zero Cost of Capital: China has massively overinvested into the downstream refining, separation, and metallic production of REE products. Official online capacity currently exceeds current global demand. This creates an environment where Chinese downstream facilities aggressively seek out REE resources and produce intermediate and finished products far below the costs that are possible outside of China.
2. Zero Investor Return: Despite VAT subsidies for downstream production of REE magnets and other favorable economic factors to boost China’s REE sector, there are no apparent “investor” return expectations or requirements. Ultimately, funding flows from government-controlled financial institutions to government-favored SOE. Note the massive consolidation of the REE industry by the central government. In short, the Chinese government is the “investor” and measures its “return on investment” on something more like Geopolitical Return on Investment (“GROI”): the net increase (or decrease) in its control over REE and other critical materials[77] (imported and exported).
3. Government Funding: China’s commercial mining, refining, and metallics industry remains directly or indirectly funded by the government, based on zero cost of capital and zero investor return requirements.[78] Profits are secondary to geopolitical goals. The U.S. capital markets require returns in proportion to relative risk and currently all REE projects outside of China are risky. China’s monopoly operates on minimal to no returns (despite the advantages detailed in this Document).[79] Consequently, U.S. / Allied REE mining projects seeking financing must minimize the disclosure of China’s competitive advantages in order to secure financing. It has also become common practice to misrepresent geochemical facts,[80] technical capabilities, operational cost, downstream goals, and potential return to investors (and the U.S. government).

Responsiveness:

1. The Chinese government can alter any rules, regulations, or restrictions across the REE industry as internal or external conditions require. China monitors its monopolistic system at all levels, both internal and external (all REE sales outside of China are monitored and scrutinized).[81] By comparison, the U.S. has not put forward a viable response to China's monopolistic policies over the last four decades.
2. The Chinese government directly oversees and controls investment in downstream infrastructure and resource production.[82]
3. The Chinese government deploys pricing and production control measures designed to promote and expand or shrink and destroy parts of China's internal REE industry, or its overseas competitors (REE pricing, controlled by China, is used to increase or decrease resource production inside and outside of China).[83]
4. China uses its monopolistic advantage to attract REE-dependent manufacturing (the U.S. finance industry has historically favored the offshoring of manufacturing, regardless of long-term economic or national security implications).
5. China's many levers for manipulating global supply, price, and the potential to withhold supply of separated Nd, Pr, Tb and Dy puts all non-Chinese REE producers at China's mercy and in a disadvantaged cost competitive position (VAT plus pricing on all non-magnetic REE products).
    a. Most downstream NdFeB magnet production outside of China remains dependent on China for high purity separated Nd and Pr for their final chemistry.
    b. All high-operating-temperature NdFeB magnet producers are 100% dependent on China for separated Tb and Dy (used in EVs, Wind and military systems). High-operating-temperature NdFeB magnets are the critical component for most if not all high value applications.

Supply Assurance:

1. China is the only source for guaranteed uninterruptable supply of NdFeB magnets. All other producers are either dependent on China for separated Nd, Pr, Tb and Dy oxides or subject to non-Chinese supplies that can be compromised by China through price or supply manipulation.[84] Supply risk is paramount to any manufacturer.[85] This greatly undermines the economic viability of non-Chinese producers on several levels (including the potential for Chinese retribution[86]). It should be noted that the price of REE magnets is not as important to Original Equipment Manufacturers ("OEM") / end-users as surety of uninterrupted supply. Until U.S. producers can demonstrate a reliable uninterrupted supply, at all levels, OEM end-users cannot be expected to switch from a Chinese supply.[87]

Regulatory Advantages:

1. China prohibits the transfer of REE technology.

2. China has limited regulatory obstacles related to thorium, a radioactive element, typically found within heavy REE ore that allow China to develop the highest value heavy REE deposits.[88] The opposite is true for the U.S. and all International Atomic Energy Agency ("IAEA") compliant countries. [89] U.S. and IAEA compliant countries are unable to economically develop thorium bearing heavy REE deposits due to regulatory standards triggered by the radiation levels (typically about 500 parts per million) that classify the material as "nuclear source material".[90] Thorium-bearing REE deposits typically contain Tb, Dy and most or all other heavy REEs. This regulatory burden and restriction assure that China has absolute control over the production of high-operating-temperature NdFeB magnets (requiring heavy REEs Tb and Dy). Without heavy REEs, the U.S. and its Allied partners cannot independently make EV, Wind, or military grade NdFeB magnets.

Resource Advantages:

1. Over 50 percent of China's REEs are the byproduct of a single iron ore mine located at the Chinese owned Bayan Obo Mine near Baotou. This provides China a significant production cost advantage.[91]
2. China's mine permitting process is highly responsive to demand and preserving its monopoly position. Curiously, a large portion of China's REE production comes from unpermitted mining operations, resulting in significant environmental damage. China only cracks down on these mines when it is to their advantage. According to China's Communist Chinese Military Companies ("CCMC"[92]) many of these mines are allowed to continue operating if they initiate environmental standards. It must be noted that China's environmental policies have improved significantly over the last 10 years. [see 63]

   China's current resource policy has shifted from internal production to external production, with the goal of preserving national resources, controlling internal production levels, and preserving its environment. China has closed hundreds of Chinese REE mines and uses "private" and government resources to develop REE mines in other countries. <u>In contrast, the U.S. has not opened a new REE mine in over 70 years</u>[93] (MP, recently featured by POLITICO magazine, is the 3rd incarnation of the same Mountain Pass deposit[94] that began operations in 1952). In fact, the U.S. regulatory and permitting process for opening a new mine typically exceeds a decade or more. [see 65]

Note: MP claims it will produce 1,000 tons per year ("tpy") of NdFeB magnets, but MP does not have access to Tb or Dy so production will be limited to low-operating-temperature magnets unless they purchase HREEs from China. The Pentagon has invested heavily into the Lynas / Blue Line project to offset this issue (Lynas would only be able to supply tiny amounts of Tb and Dy if they are successful in separating it: .008% of global demand). The prospects for successful separation are not encouraging based on the termination of the collaborative project between Lynas and Blue Line. NdFeB magnets without Tb and Dy have limited technological applications and will necessarily sell at lower margins[95] when compared to high-operating-temperature NdFeB magnets. These low-operating-temperature magnets cannot be used in EV or military applications. This undisputed statement of fact has been ignored by the Pentagon. Congress should continue to require the Pentagon to thoroughly examine geology, minerology, and geochemistry when considering funding U.S. and foreign projects before committing U.S. taxpayer dollars to any operations.[96] Congress should also inquire into the breakup of the Lynas / Blue Line collaborative project and the prospects of Noveon (formerly Urban Mining).

3. Using "private" investment companies like Shenghe Resources[97], that hold equity stakes in REE mining projects in the U.S. (i.e. 10% ownership in MP, 100% off-take agreement and technology and support for restart of the project), Vietnam, Greenland, Australia, etc.,[98] and direct government investment in countries like Myanmar, Malaysia, Thailand, Bahrain, and the Democratic Republic of the Congo through the OBOR initiative (with 68 member countries[99]), China is better able to cultivate new resource supply partners. Mine permitting in some of these countries is highly responsive to investment opportunities and politics.
4. China's use of OBOR and other strategies drives global REE production into China's massive downstream value-added capacity for separation, metallics and magnetic materials production. The success of China's OBOR initiative is best illustrated by changes in trade preferences by country.[100]
    a. U.S. and Allied challengers have unequal access to the best REE resources, as the Nuclear Regulatory Commission ("NRC") and IAEA regulations drive resource development away from heavy REE deposits that typically contain elevated levels of thorium.[101] Thorium is not a significant problem for China and may not be a problem at all for many of the countries where its OBOR program is helping to cultivate REE resource production. Consequently, China will sweep all the best heavy REE resources into its massive and efficient downstream separation and metallic conversion facilities. By cultivating production and importing these heavy REEs, China can preserve its monopoly.
    b. Due to current regulations related to thorium,[102] the U.S. and its Allies will continue to develop non-optimal resources (mostly absent Tb and Dy). As long as U.S and Allied producers are operating under onerous NRC and IAEA regulations, China's monopoly will be preserved. This obstacle must be resolved (see Recommendations).

5. While the U.S. remains fixated on domestic mining issues, with no measurable progress in over a decade, China has moved on to outsourcing mining to other countries (including the U.S.). For the U.S., *mining has never been the issue* (despite the protestations of most junior REE mining companies[103]). *The real problem is regulatory issues.*[104] For new start-up mines the regulatory issues include permitting, permitting timelines, and endless "stakeholder" challenges to development.[105] In the case of byproduct production (and for many potential new start-ups) the primary obstacle is typically thorium, a common companion element to heavy REEs. A 1980 NRC / IAEA regulatory change terminated the production of all heavy REEs in the U.S. (and about 40% of overall REE production). If the U.S. could solve the thorium issue, byproduct REE production could help meet rising U.S. demand.

China's Macro Market Advantages:

1. Because China is the world's largest consumer of REEs, at every level of the value chain,[106, 137] China can manipulate REE prices.[107]
2. Because China can manipulate REE pricing, up or down, China has the power to expand or shrink global REE production (or compromise the economics of its competitors).
3. As most official Chinese REE producers are immune to traditional market dynamics, the financial consequences, resulting from distortions in supply or price, fall disproportionately on non-Chinese producers.
4. China's control over pricing is currently used to expand non-Chinese production of REEs.[108] Nearly all the world's non-Chinese REE production flows through China's downstream REE value chain. By allowing prices to rise, China is expanding its downstream production (and control over) high value materials and is outsourcing the environmental consequences of REE mining and preserving its domestic natural resources. China can also dampen pricing.
    a. Note that the Chinese central government was able to dramatically reverse the rise in REE pricing by announcing that prices had gone too high. [see 106]
5. Because China controls nearly 100% of all REE metallics produced globally,[109] China can disrupt the production of close to 100% of the world's REE-dependent technologies and products, including U.S. weapon systems.
6. China's control over access to REE metallics / magnets gives China coercive power over all REE dependent end-users, including U.S. defense contractors.[85, 110] Because China can disrupt any competitors' access or production of finished metals, alloys or fabricated magnets, China holds a credible threat against competitive producers of REE metals, alloys, and fabricated magnets.
7. Because China can disrupt competitive suppliers of REE metals, alloys and magnets, China has incredible dissuasive powers over the decision of OEM / end-users to seek supply arrangements away from China. [see 85, 109]
8. China has a well-earned reputation for punishing or destroying detractors and disloyal customers.[see 85, 109]

Outcome Based Control:

1. China operates and manages a dozen or more coordinating agencies that direct, manage, and control all REE production across the full value chain through the four official and state-designated REE companies. All sanctioned activity is designed to maintain or enhance China's geopolitical advantage via its REE monopoly (focused on separation and metallic conversion).
    a. The U.S. and Allied systems rely on the financial markets (and more recently DoE/DoD funding) to support mining projects that are still reliant on Chinese material to produce the high-operating-temperature NdFeB magnets needed to build everything from precision missiles to nuclear submarines.[111]
2. China's system measures outcomes and adjusts polity.
    a. The U.S. and Allied systems rely on financial self-interests (investor greed – sometimes wrapped in a flag), "efficient market theory (full information[112])" and market signals (stock price) to drive investments – despite the obvious potential for conflicts. This system, as currently exploited, cannot deliver coherent national policy.

R&D / Innovation Ecosystem:

1. China's private[113] REE research efforts also independently dwarf the balance of the world's research efforts combined. For example, China has filed more REE patents than the rest of the world combined. China files about 30 REE patents for every one U.S. patent.[114]
2. Because the global REE ecosystem operates primarily inside China, and operates in a top-down coordinated fashion, new technology and applications rapidly develop. China manages a healthy and vibrant petri dish of innovation. In addition, outside innovations tend to migrate to China.

U.S. vs Chinese Research and Development:

1. China operates four national labs that exclusively work on REEs (see page 23).
    a. The U.S. does not have a single dedicated REE national laboratory and the one laboratory that does work on REEs (Ames Laboratory) does REE research on a very limited basis relative to its overall budget). China's government investment into REE research runs at about 120 full-time researchers for every 1 U.S. government-funded researcher.[115]
    b. Ames Laboratory and the DoE's recent focus on REEs cannot compensate for China's four decades of focused commitment. Ames Laboratory is staffed by academics and researchers who focus primarily on developing and maintaining grant opportunities.[116] Ames Laboratory was unable to confirm that they have a single full-time REE researcher (see 168). All DoE and DoD requests regarding full-time or full-time equivalent REE researchers were unanswered.
    c. Building a solution based on the prospect of some U.S. technological "magic bullet" will be incomplete without extensive precautions[117] because China will eventually acquire and exploit it. Solutions need to be based on a clear understanding of how China's monopoly works and a compensation plan that is resilient to such monopolistic manipulations.

Chinese IP Integration

1. Although Japan dominates downstream NdFeB magnet IP, China uses its control over access to Tb and Dy to assimilate these technologies within its borders.
2. Currently NdFeB magnet manufacturing equipment technology and IP ("Equipment Technology") originates mostly from Japan.[118] Yet the manufacturing of the Equipment Technology has been vastly outsourced to China. The Equipment Technology transfer rate is therefore increasingly in favor of Chinese manufacturers, who reverse-engineer and upscale the Equipment Technology.
3. Presently, Japanese magnet makers struggle to keep the Equipment Technology a generation ahead of Chinese competitors. Realistically future development favors China, as over 200 Chinese magnet companies regularly compete against each other (China produces >90% of the global NdFeB magnet demand). This is particularly true for the sintered NdFeB magnets produced by Grain Boundary Diffusion and Heavy-Rare-Earth-free technology, which are required for effective green-transition technologies.
4. IP Capture via Tb and Dy: To acquire IP, achieve its market dominance and enforce its ability to manufacture and sell IP-protected sintered NdFeB magnets technologies, China has substantially increased the price of Heavy Rare Earth Elements (Dy, Tb & Ho) and largely ignored IP related to so called "Grain Boundary Diffusion." This mostly Japanese Grain-Boundary-Diffusion IP significantly lowers Tb and Dy requirements (off-setting the proportional shortages from REE deposits). Despite the fact that these magnet technologies have strong patent protection and offer a cost-affordable and long-term sustainable technological solution to the worldwide Heavy-Rare-Earth-scarcity, Japanese magnet manufactures have been forced to transfer their technologies inside China due to economic pressure (the VAT pricing disparity) and supply security. This long-standing coercive environment continues to reward deviant non-market behavior which sustains the erosion of IP-rights from original IP-right owners.
5. Consolidated & Coordinated Control: China has strategically created a consolidated Rare Earth ecosystem, which effectively controls the governance, universities, institutes, mines, magnet manufacturers and more recently also electric motor manufacturers and the automotive industry (including intertwined ownership). This ecosystem has created a downstream focused, know-how-based value chain:

   Access-Control to Downstream REEs => IP Capture => / Central Planning => Basic Science Research => Rare Earth process engineering => Magnet engineering => E-motor engineering => End-Product engineering => Recycling engineering => / Build Out Excess Capacity => Intense SOE Competition => Creating a Low Margin Environment => Chinese Low Price Producer => Establishing Chinese Globally Dominant / Exclusive Supplier => Capture Global IP & Mfg => / Assess Global Environment => Start Over

a. The advantage of such an interconnected technical ecosystem is that only the end product value can be applied to the profitability equation. In other words, China's monopoly eliminates the possibility of profits outside China's protective monopoly system and derives most of its profits and geopolitical advantage from downstream products, IP capture and hegemonic control over competing economies.
b. Supported by industry output, accumulated knowledge is progressively being transferred into Chinese Intellectual Property Ownership, with the goal of securing China a dominant role in the green energy transition and technological hegemony.

Chinese Human Capital:

1. Chinese investment in human capital, operating in the commercial sphere, runs at about 740 full-time employees for every 1 U.S. full-time equivalent employee working in a commercial setting (1,500 to 1 when accounting for MP's workforce that produces REE concentrates for China). The number of full-time technical professionals working in a commercial capacity in the U.S. is just over 405 (with 216 producing REE concentrates for China and 130 producing SmCo magnets in the U.S.).[119, 162]
2. The U.S. does not have a single university with a dedicated focus on REEs, while China has at least 39 universities.[120] The only non-Chinese university that has a dedicated REE magnetics practice is the University of Birmingham in the United Kingdom.

Chinese Control Over Critical Inputs, Global Pricing & Producer/Suppliers:

1. China's control over access to critical inputs for REE magnet production, and the threat of reprisal, assures that large multi-nationals will not shift away from China sanctioned relationships[121, 85] without absolute assurance of a long-term supply chain security.
2. Every REE magnet maker producing high temp NdFeB magnets is 100% dependent on China for separated Tb and Dy. As low temp NdFeB magnets inevitably drift towards "commodity pricing" there are no realistic return expectations / profits from manufacturing these magnets outside of China.
3. Every NdFeB magnet maker in the world is largely dependent on China for separated Nd and Pr.[122]
4. China can strategically withhold Tb and Dy, forcing all non-Chinese magnet makers into the low temp NdFeB magnet production only. These high-operating-temperature NdFeB magnets are favored in all high-value applications, pushing the price of low-temperature magnets even lower. It is anticipated that the price of these low-temperature magnets could fall below their production cost.[123]

5. High-operating-temperature NdFeB magnets are critical components in the production of EVs. This Chinese monopoly extends to the EV battery market as well [(see 161)]. Chinese firms exercise control over much of the processing capacity for lithium (55 percent), cobalt (65 percent), copper (40 percent), nickel (35 percent), spherical graphite (99 percent), and synthetic graphite (78 percent) [Also see 47]. China now controls 92 percent of the global cathode capacity and 91 percent of global anode capacity. Additionally, China has made sizable investments in cell manufacturing capacity currently controlling over 79 percent of the market.[124] By 2029 it is expected that the United States will have only 3 lithium-ion battery mega-factories compared to China's 88 of a total of 115 lithium-ion battery mega-factories planned.[125] This is an example of how China's REE monopoly is multi-layered and integrated into China's other monopolies: and why simplistic "market-based" solutions will continue to fail.
6. China's top-down directives can limit outside access to upstream REE resources and boost China's downstream export value contribution. These directives can lock competing nations out, effectively controlling their ability to participate in downstream value, resulting in 100% Chinese REE-dependent technologies and industries.
7. For example, in 2016 the Ministry of Industry and Information Technology of China issued the "Rare Earth Industry Development Plan" that directed that the future development of the REE industry should be increasingly driven by innovation and the high-end applications of downstream REE products and components. Under the Plan, R&D investment would be increased from 3% to 5%, the market proportion of high-end REE materials would rise from 25% to 50%, and the export percentage of raw material exports would decrease from 57% to 30%.
8. Further, China's decision to promote and finance the development of resource producers outside of China allows China to preserve its own resources and offshore the environmental consequences of mining.
9. Another advantage of off-shoring its mining / resource needs is that China gains a political proxy position in the mine-host country (the "domestic" mine owner / operator / investor can be counted on to petition their governments in pursuit of private gain – and as their business is in the export of REEs to China, their private gain will reliably conform to China's advantage).
10. China's monopoly is constructed in such a way that its resource suppliers never actually become *off-the-leash* competitors, as can be seen in the recent changes to H.R. 5033: now titled H.R. 2849 (a production tax credit for the domestic production of rare earth magnets). These changes demonstrate how China ends up the predictable winner within our own political process.
    a. In the original Bill's wording, 100% domestic content was required to maximize the tax credit of $30 per kg.[126] The new allowance for 10% Allied foreign nation content[127] clearly reflects the fact that MP cannot produce Tb, Dy (or other heavy rare earths) necessary to produce high temperature NdFeB magnets.[128]

The maximum level of high-operating-temperature magnets MP could produce, if Lynas provided its Tb and Dy[129] (and this assumes Lynas will successfully separate its Tb and Dy – despite the fact that the Lynas / Blue Line collaboration has ended) is very limited.[130] If Lynas does transfer all of its Tb and Dy, it will presumably be at "market price": the price set by China. If that is the case, and current pricing patterns hold, the resulting economics for MP will be negative, possibly significantly negative (unless the off-taker is going to pay above market – and possibly trigger a retaliatory response from China for the balance of what they require).
However, these changes[131] would still allow MP to qualify for the maximum tax credit by producing low-operating-temperature Ce+NdFeB magnets,[132] leaving the U.S. dependent on China for all higher end applications (Note: Ce+NdFeB magnets cost 70% less to make than an EV grade magnet and are mostly used in toys and novelty items). It takes a high level of credulity to think that MP would do any differently.[133]

b. The new bill, H.R. 2849, also allows for up to 100 percent foreign content[134] from countries not defined as "non-allied foreign nations"[135] at the $20 per kg level. Again, this does nothing to address the massive shortfall of Tb and Dy collectively produced by "Allied foreign nations." China's monopoly position and control over the production of high-operating-temperature NdFeB magnets will essentially remain unchanged. It should be noted that 100 percent China-free low grade NdFeB magnets are currently made in countries outside of China, including Allied nations. The U.S. could build its own magnet facilities and produce low grade / low-operating-temperature NdFeB magnets in the U.S. (using domestic or Allied sources). However, paying a $30 per kg tax credit for non-critical low-operating-temperature NdFeB or Ce+NdFeB magnets is counterproductive (NdFeB magnet prices are primarily a function of inputs costs, not utility). Domestic producers would be incentivized to flood the market with low-end Ce+NdFeB magnets to maximize the tax credit. Based on interviews with non-Chinese magnet makers, low-operating-temperature magnets could be profitably produced in the U.S. with a tax credit of just $10 per kg if inputs and transfers are not priced on China's VAT.[136]
c. H.R. 2894 apparently assumes Lynas (or other potential allied REE producers[137]) will be able to produce meaningful quantities of Tb and Dy. However, the facts demonstrate that Lynas will not be able to fill this void.[138] The potential for other developing projects to fill this gap is unlikely, as the unresolved "thorium problem" ensures that U.S. / Allied producers will continue to avoid heavy rare earth deposits that are commonly rich in thorium.[139] .
d. These shortcomings should have been obvious. The problem is that legislators, policy makers, and the Pentagon have relied on private interests to provide an honest assessment of geochemical capabilities, economic prospects (vs China) and downstream capabilities. The historical series of bad

investments made by Wall Street, the DoE and the DoD over the last decade suggest that full disclosure and / or due diligence has been far from adequate.

e. The resulting economic incentives within the previous and new version establish a firm economic self-prohibition against the production of high-operating-temperature NdFeB magnets, as the maximum tax credit can be applied to the lowest cost / low-operating-temperature NdFeB magnet: or Ce+NdFeB magnets (used in toys and novelty items).[140] This is primarily a win for China, with private / corporate / shareholder interest in second place and U.S. economic and national security trailing far behind.
f. The takeaway from all of this is that China can rely on companies like MP[141] to abuse the U.S. political system to maximize their economic advantage.[142] Economic advantage and U.S. national interests have been on an increasingly divergent course for over 40 years.[143]
g. This is not unique to rare earth mining or magnet companies. This is observable in the largest manufacturing companies in the world that require REE, other critical materials or critical material-dependent components for their systems. [see 144]

11. Legislative efforts intended to promote REE capabilities outside of China primarily fail because conflicted resource producers have no incentive to provide policy makers information that honestly reflects the '*competitive environment',* their capabilities, limitations, financial entanglements or profit strategies.

To understand why H.R. 5033 / 2849 would result in unintended consequences one needs to consider the cost difference across the different grade of magnets and the profit motives of potential producers. The table below shows pricing for the Low-Operating-Temperature ("LOT" containing light REEs) Ce+NdFeB and NdFeB magnets and variations of High-Operating-Temperature ("HOT" containing heavy REEs) magnets for the periods April 2022 and April 2023.

What Are The Other Steps & Costs In Producing A REE NdFeB Magnet?

Additional downstream processing costs not included in the table below for a finished magnet are: conversion of RE oxides or compounds into metal/alloy (metallization), strip casting of alloy, coarse crushing of strip cast alloy (hydrogen decrepitation), jet milling in nitrogen of coarse powder to fine powder < 5 micron particles, powder blending, pressing powder in a magnetic aligning field to produce a green compact, sintering green compact to full density in vacuum/inert gas atmosphere, heat treating sintered parts to optimize magnetic properties, machine to finish dimensional shape and tolerances, swarf loss of 20% or more (collected and recycled), corrosion protective coating/plating, magnetizing, inspection and testing, packing and shipment.

RARE EARTH INPUTS PRICES FOR VARIOUS GRADES OF NdFeB MAGNET

As detailed in the Table below, the cost difference between Ce+NdFeB and NdFeB LOT magnets vs HOT magnets increases rapidly.

	Rare Earth Magnet Chemistry						REE Input Cost per kg of Magnet | April 2022 vs April 2023											
	Typical REE Weight %						April 2022 USD						April 2023 USD					
Grade / REE	CeNdFeB	NdFeB	Basic (M)	Low (H)	Med (SH)	High (AH)	CeNdFeB	NdFeB	Basic (M)	Low (H)	Med (SH)	High (AH)	CeNdFeB	NdFeB	Basic (M)	Low (H)	Med (SH)	High (AH)
LREE vs HREE	LOT	LOT	HOT	HOT	HOT	HOT	LOT	LOT	HOT	HOT	HOT	HOT	LOT	LOT	HOT	HOT	HOT	HOT
Max Op Temp	50C	65C	80c	100c	150	220c	50C	65C	80c	100c	150	220c	50C	65C	80c	100c	150	220c
NdPr	25%	33%	32%	29%	27%	22%	$ 45.00	$ 59.40	$ 57.60	$ 52.20	$ 48.60	$ 39.60	$ 23.75	$ 31.35	$ 30.40	$ 27.55	$ 25.65	$ 20.90
Dy	0%	0%	1%	3%	5%	7%			$ 5.60	$ 16.80	$ 28.00	$ 39.20			$ 4.05	$ 12.15	$ 20.25	$ 28.35
Tb	0%	0%	0%	0%	0%	2%						$ 52.00						$ 33.00
Ce	8%	0%	0%	0%	0%	0%	$ 0.38						$ 0.34					
Total Cost (REE) USD							**$ 45.38**	**$ 59.40**	**$ 63.20**	**$ 69.00**	**$ 76.60**	**$130.80**	**$ 24.09**	**$ 31.35**	**$ 34.45**	**$ 39.70**	**$ 45.90**	**$ 82.25**
	Incremental Cost Over Ce + NdFeB Magnet							30%	40%	54%	70%	190%		29%	42%	65%	91%	242%

Applications: Ce+NdFeB = Toys & Novelties, **NdFeB =** Earbuds, **Basic (M)** = iPhones, **Low (H)** = Small Motors & Sensors, **Med (SH)** = EVs, Wind & Robotics, **High (Ah)** Defense Systems

The costs above are limited to the price of Nd, Tb Dy & Ce oxides if present in the magnet. Other alloying elements include Fe, B. Many HOT magnets also include Ho, Co, Al, Nb, Ga, Ti, and other trace elements.

It is critical to understand that no rational financial actor is going to opt for the production of a standard NdFeB or HOT magnet if they can maximize the tax credit by producing a Ce+NdFeB magnet. Any additional cost in the production of a standard NdFeB or HOT magnet would reduce the recoverable amount of the tax credit that can be applied towards profit (keeping in mind that there are no profits in the production of any NdFeB magnets outside of China). It is also important to understand that higher-operating-temperature magnets are priced primarily on inputs (Nd, Pr, Tb, Dy, Ho, etc), so the extra expense cannot be recovered as REE magnet pricing does not provide a proportionate increase in margins for a higher-operating-temperature magnet.

Because the current bill, HR 2849, allows Ce+NdFeB magnets to qualify for the full $30 tax credit as written, the predictable misallocation of resources and resulting production would be near-exclusively dominated by Ce+NdFeB magnets. If Ce+NdFeB magnets were somehow excluded then production would shift near-exclusively to standard NdFeB magnets. No one would make the HOT magnets needed for EVs, Wind and U.S. weapons systems.

Based on H.R. 2849's definition of a rare earth magnet the Ce+NdFeB magnet would qualify for the full tax credit.

''(1) RARE EARTH MAGNET.—The term 'rare earth magnet' means a permanent magnet comprised of— ''(A) an alloy of neodymium, iron, and boron, which may also include praseodymium, terbium, or dysprosium"

The term "alloy" would allow for other undefined inputs like Ce. Excluding undefined REEs or other inputs does not work because many of the HOT magnets also may require Ho, Co, Al, Nb, Ga, Ti and other trace elements.

<u>Eliminating the tax credit does not work</u>. The DoE suggested in its Deep Dive report that it is not possible for anyone to profitably make NdFeB magnets outside of China.[145] Without a production tax credit, China wins.

The only way to rectify the situation is to have a bracketed or escalating tax credit that can cover the higher cost of HOT heavy rare earth content. To solve this problem, a tax credit escalator can be tied to the proportion of heavy rare earths contained within the magnet.

12. China's disproportional (and growing) competency and control of all the above advantages greatly strengthens its ability to maintain dominance in the EV sector and related markets.
13. China has defined and controls international ISO standards for downstream REE products. [146]
14. Technology: China maintains restrictions on the export of its proven separation technology and metallic conversion equipment.[147] Allied-sourced separation and metallic conversion systems typically cost 2 times that of Chinese systems with about half the productivity (or 4-X on a unit-production basis).[148] To date, none of the Allied separation technologies have been able to perform full spectrum-separation on the most important REEs: Nd, Pr, Tb, Dy and SEG.[149] The only proven full-spectrum separation technology outside of China's control is Solvay in La Rochelle, France[150], which has been suspended due to thorium (Th) issues.

Geopolitical Advantage:

1. The many geopolitical advantages gained from China's REE and Critical Materials monopoly will be used to prevent any meaningful competition in downstream REE production outside of China's control.
2. The geopolitical and economic advantages resulting from China's monopoly are disproportionately significant. These advantages allow China to capture IP and manufacturing opportunities while compromising the economies and national security of adversarial nations. China controls the global production of all high-operating-temperature NdFeB magnets used in EV drive trains and braking systems, Wind and weapon systems. China increasingly sees the global green economy as its private domain and has gone so far as to warn U.S and Allied economies to stay out of the EV battery market.[151, 46, 47]
3. The facts presented in this Document make clear that China views its control over REEs (and other critical materials) as a geopolitical and hegemonic tool of economic warfare.
4. China will not surrender this monopolistic advantage easily.

Summary:

1. China's many structural advantages make competition in the production of post-REE concentrates or other downstream products unlikely. [152]
    a. Because of China's many hard, soft, and structural subsidies it is not realistic for any company outside of China to be competitive in the downstream production of REEs without significant U.S. policy intervention like those detailed in the 117th Congressional version of [H.R. 5033, the "Rare Earth Magnet Manufacturing Production Tax Credit Act"](), which was introduced in the House in 2021 and the Senate in 2022 ([S. 4680]()). [As amended by HR 2849?]

This version has a number of defects, with the most significant defect not differentiating between low-operating-temperature NdFeB magnets (Ce+NdFeB magnets are used in toys and novelty items and standard NdFeB magnets used in earbuds) and high-operating-temperature NdFeB magnets (used in EVs, Wind and U.S. weapon systems). The original version allowed any U.S. magnet producer to maximize the tax credit for the production of low-operating-temperature magnets that are not critical to U.S. environmental or national security needs.

The problem with the new version, H.R. 2849, is that it allows for foreign Allied content that, for the most part, does not exist. Based on the geochemistry of the Lynas Mt. Weld deposit, the required amount of Tb and Dy necessary to make the U.S. independent of China does not exist. Consequently, the proposed changes will lock the U.S. into the near-exclusive production of low-temperature magnets as private companies seek to maximize available tax credits (securing China's advantage long into the future). Another problem consistent in both versions is that they are completely deficient in addressing the domestic production of REE metals, alloys, and garnets.[153] The duration of the incentives may also prove to be insufficient.[154] Any amendments, or a new bill, must address these deficiencies.

The most significant problem with both versions is that they would incentivize counterproductive behavior (rent seeking). Both bills fail to differentiate between low-operating-temperature magnets (used in earbuds and iPhones) and high-operating-temperature magnets (used in EVs, wind and weapon systems). Low-temperature-operating magnets qualify for the maximum tax credit. As a consequence, U.S. producers can be expected to produce as many low-operating-temperature magnets as possible, to collect the $30 tax credit. It would be unreasonable to expect them to make the much more expensive high-operating-temperature magnets, as the significant cost difference for the heavy rare earths inputs (Tb, Dy and Ho) would easily exceed the $30 tax credit (resulting in losses).

b. Because China has the only proven and operational REE separation infrastructure, all high value concentrates will continue to flow through China.
c. Because of China's massive overcapacity in separation, efficiency due to scale and control over global REE pricing, which reflects China's 13% VAT (acting as a price incentive for China-internal value-add to magnets before export and pre-magnetic imports to China from outside producers), global resources will continue to flow into China.
d. Because China can disrupt non-Chinese downstream production, no rational large-scale OEM / off-taker will make significant commitments to non-Chinese suppliers[155] of downstream REE products, if and when they do exist.[156, 85]

2. The inability to acknowledge China's strategic monopoly is the universal feature of all U.S and Allied responses that has contributed the most to the effectiveness and durability of China's monopoly.
    a. All U.S and Allied responses presuppose that China operates under the same rules, objectives, and principles associated with free markets, global economics, and financial profits that they do.
    b. Insufficient due diligence resulting in all the non-competitive issues outlined above continue to be glossed over, omitted, or obfuscated by private non-Chinese REEs companies seeking investor and Federal funding.[157]
    c. All U.S. / Allied public companies operate in an economically competitive and adversarial method towards each other.[158]
    d. Investors seeking returns on trending investments (e.g., critical materials, national security, EVs, Green Tech) ignore questions about long-term viability, technical capabilities, and resource compatibility – knowing that stock-profits can be made on speculative momentum.
    e. Research institutions seeking continued grant funding pursue research based on the probability of funding, not on economic viability. Research institutions are also reliably silent on anything that would compromise the continued flow of research dollars.
    f. Federal Departments such as the DoD continue to overlook basic geology, minerology, and chemistry facts and continue to fund REE projects that will not advance the U.S.'s competitive advantage in this industry. Other, more viable projects for REE production remain unfunded.
3. Bad investments by the government and Federal agencies, like DoD, can be measured by the two decades of lost corrective-policy action and other misdirected investments based on misleading disclosures.
    a. The Pentagon, for example, has a long-standing history of accepting and even disseminating deceptive data. This practice dates to 2009, when Molycorp was the first supported project which involved the practice of misclassifying light and heavy REEs.[159, 13] The Pentagon has continued this practice and continues to fund projects that appear to solve the Defense Industrial Base REE mineral supply. The Pentagon's replication of this practice is evident in other official reports[160] – ultimately distorting U.S. policy, harming investors, the economy and national security.
    b. The harm associated with this history and practice of misclassification and insufficient due diligence caused can be measured by the $7 billion in investor losses associated with the Molycorp bankruptcy and other misdirected investments based on false disclosures. [See 136, 157, 158]

PART 3 - THE PROBLEM

3.1 Control of High-Value Magnets

Due to these three levels of monopolistic advantages (soft, hard and structural) in the separation and metallic conversion[161] of REEs, China controls the production of all high value

NdFeB magnets (directly or indirectly). Even the lower value, low-temperature NdFeB magnets made outside of China largely rely on China for high purity separated Nd and Pr for final chemistry.[162] Consequently, China can impose a cost disadvantage and credible supply risk onto anyone trying to produce REE metallics outside of China.

3.2 Data Generation

A second significant problem is the generation of incorrect data that allows investors to develop their narrative and keep the grant money flowing, and the U.S. government that continues to accept and support such data with no due diligence and proper in-depth checks and balances. Questionable data, misleading graphs, and incorrectly labeled charts continue to be generated, repeated, and emphasized, sustaining false hope in long-term solutions (while maintain funding for improbable ventures and research efforts). From China's dominance in patents, to Chinese REE production, to graphite for battery anodes and other critical materials, there have been many incorrect and misleading charts, graphics, research reports and techno-economic studies.

A recent example is detailed in the graphs below. Although the Table 1 graph shows the increasing disparity in China's control over the downstream of REE products, everything becomes sunshine, rainbows, and unicorns as the U.S. and Allied companies claim an improved proportion of the global EV and Wind manufacturing market. Table 2 (with accurate information) portrays a very different story… China is the critical material supplier for all EVs and Wind. Other critical material dependence issues are also absent in the progressive REE value chain.[46, 47, 105, 113, 137, 160, 161]

TABLE 1

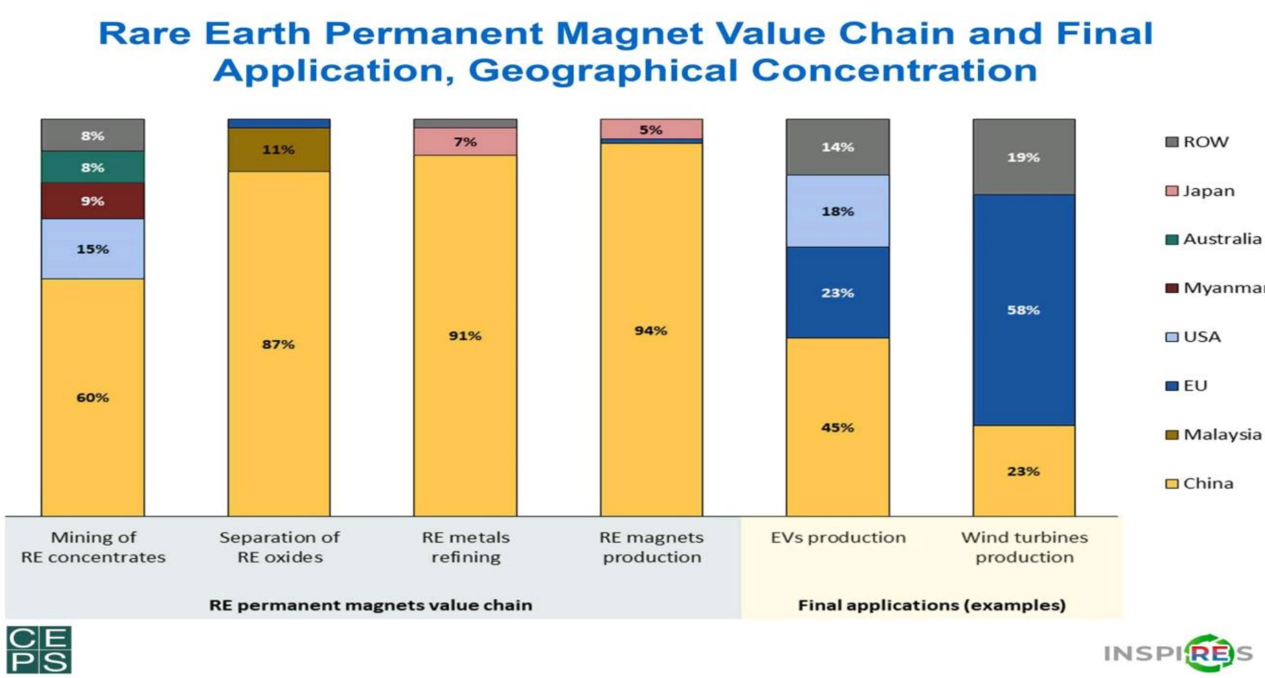
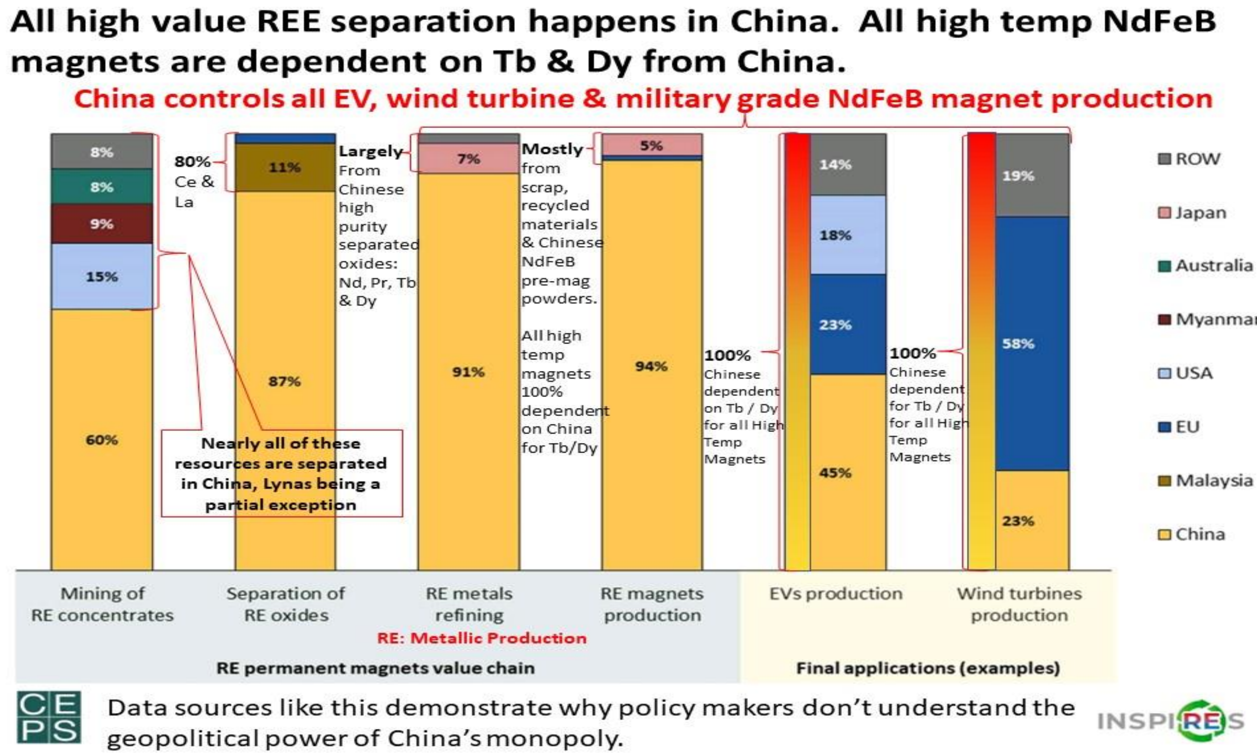
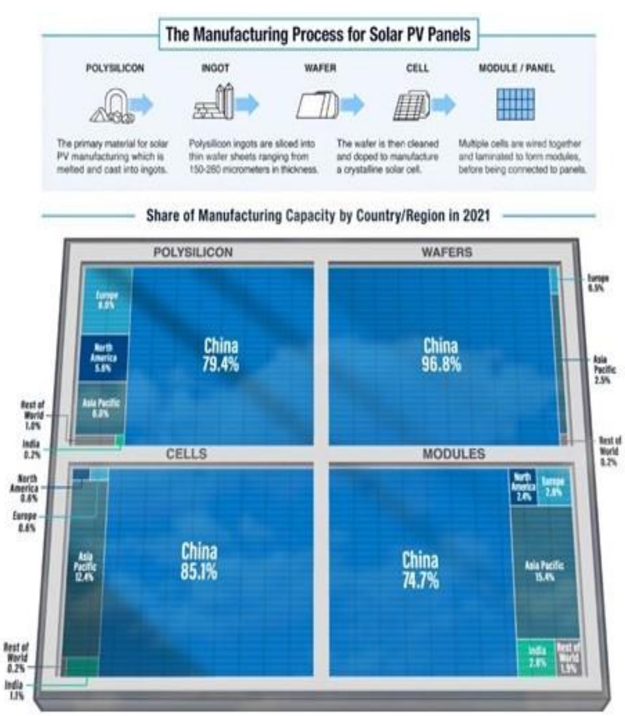


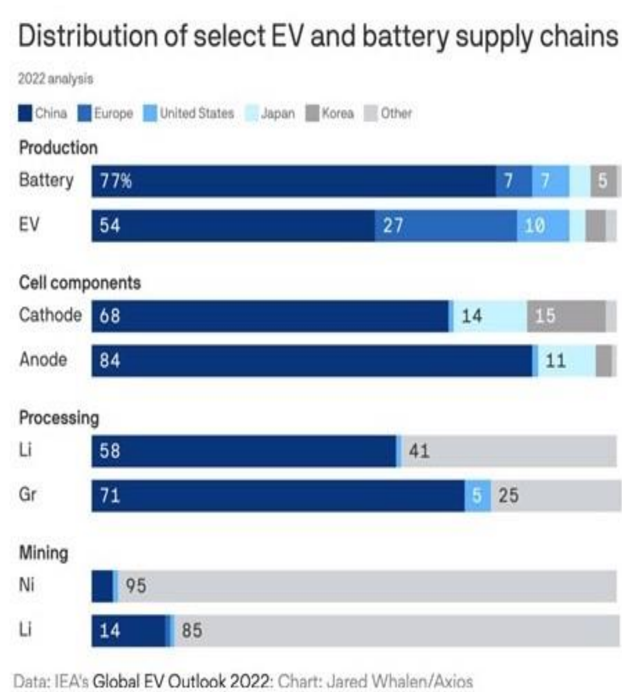
TABLE 2

The graphic above fails to detail China's overall dominance in EVs and wind turbines.



The picture of Chinese dependence is equally bad for the solar and EV battery markets: see below. (and most everything else: see 163)





For policy makers to develop realistic solutions, they need a better picture of how China has inserted itself into these markets at multiple critical junctures. The current narrative and limited level of due diligence make this task impossible.

This Document is intended to change that.

The Following Is A Chronological Outline Of Events That Were Central To China's REE Ascendance

Note that the NRC's re-classification of nuclear source material (under 10 CFR 40, Part 75), triggering the thorium problem, resulted in the transfer of all U.S., Japanese, and French REE refining, separation, metallics and magnet technology to China.

Ultimately, even the closure of the Molycorp's Mt. Pass mine was the direct result of thorium. Thorium was the offending constituent in the tailings spills that triggered environmental action and the mine's final closure.

U.S. production of high-operating-temperature NdFeB magnets, independent of China's monopoly, would require a solution to the thorium problem.

TIMELINE: CHINA'S RESEARCH INFRASTRUCTURE COMMITMENTS CHRONOLOGICALLY:[1] (1963/2022)

1963 China establishes Bayan Obo Research Institute in Mongolia.
1980 China establishes the Chinese Society of Rare Earths.
1983 China begins publication of Chinese Society of Rare Earths Journal.[i]
1983 China's first international rare earth patent application is filed.
1985 Chinese Society of Rare Earths reports that over 3,000 scientists and engineers at over 300 research institutes and 40 universities are working on rare earths in China.
1985 Baotou Research Institute of Metallurgy is renamed as the Baotou Research Institute of Rare Earths in recognition of the PRC's focus on Rare Earth. At this time this facility is the largest research organization in the world dedicated to rare earths. This is China's 1st dedicated rare earth National Laboratory.
1986 China establishes the national China Rare Earth Information Center.
1986 China launches Program 863 for the advancement of technology and material sciences, including rare earths under Deng Xiaoping.
1990 China begins Publication of the Journal of Rare Earths (published in Chinese and eventually in English).[ii]
1991 China establishes its 2nd National Lab for rare earth materials: the State Key Laboratory of rare earth materials, focused on chemistry and applications.
1991 The Chinese State Planning Commission formally places the entire rare earth industry under state control and prohibits foreign access or involvement in research, mining, exports, extraction or refining processes. Instead, foreign investment is encouraged to participate in "projects using rare earths."
1992 China establishes the Baotou Industrial Development Zone to attract foreign western corporations "for the purpose of technology transfer."
1992 Deng Xiaoping establishes rare earths as a central to China's industrial policy stating: "The Middle-East has oil, China has rare earths."
1995 China establishes the National Non-Ferrous Import Corp, focused on the import and export of rare earths and other technology metals and materials.
1995 China v ROW: Chinese rare earth production exceeds the rest of the world combined.
1995 U.S. – China: Following two years of negotiations General Motors agrees to sell its Magnequench division. Only two members of Congress challenge the sale.
1997 China initiates Program 973, to boost research and development of rare earths materials at the direction of Jiang Zemin.[iii] [iv]
1997 China's 4 highest ranking leaders establish and codify its 16-Character Economic and National Defense policy, stating: 'all national economic policies are also national defense policies'.
1997 China v USA: Cumulative Chinese rare earth patents surpass total U.S. patents (with China's first rare earth patent being filed in 1983 and the first U.S. patent in 1950).
1998 China begins closing the U.S. Magnequench facility and sends its employees to China to train Chinese workers. Magnequench is the only U.S. producer of RE magnets used in Tomahawk Cruise Missiles and other defense and technology systems.
1998 U.S. – China: During the acquisition and transfer of Magnequench to China, Lockheed Martin sells GA Powders, a company that originated within Idaho National Laboratory and producer of rare earth magnet powders, to Magnequench: effectively transferring this U.S. National Laboratory technology to China.
1998 China initiates construction of Neo Powder facility in China based on Magnequench patents, designs and equipment.
1999 China establishes its 3rd National Laboratory for rare earths in Mongolia – focused on Functional Materials Engineering.[v]
1999 China establishes the Inner Mongolia Rare Earth Group Inc., for the purpose of integrating rare earth R&D, production, and trade for the region.
1999 The Government of China announced it has stopped issuing new permits for rare-earth mining and limits on foreign investment in rare-earth processing plants and metallurgical operations. Foreign ownership of Chinese rare-earth mines was not allowed prior to these new restrictions.
2000 Neo Powders begins production of rare earth metal powders inside China.
2001 China establishes its 4th National Lab & Engineering Research Center for rare earths - focused primarily on Metallurgy.
2001 China becomes a member of the World Trade Organization.
2001 – 2020 China institutes numerous actions and policies to boost monopoly[vi], including offshoring mine production outside of China (circa 2015)
2010 – 2020 China's Shenghe acquires stake in multiple REE projects outside of China including the U.S.- MP / One Belt, One Road expands REE supply.
2021 Chinese rare earth patents surpass the rest of the world combined.
2022 China approves further consolidation of REE industry form 6 to 4.

[i] China's multiple RE Journal publications are significant on a comparative basis. By comparison the U.S. had only one REE publication series produced by Ames Laboratory. The Ames publication amounted to little more than a trade-sheet or an informal newsletter. To illustrate, when China announced that it had established the world's largest REE research facility, the Ames coverage was sparse and provided no commentary on the potential economic or geopolitical consequences.
[ii] Since 1983, in just 5 years, China's internal REE usage doubled, and production quadrupled.
[iii] Just two years before, U.S. closed its Bureau of Mines – ending the long-standing history of U.S. government's involvement in mining & minerals research.

TIMELINE: U.S.'S COUNTERPRODUCTIVE ACTIONS (1980/2006) U.S. FREE MARKET RESPONSE FAILURES (2010/2022)

1980 NRC (and IAEA) regulations result in termination of byproduct production RE's, thus ending 100% of U.S. heavy rare earth production, due to thorium. This regulation sparks the transfer of U.S. / western RE technology to China.
1980 U.S. Congressional Subcommittee on Mines and Mining publishes a warning on U.S. materials and resource dependence. At that time the U.S. was 100% import dependent on just 4 mineral commodities. Today the USGS puts U.S. supply risk on 50 mineral commodities[1] (half of the periodic table).
1980 Molycorp begins transferring rare earth ore beneficiation and processing technology to China.
1994 U.S. begins selloff of all DoD and then DoE Rare Earth stockpiles (All sales completed by 1996).
1995 U.S. Closes the U.S. Bureau of Mines– ending the long-standing history of our government's involvement in mining & minerals research.
1996 All U.S. DoE rare earth materials are transferred into the National Defense Stockpile, for public sale under Public Law 104-106.
1998 The entire remaining inventory of rare earths in the U.S. National Defense Stockpile are sold and shipped, including all previously held reserves with the Department of Energy. GM Sells Magnequench, the only U.S rare earth magnet producer, to Deng Xiaoping's family via a strawman transaction.
1998 Lockheed Martin sells GA Powders to Magnequench, and thus China. The metal powder IP originated within Idaho National Laboratory.
1998 Molycorp begins shutdown of Mt. Pass mine operations (all activity ends by 2002).
1998 Unocal halts production at its California based Molycorp rare earth separation facility in connection with environmental issues due to the discharges of mine tailings containing elevated thorium.
1998 U.S. Congress published the Cox Report, which outlined the ways and means that China uses to capture military and dual use technology, including rare earths and nuclear weapons technology via covert operations, financial incentives (to off-shore/relocate dual-use manufacturing facilities to China) and overt acquisitions.
2004 Apple begins manufacturing inside China.
2006 10-U.S.C.-2533B defines "Critical Materials" as alloys, thus allowing the Pentagon to ignore the practice of using Chinese metals and separated oxides across the entire defense industry.
2010 Molycorp, in the second reconfiguration of the Mt. Pass deposit, goes public and is bankrupt by 2015.
2017 President Trump issues Executive Order 13817: "A Federal Strategy to Ensure Secure & Reliable Supplies of Critical Minerals".
2020 MP Materials, in the third reconfiguration of the Mt. Pass deposit, goes public. The geochemistry is unchanged, and their near-term vs long-term operations and plans are similar.
2020 President Trump issues a second Executive Order 13953 – "Addressing the Threat to the Domestic Supply Chain from Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries."
2020 EXIM Board unanimously approves a new program: China & Transformational Export Program, to include RE's.
2021 President Biden issues Executive Order 14017 on "Americas Supply Chains" encouraging DOE, DOD, and DOC to examine their mineral supply chain risks and vulnerabilities.
2022 The Department of Defense gives MP Materials $35M for a U.S. separation facility and gives Lynas Rare Earths $120M for their U.S. separation facility. The geochemistry of both projects is deficient and incompatible with U.S. economic and national security needs.

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[iv] As noted in the 1999 Cox Report, in 1997 Jiang Zemin further defines China's industrial REE policy, stating "Improve the development and application of REE's and change resource advantage to economic superiority" 1997 China: China's 4 highest ranking leaders establish and codify its 16-Character Economic and National Defense policy, essentially stating: 'all national economic policies are also national defense policies'.
[v] 1998 China begins closing the U.S. Magnequench facility and sends its employees to China to train Chinese workers. Magnequench is the only U.S. producer of REE magnets used in Tomahawk Cruise Missiles and other defense and technology systems.
[vi] There are simply too many proactive actions, policies and refinements to China's REE policy to list

PART 4 - HUMAN CAPITAL IN RARE EARTH NATIONAL LABS AND COMMERCIAL ENTERPRISES

4.1 Estimating the Size of China's REE Research and Production Workforce:

The ability to confirm estimates of the number of people directly employed in REE research, production, and commercial enterprises is difficult as there is very little public data to rely upon. Most data available is not current. Consequently, this section only includes estimates. The estimates provided are not intended to be numerically precise, but to reflect the probable proportion of magnitude in scope and scale.

The goal of this section is to estimate the total number of full-time people working on REEs in a government sponsored capacity (national labs, universities, and agencies) and the number of people working in a more traditional commercial capacity (mining, refining, separation, metallics, and fabrication).

The following estimates cover researchers in full-time REE "research" across China's four national labs, hundreds of supporting research facilities and at least 39 universities, and "commercial" endeavors carried out by China's mining, refining, separation, metallics and magnet fabrication industry.

China is estimated to have over 12,000 full-time REE researchers working in its four national laboratories, hundreds of supporting research facilities and at least 39 university settings that specialize in REEs.

The U.S. is estimated to have as few as 100 full-time researchers working on REEs, on a full-time equivalent basis, across its National Lab system. Based on a recent survey of America's top mining universities, the U.S. may have as few as 200 full-time equivalent REE researchers working in its universities.[(see 169)] For example, the Ames / CMI REE funding dates back to just 2013. Most, if not all, university REE research was funded as recently as 2016.[(see 169)]

China is estimated to have over 300,000 full time employees working in the commercial REE sector. By comparison the U.S. has less than 405[164] full-time (or full-time equivalent) "commercial" workers in the mining, refining, metallics space.[165] Note that 216 of the 405 full-time workers, those currently working at MP (the only U.S. producer of REEs), produce REE concentrates for China. The domestic Samarium-Cobalt (SmCo) magnet industry produces magnets nearly exclusively for military applications. Some or all these domestic producers are acquiring separated Sm from Chinese sources. The domestic SmCo industry employs approximately 130 full time employees.

4.2 Research and Development:

China's commitment to REE research dwarfed the combined efforts of the rest of the world combined as early as 1985. In 1985 China announced the re-naming and formal establishment of what equates to its first National REE Laboratory, supported by over 3,000 scientists and engineers, with over 300 research institutes and 40 universities that have dedicated REE programs. That was nearly 40 years ago. Neither the U.S. nor the European Union have a single committed government facility or university dedicated to REE research.

According to the Biden administration's 100-day review, "Building Resilient Supply Chains, Revitalizing American Manufacturing and Fostering Broad-Based Growth," "China has 39 universities granting mineral processing and metallurgy degrees, [producing] thousands of undergraduate and graduate students [each year]… 'by comparison the U.S. has only a handful.'"[166] It should be noted that not a single U.S. university offering mining majors has developed a comprehensive or focused program in mining, refining, separation, metallic conversion of REEs[167] and none are equipped to handle thorium.

The estimates in this Document build on the 1985 announcement from the Chinese Society of Rare Earths, reporting that over 3,000 scientists and engineers at over 300 research institutes and 40 universities were working on REEs in China at that time. Assuming that today each of the other 3 national labs are supported by 3,000 employees, the total personnel could exceed 12,000 professional scientists, researchers and technical people presumably all working on the Chinese Government's payroll.[168] This estimate does not include the many administrative, coordinating, import and export agencies that manage China's national monopoly[169] across its four primary SOEs and all supporting institutions.

The only U.S. national laboratory that focuses on REEs is the Ames Laboratory in Iowa. When asked how many full-time and full-time equivalent REE researchers worked at Ames (and the associated CMI Institute) they refused to provide details. Based on a statement provided by Ames, the total number of full-time researchers appears to be zero (and no effort was made to estimate full-time equivalent researchers).[170] Estimates provided from five of America's top mining universities for full-time-equivalent REE researchers totaled less than 21,[171] (with no full-time REE researchers at any school[172]). Requests for the same information directed to the DoD and DoE went unanswered.

4.3 Mining:

China's leading SOE for REEs operates the Bayan Obo Mine[173], which is the largest REE producer in the world.[174] All REE production at this mine is a byproduct of iron ore mining, giving China a significant production cost advantage.

The Baotou enterprise, now called Northern Rare Earth, has 49 branches and wholly owned, holding, and shareholding companies, distributed in 12 provinces and autonomous regions across the country.

The REE portions of this enterprise make up China's, and the world's, largest comprehensive

REE technology research and development group. The following National Laboratories associated with the Baotou Research Institute for Rare Earths include: the State Key Laboratory of Bayan Obo Rare Earth Resources Research and Comprehensive Utilization, the National Engineering Research Center for Rare Earth Metallurgy and Functional Materials, the "National New Material Testing and Evaluation Platform-Rare Earth Industry Center and the International Cooperation Base for New Rare Earth Materials. This institute also supports several national innovation platforms, as well as the Northern Rare Earth National Enterprise Technology Center and the largest pilot test base for new REE materials in China.

All the facilities mentioned above were generated from a single SOE. There are three other semi-independent SOEs that operate under China's newly consolidated management and control system. This is what non-China companies like MP and Lynas face. The long list of China's other subsidies and structural advantages detailed in this Document suggest that the continuation of traditional market-based solutions is destined to fail.

China has at least 30 large and medium scale REE mining operations, including the Bayan Obo mine in Baotou (inner Mongolia). The Baotou mine employs 22,000 people[175] mostly employed in the production of iron ore. China also has an unknown number of small mining sites.[176] Typical large and medium scale mines in the U.S. can employ over 1,000 or fewer than 400 people. Assuming each of the 30 Chinese mines employ only 400 people, China's primary REE mines could employ at least 12,000 people.

4.4 Viability Test of Chinese Mining Workforce Estimate:

Lynas, an Australian REE mine, employs 848 people in its mining and concentration operations and claims to produce 7% of global production. Prorating this ratio of people to global production to the number of people employed by China (for the 93% balance) would suggest that China has over 12,000 people in the REE mining and concentration sector.

By contrast, the only U.S. mine, MP, does not conform with this viability test. MP should not be considered a large or medium scale mine but should be considered a small operation based on its tonnage of production and operating personnel. The MP mine employs approximately 216 people in the mining and concentration activities and claims to represent approximately 15% of global REE production, but in reality, only represents less than 3% of REEs that are in economic demand. If one were to compare the ratio of MP's 15% REE production claim with its employment numbers when compared to China's official REE production levels, China would have less than 1,500 people engaged in REE mining (and less than 9,000 at the 3% level). Comparing MP's employment to production ratios to China's REE mining industry is not applicable. (Further, note that all the MP workers technically feed China's REE industry.)

China has an estimated 1,000 smaller REE mines, many operating outside the control of the SOE.[177] Estimating that each of these mines employs approximately 10 people each, would result in 22,000 people directly employed in REE mining and concentration in China (see alternate but confirming calculation[178]).

In summary, the U.S. has one mine with 216 employees compared to possibly over one thousand mines with 22,000 employees in China. The one U.S. mine ships all its REE concentrate to China for downstream production. The U.S. mine developers claim that they will produce 1,000 tpy of NdFeB magnets (most likely Ce+NdFeB magnets) but they do not have access to Tb or Dy. Therefore, in its best case, this mine could only produce low value / low-operating-temperature NdFeB magnets which cannot be used in EVs, Wind or military applications. China's low margin on the production of metallics (typically 5%, to include a 13% cost advantage via China's VAT) suggests that the single proposed U.S. project will not be economically competitive.

Based on China's geopolitical desire to control 100% of all critical resources for advanced technologies, there is little reason to believe that China will tolerate this encroachment, unless it suits them (Note that if MP only produces 1,000 tons of NdFeB magnets per year then over 99% of its Nd and Pr may still be going to China. Based on the total production under "Chinese control," including Myanmar, Thailand, Vietnam, and the U.S.,[179] the Chinese employment number potentially exceeds 30,000.[180]

4.5 Refining and Separation:

China's REE separation industry is disproportionately massive. China has two cities, Baotou and Ganzhou, that are officially referred to as REE cities. Both cities have significant levels of industrial and trade activities related to the advancement of China's REE industry. The combined population of these two cities is 17 million people.

The only public information on refining and separation dates back to 2013 (based on 2010 data).[181] The information source stated that there were many small facilities for extraction, processing, and separation of heavy REEs in South China, and stated that only a few of the official 170 registered refiners had capacities above 5,000 tons per year.

Due to the lack of information, it has been estimated that 1% of these two combined cities' population works full-time directly or indirectly in the REE industry.[182] The activities that were referenced in the many other provinces have been ignored. This results in an estimate of 170,000 people directly working in the post-mining REE sector in China, primarily in refining and separation.

With entire cities and regional districts dedicated to the refining and separation of REEs, managed under its four SOEs, China's scale of efficiency is unmatched. Based on parsing Chinese public statements, China has close to 200 percent of the global REE separation capacity[183] — far exceeding present global demand. Small, stand-alone, non-integrated and/or piece-meal U.S. operations are unlikely challengers to China's dominance.[184] Worse yet, the 2015 bankruptcy of Molycorp[185] demonstrated that under challenging market conditions, competitive non-Chinese producers would undermine each other.[186]

4.6 Metallics and Magnetics:

The only public information available on China's metallic industry dates to 2013[187] (based on

2010 data), stating that NdFeB magnet producers were small and scattered. The 2010 data estimated that there were “only” 130 NdFeB producers, but China’s magnet making capacity of 150,000 tpy today infers that this information may be correct.

Based on data released by one of China’s most efficient magnet producers, JL MAG Rare-Earth Co., it has been estimated that the total number of people involved in NdFeB magnet production, based on a ratio of one employee per 3 tons of NdFeB magnets times 190,000 tons, is 63,000 workers. This does not account for the REE metal feedstock, which is estimated to add another 40,000 workers.[188]

Based on all of these estimates, it appears that China employs at least 100,000 people in the production of NdFeB magnets, from REE metal production to strip casting, through final machining, coating, and fabrication.

4.7 Viability Test of Workforce Estimates:

Workforce estimates can be tested against the total market value of China’s NdFeB magnet production (equal to ~95% of all REE product value)[189] vs. labor and input cost estimates. The following calculations are intended to simply demonstrate that estimates used for total labor and input costs[190] will result in a small profit.[191]

The 2021 average income in China was 97,397 Yuan. This is equal to approximately $14,000 U.S. dollars,[192] for a total labor cost of 4.2 billion USD.[193] The 2021 value of China’s NdFeB magnet production was approximately $14.3 billion.[194] This value represents close to 95% of all REE product value. Based on this estimate, the total estimated value for all REEs would be approximately $15 billion USD. The value of the raw material inputs, which consist of primarily separated Nd, Pr, Tb, Dy, Fe and B, have been estimated at approximately $45 per kg (blended cost for average temp magnet in 2021 time period)[195] multiplied by 216,500 tons multiplied by 1,000 kg per ton, for a total amount of approximately $10 billion USD.

Based on a check of the workforce estimates and the estimated material costs versus the inputs, the total cost of REEs production would exceed $14 billion USD vs $15 billion USD sales – based on mid-level pricing. In weaker magnet-price markets, the labor and input cost could exceed sales. This profitability check does not include the cost of 12,000 researchers and countless other administrative, monitoring and controlling agencies.

This viability test was prepared to confirm that the estimated employee ratio and input cost allows for only modest profitability under most market conditions. This is consistent with China’s single digit profitability targets for magnet and metal production (behind the curtain of the VAT rebate). In fact, historically, China has reported losses for the REE industry in challenging markets.

This above calculation demonstrates the plausibility of this REE workforce estimate. This Document’s crude estimates are intended to stimulate a more detailed investigation into this subject.

PART 5 - CONCLUSION

Many of the DoD- or DoE-sponsored projects have not considered the structural advantages described above at a functional level. This is also true for many/all privately-funded U.S. projects. The government's ongoing "wait-and-see approach," or its improper funding of inadequate U.S. projects has amounted to a two-decade license of undisputed Chinese dominance. From the information provided in this Document, it should be clear that all future U.S. and Allied policy measures can be easily offset by China's structural advantages.[196] In many cases they are contributing to China's monopoly and geopolitical goals (directly or indirectly). A change in overall U.S. strategy is seriously overdue.

PART 6 - RECOMMENDATIONS

6.1 Offsetting China's Hard Subsidies

The U.S. and its Allies need to develop a solid credible plan to off-set China's hard subsidies and monopolistic pricing risks. To accomplish this, a production tax credit for 100 percent domestic content and downstream value adding, similar to the original 117th Congressional version of H.R. 5033, is necessary.[197] Policy makers should consider reserving the maximum tax credit for the production of high-operating-temperature NdFeB magnets containing heavy REEs when 100% of the content is mined and modified in the U.S. (with a lower allowance for high-operating-temperature magnets containing up to 10% Allied content) and a lower tier for low-operating-temperature NdFeB magnets containing 100% U.S. content, but no heavy REEs. An alternative would be to have the production tax credit set a baseline for heavy rare earth magnets having thermal/magnetic stability, as measured by intrinsic coercivity (Hcj),[see 37] of 80^{o}c or more and provide incentives for increasing thermal stability vs. additional heavy REE content. This will promote innovation and preserve resources (when produced with 100% U.S. content and a lesser amount if the magnet included Allied content).[see 135] To meet U.S. national security and technology needs, any new or amended bill must include tax credits to produce REE base-metals & alloys (not used for magnet production) and garnets.[198] The current proposed tax credit duration may also prove to be insufficient.

6.2 Offsetting China's Soft Subsidies

The U.S. and its Allies need to off-set China's soft subsidies, including a reduction to the cost of capital, off-setting or supplementing investor return expectations (e.g., something like the 117th Congressional version of H.R. 5033), government investment into basic science, applied science, education, and the promotion of industry integration. To accomplish this, the U.S. government (and Allied governments) must focus on supporting and/or financing fully integrated REE projects (non-integrated projects are subject to Chinese price and supply manipulation[199]). The Federal government must preferentially fund scholarship programs in STEM sciences[200] with a focus on material science and the re-establishment of the Bureau of Mines.

6.3 Addressing the Thorium Problem

The U.S. and its Allies need to offset China's many structural advantages, starting with a solution to the thorium problem. To accomplish this, the NRC must employ “special exemptions” (currently available to the NRC) for the management and storage of thorium, including the development of industrial uses and markets for thorium, including energy. It is anticipated that a legislative proposal will be provided to members of Congress later this year. Solving the thorium problem solves the heavy rare earth problem[201] as well as making Tb, Dy, Ho and other heavy rare earths domestically available at, or in excess of, current U.S. / Allied demand.[202]

6.4 Further Legislation

The U.S. Congress should compose a broad-based Critical Materials bill that codifies standardized mining and environmental regulations that states can adopt.

The legislative product should offer a one-stop portal that would manage all state and Federal permitting and environmental study requirements.[203]

To promote adoption of National Standards at the state level, the Federal government should provide an incentive to the states. One such incentive would let the State “administer” the new portal system that would be fully funded by the Federal government.[204] An alternative could allow states to opt for an EPA-administered program.

All current Federal regulations should be streamlined. All mediums and venues for challenging fully compliant projects, including permitting, and other “social license issue” challenges must be classified as non-binding if all applicable regulations are met.[205]

This proposed legislation should be limited to critical material resources. Congress should avoid including traditional natural resource issues in the legislative process that are contentious, such as resource depletion tax or social license issues.

Legislation should address the many other “non-market” distortions specific to other critical materials that result from China’s monopolistic and geopolitical strategies. For example, China’s state-sponsored resource acquisition program, China’s national R&D investment into material and processing science, the relative cost of capital and the disparity in investor return expectations.

The Federal government needs to consider developing one or more national laboratories that focus on critical materials and material science, specific to commercial applications (with the obvious benefit to military applications). This is how China does it.

6.5 Policy Recommendation

Fostering Informed Policy. This policy recommendation has been reserved for the end of this Document because its conclusions are specific and targeted at policymakers.

When attempting to close research or technology gaps, the scale of resource commitment by a trailing entity or country seeking to displace the leader in the industry needs to EXCEED the leading entity’s commitment. The current market and policy landscape strongly suggests that the U.S. (and the European Union) has not made the political or commercial commitment required to seriously challenge China in the REE or Critical Materials space.

What accounts for the lack of commitment? To date, policymakers have never been presented the scale of structural risks that the U.S. faces as it relates to REEs (as detailed in this Document). The information in this Document should provide policymakers a guideline for developing strategies to solve the critical materials problem before them.

Concurrently, many research institutions and private ventures have petitioned the U.S. government for financial support without providing a professional analysis of the commercial obstacles they face in the REE industry. These long-standing omissions have collectively contributed to the U.S.'s failure to stage any realistic challenge to China in this industry.

After two decades of relying on inadequate disclosure and research for U.S. policy and investment decisions, the U.S. situation has further degraded. Concurrently, a large contingent of experts have been ignored because their message was unwelcome.[206]

If the U.S. Congress (or the current Biden Administration) has an interest in challenging China's dominance, the House and Senate must hear from an alternate panel of REE market experts and practitioners, equally balanced against the current stable of experts, enterprises, and research organizations that have failed to investigate or disclose the scope and scale of China's advantages.[207]

The authors of this paper[208] would like the opportunity to provide comprehensive and unbiased data, detailed above, to the U.S. Congress and the Biden Administration.

END NOTES*

*Note on END NOTES: END NOTES will include links to supporting articles or literature, graphics, clarifications, or additional details of a statement, continuation of the narrative, other statements and helpful links.[209]

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[1] Contributor: Dr. George Bauk is the Executive Director of PVW Resources Limited and researcher and author for a number of EU policy groups.

[2] Peer Review: Dr. Anthony Caruso, Professor of Physics and Electrical Engineering, Associate Vice Chancellor for Research at the Missouri Institute for Defense & Energy (www.umkc.edu/mide), focusing innovation for manufacturing reshoring and circular microeconomies.

[3] Peer Review: Pete Chin is studying critical material supply chain security as a Hoover Institution Veteran Fellow and earned an MBA from the University of Oxford, a master of international affairs from Columbia University focused on international security with a specialization in the Middle East, and a BA from the University of Chicago in international relations (more on Pete: Pete Chin | Hoover Institution).

[4] Peer Review: Dr. James Conca, Trustee of the Herbert M. Parker Foundation of WSU, a 40-year expert in energy and nuclear power with a PhD in Geochemistry from Caltech.

[5] Contributor: Dr. Sotiris N. Kamenopoulos holds a PhD from Technical University of Crete, Greece, School of Mineral Resources Engineering. Dr. Kamenopoulos' field of research is related to sustainable exploitation of mineral resources and Social License to Operate.

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disclosure, the lead author of this Document owns the former Pea Ridge iron ore mine in Missouri. Rare earths were/are a byproduct of iron ore production. [see 61]

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[9] Contributor: Ned Mamula, PhD Geology, former USGS, mineral resource geologist, and Author of *"Groundbreaking!" America's New Quest for Mineral Independence*, 2018.

[10] Peer Review and Introduction: Guillaume Petron, An award winning French journalist, author, researcher, documentary film maker and author of The Rare Metals War, originally released in 2018.

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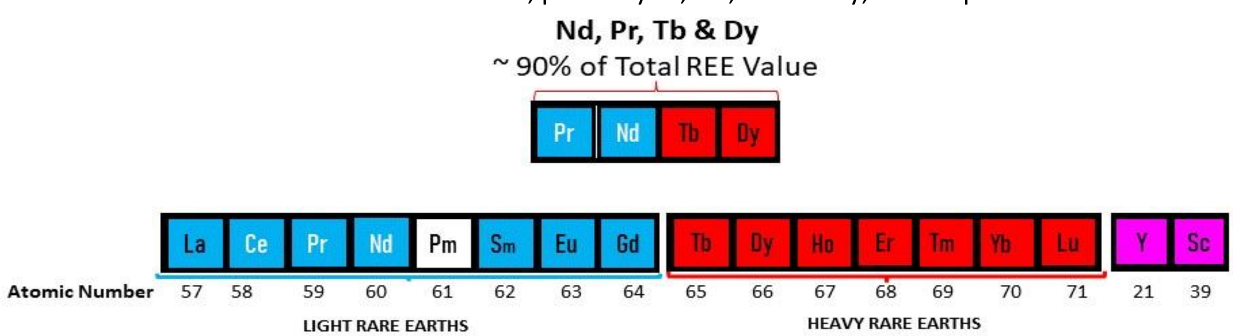
[12] There are six Anonymous contributors. These contributors are currently working in the REE magnet production industry, REE material trading, two who act as industry consultants (one of them an international REE magnet patent expert, someone associated with a U.S. heavy REE project and one academic/researcher (partially funded by China). None want to jeopardize their business, employment, or professional relationships so they have elected to remain anonymous.

[13] The official classification of light and heavy REEs. Note that just four REEs, Pr, Nd, Tb and Dy make up 90% of all REE value. Also note that metallic REEs, primarily Pr, Nd, Tb and Dy, make up 95% of all REE value.



Official USGS Classification of light and heavy rare earths
https://pubs.usgs.gov/circ/1454/circ1454.pdf

Note: Y and Sc are not Lanthanides and have lower atomic weights than any of the other elements
Note: Historically Scandium was included in the USDS heavy rare earth classification
Note: Pm is not found in the earth's crust and is not commercial element

However, some REE mining companies misleadingly include light REEs as heavy REEs in reports to investors, the DoE and DoD. The Pentagon also uses this inaccurate methodology to fund projects that do not meet the funding requirement that were established (specific to heavy rare earths).

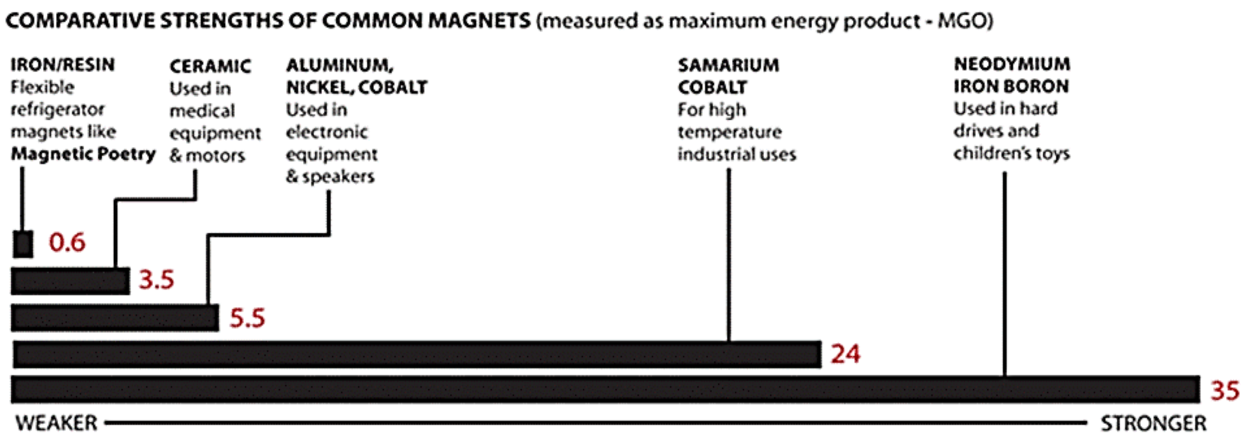
[14] High-Operating-Temperature NdFeB Magnets: Temperature resistance can be achieved by doping the NdFeB magnet with Tb, Dy and / or Ho. Tb, Dy and Ho which are heavy rare earths, typically not present or in very small quantities in REE deposits like MP and Lynas. Temperature-resistant, or high-operating-temperature NdFeB magnets, are used in high-temperature and performance critical systems such as EV drive motors and U.S. weapon systems. Standard, or low-temperature NdFeB magnets, cannot be used in these applications.

Understanding Magnet Strength vs. Operating Temperature (loss of magnetic strength) vs. Curie Point (no longer magnetic) and how doping NdFeB magnets with Tb and Dy increase the operating temperature for important applications like EVs and Weapon Systems.

Operating temperatures for EVs, Wind and weapon systems differ and variability of magnetic performance at higher temperatures affect the performance, safety, and precision for each application.

For EVs the weight of the drive train motor is primarily a function of magnetic strength. Vehicle range (and dynamic braking) becomes a function of magnetic performance under elevated operating temperatures. Consequently, these constraints eliminate ferrite and AlNiCo magnets as an option. The SmCo magnet is eliminated due to its lower magnetic strength and much higher cost. However, the undoped NdFeB magnet's operating temperature is far too low for normal EV (and hybrid) operational conditions (drive-motor and dynamic breaking, etc). Consequently, OEM / end-users must balance the many variables of magnetic strength, the cost of doping (with Tb / Dy) or the substitution of a lower strength magnet for higher operating temperatures. In the end it comes down to consumer preferences. Extending range directly correlates to higher consumer demand, and thus profits. Maximizing range is best achieved by using Tb/Dy doped NdFeB magnets.

The problem is that Tb and Dy are not recoverable in commercial quantities from deposits like MP's Mt. Pass mine (and will not be until the "thorium problem" is solved). The Australian Mt. Weld deposit mined by Lynas has very low ratios of Tb and Dy, relative to its Nd (and Pr) and cannot separate Tb and Dy so it remains 100% dependent on China for separation (plans to separate these materials in the U.S. may be in jeopardy, as the Lynas / Blue Line collaborative effort has been terminated). Consequently, any high-operating-temperature NdFeB magnet (doped with Tb/Dy) produced outside of China will remain nearly 100% dependent on China for separated Tb and Dy. However, utilizing Chinese Tb / Dy will disqualify the producer for U.S. tax credits, so no U.S. NdFeB manufacturer will produce high-operating-temperature NdFeB magnets. In other words, China continues to control U.S. and Allied access to all EV, large Wind and military grade magnets.



Magnet type	Max. Working Temperature (deg. C)	Curie Temperature (deg. C)
NdFeB-s		
N	80	310
M	100	340
H	120	340
SH	150	340
UH	180	350
EH	200	350
AH	230	350
SmCo-s		
SmCo5	250	750
Sm2Co17	250-350	800
AlNiCo		
Sintered	450	760-890
Cast	450-550	810-890
Ferrite-s	250	450

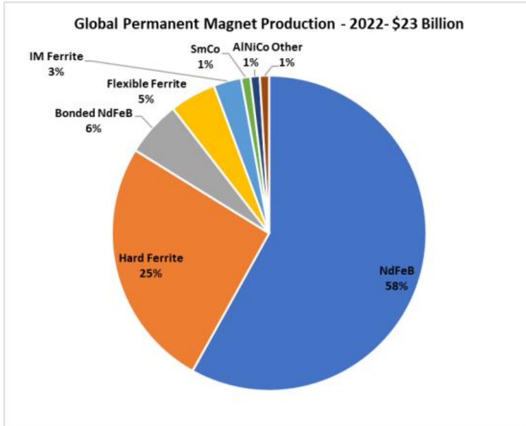
Working temperature increases with the addition & increasing levels of Tb and or Dy (with Ho substitution

[15] The standard NdFeB rare earth magnet is comprised of Neodymium (Nd), Iron (Fe) and Boron (B), also expressed as $Nd_2Fe_{14}B$ or the generic ratio by weight-percentage 29% Nd, 70% Fe, 1% B. The Basic M-Grade NdFeB magnet has a low tolerance to heat and its magnetic strength is reduced at 80ºC. A true NdFeB magnet with no HREE doping loses strength at 65ºC.

[16] This paper is focused on the NdFeB magnet, comprised of Nd (Neodymium), Fe (Iron), Boron (B). These are the most widely used rare earth magnets in the world. The un-doped NdFeB chemistry is incompatible with high-temperature operating environments (above 65^{O} C). Today the standard, or Basic M-Grade NdFeB is typically doped with small amounts of Dy to bring magnetic stability up to 80ºC. To assure reliability in higher-temperature operating environments the magnet chemistry is doped with Terbium (Tb), Dysprosium (Dy) or Holmium (Ho). Access to Tb, Dy and Ho is central to China's monopoly. Undoped NdFeB magnets cannot be used in EVs, Wind or military applications and no non-Chinese magnet manufacture has access to separated Tb, Dy or Ho. This issue is central to this Document.

The graphic below details global production of all types of permanent magnets. NdFeB sintered and bonded magnets equate to 64% of all permanent magnets. High-Operating-Temperature NdFeB magnets make up approximately 45% of all NdFeB magnets and well over 80% of the total value.

SmCo magnets equal about 1% of all magnets and are primarily used in military applications.



[17] Elon Musk's recently announced plan to produce EVs without REE drive-motors may prove to be short-lived, as his original EVs were built without REE drive-motors but consumer preferences for range and performance forced him to use REE drive-motor. see 14

[18] It is exclusively on the U.S. and Allied governments to create a solution to this problem. The monopoly is maintained to undermine the U.S. and Allied governments. Expecting the private sector to pull a "win" only demonstrates that no one has fully evaluated the strength, breadth, and depth of China's monopoly. There are no "free market" solutions to overcoming a monopoly administered by a powerful sovereign government in the absence of another sovereign nation (or nations) balancing the scale. The government of China, through its SOEs, has established and maintains control over access to downstream rare earths metals, alloys, magnets, garnets, and other critical materials as a geopolitical strategy of technological hegemony. This control gives China the power to capture IP and on-shore industries — and to even shut down the production of consumer, industrial, and defense products everywhere outside of China. How or why would anyone continue to think there is a traditional fix to this problem?

[19] The 1980 change to 10 CFR 40 part 75 defined any "processed or refined" material containing over .05% Th and or U as nuclear "source material." The change affected all byproduct production of REE in the U.S. (and IAEA-compliant states as the IAEA adopted the same language). REE ore, typically monazite, was the only source of heavy rare earths in the U.S. and Allied countries. The change in regulations pushed U.S., French, and Japanese REE companies to shift technology and production into China.

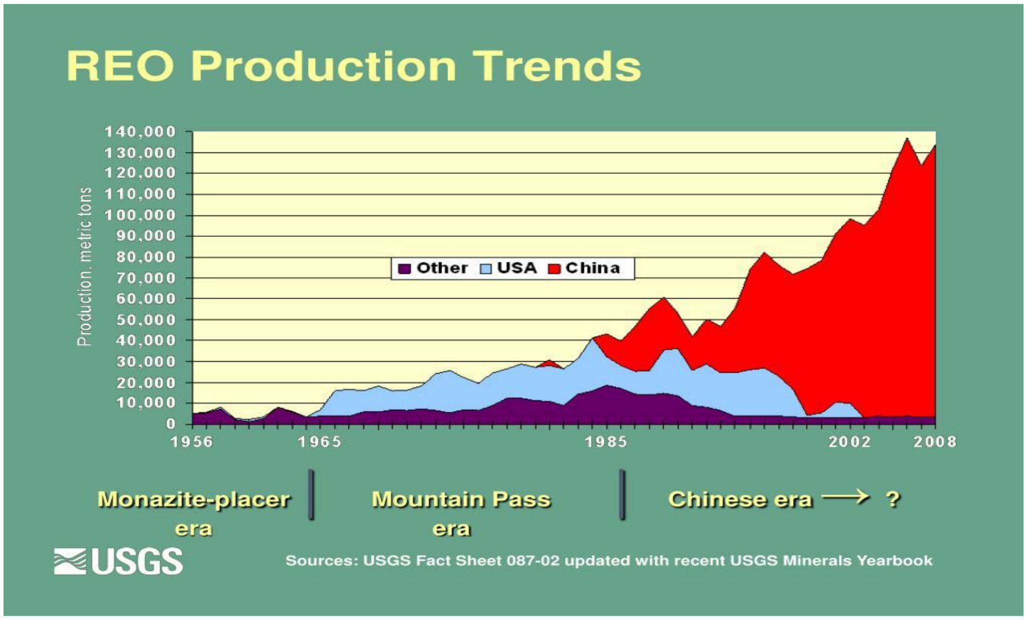
[20] This facility alone is 10 times larger than the current U.S. commitment to rare earth research. This facility is now but one such facility in a large constellation of other Chinese state and "private" research facilities.

[21] Made possible through the transfer of U.S., French, and Japanese technology. The technology transfers were largely driven by changes to regulations covering thorium in 1980 (10 CFR 40, part 75): the thorium problem.

[22] The acquisition of Magnequech, the only U.S. rare earth magnet producer for advanced electronics and U.S. weapon systems. The technology was indirectly acquired by the family of Deng Xiaoping, the leading political figure in China.

[23] China's first known outside acquisition target was the bankrupt Mt. Pass mine in 2005. China went on to invest in many other rare earth projects following the U.S. / Japan World Trade Organization (WTO) "victory" over China's restrictive export policy. The WTO "victory" gave China license to flood the market with light REEs and bankrupt Molycorp and Lynas (Lynas was bailed out by the Japanese government and its investors / off-take customers so it was never *technically* bankrupt). The influx of light REEs eventually resulted in hundreds of bankruptcies across the many public and private REE mining projects

that popped up as a consequence of the REE pricing bubble created as a result of the Japanese REE embargo in 2010. This allowed China to assess and select acquisition targets from hundreds of financially distressed projects.



[24]

[25] China Bans Rare Earth Exports to Japan Amid Tension (cnbc.com)

[26] The REE price bubble attracted at least $10 billion into over 400 REE mining projects over the next 5 years. By 2015 the only two fully funded projects were bankrupt (with Lynas being bailed out by the Japanese government and others). This created a buying opportunity for China, as many of these projects had identified potentially valuable resources and were willing to accept Chinese equity ownership to remain afloat.

[27] Rare earth miner Molycorp to start bankruptcy sale of business | Reuters

[28] Lenders rescue rare earths producer Lynas from collapse | Reuters

[29] The lead author warned the Administration, Congressional offices, and the Pentagon that the WTO case was a ruse that resulted in a Chinese victory: win or lose (China loses trade dispute over rare earth exports | Reuters).

[30] First covered in the book "Rare Earth Industry: Technology, Economic and Environmental Implications" published by Elsevier and then in a series of conferences beginning in early 2017. The lead author published a paper with the SME and presented this theory at a number of rare earth conferences in 2017, including the Society of Mining, Metallurgy, and Exploration (SME), the ERES 2nd Conference on European Rare Earth Resources and the Argus America's Rare Earth Summit. The "theory" proved to be accurate, as China has offshored a substantial portion of its mining resource needs to other countries (with internal production falling from 97% to 60% of global demand), while China's downstream monopoly remaining intact if not bolstered.

[31] Magnets, alloys and metals represent 95% of all REE value and the downstream point of application for OEM / end-users. China determined that it was best to focus on the downstream value chain and now cultivates REE mining outside China to feed its monopoly.

[32] The term "*new metals and magnets*" excludes metals and magnets produced from recycled materials (representing a large proportion of non-Chinese metal and magnet production).

[33] The reopening of Mt. Pass, first Molycorp in 2010 and then as MP Materials in 2020, was complementary to China's strategy of outsourcing resource production as all production for both companies went and continues to go to China.

Molycorp was bankrupted by China in 2015, and Lynas required a bailout in 2016, after the WTO demanded that China lift REE export restrictions in late 2014 (members of Congress and the Pentagon were warned that a WTO victory was a trap). As required under the WTO 'victory', China lifted restrictions and flooded the market with light REEs. The influx of light REEs eventually resulted in hundreds of bankruptcies across the many public and private REE mining projects that popped up as a consequence of the REE pricing bubble created as a result of the Japanese REE embargo in 2010. This allowed China to assess and select acquisition targets from hundreds of financially distressed projects.

Because no one has bothered to fully educate policy makers on the intricacies of China's monopoly, they fail to understand that China uses our system of laws and economics to bolster its advantage.

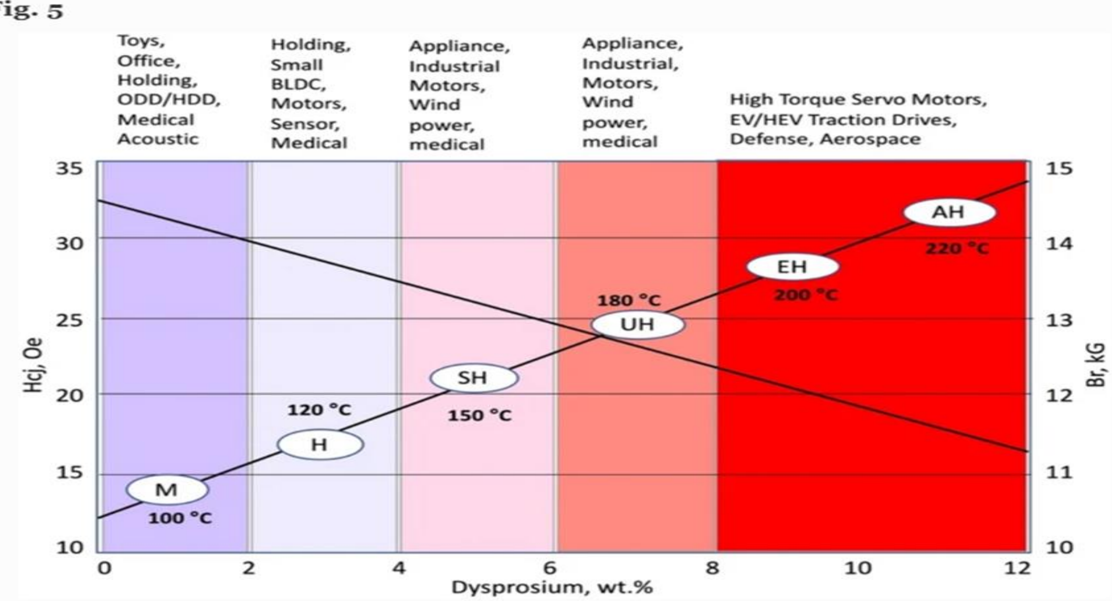
[34] Making a concentrate of mixed REEs from raw ore.

[35] The extremely complex process of separating each of the REEs to a commercial purity: typically, 99.9% or higher.

[36] High purity oxides are converted to metal alloys. These metal alloys are then ground into powders which are pressed, bonded, or sintered into magnet shapes. The pre-magnetic shapes are typically coated in nickel or some other protective layer (REEs are very reactive with oxygen and will quickly oxidize). The coated shapes are then magnetized.

[37] Without Dy and or Tb doping, the magnetic properties of a NdFeB magnet degrades at temperatures over 65°C. These magnets have limited application. Higher value applications begin with the Basic or M-Grade NdFeB magnets doped with small amounts of Dy. These M-Grade magnets are only stable up to 80°C. Wind, EV, Aerospace and defense systems require significant amounts of Dy. Currently China has 100% control over separated Dy (Tb and Ho). Allied producers tend to withhold this sort of information from investors, policy makers and the DoE & DoD, leaving a trail of 15 years of policy failures in their wake (but still holding their hands out for more funding).

Fig. 5



Effect of Dy on Nd-Fe-B's coercivity and the operating temperature for various applications. Adapted from M. J. Kramer.[10]

Coercivity - Is the measure of a permanent magnet's resistance to being demagnetized. It is an intrinsic property of a magnet but in NdFeB magnets decrease with increasing temperature. The higher the value of coercivity the greater the magnitude of an external field in an application e.g. the rotor in an electric motor, the magnet can withstand without becoming demagnetized and degrading the performance of the motor.

[38] Metal alloy powders are sintered or bonded into shapes. These shapes may be further machined into precise final forms and then coated with Nickel or some other protective coating and then magnetized.

[39] Legislative policy tends to reflect the incomplete information provided by REE companies. Academic and think tank input into the Congressional process mostly reflects the same information used by REE companies seeking funding. Contributions from the DoE, DoD, U.S. Geological Survey (USGS) Congressional Research Service (CRS), and Government Accounting Office (GAO) literature tended to follow the same narrative and, in some cases, official reports contain graphics and explanations that were produced by MP and Lynas. To the extent that DoE, DoD, USGS, CRS, and GAO reporting expands beyond the common narrative they mostly focus on U.S. resource needs relative to application requirements. Notable exceptions are the recent DoE Deep Dive report (link at end of endnotes) and some excellent work by the CRS and GAO. However, in all cases the CRS and GAO tend to obscure "bad news" (*for fear of offending*). The Pentagon's reporting is by far the worst. For example, in a Readiness Report to Congress the Pentagon unilaterally determined that "China would never use rare earths as a weapon…" Research from our national labs is largely focused on developing and expanding research funding opportunities (largely tied to constituent politics: e.g., REEs from coal).

[40] With necessary participation from Original Equipment Manufacturers (OEM) and off-takers (such as component makers and defense contractors). Why necessary? Without firm off-take agreements these projects cannot be funded (with private money).

[41] This includes the Pentagon, an institution that should instinctively assess threats in this manner. Instead, the Pentagon accepted the Molycorp and then MP Materials narrative and ignored issues as basic as geochemistry, real or imagined capabilities and prospects for profitably competing against China. In fact, the Pentagon has a tendency for self-deception. A perfect example of this is how the Pentagon relied on a regulatory definition of "critical materials" that only employed restrictions on alloys (with no concern on where the based metals came from). This allowed defense contractors to purchase base REE metals from China and alloy them in the U.S. The Pentagon obscured its reliance on this law, 10 U.S. Code § 2533b, for a decade and a half, enabling China's further advantage and compromising the integrity of the U.S. industrial defense base. This was not some oversight.

[42] Proof of this failure is that the two largest non-Chinese mining projects, MP and Lynas, have deficient geochemistry for the commercial production of EV, Wind, and military grade magnets. The proportional distribution of the critical REEs, Tb and Dy, are not present in these deposits to produce commercially significant quantities of high-operating-temperature REE magnets (and the absence of other heavy REEs, necessary for other technology and military applications). For MP, the commercial production of Tb and Dy is zero (0). For Lynas, the commercial production potential is extremely limited. Consequently, continued reliance on China for Tb and Dy will cause the U.S. and its Allied partners to remain largely dependent on China for REE magnets used in EVs, Wind, and military systems. Geologists have issued these warnings but have been ignored, suppressed, or misrepresented in pursuit of financial market positioning. This and other examples of deficient due diligence are common across all other levels of the REE industry (as detailed in this Document).

[43] Lack of foresight should be evident in MP's plan to produce 1,000 tons per year of NdFeB magnets in the U.S. The plan strongly suggests that MP does not understand the economics of metallic conversion, thermal-performance-chemistry, or the downstream economics of magnet fabrication outside of China.The fact that none of this appeared as evident to MP, GM, the Pentagon or MP-investors is

evidence that none of them has made a serious effort to evaluate the myriad of challenges built into China's monopoly (the Pentagon continues to provide funding and superficial press releases predictably propel the stock upward – that appears to be the extent of diligence on all sides). The fact that MP and others lobbied to modify H.R. 5033 suggests that they now understand and will use the legislative modifications to lock in profits for producing low-value / low-temperature magnets unrelated to national security or the Administration's EV goals. The larger issue is that this exercise may prove to be another 10-year detour. Note that Molycorp's failure was evident before 2010 (the lead author presented sufficient data to make such a determination to the Pentagon in 2009 and this project was reincarnated in 2020). Over that decade China fully consolidated its global position.

[44] The Primary challengers thus far have been Molycorp, Lynas, and MP Materials. Both Molycorp and Lynas went bankrupt in 2015. Lynas was bailed out by the Japanese government (and its customers). MP is a reboot of the same mine that was operated by Molycorp. MP sells all of its production to China.

[45] Rare earths are so central to the Chinese government's goals and aspirations that 4 of the last 5 national leaders have personally enacted national rare earth programs. More telling, at least 2 of the last 5 Chinese leaders, Deng Xiaoping and Xi Jinping, have (had) considerable family investments in the rare earth refining and metallurgical industry. In 1997 Deng's family acquired Magnequench, the only U.S. producer of NdFeB magnets, and moved it to China. Xi's family held close to $400 million in rare earth refining and metallurgical companies before he came to power.

[46] Assuming that a few mines operating outside of China, highly dependent on China as a customer or for downstream separation of the most critical REE, as evidence of success may prove illusory: as history has demonstrated. The fact that their viability is based on supplying China's monopoly makes the opposite point. They exist to serve China's monopoly.

[47] China had disproportionate control over the production and/or downstream processing of many other critical elements and materials such as cobalt (65 percent), lithium (55 percent), copper (40 percent), nickel (35 percent), spherical graphite (99 percent), and synthetic graphite (78 percent), polysilicon (80 percent) and 92 percent of the global cathode capacity and 91 percent of global anode capacity. When combined with China's near 100% control over the production of EV grade high-operating-temperature rare earth magnets, China owns the EV space and most other technologies that are dependent on these critical materials.

[48] Other elements and materials where China is the global dominant supplier: What happens if China limits access global access to these other materials, all of which China as the dominant global producer: Aluminum (55%), Antimony (84%), Arsenic (61%), Bismuth (70%), Fluorspar (59%), Gallium (96%), Germanium (72%), Indium (57%), Manganese (93%), Mercury (89%), Vanadium (60%), Tantalum (40%), and Tungsten (83%). Evidence that the Pentagon is not *situationally aware* is that China gained domination or control over half of the elements on the periodic table before the Pentagon initiated a shift in priorities (many would argue that this shift was largely involuntary).

[49] China has transitioned away from dominating REE mine production. China now outsources mine production to lesser countries, thus offshoring the resulting environmental consequences and preserving its own resources.

[50] Congressional Report: Submitted January 3, 1999, by Mr. Cox Of California, Chairman of The Select Committee: "U.S. National Security And Military/Commercial Concerns With The People's Republic Of China." The Cox Report also detailed the practice of Chinese nationals, working in the U.S., actively transferring IP and trade secrets to China.

From the 1999 Cox Report:

"In 1997, the CCP formally codified the 16-Character Policy. The "16-Character Policy" is the CCP's overall direction that underlies the blurring of the lines between State and commercial entities, and military and commercial interests. The sixteen characters literally mean:

- Jun-min jiehe (Combine the military and civil)
- Ping-zhan jiehe (Combine peace and war)
- Jun-pin youxian (Give priority to military products)
- Yi min yan jun (Let the civil support the military)"

In 1997, the PRC formally codified Deng Xiaoping's "16-Character Policy," which literally means: Combine the military and civil; combine peace and war; give priority to military products; let the civil support the military.

"This policy, a reaffirmation and codification of Deng Xiaoping's 1978 pronouncement, holds that military development is the object of general economic modernization, and that the CCP's main aim for the civilian economy is to support the building of modern military weapons and to support the aims of the PLA."

[51] Funding companies like MP without new U.S.-heavy REE ore deposits only extends China's monopoly advantage. The MP/Mt. Pass mine cannot produce Dy or Tb (or other critical heavy REEs). MP's REE magnet production plan will only produce low-value / low-temperature NdFeB magnets that cannot be used in EV systems, Wind, or military applications. The Lynas Mt. Weld deposit cannot produce geopolitically meaningful levels of Tb or Dy. Thorium regulations prevent development of heavy REE deposits in the U.S. and in other IAEA signatory states.

[52] How to Win the U.S.-China Economic War by Robert Atkinson, https://foreignpolicy.com/2022/11/08/us-china-economic-war-trade-industry-innovation-production-competition-biden/

[53] Unless success is defined as the current/ongoing process that is responsible for our nation's deindustrialization and transfer of jobs, IP and industries to China (and other places). While outside the bounds of polite discourse, this is nonetheless true.

[54] Since before 2011, there has been a misconception that the free market will solve the REE problem. It is now 2023 and the problem has only gotten worse (China's One Belt, One Road program is successfully capturing the very best high-value heavy REE production, as high-operating-temperature EV magnets are becoming the dominant high value REE magnet and only China can produce separated Tb / Dy required to manufacture them).

[55] See: https://www.hsbianma.com by entering the HS-codes below in the search field and click 查询 "enquiry". It will turn out all products under this heading with their 8-digit HS-code. Look for the column header 出口退税率, "export return tax rate":

- **Rare earth compounds** under HS-code (harmonized system code) heading 2846: No VAT refund upon export. 2846 covers all rare earth compounds.
- **Rare earth metals** under HS-code heading 2805: No VAT refund upon export. 2805 covers **all rare earth metals**.
- **Rare earth ferrosilicon**, other rare earth ferro-alloys, quick setting permanent magnet sheets, NdFeB magnetic powder and other NdFeB alloys under HS-code heading 7202: No VAT refund upon export.
- **Rare earth permanent magnets**, permanent magnets of other metals, magnetic poles, other non-metallic permanent magnets, electromagnetic couplings, clutches and brakes,

electromagnetic lifting suction cups, superconducting helical electromagnet, electromagnets used exclusively or principally in nuclear magnetic resonance imaging apparatus, other electromagnets; electromagnet or permanent magnet chucks, jigs and similar work-holding fixtures under HS-code 8505: 13% VAT refund upon export.

- **Neodymium-doped laser** under HS-code 9013 2000.80: 13% VAT refund upon export.

[56] China produces about 90% of REE metallic / pre-magnetic materials and is the primary supplier of separated Nd, Pr, and exclusive supplier of separated Tb and Dy (required by all non-Chinese producers of REE metallic / pre-magnetic materials and high-operating-temperature NdFeB magnets).

[57] This person works directly with Chinese companies and trades REEs throughout Asia; subject person's identity must be protected.

[58] Japan and the EU produce REE metallics largely from recycled materials and metallic scrap. Recycled materials alone would result in inferior magnet, so these companies also rely on China for high purity, separated Nd, Pr, Tb and Dy.

[59] NdFeB magnets that are not doped with Tb and / or Dy lose their magnetic properties at temperatures over 65°C. Consequently, un-doped magnets cannot be used in EV drive trains, braking-system, or other applications such as Wind and weapon systems.

[60] NdFeB-only magnetic strength degrades in operational environments over 65° C. All Basic M-Grade NdFeB magnets contain small amounts of Dy to bring stability up to 80°C.[see 37]

[61] China sells pre-magnetic metallics and other REE metals and alloys. These materials are sold with a 13% VAT premium, giving Chinese producers of finished magnets an economic advantage (lower labor, logistics and environmental cost advantages also come into play – the net advantage is approximately 20%). To make matters worse for non-Chinese producers, China's typical markup from separated oxides to finished metals, alloys and magnets is only 5% (suggesting another level of subsidy at lower price points). The non-Chinese oxide to metal conversion cost may exceed 5% at moderate pricing levels.

[62] The Pea Ridge Mine has three rare earth deposits. All three deposits contain significant levels of Tb and Dy (2 of the deposits have thorium far below regulatory levels). One deposit is the tailings lake, containing over 40 years of mine waste and heavy REE-phosphate minerals (and other valuable commodities). The mine is fully permitted, and the resources are proven (700,000 tons of REEs). These deposits in conjunction with a fully integrated project could meet nearly 100% of U.S. REE magnet import demand in phase 1 (starting within 24 months of financing) and more than double that amount in phase 2 (beginning in year 5). Tb, Dy levels are sufficient to produce 5,000 tons per year of exclusively high-operating-temperature magnets in phase 1 (doubling in phase 2).

Proposed project (mining, concentration, separation, metallic powders, and magnet fabrication) economics and financing are highly dependent on a tax credit similar to the original H.R. 5033 (Note: All current downstream magnet producers outside of China, or China's control, are losing money [(see 58)] or have elected to operate inside China [(see DoE Deep Dive Report)]). Without the proposed tax credit, the economics of China's monopoly make it impractical to separate the REEs and make magnets. Ultimately, the project would be forced to sell the REEs to China.

With the tax credit the project can attract downstream partners, with the goal of setting up a fully integrated domestic high-operating-temperature magnet facility (and produce other REE products).

[63] At least 39 universities in China have REE-specific/dedicated programs. According to the Biden administration's 100-day review, "by comparison the U.S. has only a handful" of universities with REE programs and none are comprehensive.

[64] The U.S. and Allied governments and related interests like to claim that China operates with no meaningful environmental regulations. This is no longer true. Near the turn of the century China became aware and active in environmental reform. For example, from an official Chinese report "In 1998, there

were more than 100 mining and dressing enterprises in the 2.97 square kilometer of the Maoniuping mining area, and most of them were small workshops. From 1998 to 2006, due to the lack of a unified plan, the Maoniuping mining area experienced serious damage to the ecological environment of the mining area. There were 10 large mining pits and 26 spoil piles formed in the upper reaches of the mining area. The hidden dangers of mudslides intensified, affecting the downstream Maoniu Village and Machang. The lives and property of 1095 people in the village are threatened." (case in point: the 2008 Sichuan earthquake). A farmer was quoted: "At the craziest time, every family would open a mine, just pick up a woven bag and hold a shovel."

Much of the reform work began as early as 2006 when the Mianning Maoniuping mining area was closed following an official report siting "Severe damage, serious soil erosion, frequent geological disasters, Maoniuping is a typical representative of disorderly mining, and is therefore listed as one of the key national remediation mines by the Ministry of Land and Resources."

In 2008 the State Administration of Worker Safety, the Ministry of Environmental Protection, the Ministry of Land and Resources, the National Development and Reform Commission, the Ministry of Industry and Information Technology and the then Rare Earth Office began enforcement against the larger and more powerful companies like Jiangxi Copper. Jiangxi was forced to "clean up the mess it had created and bring order into the chaos it had caused," including multi-billion Yuan fines. By 2013 China had brought the mining licenses and operations in the Maoniuping mining area under control so the cleanup could start.

However, Xi Jinping is credited with bringing in an age of environmental reform and compliance, beginning in 2012, with the introduction of tough mining, environmental, energy, water-consumption, emission/discharge, and rare earth extraction efficiency standards that are being enforced by at least 6 ministry task forces that employ surprise inspections. A quote from a 2013 assessment: "There are 23 geological hazards left in the history of the mining area, including 11 mud-rock flows, 12 landslides and collapses; 13 pits with a volume of 10.4 million cubic meters; 26 slag piles with a volume of 18.4 million cubic meters; part of the waste slag slope has become unstable and turned into a mudslide, which has caused serious soil erosion and environmental pollution." Enforcement actions included mitigating soil erosion and water resources related to various cleanup projects lasted until June 2019.

[65] One must also consider the relevant cost of government-imposed values as it relates to the environment and human safety. For example, in accordance with the US Environmental Protection Agency's recommendations the value of a statistical human life is $7.6 million. Per U.S. EPA's definition this is an estimation of "how much people are willing to pay for small reductions in their risks of dying from adverse health conditions that may be caused by environmental pollution." But life from the environmental perception in other countries does not seem so valuable. At the same time in China the equivalent value of statistical life in 2006 ranged between $4,000 and $16,000; hence it is 475-1900 times lower than in the US. For example, air pollution in China is considered the fourth largest hazard to the health of the Chinese people (Kamenopoulos, S. 2018. Rare Earth Elements: A historical comparison - Favoritisms as probable causing factors for market manipulation by China. World Economics Journal, Vol. 19, No 2, April-June 2018. London, UK)

[66] See SNL-mining-report-v6 (nma.org)

[67] See Myanmar's poisoned mountains | Global Witness & Toxic rare earth mines fuel deforestation, rights abuses in Myanmar, report says (mongabay.com)

[68] However, mixed oxides of NdPr and TbDy will sell at full value. Companies like Germany's Vacuumschmelze (VAC) buy these materials and fabricate finished magnets on a cost-plus basis. While this sounds like a step toward independence, China remains in control of a key part of the supply chain.

[69] Many integrated rare earth companies inside China are free to *internally price* REEs across their internal value chain, but there are other instances where overpricing could be advantageous. The following link covers accusations that Shenghe conspired to overprice REE imports: MP Materials Falls After Bonitas Research Short Report Alleging Price Manipulation (msn.com)"

[70] This 2012 document published by the Chinese Embassy noted: "In recent years, China has been actively creating a fair and open environment for foreign investment, encouraging foreign investment in… high-end application development… in the rare earth industry. Enterprises from the United States, Germany, France, Canada and Japan have invested a total of 6.1 billion yuan in China's rare earth industry, establishing 38 sole-proprietorship and joint-venture enterprises."

[71] A few of the many examples include: the Apple iPhone is manufactured in China and Chinese knockoffs were introduced the same year that the iPhone was introduced. Ford Motor Company's REE starter motor technology, developed with DoE funds, was transferred to China for initial production. China's wind industry was developed through technology transfers related to the supply of REE magnets to U.S. and EU manufacturers. The entire U.S. medical imaging industry migrated to China for access to REE materials.

[72] Extensively covered in the Cox Report and subsequent reporting.

[73] "Time for Resilient Critical Material Supply Chain Policies," RAND. December 2022. https://www.rand.org/pubs/research_reports/RRA2102-1.html

[74] The Pentagon and others have been warned that the Malaysian government could be influenced by the Chinese government directly and through the large contingent of ethnic Chinese in places of influence, including the legislature.

[75] All NdFeB REE magnets are produced from pre-magnetic metals. These powdered metallic materials are bonded or sintered into ingots, blocks or other shapes before they are magnetized.

[76] To put things in perspective, the typical markup for producing 1 ton of Nd metal from Nd oxide is less than 10% but the typical markup for producing 1 ton of steel from Fe is 200 to 500%. Note that the necessary chemical reaction for both processes is the same: removal of oxygen from the target metal. This does not conform with standard economic principles, as total global Nd metallics is less than 100,000 tons per year and global steel production is close to 2,000,000,000 tons per year.

[77] According to the U.S. Geological Survey (USGS), the U.S. is over 50 percent import-reliant for 51 minerals, which is up from 47 minerals the year before. Furthermore, it is 100 percent reliant on imports for 15 minerals, 12 of which are listed on the USGS' 2022 Final List of Critical Minerals. To make matters worse, the U.S. is more reliant on China for minerals than any other country (source: National Association of Mining).

[78] With "exceptions" such as Shenghe, that claim to be private but acknowledge direct links to Chinese SOEs and other national entities. Shenghe's status as a "private" company may be a fig-leaf for the acquisition of non-Chinese resource companies in countries that restrict direct Chinese government investment.

[79] The profitability of listed Chinese REE and magnet companies tends to show profits, but largely occur due to integration, transfer pricing or some other advantage. Note that from a Chinese policy standpoint, large profits are not even meant to occur at the mine to magnet level, but much further downstream: such as EV, Wind and other component and finished products.

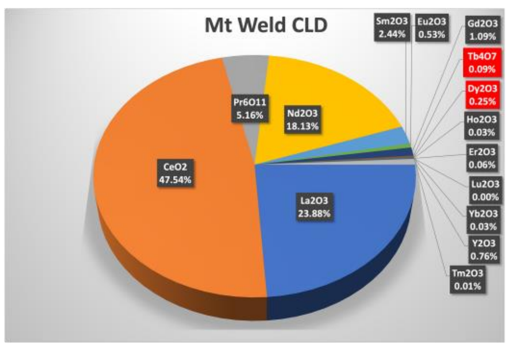
[80] The table below (Table 5) shows the REE distribution of MP's Mt. Pass deposit. Note that the table lists Lutetium as "Trace", a term that technically suggests sub-economic recovery, and Yttrium at 0.1%. For all other heavy REEs, the listed percentage is zero (0). Of course, these elements do exist at some non-economic percentage, but from an economic and national security standpoint the number should be considered as having a minimal impact.

Table 5. Distribution of rare earth elements in selected rare earth elements deposits.

[Rare earth elements listed in order of increasing atomic number; yttrium (Y) is included with these elements because it shares chemical and physical similarities with the lanthanides]

Rare earth element	Average upper crustal abundance (percent) Wedepohl (1995)	Bastnasite Mountain Pass, USA (percent) Castor (2008)	Bastnasite Bayan Obo, China (percent) Hedrick (2004)	Monazite Green Cove Spring, USA (percent) Hedrick (2004)	Xenotime Lehat, Malaysia (percent) Hedrick (2004)	High Y REE laterite Longnan, China (percent) Hedrick (2004)	Low Y REE laterite Xunwu, China (percent) Hedrick (2004)	Bulk ore Bear Lodge, USA (percent) Castor (2008)	Bulk ore Strange Lake, Canada (percent) Castor (2008)
Lanthanum	19.3	33.8	23.0	17.5	1.2	1.8	43.4	30.4	4.6
Cerium	39.2	49.6	50.0	43.7	3.1	0.4	2.4	45.5	12.0
Praseodynium	3.8	4.1	6.2	5.0	0.5	0.7	9.0	4.7	1.4
Neodymium	15.5	11.2	18.5	17.5	1.6	3.0	31.7	15.8	4.3
Samarium	2.8	0.9	0.8	4.9	1.1	2.8	3.9	1.8	2.1
Europium	0.6	0.1	0.2	0.2	Trace	0.1	0.5	0.4	0.2
Gadolinium	1.7	0.2	0.7	6.6	3.5	6.9	3.0	0.7	2.5
Terbium	0.3	0.0	0.1	0.3	0.9	1.3	Trace	0.1	0.3
Dysprosium	1.7	0.0	0.1	0.9	8.3	6.7	Trace	0.2	8.2
Holmium	0.4	0.0	Trace	0.1	2.0	1.6	Trace	0.0	1.7
Erbium	1.3	0.0	Trace	Trace	6.4	4.9	Trace	0.0	4.9
Thulium	0.2	0.0	Trace	Trace	1.1	0.7	Trace	<0.01	0.7
Ytterbium	0.9	0.0	Trace	0.1	6.8	2.5	0.3	0.5	4.0
Lutetium	0.2	Trace	Trace	Trace	1.0	0.4	0.1	<0.01	0.4
Yttrium	12.3	0.1	Trace	2.5	61.0	65.0	8.0	<0.01	52.8

By comparison, Lynas has .34% Tb and Dy. At current production rates this equates to .008% of global magnet demand.



[80] For example China just updated its Export Prohibited / Export Restricted Technology Catalogue: In order to strengthen the management of technology import and export, in accordance with the relevant provisions of the “Foreign Trade Law” and “Regulations on the Administration of Technology Import and Export,” the Ministry of Commerce, together with the Ministry of Science and Technology and other departments, reviewed the “Catalogue of Technologies Prohibited and Restricted from Export in China” (including the Ministry of Commerce and the Ministry of Science and Technology in 2008) Order No. 12 and Announcement No. 38 of 2020 by the Ministry of Commerce and the Ministry of Science and Technology (hereinafter referred to as the “Catalogue”) have been revised.

This revision plans to delete 32 technical items, modify 36 items, and add 7 new items. After the revision, the “Catalogue” has a total of 139 items, including 24 items that are prohibited from exporting and 115 items that are restricted from exporting. This revision substantially cuts down on the “Catalogue,” refines the control points of some technical items, and creates positive conditions for strengthening international technical cooperation. These revisions and additions are specific to the export of REE technology, processes and equipment. Readers can imagine the consequences of attempting to thwart these Chinese regulations and know that there is no equivalent consequence for attempting to thwart U.S. export control laws (more on this: China tightens export ban of SmCo/NdFeB and RE know-how;

China’s RE and RE magnet exports 2022; VAC sign with General Motors; India starts exports of NdPr; (substack.com)).

[82] The Chinese government regularly boosts or shuts down individual REE operations and directly selects and manages the consolidation of its industry leaders.

[83] For example, China’s response to the WTO ‘victory’ over export restrictions was to flood the market with light REEs and bankrupt Molycorp and Lynas (Lynas was bailed out by the Japanese government, investors, and off-takers).

[84] As confirmed in DoE’s “Deep Dive” report, as follows: “The advantages of producing in China has also been made evident by the fact that established magnet producers, such as TBAd , Shin Etsu, TDK, and Vacuumschmelze, have recently established production facilities in China. The availability and stability of supply of rare earth metals in China has been a key driver of this shift. Reduced export quotas and a temporary cut-off of shipments of rare earths from China to Japan, as well as the resulting price differentials between REEs for Chinese and non-Chinese buyers, led producers from outside China to be concerned about the stability of REE metal supplies. China also manufactures equipment to manufacture magnets that is about one-third to one-half the cost of Western equipment.” China prohibits the export of all REE technology.

[85] Assembly lines would be halted until supply resumed or products were redesigned to incorporate larger and heavier magnetic components.

[86] China has cut off U.S. and other end-user of REE products for various reasons. Large companies like Siemens have established multiple buying companies to assure supply (and conceal internal usage of REE). In 2016 the top lobbyist for a large U.S. defense contractor refused to provide any level of support for proposed REE legislation, stating “even if you put me in the room (a SASC committee meeting) China can get to us.” In another instance, a U.S. company testified about China and REE before the House Committee on Foreign Affairs in 2011. Shortly thereafter China disrupted shipments to the company for a period of two years. The company was forced to the edge of bankruptcy and is no longer willing to speak on the topic. China has even established guidelines for cutting off U.S. defense contractors. “In a November report, Zhang Rui, an analyst at Antaike, a government-backed consultancy in Beijing, said that US weapons makers could be among the first companies targeted by any export restriction. China’s foreign ministry said last year it would sanction Lockheed Martin, Boeing and Raytheon for selling arms to Taiwan, the self-ruled island that Beijing claims as its sovereign territory.”

[87] Exceptions would be U.S. defense contractors, who would be forced to switch over, small scale end-users and virtue-signaling companies. No big multi-national company can be expected to switch to U.S. producers without grantees or assurances from China (who is unlikely to provide assurances or allow viable competitors).

[88] China has also off-shored the mining and concentration of heavy REE to countries with even lower environmental standards.

[89] Prior to NRC / IAEA regulatory changes in 1980, 40% of the non-Chinese world’s REEs were the byproduct of some other commodity. These byproduct resources supplied 100% of the world’s heavy REEs. These resources were eliminated from the value chain for U.S. and IAEA compliant countries due to regulatory changes specific to thorium. This regulation resulted in REE technology transfers to China.

[90] Prior to 1980 thorium-bearing byproducts produced in conjunction with other commodities made up 40% of all rare earths and 100% of all heavy REEs globally. A regulatory change by the NRC (10 CFR 40, part 75) and IAEA modified language specific to mining and nuclear source material. Consequently, all thorium bearing resources were classified as nuclear source material and all NRC / IAEA compliant mining companies in the REE mining, and refining industry ended the practice of using these materials. The longer-term consequence was that all levels of the REE industry (mining, refining, separation and

metallics) transferred their technology and production capacity to China to avoid NRC/IAEA/environmental liabilities and secure supply of heavy REEs.

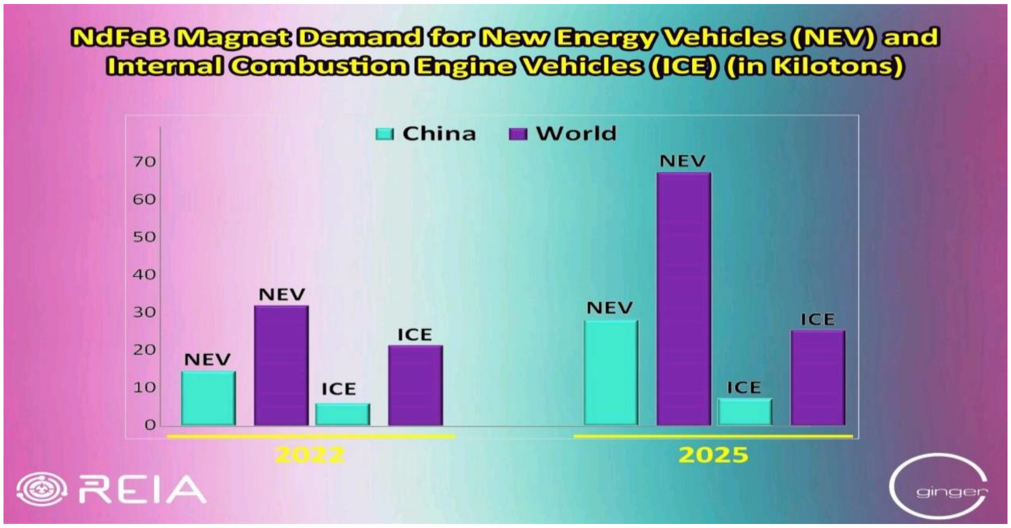
91 Rare earth production from the Baotou mine has no direct "mining" cost. The economics of MP and Lynas are based exclusively on REE production, with no other primary or secondary commodity from byproducts or co-production to off-set mining cost.

92 China Chamber of Commerce, of Metals, Minerals and Chemicals Import and Export, as authored and presented by Feng Yunguang at an Argus rare earth conference in 2017. Note that China has significantly increased environmental standards and controls since 2017. (see 63)

93 In 1950, the Molybdenum Corporation of America bought the Mountain Pass mining claims, and began production in 1952. It changed its name to Molycorp in 1974. The corporation was acquired by Union Oil in 1977, which in turn became part of Chevron Corporation in 2005. In 2007, Molycorp Inc. was merged with the Pittsburg and Midway Coal Mining Co. to form Chevron Mining Inc. In 2008, Chevron Mining sold the Mountain Pass REE mine and the rights to the Molycorp name to Rare Earth Acquisitions LLC, a special purpose company which was renamed Molycorp Minerals LLC. Molycorp filed for bankruptcy protection in late June 2015. In July 2020 the same deposit was taken public through a reverse merger with its Chinese partner Shenghe Resources, under the name MP Materials.

94 "China Dominates the Rare Earths Market. This U.S. Mine Is Trying to Change That." The article chronicles recent updates from the mine, now owned by MP. Previously owned by Molycorp, the deposit has limited traceable amounts of Tb and Dy, the heavy REE elements. https://www.politico.com/news/magazine/2022/12/14/rare-earth-mines-00071102

95 As non-Chinese companies gear up to produce low-temperature NdFeB magnets, margins can be expected to drop below zero. In fact, Vacuumschmelze and other EU producers of NdFeB magnets (using domestically sourced recycled-NdPr and Chinese separated oxides) are amassing unsustainable losses and operating far below capacity. Specifically, regarding EU NdFeB magnet production, VAC did turn a profit of ~EUR5 mio in 2021, an amount equivalent to "other business income" (as per German tax law it arises when an asset - not inventory - is sold at a price in excess of its current book value) plus profits of foreign subsidiaries (China 49% JV with Zhongke Sanhuan, Slovakia and Malaysia, 100% subsidiaries each).



The number of high-operating-temperature NdFeB magnets is expected to double over the next 3 years (See graphic: NEV = EVs / hybrids, etc., all requiring high temp magnets). That rate of growth will continue to accelerate as consumers move towards EVs. China controls +99% of the world's Tb and Dy.

China separates 100% of the world's Tb and Dy. Tb and Dy are critical inputs for high temp NdFeB magnets used in EVs, Wind and weapon systems.

[96] If the Pentagon is betting on Lynas to produce Tb and Dy through the Pentagon funded Lynas / Blue Line project in Texas, they should make an inquiry into that project's progress. The project partners have separated.

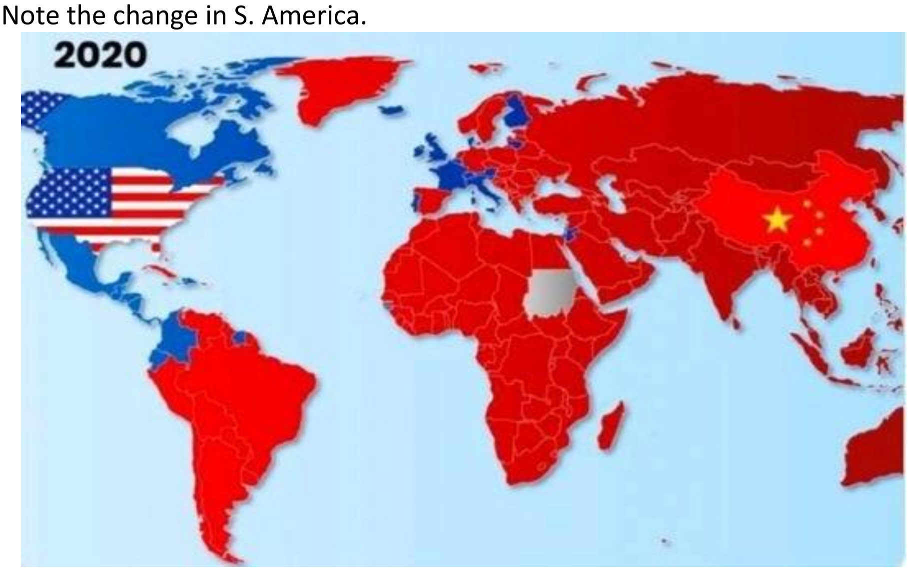
[97] Shenghe describes its ownership as "mixed" — that is, partially state-owned. It has close ties with the Chinese government: its largest shareholder is a research institute within the government-owned China Geological Survey, which sits directly under the Ministry of Natural Resources. It is also affiliated with the Aluminum Corporation of China (Chinalco), one of the six major state-owned firms that dominate the domestic REE industry. A Chinalco representative sits on Shenghe's board of directors, and according to Chinese stock analysts, Chinalco is "involved in Shenghe's production, operation and strategic decision-making."

[98] For example, Shenghe recently took a board seat at Peak Rare Earth. In December Shenghe Resources quietly took a board seat at Peak: Since early 2014, Ms Shasha Lu has been the Managing Director of **Shenghe Resources Overseas Development** where she leads and manages overseas investment, cross-border corporate management, international trade and the building of a complete rare earth/monazite supply chain. Prior to that, Ms Lu was an Executive Director and CEO of **Hong Kong East China Non-Ferrous Mineral Resources Co. Ltd** [China state-owned entity holding shares in Arafura] **& Sino-Australia International Mineral Resources Limited,** responsible for overseas investment, scientific research and management. Ms Lu has previous experience as a director of ASX-listed companies, having been an **Executive Director of Arafura Resources Limited** and an **Executive Director and Vice President of Globe Metals and Mining Corporation** [critical metals tantalum and niobium]**.** Note 1: Shortly after giving Shenghe a seat on the board Peak announced the contract settlement with the Tanzanian government. Note 2: **Shenghe are a state-owned holding company:**

Shenghe Resources are an entity controlled by the State-owned Assets Supervision & Administration Commission (SASAC) under China's State Council. The Ministry of Finance of the People's Republic of China is the ultimate controller of Shenghe Resources, as is glaringly evident from every single annual report of Shenghe Resources. The Archive-Search function will reveal everything we disclosed about Shenghe Resources.

[99] 

[100] Update in change in trade preferences from 2018-2020 (https://howmuch.net/articles/trade-timelapse-usa-china). Note the change in S. America.



Also consider the rapid expansion of the Shanghai Cooperation Organization:

Worse yet, there are now 23 states that are developing alternate trading relationships in order to move away from the U.S. dollar and SWIFT system (60% of the world's GDP are setting up swap lines which bypass the dollar and SWIFT, which is the dollar-based worldwide financial transaction system).

These countries include Russia, China, India, Maylasia, Pakistan, Iran, Saudi Arabia, the United Arab Emirates, much of Africa, to include other BIRCS members Algeria, Egypt, Argentina, Mexico, and Nigeria and Venezuela. Even Germany, France, and the United Kingdom are looking for alternatives (the IMF and UN are pushing for an alternate “world currency”).

[101] Thorium is classified as a nuclear fuel and is subject to the same laws, restrictions, and liabilities as uranium and plutonium. However, thorium has no direct nuclear weapon application potential and can be easily and safely managed (it can be converted into a form of uranium: U-233), but this was tried by the U.S. and other nation states and abandoned because it is deemed impractical and is considered *impossible* for non-nation-state actors by our own experts. Thorium is also relatively plentiful, widely distributed, and easily acquired and purified. Thorium is fertile not fissile, not water soluble and not bio-available, so human and environmental risks are very limited. Thorium does have potential as an ultra-safe nuclear liquid fuel (the liquid fueled reactor was developed and proven by Oak Ridge National Lab). The reactor is much safer than traditional solid fuel uranium light water reactors (LWR). The reactor cannot blow up, melt down, or have a wide-spread radiation release and the nuclear waste is easily managed by comparison to solid fuels used in LWRs. Unfortunately, the technology was transferred to China in 2011. China has recently built its first thorium liquid fueled reactor and plans on developing them commercially for global distribution (to its One Belt, One Road partners according to Chinese public statements). For more on this topic, please contact the Thorium Energy Alliance (John Kutsch, the executive director, is a contributor to this paper).

[102] UNITED STATES REGULATION 10 CFR 40. Atomic Energy Act (AEA) And The US NRC Refer To “Source Material” Per the Atomic Energy Act of 1954, as amended by the Uranium Mill Tailings Radiation Control Act of 1978, generated through the Cooperative, consistent with the regulations in Title 10 Code of Federal Regulations Parts 20, 40, Appendix A to Part 40 (as in effect on the date of the enactment of this Act). The following definitions apply to source material: US Atomic Energy Act (AEA) Section 11.z. The term “source material” means (1) uranium, thorium, or any other material which is determined by the Commission (i.e., the US NRC) pursuant to the provisions of Section 61 to be source material; or (2) ores containing one or more of the foregoing materials, in such concentration as the Commission may by

regulation determine from time to time. Title 10 Code of Federal Regulations Part 40, Section 40.4 (10 CFR 40.4)d

Definitions. "Source material" means: (1) uranium or thorium, or any combination thereof, in any physical or chemical form or (2) ores which contain by weight, one-twentieth of one percent (0.05%) or more of: (1) uranium, (2) thorium, or (3) any combination thereof, 10 CFR 40.13(c)

Exemptions for low thorium-bearing ores: Any person is exempt from the regulation in this part and from the requirements for a license set forth in section 62 of the Act to the extent that such person receives, possesses, uses, or transfers: (1) (vi) rare earth metals and compounds, mixtures, and products containing not more than 0.25 percent by weight thorium, uranium, or any combination of these (basically Molycorp's Mt. Pass).

[103] For example, existing mines like MP and non-operational mines like Texas Mineral Resources Corp (USA Rare Earths), UCore Rare Metals, Avalon, Quest Rare Minerals, Great Western Minerals, Commerce Resources, and Medallion lobbied Congress (directly, or via the National Association of Mining) for reductions in mine permitting timelines & standards. However, in some cases these companies and others simply asked that the various agencies (the Forest Service, DOE, DOD, OSTP, CEQ , NRC, the House and Senate Energy Committees on Natural Resources as well as Senate Committee on Environment and Public Works) conform to the existing standards and published timelines.

[104] 10 CFR 40, part 75, that classified thorium bearing REE byproducts (of some other mined commodity) as nuclear source material. These extracted resources are treated as mining waste to avoid NRC regulatory costs and liabilities.

[105] New start-up projects in the U.S. face endless challenges from multiple Federal (EPA, NRC, Forest Service, Bureau of Land Management) and state agencies (see recent BLM ban on U.S. Cobalt / Copper mine). They can also be subject to endless challenges from groups that claim to be "stakeholders." The stake-holder challenges can translate into endless jurisdictional challenges at the state and Federal level: post permitting.

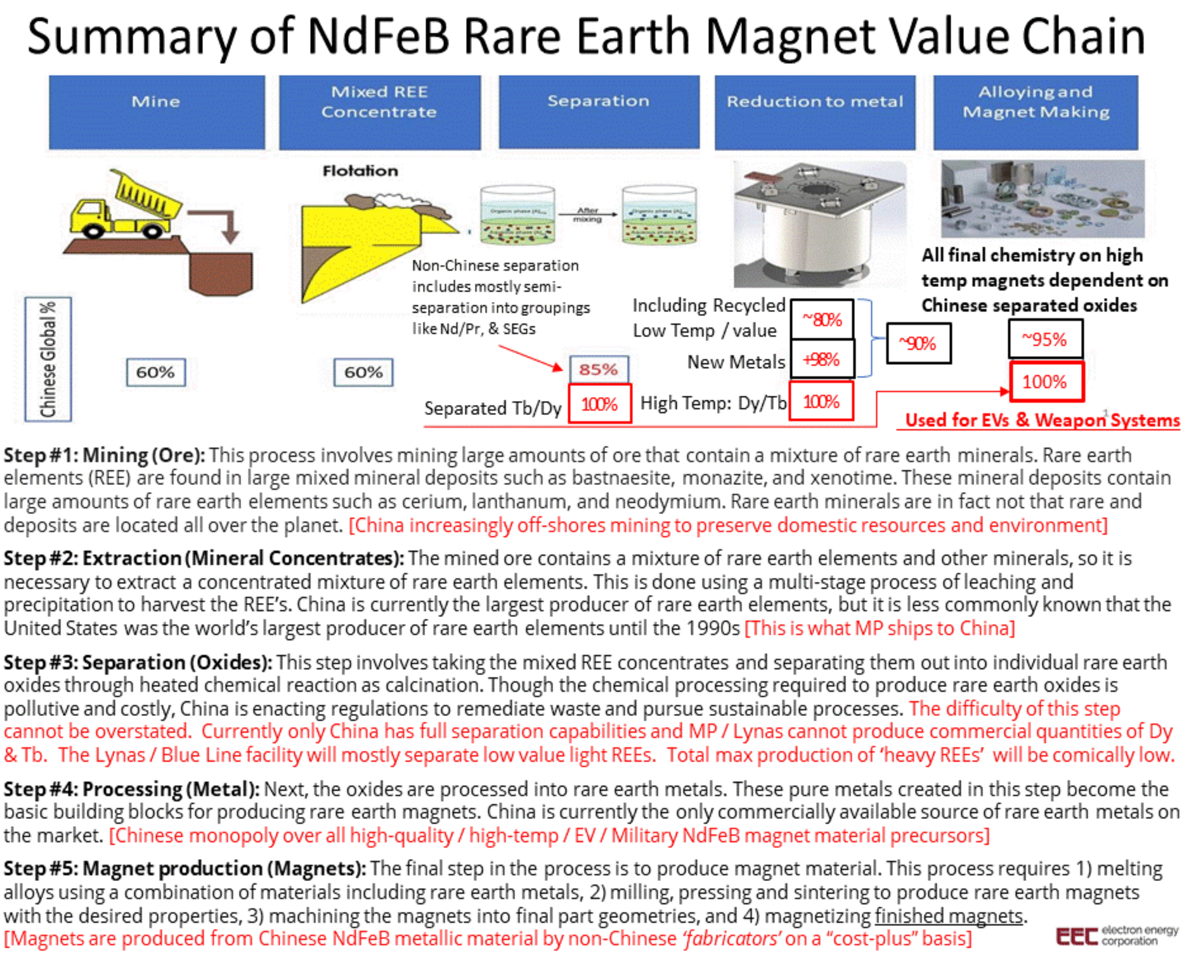
When evaluating a mining project, investors must take the overall cost of the project, the timeline to permitting (typically 10 years or more) and the uncertainty of production, due to uninhibited challenges, into account. The uncertainty of never acquiring a permit or initiating production causes the measure of financial risk to become unlimited. As outlined above, it is understood that time over dollars (e.g., time/$) invested acts as a discounter to anticipated returns (e.g., $800 million dollars invested over 10 years (or more) to achieve permitted operations), however, uncertainty of ever achieving operations (or having operations terminated via jurisdictional fiat) discounts anticipated returns at a highly-factored rate. For example, as the measure of risk becomes infinite (uncertainty = infinite risk) the measure of profitability becomes massively negative.

This environment does not support the participation of rational capital. This phenomenon can be observed by the types of projects that receive funding in the U.S. New greenfield projects tend to miscalculate permitting risk, timelines and or potential profitability (and few ever go into production). In the case of reopening former deposits, the reopening success rates are much higher. In some cases, the developers tend to misrepresent geochemistry vis-à-vis projected downstream products or the competitive environment (see "Story of Mt. Pass" below).

As a consequence, investment capital migrates to lower risk environments such as Canada or Australia, that have reduced timelines and higher reliability / certainty of acquiring mining permits. This is inconsistent with the establishment of domestic supply security (in "free markets" why would the private owners of a mining project in Canada, Australia or Zambia not sell to the highest bidder: and that bidder could be China or one of its proxies?).

Story of Mt. Pass

For example, Mt. Pass mine has been reopened twice but developers never fully disclosed the reasons the initial project was terminated. The first closure was primarily due to economics. China rapidly ramped up REE production, undermining Mt. Pass's primary market: La sold to W.R. Grace (had the REE market outlook remained profitable Unocal would have remained in the business). When Mt. Pass was reopened the second time the economics of its geochemistry was unfavorable to the new market environment (La and Ce, making up over 80% of the REE distribution, sold far below their production cost). The lack of heavy REEs made the deposit incompatible with technology and defense application trends. To make matters worse, China had become "the market" and was able to set price – representing a real viability risk to the California mining project. To attract financing the management team misrepresented the deposit's geochemistry, its downstream capabilities (specifically to defense applications) and the competitive risk of operating under China's sovereign monopoly. MP Materials, the third incarnation of the Mt. Pass deposit, is no different from its predecessor (other than the overt Chinese relationship). Summary by Author #6



106

107 This is an example of the Chinese government directly controlling price. It was announced on March 4, 2022, that rare earth prices were too high and that Chinese companies should bring them back to "reasonable levels.

The Federal Reserve does not have anything close to this level of 'market persuasion'.

See: China calls on rare earths companies to bring prices back to "reasonable" level | Reuters

[108] This tool can be easily reversed via price manipulation or expansion of domestic (Chinese) production.

[109] China directly produces close to 90% of all REE metals, alloys, and pre-magnetic alloys. For the balance of global REE metal production China indirectly controls the final chemistry for most of this production (because nearly every NdFeB magnet is dependent on high purity separated Nd, Pr, Tb and Dy). China controls nearly all separated Nd and Pr and 100% of the world's separated Tb and Dy.

[110] For example, China has cut off U.S. and other end-user of rare earth products for various reasons. Large companies like Siemens have established multiple straw-man buying companies to assure supply (and conceal internal usage of REE). In 2016 the top lobbyist for a large U.S. defense contractor refused to provide any level of support for proposed rare earth legislation, stating "even if you put me in the room (a SASC committee meeting) China can get to us". In another instance, a U.S. company testified about China and REE before the House Committee on Foreign Affairs in 2011. Shortly thereafter China disrupted shipments to the company for a period of two years. The company was forced to the edge of bankruptcy and is no longer willing to speak on the topic. China has even established guidelines for cutting off U.S. defense contractors. Another example, responding to inquiries about how badly companies in the US and Europe, including defense contractors, would be affected if China restricted rare earth exports during a bilateral dispute prompted the following response Hu Xijian, the then-editor of Beijing's Global Times: "No matter how much lethality the 'rare-earth war' can pose, the power is in China's hands…this is also a prerequisite to strike back when necessary at foreign companies which harm China's national interests." Hu closed by saying that, although cooperation benefits both and confrontation services neither, "if China is severely hurt, its powerful revenge will be inevitable." China also recently indicated that it would impose sanctions on Lockheed Martin in retaliation for a U.S. decision to sell missiles to Taiwan. China could "cut off material supply including rare earths, which are crucial to advanced weapons production." That would mark the latest phase in the weaponization of rare earths.

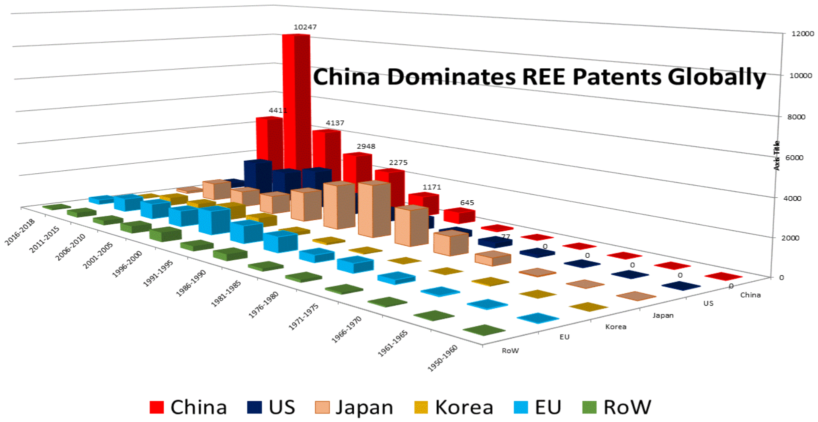
"In a November report, Zhang Rui, an analyst at Antaike, a government-backed consultancy in Beijing, said that US weapons makers could be among the first companies targeted by any export restriction. China's foreign ministry said last year it would sanction Lockheed Martin, Boeing and Raytheon for selling arms to Taiwan, the self-ruled island that Beijing claims as its sovereign territory."

[111] Notably, the predicament the U.S. faces today was the direct result and application of *free market principles* as defined by Milton Friedman, the Chicago School of Economics and Neo-Classical Economics (these principles are literally opposite the principles outlined by Adam Smith and all Classical

Economics). As currently defined, unconstrained *"free market"* actions can only bring us back to this same point again and again.

[112] Efficient Market Theory refers to how well current prices should reflect all available, relevant information about the actual value of the underlying assets. It is assumed that every investor's desire to secure greater returns will ensure that investors seek (and find) the most current and accurate information. The problem with this theory is that investors and corporations have learned that huge fortunes can be made off of short-term sensationalism, unworkable business models and outright fraud. This would include corporations not disclosing shortcomings (in geochemistry) and competitive risk (against a sovereign government monopoly) and investors indifferent to such details, knowing that government funding, sensationalism and momentum will result in significant stock market returns.

[113] Although companies like Shenghe, the primary technical and financial backer behind the reopening of the Mountain Pass deposit in California, claim to be "private" corporations in most instances they are also on record acknowledging their direct ties to the Chinese government.

[114] 

Data on global rare earth patent filings. For every 1 U.S. patent filing China files over 30.
[No title on the 3rd axis i.e. patent filings]

[115] No U.S. government agency would respond to our request for full-time REE researchers. Ames Lab / CMI refused to provide this information, but its statement suggested that they did not have a single full-time REE researcher. By default, it will be assumed that the U.S. National Labs may collectively have 100 full time REE researchers.

[116] Other than the excellent work on Ce/Al alloy research, most of the Ames / CMI work is on extracting REEs from coal, coal waste, or coal overburdens. None of this work will translate into commercial solutions as other more viable options are ignored such as Thorium-bearing REEs byproducts of iron ore mines that are superior and abundant).

[117] History has demonstrated that everything is subject to China's highly developed forms of espionage and financial enticement.

[118] The *Intellectual property (IP)* landscape of Rare Earth magnets, sintered Nd-Fe-B magnets, can be divided into: IP of Rare Earth Elements separation, IP of Rare Earth metal making, IP of Sintered Nd-Fe-B magnets manufacturing, IP of Nd-Fe-B magnets Recycling, and IP of Manufacturing equipment. The Rare Earth-magnets upstream and recycling IP is particularly dominated by Chinese patent owners, including equipment IP. Contrary, the magnet manufacturing technology and equipment IP, is up to date still predominantly owned by Japanese magnet and equipment manufacturers.

[119] MP lists 216 employees. Blue Line lists 30. Energy Fuels has 4 full-time equivalent employees at Chemours. Electron Energy, producing Samarium Cobalt (SmCo) REE magnets for the U.S. defense

industry has 130 full-time employees. There are no other "commercially" operating facilities. All other REE enterprises are in the developmental / financing stage. None have competitive operational strategies. Note that the U.S. work force supplies China's downstream REE monopoly.

[120] China has stated it has 40 universities in its 1985 announcement.

[121] China sells separated oxides (Pr, Nd, Tb and Dy) metals and pre-magnetic alloyed powders to non-Chinese magnet makers and fabricators. These companies, like LCM or VOC, cannot independently produce magnets or fabricate magnets without Chinese supply – thus China's monopoly and capability to terminate supply remain intact.

[122] Vested parties should be skeptical of MP's plans to produce NdFeB magnets. The measured and professional assessment of the lead author is that MP's stated goal to produce 1,000 tons of low temp NdFeB magnets is a geopolitical diversion, largely serving China's interests. Note that MP was placed back into production and full operability by its Chinese partner Shenghe. The DoD funded magnet project will take years to start up and will most likely take a few more years to fail (based on anticipated prices for NdFeB only magnets). The decade or more that the DoD will invest in the project will not result in the production of any military, EV, or Wind grade magnets. The project's most likely consequence is to assure China more time to consolidate control over REEs and related technologies. **Note that the 1,000 ton per year production plan equates to 350 tons of Nd and Pr, representing less than 1% of total Nd / Pr production. What happens with the balance of Nd / Pr? Does it continue to flow to China? If so, this is little more than a distraction for the benefit of China.**
MP's Chinese partner Shenghe: (See MP's Security Exchange Commission filing detailing Chinese investment of equity and other commitments exceeding $200 million and offtake arrangements for all production: https://www.sec.gov/Archives/edgar/data/1801368/000180136821000036/mp-20210630.htm). Note that the lead author advised the Pentagon in 2009 that Molycorp was also a non-viable diversion that served China's interests (resulting in the loss of 10 years in misdirected policy). See https://threeconsulting.com/mt-content/uploads/2021/04/sme2017webv.pdf

[123] Profitability from the production of low temp NdFeB magnets may fall below zero inside China as well.

[124] "Time for Resilient Critical Material Supply Chain Policies," RAND Corp. December 2022. https://www.rand.org/pubs/research_reports/RRA2102-1.html

[125] https://www.instituteforenergyresearch.org/international-issues/china-dominates-the-rare-earths-supply-chain/

[126] This was not a perfect bill to start with, but the original was far superior to the new concessions and changes secured by the usual suspects: MP, Lynas, GM, VAC and Noveon.

[127] Tb, Dy and Ho (a heavy rare earth substitute) content in a high-operating-temperature NdFeB magnet typically ranges from 1 to 9%. The 10% allowance suggests that MP anticipates that it may continue to utilize non-U.S. sourced high purity separated Nd and Pr.

[128] The changes to the bill do nothing to offset China's current control over 100 percent of separated Tb and Dy. The anticipated contribution from Lynas equates to .008% of global demand based on current production (note that doubling or even tripling production would have little impact on the Japanese / U.S. relative position vis à vis China). Consistent with the history of the Pentagon investing into unlikely solutions and private interests misrepresenting REE capabilities to gain public (and private) funding, the Lynas / Blue Line collaboration has ended (to be clear, the authors are not impugning the reputation or capabilities of Blue Line). The Pentagon funded the Lynas / Blue Line project under strict "heavy rare earth" separation requirements. However, this project was initially billed as a SEG separation program (Sm, Eu, Ga are light rare earths). The separation goals for Tb and Dy were added post funding (likely due to challenges over the legitimacy of the funding award). Like Molycorp's many verifiably untrue

claims of capabilities (and goals) that were funded by the Pentagon, this collaborative project has reached its terminus. Note that MP's claims and goals are nearly identical to those of Molycorp.

[129] Lynas is the only known potential producer of Tb and Dy that could feed into U.S. magnet production but Lynas's known rare earth distribution and production profile only account for .008% of global Tb / Dy demand. Consequently, that would be the limit of U.S. production of high-operating-temperature NdFeB magnets (doubling or tripling production makes little difference at that level). The Bill's maximum allowable tax incentive does not differentiate between low and high-operating-temperature NdFeB magnets so all manufactures will maximize the incentive based on available qualifying resources.

[130] The new legislation would lock in the maximum production of U.S. high-operating-temperature NdFeB magnets based on the limited amount of Tb and Dy that Lynas can produce (estimated at .008% of global demand [(see 113)]). Other potential sources, like Chemours, have a production cap based on available monazite. Known potential U.S. monazite resources maximize Tb + Dy production at less than 25 tons per year. The changes to the bill also limit qualified outside sources to "non-allied foreign nations" thus allowing sourcing from countries that are not U.S. formal Allies, but not designated as such. This is an unwarranted risk, as many of these nations could be pulled into China's orbit as it relates to supplying the U.S.

[131] The new language is as follows: ''(1) $20 per kilogram of rare earth magnets manufactured or produced in the United States by the taxpayer during the taxable year, or ''(2) $30 per kilogram of rare earth magnets manufactured or produced in the United States by the taxpayer during the taxable year if not less than 90 percent the component rare earth material of such magnets are produced within the United States."

As written, the bill would allow domestic producers to receive the maximum tax credit for producing Ce+NdFeB magnets. These magnets are mostly used in toys and novelty items. They cannot be used in an EV, wind turbine or weapon system. As written, MP or any other domestic producer would produce as many kg possible of these magnets (even to the point of a loss on a non-tax credit basis). This would be perfectly rational behavior and the normal response to poorly structured tax incentive programs.

Legislators should understand that there are a number of non-Chinese NdFeB magnet manufacturers that rely on China for all or small amounts of Nd and Pr for final chemistry. All pre-magnetic pricing is set at China's VAT premium, giving China's magnet producers a 13% cost advantage. U.S. / domestic magnet producers could be competitive against China in the production of low grade / low-operating-temperature NdFeB magnets if: 1. MP can successfully create a mixed Nd/Pr oxide, 2. if magnet production is supported by a domestic tax credit as small as $10 per kg, 3. and these domestic inputs are not transferred to the magnet producer at China's VAT plus pricing. If MP is successful in separating the Nd and Pr they would be able to support the production of higher grade low-operating-temperature magnets. Of course, this does nothing to resolve the need for high-operating-temperature magnets for EVs, Wind and U.S. weapon systems or meeting the needs of other technologies and military system that require heavy REE metals, alloys or garnets.

To be clear, these magnets are MADE NOW by non-Chinese and Allied nations (currently at a loss, or above China's price). However, in all cases a $10 per kg tax credit would allow for normal profits and production expansion if the material was not sold/transferred at China's VAT plus pricing. As pointed out by one of the anonymous authors at the beginning of this Document, the 13% VAT premium price is now hard-baked into the economics of all non-Chinese producers. The elimination of the VAT has the potential to undermine many of these producers in lower REE pricing environments (and would adversely affect their ability to raise capital in any market environment).

It cannot be overstated how problematic it is for non-Chinese magnet companies to compete against China when all/global pre-magnetic REE prices are set equal to China's VAT export price premium. As noted in this Document, China's VAT may prove to be a powerful weapon against non-Chinese upstream producers of concentrates and oxides. If all non-Chinese pre-metallic producers can be compromised then all non-Chinese downstream magnet producers can be compromised. This reflects Chinese non-linear strategic thinking vs U.S. / Western linear thought.

[132] Do the sponsors of this Bill fully understand the difference between a low- and high-temperature magnet relative to its applications? Does it make sense to pay $30 per kg for magnets that cannot be used in EVs, large Wind and U.S. weapon systems? Will this bill act as a subsidy for the production of low-end magnets destined for use in low-value end-uses? Does this bill just lock the U.S. into the bottom end of the market and preserve China's position in all high value markets?

[133] The Bill creates a strong disincentive for MP, or any other U.S. REE magnet producer, to produce high-operating-temperature NdFeB magnets because China retains control over the balance of global Tb and Dy (beyond the limited amount of Tb and Dy that Lynas can produce). Using Chinese Tb and Dy would disqualify them from the tax credit. No U.S. company will elect to produce non-qualifying NdFeB magnets without the tax credit. NdFeB magnet making is unprofitable outside of China or companies operating under Chinese control (see DoE Deep Dive Report [204]).

[134] The new 5033 bill inclued this single restricton: ''(c) RESTRICTION ON COMPONENT SOURCING.—A taxpayer is not eligible for the credit determined under subsection (a) with respect to a rare earth magnet if any component rare earth material used to manufacture or produce such magnet was produced in a non-allied foreign nation."

[135] Basically, any country other than North Korea, China, Russia and Iran. The new bill uses the term "non-allied foreign nation" as defined under 10 USC § 2533c (d) (2), but the actual legal term under U.S. law is actually "covered nation" meaning — (A) the Democratic People's Republic of North Korea; (B) the People's Republic of China; (C) the Russian Federation; and (D) the Islamic Republic of Iran.

[136] Estimate based on statements made by a non-Chinese / Allied NdFeB magnet producer that were made available for the U.S. Pentagon in a 2019 report.

The current cost for an imported block of standard N38 NdFeB metallic material (pre magnetized) is about $35 per kg as of March 2023 (shipping and any U.S. import taxes included). NdFeB magnet pricing always reflects the cost of inputs plus a small markup, typically in the single digits (Note that there is no profit premium for producing high-operating-temperature magnets – pricing is directly related to the cost of Tb and Dy inputs). The non-Chinese magnet producer that contributed to our Pentagon report stated that the price difference between their metallics and alloy production was less than 20% in additional cost vs China (REE inputs for all non-Chinese production is based on China's +13% VAT pricing plus presumably higher domestic labor and energy costs for that European country). Based on this information a $10 per kg tax credit would make U.S. magnet producers 'competitive' with Chinese pre-magnetic alloys: the basis of all fabricated magnet costs.

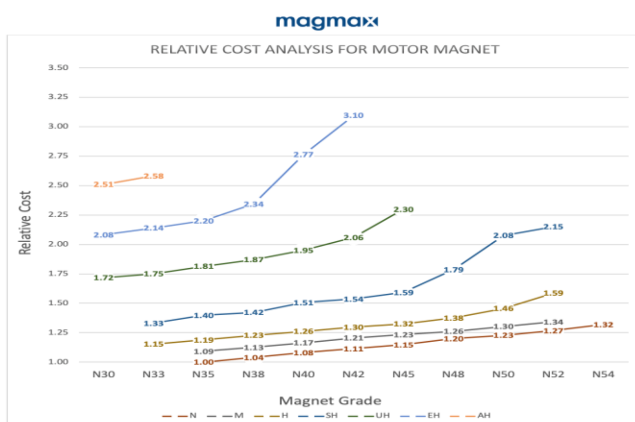
If MP or some other REE producer transferred the separated oxides or pre-magnetic NdFeB alloys at a price that did not reflect China's 13% VAT export premium then additional profits would be increased by roughly that same amount (13%), reflecting a very respectable profit.

However, this level of profitability would not be reflected in downstream fabrication cost if the pre-magnetic producer transferred the NdFeB material to a downstream fabricator at China's VAT export price. The only way to solve this problem is to eliminate the VAT premium from all U.S. / Allied trade in REE materials or limit tax credit payments to integrated producers that transferred pre-magnetic materials on an at-cost basis (absent the VAT premium). If downstream fabricators were supplied with pre-magnetic REE metals and/or NdFeB alloys at internal-transfer-pricing (pricing that did not reflect Chinese

VAT pricing for pre-magnetics) domestically fabricated standard NdFeB magnets would be competitive with Chinese pricing (as fabrication pricing is based on a ~15% cost plus basis).

When producing high-operating-temperature NdFeB magnets with higher Tb/Dy doping requirements the proposed maximum $30 per kg in H.R. 5033 may not always cover the cost difference. As stated above, the best way to resolve this problem is through full integration and at-cost transfer pricing. Alternatively, this can be resolved by instituting a production tax credit that is 20% above Chinese pricing for each grade of magnet. However, a 120% markup may prove difficult as there are no "market prices" for many / most of the highly specialized high-operating-temperature magnets. Another approach is to set a baseline for heavy rare earth magnets and provide incentives for increasing their thermal stability – not heavy REE content. This would promote innovation and potentially minimize heavy REE consumption (HREEs are one of the primary limiting factors).

Note on grades: NdFeB magnets are sold in various grades to meet magnetic and thermal performance requirements. For example, a NdFeB magnet's strength is indicated by its initial letter and 2-digit numeric designation (e.g. N38, or N45, or N52). These designations rate the magnets performance (maximum energy product or (BH)max) and stability to a maximum operating of 80^{C}. A magnet with a letter or letters as the suffix indicates the magnets thermal stability, performance and maximum operating temperature. So, for example, the suffix "M" (e.g. N35M, N42M, etc.) generally means that a magnet can be used in an operating environment up to 100^{C}. An "H" designated magnet is good up to 120^{C}, "SH" up to 150^{C}, "UH" up to 180^{C}, "EH" up to 200C, and a "TAH" up to 220^{C}. There are currently over 50 different grades of NdFeB magnet. Again, these are general specifications and other factors do play a role in application coercivity decisions.



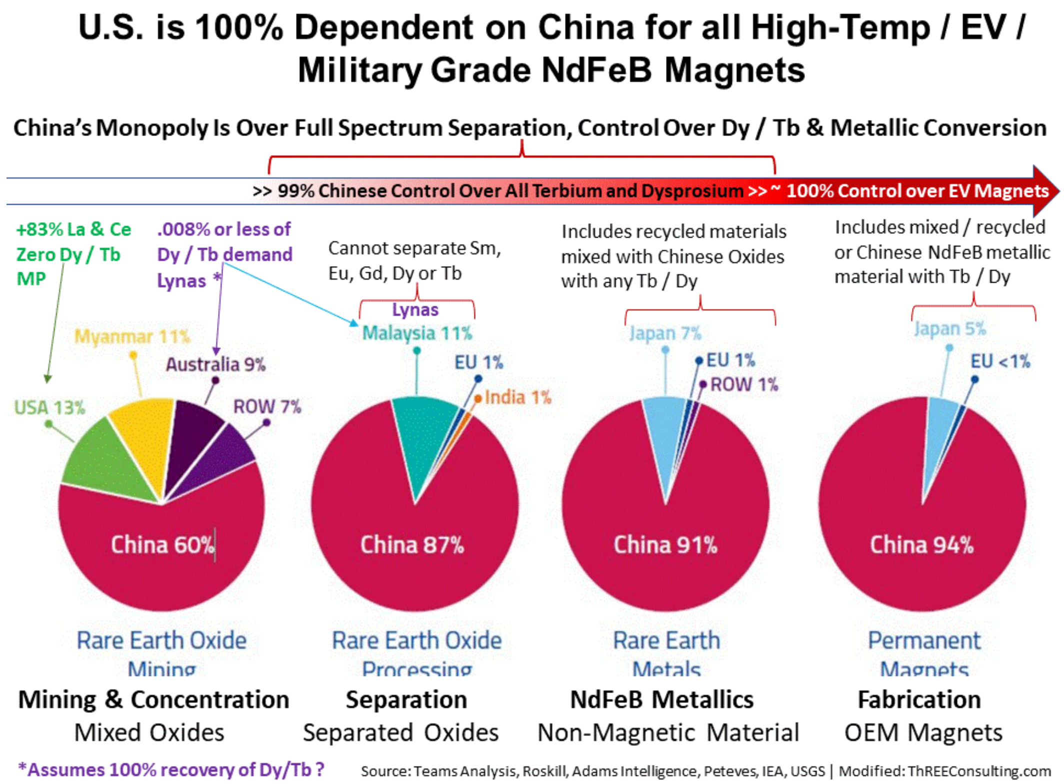
Note that under China's VAT all pre-magnetic materials have a 13% markup upon export but finished magnets do not. The Chinese magnet producer actually gets a 13% rebate. This assures Chinese profitability and undermines non-Chinese profitability in a '*market environment'* with single digit returns for Chinese producers (that include the 13% rebate) and non-Chinese producers are forced to swallow the 13% premium on pre-magnetic inputs.

[137] Realistically, most of the prospective projects are 5 or 10 years away from permitting and financing. If and when they do come on-line, none of the well-known deposits contain sufficient levels of Tb and Dy to fill the gap. The reason for anticipated shortfalls in Tb and Dy is that they tend to positively correlate thorium. Simply stated, if there is more thorium, then there is more Tb / Dy. U.S. and Allied resource producers avoid deposits with elevated thorium. Even if new Tb/Dy production materializes, the separation capabilities promoted by Lynas are still unproven (why has Blue Line exited the collaborative relationship?).

Why mislead U.S. policy makers? The motivations of MP, Lynas and any potential downstream off-takers is limited to the economic benefit of their shareholders. This ongoing policy failure reflects the fact that corporate / investor self-interest drives policy through disinformation and misinformation: there is no money in telling the truth about resource and capabilities shortcomings.

The tax incentive, giving equal credit for low and high-operating-temperature NdFeB magnets, will constrict the production of high-operating-temperature NdFeB magnets to the availability of Tb and Dy resources. This is and may continue to be a very limited quantity (inconsistent with economic and national security interest).

[138] As may be seen from the graphic, Lynas's projected Tb / Dy production would only meet .008% of global demand based on mining projections. Doubling projections does little on a relative basis and is diluted by the rapid growth in demand.



[139] Heavy REEs like Tb and Dy are more common in thorium-rich REE deposits. Heavy rare earths are uncommon in or absent in low thorium deposits. U.S. and other Allied resource developers avoid any deposit with elevated levels of thorium to avoid regulatory costs and liabilities.

[140] Total U.S. production of high-operating-temperature NdFeB magnets will be capped at what Lynas and others can mine, refine and separate within the confines of approved countries. At this point in time the amount of Tb and Dy that would qualify is zero kg. A survey of all well-known projects hoping to come on-line does not bode well for the U.S. Tb / Dy levels for nearly all of these projects is woefully insufficient. The prospects for separation remain uncertain (the Lynas / Blue Line collaboration was terminated).

[141] China is MP's only off-taker and will remain its primary off-taker even under MP's current magnet production plan (to produce 1000 tons per year of NdFeB magnets). The MP plan would only utilize about 350 tons of Nd / Pr, or less than 1% of MP's annual production. As for available Tb / Dy, the tiny amounts produced by Lynas would limit the amount of high-operating-temperature magnets that MP or

any other NdFeB magnet producer would not elect to produce because of the resulting loss of the tax credits (as the only source of Tb and Dy, beyond Lynas's meager contribution, will continue to be from China). Regarding MP's 1000 ton per year plan, what do they plan to do with the disproportional balance of Nd and Pr? Do they continue to sell it to their Chinese partner? MP's commitment to produce 1000 tons per year of NdFeB magnets may prove to be nothing more than a distraction (with no high-operating-temperature magnet production beyond what Lynas can contribute in Tb and Dy).

More realistically, MP would elect to produce as much Ce+NdFeB material as possible, capturing the full $30 per kg tax credit. Others would follow. Note that the Ce+NdFeB magnet is primarily used in toys and novelty items.

What deductions can be made from these political actions? Changes to H.R. 5033 reflect the fact that MP cannot produce Tb or Dy. The changes reflect that legislators were convinced that Lynas could fill the gap. These beliefs are woefully misplaced. The changes demonstrate that MP, Lynas, and other downstream end-user companies that pushed for this legislation only concerned themselves with "shareholder" interests. Shareholder interests typically do not correlate with national interests and more frequently conflict with national interests. In this case shareholder interests align with China's interests.

[142] Another way this works is that China conceals its ownership or influence over '*U.S. companies'* that present themselves as home-grown domestic companies dedicated to promoting U.S. commercial and national interests. In some instances, these companies have filed for and were granted U.S. government funding awards. For example, a federal grant was awarded to the company Microvast despite the company having documented ties to the CCP and operating primarily out of China. The grant was part of the Infrastructure Investment and Jobs Act (IIJA), which aimed to help secure America's domestic supply chains by being less reliant on China for materials such as lithium-ion battery cells or critical minerals. According to Reuters, over 200 companies competed for grants under the IIJA last year, but only 20 companies were awarded, including this Chinese-backed company. In a press release the company describes itself as: a leading global provider of next-generation battery technologies for commercial and specialty vehicles ("Microvast" or the "Company") and Tuscan Holdings Corp. (Nasdaq: THCB) ("Tuscan"), a publicly-traded special purpose acquisition company. However, Microvast is owned by holdings company Microvast Holdings Inc. In a December 14, 2021, filing to the Securities and Exchange Commission (SEC), Microvast Holdings Inc. stated, "A substantial portion of our facilities are currently located in the People's Republic of China, which we refer to as the 'PRC' or 'China.'" The filing also said, "We are a holding company, and we conduct all of our operations through our subsidiaries, and principally through our subsidiary in China." It also stated that investing in Microvast Holding Inc. involved "substantial risks" related to the fact that the company "conduct[s] a substantial majority of our operations through our operating entities established in the PRC".

[143] Demonstrated in the fact that U.S. corporations divested, offshored, and transferred nearly all transferrable industry and IP to China or some other low-cost environment in pursuit of profits.

[144] For EV batteries see: Joint Ford-China Electric Vehicle Battery Plant Not in American Interests (dailysignal.com). Medical Imaging: GE moves its Medical Imaging business to China: GE moving X-ray business to China - The Boston Globe – the article does not disclose that GE made this move for access to high powered REE magnets (This is exactly what happened to another medical imaging company in Florida). Smart Phones: Apple moved to China in 2004 for access to rare earths and inexpensive labor. Apple introduced the iPhone in 2007 and a Chinese SOE was producing knock-offs the same year. Today China produces more smartphones than Apple (and has sued Apple for trademark and IP infringement). Apple, Google and other big tech companies cooperate with China's social monitoring and data restrictions policies inside China. R&D / Material Science: GM moved its Automotive R&E, research

laboratories to China. The move included several GM technical development and design programs, including GM's Science Lab, Vehicle Engineering Lab, Advanced Materials Lab, Advanced Powertrain Engineering Lab and Advanced Design Center. Reportedly it includes 62 test labs and nine research labs, and employs up to 250 engineers, designers, researchers, and technicians. Defense Industry: The Pentagon allowed subcontractors to use Chinese-sourced materials for nearly two decades by defining "critical materials" at the alloy level. The law, 10 USC 2533b, created a loophole for using separated oxides and base metals from China. Admittedly, it was customary to make some effort in obfuscating the origin of these materials (as detailed by a panelist directly involved in the design and fabrication of REE motors and actuators for the aerospace and defense industry during a Congressional Briefing on REE on July 26, 2019).

[145] Stating that Japanese magnet manufacturers are moving to China to remain profitable.

[146] Internationalization of China's rare earth standards

Since 2015 there has been a ISO working group called ISO/TC 298 to internationalize China's rare earth industrial standards.

They have internationalized 7 (yes, seven) standards during all these years:

- 2 on vocabulary/terminology;
- 2 on recycling;
- 1 on exchange of information;
- 1 on packaging and labelling;
- 1 on traceability;

A further 9 are in the pipeline. [Remove Bullet Point]

[147] China bans foreign direct investment in rare earths and rare earth processing as per its so-called "Negative List," published by the National Development and Reform Commission (NDRC - used to be called *State Planning Commission)*:

外商投资准入特别管理措施（负面清单）（2021 年版）

序号	特别管理措施
一、农、林、牧、渔业	
1	小麦新品种选育和种子生产的中方股比不低于 34%、玉米新品种选育和种子生产须由中方控股。
2	禁止投资中国稀有和特有的珍贵优良品种的研发、养殖、种植以及相关繁殖材料的生产（包括种植业、畜牧业、水产业的优良基因）。
3	禁止投资农作物、种畜禽、水产苗种转基因品种选育及其转基因种子（苗）生产。
4	禁止投资中国管辖海域及内陆水域水产品捕捞。
二、采矿业	
5	禁止投资稀土、放射性矿产、钨勘查、开采及选矿。
三、制造业	

Special Management Measures (Negative List) for Foreign Investment Access (2021 Edition) "Investment in rare earth, radioactive minerals, tungsten exploration, mining and mineral processing is prohibited."
Source: NDRC

[148] Based on price and production capabilities of Chinese vs. U.S./allied strip-caster systems.

[149] Samarium, Europium, and Gadolinium.

[150] And potentially, a small facility in Vietnam.

[151] China warning to stay out of battery metals: [Chinese Envoy Warns US Not To Cut China Out of EV Supply Chain (jalopnik.com)](https://jalopnik.com) , and stay out of REEs [China's Monopoly on Rare Earth Elements—and Why We Should Care - Foreign Policy Research Institute (fpri.org)](https://fpri.org)

[152] This is exactly the case with LCM and the German company VAC. Both produce NdFeB magnets above the market price set by China. Both rely on China for critical inputs. Both are vulnerable to price and supply manipulation. Neither of these NdFeB magnet producers are independently viable.

[153] Rare earth metals, alloys, and garnets are used in many consumer & commercial products and are critical for many U.S. weapon systems. The H.R. 5033 (either version) bill does not incentivize the production of these materials so it is unlikely any U.S. company will make them. The reasons for this are threefold. First, is material substitution. A U.S. company may need to forego profitable magnet production (with a tax credit) to make metals, alloys and garnets that don't qualify for a tax credit. Second, China will still hold a production cost advantage for these materials. Third, many of these alloys require heavy rare earths that MP and Lynas cannot produce in any meaningful quantity.

[154] The historical strategy of all successful monopolies includes the ability to undercut a competitor's price and withstand the resulting losses for an extended period of time. By stating the expiration of U.S. tax credits may act as a signal to China for when to resume its monopoly pricing strategy.

[155] Contracts between companies like GM and MP are a small portion of overall supply needs. Other contracts are needed for GM demand. They have made explicit commitments to Buy American and Buy Domestic for their battery raw materials through 2025. Projects have been announced, funding set aside, but permitting and other obstacles remain. It remains to be determined how they will meet similar REE demand.

[156] China has a well-earned reputation for reprisal, in the form of disrupting supply to companies that do something as simple as speak publicly on this topic. In one case, a U.S. company testified before Congress and China disrupted supply of REE magnets for two years, pushing the company to near bankruptcy (also see endnote [109]).

[157] In the case of the former Molycorp company, the company generated $7 billion in "shareholder value" before going bankrupt in 2015, affecting retail investors and the Pentagon, who supported it in 2010. See: https://www.defenseone.com/ideas/2020/08/rare-earths-pentagon-making-same-mistake-twice/167585/. Another announcement by GM and Vacuumschmelze (VAC) states that the magnets will be produced from "locally sourced raw materials." The only "local" source of REEs is MP. However, MP sends 100% of its production to China for separation. That makes China the supplier of these *"locally sourced materials."* Looking deeper, MP's Mt. Pass mine cannot produce Tb or Dy so these critical components for any EV magnet will be *"sourced"* in China. Similarly, GM and Vacuumschmelze have claimed that the Tb and Dy will be coming from Lynas, an Australian mining company that ships its concentrates to Malaysia, with plans to then ship its mixed oxides to Texas for final separation. Note that the original Lynas / Blue Line collaboration has ended (with no public statements of why or how Lynas will proceed). Assuming the Lynas facility is successful in the separation of its Sm, Eu, Gd and tiny amounts of Tb and Dy, it can be assumed that Lynas's mostly Japanese investor and purchasers will not allow GM to take all the Tb and Dy (a single GM EV model could require more than 100% of the projected TbDy production). The question becomes, why the Pentagon is funding Lynas if GM ends up with all the high-operating-temperature NdFeB magnets (leaving no offtake for the defense industry). Other questions for consideration is why Blue Line opted out and what is the future status of the Lynas Malaysian facility (the Malaysian government has pulled their operating license again over thorium

waste and accumulation) https://advancedmagnetsource.com/2022/08/03/gm-and-vacuumschmelze-vac-to-build-a-new-magnet-factory-in-us-to-support-ev-growth/

[158] The defining calculus of U.S. and allied publicly traded companies (or companies looking to go public) is ultimately reduced to seeking investor patronage in the form of a higher stock price. For "speculative" companies this is accomplished by churning out press releases (Estimated resources, downstream partnerships, project development goals, DoD/DoE or partner funding – but achieving stated targets tends to not happen for most REE companies: with estimates of over 400 bankruptcies in this space since 2010). For operational companies this can be done by displacing a competitor's market share. To believe otherwise is contradictory to the nature of publicly traded companies over the last 40 years (Note that all of China's REE capabilities were transferred to it by U.S./allied companies looking to boost profits and/or off-shore environmental risk).

[159] Initially, during the 2010 – 2015 time period, the Pentagon may have been misled by Molycorp into believing the classification as a Heavy REE ore body capable of feeding permanent magnet supply chains. However, the lack of supporting minerology in Mountain Pass' mine was pointed out to the Pentagon many times by members of Congress and this Document's authors. More recently the Pentagon has adopted this disingenuous classification to justify inappropriate funding of unqualified REE projects.

[160] Consider the data provided by the Pentagon in this report: "BUILDING RESILIENT SUPPLY CHAINS, REVITALIZING AMERICAN MANUFACTURING, AND FOSTERING BROAD-BASED GROWTH: 100-Day Reviews under Executive Order 14017, June 2021: A Report by The White House" 100-day-supply-chain-review-report.pdf (whitehouse.gov). In the section prepared by the Pentagon titled "REVIEW OF CRITICAL MINERALS AND MATERIALS DEPARTMENT OF DEFENSE" invalid data was inserted (see table 5, below). The incorrect data relates to the misclassification of heavy vs. light REEs (compare to the official USGS classification in footnote 8). This misclassification was first introduced by now bankrupt Molycorp in 2010, to obfuscate questions about the geochemical deficiencies of its deposit (and absence of heavy REEs, other than tiny amounts of Y). The misclassification was used to deter inquiry specific to the company's ability to produce critical downstream products, including representations made to the Pentagon and investors. The classification below, provided by the Pentagon to the White House report, misclassifies Eu and Gd as heavy REEs. Since 2009, the expert authors of this report have attempted to inform the Pentagon of this misclassification.

The Pentagon's reintroduction of this misclassification results in three errors. First, it provides cover for the Pentagon's inappropriate funding of MP, as the primary condition of a recent funding award was specific to Heavy Rare Earths (MP cannot be classified as a heavy REE project, and the Lynas / Blue Line project is questionable on the same grounds. It should be noted that Blue Line is no longer affiliated with Lynas.) Second, it silences the many experts in the field who have pointed out MP's irreconcilable geochemical incompatibility with U.S. economic and national security needs. Third, it demonstrates the Pentagon's limited understanding of the REE issue, as it relates to national security. Why is this important and significant? The misclassification allows U.S. policy and Federal funding to continue to back fatally flawed projects (Pentagon funding stimulates private investment into selected projects and away from alternative projects).

Why are these projects fatally flawed? They lack commercially relevant quantities of Dy and Tb. These elements are used to make high-temperature-tolerant NdFeB magnets. Without these elements, it is impossible to make high-operating-temperature NdFeB magnets used in weapon systems and for EVs and other green technologies. By funding these projects, the Pentagon leaves China in control regarding access to separated Dy and Tb.

Table Below was produce by DoD for the White House. **Note: Eu & Gd ARE NOT HEAVY REEs:**

Figure 5: Downstream Applications for Rare Earth Elements:

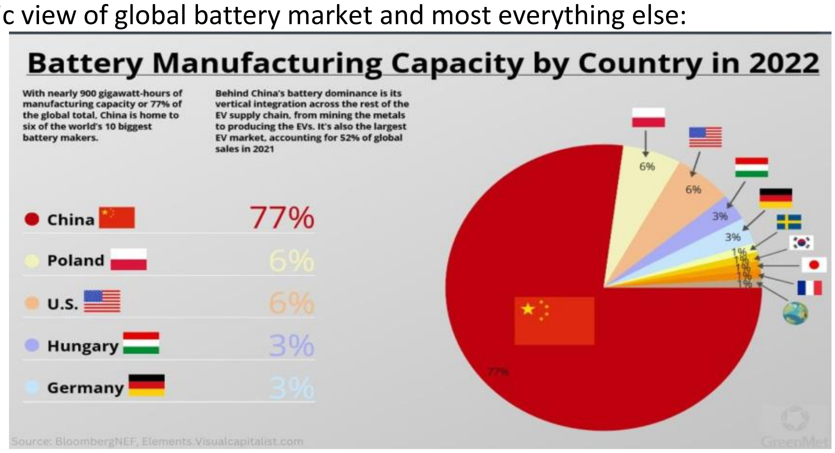
Element		Major Applications
LREE	**Lanthanum**	Fluid catalytic cracking for petroleum refining, nickel metal hydride (NiMH) batteries, metallurgical applications, glass and polishing ceramics lighting.
	Cerium	Automobile catalysts and additive, FCC additives, catalysts, metallurgy, polishing, powders and glass and others such as fertilizer, paint drying, and a stabilizer in plastics. Applications often overlap with lanthanum.
	Praseodymium	NdFeB, metallurgical applications, pigments, batteries, and catalysts.
	Neodymium	NdFeB magnets, glass and ceramics applications such as ceramic capacitors, metallurgical applications such as a minor alloying element for iron and steel alloys and magnesium alloys, luminophores, and other applications such as NiMH batteries, catalysts, and lasers. NdFeB magnets are used in products such as computer hard disk drives, magnetic resonance imaging (MRI), precision guided munitions, automotive motors, wind turbines, and loudspeakers.
	Samarium	Samarium cobalt permanent magnets, which are used in electronics (including military systems), automobiles, aerospace, pumps, and medical devices. Other applications include infrared absorption glass, optical glass, fuel cells, for nuclear applications, and capacitors for microwave frequencies.
HREE	**Europium**	Phosphors and luminophores, which are used in TV and computer screens, compact fluorescent lighting, light emitting diodes (LEDs), and sensors. Other applications include nuclear and medical applications and for some specialty alloys and lasers.
	Gadolinium	Metallurgical applications such as magnetic refrigeration, magnesium alloys, and specialty alloys. Also used in small amounts for samarium cobalt magnets. Other uses include MRI contrasting agent and phosphors for dental and medical applications.
	Terbium	Phosphors (green) for displays, LEDs, and in medical applications, in permanent magnets, and for other applications such as high-temperature fuel cells, lasers, and magnetostrictive alloys for solid-state transducers and actuators used in sonar and other dual use technologies.
	Dysprosium	Neodymium iron boron permanent magnets in which it makes up generally about 0.8 percent to 1.2 percent by weight of the magnet; magnetostrictive alloys.
	Holmium	Magnets, magnetostrictive alloys for sensors and actuators.
	Erbium	Nearly all erbium is used in polishing and in highly specialized glass lens applications and fiber optics.
	Thulium	Portable X-ray devices, research, and a dopant in solid-state lasers and highly specialized fiber optics.
	Ytterbium	Metallurgical applications for rare earth magnesium alloys and specialty aluminum alloys.
	Lutetium	Used in medical equipment and small quantities in phosphors.
	Yttrium	Yttrium-stabilized zirconia (YSZ) ceramics, phosphors, and metallurgy. Some specific applications include thermal barrier coatings, lasers, oxygen sensors, and solid electrolytes for solid oxide fuel cells (SOFCs). Phosphors, optical glasses, rotary-wing aircraft alloys, and nickel-metal hydride (NiMH) batteries.
	Scandium	Solid oxide fuel cells (SOFC), aluminum alloys for aerospace and sporting goods, scandium-sodium lamps for outdoor venues, laser, optoelectronic materials, LEDs.

[161] China has transitioned away from dominating mine production. China now outsources mine production to other countries, thus offshoring the resulting environmental consequences and preserving its own resources.

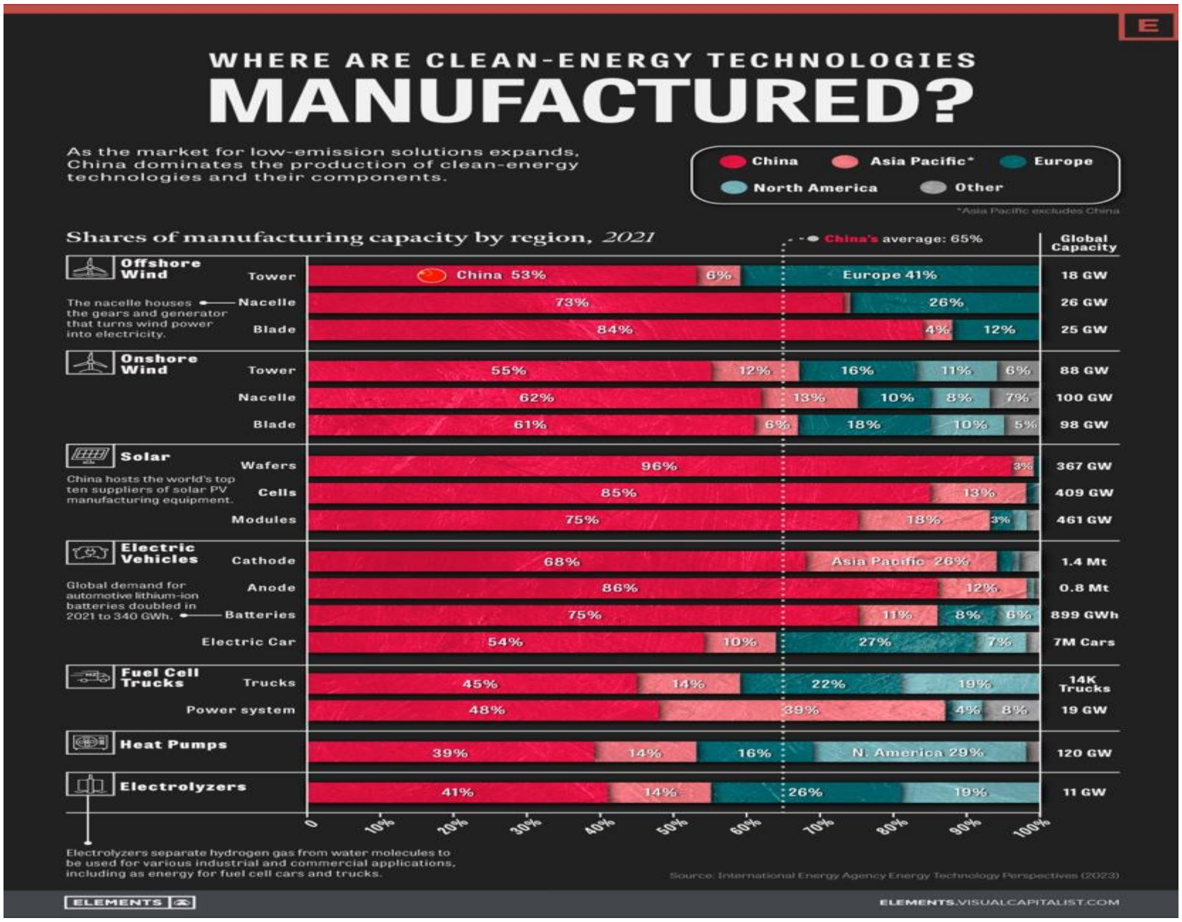
[162] For separated Nd or NdPr oxide, some limited non-Chinese capability exists. Lynas Corp operates a REE mine in Western Australia and ships concentrate to Malaysia for separating into Ce, La, and NdPr. Toyotsu Rare Earths India (“**TREI**”) was established as a JV company between Toyota and the Indian

state-owned REE company IREL Ltd. Finally, Neo Materials is the owner of a REE separation plant in Estonia but is considered geopolitically aligned with China. None of the existing non-Chinese separation plants alone can come close to resolving the U.S. and allied world's dependency on China for REE magnet materials. Both Lynas and TREI prioritize supply to Japanese customers. Neo Materials supplies mainly to their in-house magnet powder facilities located in China and Thailand. Furthermore, Neo Materials is presently dependent on Russia for raw material feed. Whereas steps are being taken to alleviate this dependency, including some supply from the USA via Chemours and Energy Fuels, Neo Material's scope for expanding their separation activities will require new raw material feeds from ventures yet to become operational. Neo Materials is seen by several this paper's contributors as a proxy agent of China and whose actions tend to correlate with Chinese geopolitical interests. As an additional consideration, none of these ventures separate Tb or Dy, and, although Lynas has announced plans to establish such separation in the USA, the nature of the ore bodies being processed means there will be insufficient Tb and Dy to meet projected demand. The background to both Lynas (and TREI see below) illustrates the[?] type of measures that are essential for any non-Chinese venture to become established. Both companies required significant levels of government intervention, and in the case of Lynas direct Japanese investment in its startup and a financial bailout in 2016 (with direct support from the Japanese government and its off-take partners), and the more recent financial support from the U.S. government (none of this support solves the Tb/Dy deficiency in their ore deposit). Note: TREI was established as a JV company between Toyota and the Indian state-owned rare earth company IREL Ltd.

[163] Alternate graphic view of global battery market and most everything else:



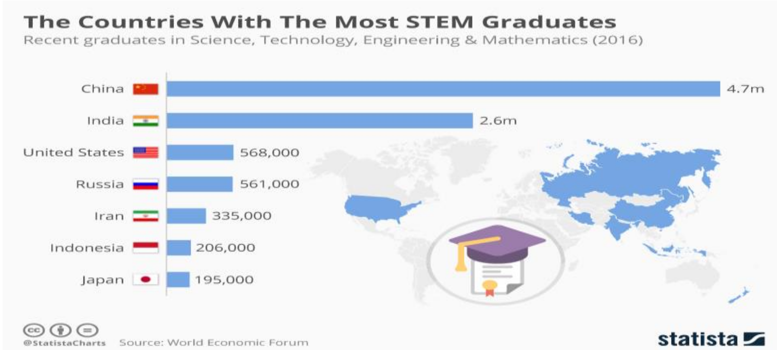
AND MOST EVERYTHING ELSE



164 Includes all 216 MP employees, all 25 employees at Blueline, 30 full time equivalent employees at Energy Fuels and 4 full-time equivalent employees at Chemours. Electron Energy does produce Samarium Cobalt (SmCo) REE magnets in the U.S. with about 130 full-time employees. SmCo magnets represent about 2% of all REE magnets and are exclusively used in defense systems. Currently China separates most or all Sm. The metallic conversion process is not the same as for NdFeB magnets. These magnets are produced in the U.S. and the EU., mostly Chinese-separated Sm oxide. Not Included: Noveon, formerly Urban Mining, has about 40 full-time employees and plans on producing NdFeB magnets from recycled materials. Based on what is publicly available and a failure to respond to multiple inquiries, Noveon will not be considered a "commercial enterprise." None of the other U.S. REE companies are operational / commercial enterprises. Companies like UCore, U.S. Rare Earths and others are pre-economic and pre-production entities. No employment numbers have been included. Out of the 405 full-time U.S. employees, over half of them are actively supplying China's downstream REE monopoly. Not Included: Phoenix Tailings: Although the company has demonstrated downstream capabilities, according to their most recent public statements, as of January 19, 2023 they have not begun commercial production (despite the headline): Phoenix Tailings Massachusetts Facility the First Rare Earth Metal Refinery in the U.S. Recent statements by Phoenix Tailings Chief Executive Officer and Co-Founder Nick Myers suggest that they are still very much reliant on China [or something like that]: "We are currently seeing a rush of new players in the rare earths space who are focused on the extraction or concentrate production. Unfortunately, these materials still need to be sent to China to be refined."

[165] Many of the people working in the U.S. REE industry are working for non-commercial enterprises, such as non-permitted, non-operating REE mines or nascent refining, separation, metallic or REE recycling companies.

[166] Lynas and Lifton Agree that the #1 Shortfall in the Critical Minerals Industries are People. – Investor Intel



https://www.statista.com/chart/7913/the-countries-with-the-most-stem-gradua

[167] Note that the capabilities for all U.S. universities working on REEs is very limited in scope.

[168] Note that all "research" at the four major Chinese REE SOEs is considered by the Document's authors to be government-sponsored.

[169] Regarding the definition of a non-REE monopoly in practice, the world price for niobium products is set by CBMM, which produces 85+% of the global demand for niobium. CBMM has the world's largest accessible deposits of pyrochlore. Similarly, China, Inc., produces at least 80, perhaps closer to 90%, of the world's LREEs and SEGs. Similarly, it processes 100% of the world's HREEs. Therefore, China is the price setter for all REEs. A defining characteristic of a monopoly is that it can produce ALL of the market's demand, if necessary.

[170] Ames Laboratory, the only national lab that specializes in REEs, would not respond when asked to estimate the number of full-time or full-time equivalent employees working on REEs. The only statement from Adam J. Schwartz, Director, Ames National Laboratory was as follows: "The research projects at Ames National Laboratory are structured based on expertise and as such are focused on many different materials systems. Funding for these projects is not broken down according to specific material families. Similarly, our research staff work across many projects, based on their expertise and the "full time equivalent effort" on any given project or materials systems is not tabulated."

[171] Based on a survey of 5 of the top U.S. mining schools, it is estimated that there may be as few as 200 full time equivalent researchers across the U.S. university system. No U.S. university surveyed had a full-time REE research position.

U.S. Full-Time REE Research Across 5 Of America's Top Mining Schools Total Less Than 21:

Virginia Tech estimates "*8.1 full-time equivalents, including graduate students doing grant research, largely related to REE recovery from coal. Most or all of this research began in 2016*."

University of Kentucky estimates 5 full-time equivalents. "*The University of Kentucky has at least 5 full-time equivalent REE researchers. Most of this research began in 2017*."

South Dakota School of Mines and Technology has 12 full-time or full-time equivalents spread across all tech metals but did not respond to requests for REE specific work. Consequently, one-third of the workload was estimated to specific to REEs, or 4 full-time equivalent researchers.

Colorado School of Mines has 3 full-time equivalents, stating that *"We do not have a single dedicated REE program at Colorado School of Mines. We have separate programs in geology, mining engineering, metallurgical engineering, and mineral economics - each of which has a person or two with some* *expertise in rare earths." "For Colorado School of Mines, I estimate 3 FTE representing 6 people each of whom are spending about half of their time on rare earths."*

Missouri Science and Technology (MS&T) University in Rolla less than 1 full-time equivalent, stating that *"My best estimate is less than 1. Probably less than 0.5FTE. We have two people who work directly on rare earths – Lana who does separation research and Marek who does exploration and characterization work. But these two don't work exclusively on rare earths and work on other critical minerals too. Given that they are both on 40% research appointments (40% research, 40% teaching and 20% service), I will guess their FTE dedicated to rare earths is probably in the order of 10-20% each. There are others like me and Mike Moats who do other things (sustainability) that tangentially affect rare earths but no one else is directly involved in rare earths research besides Lana and Marek at this time. I think part of it is that we've been more successful with research funding in other areas beside rare earths. I know Lana, in particular, will like to do more rare earths research if there was funding."*

Note that much/most of this work is in response to the current level of DoE / DoD funding available. When I asked Aaron Noble, Associate Professor with the Virginia Tech program, if most of this work was coal-related and when it began, he replied: *"You are correct. Nearly all of our work has been funded through the NETL program, which is focused on the recovery of REEs from coal and coal byproducts. The program is now denoted as the "Critical Minerals Sustainability" division:* https://netl.doe.gov/resource-sustainability/minerals-sustainability. *Wencai and I have had some projects funded through APRPA-e, and I believe Wencai has at least one funded through EERE, but these tend to be focused more broadly on critical minerals with REEs being a subset. Some projects have been funded by private industry. Regarding your second question (when did this work begin), I had to look deep into my records. The first solicitation was issued back in June 2015…"*

[172] On the research side, most U.S. university REE "experts" are not employed in REEs as a full-time responsibility. Few have any commercial experience.

[173] Baotou Steel operates the mine. China Northern buys the mixed rare earth carbonate from Baotou Steel. Baotou Steel auctions off the monazite. Of course, Baotou Steel is a dominating shareholder in China Northern and management personnel among the two is shared. Technically speaking these are separate entities.

[174] DATA OF 2019 (AUTO-TRANSLATED FROM CHINESE): www.reht.com: Source: https://www.reht.com/h-nd-104.html#_jcp=1&_np=107_0

[175] Bayan Obo world biggest rare earths mine, Baotou, Inner Mongolia, China | EJAtlas

[176] Including hundreds (possibly thousands) of illegal mining operations.

[177] According to a report by the China Chamber of Commerce, of Metals, Minerals and Chemicals Import and Export, presented by Feng Yunguang at an Argus rare earth conference in 2017, China's black market REE production exceeds its official production by as much as 150%. The report also noted that during the year 2016 over 415 illegal mines were inspected.

[178] Total assigned quota for 2022:

- China Northern Rare Earth (Group) High-Tech Co., Ltd.: 128,934 mt
- China Rare Earth Group Co., Ltd.: 58,499
- Guangdong Rare Earth Industry Group Co., Ltd.: 10,604 mt
- Xiamen Tungsten: 6,620 mt

Total estimated quota quantity for 2022 is 204,657 million tons ("**mt**"). Add to that ~36,000 mt as REO from Shenghe Resources (estimate for 2022) resulting in the theoretical total of the company subject to quota plus Shenghe Resources (not under quota owing to imports) for 2022 is 240,957 mt. That would be equivalent to 17.2 mt per employee per year for these 4 companies. Estimated total output of REO in 2022 would be approximately 280,000 tons (including material produced from imports which do not fall under the quota and recycling), i.e., an additional 2,400 direct employees of REE enterprises, bringing the total of directly employed people in China's REE processing industry to 17,000.

Test of estimate:

- China Northern quota of 128,934 mt, using 9,511 self-announced employees equals 1 employee per 13.5 mt of output.
- Leshan Shenghe capacity of 5,500 tons as oxides, using 320 employees equals 1 employee per 17.2 mt of capacity.
- Baotou Hefa capacity of 15,000 tons as oxides, using 800 employees equals 1 employee per 18.75 mt of capacity.
- Baotou Ruixin REE Materials Co., Ltd., capacity of 8,000 tons as oxides, using 409 employees equals 1 employee 19.56 mt.

Alternately: China's "official" processing capacity of 250,000 t as REO divided by 17.2 mt capacity per employee equals 14,535 direct employees in China's REE processing industry. An overall estimate of approximately 20,000 employees, excluding upstream and downstream from separated REE compounds and metals would be a reasonable estimate.

179 Technically the only U.S. REE mine actually produces for China, so the 216 workers could be considered part of China's REE mining workforce.

180 MP and most other REE resource producers (including Lynas to a very small extent) currently exist as resource suppliers to China's downstream value chain.

181 Source: Jost Wübbeke, 2013, Rare earth elements in China: Policies and narratives of reinventing an industry. Resources Policy 38, 384-394

182 By comparison, a famous American industrial city, Gary, Indiana, had 32,000 steelworkers and 175,415 residents in 1970, or nearly 20% of the population working directly in the production of steel (How Gary, Indiana Went From The Magic City To America's Murder Capital (allthatsinteresting.com)).

183 China 2025 includes a target capacity for rare earth permanent magnets of 300 kilotons per annum ("kta"). This would require 90,000 kta of NdPr. The typical monazite is 22% of TREO as NdPr. This would require 450 kta of separation capacity. It seems incredible but is consistent with China's history of maintaining about 200% of global demand capacity on a rolling basis. For example, in 2013 at the Computerized Speech Recognition Environment/Agricultural Climate Resilience Enhancement Initiative conference in Ganzhou, the Chinese stated that they then had more than 200 kta separation capacity.

184 Rare earth U.S. employment 2021 | Statista Estimates 290 people working in the rare earth mining sector. The estimated numbers include many non-operating / pre-financed mines.

185 The production ramp-up resulted in both companies being technically bankrupt. However, Lynas was bailed out by the Japanese government and its off-take customers (in the form of massive debt forgiveness and price supports). Lynas required a bailout led by Japan Oil, Gas and Metals National Corp in 2016.

186 Following the World Trade Organization's "victory" over China's trade practices the predictable flood of REEs drove prices sharply downward. Molycorp and Lynas's response was to rapidly expand production, further pushing prices lower. Because Lynas and Molycorp's REE production was limited to light REEs, some already in oversupply, this compounded their economic distress but left China's heavy REE pricing and profits unaffected.

187 Source: Jost Wübbeke, 2013, Rare earth elements in China: Policies and narratives of reinventing an industry. Resources Policy 38, 384-394. [link?]

188 JL Mag in Jiangxi Province is one of the largest, highest quality and most well-known magnet producers in China (E.g., Xi Jinping toured the factory in 2019). Public information states 2021 output to be just over

10 kt of magnets with 3,500 employees. Hence, output of 3 tons of magnets per employee. If this ratio is extended across the full Chinese output of 190 kt per annum, they would have 63,000 people across the country working on magnet production.

Note that JL Mag's incoming raw materials are REE metals, iron and ferroboron. Their production starts with strip casting alloy from metal, meaning that an upstream producer is supplying the metals. Metal ingot production can be labor-intensive, but it is not a multi-step process like magnet fabrication. This Document estimates that the REE metal production requires another 40,000 people.

[189] See excellent summary: [China NdFeB Magnet Output and Market in 2021 Interests Downstream Application Manufacturers Manufacturer China (horizonmagnet.com)]

[190] Average income levels inside China: [China: average annual salary of an employee 2021 | Statista]

[191] Reflecting the average 5% markup on RE oxides to metals and overall low margins associated with China's REE industry.

[192] Currency converter: [1 CNY to USD - Chinese Yuan Renminbi to US Dollars Exchange Rate (xe.com)]

[193] Does not include labor cost for the estimated 12,000 government-funded / national lab researchers.

[194] Using an average of $65/kg for sintered NdFeB and $85/kg for Bonded NdFeB, or $13.5 billion for sintered NdFeB and $800 million for bonded NdFeB magnets produced inside China.

[195] NdFeB magnets typically contain the RE elements Nd, Pr, Dy/Tb and non-REE elements Fe + B. RE contents vary from 27% RE (low-temp magnets) to 32% RE (high-temp +Tb/Dy magnets). The largest component of the magnet is Fe, an inexpensive commodity representing 67 to 73% of the magnet's weight. B represents about 1% of the magnet's weight. Rare earths only make up about 32% of a magnet's total composition. Fe is relatively inexpensive.

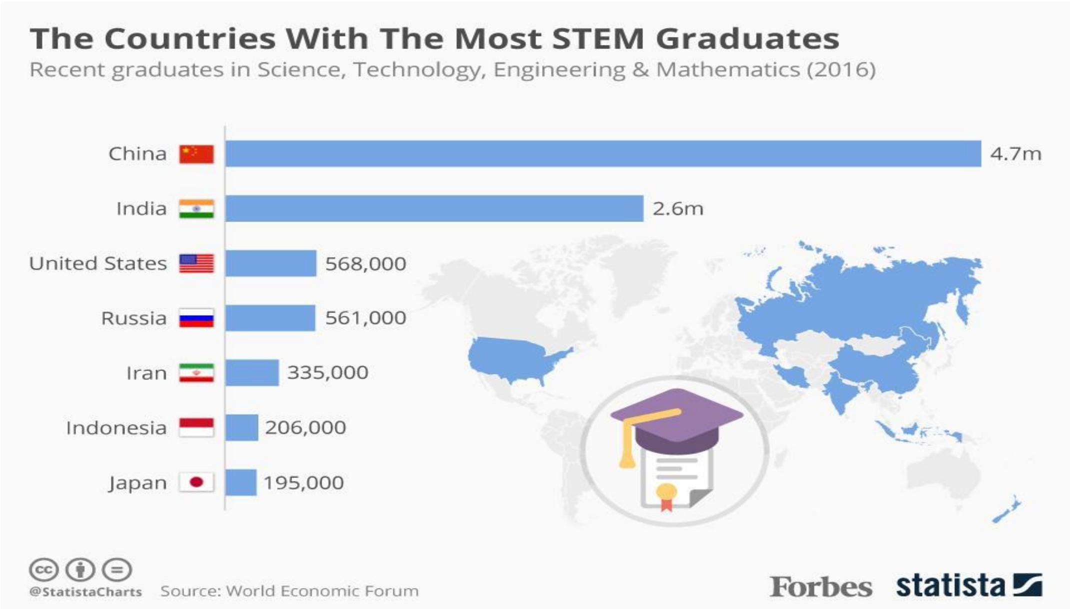
[196] In the case of mining, the U.S. government spent a decade on REE mining policy solutions that neglected to acknowledge China's strategy and advantage in offshoring mining to others. This misallocation of policy was driven by faulty narratives, failure to fully assess the non-competitive environment and a lack of due diligence.

[197] Allied producers collectively can only meet .008% of the Tb and Dy demand based on mining projections. Consequently, the 118th Congressional version maximizes financial rewards for the production of low-temperature magnets. No NdFeB magnet producer will forgo the tax credit and use Chinese-sourced Tb and Dy. There is also no reason for any U.S. magnet producer to bother developing Tb / Dy supply lines. The original and new version of the Magnet Production Tax Credit Act both (H.R. 5033 and H.R. 2849) monetize the status quo in favor of deficient resource producers: with China's continued control over the production of high-operating-temperature magnet production. The bill would result in a financial windfall to MP for the production of low-operating-temperature Ce+NdFeB magnets (the economics and access to HREE resources would dictate this behavior). This would be scored as another win for China.

[198] Rare earth crystals used in industrial, medical and military lasers.

[199] With each independent business segment seeking market pricing, set by China, there is no ability to buffer transfer cost differentials – with China's subsidy and monopoly pricing power focused on the point of separation, metallics and magnets.

[200] China has by far the most STEM graduates (see graphic).



201 Note that MP (Lynas and others) lobbied hard against this solution because it would greatly reduce the scarcity of REEs and consequently reduce price and profits (confirmation of this can be arranged under special circumstances).

202 A 2014 USGS report by Poul Emsbro and others shows that the U.S. phosphate industry alone could meet 65% of global REE demand, with heavy REE distributions far in excess of current global distributions. The obstacle, not disclosed in the report, is the presence of thorium and uranium associated with these deposits. Rare earth elements in sedimentary phosphate deposits: Solution to the global REE crisis? Authors: Poul Emsbo a, Patrick I. McLaughlin b , George N. Breit a , Edward A. du Bray a , Alan E. Koenig U.S. Geological Survey, Box 25046, MS-973, Denver Federal Center, Denver, CO 80225, USA b Wisconsin Geological and Natural History Survey, University of Wisconsin—Extension, 3817 Mineral Point Rd., Madison, WI 53705, USA

203 The portal would be a digital access point with pull-down selection for permitting, environmental reporting, and project assessment. The portal would accept independent and 3rd party reporting, based on the reporting entity demonstrating its qualifications (with significant financial and legal penalties for misrepresentation and fraud). The portal could match-up or outsource project assessment and highly technical evaluations to qualified and independent engineering firms.

204 This is consistent with Federal needs and goals, as this is a national security issue. If a state chooses to self-administer, Federal funds can be withheld if the state deviates from the uniform regulations.

205 Federal Regulations will need to be based exclusively on science and best practices and be able to dismiss spurious challenges.

206 This link is to a peer-reviewed research study that details the economic viability of the Mt. Pass deposit. It is in stark contrast with investor and DoD expectations.

207 Most currently funded research participants and ongoing projects have benefited from supporting the prevailing narrative that overlooks China's many structural advantages. To fully acknowledge the market challenge, their input would increase a project's probability of success to benefit the government and/or the project investors.

208 For more than a decade, a number of the authors of this Document have presented the following information: 1 - Engaged members of Congress and the Pentagon, beginning in 2008, detailing the scope and breadth of China's rare earth monopoly; 2 - Detailed the mechanisms by which China could

intermediate the economic viability of would-be competitors; 3 – Provided detailed analysis of why Pentagon-sponsored projects were not economically viable and incompatible with U.S. economic and national security needs; 4 - Provided detailed analysis and evidence of China's ability to disproportionately manipulate REE markets (China REE production capacity was historically maintained at 2 X global demand, China maintained massive REE reserves that could be used to alter market price and has the market-power to set price [above and beyond labor and environmental cost advantages] – all classic Monopoly strategies). 5 - Detailed the practice of withholding REE supply guarantees to U.S. and Allied technology companies (including firsthand accounts from desperate U.S. technology companies) as a means for forcing the relocating of Allied manufacturing inside China: thus, capturing IP. 6 - Provided firsthand accounts of U.S. companies that were punished by China for petitioning the U.S. government for protection against China's actions. 7 - Detailed how resolving "the thorium problem" would create an abundant and uninterruptable domestic supply of rare earths (including heavy REE) as a byproduct from existing and operating U.S. mines. 8 - Provided details on how no amount of new mining projects would solve this problem (for the first 10 years of this policy debate, nearly all Pentagon and legislative strategies were limited to opening new mines). 9 - Detailed the equally critical downstream processes and how China's monopoly structure is designed to undermine the economic viability of would-be competitors on many levels. 10 - Promoted the development of a multi-national collaborative platform for rare earths and other critical material to counter China nearly a decade ago (detailed in the legislation below), now being considered by this Administration.

All of this was ignored by the Pentagon. Members of Congress did introduce a bill (in the 16th Congress: S. 2093 and H.R. 4410, and in the 113th Congress: S. 2006 and H.R. 4883) that would create a viable operating environment for U.S. companies to develop a U.S. REE magnet value chain. This bill was opposed by Molycorp, MP, Lynas, other would-be REE producers, contracted "industry experts" and / or their agents, the financial backers of these projects and the Pentagon (based on feedback from Congressional staffers). These proposed bills would have allowed significant quantities of HREE byproduct production, widely available in the U.S., to feed domestic value chains while the problematic thorium would be managed separately. Existing producers of LREE feared increased supply and lower profits.

[209] USGS - Rare Earths Statistics and Information | U.S. Geological Survey (usgs.gov)
Congressional Research Service (rare earths) – CRS 2020 An Overview of Rare Earth Elements and Related Issues for Congress (everycrsreport.com), CRS 2019 R45810 (1).pdf, CRS 2019 summary IF11259.pdf, CRS 2013 R41347.pdf

DOE – DEEP DIVE REPORT ON RARE EARTH MAGNETS: https://www.osti.gov/servlets/purl/1871577

RAND Corp REPORT ON CRITICAL MATERIALS SUPPLY CHAINS: https://www.rand.org/pubs/research_reports/RRA2102-1.html

Biden administration's 100-DAY REVIEW, "Building Resilient Supply Chains, Revitalizing American Manufacturing and Fostering Broad-Based Growth"

Excellent General Information Document on Rare Earths: 20230330 GITI Presentation 121 Mining SG.pdf