The Effect of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets on the National Security

An Investigation Conducted Under Section 232 of the Trade Expansion Act of 1962, as Amended

U.S. Department of Commerce
Bureau of Industry and Security
Office of Technology Evaluation

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APPENDICES

1. Executive Summary

This report summarizes the findings of an investigation conducted by the U.S. Department of Commerce (the "Department") pursuant to section 232 of the Trade Expansion Act of 1962, as amended, into the effect of imports of neodymium-iron-boron (NdFeB) permanent magnets on the national security of the United States.[1] Secretary of Commerce Gina Raimondo initiated the investigation on September 21, 2021, in response to a recommendation in the June 2021 White House Report "*Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100 Day Reviews under Executive Order 14017.*"[2][3]

As required by the statute, the Secretary considered all factors set forth in Section 232(d). In particular, the Secretary examined the effect of imports on national security requirements, specifically:

i. domestic production needed for projected national defense requirements;

ii. the capacity of domestic industries to meet such requirements, including the commercial demand needed for economic viability;

iii. existing and anticipated availabilities of the human resources, products, raw materials, and other supplies and services essential to the national defense;

iv. the requirements of growth of such industries and such supplies and services including the investment, exploration, and development necessary to assure such growth; and

v. the importation of goods in terms of their quantities, availabilities, character, and use as those affect such industries; and the capacity of the United States to meet national security requirements.

In preparing this report, the Secretary also recognized the close relationship between the economic welfare of the United States and its national security. Factors that can compromise the nation's economic welfare include, but are not limited to, the impact of "foreign competition on the economic welfare of individual domestic industries; and any substantial unemployment, decrease in revenues of government, loss of skills, or any other serious effects resulting from the displacement of any domestic products by excessive imports." *See* 19 U.S.C. § 1862(d). In

[1] NdFeB magnets are also called NdFeB permanent magnets, neodymium-iron-boron (permanent) magnets, or neodymium (permanent) magnets. This report uses the term NdFeB magnets.
[2] Section 4 of this Report, "Product Scope of the Investigation," discusses the products under investigation. Section 4 also details ancillary products the Department examined to provide traction on the investigation.
[3] *See* "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100 Day Reviews Under Executive Order 14017," The White House, June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

particular, this report assesses whether NdFeB magnets are being imported "in such quantities" and "under such circumstances" as to "threaten to impair the national security."[4]

The investigation was initiated to evaluate the effects of imports of NdFeB magnets on the national security. There are two types of NdFeB magnets – sintered and bonded. However, the investigation and this report largely focus on sintered NdFeB magnets because: 1) Sintered NdFeB magnets comprise over 93 percent of the global NdFeB magnet market and are forecast to grow to over 97 percent of the global market by 2030; 2) Sintered NdFeB magnets have a greater maximum energy product than bonded NdFeB magnets, making them essential in high-temperature applications required by the defense and critical infrastructure sectors; and 3) Sintered NdFeB magnets are less easily substituted for than their bonded counterparts.[5] [6]

NdFeB magnets are the strongest permanent magnets commercially available and improve the efficiency of electrical machines. NdFeB magnets are used in hundreds of products ranging from the ubiquitous, such as headphones and air conditioners, to the highly specialized, like industrial robots. Of particular importance for evaluating the effects of imports of NdFeB magnets on the national security are NdFeB magnets' use in defense systems, including ship propulsion systems and guided missile actuators, as well as numerous critical infrastructure applications such as electric vehicle motors and offshore wind turbine generators.[7] Although NdFeB magnets' value tends to be small relative to the cost of the end-product, they are nonetheless key to product performance.

NdFeB magnets are composed of about 69 percent iron, 30 percent rare earths, and one percent boron by weight.[8] NdFeB magnets contain a mix of rare earth elements, primarily neodymium, praseodymium, dysprosium, and terbium, depending on the end use.[9] NdFeB magnets' iron-

[4] 19 U.S.C. § 1862(b)(3)(A).
[5] Energy product refers to the magnetic energy stored in material, dependent on coercivity and magnetization. "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[6] References to NdFeB magnets indicate sintered NdFeB magnets, except where otherwise specified.
[7] The Presidential Policy Directive on Critical Infrastructure Security and Resilience (PPD-21) advances a national policy to strengthen and maintain secure, functioning, and resilient critical infrastructure. The Cybersecurity and Infrastructure Security Agency maintains a list of 16 critical infrastructure sectors "whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof." Most relevant to NdFeB magnet applications are the Critical Manufacturing, Defense Industrial Base, and Energy sectors, although NdFeB magnets are used widely in other critical infrastructure sectors, including the Healthcare and Public Health and the Information Technology sectors. *See* "Critical Infrastructure Sectors," Cybersecurity and Infrastructure Security Agency, October 21, 2020, https://www.cisa.gov/critical-infrastructure-sectors.
[8] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.
[9] Toyota announced in 2018 that it had developed a NdFeB magnet that substituted cerium and lanthanum for neodymium, lowering total neodymium use by 50 percent. Although cerium substitution typically leads to reduced performance in the form of lower heat resistance and coercivity, Toyota claimed to have discovered a ratio at which

boron component is made up of American Iron and Steel Institute 1001 steel and ferroboron.[10] [11] Small amounts of material, such as nickel and copper, dry-sprayed epoxy, or e-coat (epoxy), are also used to coat NdFeB magnets to prevent corrosion.[12] The rare earth element component constitutes the largest portion of NdFeB magnet cost.

There are five main value chain steps prior to the production of NdFeB magnets: mixed rare earth element mining, processing of rare earth elements into rare earth carbonates, separation of rare earth carbonates into individual rare earth oxides, reduction of rare earth oxides into metals, and alloying of rare earth metals.[13] [14] Magnet manufacturers then process rare earth alloys into either sintered or bonded NdFeB magnets. Sintered magnets are produced by compacting powdered alloy into a solid mass by vacuum pressure without melting it to the point of liquefaction. Bonded magnets are made of rapidly quenched NdFeB magnetic powder mixed into binder and shaped through compression, injection molding, or calendaring.

Except for rare earths mining, the United States is not presently a major participant in the NdFeB magnet value chain. The United States has extremely limited capacity to manufacture NdFeB magnets and is nearly one hundred percent dependent on imports to meet commercial and defense requirements. In 2021, the United States imported 75 percent of its sintered NdFeB magnet supply from China, with nine percent, five percent, and four percent coming from Japan, the Philippines, and Germany, respectively.[15] [16] [17] There is currently only one firm in the United States, Noveon (formerly Urban Mining Company), that produces sintered NdFeB magnets,

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deterioration is suppressed. At the time of the announcement, Toyota expected the magnets would be used in the first half of the 2020s, but more recent updates are not available. *See* "Toyota Develops New Magnet for Electric Motors Aiming to Reduce Use of Critical Rare-Earth Element by up to 50%," Toyota, February 20, 2018, https://global.toyota/en/newsroom/corporate/21139684.html.

[10] The American Iron and Steel Institute and the Society of Automotive Engineers assign designations to types of steel. 1001 steel refers to a type of carbon steel. *See* "Introduction to the SAE/AISI Steel Numbering System," The Process Piping, n.d., https://www.theprocesspiping.com/introduction-sae-aisi-steel-numbering-system/.

[11] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.

[12] Ibid.

[13] Rare earth carbonates are also referred to as mixed intermediates, although the term mixed intermediates can cover rare earth chlorides.

[14] Some publications condense processing and separation or metallization and alloying into single value chain steps, for a total of three or four value chain steps prior to magnet production. The Department elected to divide the value chain into five steps prior to magnet production based on industry consultation.

[15] The import figures cited here corresponds to the value of magnet imports. Using data on unit imports of magnets increases China's import share to almost 85 percent.

[16] The Department's calculations using USITC data. "USITC Dataweb," U.S. International Trade Commission, last modified October 25, 2021, https://dataweb.usitc.gov/trade/search/Import/HTS.

[17] Imports from the Philippines reflect activity by Japanese firms. *See* Appendix E, "Global NdFeB Magnet Production: A Firm-Level Perspective," for more information.

albeit in small quantities.[18] [19] [20] The United States has no domestic production of rare earth oxides or metal. The United States is dependent on foreign sources, especially China, for NdFeB magnets.

China dominates all steps of the global NdFeB magnet value chain.[21] In 2020, China controlled about 92 percent of the global NdFeB magnet and magnet alloy market.[22] China also dominated the 2020 upstream value chain steps, controlling about 58 percent of the rare earth mining market, 89 percent of the oxide separation market, and 90 percent of the metallization market.[23] [24] [25] China controls an even higher percentage of the heavy rare earth mining market, including dysprosium and terbium, which are critical for high performance NdFeB magnets.[26] [27] China's dominant position in the global NdFeB magnet value chain enables it to set prices at levels that can make production unsustainable for firms operating in market economies.[28]

China is the only country with operations in all steps of the NdFeB magnet value chain, including upstream (mining, carbonates production, and separation to oxides) and downstream (metal refining, alloy production, and final magnet production) markets. All other countries maintain operations in only some steps of the upstream or downstream magnet value chain. Firms in the European Union, and especially Japan, specialize in the production of NdFeB magnets and alloys, but have no mining capacity. Japan is the second largest producer of NdFeB

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[18] Noveon indicated it can produce NdFeB magnets from recycled or new or "virgin" material. Meeting between Noveon and the Department of Commerce, (Virtual Meeting, November 12, 2021).

[19] There are three firms, Bunting Magnetics, the Electrodyne Company, and Tengam Engineering, that produce bonded NdFeB magnets in the United States. Meeting between the Defense Logistics Agency and the Department of Commerce, (Virtual Meeting, November 23, 2021).

[20] Noveon was called Urban Mining Company until May 2022. *See* "Urban Mining Company is now Noveon Magnetics: The Nation's Only Manufacturer of Sustainable Rare Earth Magnets Powering our Electrified Future," NewsDirect, May 16, 2022, https://newsdirect.com/news/urban-mining-company-is-now-noveon-magnetics-the-nations-only-manufacturer-of-sustainable-rare-earth-magnets-powering-our-electrified-future-214013391.

[21] *See* Section 7, "Global NdFeB Magnet Industry," and especially Appendix E, "Global NdFeB Magnet Production: A Firm-level Perspective," for more information on global NdFeB magnet value chains.

[22] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.

[23] China produced about 60 percent of global rare earths in 2021. Daniel Cordier, "Mineral Commodity Summaries 2022: Rare Earths," U.S. Geological Survey, January 31, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.

[24] China's share of global rare earths mining increased from 58 percent in 2020 to 60 percent in 2021. *See* Section 7.1, "Global Demand."

[25] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.

[26] "Hyperion Testwork Confirms High Value Heavy Rare Earths," Mining Stock Education, August 9, 2021, https://www.miningstockeducation.com/2021/08/hyperion-testwork-confirms-high-value-heavy-rare-earths/.

[27] USA Rare Earth indicated that China produces one hundred percent of the global supply of dysprosium. Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).

[28] For example, Molycorp, a U.S. mining firm that operated the Mountain Pass Mine in California, declared bankruptcy after China increased its export quotas and rare earth prices fell. Tom Hals, "Creditors of bankrupt rare earths miner Molycorp reach deal," Reuters, February 23, 2016, https://www.reuters.com/article/molycorp-bankruptcy-idUSL2N1621G0.

magnets after China, comprising about seven percent of the global market. Japanese firms also maintain magnet, alloy, and metal capacity in other countries. Firms in Germany, Finland, the Netherlands, and Slovenia produce minimal amounts of NdFeB magnets (less than one percent of global production).[29] [30] Japanese and European firms are almost completely reliant on imported feedstocks to produce metals, alloys, and ultimately NdFeB magnets.[31]

The top upstream producers of rare earth minerals in 2021 were China (60 percent), the United States (15 percent), Burma, (nine percent), and Australia (eight percent).[32] Malaysia comprises seven percent of the 2020 market for rare earth oxide separation, due entirely to the Australian firm Lynas Rare Earths.[33] Outside of China, production of metals is fragmented between Estonia, Laos, Thailand, the United Kingdom, Vietnam, and other countries, with no country having more than three percent of the market.[34]

The NdFeB magnet value chain's fragmentation means that even countries which produce NdFeB magnets remain dependent in part on Chinese inputs. Japan began diversifying its sources of rare earth elements, carbonates, and oxides away from China in the early 2010s, and the European Union has ongoing initiatives to develop a resilient non-Chinese NdFeB magnet supply chain. Despite these efforts, both economies and the United States remain reliant, to differing degrees, on Chinese inputs. China has previously appeared to leverage its market dominance to achieve foreign policy outcomes. For example, in 2010 China restricted exports of rare earth elements to Japan for two months after a collision between a Chinese fishing boat and the Japanese coast guard in disputed waters.[35] [36] Dependence on China leaves U.S. firms and U.S. allies vulnerable to similar Chinese coercion that could have a negative impact on national defense and the preservation of domestic critical infrastructure, such as transportation and energy.

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[29] "About Magnet e Motion," Magnet e Motion, n.d., https://magnetemotion.com/about-magnet-e-motion.html.
[30] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[31] Neo Performance Materials produces rare earth oxides in Estonia from non-European Union feedstock. Meeting between Neo Performance Materials and the Department of Commerce, the Department of Defense, and the U.S. Geological Survey, (Virtual Meeting, November 30, 2021).
[32] Daniel Cordier, "Rare Earths: Mineral Commodity Summaries 2022," U.S. Geological Survey, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.
[33] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[34] Ibid.
[35] "China resumes rare earth exports to Japan," BBC, November 24, 2010, https://www.bbc.com/news/business-11826870.
[36] More broadly, China has encouraged localized production and technology transfer in return for a steady supply of rare earths. *See* Wayne M. Morrison and Rachel Tang, "China's Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States," Congressional Research Service, April 30, 2012, https://sgp.fas.org/crs/row/R42510.pdf.

Ongoing efforts by the U.S. Government and the private sector are intended to mitigate this reliance on Chinese inputs and to establish U.S. production capacity at all steps of the NdFeB magnet value chain. The Department of Defense and the Department of Energy have made limited investments in organizations with the goal of reestablishing domestic production capacity throughout the supply chain. Noveon plans to expand production over the next four years. In addition, three U.S.-headquartered firms – MP Materials, Quadrant Magnetics, and USA Rare Earth – and the German company Vacuumschmelze plan to establish U.S. NdFeB magnet manufacturing facilities by 2026.[37] Noveon and MP Materials have received Department of Defense funding. MP Materials and USA Rare Earth are also looking to develop U.S. capacity in pre-magnet value chain steps, including rare earths mining, rare earth carbonates processing, rare earth oxides separation, metallization, and alloying. Other non-magnet makers are considering building U.S. facilities to produce rare earth oxides and metals. These efforts, if successful, have the potential to create a complete supply chain to produce NdFeB magnets in the United States. Based on forecasted NdFeB magnet production, domestic sources could potentially satisfy up to 51 percent of total U.S. demand by 2026.[38]

If successful, these efforts to produce NdFeB magnets in the United States will be more than sufficient to satisfy U.S. defense-related demand. However, given the fact that defense demand accounts for only a small percentage of total demand, domestic firms in the NdFeB magnet value chain cannot rely solely on defense-related contracts to be viable. The nascent U.S. NdFeB magnet value chain will require substantial and consistent commercial demand and need a broad customer base to be economically sustainable. While domestic production is expected to be substantially less than total U.S. demand, direct U.S. demand for NdFeB magnets will be less than total demand because many NdFeB magnets are integrated into intermediate and final products overseas. These products – and the embedded magnets – are then imported into the United States. In addition, firms that integrate NdFeB magnets in the U.S. may be unwilling to

[37] On MP Materials, *see* "MP Materials to Build U.S. Magnet Factory, Enters Long-Term Supply Agreemenwt with General Motors," MP Materials, December 9, 2021, https://mpmaterials.com/articles/mp-materials-to-build-us-magnet-factory-enters-long-term-supply-agreement-with-general-motors/; On Quadrant Magnetics, *see* "Quadrant's NeoGrass to Become New Magnet Plant in US," Magnetics Business and Technology, April 5, 2022, https://magneticsmag.com/quadrants-neograss-to-become-new-magnet-plant-in-us/; On USA Rare Earth, *see* Trish Saywell, "USA Rare Earth outlines mine-to-magnet strategy," Mining.com, January 8, 2021, https://www.mining.com/usa-rare-earth-outlines-mine-to-magnet-strategy/; On Vacuumschmelze, *see* "General Motors and Vacuumschmelze (VAC) Announce Plans to Build a New Magnet Factory in the U.S. to Support EV Growth," General Motors, December 9, 2021, https://investor.gm.com/news-releases/news-release-details/general-motors-and-vacuumschmelze-vac-announce-plans-build-new.

[38] This is a very optimistic figure with several strong assumptions and should be taken as the maximum potential contribution of the U.S. NdFeB magnet industry. The Department used data from its survey of the U.S. NdFeB magnet industry to forecast U.S. NdFeB magnet production through 2026. This does not consider domestic production of NdFeB magnet inputs such as alloy or metal, which may constrain the ability of U.S.-based firms to use domestic feedstock to produce NdFeB magnets. [redacted] the demand estimate includes NdFeB magnets that are and may continue to be incorporated into intermediate and final products overseas. The 2030 total demand estimate is a high-growth scenario. *See* Section 8.1.4, "Estimated NdFeB Magnet Import Penetration, 2017 to 2026," for more details.

pay a premium for domestic magnets, which are expected to cost more than their Chinese counterparts.

On a potentially positive note, global and domestic demand for NdFeB magnets is forecast to increase dramatically by 2030 and even more so by 2050. The increase in demand is largely driven by global efforts to reduce greenhouse gas emissions which boost the electric vehicle and wind turbine industries. Substantial demand growth may result in a supply crunch for NdFeB magnets but also represents a critical opportunity to establish and maintain a resilient and economically viable domestic NdFeB magnet supply chain.

1.1 Findings

In conducting the investigation, the Secretary came to the following key findings:

1. NdFeB magnets are essential to U.S. national security:

    a. NdFeB magnets are required for national defense systems. NdFeB magnets are currently irreplaceable in key defense applications such as fighter aircraft and missile guidance systems.

    b. NdFeB magnets are required for critical infrastructure. NdFeB magnets are used in critical infrastructure sectors including but not limited to the energy sector (e.g., offshore wind turbines), the healthcare and public health sector (e.g., some open MRI machines and other medical equipment), and the critical manufacturing sector (e.g., electric vehicle motors).

    c. NdFeB magnets are required for infrastructure that is critical for climate change mitigation, identified by the President as an essential element of U.S. national security, and the transition to a green economy.[39] In particular, NdFeB magnets are the technology of choice for electric vehicles and offshore wind turbines.

2. Total domestic demand for NdFeB magnets is expected to grow:

    a. Total U.S. consumption of NdFeB magnets is forecast to more than double from 2020 to 2030, driven by increased demand from the electric vehicle and wind energy industries.

    b. Total domestic demand growth provides an opportunity to develop the U.S. NdFeB magnet industry if enough end-user applications are manufactured in the

[39] *See* "Executive Order on Tackling the Climate Crisis at Home and Abroad," The White House, January 27, 2021, https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/.

United States and the price differential between U.S. and Chinese magnets is narrowed.

3. The United States and its allies are dependent on imports from China:

    a. The United States is essentially one hundred percent dependent on imports of sintered NdFeB magnets and is highly dependent on imports of bonded NdFeB magnets, primarily from China. The United States also lacks domestic capacity at various earlier steps in the NdFeB magnet value chain.

    b. U.S. allies are also dependent on Chinese production, which provides China political leverage.

4. The United States will continue to depend on imports:

    a. There are multiple firms that intend to establish domestic capacity at different steps of the NdFeB magnet value chain. Although these plans have the potential to create a U.S. NdFeB magnet value chain from mine to magnet, they will not produce enough magnets to eliminate U.S. dependence on Chinese imports.

    b. Domestic NdFeB magnet manufacturing will be constrained by capacity limitations at earlier steps in the value chain, in particular rare earth metal refining and NdFeB alloy production. Some U.S. NdFeB magnet manufacturers will have to rely on imported metal and alloy feedstocks to produce NdFeB magnets.

    c. The U.S. NdFeB magnet industry will struggle to fulfill total critical infrastructure demand.

5. The U.S. NdFeB magnet industry faces significant challenges:

    a. The nascent U.S. NdFeB magnet industry faces significant barriers to reaching its production targets. These include but are not limited to Chinese competition, financial and human capital constraints, and consistent demand for more expensive domestic magnets.

1.2 Determination

Based on the findings in this report, the Secretary concludes that the present quantities and circumstances of NdFeB magnet imports threaten to impair the national security as defined in Section 232 of Trade Expansion Act of 1962, as amended.

1.3 Recommendations

The Department has identified several non-exhaustive actions that would facilitate the development of a domestic NdFeB magnet industry, support a reliable supply of NdFeB magnets, and lessen the risk that NdFeB magnet imports threaten the national security. The Secretary recommends pursuing all proposed actions.

1. The U.S. Government should engage with allies through existing fora to efficiently develop production from diverse sources, promote research on NdFeB magnet-related technologies, encourage intellectual property licensing, and cooperate on foreign investment review mechanisms.

2. To bolster the U.S. NdFeB magnet industry by targeting domestic supply the U.S. Government should:

    a. Establish a tax credit for domestic manufacturing of rare earth elements, NdFeB magnets, and NdFeB magnet substitutes.

    b. Continue to direct Defense Production Act (DPA) Title III funding to firms in the U.S. NdFeB magnet industry, in particular to establish metal refining and alloy production facilities.

    c. Encourage eligible NdFeB magnet industry participants to use Export-Import Bank financing through the Make More in America Initiative and the China and Transformational Exports Program.

    d. Allocate additional funding to NdFeB magnet industry participants through other applicable instruments, such as the Bipartisan Infrastructure Law.

    e. Use the Defense Priorities and Allocations System to facilitate NdFeB magnet industry participants' acquisition of critical equipment and feedstock.

    f. Evaluate the use of export controls for domestic producers who face difficulties acquiring feedstocks from domestic sources due to competition with foreign consumers.

    g. Increase the National Defense Stockpile inventories of rare earth elements and other strategic and critical materials related to NdFeB magnets.

3. To promote the development of a domestic industry by enhancing domestic demand the U.S. Government should:

   a. Establish a forum under a lead U.S. Government agency to facilitate cooperation and share information about industry-wide issues between producers and consumers of NdFeB magnets, alloys, rare earth metals, and rare earth oxides. In particular, the U.S. Government should use DPA Title VII to promote offtake agreements using voluntary agreements.

   b. Promote the recycling and reprocessing of NdFeB magnets by developing labeling requirements for end-of-life products using NdFeB magnets, leveraging the Defense Logistics Agency's Strategic Material Recovery and Reuse Program, U.S. Government-owned data centers, and other U.S. Government-owned products like electric vehicles to establish a source of recyclable feedstock, and exploring reuse of other potential feedstocks such as heavy mineral sands and coal tailings.

   c. Mandate minimum domestic and ally content requirements for NdFeB magnets used in U.S. Government-owned electric vehicles and offshore wind turbines that power U.S. Government-owned buildings. NdFeB magnets used in these products should be produced domestically or by allies and contain feedstock sourced domestically or from allies. To minimize disruption, content requirements can be phased-in and waived if there are insufficient eligible sources.

   d. Establish a consumer rebate for products, such as electric vehicles, that use U.S. or ally produced NdFeB magnets.

4. To support the medium- to long-term development of the U.S. NdFeB magnet industry and enhance the resiliency of the U.S. NdFeB magnet supply chain, the U.S. Government should:

   a. Continue to fund research to reduce the use of rare earth elements in NdFeB magnets, develop magnets that can substitute for NdFeB magnets, and develop technologies that avoid the use of magnets – including NdFeB magnets – in electric vehicle motors and wind turbine generators.

   b. Support the development of the human capital required by the nascent NdFeB magnet industry, including materials scientists and production line workers, through applicable funding sources.

5. The U.S. Government should continue to monitor the NdFeB magnet value chain to ensure that U.S. and ally firms are not adversely impacted by non-market factors or unfair trade actions, such as intellectual property violations or dumping.

2. Legal Framework

2.1 Section 232 Requirements

Section 232 of the Trade Expansion Act of 1962, as amended, provides the Secretary with the authority to conduct investigations to determine the effect on the national security of the United States of imports of any article. It authorizes the Secretary to conduct an investigation if requested by the head of any department or agency, upon application of an interested party, or upon their own motion. *See* 19 U.S.C. § 1862(b)(1)(A).

Section 232 directs the Secretary to submit to the President a report with recommendations for "action or inaction under this section" and requires the Secretary to advise the President if any article "is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security." *See* 19 U.S.C. § 1862(b)(3)(A).

Section 232(d) directs the Secretary and the President to, in light of the requirements of national security and without excluding other relevant factors, give consideration to the domestic production needed for projected national defense requirements and the capacity of the United States to meet national security requirements. *See* 19 U.S.C. § 1862(d).

Section 232(d) also directs the Secretary and the President to "recognize the close relation of the economic welfare of the Nation to our national security, and …take into consideration the impact of foreign competition on the economic welfare of individual domestic industries" by examining whether any substantial unemployment, decrease in revenues of government, loss of skills or investment, or other serious effects resulting from the displacement of any domestic products by excessive imports, or other factors, results in a "weakening of our internal economy" that may impair the national security.[40] *See* 19 U.S.C. § 1862(d).

Once an investigation has been initiated, Section 232 mandates that the Secretary provide notice to the Secretary of Defense that such an investigation has been initiated. Section 232 also requires the Secretary to do the following:

1. "Consult with the Secretary of Defense regarding the methodological and policy questions raised in [the] investigation;"

2. "Seek information and advice from, and consult with, appropriate officers of the United States;" and

[40] An investigation under Section 232 looks at excessive imports for their threat to the national security, rather than looking at unfair trade practices as in an antidumping investigation.

3. “If it is appropriate and after reasonable notice, hold public hearings or otherwise afford interested parties an opportunity to present information and advice relevant to such investigation.”[41] *See* 19 U.S.C. § 1862(b)(2)(A)(i)-(iii).

As detailed in the report, all of the requirements set forth above have been satisfied.
In conducting the investigation, Section 232 permits the Secretary to request that the Secretary of Defense provide an assessment of the defense requirements of the article that is the subject of the investigation. *See* 19 U.S.C. § 1862(b)(2)(B).

Upon completion of a Section 232 investigation, the Secretary is required to submit a report to the President no later than 270 days after the date on which the investigation was initiated. *See* 19 U.S.C. § 1862(b)(3)(A). The report must:

1. Set forth “the findings of such investigation with respect to the effect of the importation of such article in such quantities or under such circumstances upon the national security;”

2. Set forth, “based on such findings, the recommendations of the Secretary for action or inaction under this section;” and

3. “If the Secretary finds that such article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security . . . so advise the President.” *See* 19 U.S.C. § 1862(b)(3)(A).

All unclassified and non-proprietary portions of the report submitted by the Secretary to the President must be published.

Within 90 days after receiving a report in which the Secretary finds that an article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security, the President shall:

1. “Determine whether the President concurs with the finding of the Secretary” and

2. “If the President concurs, determine the nature and duration of the action that, in the judgment of the President, must be taken to adjust the imports of the article and its derivatives so that such imports will not threaten to impair the national security.” *See* 19 U.S.C. § 1862(c)(1)(A).

[41] Department regulations (i) set forth additional authority and specific procedures for such input from interested parties, *see* 15 C.F.R. §§ 705.7 and 705.8, and (ii) provide that the Secretary may vary or dispense with those procedures “in emergency situations, or when in the judgment of the Department, national security interests require it.” Id., § 705.9.

2.2 Discussion

Although Section 232 does not specifically define "national security," both Section 232, and the implementing regulations at 15 C.F.R. Part 705, contain non-exclusive lists of factors that the Secretary must consider in evaluating the effect of imports on the national security. Congress in Section 232 explicitly determined that "national security" includes, but is not limited to, "national defense" requirements. *See* 19 U.S.C. § 1862(d).

In a 2001 report, the Department determined that "national defense" includes both the defense of the United States directly, and the "ability to project military capabilities globally."[42] The Department also concluded in 2001 that, "in addition to the satisfaction of national defense requirements, the term "national security" can be interpreted more broadly to include the general security and welfare of certain industries, beyond those necessary to satisfy national defense requirements, which are critical to the minimum operations of the economy and government." The Department called these "critical industries."[43] Although this report applies these reasonable interpretations of "national defense" and "national security," it relies on the more recent 16 critical infrastructure sectors identified in Presidential Policy Directive 21 instead of the 28 industry sectors identified in the 2001 Report.[44] [45]

Section 232 directs the Secretary to determine whether imports of any article are being made "in such quantities" or "under such circumstances" that those imports "threaten to impair the national security." *See* 19 U.S.C. § 1862(b)(3)(A). The statutory construction makes clear that either the quantities or the circumstances, standing alone, may be sufficient to support an affirmative finding. The two may also be considered together, particularly when the circumstances act to prolong or magnify the impact of the quantities being imported.

The statute does not define a threshold for when "such quantities" of imports are sufficient to threaten to impair the national security, nor does it define the "circumstances" that might qualify.

Similarly, the statute does not require a finding that the quantities or circumstances are impairing the national security. Instead, the threshold question under Section 232 is whether the quantities or circumstances "threaten to impair the national security." *See* 19 U.S.C. § 1862(b)(3)(A). This

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[42] "The Effects of Imports of Iron Ore and Semi-Finished Steel on the National Security," Department of Commerce, Bureau of Export Administration, October 2001 ("2001 Iron and Steel Report"), at 5, https://www.bis.doc.gov/index.php/documents/steel/2224-the-effect-of-imports-of-steel-on-the-national-security-with-redactions-20180111/file.
[43] Ibid.
[44] Presidential Policy Directive 21, "Critical Infrastructure Security and Resilience," February 12, 2013 ("PPD-21").
[45] "The Effects of Imports of Iron Ore and Semi-Finished Steel on the National Security," Department of Commerce, Bureau of Export Administration, October 2001 ("2001 Iron and Steel Report"), https://www.bis.doc.gov/index.php/documents/steel/2224-the-effect-of-imports-of-steel-on-the-national-security-with-redactions-20180111/file.

makes evident that Congress expects an affirmative finding under Section 232 before an actual impairment of the national security.[46]

Section 232(d) contains a list of factors for the Secretary to consider in determining if imports "threaten to impair the national security"[47] of the United States, and this list is mirrored in the implementing regulations. *See* 19 U.S.C. §1862(d) and 15 C.F.R. § 705.4. Congress was careful to note twice in Section 232(d) that the list provided, though mandatory, is not exclusive.[48] Congress' illustrative list is focused on the ability of the United States to maintain the domestic capacity to provide the articles in question as needed to maintain the national security of the United States.[49] Congress broke the list of factors into two equal parts using two separate sentences. The first sentence focuses directly on "national defense" requirements, thus making clear that "national defense" is a subset of the broader term "national security." The second sentence focuses on the broader economy and expressly directs that the Secretary and the President "shall recognize the close relation of the economic welfare of the Nation to our national security."[50] *See* 19 U.S.C. § 1862(d).

In addition to "national defense" requirements, two of the factors listed in the second sentence of Section 232(d) are particularly relevant in this investigation. Both are directed at how "such quantities" of imports threaten to impair national security *See* 19 U.S.C. § 1862(b)(3)(A). In administering Section 232, the Secretary and the President are required to "take into consideration the impact of foreign competition on the economic welfare of individual domestic industries" and any "serious effects resulting from the displacement of any domestic products by

[46] The 2001 Iron and Steel Report used the phrase "fundamentally threaten to impair" when discussing how imports may threaten to impair national security. *See* 2001 Iron and Steel Report at 7 and 37. Because the term "fundamentally" is not included in the statutory text and could be perceived as establishing a higher threshold, the Secretary expressly does not use the qualifier in this report. The statutory threshold in Section 232(b)(3)(A) is unambiguously "threaten to impair" and the Secretary adopts that threshold without qualification. 19 U.S.C. § 1862(b)(3)(A).
[47] 19 U.S.C. § 1862(b)(3)(A).
[48] *See* 19 U.S.C. § 1862(d) ("the Secretary and the President shall, in light of the requirements of national security and without excluding other relevant factors . . . " and "serious effects resulting from the displacement of any domestic products by excessive imports shall be considered, without excluding other factors . . . ").
[49] This reading is supported by Congressional findings in other statutes. *See*, e.g., 15 U.S.C. § 271(a)(1) ("The future well-being of the United States economy depends on a strong manufacturing base…") and 50 U.S.C. § 4502(a) ("Congress finds that – (1) the security of the United States is dependent on the ability of the domestic industrial base to supply materials and services . . . (2)(C) to provide for the protection and restoration of domestic critical infrastructure operations under emergency conditions . . . (3) . . . the national defense preparedness effort of the United States government requires – (C) the development of domestic productive capacity to meet – (ii) unique technological requirements . . . (7) much of the industrial capacity that is relied upon by the United States Government for military production and other national defense purposes is deeply and directly influenced by – (A) the overall competitiveness of the industrial economy of the United States; and (B) the ability of industries in the United States, in general, to produce internationally competitive products and operate profitably while maintaining adequate research and development to preserve competitiveness with respect to military and civilian production; and (8) the inability of industries in the United States, especially smaller subcontractors and suppliers, to provide vital parts and components and other materials would impair the ability to sustain the Armed Forces of the United States in combat for longer than a short period.").
[50] *Accord* 50 U.S.C. § 4502(a).

excessive imports" in "determining whether such weakening of our internal economy may impair the national security." *See* 19 U.S.C. § 1862(d).

After careful examination of the facts in this investigation, the Secretary has determined that the present quantities and circumstance of NdFeB magnets imports threaten to impair the national security, as defined in Section 232.

3. Investigative Process

3.1 Initiation of Investigation

On September 21, 2021, Secretary of Commerce Gina Raimondo initiated the investigation to determine the effects of imports of NdFeB magnets on the national security based on a recommendation in the June 2021 White House Report "*Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100 Day Reviews under Executive Order 14017*" ("White House Report").[51] The White House Report noted that the United States is heavily dependent on imports of NdFeB magnets, which are important components of defense and civil industrial systems, and therefore recommended that the Department evaluate whether to initiate an investigation under section 232 of the Trade Expansion Act of 1962, as amended. Pursuant to Section 232(b)(1)(b), the Department notified the U.S. Department of Defense of its intent to conduct an investigation in a letter of September 21, 2021, from Secretary Raimondo to Secretary of Defense, Lloyd Austin III (*see* Appendix A).

3.2 Public Comments

On September 27, 2021, the Department published a *Federal Register* Notice announcing the initiation of an investigation to determine the effect of imports of NdFeB magnets on the national security (*see* Appendix B).[52] The notice also announced the opening of the public comment period. In the notice, the Department invited interested parties to submit written comments, opinions, data, information, or advice relevant to the criteria listed in Section 705.4 of the National Security Industrial Base Regulations (15 C.F.R. § 705.4) as they affect the requirements of national security, including the following:

(a) Quantity of the articles subject to the investigation and other circumstances related to the importation of such articles;

[51] "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100 Day Reviews Under Executive Order 14017," The White House, June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.
[52] *See* also "Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," Federal Register, September 27, 2021, https://www.federalregister.gov/documents/2021/09/27/2021-20903/notice-of-request-for-public-comments-on-section-232-national-security-investigation-of-imports-of.

(b) Domestic production capacity needed for these articles to meet projected national defense requirements;

(c) The capacity of domestic industries to meet projected national defense requirements;

(d) Existing and anticipated availability of human resources, products, raw materials, production equipment, facilities, and other supplies and services essential to the national defense;

(e) Growth requirements of domestic industries needed to meet national defense requirements and the supplies and services including the investment, exploration and development necessary to assure such growth;

(f) The impact of foreign competition on the economic welfare of any domestic industry essential to our national security;

(g) The displacement of any domestic products causing substantial unemployment, decrease in the revenues of government, loss of investment or specialized skills and productive capacity, or other serious effects;

(h) Relevant factors that are causing or will cause a weakening of our national economy; and

(i) Any other relevant factors

The public comment period closed on November 12, 2021. The Department received 41 submissions. Parties who submitted comments included representatives of the domestic NdFeB magnet industry, including firms at different stages of the NdFeB magnet value chain, representatives of the foreign NdFeB magnet industry, representatives of consumers of NdFeB magnets such as the automobiles and electronics industries, representatives of the governments of Australia, Canada, the European Union, and Japan, and other concerned parties.

The Department carefully reviewed the public comments and factored all arguments and data into the investigative process. Public comments from representatives of consumers of NdFeB magnets tended to oppose the implementation of tariffs, citing the negative impact of tariffs for domestic industries that incorporate NdFeB magnets into end products. Representatives of foreign governments echoed concern for the imposition of tariffs and urged the investigation to recognize the strong ties between the United States and its allies. Representatives of the domestic NdFeB magnet industry discussed their future production plans, enumerated the difficulties firms faced in establishing a domestic value chain for the production of NdFeB magnets, and proposed recommendations to alleviate challenges. Two of the most cited challenges were Chinese competition, aided by favorable tax policies, lower environmental and labor costs, and domestic subsidies, and the difficulty of acquiring key intellectual property for sintered NdFeB magnets owned by Hitachi. A number of NdFeB magnet industry stakeholders indicated support for tax credit legislation for domestically produced NdFeB magnets. The public comments of key stakeholders are summarized in Appendix C, "Public Comment Summaries," which also includes a link to the docket number (BIS-2021-0035) under which all public comments can be viewed in full on Regulations.gov.[53]

3.3 Information Gathering and Data Collection Activities

Due to the limited number of firms engaged in the U.S. NdFeB magnet industry, it was determined that a public hearing was not necessary to conduct a comprehensive investigation. In lieu of holding a public hearing on this investigation, the Department fielded a mandatory U.S. NdFeB Permanent Magnet Industry Survey (the "survey") (*see* Appendix D, "U.S. NdFeB Permanent Magnet Industry Survey") to participants in the U.S. NdFeB magnet industry using statutory authority pursuant to section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. § 4555) (DPA). The Department deployed the survey on January 31, 2022, to 60 firms that it identified as current or prospective manufacturers and/or distributors of NdFeB magnets, producers of components used in the production of NdFeB magnets, and significant consumers of NdFeB magnets in critical end-use sectors, with one or more facilities in the United States. Although participants represented all steps of the NdFeB value chain, the Department made a particular effort to identify and deploy the survey to all current or near-commercialization producers of NdFeB magnets and/or components used in the production of NdFeB magnets, and only sampled a small number of distributors and end-users. Seven NdFeB magnet value chain producers headquartered outside of the United States were invited to submit responses reflecting their foreign operations on a voluntary basis. The Department received 51 complete responses.

The survey provided a mechanism for respondents to disclose confidential and non-public information. The survey collected detailed information concerning factors such as current and planned facilities, production, capacity utilization, purchases/sales, employment, capital expenditure, critical machinery, research and development, and challenges and competition. The resulting data provided the Department with detailed industry information that was otherwise not publicly available and was needed to effectively conduct analysis for this investigation.

The Department deems the information furnished in the survey responses business confidential and will not publish or disclose it except in accordance with section 705 of the DPA, which prohibits the publication or disclosure of this information unless the President determines that the withholding of such information is contrary to the interest of the national defense. Therefore, the information submitted to the Department in response to the survey will not be shared with any non-government entity other than in aggregate form.

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[53] *See* also "86 FR 53277 NdFeB Permanent Magnets 232 investigation_published 9-27-21_comments due 11-12-21," Regulations.gov, September 27, 2021, https://www.regulations.gov/document/BIS-2021-0035-0001.

The Department also held 17 meetings with 19 unique U.S. NdFeB magnet industry stakeholders to gather information on firms' perspectives on the industry. Table 1 displays the firms the Department held meetings with, along with their place in the value chain and the domicile of their parent firm.

Table 1: Industry Stakeholder Meeting Participants

Firm Name	Parent Location	Current Market Segment Participation	Description of Current and Planned Market Segment Participation
American Resources	United States	N/A	Planned producer of rare earth oxides from rare earth element waste from a variety of feedstocks, including battery metals and end of life products.
Arnold Magnetics	United States	N/A	Current producer of samarium-cobalt magnets that indicates it could produce NdFeB magnets if it had access to relevant intellectual property.
Energy Fuels	United States	Rare Earth Carbonates Processing	Current producer of mixed rare earth carbonates from monazite. Prospective producer of rare earth oxides and rare earth metals.
General Motors	United States	NdFeB Magnet Consumer	Current consumer of NdFeB magnets. Has a binding agreement with MP Materials and a non-binding agreement with Vacuumschmelze to purchase NdFeB magnets.
IperionX	Australia	N/A	Planned domestic producer of heavy mineral sands and monazite, which can be processed into rare earth carbonates.
Lynas Rare Earths	Australia	Rare Earth Element Mining; Rare Earth Oxide Separation	Current rare earth element miner and producer of mixed and separated rare earth oxides. Current production is outside of the United States but planned rare earth oxide production in the United States.
MP Materials	United States	Rare Earth Element Mining	Current producer of rare earth elements. Planned producer of rare earth oxides, rare earth metals, rare earth alloys, and NdFeB magnets.
National Electrical Manufacturers Association	United States	NdFeB Magnet Consumer	An industry association that includes current consumers of NdFeB magnets. Representatives of Danfoss (products include heat pumps and motors), NIDEC (products include motors), and ABB (products include robotics) participated.
Neo Performance Materials	Canada	Rare Earth Oxide Separation; Metal Refining; Rare Earth Alloy Production; NdFeB Magnet Production	Current producer of rare earth oxides, rare earth metals, rare earth alloys, and NdFeB magnets. Production is entirely outside of the United States.
Niron Magnetics	United States	N/A	Planned producer of iron-nitride magnets, a NdFeB magnet substitute.
Quadrant Magnetics	United States	N/A	Planned producer of NdFeB magnets.
Shin-Etsu	Japan	Metal Refining; Rare Earth Alloy Production; NdFeB Magnet Production	Current producer of rare earth metals, rare earth alloys, and NdFeB magnets. Production is entirely outside of the United States.
Turntide Technologies	United States	NdFeB Magnet Substitute Production	Current producer of a NdFeB magnet-free motor.
Noveon	United States	NdFeB Magnet Production; NdFeB Magnet Recycling	Current recycler and remanufacturer of NdFeB magnets. [redacted]
USA Rare Earth	United States	N/A	Planned rare earth element miner and planned producer of rare earth carbonates, rare earth oxides, and NdFeB magnets.
Vacuumschmelze	Germany	NdFeB Magnet Production	Current producer of NdFeB magnets. Planned NdFeB magnet production in the United States.

3.4 Interagency Consultation

The Department consulted with the Department of Defense's Office of Industrial Base Policy and the Defense Logistics Agency regarding estimates of defense-related demand, as well as methodological and policy questions that arose during the investigation. The Department also consulted with other U.S. Government agencies with expertise and information regarding the NdFeB magnet industry including the Department of Energy, the Department of State, and the Environmental Protection Agency.

4. Product Scope of the Investigation

The directive of the investigation is to assess the effects of imports of NdFeB magnets on the national security of the United States. NdFeB magnets can be produced through bonding or sintering processes. Sintered magnets currently comprise approximately 93 percent of the global NdFeB magnet market, can be used in more demanding applications, and are not easily substitutable with alternative materials.[54] [55] Harmonized Tariff Schedule (HTS) 8505.11.0070 covers the imports of "Permanent magnets and articles intended to become magnets after magnetization: Of metal: Sintered neodymium-iron-boron." Bonded NdFeB magnets do not have their own HTS code but fall under HTS 8505.11.0090 ("Permanent magnets and articles intended to become magnets after magnetization: Of metal: Other").

In order to ensure that the full NdFeB magnet value chain was covered, the Department also examined the supply chains of feedstocks and primary and intermediate products essential to the production of NdFeB magnets. These include rare earths, rare earth carbonates, rare earth oxides, rare earth metals, and rare earth alloys. NdFeB magnets generally use four rare earth elements with supply chain vulnerabilities: neodymium, praseodymium, dysprosium, and terbium.[56] Although iron in the form of 1001 steel, boron, and coating materials such as copper are also components of NdFeB magnets, their supply chains are not expected to pose major issues for magnet production and were not a focus of this investigation.[57]

As of 2020, consumer electronics constituted the largest source of total U.S. demand for NdFeB magnets (45 percent), followed by industrial motors (30 percent).[58] However, this investigation

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[54] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[55] Meeting between the Critical Materials Institute and the Department of Commerce, (Virtual Meeting October 6, 2021).
[56] Cerium is sometimes used in NdFeB magnets but is an overproduced rare earth element and as such does not pose a supply chain vulnerability.
[57] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[58] Ibid.

and report focuses on NdFeB magnets' use in electric vehicles and wind turbines, in addition to defense systems, for several reasons. The U.S. Government has recognized the electric vehicle and wind turbine industries as critical infrastructure.[59] These industries are forecast to be the main drivers of total demand growth for NdFeB magnets, reaching 55 percent of total U.S. demand by 2030 and 61 percent of total U.S. demand by 2050 (*see* Section 6.2, "U.S Demand").[60] In addition, U.S. leadership in and adoption of these technologies are key to the U.S. Government's efforts to address the existential threat caused by climate change. The investigation therefore also considered industries that depend on NdFeB magnets, focusing on the electric vehicle and wind turbine industries. Understanding and considering the effects of any determinations and recommendations on these and other NdFeB magnet-consuming sectors is necessary to ensure a complete analysis of the effect of NdFeB magnet imports on the national security.

5. NdFeB Magnet Production

5.1 Production Process and Value Chain Steps

NdFeB magnets are an intermediate product composed of rare earths and other elements and are necessary for incorporation into a variety of consumer, infrastructure, and defense end-uses.[61] By weight, NdFeB magnets are typically composed of about 30 percent rare earth elements, 69 percent iron, and one percent boron. NdFeB magnets primarily use neodymium and praseodymium, with various amounts of dysprosium or terbium added to increase coercivity at elevated temperatures (i.e., heat resistance). As mentioned earlier, this investigation focuses on the rare earths value chain and current and prospective U.S. production and does not consider iron and boron. There are six main steps in the NdFeB magnet value chain inclusive of magnet production: mining, mixed rare earths processing to carbonates, separation of carbonates into oxides, refinement of oxides into metal, alloy production, and magnet production.

Rare earth elements can be extracted from mining, unconventional sources, and recycled materials. There are two groups of rare earths – light rare earths and heavy rare earths – defined by their atomic weights. In the United States, rare earths are mined from bastnaesite, a light rare earth-rich ore, or monazite, generally as a byproduct of heavy mineral sands.[62] Outside of the

[59] *See* "Critical Infrastructure Sectors," Cybersecurity and Infrastructure Security Agency, October 21, 2020, https://www.cisa.gov/critical-infrastructure-sectors.
[60] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf
[61] Except where otherwise noted, this section summarizes information on the NdFeB magnet value chain found in the DoE's "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report." *See* "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[62] Heavy mineral sands are mainly mined for titanium and zircon. *See* "Heavy Mineral Sand," Science Direct, n.d., https://www.sciencedirect.com/topics/engineering/heavy-mineral-sand.

United States, ion adsorption clays, sometimes called ionic clays, are also a source of rare earths, especially heavy rare earths.[63] [64] Mining projects are often referred to by their grade, which indicates the percentage of rare earths contained in the mined ore. For reference, the Mountain Pass Mine in California, owned and operated by MP Materials, is considered one of the world's highest-grade deposits of bastnaesite, containing on average about seven percent rare earths content.[65] Lynas Rare Earths' Mt. Weld deposit in Western Australia, the other major non-Chinese deposit currently in operation, has a designated grade of about eight percent.[66] Once mined, rare earths are beneficiated using one of several techniques to increase the concentration of rare earths. Research has also been done on extracting rare earths from unconventional sources, such as coal ash and mine tailings, although these techniques have not been commercialized.

Once mined and concentrated, rare earths are separated into individual rare earth oxides. The primary method used to separate rare earth oxides is solvent extraction. The first step in the process is usually to remove cerium, since it is a low-value rare earth element. The cerium-free rare earth oxide mixture is then placed in mixer settlers composed of acidic reagents to separate rare earth elements based on their atomic weight. As a result, solvent extraction consumes significant quantities of acid and water and generates environmentally unfriendly waste. Solvent extraction processes are also tailored to feedstocks. Although facilities can be reorganized to accommodate new sources of rare earth concentrate, it takes time and resources to do so.[67] [redacted][68] Rare earths can also be extracted from end-of-life products.

Rare earth oxides are then refined into metals, most often through electrowinning and calcium reduction.[69] Electrowinning uses a cell made of anodes and cathodes and an electrolyte, while calcium reduction relies on sodium metal to reduce anhydrous rare earth salts. Industry participants indicate that metallization is an energy intensive and potentially hazardous process.[70]

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[63] Although there may be deposits of ionic clays in the United States, they are not currently a source of rare earth elements. *See* "Rare Earth Element Accumulation Processes Resulting in High-Value Metal Enrichments in Regolith," U.S. Geological Survey, August 3, 2018, https://www.usgs.gov/centers/geology%2C-energy-%26amp%3Bamp%3B-minerals-science-center/science/rare-earth-element-accumulation#overview.
[64] Ionic clays are an important source of heavy rare earths in China. *See* Daniel J. Packey and Dudley Kingsnorth, "The impact of unregulated ionic clay rare earth mining in China," Resources Policy 48: 112-116, https://doi.org/10.1016/j.resourpol.2016.03.003.
[65] Comments of MP Materials to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[66] "2021 Annual Report," Lynas Rare Earths, Ltd., 2021, https://wcsecure.weblink.com.au/pdf/LYC/02434182.pdf.
[67] Meeting between Lynas Rare Earths and the Department of Commerce, (Virtual Meeting, March 30, 2022); Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).
[68] Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).
[69] Thomas Lograsso, Critical Materials Institute, written communication, May 8, 2022.
[70] Meeting between Energy Fuels and the Department of Commerce, (Virtual Meeting, March 1, 2022).

Finally, alloys are made by combining selected rare earth metals with iron and boron. There are two types of alloying approaches depending on whether they are meant to produce bonded or sintered NdFeB magnets. Although both sintered and bonded NdFeB magnets use neodymium and praseodymium, sintered NdFeB magnet alloy includes between 0.5 and 11 percent dysprosium or terbium by weight to improve high-temperature resistance to demagnetization, while the absence of these elements in bonded magnets precludes their use in elevated temperature applications.

Sintered NdFeB magnets are manufactured using powder metallurgy. For sintered magnets, specific alloys are first produced and melted. The molten alloy is then poured on the outer surface of a rotating metal cylinder in a process known as strip casting. After strip casting, the as-cast strips are jet milled into a powder with small grains that can be used for magnet production. Jet milling shapes the grains that define the magnet microstructure and affects the magnet's performance parameters. The powder is next aligned and pressed in a magnetic field before being sintered in a high temperature furnace to form the anisotropic magnets. The magnets are then machined to specified shapes depending on their end-use and coated with a metal film to protect the magnet from corrosion. The most common coating is a nickel-copper-nickel layer, although other coatings use gold, chrome, copper, and dry-sprayed epoxy or e-coat epoxy. Finally, magnets are magnetized using a high magnetic field to align the magnetization of the grains.

Bonded NdFeB magnets follow a similar process to sintered NdFeB magnets through the production of magnetic powder. Bonded NdFeB magnets are often made from rapidly solidified material turned into ribbons through melt-spinning or jet casting, which is subsequently milled, or from spherical powders through gas or centrifugal atomization.[71] Bonded NdFeB magnets can also be made from strip cast material after hydrogen decrepitation.[72] The rapidly solidified powder feedstock is then mixed with a binder to form a final shape using compression bonding, injection molding, or calendaring.[73] In compression bonding a liquid coating of thermoset epoxy is applied to the powder, which is then added to a press cavity and compacted under heat to produce a rigid magnet.[74] Injection molding entails blending powder with a thermoplastic compound and injecting it into a mold cavity to form a rigid or flexible magnet.[75] Calendaring

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[71] John J. Croat, "4 – Production of rapidly solidified NdFeB magnetic powder," Rapidly Solidified Neodymium-Iron-Boron Permanent Magnets, 2018, https://doi.org/10.1016/B978-0-08-102225-2.00004-1; B.M Ma et al., "Recent development in bonded NdFeB magnets," Journal of Magnetism and Magnetic Materials 239 (1-3): 418-423, February 2002, https://doi.org/10.1016/S0304-8853(01)00609-6.

[72] John J. Croat, "Chapter 6 – Compression bonded NdFeB permanent magnets," Modern Permanent Magnets, 2022, https://doi.org/10.1016/B978-0-323-88658-1.00007-8.

[73] Steve Constantinides and John de Leon, "Permanent Magnet Materials and Current Challenges, Arnold Magnetic Technologies, n.d., http://www.arnoldmagnetics.com/wp-content/uploads/2017/10/Permanent-Magnet-Materials-and-Current-Challenges-Constantinides-and-DeLeon-PowderMet-2011-ppr.pdf; Jun Cui et al., "Manufacturing Processes for Permanent Magnets: Part II – Bonding and Emerging Methods," JOM 74: 2492-2506, June 2022, https://doi.org/10.1007/s11837-022-05188-1.

[74] Ibid.

[75] Ibid.

uses a roll press to form flexible magnet sheets.[76] Rigid magnets require binders such as nylon, Teflon, vinyl, and thermoset epoxy, while flexible magnets rely on binders like nitrile rubber and vinyl.[77]

5.2 Rare Earth Element Losses in Magnet Production

It is difficult to estimate rare earth element losses from the mining to metallization value chain steps. Rare earth recovery from ore is complex since there are a variety of different rare earth minerals including bastnaesite, monazite, and ionic clays.[78] Additionally, the process of concentrating rare earth bearing ore is tailored to specific ore deposits.[79] Once the rare earth elements are concentrated, they are generally chemically leached into solution. Depending on the specific leaching technology utilized and the technological optimization of the process stream, recovery of rare earth elements in bastnaesite ranges from 85 to 90 percent, in monazite from 89 to 98 percent, and in ionic clays from 80 to 90 percent.[80] As discussed in the previous section, various approaches, including solvent extraction, are employed to separate individual rare earth elements from mixed carbonates or mixed oxides. Total recovery of rare earth elements during solvent extraction is typically 90 to 95 percent depending on the specific process and strategy utilized.[81] Individual rare earth oxides are turned into metal using electrowinning and calcium reduction.[82] [83] Although specific data on the efficiency of electrowinning of individual rare earth elements could not be identified, the electrowinning process generally exhibits a 90 to 95 percent metal recovery rate.[84]

[76] Ibid.
[77] John Ormerod, "Bonded Magnets: A Versatile Class of Permanent Magnets," Magnetics Business and Technology, 2015, https://bunting-dubois.com/wp-content/uploads/2021/04/Magnetics-Business-Technology-Summer-2015-8-9.pdf.
[78] On sources of rare earth elements, *see* "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[79] Meeting between Lynas Rare Earths and the Department of Commerce, (Virtual Meeting, March 30, 2022); Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).
[80] Sebastiaan Peelman et al., "Leaching of Rare Earth Elements: Past and Present," ERES2014: 1st European Rare Earth Resources Conference, September 4 to 7, 2014, http://www.eurare.org/docs/eres2014/seventhSession/SebastiaanPeelman.pdf; Sebastiaan Peelman et al., "Chapter 21: Leaching of Rare Earth Elements: Review of Past and Present Technologies," Rare Earths Industry: Technological, Economic, and Environmental Implications: 319-334, 2016, https://doi.org/10.1016/B978-0-12-802328-0.00021-8.
[81] Laura Talens Peiro and Gara Villalba Mendez, "Material and Energy Requirement for Rare Earth Production," JOM 65: 1327-1340, 2013, https://doi.org/10.1007/s11837-013-0719-8.
[82] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[83] Thomas Lograsso, Critical Materials Institute, written communication, May 8, 2022.
[84] Danielle Miousse, "A New Spin on Electrowinning," PF Products Finishing, May 1, 2007, https://www.pfonline.com/articles/a-new-spin-on-electrowinning.

There is more information on material losses from alloying to magnet production.[85] Metal recovery from strip casting, used to produce NdFeB alloy, is estimated at 97 percent. Hydrogen decrepitation and jet milling, which are used to make NdFeB powder, have estimated recovery rates of 99 percent. Pressing in a magnetic field, which is used to produce the sintered magnet, has a 99 percent recovery rate, while the subsequent sintering and heat-treating steps have 98 percent recovery rates. The greatest material loss occurs when machining the sintered magnet block into a usable magnet according to end-use-determined specifications. Depending on the size and complexity of the final magnet machining has a recovery rate of 60 to 90 percent. Although considerable material is lost during the magnet machining step, the resulting waste, also known as magnet swarf, is often recycled and returns to the process flow stream.[86] Indeed, some industry participants question the viability of magnet manufacturing that does not recycle swarf.[87] The final steps in NdFeB magnet manufacturing are plating for corrosion and final magnetization, both of which have a yield of 99 percent. As a result, total recovery from alloy to magnet production can range from about 54 to 81 percent.[88]

6. U.S. NdFeB Magnet Industry

6.1 Historical Overview

The United States is essentially one hundred percent dependent on imports of NdFeB magnets to satisfy demand. However, the United States did not always have negligible capacity in the NdFeB magnet value chain. Rare earths were first discovered at Mountain Pass in California in 1949 and extracted by the mining firm Molycorp beginning in 1951.[89] In the 1950s, research by the Ames Laboratory advanced rare earths processing technology.[90] The combination of favorable factor endowments and research and development caused the U.S. rare earths industry to flourish. By the 1980s, Mountain Pass supplied over 70 percent of the world's rare earth elements.[91] Meanwhile, commercialized processing technologies facilitated rare earth oxide production and consumption by a growing array of end-users.[92] NdFeB magnet manufacturers were one such consumer: in 1983, General Motors and Sumitomo of Japan independently announced the development of NdFeB magnets.[93] In 1986 General Motors established a

[85] Unless otherwise noted, this paragraph summarizes information in a Department of Energy report on the NdFeB magnet supply chain. *See* "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[86] Meeting between Lynas Rare Earths and the Department of Commerce, (Virtual Meeting, March 30, 2022)
[87] Ibid.
[88] The Department reached this calculation using the information on material loss from alloy to magnet production discussed in earlier in the paragraph.
[89] Joanne Abel Goldman, "The U.S. Rare Earth Industry: Its Growth and Decline," Journal of Policy History 26 (2): 139-166, 2014, https://doi.org/10.1017/S0898030614000013.
[90] Ibid.
[91] Ibid.
[92] Ibid.
[93] Ibid.

subsidiary called Magnequench to commercialize production.[94] Magnequench began production of rapidly solidified powders for isotropic bonded magnets, full dense hot pressed isotropic magnets, and fully dense anisotropic magnets in 1987.[95] [96]

However, the 1980s were marked by growing foreign competition that presaged the end of the U.S. rare earths industry. By 1985 Japan had already exceeded the United States in NdFeB magnet production and by 1987 produced over half the world's magnets.[97] Starting in the second half of the 1980s, several U.S. magnet companies licensed Sumitomo patents to produce and sell sintered NdFeB magnets.[98] In the 1980s, China also began to develop its rare earth and NdFeB magnet industries. A combination of low labor costs, less stringent environmental regulations, and tax rebates and subsidies made it difficult for U.S. firms to compete.[99] In response to imports of unlicensed Chinese magnets, in 1995 U.S. magnet manufacturer Crucible Materials filed a complaint with the U.S. International Trade Commission (U.S. ITC) requesting a Section 337 investigation.[100] Although the U.S. ITC found a violation and issued a cease-and-desist order to a domestic respondent as well as a general exclusion order, these actions did not prevent the offshoring of domestic industry.[101] In 1998, Molycorp suspended operation at Mountain Pass Mine, ending U.S. involvement in the upstream steps of the NdFeB magnet value chain.[102] The downstream steps of the value chain followed. For example, after being sold to Chinese owners Magnequench's U.S. factories were closed and offshored starting in 1998, and it eventually ceased U.S. production in 2006.[103] Similarly, in 2005, Hitachi closed its sintered NdFeB magnet manufacturing facility in Edmore, MI, which it had previously acquired from General Electric.[104]

The U.S. NdFeB magnet value chain experienced a brief revival in the late 2000s and early 2010s, in part due to rising rare earths prices.[105] In 2008, Molycorp sought to restart production

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[94] Jeffrey St. Clair, "The Saga of Magnequench," Counterpunch, April 7, 2006, https://www.counterpunch.org/2006/04/07/the-saga-of-magnequench/.
[95] Ibid.
[96] V. Panchanathan, "Magnequench Magnets Status Overview," Journal of Materials Engineering and Performance, 4 (4) 423-429, 1995, https://doi.org/10.1007/BF02649302.
[97] Joanne Abel Goldman, "The U.S. Rare Earth Industry: Its Growth and Decline," Journal of Policy History 26 (2): 139-166, 2014, https://doi.org/10.1017/S0898030614000013.
[98] John Ormerod, "NdFeB Magnet Patents: Updated 2021," Bunting, n.d., https://bunting-dubois.com/tech-briefs/ndfeb-magnet-patents-update-2021/.
[99] Joanne Abel Goldman, "The U.S. Rare Earth Industry: Its Growth and Decline," Journal of Policy History 26 (2): 139-166, 2014, https://doi.org/10.1017/S0898030614000013.
[100] John Ormerod, "NdFeB Magnet Patents: Updated 2021," Bunting, n.d., https://bunting-dubois.com/tech-briefs/ndfeb-magnet-patents-update-2021/; "Certain Neodymium-Iron-Boron Magnets, Magnet Alloys, and Articles Containing Same: Investigation No. 337-TA-372," U.S. International Trade Commission, May 1996, https://usitc.gov/publications/337/pub2964.pdf.
[101] Ibid.
[102] Joanne Abel Goldman, "The U.S. Rare Earth Industry: Its Growth and Decline," Journal of Policy History 26 (2): 139-166, 2014, https://doi.org/10.1017/S0898030614000013.
[103] Jeffrey St. Clair, "The Saga of Magnequench," Counterpunch, April 7, 2006, https://www.counterpunch.org/2006/04/07/the-saga-of-magnequench/.
[104] Walter Benecki, "Magnetics Industry Overview," 2005, http://www.waltbenecki.com/uploads/Another_Year_of_Significant_Change_in_the_Magnetics_Industry.pdf.
[105] *See* Section 8.3.4, "Prices and Price Volatility," for more details on neodymium oxide and metal prices.

at Mountain Pass Mine.[106] When China dramatically restricted exports of rare earths in 2010 and prices increased, Molycorp appeared poised to benefit.[107] [108] In 2012 it acquired Magnequench, which at the time had NdFeB magnet powder facilities in China and Thailand, in order to create a vertically integrated mine to magnet firm.[109] [110] By 2013 it had achieved domestic production of 5,500 tons of rare earth oxides and had established a joint venture with Mitsubishi and Daido Steel to produce magnets in Japan.[111] [112] [113] However, Molycorp struggled to remain solvent and suffered from the decline in rare earths prices that occurred in part due to China's reversal of its export restrictions, ultimately declaring bankruptcy in 2015.[114] [115] The United States has in recent years been highly reliant (well above 80 percent) on imports of bonded NdFeB magnets and essentially one hundred percent dependent on imports of sintered NdFeB magnets.

6.2 U.S. Demand

As one of the strongest types of permanent magnets, NdFeB magnets, in particular sintered NdFeB magnets, are used in an extensive range of products. Example applications include actuators for machine tools, robots, and water pumps, refrigerator and air conditioner compressors, speakers in phones and laptops (as well as more advanced applications in computing and telecommunications), and traction motors in electric vehicles.

The Department of Energy's (DoE) "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report" estimates total domestic demand for selected NdFeB magnet applications in aggregate

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[106] Jeffrey A. Green, "The collapse of American rare earth mining – and lessons learned," Defense News, November 12, 2019, https://www.defensenews.com/opinion/commentary/2019/11/12/the-collapse-of-american-rare-earth-mining-and-lessons-learned/.

[107] China implemented export quotas starting in 2005, but dramatically decreased the export quota by almost 40 percent in 2010. China's export quotas are broadly seen as part of a strategy of economic resource nationalism, wherein economic advantage can be transferred from foreign to local firms, although some argue they reflect an effort to gain a geopolitical advantage. China itself contended quotas were meant to decrease environmental costs, but this argument was rejected by the WTO in 2014. *See* Kristen Vekasi, "Politics, markets, and rare commodities: Responses to Chinese rare earth policy," Japanese Journal of Political Science 20(1): 2-20, 2019, https://doi.org/10.1017/S1468109918000385.

[108] Neodymium oxide prices rose by over 1,200 percent from $27.95 per kg at the end of January 2010 to a peak of $369.75 at per kg at the end of July 2011. The Department's calculations from Bloomberg data. *See* Section 8.3.4, "Prices and Price Volatility," for more details.

[109] Artem Golev et al., "Rare earths supply chains: Current status, constraints, and opportunities," Resources Policy 41: 52-59, 2014, http://dx.doi.org/10.1016/j.resourpol.2014.03.004.

[110] Magnequench was later acquired by Neo Performance Materials after Molycorp's bankruptcy.

[111] Eugene Gholz, "Rare Earth Elements and National Security," Council on Foreign Relations, October 2014, https://cdn.cfr.org/sites/default/files/pdf/2014/10/Energy%20Report_Gholz.pdf.

[112] Joseph Gambogi, "Mineral Commodity Summaries: Rare Earths," U.S. Geological Survey, January 2017, https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/mineral-pubs/rare-earth/mcs-2017-raree.pdf.

[113] All quantities specified as tons in this report refer to metric tons, unless otherwise noted.

[114] Tiffany Hsu, "Molycorp – sole U.S. rare earth producer – files for bankruptcy," Los Angeles Times, June 25, 2015, https://www.latimes.com/business/la-fi-molycorp-rare-earth-bankruptcy-20150625-story.html.

[115] When Molycorp declared bankruptcy in June 2015, neodymium oxide prices were down by over 88 percent to $43.00 per kg from a peak of $369.75 per kg in July 2011. The Department's calculations from Bloomberg data. *See* Section 8.3.4, "Prices and Price Volatility," for more details.

and by broad application area, as detailed in Table 2.[116] [117] It estimated total consumption at about 16,100 tons in 2020. Based on DoE estimates, total U.S. demand for NdFeB magnets for these applications is projected to increase under a high growth scenario to 37,000 tons in 2030, with the bulk of increasing demand accounted for by offshore wind turbines and electric vehicles.

Table 2: Total U.S. demand for selected NdFeB magnet applications, thousands of tons*

Application	Total demand in 2020		Projected total demand in 2030 (high growth)		Projected total demand in 2050 (high growth)	
	Amount (kt)	Share	Amount (kt)	Share	Amount (kt)	Share
Offshore wind turbines	0	0.0%	10.1	27.3%	19	27.7%
Electric vehicles	1.8	11.2%	10.2	27.6%	23.1	33.7%
Consumer electronics (hard disk drives, cell phones, loudspeakers, other)	7.2	44.7%	7.4	20.0%	11.8	17.2%
Industrial motors	4.9	30.4%	5.9	15.9%	9.5	13.8%
Non-drivetrain motors in vehicles	1.5	9.3%	2.4	6.5%	3.9	5.7%
Other sintered magnets (Power tools, electric bikes)	0.1	0.6%	0.1	0.3%	0.2	0.3%
Bonded magnets	0.6	3.7%	0.8	2.2%	1.3	1.9%
Total	16.1	100.0%	37	100.0%	68.6	100.0%

*The figures presented represent total – or the sum of direct and embedded – demand.
Source: "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

Since U.S. production of NdFeB magnets is minimal almost all the United States' direct and indirect NdFeB magnet consumption is met through imports.[118] The United States directly imported about 7,500 tons of sintered NdFeB magnets in 2021.[119] However, direct imports of NdFeB magnets represent only a portion of U.S. consumption and the majority of U.S. demand is in the form of imported products with the magnets embedded in them. As the list of imported goods containing NdFeB magnets is extensive, and their magnet content (weight and type) unknown, it is difficult to precisely estimate indirect consumption by application. The Defense Logistics Agency Strategic Materials estimates 60 percent of essential civilian demand for

[116] The Department notes that the global NdFeB magnet supply chain is opaque and as a result valid and reliable estimates of total as well as direct and embedded demand are difficult to generate, both in aggregate and at the end-use-level. [redacted] Estimates of total, direct, and embedded demand in aggregate and by end-use category should be approached with caution.
[117] The DoE report and the figures provided in this report reflect total demand, in other words the sum of direct and indirect or embedded demand, for selected NdFeB magnet applications.
[118] U.S. imports and exports of NdFeB magnets are further discussed in Section 6.4, "U.S. Trade in NdFeB Magnets."
[119] "USITC Dataweb," U.S. International Trade Commission, last modified October 25, 2021, https://dataweb.usitc.gov/trade/search/Import/HTS.

NdFeB magnets was fulfilled through embedded imports [redacted].[120] [121]

6.3 NdFeB Magnets in Defense and Critical Infrastructure Applications

Presidential Policy Directive 21 (Critical Infrastructure Security and Resilience) designates 16 critical infrastructure sectors as vital to national security, national economic security, and/or national public health and safety.[122] NdFeB magnets are used so extensively across industries that they support virtually all 16 sectors, including the critical manufacturing, defense industrial base, energy, healthcare and public health, transportation systems, and water and wastewater systems sectors. The following sections will discuss the use of NdFeB magnets in defense applications and two key critical infrastructure applications: electric vehicles and offshore wind turbines. Defense-related uses and demand are central to the investigation's directive to assess the effects of NdFeB magnet imports on national security. Electric vehicles and offshore wind turbines are important to the Biden Administration's Clean Energy Plan and efforts to combat climate change. They will also drive demand for NdFeB magnets and are key sales targets for NdFeB magnet manufacturers.

6.3.1 Defense Applications

Consistent with their broad commercial applications, NdFeB magnets are used in a variety of defense end-uses.[123] Defense usage is not limited to specific magnet characteristics such as high coercivity. Instead, each defense application requires a specially designed magnet, of varying sizes, grades, and performance characteristics. [redacted] Aircraft, missiles, and munitions use small high-powered rare earth magnet actuators that control the various surfaces during operation. NdFeB magnets can also be used as fasteners. Although substitutes can be used in some applications, they are usually not as effective.[124]

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[120] "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth," The White House, June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

[121] Meeting between the Defense Logistics Agency and the Department of Commerce (Virtual Meeting, November 23, 2021).

[122] "Critical Infrastructure Sectors," Department of Homeland Security, last modified October 21, 2020, https://www.cisa.gov/critical-infrastructure-sectors.

[123] [redacted]

[124] "Defense Federal Acquisition Regulation Supplement: Restriction on the Acquisition of Certain Magnets and Tungsten," Federal Register, April 30, 2019. https://www.federalregister.gov/documents/2019/04/30/2019-08485/defense-federal-acquisition-regulation-supplement-restriction-on-the-acquisition-of-certain-magnets?msclkid=9f790985ac5011eca53be28a54128eac.

[redacted]

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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]				

As with total domestic consumption of NdFeB magnets, a precise total for defense-related demand is not possible. [redacted][126] Thus, despite their importance to national security, defense demand for NdFeB magnets is only a small portion of overall demand and insufficient to support an economically viable domestic industry.

6.3.2 U.S. Government Actions to Reduce Defense Dependencies

Given NdFeB magnets' usage in and importance to the performance of myriad military systems, and the United States' near one hundred percent reliance on imports of NdFeB magnets, the U.S.

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[125] [redacted]

[126] [redacted] Noveon's *Federal Register* Notice submission estimated defense-related demand at two to ten percent. Comments of Noveon to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.

Government has taken several steps in recent years to mitigate this reliance and address potential supply disruptions. One such measure is legislation implemented through a Defense Federal Acquisition Regulation Supplement (DFARS) that restricts the use of foreign NdFeB magnets in the military supply chain from 2019.[127] Specifically, Section 871 of the National Defense Authorization Act for 2019 (P.L. 115-232) prohibits the acquisition of samarium-cobalt and NdFeB magnets melted or produced in North Korea, China, Russia, or Iran because these materials play an essential role in national defense. This requirement was originally codified in 10 U.S.C. 2533c but is now 10 U.S.C. 4872. There are exceptions for "some commercially available off-the-shelf magnets incorporated into end items and for electronic devices," as well as for recycled magnets where the first melt may have taken place in China but subsequent recycling and milling takes place in the United States.[128]

The Department of Defense's (DoD) Office of Industrial Base Policy has fostered domestic production capacity across the NdFeB magnet value chain from mining to magnet manufacturing through the allocation of funding under DPA Title III and the Industrial Base Analysis and Sustainment (IBAS) programs. Other important DoD funding sources for rare earth supply chain research and scale-up include the National Defense Stockpile Program, the Rapid Innovation Fund, and the Small Business Innovation Research (SBIR) program.

Upstream in the NdFeB magnet value chain, DoD has funded the development of oxide separation capacity. In February 2021, Lynas USA LLC, a subsidiary of Australian mining firm Lynas Rare Earths, received $30.4 million to establish a facility to produce light rare earth oxides, including neodymium.[129] [130] [redacted] This facility is also expected to produce heavy rare earth oxides such as dysprosium.[131] [redacted][132] In February 2022, DoD awarded MP Materials $35 million under the IBAS program for a heavy rare earth oxide separation facility, on top of a previous $9.6 million commitment in December 2020 to develop light rare earth oxide separation capabilities.[133] MP Materials expects to commence production by the end of 2022.[134] DoD has also provided funding for NdFeB magnet production. In July 2020, under DPA Title III, Noveon was provided $28.8 million to develop NdFeB magnet

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[127] For more information, please refer to the *Federal Register* Notice of the rule. "Defense Federal Acquisition Regulation Supplement: Restriction on the Acquisition of Certain Magnets and Tungsten," Federal Register, April 30, 2019, https://www.federalregister.gov/documents/2019/04/30/2019-08485/defense-federal-acquisition-regulation-supplement-restriction-on-the-acquisition-of-certain-magnets.
[128] Ibid.
[129] "DoD Announces Rare Earth Element Award to Strengthen Domestic Industrial Base," Department of Defense, February 1, 2021, https://www.defense.gov/News/Releases/Release/Article/2488672/dod-announces-rare-earth-element-award-to-strengthen-domestic-industrial-base/.
[130] Unless otherwise stated, all values cited in this report are U.S. dollars.
[131] "2021 Annual Report," Lynas Rare Earths, Ltd., 2021, https://wcsecure.weblink.com.au/pdf/LYC/02434182.pdf.
[132] Meeting between Lynas Rare Earths and the Department of Commerce, (Virtual Meeting, March 30, 2022).
[133] "MP Materials Awarded Department of Defense Heavy Rare Earth Processing Contract," MP Materials, February 2, 2022, https://investors.mpmaterials.com/investor-news/news-details/2022/MP-Materials-Awarded-Department-of-Defense-Heavy-Rare-Earth-Processing-Contract/default.aspx.
[134] "Form 10-K," MP Materials, February 28, 2022, https://d18rn0p25nwr6d.cloudfront.net/CIK-0001801368/77b2894e-b746-43c5-938a-a3f524823baa.pdf.

manufacturing, which will begin in 2022 and ramp up thereafter.[135] Noveon later received $0.86 million for an inventory demonstration.[136] In November 2020, DoD also provided $2.3 million in DPA Title III funding to TDA Magnetics for a rare earth element supply chain study.[137]

The U.S. Government also funded projects related to the NdFeB magnet value chain through the SBIR program.[138] SBIR provides funding on a competitive basis to encourage high technology innovation by small businesses with less than 500 employees. In general, funding of up to $275,000 over a six month to one year period is granted for Phase I projects (i.e., projects at the technical assessment and feasibility stage), and up to $1.8 million over a two-year period for Phase II projects (to allow for continued research and development after a successful Phase I). Like other federal awards, SBIR contracts allocate intellectual property rights between the U.S. Government and the awardee according to a detailed regulatory regime. A typical SBIR patent rights clause generally permits the SBIR awardee to retain ownership of inventions, but grants the U.S. Government a "non-exclusive, nontransferable, irrevocable paid-up license to practice the subject invention throughout the world."[139]

In 2020 and 2021, SBIR awards directly related to neodymium were made to ten organizations – DoD units funded three of these, and DoE units funded seven. Projects included novel separation and metal reduction technologies, as well as recycling/reclaiming rare earths and magnets from end-of-life products and waste feedstocks. Additional projects focused on the development of electric motors that are free of rare earth elements or have reduced rare earth element content. If expanded to include SBIR awards related more broadly to rare earth elements, the total number of projects funded increases to 52 in 2020 and 2021 alone, and over 300 over the history of the SBIR program.

In one example, the Defense Logistics Agency – Strategic Materials is leveraging SBIR funding and Rapid Innovation Funding to accelerate the development of new rare earth processing technologies through a grant to Rare Earth Salts.[140] Rare Earth Salts will use this money to scale production of separate rare earth oxides to 20 tons of neodymium-praseodymium at its facility in Beatrice, NE. Using a unique separations process, Rare Earth Salts claims it can separate and

[135] "DoD Announces $77.3 Million in Defense Production Act Title III COVID-19 Actions," Department of Defense, July 24, 2020, https://www.defense.gov/News/Releases/Release/Article/2287490/dod-announces-773-million-in-defense-production-act-title-iii-covid-19-actions/.
[136] "DoD Announces Rare Earth Element Awards to Strengthen Domestic Industrial Base," Department of Defense, November 17, 2020, https://www.defense.gov/News/Releases/Release/Article/2418542/dod-announces-rare-earth-element-awards-to-strengthen-domestic-industrial-base/.
[137] Ibid.
[138] Information in this paragraph is drawn from the SBIR website. *See* "SBIR," Small Business Administration, n.d., https://www.sbir.gov/?msclkid=fddb897aac5011ec87c1465b3f85f68e.
[139] "37 CFR § 401.14 - Standard patent rights clauses," Cornell Law School Legal Information Institute, n.d., https://www.law.cornell.edu/cfr/text/37/401.14.
[140] "DOD Announces Rare Earth Element Awards to Strengthen Domestic Industrial Base," Department of Defense, November 17, 2020, https://www.defense.gov/News/Releases/Release/Article/2418542/dod-announces-rare-earth-element-awards-to-strengthen-domestic-industrial-base/msclkid/dod-announces-rare-earth-element-awards-to-strengthen-domestic-industrial-base/.

refine all seventeen rare earth elements, providing DoD with a viable alternative to foreign sources.[141]

DoE has also provided funding related to the NdFeB magnet value chain. For example, DoE has advanced research on recovering rare earths from unconventional sources, including coal, coal byproducts, and other waste materials.[142] Through basic and applied research conducted in DoE labs, small businesses, and universities, DoE was able to establish pilot scale facilities capable of producing small quantities of high purity, mixed rare earth oxides. DoE expanded this program in 2020 in response to Executive Order 13817 to include upstream beneficiation yielding mixed rare earth oxides, midstream processing, separation, recovery of rare earth elements and critical minerals, and ultimately onshore downstream manufacturing that incorporates these materials into consumer and national defense products. In 2021, efforts were initiated that address the development of innovative, cost-reduced processing for the separation of mixed rare earth elements into individual, high purity oxides, and reduction of these materials to metals for use in alloy production, advanced technology development, and component manufacturing. The final goal is to produce one to three tons a day of mixed rare earth oxides and metals in prototype separation facilities by 2026.

In April 2021, DoE, through the National Energy Technology Laboratory, announced $19 million in grants to support production of rare earth elements and critical minerals vital to manufacturing batteries, magnets, and other products important to the clean energy economy.[143] The grants, of up to $1.5 million each, were allocated to 13 projects across the country to assess resources and extract and process rare earth elements and critical minerals in traditionally fossil-fuel producing communities. Not only will these initiatives help alleviate shortages in domestic supply and place the United States at the forefront of the clean energy economy, but they support regional economic growth and job creation in economically distressed communities. Many of these projects relate to reclaiming and processing rare earth elements from coal mine-derived waste.

6.3.3 NdFeB Magnets, Climate Change, and the National Security

The Department of Defense, the Department of Homeland Security, the National Security Council, and the Director of National Intelligence have identified climate change as a threat to

[141] "Defense Logistics Agency Research and Development: Small Business Innovation Programs," Defense Logistics Agency, n.d. 2022, https://www.dla.mil/Portals/104/Documents/SmallBusiness/Always%20Accountable%20Program%20Sheet_10%20NOV%202020.pdf?ver=2A6BDQejXejBr5xDhoLDyQ%3D%3D.

[142] Information in this paragraph is drawn from a DoE document describing the program. *See* "Rare Earth Elements and Critical Minerals," National Energy Technology Laboratory, February 2022, https://www.netl.doe.gov/sites/default/files/2022-02/Program-141.pdf.

[143] The information in this paragraph is drawn from a DoE press announcement. *See* "DOE Awards $19 Million for Initiatives to Produce Rare Earth Elements and Critical Minerals," Department of Energy, April 29, 2021, https://www.energy.gov/articles/doe-awards-19-million-initiatives-produce-rare-earth-elements-and-critical-minerals.

national security. Climate-fueled events and scarce resources create instability, heightened military tensions, and financial hazards which can lead to worsening conflicts between countries.[144] Climate change and extreme weather events may also significantly increase the dislocation and migration of people.[145] Climate change is an existential crisis that poses a grave threat to the United States and the international community. To address this crisis, President Biden established a national goal to achieve net-zero carbon emissions by 2050.[146] Transitioning away from gas powered to electric vehicles is an important part of U.S. and global efforts to address climate change by slashing greenhouse gas emissions, and NdFeB magnets are key to electric vehicle performance. In addition, NdFeB magnets power offshore wind turbine generators, which are another key element in achieving clean energy goals.

6.3.4 Electric Vehicles

Although the United States currently lags many other countries in the percentage of vehicles sold that are electric, President Biden has set a goal that by 2030 half of all new vehicles sold will be electric.[147] This will reduce greenhouse gas emissions by more than 60 percent over 2020 levels and positions the country to be a leader in the automobile manufacturing of the future. Funds have already been dedicated to advancing the domestic electric vehicle industry and key components such as batteries.

The global transition to electric vehicles is expected to lead to a rapid increase in demand for NdFeB magnets. Although automobile manufacturers can use non-NdFeB magnet motors, up to 95 percent of electric vehicles use rare earth magnets in their traction drive motors.[148] NdFeB magnets are highly desirable in traction drive motors because they provide high energy efficiency which allows for increased driving range. Electric vehicle drive train motors typically

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[144] Christopher Flavelle et al., "Climate Change Poses a Widening Threat to National Security," The New York Times, October 21, 2021, https://www.nytimes.com/2021/10/21/climate/climate-change-national-security.html.

[145] Renee Cho, "Climate Migration: An Impending Global Challenge," Columbia Climate School, May 13, 2021, https://news.climate.columbia.edu/2021/05/13/climate-migration-an-impending-global-challenge/; David J. Kazcan and Jennifer Orgill-Meyer, "The impact of climate change on migration: a synthesis of recent empirical insights," Climatic Change 158: 281-300, 2020, https://doi.org/10.1007/s10584-019-02560-0; "Groundswell Part 2: Acting on International Climate Migration," World Bank, September 13, 2021, https://openknowledge.worldbank.org/handle/10986/36248.

[146] *See* "Fact Sheet: President Biden Signs Executive Order Catalyzing America's Clean Energy Economy Through Federal Sustainability," The White House, December 8, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/08/fact-sheet-president-biden-signs-executive-order-catalyzing-americas-clean-energy-economy-through-federal-sustainability/.

[147] *See* "Executive Order on Strengthening American Leadership in Clean Cars and Trucks," The White House, August 5, 2021, https://www.whitehouse.gov/briefing-room/presidential-actions/2021/08/05/executive-order-on-strengthening-american-leadership-in-clean-cars-and-trucks/; "Fact Sheet: President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks," The White House, August 5, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-american-leadership-forward-on-clean-cars-and-trucks/.

[148] Roland Gaus et al., "Rare Earth Magnets and Motors: A European Call for Action," European Raw Materials Alliance, September 2021, https://erma.eu/app/uploads/2021/09/01227816.pdf.

require higher grade NdFeB magnets (using six percent or more of dysprosium) due to the high temperature environment.

In addition to traction drive motors, NdFeB magnets, often of lesser grades, are used in various other automotive systems in both electric and conventional vehicles, including motors for door locks, mirrors, seat positioning, power steering, alternators, suspension control, anti-lock brakes, water pumps, and loudspeakers. Most sources estimate that electric vehicle drive trains use between one and two kilograms (kgs) of NdFeB magnets, with other applications using smaller amounts of NdFeB magnets.[149] [150] NdFeB magnets are a small percentage of the cost of production. The European Raw Materials Alliance (ERMA) forecasts that rare earth magnets used in electric vehicles will account for $2.3 to $3.5 billion out of a global electric vehicle market of $725 to $1,160 billion, or less than 0.5 percent of the value of the market.[151] NdFeB magnets are nonetheless key to enhancing vehicle performance over non-magnet alternatives.

The developing electric vehicle industry in the United States, in addition to the global electric vehicle market, represents a valuable opportunity for current and potential NdFeB magnet manufacturers. In one extreme example, if all new vehicle sales in 2040 were electric vehicles – an estimated 125 million vehicles globally – the global electric vehicle industry alone would consume at least 156,000 tons of NdFeB magnets and 342,000 tons of total rare earth oxides.[152] By comparison, in 2020 about three million electric vehicles were sold globally (4.6 percent of total) and electric vehicles consumed 7,300 tons of NdFeB magnets.[153] [154] [155] Consumer

[149] Roland Gaus et al., "Rare Earth Magnets and Motors: A European Call for Action," European Raw Materials Alliance, September 2021, https://erma.eu/app/uploads/2021/09/01227816.pdf; "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf; Steve Constantinides, "The Big Picture: Putting the Magnet Market Trends Together," Presentation at Magnetics 2018 at Orlando, FL, February 8, 2018.

[150] Conventional vehicles also use small amounts of NdFeB magnets. Estimates of total NdFeB magnet rare earths content ranges from 4 grams to 356 grams per vehicle. *See* Ruby T. Nguyen et al., "NdFeB content in ancillary motors of U.S. conventional passenger cars and light trucks: Results from the field," Waste Management 83: 209-217, 2019, https://doi.org/10.1016/j.wasman.2018.11.017.

[151] The original figures were quoted in euros: two to three billion euros for the value of rare earth magnets used in electric vehicles and 625 to 1000 billion euros for the value of the global electric vehicle market. These figures were converted into dollars at an exchange rate of 1.16 euro to the dollar, at the lower end of the exchange rate in September 2021 when the ERMA forecast was published, which fluctuated between 1.16 and 1.19 euro to the dollar. Roland Gaus et al., "Rare Earth Magnets and Motors: A European Call for Action," European Raw Materials Alliance, September 2021, https://erma.eu/app/uploads/2021/09/01227816.pdf.

[152] This figure assumes each electric vehicle consumes 1.25 kgs of NdFeB magnets. This calculation relies on electric vehicle drive trains only to calculate demand. Actual demand will be higher because of NdFeB magnet use in ancillary products, such as door locks and speakers. *See* Steve Constantinides, "The Big Picture: Putting the Magnet Market Trends Together," Presentation at Magnetics 2018 at Orlando, FL, February 8, 2018.

[153] "Global EV Outlook 2021," International Energy Agency, April 2021. https://www.iea.org/reports/global-ev-outlook-2021.

[154] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

[155] The differences in magnet weight per vehicle is likely attributable to the opacity of NdFeB magnet usage across the sector. The Department of Energy estimates each electric vehicle drive train uses between one and two kgs of

preferences, coupled with government actions to achieve the goal of having half of vehicles sold in the United States be electric by 2030, constitute a key opportunity for the nascent U.S. NdFeB magnet industry. If enough electric vehicle drive trains are manufactured in the United States, electric vehicles are a potential source of consistent demand that could sustain a domestic NdFeB magnet industry.[156] General Motors' plan to manufacture electric vehicles in the United States and use U.S. NdFeB magnets is important step in this direction, and similar actions should be encouraged to ensure the viability of U.S. NdFeB magnet manufacturers.[157]

6.3.5 Wind Energy

Wind turbines, particularly offshore wind turbines, also represent a large growth market for NdFeB magnets. NdFeB magnets are used in wind turbines' permanent magnet synchronous generators, also referred to as direct drive generators. Although not all wind turbine systems require rare earth magnets, they are the preferred choice for offshore wind turbines due to reduced maintenance costs, generator efficiency, and generator weight (which allows for the construction of larger, higher capacity wind turbines).[158] Each wind turbine can use a ton or more of NdFeB magnets.[159] As with electric vehicles, NdFeB magnets are a negligible percentage of total wind turbine costs but are critical to performance.[160] Chinese and European firms dominate wind turbine manufacturing with 23 percent and 58 percent market share, respectively.[161] GE Renewable, the only major U.S. manufacturer, had an estimated market share of just under 12 percent in 2020.[162] However, offshore wind turbine generators that constitute the largest source of demand for NdFeB magnets are not currently produced in the United States.

NdFeB magnets, while Constantinides (2018) estimates each electric vehicle drive train uses 1.25 kgs of NdFeB magnets. In addition, as mentioned earlier electric vehicles also use NdFeB magnets in non-drive train applications. *See* Steve Constantinides, "The Big Picture: Putting the Magnet Market Trends Together," Presentation at Magnetics 2018 at Orlando, FL, February 8, 2018; "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

[156] Indeed, electric vehicles appear to be the key market for prospective NdFeB magnet manufacturers. For example, potential market entrants cite the industry as a sales target in public documents. "Form 10-k," MP Materials, February 28, 2022, https://d18rn0p25nwr6d.cloudfront.net/CIK-0001801368/77b2894e-b746-43c5-938a-a3f524823baa.pdf.

[157] "Paul A. Eisenstein," General Motors to source rare earth metals domestically for its electric vehicles," NBC, December 9, 2021, https://www.nbcnews.com/business/autos/general-motors-announces-deal-source-rare-earth-metals-electric-vehicl-rcna8265.

[158] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

[159] Roland Gaus et al., "Rare Earth Magnets and Motors: A European Call for Action," European Raw Materials Alliance, September 2021, https://erma.eu/app/uploads/2021/09/01227816.pdf.

[160] [redacted]

[161] Roland Gaus et al., "Rare Earth Magnets and Motors: A European Call for Action," European Raw Materials Alliance, September 2021, https://erma.eu/app/uploads/2021/09/01227816.pdf.

[162] Shashi Barla, "Global wind turbine market: state of play," Wood Mackenzie, April 14, 2021, https://www.woodmac.com/news/opinion/global-wind-turbine-market-state-of-play/.

At present, the United States has just seven offshore wind turbines in two operating projects.[163] The Block Island Wind Farm off the coast of Rhode Island comprises five turbines, with a generating capacity of 30 megawatts, and the Coastal Virginia Offshore Wind pilot project operates an additional two turbines, with a capacity of 12 megawatts. In contrast, Europe has 25,000 megawatts of offshore wind capacity installed. To support the President's clean energy objectives, DoE has established a goal of deploying 30 gigawatts (30,000 megawatts) of offshore wind power by 2030. To fulfill this goal, in February 2022 the U.S. Government opened bidding for offshore wind leases to developers for the New York Bight off the Atlantic coast that could generate up to seven gigawatts of energy and require 600 to 700 wind turbines. Beyond the national-level goal, eight states – Connecticut, Maryland, Massachusetts, New Jersey, New York, North Carolina, Rhode Island, and Virginia – are aiming to procure at least 39,298 megawatts of offshore wind capacity by 2040.

The goal to expand offshore wind capacity is tied to the Biden Administration's broader efforts to transition to a clean energy economy. To meet DoE's target of 30 gigawatts of offshore wind power by 2030, the industry is projected to generate over 31,000 construction period and 13,400 operating period jobs.[164] This represents a promising demand stream for emerging domestic NdFeB magnet production and may encourage further investment in domestic capacity, especially if wind turbine generators are manufactured in the United States. Already, one of the leading wind turbine manufacturers, Siemens Gamesa, announced plans to build a wind turbine blade facility in Virginia.[165] Although NdFeB magnets are primarily used in generators, this indicates some willingness on the part of the wind turbine industry to establish domestic component manufacturing. Encouraging additional domestic manufacturing of wind turbine generators would promote U.S.-based demand for NdFeB magnets and aid in the development of the U.S. NdFeB magnet industry.

6.4 U.S. Trade in NdFeB Magnets

As noted earlier in this report, the U.S. is highly dependent on imports for nearly all its direct demand for NdFeB magnets.[166] However, using direct imports underestimates U.S. import dependence because NdFeB magnets are often embedded in imported intermediate and final goods, such as computers and headphones.

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[163] This paragraph uses data from the Department of Energy's Offshore Wind Market Report 2021. Walter Musial et al., "Offshore Wind Market Report: 2021 Edition," Department of Energy, August 30, 2021, https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf.

[164] Ibid.

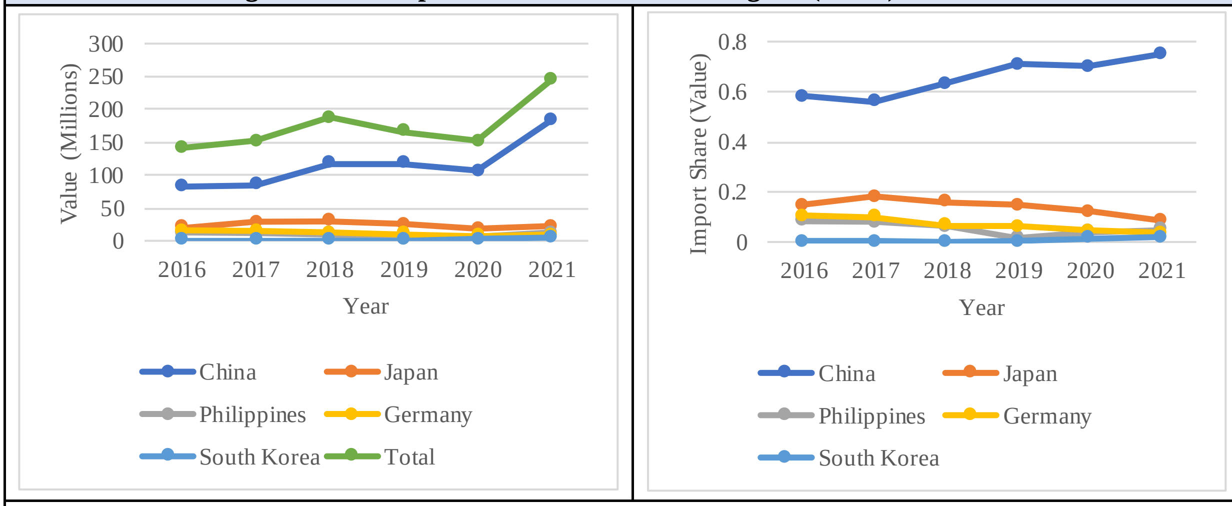
[165] "Global leadership grows: Siemens Gamesa solidifies offshore presence in U.S. with Virginia blade facility," Siemens Gamesa, October 25, 2021, https://www.siemensgamesa.com/newsroom/2021/10/offshore-blade-facility-virginia-usa.

[166] Unless otherwise noted, all data in this section are from the U.S. International Trade Commission. *See* "USITC Dataweb," U.S. International Trade Commission, last modified October 25, 2021, https://dataweb.usitc.gov/trade/search/Import/HTS.

To analyze U.S. reliance on imports of NdFeB magnets, the Department examined imports of sintered NdFeB magnets (HTS 8505.11.0070) for the years 2016 to 2021 from the United States' top five import sources (as of 2021) by value, in raw numbers and by share of imports (*see* Figure 1).[167] [168] Figure 2 show the same series but using quantity (units). China is the predominant source of imports to the United States, having increased its share of magnet imports to the United States in quantity from about 70 percent in 2016 to almost 85 percent in 2021 and in value from almost 60 percent in 2016 to about 75 percent in 2021. Germany and Japan are the next largest source of imports. Japan is particularly important in terms of magnet value, representing almost nine percent of imports by value compared to under five percent of imports by quantity. This substantiates a commonly held view that Japanese magnets tend to be of higher quality or used in more specialized end products than their Chinese counterparts.[169] These data may underestimate the contribution of Japanese firms, given that exports from the Philippines and Malaysia likely reflect Japanese production facilities in these locations.[170] The share of German magnet imports to the United States has fallen substantially from about 14 percent in 2016 to under two percent in 2021 in terms of quantity and almost 11 percent in 2016 to under four percent in 2021 in terms of value.

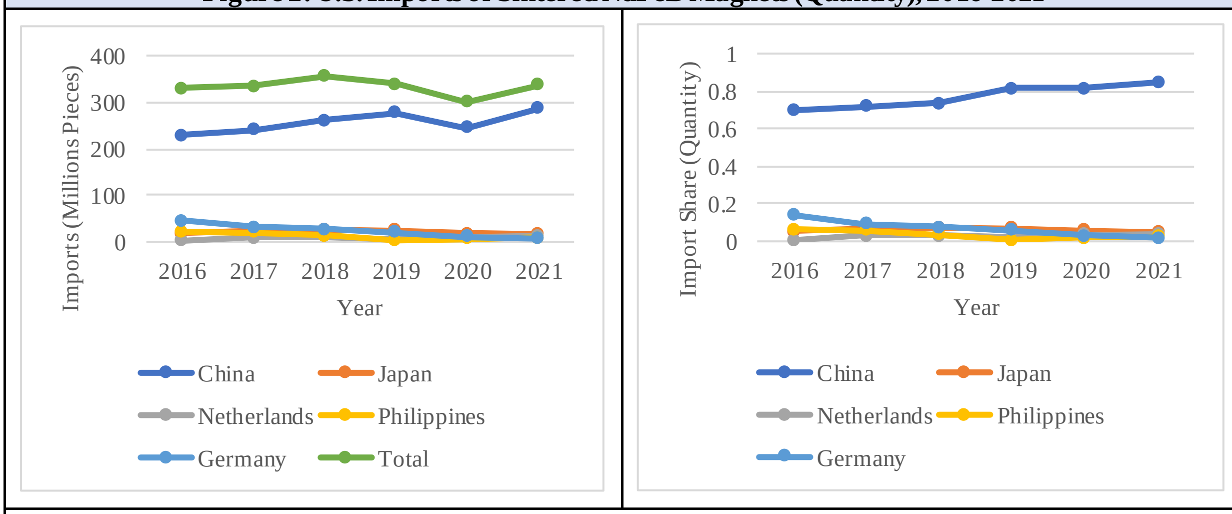
[167] Bonded NdFeB magnets do not have their own HTS code and instead fall into HTS 8505.11.0090 ("Permanent magnets and articles intended to become permanent magnets after magnetization: Of metal: Other"). Bonded NdFeB magnets comprise about seven percent of the global market, are of lower grade, and are substitutable with other magnets. Meeting between the Critical Materials Institute and the Department of Commerce, (Virtual Meeting October 6, 2021); "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf
[168] The Department also examined imports of neodymium metal (HTS 2805.30.0020). Neodymium and praseodymium metal are the only NdFeB magnet components that have their own HTS codes. Imports of neodymium metal are minimal (about $371,000 in 2021) and come almost entirely from China (about 94 percent in 2021) with the remainder imported from the United Kingdom. "USITC Dataweb," U.S. International Trade Commission, last modified October 25, 2021, https://dataweb.usitc.gov/trade/search/Import/HTS.
[169] Damien Ma and Joshua Henderson, "The Impermanence of Permanent Magnets: A Case Study on Industry, Chinese Production, and Supply Constraints," Paulson Institute, November 16, 2021. https://macropolo.org/analysis/permanent-magnets-case-study-industry-chinese-production-supply/.
[170] "Annual Report 2021", Shin-Etsu Chemical Co., Ltd., 2021, https://www.shinetsu.co.jp/wp-content/uploads/2021/07/Annual-Report-2021-for-viewing.pdf.

Figure 1: U.S. Imports of Sintered NdFeB Magnets (Value), 2016-2021



Source: The Department's calculations, from "USITC Dataweb," U.S. International Trade Commission, last modified October 25, 2021, https://dataweb.usitc.gov/trade/search/Import/HTS.

Figure 2: U.S. Imports of Sintered NdFeB Magnets (Quantity), 2016-2021



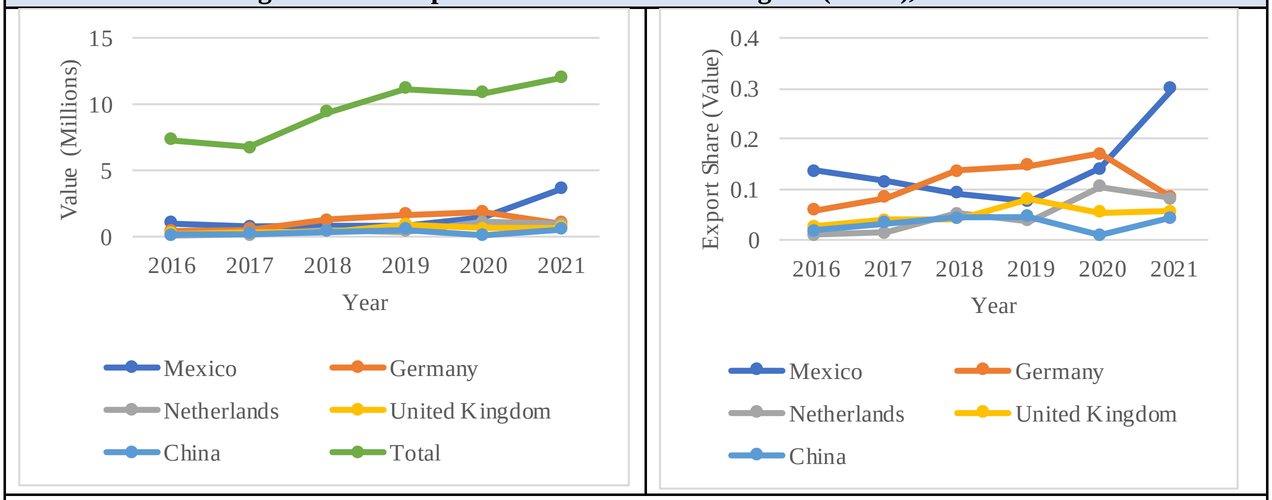
Source: The Department's calculations, from "USITC Dataweb," U.S. International Trade Commission, last modified October 25, 2021, https://dataweb.usitc.gov/trade/search/Import/HTS.

The Department also examined U.S. exports of sintered NdFeB magnets in total and to the top five destinations (as of 2021) for the same 2016 to 2021 period (*see* Figure 3).[171] Domestic exports of sintered NdFeB magnets ranged from a little over $7 million in 2016 to about $12 million in 2021. Mexico was the top destination for U.S. exports in 2021, although it still only accounted for about 30 percent of domestic sintered NdFeB magnet exports. Germany, the second most popular destination, accounted for less than nine percent of domestic sintered

[171] These data reflect domestic exports rather than total exports. Domestic exports measure goods that are grown, produced, or manufactured in the United States or which may have been changed, enhanced in value, or improved in condition in the United States. It therefore excludes unimproved reexports. *See* "USITC Dataweb," U.S. International Trade Commission, last modified October 25, 2021, https://dataweb.usitc.gov/trade/search/Export/HTS.

NdFeB magnet exports. U.S. magnet export destinations have also seen considerable turnover. In 2016, Singapore and Malaysia were the top destinations for U.S. sintered NdFeB magnet exports, accounting for about 28 percent of domestic exports ($2 million) and 15 percent of domestic exports ($1.1 million), respectively. By 2021, they were seventh at four percent ($488,000) and sixteenth at less than two percent ($185,000), respectively. Using 2021 figures, the United States imported more than 20 times the value of its domestic NdFeB magnet exports. Although there is only one active domestic producer of sintered NdFeB magnets, the United States does have an active ecosystem of magnet finishers and fabricators. These firms' activities almost certainly drive the modest value of U.S. NdFeB magnet domestic exports.

Figure 3: U.S. Exports of Sintered NdFeB Magnets (Value), 2016-2021



Source: The Department's calculations, from "USITC Dataweb," U.S. International Trade Commission, last modified October 25, 2021, https://dataweb.usitc.gov/trade/search/Export/HTS.

6.5 Duties on NdFeB Magnet Imports

NdFeB magnets and constituent products, including rare earth elements, rare earth carbonates, rare earth oxides, metals, and alloys, are subject to general tariff rates and the special tariff rate (*see* Table 5). The core product in this investigation, sintered NdFeB magnets (HTS 8505.11.0070) are subject to a general rate of 2.1 percent or a preferential rate of zero percent.[172] The overall effect of these duties on end-users is small, although not nonexistent. Some NdFeB magnet distributors/finishers/consumers note reducing tariffs on sintered NdFeB magnets would reduce their input costs [redacted].[173]

[172] The general rate for all 10-digit HTS codes under HTS 8505.11.00 ("Permanent magnets and articles intended to become permanent magnets after magnetization: Of metal") is the same at 2.1 percent. Bonded NdFeB magnets, which fall under 8505.11.0090 ("Permanent magnets and articles intended to become permanent magnets after magnetization: Of metal: Other"), are therefore subject to the same rates as their sintered counterparts. The preferential tariff rate applies to qualifying imports under U.S. free trade agreements and other preference programs.
[173] U.S. Department of Commerce, Bureau of Industry and Security, NdFeB Survey.

Table 5: Tariff Rates for NdFeB Magnets and Magnet Components					
HTS Code	**Product Description**	**General Rate**	**Preferential Rate**	**Japan General Rate**	**EU General Rate**[174]
8505.11.0070	Sintered NdFeB magnets	2.1 percent	Free	Free	2.2 percent
8505.11.0090	Other permanent magnets and articles intended to become permanent magnets after magnetization of metal	2.1 percent	Free	Free	2.2 percent
2805.30.0020	Neodymium metal	5 percent	Free	Free	2.7 to 5.5 percent[175]
2805.30.0015	Praseodymium metal	5 percent	Free	Free	2.7 to 5.5 percent
2805.30.0050	Other rare earth metals, not intermixed or interalloyed	5 percent	Free	Free	2.7 to 5.5 percent
2805.30.0090	Other rare earth metals, intermixed or interalloyed	5 percent	Free	Free	2.7 to 5.5 percent
2846.90.20	Mixtures of rare earth oxides or rare earth chlorides	Free	Free	Free	Free to 3.2 percent[176]
2846.90.80	Mixtures of rare earth carbonates other than cerium carbonate	3.7 percent	Free	Free	Free to 3.2 percent

Sources: "HTS Search," U.S. International Trade Commission, last accessed April 19, 2022, https://hts.usitc.gov/; "Access2Markets," European Commission, last accessed April 19, 2022, https://trade.ec.europa.eu/access-to-markets/en/home; "Japan's Tariff Schedule as of April 1 2022," Japan Customs, last accessed April 19, 2022, https://www.customs.go.jp/english/tariff/2022_04_01/index.htm.

The hundreds of products containing embedded NdFeB magnets, such as electric motors, MRI machines, and consumer electronics like headphones and printers are also tracked by HTS code. Some end-use categories, including electric motors and MRI machines, are not subject to general tariff rates, while others, such as generators for wind turbines, are subject to tariffs – 2.5 percent in the case of generators.[177] As discussed earlier, the NdFeB magnet contained within final goods is generally a small percentage of the overall cost of the product.

7. Global NdFeB Magnet Industry

7.1 Global Demand

Total global demand for NdFeB magnets was estimated at about 119,000 tons in 2020, of which sintered magnets account for over 93 percent of total demand and bonded magnets the remaining

[174] These figures reflect the stated third country duty. Autonomous tariff suspension rates may be lower – zero percent in the case of 8505.11.0070, sintered NdFeB magnets.
[175] Exact concordance for HTS 2805 not available.
[176] Exact concordance for HTS 2846.90 not available. The relevant products for NdFeB magnets face third country duties of 3.2 percent (neodymium and praseodymium compounds, as well as compounds of mixtures of metals) or zero percent (terbium and dysprosium compounds).
[177] "HTS Search," U.S. International Trade Commission, last accessed April 19, 2022, https://hts.usitc.gov/.

seven percent.[178] [179] As of 2020, consumer electronics and industrial motors are the primary consumers of NdFeB magnets, with about 30 percent of the market each. Offshore wind turbines account for another 14 percent of total NdFeB magnet demand, with smaller shares for electric vehicles, motors for other types of vehicles, and other applications (*see* Table 6). The magnet content in these products varies but in general accounts for a small portion of the material costs of production. Wind turbines and MRI machines use large amounts of magnets but are produced and consumed in relatively small numbers, while consumer electronic devices contain very small amounts of magnets but are produced in the millions of units. The automotive sector lies somewhere in between, with each electric vehicle drive train consuming between one and two kg of NdFeB magnets.[180] Regardless of the weight of the magnet, the strong magnetic properties provided by NdFeB magnets are key to effective and efficient product performance.

Table 6: Expected magnets contained in total global demand for selected NdFeB magnet applications, thousands of tons*

Application	**Total demand in 2020**		**Total projected demand in 2030 (high growth)**		**Total projected demand in 2050 (high growth)**	
	Amount (kt)	**Share**	**Amount (kt)**	**Share**	**Amount (kt)**	**Share**
Offshore wind turbines	16.9	14.2%	139.2	36.0%	273.7	36.3%
Electric vehicles	7.3	6.1%	114.1	29.5%	266	35.3%
Consumer electronics (hard disk drives, cell phones, loudspeakers, other)	35.1	29.4%	41	10.6%	65.4	8.7%
Industrial motors	36.0	30.2%	53.7	13.9%	85.7	11.4%
Non-drivetrain motors in vehicles	9.4	7.9%	18.3	4.7%	29.3	3.9%
Other sintered magnets (Power tools, electric bikes)	6.5	5.5%	9.6	2.5%	15.3	2.0%
Bonded magnets	8.0	6.7%	11.1	2.9%	17.7	2.3%
Total	**119.2**	**100.0%**	**387**	**100.0%**	**753.2**	**100.0%**

* The figures presented represent total – or the sum of direct and embedded – demand.
Source: "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

Total global demand for NdFeB magnets is expected to grow dramatically over the next decade, increasing from 119,000 tons in 2020 to 387,000 tons by 2030 and over 750,000 tons by 2050 in a net zero carbon emission scenario. This equates to an average annual growth rate of 12.5 percent through 2030 and 6.3 percent through 2050. Electric vehicles and offshore wind turbines will drive this growth and are projected to account for almost 30 percent and about 36 percent of NdFeB magnet demand, respectively, by 2030 as a result of the world's evolving clean energy goals. The push for energy efficiency in other sectors, including traditional NdFeB magnet

[178] Except where otherwise noted this section draws on the DoE's "Rare Earth Permanent Magnets" report. *See* "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[179] As noted earlier, valid and reliable estimates of demand are difficult to generate because of the opacity of the global NdFeB magnet supply chain and these estimates of global demand, both in aggregate and by end-use application, should be approached with caution.
[180] "Critical Materials Strategy," Department of Energy, December 2011, https://www.energy.gov/sites/default/files/DOE_CMS2011_FINAL_Full.pdf.

applications such as consumer electronics and industrial motors, will also contribute to increased demand for NdFeB magnets. However, growth in these areas is expected to be more modest, with their share of total demand shrinking from almost 60 percent of total demand in 2020 to less than 25 percent of total demand in 2030.

The rapid growth in demand for NdFeB magnets is expected to strain the current global value chain. One market research firm forecasts that combined neodymium, praseodymium, and neodymium-praseodymium oxide shortages will rise to 21,000 tons by 2030 and 68,000 tons by 2035, while NdFeB alloy and powder shortages will reach 66,000 tons by 2030 and 206,000 tons by 2035.[181] For reference, the Department's survey of the U.S. NdFeB magnet industry indicates that by 2026 the U.S. may produce a little under [redacted] of rare earth oxides and about [redacted] of NdFeB alloys.

7.2 Global NdFeB Magnet Value Chain

The Department synthesized primary and secondary data on the global NdFeB magnet value chain's market conditions (*see* Appendix E, "Global NdFeB Magnet Production: A Firm-Level Perspective"). The Department focused on five important current and potential industry producers outside of the United States: Australia, Canada, China, the European Union, and Japan. For each country or region, participation in the main market segments (mining, processing of carbonates/separation of oxides, metallization/alloying, magnet production) plus recycling and substitution is described. The major firms involved in production, often multinationals with global operations, are also discussed.

Table 7 provides a review of market share by country for the consolidated market segments of mining, separation, metallization, and alloying/magnet manufacture. As noted earlier, China has the largest share of global production, by a large margin, at every step of the NdFeB magnet value chain. [redacted][182] Australia is the third largest miner after China and the United States, and the Australian firm Lynas Rare Earths is responsible for Malaysia's seven percent share of the refined oxide market. Japan is the second largest alloy and magnet producer (seven percent in 2020), and its firms produce metals, alloys, and magnets in Japan, Southeast Asia, and China. [redacted][183] The European Union has plans for significant growth in rare earth mining and magnet production, and seeks to grow its relatively small share of the oxide separation, alloying, and magnet production markets. [redacted]

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[181] "Adamas Intelligence forecasts global demand for NdFeB magnets to increase at CAGR of 8.6% through 2035; shortages of alloys, powders, REE expected," Green Car Congress, April 20, 2022, https://www.greencarcongress.com/2022/04/20220420-adamas.html.
[182] Adamas Intelligence, "Rare Earth Magnet Market Outlook to 2030," 2020.
[183] Ibid.

[redacted][184] Finally, Canada also plans to establish rare earth mining and separation capacity, in addition to Canadian firms such as Neo Performance Materials who maintain global capacity in multiple steps of the magnet value chain.

Table 7: Market Share by Country, 2021 for Mining and 2020 for Other Steps

Country	Mining[185]	Separation[186]	Metal refining[187]	Magnet alloy manufacturing[188]
China	60%	89%	90%	92%
U.S.	15%	-	-	<1%
Myanmar (Burma)	9%	-	-	-
Australia	8%	-	-	-
Madagascar	1%	-	-	-
India	1%	1%	-	-
Russia	1%	-	-	-
Thailand	3%	-	~3%	-[189]
Malaysia	-	7%	-	-
Estonia	-	1%	~2%	-
Japan	-	-	-	7%
Vietnam	>1%	-	~3%	1%
Laos	-	-	~2%	-
Germany	-	-	-	<1%
Slovenia	-	-	-	<1%
Finland	-	-	-	<1%
U.K.	-	-	<1%	-
Other countries	1%	2%	<1%	<1%

Source: "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf; Daniel Cordier, "Rare Earths: Mineral Commodity Summaries 2022," U.S. Geological Survey, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.

184 Ibid.
185 For 2021 estimates of rare earth mine output by country, *see* Daniel Cordier, "Rare Earths: Mineral Commodity Summaries 2022," U.S. Geological Survey, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.
186 Calculated based on current understanding of where concentrate from specific producers is separated (for example, output from Lynas' Mount Weld Mine in Australia is separated at its LAMP facility in Malaysia and HREs mined in Myanmar are transported to China for further processing). "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
187 Current hypothesis based on expert consultation. "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
188 "Rare earth magnet market outlook to 2030," Adamas Intelligence, August 2020.
189 In 2019, Thailand accounted for about eight percent of bonded NdFeB powders. Neo Magnequench (a subsidiary of Neo Performance Materials) manufactures bonded magnetic powders at its facility in Korat, Thailand. "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20%20Final.pdf.

7.3 Russia and the NdFeB Magnet Industry

Russia is not a major direct participant in the NdFeB magnet value chain. In 2021 Russian production of rare earth elements was estimated at 2,700 tons, equal to about one percent of the global market.[190] However, Russia has significant reserves of rare earths, estimated at 21 million tons or about 17.5 percent of the global total.[191] Canadian firm Neo Performance Materials states it uses Russian feedstocks in its Estonian separation facility, along with feedstocks from Australia, China, and the United States.[192] Russia does not participate in any downstream segments of the value chain.[193] In addition, the United States imports 1001 steel from Germany and sometimes Brazil, and ferroboron is produced in China, India, and Turkey.[194] Finally, based on market research and industry meetings, Russia does not appear to be a source of critical equipment for NdFeB magnet production.

[redacted]

One method to evaluate the exposure of the NdFeB magnet industry to Russia is to examine the effects of Russia's invasion of Ukraine on investor expectations using an event study.[195] If investors think that the NdFeB magnet industry will be negatively affected by Russia's invasion

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[190] Daniel Cordier, "Rare Earths: Mineral Commodity Summaries 2022," U.S. Geological Survey, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.
[191] Ibid.
[192] "Neo Performance Materials MD&A," Neo Performance Materials, 2021, https://www.neomaterials.com/wp-content/uploads/2021/03/NPM_12-31-2020_MDA.pdf.
[193] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[194] Ibid.
[195] For an overview of event studies, *see* e.g., John Binder, "The Event Study Methodology Since 1969," Review of Quantitative Finance and Accounting 11: 111-137, 1998, https://link.springer.com/article/10.1023/A:1008295500105; S.P. Kothari and Jerold B. Warner, "Chapter 1 – Econometrics of Event Studies," Handbook of Empirical Corporate Finance, Volume 1, 2007, https://doi.org/10.1016/B978-0-444-53265-7.50015-9; Abigail McWilliams and Donald Siegel, "Event Studies in Management Research: Theoretical and Empirical Issues," Academy of Management Journal 40 (3): 626-657, 1997, https://doi.org/10.5465/257056.

of Ukraine, an abnormal negative market return for publicly traded firms in the NdFeB magnet industry should be observed around that event. The Department therefore estimated the abnormal market return around the time of Russia's invasion of Ukraine for four NdFeB magnet industry firms: MP Materials, a rare earths miner who plans to create a vertically integrated mine to magnet firm in the United States; Energy Fuels, a U.S. rare earths processor who is considering separating oxides; Neo Performance Materials, a Canadian firm that produces rare earth oxides in Estonia, metals and alloys in Thailand and China, and NdFeB magnets in China; and Lynas Rare Earths, an Australian rare earths miner that produces oxides in Malaysia. Other public companies involved in the NdFeB magnet value chain were excluded because they are conglomerates with significant non-NdFeB magnet operations (e.g., Shin-Etsu, TDK, Hitachi), tangentially involved in the NdFeB magnet industry (e.g., Chemours), or at a more nascent stage of production (e.g., IperionX, Peak Rare Earths). The Department downloaded stock price data for each of these firms and the S&P 500 index from January 1, 2021, through February 24, 2022, from Yahoo Finance. The Department then calculated the daily return of each firm and the S&P 500 index. In line with a simple market model event study, the Department estimated each firm's abnormal return in two steps. For each firm, the Department first regressed the firm's daily return on the S&P 500 index's daily return in a trading window of 250 days to 30 days prior to Russia's invasion of Ukraine (February 24, 2022). The Department then used the estimated coefficients from this regression and the S&P 500 index's daily return to predict the firm's return in a trading window one day prior to one day after the invasion. Finally, the Department subtracted the firm's predicted daily return from the firm's observed daily return to generate an estimate of the firm's abnormal return in a trading window one day prior to one day after the invasion.

This event study analysis supports market research that suggests the NdFeB magnet industry is not highly exposed to Russia.[196] Using a one sample t-test, the average abnormal return is positive at $p<.05$ with a sample mean of 0.026 and a 95 percent confidence interval of 0.001 to 0.051.[197] A positive abnormal return indicates that firms' stock prices increased more than they would have in the absence of an invasion, suggesting that investors did not expect the invasion to negatively affect the NdFeB magnet industry. Not only is the sign of the abnormal return different than what would be expected if investors believed the invasion would negatively affect the NdFeB magnet industry, but it is statistically significant. This analysis provides additional evidence corroborating the NdFeB magnet industry's lack of exposure to Russia.

To assess whether one firm was driving this result, the Department iteratively dropped each observation, resulting in a sample mean of .018 without Energy Fuels (not significant at $p<.05$), 0.025 without Lynas Rare Earths (not significant at $p<.05$), 0.024 without MP Materials (not

[196] The Department strongly cautions against overinterpreting the results of this analysis because Russia's invasion was not wholly unanticipated and investors should therefore have partially priced in the costs of conflict, and the sample size is very small. Nevertheless, this analysis provides suggestive evidence of the NdFeB magnet industry's minimal exposure to Russia.

[197] Using a two-day trading window – the day of the event and the day after – results in an average abnormal return of 0.018, not significant at $p<.05$.

significant at p<.05), and 0.037 without Neo Performance Materials (significant at p<.05). Neo Performance Materials' stock price did not experience as positive an abnormal return as the other three firms', suggesting that investors were relatively less optimistic about the effects of the invasion on Neo Performance Materials. This is consonant with market research expectations, because Neo Performance Materials sources some rare earths from Russia (along with Australia, China, and the United States) and therefore has more direct exposure to Russia than the other three firms.[198]

8. Status and Forecast of the U.S. NdFeB Magnet Industry

8.1 U.S. Production of NdFeB Magnets and Components, 2017 to 2026

This section covers U.S. production of NdFeB magnets and magnet components, including mixed rare earth oxides, rare earth carbonates, individual rare earth oxides, rare earth metals, and rare earth alloys, from 2017 to 2026.[199] It focuses on identifying current and planned producers, their participation in the NdFeB magnet value chain, and the current and anticipated quantity of U.S. production at each value chain step. Later sections will elucidate the challenges the industry faces in meeting its production forecasts.

8.1.1 Firm Participation in the U.S. NdFeB Magnet Value Chain

Except for rare earths mining, the United States was not a major participant in the NdFeB magnet value chain from 2017 to 2021 and only seven firms participated in any step of the NdFeB magnet value chain over this period (*see* Figure 4). [redacted]

The Department forecasts U.S. industry growth starting in 2022, due to a combination of expected demand growth, U.S. Government and private sector interest in supply chain resiliency, and rising rare earths prices. Between 2022 and 2026, ten additional firms indicate they will enter the market while the seven original firms noted in the 2017 to 2021 period plan to continue, and in some cases expand, their operations. A total of 17 firms are expected to participate in the NdFeB magnet value chain by 2026 (*see* Figure 5). [redacted]

[198] "Neo Performance Materials MD&A," Neo Performance Materials, 2021, https://www.neomaterials.com/wp-content/uploads/2021/03/NPM_12-31-2020_MDA.pdf.

[199] [redacted]

[redacted]

[redacted]								
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]							[redacted]	
[redacted]	[redacted]							
[redacted]							[redacted]	
[redacted]		[redacted]					[redacted]	
[redacted]	[redacted]							
[redacted]						[redacted]		[redacted]
[redacted]							[redacted]	
[redacted]								

[redacted]								
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]			[redacted]					[redacted]
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[redacted]	[redacted]							
[redacted]							[redacted]	
[redacted]		[redacted]	[redacted]	[redacted]				
[redacted]			[redacted]					
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]						
[redacted]					[redacted]	[redacted]		[redacted]
[redacted]			[redacted]	[redacted]	[redacted]			[redacted]
[redacted]						[redacted]		
[redacted]			[redacted]					[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]		
[redacted]					[redacted]	[redacted]		
[redacted]	[redacted]							
[redacted]								

8.1.2 Production of NdFeB Magnets and Magnet Components, 2017 to 2026

Rare Earth Element Production (Mining and Recycling)

Between 2018 and 2021, U.S. production of NdFeB magnet-related rare earths increased by [redacted] (*see* Figure 6).[200] Between 2022 and 2026, U.S. rare earths production is expected to increase [redacted]. For the full 2018 to 2026 period, U.S. rare earths production is expected to increase by [redacted]. Mining is expected to remain the predominant source of rare earths feedstock, occupying roughly [redacted] of production for the period. Recycling is expected to account for the remaining [redacted].

[redacted]

[redacted]

[redacted]

[redacted]

Of the rare earths used in NdFeB magnets, neodymium and praseodymium account for [redacted] of the 2017 to 2026 market, with neodymium making up around [redacted] and praseodymium around [redacted]. Dysprosium production is slated to increase starting in [redacted] and will bring neodymium and praseodymium's combined market share down to [redacted] by 2026. An increase in dysprosium production to over [redacted] in 2026 is significant due to previously cited concerns about single source concentrations in China.[201] Should dysprosium production develop, the United States may become a feasible alternative to China for some dysprosium sourcing.

[200] No production was recorded for 2017.
[201] Comments of USA Rare Earth to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.

[redacted]

Rare Earth Carbonates

Between 2023 and 2026, U.S. rare earth carbonates production is expected to increase [redacted] (*see* Figure 7).[202] Of these carbonates, those containing [redacted] are anticipated to be the main driver for this growth, accounting for [redacted] of total carbonates growth. Carbonates containing [redacted] make up most of the remaining production with small amounts of carbonates containing [redacted] expected to be produced starting in [redacted].

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[202] [redacted]

[redacted]

Separated Rare Earth Oxides

Between 2023 and 2026, U.S. separated rare earth oxides production is expected to increase [redacted] (*see* Figure 8).[203] Of these oxides, [redacted] are the main driver of growth, accounting for on average [redacted] of total growth. [redacted] most of the remaining growth is due to [redacted] production, with a small [redacted] due to [redacted] and a negligible amount to [redacted].

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[203] No production was recorded for 2017 to 2021 [redacted].

Rare Earth Metals

Between 2023 and 2026, U.S. rare earth metals production is expected to increase by [redacted] (*see* Figure 9).[204] At this production rate, the United States could produce between about [redacted] of NdFeB magnets.[205] Of these metals, [redacted] rare earth metal is the main driver for growth, accounting for on average [redacted] of total rare earth metals growth. [redacted] will make up much of the remaining growth. The Department expects U.S. firms will refine negligible amounts of [redacted].

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Rare Earth Alloys

Between 2023 and 2026, U.S. rare earth alloys production is expected to increase by [redacted] (*see* Figure 10).[206] At this production rate, the United

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[204] No production was recorded for 2017 to 2021 [redacted].

[205] The Department reached this estimate by first calculating the amount of NdFeB alloy [redacted] of rare earth metal could produce based on 30 percent rare earths content in NdFeB magnets, then estimating the range of potential material loss from alloy production to magnet production (*see* Section 5.2, "Rare Earth Element Losses in Magnet Production," for estimates of material loss from alloy production to magnet production).

[206] No production was recorded for 2017 to 2021 [redacted].

States would produce enough alloy for between [redacted] of NdFeB magnets.[207] Of these alloys, [redacted] is anticipated to be the main driver of growth, representing on average [redacted] of total alloy growth. Production of [redacted] are expected to represent [redacted] of growth, respectively. NdFeB alloys containing heavy rare earths including dysprosium and terbium are critical for high heat tolerant NdFeB magnets used in products like electric vehicle drive trains.

[redacted]

[redacted]

[redacted]

[redacted]

NdFeB Magnet Production

Between 2017 and 2022, no sintered NdFeB magnet production was recorded in the United States. [redacted], commercial-scale production is not expected until 2023. Between 2023 and 2026, U.S. sintered NdFeB magnet production is expected to increase [redacted] to over 14,000 tons (*see* Figure 11).

[207] *See* Section 5.2, "Rare Earth Element Losses in Magnet Production," for estimates of material loss from alloy production to magnet production.

[redacted][208]

[redacted]

On average, sintered NdFeB magnet production is expected to account for roughly 97 percent of aggregate U.S. NdFeB magnet production. Although occupying a small portion of the market, it is important to note that domestic bonded NdFeB magnet production existed during the 2017 to 2021 period. Between 2017 and 2021, bonded NdFeB magnet production increased by [redacted] (*see* Figure 11). Between 2022 and 2026 production is expected to increase by a further [redacted] from about [redacted], with total production increasing by [redacted] between 2017 and 2026.

[208] "General Motors and MP Materials Enter Long-Term Supply Agreement to Scale Rare Earth Magnet Sourcing and Production in the U.S.," General Motors, December 9, 2021, https://investors.gm.com/news-releases/news-release-details/general-motors-and-mp-materials-enter-long-term-supply-agreement.

[redacted]

8.1.3 Company Profiles

To better illuminate the plans, requirements, and challenges U.S. firms face in establishing production, the Department developed profiles of those firms that are expected to be major participants in the U.S. NdFeB magnet industry (*see* Appendix F, "U.S. NdFeB Magnet Industry: Company Profiles"). [redacted] These profiles emphasize information on current and planned facilities, including location, initial dates of production, and capacity, planned facilities' fixed costs, future production volumes, employment, and challenges.

8.1.4 Estimated NdFeB Magnet Import Penetration, 2017 to 2026

The Department used the data from its survey of the U.S. NdFeB magnet industry and estimates of U.S. NdFeB magnet demand to estimate import penetration for sintered and bonded NdFeB magnets from 2017 to 2026 (*see* Figures 12 and 13).[210] Based on these data and the assumptions detailed in footnote 210, the Department estimates sintered NdFeB magnet import penetration from 2017 to 2021 at one hundred percent. There was no domestic production of NdFeB magnets during this period. From 2022 to 2026 import penetration could fall to as low as 49 percent as

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[209] [redacted]

[210] The Department's figures rely on several demand and export assumptions and should be taken as lower bound for import penetration. U.S. production estimates are taken from the Department's survey and reflect firms' production forecasts as of February and March 2022. The quantity of domestic production in Figures 20 and 21 will require significant capital expenditure and faces additional constraints in the form of workforce issues and other challenges, discussed in more detail below. In addition, by relying on production of NdFeB magnets this analysis reflects direct imports only and does not take into account trade in value added. There are several domestic magnet integrators and finishers who purchase magnets or magnet blocks and shape and integrate them into intermediate and final products, some of which are exported. The Department's analysis does not account for these value-add activities. Further, the Department asked firms to only provide sales data if contracts or memorandums of understanding were in place. No prospective U.S. sintered NdFeB magnet producer indicated sales to foreign customers [redacted]. The Department therefore assumed no foreign sales of sintered NdFeB magnets [redacted]. Any foreign sales (i.e., domestic exports) will increase import penetration. The Department used estimates of total U.S. demand provided by the Department of Energy (DoE). DoE estimated total 2020 and 2030 U.S. demand for NdFeB magnets, with the 2030 figure representing a high growth scenario. DoE's demand estimates reflect both direct and embedded demand. [redacted].

domestic production ramps up. The Department estimates bonded NdFeB magnet import penetration from 2017 to 2021 at between 85 and 87 percent. This figure is expected to fall to about 79 percent due to expanded U.S. production. The Department emphasizes that, because of the optimistic production estimates and the modelling assumptions detailed in footnote 210, these import penetration estimates should be taken as a floor and actual import penetration is expected to be higher.

Figure 12: Estimated U.S. Sintered NdFeB Magnet Import Penetration, 2017 to 2026, Tons

Figure/Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
U.S. Production	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
U.S. Imports for Consumption*	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
U.S. Domestic Exports**	-	-	-	-	-	-	-	-	-	-
U.S. Apparent Consumption***	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Import Penetration (No Exports)****	100%	100%	100%	100%	100%	99.7%	91%	74%	56%	49%

Source: U.S. Department of Commerce, Bureau of Industry and Security, NdFeB Survey, 3a, Section G.
Source: "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
*Imports for consumption are calculated as U.S. Apparent Consumption (i.e., total demand) less U.S. production and therefore differs from direct imports.
**No exports recorded (measured in tons) over the period.
*** [redacted]
****Import penetration estimates shown are minimums. Actual figures are expected to be higher due to modelling assumptions and optimistic production estimates.

Figure 13: Estimated U.S. Bonded NdFeB Magnet Import Penetration, 2017 to 2026, Tons

Figure/Year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
U.S. Production	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
U.S. Imports for Consumption*	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
U.S. Domestic Exports**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
U.S. Apparent Consumption***	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Import Penetration (No Exports)****	87%	87%	87%	85%	87%	86%	86%	85%	79%	79%

Source: U.S. Department of Commerce, Bureau of Industry and Security, NdFeB Survey, 3a, Section G.
Source: "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
* Imports for consumption are calculated as U.S. Apparent Consumption (i.e., total demand) less U.S. production and therefore differs from direct imports.
** [redacted]
*** [redacted]
****Import penetration estimates shown are minimums. Actual figures are expected to be higher due to modelling assumptions and optimistic production estimates.

8.2 Requirements to Establish the U.S. NdFeB Magnet Industry

8.2.1 Facility Costs and Capital Expenditures

As indicated in the earlier section on firm-level profiles, the facilities required to produce NdFeB magnets and components of NdFeB magnets are costly to establish. In meetings with industry stakeholders, company representatives emphasized the substantial investment requirements to establish U.S. capacity. MP Materials announced in 2019 that it was spending $200 million to establish a domestic processing and separation facility and announced in February 2022 plans to spend $700 million to establish a vertically integrated NdFeB magnet supply chain in the United States.[211] [212] [redacted] [213] On the lower end of the spectrum, Quadrant Magnetics announced that it plans to invest $95 million to construct a U.S. NdFeB magnet manufacturing facility, with anticipated capacity of [redacted].[214] Other industry stakeholders, while not reporting specific costs, indicated that expenditures made it difficult to construct facilities without demand from anticipated customers. These figures emphasize the need for increased certainty of demand, ideally through definitive offtake agreements, and the limitations of current U.S. Government funding mechanisms, such as the Title III program, to provide sufficient capital.

The Department's survey provides further evidence on the costs to establish U.S. production facilities. Respondents were asked to list all future facilities that would start production between 2022 and 2026.[215] For each facility, respondents were asked to estimate the total cost it would take to reach full production capacity. There is considerable variation in facility costs between value chain steps (*see* Figure 14). The upstream steps of the value chain are generally the most expensive to establish, with the median mining facility estimated to cost [redacted] and the median oxide facility estimated to cost about [redacted]. In comparison to mining facilities, plants that reclaim/recycle rare earth elements from waste feedstocks are relatively inexpensive at [redacted]. Facility costs are generally lower in the downstream steps of the value chain. Respondents estimate that the median metal facility costs [redacted], the median alloy facility [redacted], and the median sintered NdFeB magnet facility around [redacted].

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[211] Ernest Scheyder, "California rare earths miner races to refine amid U.S.-China trade row," Reuters, August 23, 2019, https://www.reuters.com/article/us-usa-rareearths-mpmaterials-idUSKCN1VD2D3.
[212] John Wagner and Amy B. Wang, "Biden announces new spending on mineral production to address supply chain challenges," Washington Post, February 22, 2022, https://www.washingtonpost.com/politics/2022/02/22/biden-minerals-supply-chain-announcement/.
[213] Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).
[214] Eleanor Tolbert, "Global Manufacturer Plans $95 million facility in Louisville," Louisville Business First, January 28, 2022, https://www.bizjournals.com/louisville/news/2022/01/28/manufacturer-plans-95-million-facility.html.
[215] Although respondents were asked to provide infomation on any future facilities regardless of location, respondents only indicated future facilities in the United States or in undecided locations.

[redacted]

[redacted]

[redacted]

Firms face considerable financial shortfalls when it comes to new facilities. Figure 15 shows the median and mean difference at the facility-level between the amount needed to reach full production and amount firms have allocated to reach full production, as well as the sum of differences over facilities, grouped by facility value chain step. The similarity between the median and mean differences between funds need and funds allocated suggest that there are few well-funded outliers. In addition, the differences between funds needed and funds allocated are similar to the facility costs in Figure 14, indicating that most firms have allocated little to no money for the construction of new facilities. The total funding needed to bring all planned facilities online is considerable but varies widely between value chain steps. The seven new sintered NdFeB magnet facilities, which are critical to achieving the ambitious production estimates discussed earlier, are expected to require over [redacted].[216] This is not even the largest shortfall in the NdFeB magnet value chain: [redacted]. Metal and alloy plants have the smallest shortfall, requiring a further [redacted], respectively. As relatively low levels of domestic metal and alloy production are expected to constrain the use of domestic metals and alloys in NdFeB magnets, the comparatively small gap between allocated and required funds for metal and alloy plants is of particular interest. Without substantial new funding, U.S. producers will not meet the production estimates described earlier.

216 [redacted]

[redacted]

[redacted]

[redacted]

Data on firms' capital expenditures from 2017 to 2026 corroborate the significant financing needed to achieve production forecasts. From 2017 to 2020 annual capital expenditures were well under [redacted] annually, reflecting the fact that prior to 2021 the only active domestic value chain steps were mining and bonded NdFeB magnet production (*see* Figure 16). In 2021, capital expenditures increased to just under [redacted] and are forecasted to jump in 2022 to over [redacted]. The massive increase in capital expenditure to around [redacted] annually for 2022 to 2024 is further evidence of the considerable funding needed to establish a U.S. NdFeB magnet value chain.

[redacted]

[redacted]

[redacted]

The sources of capital expenditure funding in 2021 indicate the potential need for additional sources of financing to cover anticipated outlays. Even in 2021, when aggregate industry capital expenditure is a comparatively low [redacted], over [redacted] of recorded spending was self-funded (*see* Figure 17). Department of Defense funds covered less than [redacted] of total expenditure. Given Title III funding constraints, it is unlikely that current Department of Defense funding mechanisms will be able to scale support for the U.S. NdFeB magnet industry when annual capital expenditures increase to over [redacted] in 2022. Additional private sector financing that can bolster internal sources of capital expenditure funding will be critical to achieving production estimates.

[redacted]

[redacted]

[redacted]

8.2.2 Critical Equipment

In addition to costly facilities, the production of NdFeB magnets and components of NdFeB magnets requires expensive critical equipment. 22 firms indicated 130 pieces of equipment that are critical to production in the Department's survey. Firms identified the most pieces of equipment for NdFeB magnet production [redacted], followed by alloy production [redacted]. Firms identified the fewest pieces of equipment for recycling rare earths [redacted] and mining [redacted].[217]

The most cited source of equipment was the United States, followed by Japan, China, and Germany. The high degree of machinery sourcing from the United States may reflect the location of assembly rather than where machine components were produced. Industry participants indicated that the most sophisticated machinery relevant to NdFeB magnets come from Japan and Germany, with additional equipment sourced from China.[218] Japan was the top source for

[217] The distribution of equipment may reflect the composition of our sample.

[218] [redacted]

equipment needed to produce magnets. Respondents indicated equipment also came from [redacted].

Mining equipment was on average the most expensive critical machinery, with a mean of over [redacted] (*see* Figure 18). Machinery to produce magnets was the second most expensive at an average of [redacted], closely followed by oxide production equipment at over [redacted]. Metal production equipment was on average the least expensive at [redacted]. The relative cost of equipment across value chain steps partially reflects the costs of facilities: mining is the most expensive, oxides and magnets are less so, and metals and alloys the least costly.

[redacted]

[redacted]

[redacted]

[redacted]

In addition to cost, some industry representatives have indicated the potential for supply chain issues in the acquisition of necessary capital equipment.[219] The NdFeB magnet industry has, like other industries, seen long lead times, which industry participants tend to attribute to COVID-19-related supply chain issues. Across all pieces of equipment, the average lead time is 238 days, and the median lead time is 240 days. When disaggregating by value chain step, equipment needed to produce carbonates faces somewhat shorter lead times, while equipment needed to produce magnets and oxides faces somewhat longer lead times (*see* Figure 19). There do not appear to be strong patterns when disaggregating by equipment criticality. Equipment that is critical to production tends to face longer lead times across value chain steps, but this is not the case for equipment to produce magnets and the differences are sometimes small. The Department also examined average lead times by source country and value chain step. At the country-level lead times for the United States were somewhat lower than for other countries, although not across all value chain steps. No other strong patterns emerged, in part reflecting the small sample size when cross tabulating the survey data in this way.

[redacted]

219 [redacted]

[redacted]

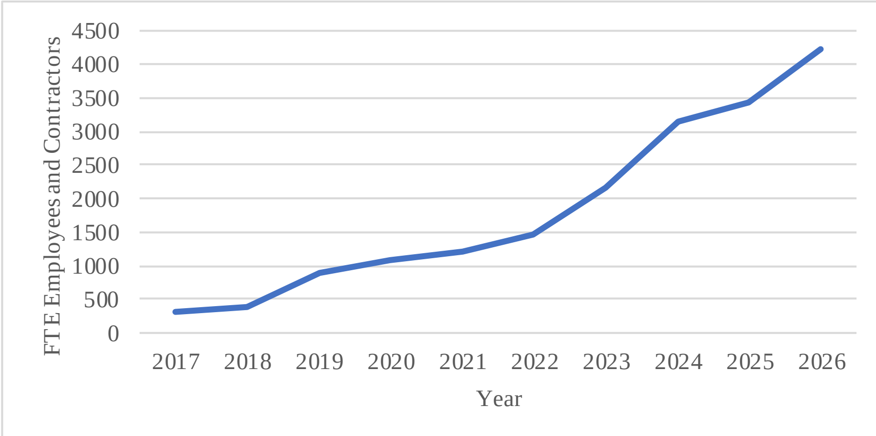
Even within pieces of equipment there is considerable heterogeneity. [redacted]

8.2.3 Employment

The U.S. NdFeB magnet industry directly employs a relatively small number of individuals.[220] Mine to magnet production has increased total full time equivalent (FTE) employment from 314 in 2017 to 1,214 in 2021 and is expected to increase to 4,226 by 2026 as facilities at different steps of the value chain start production (*see* Figure 20). By comparison, employment in the North American Industry Classification System (NAICS) corresponding to NdFeB magnets ("All Other Miscellaneous Fabricated Metal Product Manufacturing" – 332999) was 76,918 in 2020 and employment in the NAICS corresponding to carbonates, oxides, and metals ("Other Basic Inorganic Chemical Manufacturing" – 325180) was 39,700 in 2020. Even assuming no growth in non-NdFeB magnet employment in these NAICS the U.S. NdFeB magnet industry would contribute less than four percent to direct employment in 2026.

[220] The Department notes that this does not consider employment in the many sectors that rely on NdFeB magnets, such as electric vehicles and wind turbines.

Figure 20: U.S. Workforce, NdFeB Magnet Value Chain, 2017-2026



Source: U.S. Department of Commerce, Bureau of Industry and Security, NdFeB Survey, 6, Part A. [redacted]

Respondents: 17

As mentioned earlier, the U.S. NdFeB magnet industry is emerging and many of the firms involved plan to expand production and enter other value chain steps. To better understand which occupations will likely be in demand, the Department compared employment by occupation between mature magnet firms and the current U.S. industry. Three mature magnet firms provided employment data in their responses to the Department's survey.[221] These firms are established NdFeB magnet producers with significant output and provide insight into the employment makeup of a typical magnet firm. Figure 21 compares the mean proportion employed in each of five broad occupational categories between these two samples. Mature magnet firms employ relatively similar proportions across occupational categories: [redacted] are manufacturing engineers, scientists, and research and development (R&D); approximately [redacted] are in production line operations; around [redacted] in sales, administrative, and management; about [redacted] in testing and quality control; and [redacted] in information technology. By contrast, as indicated by the wide standard deviations, current U.S. producers are very heterogeneous in the proportion employed across occupational categories. They also employ a far smaller percentage of production line operations employees (about [redacted]). Based on occupational data from current mature magnet producers, U.S. firms are likely to employ a greater percentage of production line operations employees as they develop capacity.

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221 [redacted]

[redacted]

Industry stakeholders indicated to the Department a range of perspectives on employment challenges. For example, MP Materials stated that the United States "has limited skilled labor and human resources needed for the production of this high-technology product."[222] In contrast, the United States Magnetic Materials Association said that "the knowledge of how to produce the magnets does exist" and cited the inability to obtain licenses for critical intellectual property and return on investment as more significant barriers to domestic production.[223] This is consistent with Arnold Magnetics' public comments, in which it indicated it could shift production from Samarium-Cobalt magnets to NdFeB magnets.[224] [redacted]

[222] Comments of MP Materials to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[223] Comments of the United States Magnetic Materials Association to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[224] Comments of Arnold Magnetics to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.

Survey respondents were requested to indicate what labor market issues they faced, including the timeframe and the primary affected occupation. For U.S. producers, the primary workforce issues faced were finding qualified and experienced workers, followed by attracting workers to their location and finding U.S. citizens (*see* Figure 22). U.S. producers were likely to select high wage occupations as the primary occupation affected and were much more likely to do so when compared to non-producers, although production line operations were also frequently cited. The U.S. NdFeB magnet industry may face human capital challenges, in particular finding engineers and scientists.

[redacted]

[redacted]

[redacted]

Qualitative survey responses provide further evidence of the NdFeB magnet industry's potential difficulties in attracting human capital. The lack of available and experienced high wage labor was a particularly common refrain. [redacted]

Firms that can find workers face competition and difficulties attracting them. [redacted] Many NdFeB magnet firms are located outside major urban centers, which can cause issues attracting talent. [redacted]

8.3 Additional Challenges to Domestic Production

8.3.1 Import Competition, Production Costs, and General Challenges

The Department's survey of the U.S. NdFeB magnet industry asked firms about whether they struggled to compete against imports. 29 firms – 57 percent of the sample and 67 percent of current or planned U.S. NdFeB magnet value chain producers – responded affirmatively. The Department then asked the percentage of operating costs attributable to eight input conditions. Figure 23 shows the median cost for each input condition for all respondents, non-producers, current or planned U.S. producers, and foreign producers.[225] Producers indicated that feedstock purchases are the single largest contributor to operating costs. [redacted] By contrast, non-producers indicated sourcing feedstock is a distant second to labor costs. This is consonant with the high cost of rare earths in NdFeB magnets. The cost of sourcing feedstock is one vector of Chinese competition. [redacted] Labor is the second largest contributor to U.S. producer operating costs, representing about [redacted], followed by electricity at [redacted].

[redacted]

[redacted]

[redacted]

The Department also asked survey respondents to indicate which of 30 challenges affected their competitive position and to rank the top five challenges (*see* Figure 24). Foreign competition is the most important challenge for U.S. NdFeB magnet industry participants. [redacted]

[225] Proportions do not sum to one for each category because firms were not compelled to complete this section. In addition, there is an "Other" category that is mainly described as miscellaneous or overhead costs.

current and future U.S. producers ranked foreign competition in their top five challenges, and [redacted] current and future U.S. producers ranked it as their number one challenge. [redacted] of current and future U.S. producers ranked input availability as their number one challenge, making it the second most frequently cited number one challenge. [redacted] current and future U.S. producers included labor availability in their top five challenges, making it the second most frequently cited challenge overall. Current and future U.S. producers also indicated financing/credit availability is an issue, with [redacted] of respondents ranking it in their top five challenges. [redacted] U.S. producers also indicated financing/credit availability is a minor issue, with only [redacted] including it in their top five challenges.

[redacted]	
[redacted]	[redacted]
[redacted]	

Qualitative explanations underscore foreign competition, in particular with China, as a major challenge for domestic production. Many respondents who cited foreign competition directly compete with Chinese firms, which they claim are unfairly advantaged through government policies, subsidies, and market manipulation. Several respondents noted that the lack of environmental regulations and enforcement in China allows Chinese magnet producers to undercut prices for NdFeB magnets. Others noted the near total domination that Chinese firms had throughout the NdFeB magnet supply chain, which enables China to set market prices. China is also mentioned in terms of input availability. Some firms indicate that there are few sources of feedstocks outside of China, [redacted] Chinese firms also compete with U.S. producers for inputs. [redacted]

Respondents were also likely to cite Chinese competition as the primary challenge to increasing their market share. One U.S. magnet integrator noted that China is a low-cost producer of NdFeB magnets and end-users often purchase from the cheapest source regardless of country of origin. Other respondents reiterated that Chinese suppliers are unfairly subsidized and because of their dominant position can set prices. A related factor cited by one U.S. producer is the higher cost of labor in the United States compared to foreign competitors. Another often-mentioned challenge to expanding operations and market share is accessing the necessary financing for capital investments. Finally, several respondents experienced challenges in developing a resilient supply chain for their operations, such as securing diverse sources for necessary feedstocks. Domestic sources are a particular challenge given the lack of U.S. production capacity in all stages of the NdFeB magnet value chain. Reflecting the more general challenges discussed earlier, Chinese competition, feedstocks, and capital are major barriers to expanding production.

8.3.2 Environmental Factors

Rare earths mining and processing can cause damage to the environment because it produces large amounts of hazardous and radioactive waste.[226] Mining waste, also known as tailings, is typically stored in impoundments engineered to minimize waste seepage.[227] [228] Further

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[226] Gwenolyn Bailey, Nabeel Mancheri, and Karel Van Acker, "Sustainability of Permanent Rare Earth Magnet Motors in (H)EV Industry," Journal of Sustainable Metallurgy 3: 611-626, 2017, https://link.springer.com/article/10.1007/s40831-017-0118-4.

[227] "What are Tailings," Society for Mining, Metallurgy, and Exploration, n.d., https://www.smenet.org/What-We-Do/Technical-Briefings/What-are-Tailings.

[228] Mining waste, such as coal tailings and heavy mineral sands, can be processed and recycled to extract contained rare earth elements. [redacted] Austyn Gaffney and Dane Rhys, "In coal country, a new chance to clean up a toxic legacy," Washington Post, May 19, 2022, https://www.washingtonpost.com/climate-solutions/2022/05/19/coal-mining-waste-recycling/.

downstream the value chain, the disposal and recycling of electronic waste can release heavy metals into the environment, with negative consequences for natural ecosystems.[229] In countries with less-stringent environmental regulations such as China, heavy metals can reach and contaminate groundwater during the mining process.[230] By contrast, environmental regulation in more highly-regulated economies pose additional costs and risks to market participants.[231] [232] For example, a Government Accountability Office report found that between 2010 and 2014 it took the Department of the Interior's Bureau of Land Management and the Department of Agriculture's Forest Service between one month and 11 years to approve mine plans, with an average approval time of two years.[233] Of the 68 mine plans reviewed, 13 had not begun operations in November 2015, partially attributed to the need to obtain other required federal and state permits.[234] Environmental studies are a time-intensive part of the permitting process.[235] Meanwhile, regulation requirements for depolluting infrastructure increase U.S. production costs.[236] Table 8 displays a non-exhaustive list of relevant statutes and treaties.[237]

Table 8: Partial List of Relevant Federal and International Environmental Regulations

Name	Scope	Relevant Body	Brief Summary
Atomic Energy Act of 1954	Waste	Federal	The Nuclear Regulatory Commission ("NRC") oversees the regulatory framework governing the control of radioactive materials, including beneficiation and processing of rare earths that contain radioactive source materials.

[229] Duc Huy Dang et al., "Toward the Circular Economy of Rare Earth Elements: A Review of Abundance, Extraction, Applications, and Environmental Impacts," Archives of Environmental Contamination and Toxicology 81: 521-530, 2021, https://link.springer.com/article/10.1007/s00244-021-00867-7.
[230] Gwenolyn Bailey, Nabeel Mancheri, and Karel Van Acker, "Sustainability of Permanent Rare Earth Magnet Motors in (H)EV Industry," Journal of Sustainable Metallurgy 3: 611-626, 2017, https://link.springer.com/article/10.1007/s40831-017-0118-4.
[231] Environmental regulations are critical for public health and safety. Noting that highly regulated jurisdictions are associated with higher production costs is a strictly factual observation and is not an endorsement of deregulation.
[232] Another example of risk is Lynas Rare Earths' Malaysian separation facility, which has brought the company into conflict with the Malaysian government over waste disposal. Currently, Lynas plans to establish a disposal facility as a condition of their license. Interview with Kristin Vekasi, "China's Control of Rare Earth Metals," The National Bureau of Asian Research, August 13, 2019, https://www.nbr.org/publication/chinas-control-of-rare-earth-metals/; "2021 Annual Report," Lynas Rare Earths, Ltd., 2021, https://wcsecure.weblink.com.au/pdf/LYC/02434182.pdf.
[233] "Hardrock Mining: BLM and Forest Service Have Taken Some Actions to Expedite the Mine Plan Review Process but Could Do More," United States Government Accountability Office, January 2016, https://www.gao.gov/assets/gao-16-165.pdf.
[234] Ibid.
[235] Duc Huy Dang et al., "Toward the Circular Economy of Rare Earth Elements: A Review of Abundance, Extraction, Applications, and Environmental Impacts," Archives of Environmental Contamination and Toxicology 81: 521-530, 2021, https://link.springer.com/article/10.1007/s00244-021-00867-7.
[236] Gwenolyn Bailey, Nabeel Mancheri, and Karel Van Acker, "Sustainability of Permanent Rare Earth Magnet Motors in (H)EV Industry," Journal of Sustainable Metallurgy 3: 611-626, 2017, https://link.springer.com/article/10.1007/s40831-017-0118-4.
[237] In addition to the listed statutes and treaties, firms face state and local as well as further federal regulations. For example. MP Materials notes their activities are subject to federal, state, and local laws and regulations covering a wide range of issues, such as air emissions, water usage, and waste management. The Mountain Pass Mine, for instance, has 16 environmental permits from 11 entities with various expiration dates. *See* "Form 10-K," MP Materials, February 28, 2022, https://d18rn0p25nwr6d.cloudfront.net/CIK-0001801368/77b2894e-b746-43c5-938a-a3f524823baa.pdf.

Basel Convention	Waste	International	The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes is an international treaty signed in 1989 and entered into force in 1992. It currently has 188 signatories and establishes a "notice and consent" regime for the export of hazardous waste to other countries. The United States is not currently a party to the Basel Convention.
Clean Air Act	Air	Federal and State	Authorizes the Environmental Protection Agency (EPA) to establish national ambient air quality standards and maximum achievable control technology emission standards for hazardous and toxic pollutants. Establishes an air quality control permitting program implemented by EPA and authorized states.
Clean Water Act	Water	Federal and State	Authorizes EPA to establish national water quality criteria and establishes two permitting programs. The National Pollutant Discharge Elimination System (NPDES) Program prohibits the discharge of pollutants through a point source into a water of the United States without a NPDES permit. NPDES permits are issued by EPA or authorized states. The NPDES permit program also includes "Effluent Guidelines," including the Mineral Mining and Processing Effluent Guidelines and Standards, the Ferroalloy Manufacturing Effluent Guidelines and Standards, and the Metal Finishing Effluent Guidelines. Clean Water Act Section 404 permits, issued by the U.S. Army Corps of Engineers or authorized states, are required for the discharge of dredge and fill material in waters of the United States.
Comprehensive Environmental, Response, Compensation and Liability Act	Waste	Federal	Provides Federal authority for responding to releases or threatened releases of hazardous substances that may endanger public health or the environment.
The Endangered Species Act	General	Federal	Regulates activities that could have an adverse effect on threatened and endangered species, including the habitat and ecosystems upon which they depend.
Federal Mine Safety and Health Act of 1977, as amended by the Mine Improvement and New Emergency Response Act of 2006	Mining	Federal	Imposes health and safety standards on mining operations, including training of mine personnel, mining procedures, blasting, the equipment used in mining operations and other matters. In 2006, the Mine Safety and Health Administration promulgated new emergency mine safety rules addressing mine safety equipment, training, and emergency reporting requirements.
Mobile Phone Partnership Initiative (MPPI)	Waste	International	Launched in 2002 to promote awareness raising - design considerations, collection of used and end-of-life mobile phones, transboundary movement of collected mobile phones, refurbishment of used mobile phones, and material recovery/recycling of end-of-life mobile phones. Has not met since 2011.
The National Environmental Policy Act	General	Federal	Requires Federal agencies to integrate environmental considerations into certain decision-making processes by evaluating the environmental impacts of their proposed actions, including issuance of permits to mining facilities, and assessing alternatives to those actions.
Partnership for Action on Computing Equipment (PACE)	Waste	International	Developed as a multi-stakeholder public-private partnership that provides a forum for representatives of personal computer manufacturers, recyclers, international organizations, associations, academia, environmental groups, and governments to tackle environmentally sound refurbishment, repair, material recovery, recycling, and disposal of used and end-of-life computing equipment.

Resource Conservation and Recovery Act (RCRA)	Waste	Federal and State	Gives the EPA and authorized states the authority to regulate hazardous from cradle to grave under Subtitle C. RCRA establishes the framework for a national system of solid waste control where EPA sets minimum national technical standards for how disposal facilities should be designed and operate. States play the lead role under Subtitle D. Most extraction and beneficiation wastes from hardrock mining are excluded from federal hazardous waste regulations under Subtitle C.
The Safe Drinking Water Act	Water	Federal and State	Authorizes EPA to establish standards to protect underground sources of drinking water and establishes the underground injection control program that regulates the drilling and operation of subsurface injection wells. Permits are issued by EPA or authorized states.

The Department used data from its survey of the U.S. NdFeB magnet industry, a previous industrial base assessment on rare earth elements, meetings with NdFeB magnet industry participants, and market research to assess the relationship between the NdFeB magnet value chain and environmental regulations. Based on these data, a preliminary picture emerged that although historically NdFeB magnet industry participants saw environmental factors as a constraint, the current NdFeB magnet industry is using new methods and technologies to reduce its environmental impact and sees these processes as enabling competition with China, even though weaker Chinese environmental regulations increase the price gap between Chinese and non-Chinese magnets.

In 2014 the Department conducted a survey under section 705 of the DPA of U.S. rare earth suppliers and product manufacturers to support a 2016 supply chain assessment on dysprosium, erbium, neodymium, terbium, and ytterbium called "U.S. Strategic Material Supply Chain Assessment: Select Rare Earth Elements" ("2016 Rare Earths Assessment"). Of the 160 respondents, 126 indicated they used one of the rare earths that make up NdFeB magnets – neodymium, praseodymium, terbium, or dysprosium – and 115 indicated they used neodymium.

These survey data suggest that in the early 2010s environmental factors constrained multiple steps in the U.S. rare earths value chain. 36 respondents (22.5 percent) indicated that environmental regulations/remediation had a current and/or future impact on their rare earth element-related business lines.[238] Upstream in the value chain, mining firms stated environmental regulations were a source of concern. [redacted] The impact of environmental regulations propagated downstream to customers. [redacted]

[238] This analysis uses the larger sample of companies involved in any NdFeB magnet-related rare earths production, except when stated otherwise.

In contrast, the current U.S. NdFeB magnet industry sees environmental factors as a relatively minor concern and cites environmentally friendly technologies as a source of opportunity. The Department's survey of the U.S. NdFeB magnet industry asked firms to identify the primary challenges affecting their competitive positions and rank the top five from a list of 30 potential responses. Among the 16 current or future U.S. producers that provided responses, [redacted] Restricting the sample to the top five challenges, environmental regulations are tied with four other issues for the seventh most cited challenge. [redacted] These data suggest that environmental regulations matter but are relatively less important in comparison to the other challenges faced by the U.S. NdFeB magnet industry.

Input cost data from the Department's survey of the U.S. NdFeB magnet industry lend support for the view that environmental regulations are minor in comparison to other factors. The Department's survey asked respondents to estimate the percentage of operating costs due to a series of inputs, including environmental regulations. The median response from current or planned U.S. producers regarding environmental regulations was [redacted], lower than sourcing feedstock material ([redacted]), labor ([redacted]), other ([redacted] most often described as operating or overhead costs), electricity ([redacted]), transportation costs ([redacted]), and taxes ([redacted]). Only VAT taxes/tariffs/trade duties ([redacted]) and export regulations ([redacted]) ranked lower.

Environmental regulations increase the price gap between Chinese and non-Chinese NdFeB magnets, but consonant with their minor contribution to U.S. firms' production costs their impact appears to be small relative to other factors.[239] [redacted][240] [redacted][241] [redacted] However, other industry participants tend to attribute differences in NdFeB magnet production costs more to Chinese tax policies or energy costs than environmental regulations. [redacted]

[239] However, in response to the Department's survey of the U.S. NdFeB magnet industry only [redacted] current or future U.S. producers (of 11 who provided responses) indicated that changing government regulations or incentives around environmental regulations would improve price competitiveness.
[240] Kazuaki Kobayashi, "Trusted Supply-Chain for Rare Earths in the Age of Carbon Neutrality," Ministry of Economy, Trade, and Industry, n.d.
[241] Meeting between the Ministry of Economy, Trade, and Industry and the Department of Commerce, (Virtual Meeting, December 21, 2021)

[redacted][242] Despite the minor role of environmental regulations, any price gaps can affect customer behavior. [redacted][243]

Both upstream and downstream in the NdFeB magnet value chain, some firms see environmental factors as a competitive advantage and tout their small environmental footprints and new technologies that help minimize environmental waste.[244] [redacted][245] [redacted][246][247] [redacted][248] [redacted]

Downstream in the value chain, Noveon highlighted its low environmental impact, [redacted][249] Joint research with Purdue University suggests a 50 percent net reduction across a range of environmental indicators, including smog formation,

[242] Meeting between Neo Performance Materials and the Department of Commerce, the Department of Defense, and the U.S. Geological Survey, (Virtual Meeting, November 30, 2021).
[243] Meeting between Lynas Rare Earths and the Department of Commerce, (Virtual Meeting, March 30, 2022).
[244] This anecdotal evidence is consistent with a view that environmental regulation may spur technological innovation and reduce marginal costs. Some research suggests that this process has meant environmental regulations have had no to a positive effect on rare earths exports from China. An Pan et al., "How environmental regulation affects China's rare earth export?," PLoS One 16 (4), 2021, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8062019/.
[245] Meeting between MP Materials and the Department of Commerce, (Virtual Meeting, November 17, 2021).
[246] Energy Fuels briefing to the NSTC Critical Minerals Subcommittee, (Virtual Meeting, November 29, 2021).
[247] [redacted] Meeting between Energy Fuels and the Department of Commerce, (Virtual Meeting, March 1, 2022).
[248] Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).
[249] Meeting between Noveon and the Department of Commerce, (Virtual Meeting, November 12, 2021).

acidification, and respiratory effects.[250] [251] [redacted][252] NdFeB magnet industry participants throughout the value chain emphasize their low environmental impact and suggest that their more environmentally friendly technologies could act as a competitive advantage in the global marketplace.

8.3.3 Intellectual Property

NdFeB magnets were concurrently invented in 1983 by General Motors in the United States and by Sumitomo in Japan.[253] General Motors commercialized its intellectual property by founding Magnequench, which was eventually acquired by the Canadian firm Neo Performance Materials. The Sumitomo intellectual property passed to Hitachi, which has an extensive NdFeB magnet-related patent portfolio of over 600 patents, including about one hundred U.S. patents.[254] Of these, there are four key U.S. patents for sintered NdFeB magnets that expired in 2021 or will expire in 2022.[255] Other relevant patents with longer expiration dates may exist.[256] In the public comments received for this investigation, many U.S. companies noted that Hitachi has repeatedly declined to offer licenses to U.S. companies. Hitachi granted licenses to eight Chinese firms as early as 2013, which facilitated Chinese firms' entrance in to the sintered NdFeB magnet market.[257] [258] [redacted]

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[250] "With Urban Mining, Recycled Bird Magnets are Transforming our Electric Future," Bird Cities Blog, June 6, 2021, https://www.bird.co/blog/urban-mining-recycled-bird-magnets-transforming-electric-future/.
[251] Hongyue Jin et al., "Comparative Life Cycle Assessment of NdFeB Magnets: Virgin Production versus Magnet-to-Magnet Recycling," Procedia CRIP 48: 45-50, 2016, https://www.sciencedirect.com/science/article/pii/S2212827116006508.
[252] Meeting between Noveon and the Department of Commerce, (Virtual Meeting, November 12, 2021).
[253] The method developed by General Motors to produce NdFeB magnets is the predecessor to bonded magnets. The method developed by Sumitomo is the predecessor of sintered NdFeB magnets. Hitachi is an organizational descendent of Sumitomo and therefore holds the intellectual property for sintered magnets.
[254] "Chinese Court Enforces Mandatory Licensing for "Essential Facility" Patents in Antitrust Case," Jones Day, June 2021, https://www.jonesday.com/en/insights/2021/06/chinese-court-enforces-mandatory-licensing-for-essential-facility-patents-in-antitrust-case.
[255] Some industry participants expressed concern that Hitachi may attempt to renew these patents, but the Department could not locate information on whether Hitachi had done so. Industry participants also mentioned that Bain Capital's potential acquisition of Hitachi Metals may shape Hitachi's behavior. For information on Bain Capital's potential acquisition of Hitachi Metals, *see* Appendix E, "Global NdFeB Magnet Production: A Firm Level Perspective" at footnote 144. [redacted]
[256] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[257] Nathan Bush and Ray Xu, "Framing patents as essential facilities in Chinese antitrust: Ningbo Ketian Magnet Co., Ltd. v. Hitachi Metals," DLA Piper, September 7, 2021, https://www.dlapiper.com/en/us/insights/publications/2021/09/antitrust-matters-september-2021/framing-patents-as-essential-facilities-in-chinese-antitrust/.
[258] "Chinese Court Enforces Mandatory Licensing for "Essential Facility" Patents in Antitrust Case," Jones Day, June 2021, https://www.jonesday.com/en/insights/2021/06/chinese-court-enforces-mandatory-licensing-for-essential-facility-patents-in-antitrust-case.

[redacted][259] Additional Chinese firms may gain de jure access to Hitachi licenses as a result of a 2021 ruling by the Ningbo Intermediate People's Court in China in which NdFeB magnet licenses were held to be essential facilities.[260] Under the essential facilities doctrine, a firm that controls an essential facility is obliged to make that facility available to competitors on non-discriminatory terms.[261] Hitachi has appealed the case, but may be required to license sintered NdFeB magnet patents to additional Chinese firms.

Hitachi has also defended its intellectual property rights in U.S. courts. In 2012, Hitachi filed a complaint with the United States International Trade Commission (U.S. ITC) against 29 manufacturers and importers of sintered rare earth magnets and products containing sintered rare earth magnets.[262] It sought an exclusion order prohibiting imports of these unlicensed NdFeB magnets and cease and desist orders to produce NdFeB magnets.[263] Some defendants settled with Hitachi, with five Chinese firms agreeing to new licenses. In 2013 Hitachi announced additional settlements and withdrew the U.S. ITC case. Later, some defendants filed for inter partes review with the United States Patent and Trademark Office, which granted the request and found the challenged claims obvious.[264] In an appellate opinion in 2017, the United States Court of Appeals for the Federal Circuit largely affirmed this ruling.[265] U.S. industry participants noted these actions instigated considerable discussion in the NdFeB magnet industry and deterred potential market entrants.[266]

In conversations with industry participants Hitachi's ownership of sintered NdFeB magnet patents was characterized on a spectrum from a critical barrier to entry to a nonexistent risk.[267] Arnold Magnetics considered Hitachi's patents to be a key barrier to market entry and indicated it could produce sintered NdFeB magnets if it had a license.[268] [redacted][269] [redacted]

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[259] U.S. Department of Commerce, Bureau of Industry and Security, NdFeB Survey, 10, Part D.
[260] "Chinese Court Enforces Mandatory Licensing for "Essential Facility" Patents in Antitrust Case," Jones Day, June 2021, https://www.jonesday.com/en/insights/2021/06/chinese-court-enforces-mandatory-licensing-for-essential-facility-patents-in-antitrust-case.
[261] There is no accepted definition of essential facility. *See* Christopher Seelen, "The Essential Facilities Doctrine: What Does It Mean To Be Essential?," Marquette Law Review (80), Summer 1997, https://scholarship.law.marquette.edu/cgi/viewcontent.cgi?article=1517&context=mulr.
[262] Walter T. Benecki, "Hitachi Metals, Ltd. The Magner Industry Newsmaker," Magnetics: Business and Technology, November 26, 2013, https://magneticsmag.com/hitachi-metals-ltd-the-magnet-industry-newsmaker/.
[263] Ibid.
[264] Anthony McCain, "Patentlyo Bits and Bytes," Patentlyo, July 31, 2017, https://patentlyo.com/2017/07.
[265] "Hitachi Metals, Ltd., v. Alliance of Rare-Earth Magnet Industry," United States Court of Appeals for the Federal Court, July 6, 2017, https://cafc.uscourts.gov/sites/default/files/opinions-orders/16-1824.Opinion.7-5-2017.1.PDF.
[266] [redacted]
[267] Meeting between Arnold Magnetics and the Department of Commerce, (Virtual Meeting, December 6, 2021); Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021); Meeting between Noveon and the Department of Commerce, (Virtual Meeting, November 12, 2021).
[268] Comments of Arnold Magnetics to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[269] Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).

[redacted][270] Some industry representatives also expressed hope that the acquisition of Hitachi's magnets business by Bain Capital may change Hitachi's willingness to license the patents to potential market entrants.[271] In contrast, Noveon relies on new proprietary technology to process recycled magnets and produce new material and is therefore unaffected by Hitachi's reluctance to license its patents. A related concern is whether magnets would need to be produced under licensed patents to be incorporated into some end-user's assemblies and, if so, how expensive qualification of alternative production methods may be. For example, some end-users may qualify magnets for use in their products based on the technology used to produce the magnets.

The Department's survey of the U.S. NdFeB magnet industry supports the view that intellectual property does not pose a major barrier to NdFeB magnet production, although access to Hitachi's technology would facilitate domestic production. In response to the question, "Has your organization encountered difficulties in obtaining NdFeB Magnet related IP?" [redacted] Intellectual property is unlikely to derail current production estimates but may pose constraints on growth and use.

8.3.4 Prices and Price Volatility

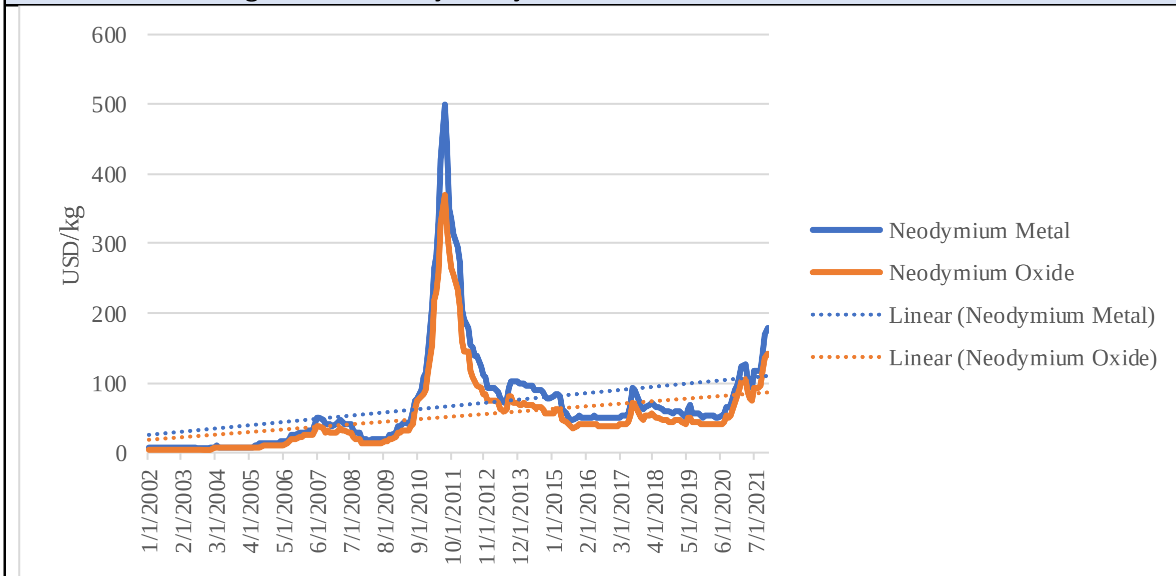
NdFeB Magnet Feedstock Prices and Price Volatility

In comparison to NdFeB magnets, neodymium oxide and metal are relatively standard products for which comparable price data are available. Neodymium oxide and metal prices have seen considerable shifts over the previous 20 years (*see* Figure 25). Oxide and metal price changes are

[270] Ibid.
[271] For information on Bain Capital's potential acquisition of Hitachi Metals, see Appendix E, "Global NdFeB Magnet Production: A Firm Level Perspective" at footnote 144.

closely related because neodymium oxide is processed into neodymium metal.[272] Price data indicate two periods of relative stability (2002 to mid-2010 and 2013 to mid-2020) punctuated with two sharp price increases corresponding to China's cuts to its export quotas in the early 2010s and the early 2020s' rise in prices, which may reflect increased demand.[273] The overall trendline from 2002 to 2021 is of increasing prices – neodymium oxide prices increased by 3,209 percent from $4.3 per kg in 2002 to $142.3 per kg in 2021, while neodymium metal prices increased by 2,443 percent from $7 per kg in 2002 to $178 per kg in 2021.[274] [275]

Figure 25: Monthly Neodymium Oxide and Metal Price, 2002-2021



Source: The Department's calculations from Bloomberg data, NDCNRGYY Index.

Although the neodymium oxide and metal price series appear to indicate high volatility, prices of neodymium and other rare earth elements used in NdFeB magnets are less volatile than other metals and materials. DoE estimated price volatility for the four key rare earth oxides used in NdFeB magnets (neodymium, praseodymium, dysprosium, and terbium), by analyzing changes in monthly average prices between January 2010 and June 2020, a period that includes the early 2010s price spike but not the more recent rise in prices. DoE found that price volatility was 0.1 for neodymium oxide, 0.09 for praseodymium oxide, 0.13 for dysprosium oxide, and 0.14 for

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272 The daily price of neodymium oxide and the daily price of neodymium metal are almost perfectly positively correlated at 0.99.

273 In contrast to the early 2010s spike, there is not a clear cause for the price increases that have occurred since mid-2020. Increased demand from end-users is the most common explanation, based on meetings with industry.

274 Dysprosium oxide and terbium oxide prices have also increased. Dysprosium oxide prices are up almost 120 percent and terbium oxide prices increased over 375 percent from January 2017 to mid-April 2022, compared to over 265 percent and 188 percent for neodymium oxide and praseodymium oxide, respectively. *See* "Rare Earth 2022 April 18," The Rare Earth Observer, April 18, 2022, https://treo.substack.com/p/shanghai-infinite-lockdown-price?s=r.

275 For comparison, China's consumer price index increased by an average of 2.2 percent, with a range of -0.7 to 5.9 percent. *See* "Inflation, consumer prices (annual %) – China," World Bank World Development Indicators, last accessed May 17, 2022, https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?locations=CN.

terbium oxide, lower than the average of a set of 30 by-product metals and materials.[276] However, DoE still emphasizes the potential for large price swings, citing the high price volatility resulting from Chinese government policies in the early 2010s.[277]

Industry representatives emphasize the distortionary effects of price volatility. [redacted] The Chinese government has recently expressed concern about rising prices, calling on major Chinese rare earths producers to maintain a steady supply chain and reduce price increases.[278] Anecdotally, price increases do not appear to have strongly negatively affected Chinese firms in the value chain. For example, "Advanced Technology & Materials, a Chinese producer of NdFeB magnets, [said] the rare earth price increase has had "little impact" on the company because it has a guaranteed supply of raw materials at "favorable prices" from the state-owned giant China Northern Rare Earth Group."[279]

Price increases also have the potential to change consumer behavior and lead to greater interest in substitutes and alternatives. [redacted][280] Neo Performance Materials also said heightened prices could incentivize substitution research.[281] [redacted][282]

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[276] Michael Redlinger and Roderick Eggert, "Volatility of by-product metal and mineral prices," Resources Policy, 47: 69–77, 2016, https://doi.org/10.1016/j.resourpol.2015.12.002.
[277] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[278] "China Calls on Rare Earths Companies to Bring Prices Back to "Reasonable" Level," Reuters, March 4, 2022, https://www.reuters.com/business/china-calls-rare-earths-companies-bring-prices-back-reasonable-level-2022-03-04/.
[279] Mary Hui, "Are High Rare Earth Prices Good for China?," Quartz, March 7, 2022, https://finance.yahoo.com/news/high-rare-earth-prices-good-220022712.html.
[280] Meeting between General Motors and the Department of Commerce, (Virtual Meeting, February 2, 2022).
[281] Mary Hui, "Are High Rare Earth Prices Good for China?," Quartz, March 7, 2022, https://finance.yahoo.com/news/high-rare-earth-prices-good-220022712.html.
[282] Meeting between Turntide Technologies and the Department of Commerce, (Virtual Meeting, February 17, 2022).

8.4 Recycling and Substitution

8.4.1 NdFeB Magnet Recycling

Recycling NdFeB magnets or NdFeB magnet swarf, the waste produced by shaping magnets, represents a potentially significant and largely untapped source of rare earth material.[283] In an extreme example, if all U.S. computer hard disk drives (HDDs) were recycled, the contained NdFeB magnets could satisfy up to 80 percent of electric vehicle magnet demand.[284] One market research firm estimates that in 2030 upwards of 90,000 tons of NdFeB magnets will be entering waste streams globally, equal to 23 percent of projected 2030 demand.[285] In the past 15 years, significant academic research has been conducted on NdFeB magnet recycling and reuse technologies.[286] The research directly led to attempts at commercialization either through firms that manufacture end-use products (e.g., Nissan) or via specialized companies focused on the remanufacturing of sintered NdFeB magnets (e.g., Noveon). Increased demand for NdFeB magnets is likely to further pressure end-users to commercialize recycling technologies.

Separating NdFeB magnets from the products which house them is a major challenge of the recycling process. Firms that recycle magnets have limited visibility into the construction and design of products that use magnets, which makes disassembly difficult.[287] Continuing with the example of HDDs as a feedstock for NdFeB magnet recycling, the first difficulty in recycling HDDs is that most drives are shredded due to data sensitivities. Shredding reduces the ability to recover and recycle the NdFeB magnets and results in significant material loss.[288] Another option is manual removal, which recovers more material and has a lower environmental cost but is very time consuming.[289] In 2010, Hitachi announced that it had developed a machine to dismantle neodymium magnets from hard discs and compressors. The machine has a capacity of one hundred magnets per hour, about eight times faster than manual labor. The machine was supposed to be employed in commercial operations in 2013 but no follow up details are

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[283] Magnet material known as swarf is generated when magnet blocks are shaped to customer specifications.
[284] Meeting between the Critical Materials Institute and the Department of Commerce, (Virtual Meeting, October 6, 2021).
[285] "Adamas: cerium, lanthanum, terbium, and recycling can help fill the magnet rare earth gap," Green Car Congress, September 3, 2020, https://www.greencarcongress.com/2020/09/20200903-adamas.html; "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[286] Recycling refers to deconstructing NdFeB magnets and reprocessing the contained rare earth elements. In contrast, reuse refers to integrating NdFeB magnets contained in end-of-life products into new products. As discussed later in this section, research and attempts at commercialization generally focus on recycling.
[287] Meeting between the Critical Materials Institute and the Department of Commerce, (Virtual Meeting, October 6, 2021).
[288] "Analysis of material efficiency aspects of personal computers product group," European Commission Joint Research Center, January 2018, http://dx.doi.org/10.2788/89220.
[289] Raymond Moss et al., "Critical Metals in the Path towards the Decarbonisation of the EU Energy Sector: Assessing Rare Metals as Supply-Chain Bottlenecks in Low-Carbon Energy Technologies," European Commission Joint Research Center, 2013, https://publications.jrc.ec.europa.eu/repository/handle/JRC82322.

available.[290] One solution to the issue of separating magnets from end-of-life products is a labeling system to describe the specifications of contained NdFeB magnets, which would facilitate magnet recovery and the recycling process.[291]

The complexities involved in NdFeB magnet separation increase recycling costs. In 2014 a company approached by Japanese magnet manufacturers found they could not dismantle rare earth elements from HDDs at a profit.[292] That said, end-user firms in the United States and abroad have expressed interest in recycling magnets.[293] [294] This interest has helped to facilitate the commercialization of Noveon's magnet recycling and reengineering technology, [redacted][295] More generally, increased demand for NdFeB magnets is likely to incentivize the commercialization of magnet recycling technologies.

In theory, NdFeB magnet reuse is possible without dismantling assemblies and remanufacturing contained magnets because magnets do not lose much strength over their lifetime. However, NdFeB magnets are often produced and shaped for a specific end-use product, and it is difficult to change the properties of the manufactured magnets, such that reuse is generally uncommon.[296]

Returning to the 2016 Rare Earths Assessment, 30 respondents indicated they recycled rare earth elements or rare earth element-related products, and 25 indicated they used recycled rare earth elements or rare earth element-related products. However, a number of these respondents do not operate in the NdFeB magnet value chain and their operations are unrelated to magnets. Other respondents explained that they sold material to be recycled or outsourced recycling operations, including to known magnet producers. [redacted] Some of the pessimistic responses reflect the contemporaneous state of technology. For example, [redacted]

The Department's survey of the U.S. NdFeB magnet industry presents a more encouraging picture of the potential contributions of recycled rare earths to the U.S. NdFeB magnet value

[290] Ibid.
[291] Meeting between the Critical Materials Institute and the Department of Commerce, (Virtual Meeting, October 6, 2021).
[292] Meeting between Hongyue Jin, Critical Materials Institute, and the Department of Commerce, (Virtual Meeting, October 22, 2021).
[293] Ibid.
[294] "Bentley sets out path to sustainable, recyclable electric motors," Automotive World, February 18, 2021, https://www.automotiveworld.com/news-releases/bentley-sets-out-path-to-sustainable-recyclable-electric-motors/.
[295] Meeting between Noveon and the Department of Commerce, (Virtual Meeting, November 12, 2021).
[296] Raymond Moss et al., "Critical Metals in the Path towards the Decarbonisation of the EU Energy Sector: Assessing Rare Metals as Supply-Chain Bottlenecks in Low-Carbon Energy Technologies," European Commission Joint Research Center, 2013, https://publications.jrc.ec.europa.eu/repository/handle/JRC82322.

chain. Survey participants included five current and potential recyclers: [redacted]

[redacted]

In addition to these firms, in February 2022 the Critical Materials Institute (CMI) announced it had partnered with TdVib of Boone, IA, to commercialize rare earth element recycling.[298] In 2017, CMI first developed a novel NdFeB magnet recycling process to recover rare earth elements that dissolved magnets in an acid-free solution.[299] CMI's method can handle shredded electronic waste like HDDs and obviates the need to pre-process – for example, sort – the NdFeB magnets.[300] Being acid-free, CMI's technology is also more environmentally friendly than acid-based recycling processes.[301] TdVib has licensed this technology and intends to produce three to five tons of rare earth oxides in the next one to two years as part of the method's eventual commercialization.[302] The Small Business Innovation Research Program awarded TdVib Small Business Technology Transfer funding for this partnership, $200,000 in Phase I and $1.1 million in Phase II.[303]

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297 [redacted]

298 "Green rare-earth recycling goes commercial in the US," Ames Laboratory, February 25, 2022, https://www.ameslab.gov/index.php/news/green-rare-earth-recycling-goes-commercial-in-the-us.

299 "Critical Materials Institute develops new acid-free magnet recycling process," Ames Laboratory, September 5, 2017, https://www.ameslab.gov/news/critical-materials-institute-develops-new-acid-free-magnet-recycling-process.

300 Ibid.

301 "Green rare-earth recycling goes commercial in the US," Ames Laboratory, February 25, 2022, https://www.ameslab.gov/index.php/news/green-rare-earth-recycling-goes-commercial-in-the-us.

302 Ibid.

303 "TdVib LLC," SBIR, n.d., https://www.sbir.gov/node/1653561.

8.4.2 NdFeB Magnet Substitutes

NdFeB magnet substitution can occur through several paths.[304] One NdFeB magnet input, such as dysprosium, could be substituted with another input, such as terbium. Alternatively, NdFeB magnets can be redesigned to reduce the content of certain inputs. As discussed in more detail below, some end-users are developing methods to decrease the quantity of heavy rare earth elements due to their high cost and concentrated supply chains. Products that rely on NdFeB magnets can also be redesigned to require NdFeB magnets with different characteristics. Finally, NdFeB magnets themselves can be replaced with alternative technologies. This could either be in the form of another type of magnet or by eliminating the need for magnets.

Background and Status of NdFeB Magnet Substitution

The U.S. Government has provided valuable funding for research on NdFeB magnet substitutes. In 2011, the Advanced Research Projects Agency – Energy (ARPA-E) funded 14 projects aimed at developing replacements for rare earth elements in electric vehicles and wind turbines through its Rare Earth Alternatives in Critical Technologies (REACT) Program.[305] These projects included research into cerium-based magnets, iron-nitride alloy magnets, manganese-aluminum based magnets, iron-nickel-based magnets, and carbon-based magnets, as well as rare earths-free applications like superconducting wire.[306] Although none of these alternatives have resulted in a mainstream alternative to NdFeB magnets, there have been some initial steps towards commercialization.[307] For example, the Critical Materials Institute is partnering with bonded NdFeB magnet producer Bunting Magnetics to test and conduct a feasibility study for cerium-based magnets.[308] This research has also been applied to end-products. For example, GE Renewables is planning to produce a prototype of a wind turbine generator using superconducting wire instead of NdFeB magnets in mid-2023.[309] In other cases such as carbon-based magnets, academic research has continued with little commercial success.[310]

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[304] This paragraph draws on the DoE's "Rare Earth Permanent Magnets" report. "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

[305] "Rare Earth Alternatives in Critical Magnets," Advanced Research Projects Agency – Energy, n.d., https://arpa-e.energy.gov/technologies/programs/react.

[306] "REACT Program Overview," Advanced Research Projects Agency – Energy, n.d., https://arpa-e.energy.gov/sites/default/files/documents/files/REACT_ProgramOverview.pdf.

[307] Research on iron-nitride magnets was spun-out to a private enterprise called Niron Magnetics, which is discussed later in this report and in Appendix G, "NdFeB Magnet Substitutes: Niron Magnetics."

[308] "Commercialization of Cerium-based gap magnets – TCF award," Ames Laboratory, October 4, 2021, https://www.ameslab.gov/cmi/research-highlights/commercialization-of-cerium-based-gap-magnets-tcf-award.

[309] Brett Nelson, "How Cool is This: Superconducting Generators Aim to Unlock More Offshore Wind Power at Lower Cost," GE Renewables, February 24, 2021, https://www.ge.com/news/reports/how-cool-is-this-superconducting-generators-aim-to-unlock-more-offshore-wind-power-at-lower.

[310] "Revolutionary Carbon-Based Magnetic Material Finally Synthesized After 70 Years," SciTech Daily, January 28, 2022, https://scitechdaily.com/revolutionary-carbon-based-magnetic-material-finally-synthesized-after-70-years/.

In 2020, the Defense Advanced Research Projects Agency's Basic Energy Sciences division awarded a total of $20 million to five projects dealing with rare earth extraction.[311] Another $30 million was awarded in August 2021 to 13 projects focused on the "isolation of critical elements from natural and recycled resources" and which may reduce or eliminate the use of critical elements without functionality losses.[312] Although it is too early to tell whether these projects will lead to commercial products, the U.S. Government's continued support for research that may reduce dependence on rare earths and enhance supply chain resiliency is critical.

The private sector has also actively pursued substitution research. Turntide Technologies manufactures motors using switch reluctance motors that do not use NdFeB magnets.[313] [redacted][314] Among automobile manufacturers, Toyota has been working to develop NdFeB magnet substitutes for over a decade. In 2011, Toyota announced that it was researching rare earth-free motors.[315] In 2018, Toyota announced that it had produced a preliminary design for a magnet that partially replaced neodymium with lanthanum and cerium, reducing total neodymium content in the magnet by 20 to 50 percent.[316] In 2022, Toyota's subsidiary Denso announced that it is developing rare earths-free iron-nickel magnets, although it did not give a timeline for commercialization.[317] In 2016, Honda also announced it would use a heavy rare earth element-free motor in some hybrid electric vehicles.[318] Other automobile manufacturers, including BMW, Daimler, Nissan, and Volkswagen, are researching methods to reduce the amount of rare earth elements used in NdFeB magnets.[319] For example, the German firm Mahle

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[311] "DOE Awards $20 Million for Research on Rare Earth Elements," Department of Energy, August 25, 2020, https://www.energy.gov/articles/doe-awards-20-million-research-rare-earth-elements.
[312] "Critical Minerals and Materials: Chemical and Materials Sciences Research on Rare Earth and Platinum Group Elements," Department of Energy, https://science.osti.gov/-/media/bes/pdf/Funding/2021/FY2021_CM_Awards.pdf?la=en&hash=D76330B7A090B12B63F0EB2AB83DD43FB367D61C.
[313] Meeting between Turntide Technologies and the Department of Commerce, (Virtual Meeting, February 17, 2022).
[314] Ibid.
[315] Nikki Gordon-Bloomfield, "Toyota Seeks to Ditch Rare Earth Metals from Electric Motors, Green Car Reports, January 17, 2011, https://www.greencarreports.com/news/1053778_toyota-seeks-to-ditch-rare-earth-metals-from-electric-motors.
[316] Megan Geuss, "Toyota's new magnet won't depend on some key rare-earth minerals," ArsTechnica, February 28, 2018, https://arstechnica.com/cars/2018/02/neodymium-more-like-neo-dont-mium-new-magnet-uses-fewer-key-rare-earths/.
[317] "High-performance magnet that does not use rare earths," Chunichi Shimbun, January 8, 2022, https://www.chunichi.co.jp/article/394835.
[318] Lindsay Brooke, "Honda's new e-motor magnet aims to mitigate China rare-earth monopoly," SAE International, July 17, 2016, https://www.sae.org/news/2016/07/hondas-new-e-motor-magnet-aims-to-mitigate-china-rare-earth-monopoly.
[319] "Factbox: Automakers Cutting Back on Rare Earth Magnets," Reuters, July 19, 2021, https://www.reuters.com/business/autos-transportation/automakers-cutting-back-rare-earth-magnets-2021-07-19/; Claudiu C. Pavel et al., "Role of substitution in mitigating the supply pressure of rare earths in electric road transport applications," Sustainable Materials and Technologies (12): 62-72, July 2017, https://doi.org/10.1016/j.susmat.2017.01.003.

announced rare earths-free motors for vehicle applications, with mass production to commence around 2024.[320]

Example: NdFeB Magnet Substitution Using Iron-Nitride Magnets

Iron-nitride magnets are a potential NdFeB magnet substitute with several attractive qualities.[321] Iron-nitride magnets are made of iron and nitrogen powder. [redacted][322] [redacted][323] [redacted][324] [redacted][325]

Although iron-nitride has been known for many years, it has yet to be commercialized because of the difficulties involved in manufacturing.[326] Researchers at the University of Minnesota, funded by ARPA-E's REACT program, were the first to produce an iron-nitride magnet prototype. This research was spun out into a commercial venture called Niron Magnetics. Niron Magnetics continues to develop this technology [redacted][327] [redacted][328] [redacted][329]

Example: NdFeB Magnet Substitution Using Nanotechnology

Sintered NdFeB magnets used in critical infrastructure and high growth applications, such as electric vehicles and offshore wind turbines, require elevated temperature properties that necessitate the addition of heavy rare earths like dysprosium and terbium. Heavy rare earth deposits are even more concentrated in China than neodymium and, after recent Chinese industry

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[320] Philip E. Ross, "In Mahle's Contact-Free Electric Motor, Power Reaches the Rotor Wirelessly," IEEE Spectrum, May 12, 2021, https://spectrum.ieee.org/mahles-electric-motor-says-look-ma-no-contacts.
[321] [redacted]
[322] Meeting between Niron Magnetics and the Department of Commerce, (Virtual Meeting, January 7, 2022).
[323] Ibid.
[324] "Niron Magnetics: Summary of Environmental Life Cycle Analysis," Niron Magnetics, November 25, 2021.
[325] Meeting between Niron Magnetics and the Department of Commerce, (Virtual Meeting, January 7, 2022).
[326] Ibid.
[327] Ibid.
[328] Ibid.
[329] Ibid.

consolidation, a single state-owned enterprise – China Rare Earth Group – will control most capacity.[330] [331] Although USA Rare Earth's Round Top Mine in Texas is expected to produce dysprosium, China will continue to dominate global production.[332]

MQ3 magnets, first developed by General Motors in 1985 and later commercialized by Magnequench in 1987, are a type of NdFeB magnet that may offer a reduced heavy rare earth element or heavy rare earth element-free alternative to sintered NdFeB magnets.[333] [334] With the exception of a reduced need for heavy rare earth elements, MQ3 magnets rely on similar feedstocks as sintered and bonded NdFeB magnets. However, MQ3 magnets are manufactured using different methods that affect their heavy rare earth element requirements. MQ3 magnets rely on thermomechanical processes to produce dense anisotropic microstructures that enable the development of high energy products required for elevated temperature applications like electric vehicles.[335] The production of MQ3 magnets involves the following steps: 1) rapid solidification of feedstock into ribbon and then milling into powder (also used for bonded NdFeB magnets), 2) hot deformation of powder into fully dense isotropic magnets through hot pressing, hot extrusion, or spark plasma sintering (called MQ2), and 3) die-upsetting or back extrusion to form fully dense anisotropic magnets (called MQ3).[336] MQ3 magnets can be made with very high energy density. In the 1990s, researchers reported energy products in MQ3 magnets comparable to high energy sintered NdFeB magnets.[337] [338] MQ3 magnets can possess similar characteristics as sintered NdFeB magnets, despite their different manufacturing processes.

While comparable in performance metrics to sintered NdFeB magnets, MQ3 magnets use a smaller amount of heavy rare earth elements due to microstructural differences. As the grain size of NdFeB magnets' microstructure is reduced, the magnets' resulting coercivity increases due to higher domain wall pinning.[339] MQ3 magnets' thermomechanical manufacturing process means that their grain sizes are in the range of 20 to one hundred nanometers, orders of magnitude smaller than the five to ten micrometers in a typical sintered NdFeB magnet.[340] MQ3 magnets

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[330] Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).
[331] Sun Yu and Tom Mitchell, "China Merges 3 Rare Earth Miners to Strengthen Dominance of Sector," Financial Times, December 23, 2021, https://www.ft.com/content/4dc538e8-c53e-41df-82e3-b70a1c5bae0c.
[332] Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021).
[333] R. W. Lee, "Hot-pressed neodymium-iron-boron magnets," Applied Physics Letters 46: 790, 1985, https://doi.org/10.1063/1.95884.
[334] V. Panchanathan, "Magnequench Magnets Status Overview," Journal of Materials Engineering and Performance, 4 (4) 423-429, 1995, https://doi.org/10.1007/BF02649302.
[335] Ibid.
[336] Ibid.
[337] C. D. Fuerst and E. G. Brewer, "High-remanence rapidly solidified Nd-Fe-B: Die-upset magnets," Journal of Applied Physics 73: 5751, 1993, https://doi.org/10.1063/1.353563.
[338] V. Panchanathan, "Magnequench Magnets Status Overview," Journal of Materials Engineering and Performance, 4 (4) 423-429, 1995, https://doi.org/10.1007/BF02649302.
[339] J. F. Herbst, "$R_2Fe_{14}B$ materials: Intrinsic properties and technological aspects," Reviews of Modern Physics, 63 (4): 819-898, 1991, https://doi.org/10.1103/RevModPhys.63.819.
[340] Ibid.

thus display higher coercivity, including at elevated temperatures. As a result of these properties, MQ3 magnets require less heavy rare earth elements than sintered NdFeB magnets.[341] [342]

Extant research indicates that substituting MQ3 magnets for sintered NdFeB magnets could substantially reduce or even eliminate the use of heavy rare earth elements. In one study comparing equivalent MQ3 and sintered NdFeB magnets, dysprosium-free MQ3 magnets were equivalent to sintered NdFeB magnets with 3.43 percent dysprosium by weight.[343] Although MQ3 magnets needed to be four percent dysprosium by weight to be equivalent to a sintered NdFeB magnet composed of 6.45 percent dysprosium by weight, this still represents a considerable reduction in heavy rare earth element content.[344] In another study comparing MQ3 and sintered NdFeB magnets with similar temperature coercivities at 180 degrees, the MQ3 magnets required four percent less dysprosium by weight than their sintered NdFeB magnet counterparts.[345] Future research could further optimize the microstructure, reduce grain sizes to exhibit single domain behavior, and maximize pinning dominated demagnetization, which may enhance coercivity and result in even greater reductions in heavy rare earth element content.

Although the method to produce MQ3 magnets was first discovered in 1985, the current NdFeB magnet industry primarily produces bonded and especially sintered NdFeB magnets. One major reason for this equilibrium is that the processing costs for MQ3 magnets are higher than for sintered NdFeB magnets.[346] However, the rise in heavy rare earth prices has increased the proportion of magnet costs attributable to feedstock prices and may make MQ3 magnets more economically competitive. That said, MQ3 magnets were never fully decommercialized. There are currently at least two firms that produce MQ3 magnets: Neo Performance Materials of Canada and Magnet e Motion of the Netherlands.[347] [348] In addition to these magnet manufacturers, Honda appears to have commercialized the use of MQ3 magnets.[349] In July 2016, Honda and Daido Steel announced the use of MQ3 magnets in one of its hybrid electric traction drive motors, with production to commence in August 2016.[350] Daido Steel planned to use

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[341] "Automotive," Neo Magnequench, n.d., https://mqitechnology.com/applications/automotive/.
[342] "Radially oriented, anisotropic Nd-Fe-B ring magnets (NEOQUENCH-DR)," Daido Electronics, n.d., http://daido-electronics.co.jp/english/product/neoquench_dr/index.html?msclkid=a3ef65e0cbb811ecb84db59d0093c2de.
[343] Steve Constantinides, "Manufacture of Modern Permanent Magnet Materials," Arnold Magnetic Technologies, n.d., https://www.arnoldmagnetics.com/wp-content/uploads/2017/10/Manufacture-of-Modern-Permanent-Magnet-Materials-Constantinides-PowderMet-2014-ppr.pdf.
[344] Ibid.
[345] John Ormerod, "MQ3 Fully Dense NdFeB Magnets," Bunting, n.d., https://bunting-dubois.com/tech-briefs/types-of-rare-earth-magnets-part-3/.
[346] David Brown, Bao-Min Ma, and Zhongmin Chen, "Developments in the processing and properties of NdFeb-type permanent magnets," Journal of Magnetism and Magnetic Materials, 248 (3): 432-440, 2002, https://doi.org/10.1016/S0304-8853(02)00334-7.
[347] "Products," Neo Magnequench, n.d., https://mqitechnology.com/products/.
[348] "Hot Formed NdFeB Magnets (MQ3)," Magnet e Motion, n.d., https://magnetemotion.com/technology-mq3-ndfeb-extrusion.html.
[349] "Daido Steel and Honda develop neodymium magnet free of heavy rare earth elements; Honda Freed hybrid first to adopt resulting new motor," Green Car Congress, July 12, 2016, https://www.greencarcongress.com/2016/07/20160712-honda.html.
[350] Ibid.

feedstock from Neo Performance Materials' predecessor Magnequench International to produce the magnets at a facility in Japan.[351] [redacted]

In summary, there are two different approaches which can be used to improve coercivity and resulting resistance to demagnetization at elevated temperature, one of which – MQ3 magnets – is less reliant on heavy rare earth elements. In sintered NdFeB magnets, heavy rare earths such as terbium and dysprosium are added which results in higher feedstock costs and an even greater reliance on Chinese supply chains. MQ3 magnets' smaller grain size enables manufacturers to reduce or eliminate heavy rare earth elements while maintaining comparable performance. Although MQ3 magnets' processing methods are more expensive than sintered NdFeB magnets', heavy rare earth element feedstock prices may make MQ3 magnets economically competitive. In addition, using less heavy rare earth elements would decrease dependence on China, which dominates global heavy rare earth element production even more than global light rare earth element production. MQ3 magnets are a potential substitute for sintered NdFeB magnets and would be particularly useful in reducing U.S. dependence on heavy rare earth elements.

Commercial Viability of NdFeB Magnet Substitutes

Despite advances, most substitution technologies are still at least several years away from commercialization, which means they will be unable to satisfy growing demand for NdFeB magnets from green technology (e.g., electric vehicles and wind turbines) over the same timeframe.[352] In addition, most substitutes currently being researched would require other rare earth elements (such as lanthanum) and would only replace lower-grade NdFeB magnets, meaning that NdFeB magnets would still be required in high heat application, including electric vehicle drive trains, or when efficiency is highly desired. Although other rare earth elements are cheaper, China dominates rare earth production. Any viable substitute would also have to quickly scale up production. The manufacture of different types of magnets is similar, so shifting a production facility from NdFeB magnets or samarium cobalt magnets to a substitute may be possible but would still require available facilities. Finally, because NdFeB magnets are highly tailored to end-user specifications, customers would have to make product adjustments to account for substitutes.[353] Substitution research has the potential to impact production in the long-term but requires present action to enable success.

[351] Ibid.

[352] [redacted]

[353] [redacted]

The Department's survey of the U.S. NdFeB magnet industry provides support for the view that current substitutes are of limited commercial viability. The survey asked producers of assemblies or systems containing NdFeB magnets to indicate whether magnet substitutes were available for their primary products, and if so, to identify the potential substitute and discuss the advantages and disadvantages of the substitute. 21 firms indicated 57 products in response. [redacted][354] [redacted] 14 firms indicated 38 products (67 percent) where no substitutes were available for NdFeB magnets.[355] [redacted] these were a mix of rotors and motors, in addition to speakers, wind turbines, and other products, to be used in 15 different industries.[356] For the vast majority of firms in our sample [redacted] substitutes were either unknown or unavailable for most products [redacted], and the only substitute listed was another rare earth magnet, speaking to the dearth of currently commercially viable NdFeB magnet substitutes.

The relationship between NdFeB magnet component prices and NdFeB magnet imports further underscores the lack of commercially viable NdFeB magnet substitutes. If NdFeB magnet substitutes are commercially available, then end-users should be able to switch production to use NdFeB magnet substitutes. As a result, as NdFeB magnet prices rise demand should fall, and vice versa. To examine whether this is the case, the Department analyzed the relationship between neodymium oxide prices and NdFeB magnet imports. Neodymium oxide prices are a good proxy for NdFeB magnet prices because neodymium is the largest contributor to NdFeB magnet cost. NdFeB magnet imports are a relatively reliable indicator of direct demand because the United States is nearly one hundred percent dependent on imports.[357] The correlation between the daily price of neodymium oxide and the daily value of NdFeB magnet imports from 2016 to 2021 is 0.23, while the equivalent correlation for the daily quantity (units) of NdFeB magnet imports is 0.06. Neodymium oxides prices are thus somewhat positively associated with the value of NdFeB magnet imports, given that increases in the value of NdFeB magnet components should raise the value of NdFeB magnets. However, the correlation with the quantity of NdFeB magnet imports is very weak, suggesting that end-users do not change their importing behavior in response to increases in NdFeB magnet costs. The relatively weak correlation between the price of neodymium oxide and the quantity of NdFeB magnet imports lends further credence to the view that although other magnets or non-magnet components can substitute for NdFeB magnets in certain situations, wholesale substitution is currently not possible.

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[354] The NdFeB magnets in question were all sintered NdFeB magnets.

[355] [redacted]

[356] The industries cited included all [redacted] industries where the NdFeB magnets that could be substituted for [redacted] were destined to be used.

[357] The Department acknowledges that there is significant indirect demand for NdFeB magnets.

9. Conclusion

9.1 Findings

In this section the Department discusses the key findings from its investigation into the effects of imports of NdFeB magnets on U.S. national security. These findings are based on data collected from an industry survey, industry meetings, extant U.S. Government research, and other sources, as discussed in earlier sections.

9.1.1 NdFeB Magnets are Essential to U.S. National Security

NdFeB Magnets are Key Components of National Defense Systems

NdFeB magnets are critical to the functioning of numerous defense systems, including fighter aircraft and missile guidance systems. Although NdFeB magnets can sometimes be substituted for with alternative products, these products are usually not as effective and may reduce system performance. NdFeB magnets are therefore essential to U.S. national security.

NdFeB Magnets are Key Components of Critical Infrastructure

NdFeB magnets are used in a broad range of products across virtually all 16 critical infrastructure sectors. NdFeB magnets are necessary and largely non-substitutable components of goods in multiple critical infrastructure sectors. NdFeB magnets are particularly important for the critical manufacturing and critical energy sectors, as they are key to the functioning of electric vehicle drive trains and offshore wind turbine generators. They also have an important role in the critical healthcare and public health sector, where they are used in MRI machines and other medical instruments, and the critical defense industrial base sector.

The Department previously determined that "national security" can be interpreted to include the general security and welfare of certain "critical industries."[358] The Department currently uses the 16 critical infrastructure sectors identified in Presidential Policy Directive 21 to define critical industries.[359] NdFeB magnets are therefore also essential to U.S. national security by virtue of their indispensable use in critical infrastructure sectors. NdFeB magnets' criticality is heightened by the fact they are key components of electric vehicles and offshore wind turbines. These

358 "The Effects of Imports of Iron Ore and Semi-Finished Steel on the National Security," Department of Commerce, Bureau of Export Administration, October 2001 ("2001 Iron and Steel Report"), at 5, https://www.bis.doc.gov/index.php/documents/steel/2224-the-effect-of-imports-of-steel-on-the-national-security-with-redactions-20180111/file.
359 Presidential Policy Directive 21, "Critical Infrastructure Security and Resilience," February 12, 2013.

products are central to achieving the United States' clean energy goals and combating climate change, which have important national security implications.[360]

9.1.2 Domestic Demand for NdFeB Magnets is Expected to Grow

Total U.S. – and global – demand for NdFeB magnets is expected to grow significantly in the coming decades, driven by increased production of electric vehicles and offshore wind turbines. Under high growth scenarios, total domestic demand is expected to more than double from 2020 to 2030, growing from just over 16,000 tons to 37,000 tons, and more than quadruple from 2020 to 2050, increasing to almost 69,000 tons.[361] Total global demand is forecasted to grow even more quickly, tripling from 2020 to 2030 from 119,000 tons to 387,000 tons and increasing sixfold from 2020 to 2050 to over 750,000 tons. Domestically, electric vehicles will consume more than 10,000 tons by 2030 and 23,000 tons by 2050, up from just under 2,000 tons in 2020. Domestic offshore wind turbine-driven demand will increase from zero in 2020 to over 10,000 tons in 2030 and 19,000 tons in 2050. Together, these critical infrastructure products will make up almost 55 percent of total U.S. demand in 2030 and over 61 percent of total U.S. demand by 2050, up from 11 percent in 2020. Total domestic demand from traditional end-users is also expected to grow, albeit at a slower rate.

A key outstanding question is the extent to which firms will locate the production of assemblies that integrate NdFeB magnets, such as electric vehicle motors and wind turbine generators, in the United States. If firms elect to produce products containing NdFeB magnets overseas this will increase embedded U.S. demand for NdFeB magnets but not affect direct U.S. demand or contribute to a domestic market for NdFeB magnets. U.S. NdFeB magnet value chain participants are more likely to successfully establish and maintain production if they are proximate to their customers, due to transportation costs and turn times.[362] In addition, even end-users that manufacture domestically may be unwilling to pay a premium for domestic or ally magnets over Chinese magnets. Onshoring or nearshoring of end-user industries and incentivizing the use of domestic NdFeB magnets will be critical to the success of the U.S. NdFeB magnet industry.

The substantial growth in total U.S. demand will increase U.S. dependence on imports of NdFeB magnets without the rapid development of a competitive U.S. NdFeB magnet industry. However, it also presents an opportunity to facilitate the formation of just such an industry. If a large enough proportion of the products that directly incorporate NdFeB magnets – such as electric

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[360] David Vergun, "Climate Change Has National Security Implications, DOD Official Says," Department of Defense, https://www.defense.gov/News/News-Stories/Article/Article/2707739/climate-change-has-national-security-implications-dod-official-says/.
[361] This section uses demand data from the DoE's "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report." *See* "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[362] Meeting between Lynas Rare Earths and the Department of Commerce, (Virtual Meeting, March 30, 2022); Meeting between Quadrant Magnetics and the Department of Commerce, (Virtual Meeting, February 15, 2022).

vehicle drive trains – are manufactured in the United States and the price differential between U.S. and Chinese magnets can be sufficiently narrowed, domestic NdFeB magnet producers may benefit from a sizeable and stable source of demand.

9.1.3 The United States and its Allies are Dependent on Imports from China

The United States is currently one hundred percent dependent on imports of sintered NdFeB magnets and is highly dependent on imports of bonded NdFeB magnets. The United States does not currently possess the capacity to manufacture sintered NdFeB magnets and only makes a small amount of bonded NdFeB magnets. In addition, the United States does not produce rare earth oxides, NdFeB-related metals, or NdFeB alloys, such that current bonded NdFeB magnet manufacturers are dependent on imported feedstocks. The majority of direct U.S. NdFeB magnet demand is satisfied by imports from China. In 2021, China accounted for 75 percent of U.S. sintered NdFeB magnet imports by value, up from under 60 percent in 2016. Given substantial indirect demand, this may even underestimate the United States' overall dependence on China for NdFeB magnets. For example, up to 60 percent of essential civilian demand is satisfied through embedded imports.[363]

U.S. allies are also dependent to varying degrees on China. Although the European Union and Japan operate in the downstream steps of the NdFeB magnet value chain, they are dependent on China for feedstock to produce metals, alloys, and magnets. Other U.S. allies, such as Australia, only operate in the upstream portions of the NdFeB magnet value chain. More broadly, China can shape global prices due to its dominance in all value chain steps and the increasing concentration of its domestic industry.

9.1.4 The United States Will Continue to Depend on Imports

Multiple firms intend to establish domestic capacity at different steps of the NdFeB magnet value chain. If successful, these plans have the potential to create a U.S. NdFeB magnet value chain from mine to magnet and would reduce – but far from eliminate – import dependence on China. Based on its survey of the U.S. NdFeB magnet industry, the Department estimates that the United States could produce more than 14,000 tons of sintered NdFeB magnets by 2026. Should all these magnets be consumed domestically, import penetration may decline from one hundred percent in 2021 to as low as 49 percent in 2026.[364] Despite this potentially significant decline in import penetration, U.S. production would likely struggle to fulfill critical infrastructure demand. Assuming linear growth from 2020 to 2030, combined domestic NdFeB magnet demand from the automobile and wind energy sectors will be almost 15,000 tons in 2026, exceeding domestic

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[363] "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth," The White House, June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

[364] For further information on the assumptions and data used to reach these figures, *see* Section 8.1.4, "Estimated NdFeB Magnet Import Penetration, 2017 to 2026."

production.[365] In addition, domestic NdFeB magnet manufacturing will be constrained by domestic production of rare earth metals and NdFeB alloys. The Department estimates the U.S. NdFeB magnet industry will produce [redacted] of NdFeB alloy by 2026, enough for between [redacted] of NdFeB magnets, far less than overall and critical infrastructure demand.[366] Despite diverse efforts to establish a U.S. NdFeB magnet industry, the United States will continue to depend on imports of NdFeB magnets and related feedstock to fulfill demand, including from critical infrastructure sectors.

9.1.5 The U.S. NdFeB Magnet Industry Faces Significant Challenges

The nascent U.S. NdFeB magnet industry faces significant barriers to achieve its production targets. In particular, the U.S. NdFeB magnet industry participants will need to compete with Chinese manufacturers, who benefit from favorable tax and tariff policies, low labor and energy costs, and comparatively relaxed environmental regulations, among other factors. Indeed, U.S. producers consistently cite foreign competition as a top challenge to their competitive position. Chinese competition is also often mediated by other major challenges such as labor costs and input availability.

In addition to Chinese competition, U.S. firms face financial and human capital constraints. NdFeB magnet facilities – and facilities at earlier value chain steps – are expensive, and U.S. firms have currently allocated almost no funds to establish planned facilities. For example, sintered NdFeB magnet facilities cost on average [redacted], but firms have on average allocated less than [redacted] for each facility. Further, the collapse of the U.S. NdFeB magnet industry in the 1990s means that planned U.S. NdFeB magnet producers struggle to find qualified and experienced workers, especially high wage employees such as materials scientists.

Finally, there is high uncertainty over demand for U.S. NdFeB magnets. Not only do a significant portion of end-users manufacture products overseas, but even domestic manufacturers may prefer to continue using less expensive Chinese NdFeB magnets. Ensuring that enough end-users integrate magnets into intermediate and final products in the United States will be crucial for the success of the U.S. NdFeB magnet industry. Planned U.S. NdFeB magnet industry participants may struggle to achieve production estimates, given these and other obstacles.

[365] This figure combines estimates of total U.S. demand for electric vehicles, offshore wind turbines, and non-electric vehicle drive trains, [redacted]. For the demand estimates *see* "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[366] *See* Section 5.2, "Rare Earth Element Losses in Magnet Production," for estimates of material loss from alloy production to magnet production.

9.2 Determination

Based on the findings in this report, the Secretary concludes that the present quantities and circumstances of NdFeB magnet imports threaten to impair the national security as defined in section 232 of Trade Expansion Act of 1962, as amended.

9.3 The United States Should Not Restrict NdFeB Magnet Imports

Despite the heavy dependence of the United States on direct and indirect imports of NdFeB magnets, the Department currently recommends that the Administration not impose tariffs, quotas, or other import restrictions on NdFeB magnets or component products. Given the current severe lack of domestic production capability throughout the magnet supply chain, tariffs and quotas would have an adverse impact on consuming sectors and might incentivize businesses to move operations incorporating NdFeB magnets offshore. In both industry meetings and public comments, most representatives of consuming sectors oppose the imposition of trade restrictions for these reasons. As Dana, a manufacturer of electric motors, stated, tariffs "would potentially curtail any future plans to bring parts of its electric motor manufacturing to the U.S."[367] Even planned magnet manufacturers, such as MP Materials, emphasize that tariffs could incentivize substitution or offshoring, although they do not discount the ability of tariffs or quotas to aid an established NdFeB magnet manufacturing sector. The U.S. Government may reconsider the merits of imposing tariffs or other import restrictions, based on section 232 of the Trade Expansion Act of 1962, as amended, or other policy levers, as the domestic supply chain develops production capacity.

9.4 Recommendations

The Department has identified several actions that would help to ensure reliable domestic sources of NdFeB magnets and lessen the risk that imports threaten the national security. These actions are not intended to be exhaustive or exclusive, and the Secretary recommends that the Administration pursue all proposed actions.

9.4.1 Engagement with Allies and Partners

U.S. Ally Vulnerabilities

The national security of U.S. allies and partners is essential to U.S. national security, and both are undermined by allies' and partners' reliance on China with respect to the NdFeB magnet value chain. Australia relies on China to buy rare earth materials, while both Japan and the European Union rely on China to purchase rare earth oxides and metals to make NdFeB magnets.

[367] Comments of Dana to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.

There is also broad reliance by U.S. allies on China for NdFeB magnets – [redacted][368] Such reliance leaves allies open to supply chain disruptions or potential economic coercion by China. For example, China has previously restricted its imports of Australian coal and its exports of rare earths to Japan. China's export restrictions to Japan in 2010, while only lasting two months, caused supply chain problems for Japanese firms and galvanized Japan into diversifying its supply of rare earths.[369]

Multilateral Engagement on Critical Minerals

Shared vulnerabilities highlight the value of current multilateral – as well as bilateral – engagements on critical minerals, which can help transition the United States and allies from reliance on a potential adversary and national security threat. Continued multilateral engagement through existing fora, such as the Conference on Critical Materials and Minerals, in concert with current bilateral engagements, including with Australia, Canada, and the European Union, will facilitate efficient coordination on supply chain resiliency issues across the full NdFeB magnet value chain. The United States should work with allies through these existing engagements to develop production at different steps of the value chain, encourage intellectual property licensing, and cooperate on foreign investment reviews, in addition to other actions.

The United States and allies should leverage burgeoning multilateral mechanisms to enhance focus on identifying the most cost-effective deposits, prioritizing the most commercially viable ones, and then pooling funding for production. The United States has one of the highest-grade deposits of rare earth elements in the world at Mountain Pass Mine in California. Round Top Mine in Texas, scheduled to begin production in 2023, may become a viable source of dysprosium. Meanwhile, Australia has some of the richest deposits of uranium and gallium, along with significant rare earth elements. Leveraging assets and comparative advantage amongst allies and partners will help develop a critical minerals supply chain in economically viable locations in a manner consistent with the United States' labor, environmental, equity, and other values.

In addition to funding market development, multilateral action should address technology sharing. While not cited as a critical barrier to entry, NdFeB magnet industry participants indicate intellectual property licensing would facilitate production. Industry participants are also researching NdFeB magnet substitutes and methods to reduce rare earths content that would increase supply chain resiliency, the commercialization of which should be promoted.

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368 [redacted] *See* Adamas Intelligence, "Rare Earth Magnet Market Outlook to 2030," 2020; "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

369 Restrictions to Japan were first reported in September 2010 and were lifted two months later in November 2010. Kristen Vekasi, "Politics, markets, and rare commodities: Responses to Chinese rare earth policy," Japanese Journal of Political Science 20 (1): 2-20, 2019, https://doi.org/10.1017/S1468109918000385; "China resumes rare earth exports to Japan," BBC, November 24, 2010, https://www.bbc.com/news/business-11826870.

Intellectual property licensing to firms from ally and partner countries should be encouraged and facilitated, especially when it reduces reliance on sourcing from non-allies. Allies and partners should reciprocate and respect all intellectual property. Emphasis should be placed on sharing technology that reduces the negative impacts of mining or separation, improves the extraction of rare earth elements from unconventional sources, fosters novel and effective recycling technologies, and develops effective magnet substitutes.

Coordinating foreign investment review mechanisms, which affect how quickly international capital can flow to priority facilities, should also be part of multilateral engagements. U.S. foreign investment law has exceptions for investors from certain countries, including important NdFeB magnet value chain participants such as Australia and Canada.[370] Those exceptions facilitate investments between the United States and its allies; other countries should be encouraged to reciprocate for U.S.-origin investments. Coordinating inbound investment review regimes may also help protect against the risk that an untrusted investor gains access to an important piece of the supply chain by investing in a trusted country. Outbound investment controls, similar to the ones currently before Congress, may reduce the risk that a firm based in an allied country will sell key assets located overseas to a foreign adversary.[371] The Australian firm Peak Rare Earths is an example of how foreign investment controls could be used to monitor and reduce risk in the NdFeB magnet supply chain. Peak Rare Earths is a potentially important non-Chinese rare earths market participant. As discussed in Appendix E, "Global NdFeB Magnet Production: A Firm-level Perspective," a Chinese firm recently took a significant stake in Peak Rare Earths in an inbound transaction to Australia. Outbound review could protect against the risk of Peak Rare Earths' Chinese investors compelling it to sell critical facilities to Chinese owners, whether those facilities are in allied countries (such as its planned rare earth oxide separation facility in the United Kingdom) or elsewhere (such as its Ngualla mining project in Tanzania).[372]

There are several established and relevant fora which can serve as venues for structured engagement with allies on these and other issues related to NdFeB magnets. For example, the Conference on Critical Materials and Minerals, which brings together Australia, Canada, the European Union, Japan, and the United States, is an important venue to regularly exchange information on policies for critical materials, research and development, and other efforts, and could be the site of further multilateral engagement.[373] In March 2022, the International Energy Agency announced a voluntary critical materials security program that could be another forum to

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[370] "CFIUS Exempted Foreign States," U.S. Department of the Treasury, https://home.treasury.gov/policy-issues/international/the-committee-on-foreign-investment-in-the-united-states-cfius/cfius-excepted-foreign-states.

[371] "Text – H.R. 5421- United States Innovation and Competition Act," U.S. House of Representatives, February 4, 2022, https://www.congress.gov/bill/117th-congress/house-bill/4521/text/eh (Section 104001).

[372] Note that Shenghe Resources, the Chinese investor in Peak Rare Earths, also purchased eight percent of U.S. mining firm MP Materials. *See* Mary Hui, "A Chinese rare earths giant is building international alliances worldwide," Quartz, February 19, 2021, https://qz.com/1971108/chinese-rare-earths-giant-shenghe-is-building-global-alliances/.

[373] For additional information on the Conference on Critical Materials and Minerals, *see* "12th Conference on Critical Materials and Minerals Held," Ministry of Economy, Trade, and Industry, December 9, 2021, https://www.meti.go.jp/english/press/2021/1209_002.html.

coordinate on issues related to NdFeB magnets.[374] In addition to these multilateral fora, the Japan-U.S. Industrial Cooperation Partnership, the U.S.-Australia Action Plan, U.S.-Brazil Critical Minerals Working Group, the U.S.-Canada Action Plan, and the U.S.-E.U. Trade and Technology Council are all important bilateral venues in which the United States could engage in structured dialogue and coordination with allies on NdFeB magnet-related supply chain resiliency issues.

9.4.2 Bolster Domestic Supply

Establish Rare Earths Tax Credits

The Department recommends that the Administration support the passage of H.R. 5033, the Rare Earth Magnet Manufacturing Production Tax Credit Act, or similar legislation.[375] This bipartisan legislation would establish a $20 per kilogram tax credit for rare earth magnets manufactured in the United States, and an enhanced $30 per kilogram credit for magnets manufactured in the United States for which all the component materials are produced domestically. This legislation covers both NdFeB magnets and samarium-cobalt magnets. In both the public comments and in industry meetings, NdFeB magnet producers and value chain participants expressed support for this legislation. Although they did not cite this legislation directly, end-users indicated support for domestic manufacturing incentives as opposed to tariffs. H.R. 5033 or similar legislation would increase the cost competitiveness of U.S. NdFeB magnets and magnet feedstocks relative to their Chinese counterparts and galvanize the development of a U.S. NdFeB magnet value chain. A tax credit should include magnets produced by or using materials from U.S. allies.

In addition to a tax credit for NdFeB magnets, the Department recommends that the Administration support the development of tax credits for non-NdFeB magnets that can substitute for NdFeB magnets and upstream rare earth products including carbonates, oxides, metals, and alloys. NdFeB magnet substitute and upstream rare earth product tax credits would similarly improve cost competitiveness and facilitate the growth of U.S.-produced magnetic materials. As with a rare earth tax credit, any NdFeB magnet substitute and upstream rare earth product tax credits should include materials produced by U.S. allies.

Defense Production Act Title III Funding

As discussed earlier, the Department of Defense (DoD) has made several notable awards through the Defense Production Act (DPA) Title III program to firms in the NdFeB magnet value chain. These awards have largely focused on the development of oxide separation and sintered NdFeB magnet production facilities. Further DoD awards for alloying and metallization production could facilitate the development of a holistic domestic NdFeB magnet value chain. Alloy and especially metal production are currently anticipated to be weak links in the future U.S. NdFeB

[374] *See* "2022 IEA Ministerial Communiqué," International Energy Agency, March 24, 2022, https://www.iea.org/news/2022-iea-ministerial-communique.
[375] *See* "H.R. 5033 – Rare Earth Magnet Manufacturing Production Tax Credit Act of 2021," Congress.gov, n.d., https://www.congress.gov/bill/117th-congress/house-bill/5033.

value chain. Based on the Department's survey of the U.S. NdFeB magnet industry, alloy and metal production facilities are also, on average, less expensive than domestic mining or magnet facilities. DoD DPA funding for alloy and metal facilities would be an efficient use of resources to strengthen the nascent NdFeB magnet value chain.

Encourage the Use of Export-Import Bank Financing

Eligible U.S. NdFeB magnet industry participants, including NdFeB magnet manufacturers and producers at upstream and downstream steps in the value chain, should be encouraged to apply for loans from the Export-Import Bank of the United States (EXIM). EXIM financing is another mechanism to help ease the financial constraints faced by the nascent U.S. NdFeB magnet industry. EXIM has two initiatives that are particularly relevant for the U.S. NdFeB magnet industry: the Make More in America Initiative and the China and Transformational Exports Program (CTEP).[376] [377] The Make More in America Initiative extends EXIM's existing medium- and long-term loans and loan guarantees to domestic manufacturers that export a sufficient percentage of production (15 percent or 25 percent depending on firm characteristics), scaled by jobs created. Importantly, export suppliers are also eligible. U.S. NdFeB magnet industry participants who meet export thresholds directly or because of their customer relationships, and are facing financing gaps, should be encouraged to apply for EXIM loans and loan guarantees under this initiative.

CTEP is meant to help U.S. exporters facing competition from China and ensure that the United States leads in ten transformational export areas, including renewable energy, energy storage, and energy efficiency. It is highly probable that U.S. NdFeB magnet industry participants that seek to enter export markets will face considerable competition from Chinese firms, given that China is the global leader in the NdFeB magnet value chain and Chinese magnets are less expensive than their non-Chinese counterparts because of favorable tax rebates and subsidies, among other factors. NdFeB magnet industry participants should also be encouraged to apply for EXIM financing under CTEP.

Provide Additional Support for Domestic Manufacturing

As directed by the Bipartisan Infrastructure Law, the Department of Energy has allocated nearly $3 billion to boost domestic production of technologies critical to clean energy of the future, including electric vehicles. Although much of this funding is directed at electric vehicle battery-related technologies, a portion of it could be devoted to funding domestic NdFeB magnet production, as these are critical to clean energy and national security.[378] For example, $140 million is earmarked for the design, construction, and build-out of a facility to demonstrate the commercial feasibility of a full-scale integrated rare earth element extraction and separation

[376] On the Make More in America Initiative, *see* "Make More in America Initiative," Export-Import Bank of the United States, n.d., https://www.exim.gov/about/special-initiatives/make-more-in-america-initiative.
[377] On the China and Transformational Exports Program, *see* "China and Transformational Exports Program," Export-Import Bank of the United States, n.d., https://www.exim.gov/about/special-initiatives/ctep.
[378] "Biden Administration, DOE to Invest $3 Billion to Strengthen U.S. Supply Chain for Advanced Batteries for Vehicles and Energy Storage," Department of Energy, February 11, 2022, https://www.energy.gov/articles/biden-administration-doe-invest-3-billion-strengthen-us-supply-chain-advanced-batteries.

facility and refinery. The facility will use recycled feedstock derived from acid mine draining, mine waste, or other deleterious material to separate rare earths into oxides and refine oxides into metals. Building domestic capacity in this phase of the supply chain would support both electric vehicle battery and NdFeB magnet production.

In addition to these existing funding sources, the Department recommends that the Administration support legislative action to develop resilient supply chains through the allocation of additional funding, such as the Supply Chain Resilience Program. Additional funding from such programs should support investment in domestic manufacturing in all steps of the NdFeB magnet value chain.

Defense Priorities and Allocation System

The investigation into NdFeB magnets focuses foremost on the national security. Under Title I of the Defense Production Act (DPA), the President is authorized to require preferential acceptance and performance of contracts or orders (other than contracts of employment) supporting certain approved national defense and energy programs.[379] The Department is delegated authority, through Executive Order 13603, to implement these authorities for industrial resources, which it does through the Defense Priorities and Allocation System (DPAS) regulation. The Department has delegated specific priority rating authority with respect to industrial resources to DoD, DoE, DHS, and the General Services Administration (GSA). The U.S. Government should prioritize contracts for DoD programs while considering the extensive use of NdFeB magnets in U.S. critical industry to minimize "disruption to normal commercial activities" and "provide an operating system to support rapid industrial response in a national emergency."[380]

Access to neodymium and NdFeB magnets is critical to the industrial base as a highly customizable component with a variety of uses. DoD, DoE, and DHS should use or continue to use their delegated authority under the DPAS to place priority ratings on contracts for programs related to or containing NdFeB magnets and magnet components. DPAS use ensures that approved national defense programs receive the appropriate priority in the marketplace. DPAS authorities could be particularly useful in ensuring that U.S. NdFeB magnet industry manufacturers are able to acquire critical equipment in a timely fashion. Across the industry, potential domestic producers face average lead times of around eight months for equipment, and for some market segments this increases to ten months for critical equipment. The Department's survey of the U.S. NdFeB magnet industry indicated the United States is the top source for equipment. DPAS could therefore be successfully deployed to shorten lead times and hasten the development of the U.S. NdFeB magnet industry. In addition, once sufficient domestic sources of feedstock are available, employing DPAS authorities could enhance the timeliness and stability of supply and increase the ability of U.S. NdFeB magnet firms to maintain production.

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[379] The DPA's definition of "national defense" includes military, energy, homeland security, emergency preparedness, critical infrastructure and restoration, and military and critical infrastructure assistance to foreign nations. *See* e.g., "Defense Production Act Program Definitions," FEMA, n.d., https://www.fema.gov/disaster/defense-production-act/dpa-definitions.

[380] "Defense Priorities and Allocation System," Department of Defense, n.d., https://www.dcma.mil/DPAS/.

Export Controls

The Department recommends the Administration consider restrictions on exports of materials relevant to the NdFeB magnet value chain under the International Emergency Economic Powers Act (IEEPA). Export controls could address market distortions in the NdFeB magnet value chain that create substantial difficulties acquiring or face inflated prices for feedstocks from domestic sources due to competition with foreign consumers. [redacted][381] [redacted] The economic implications of export controls on the value chain should be analyzed to determine their efficacy while considering their impact on U.S. allies.

National Defense Stockpile

The Strategic and Critical Minerals Stockpiling Act (50 U.S.C. §§ 98 et seq.), as amended, provides for the acquisition and retention of strategic and critical minerals stocks to decrease and preclude U.S. dependence on foreign sources or single points of failure for supplies during national emergencies.[382] The Defense Logistics Agency (DLA) Strategic Materials oversees the National Defense Stockpile. In Fiscal Year 2023, DLA announced potential acquisitions of one hundred metric tons of rare earth magnet block, 600 tons of neodymium, and 70 tons of praseodymium, potential conversions of 12 tons of rare earth elements, and potential recovery

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[381] [redacted]

[382] "The Strategic and Critical Materials Stockpiling Act (50 U.S.C. § 98 et seq.): As amended through Public Law 115-232, the National Defense Authorization Act for Fiscal Year 2019," Defense Logistics Agency, n.d., https://www.dla.mil/Portals/104/Documents/Strategic%20Materials/The%20Strategic%20and%20Critical%20Materials%20Stock%20Piling%20Act%20Amended%20Thru%20FY2019.pdf?ver=2019-01-09-151703-093.

from government sources of ten tons of rare earths.[383] [384] [385] These potential acquisitions are part of the Annual Materials Plan, which is an unconstrained budget estimate that assumes that Congressional authorization and funding are available. Actual acquisitions may be lower. In DLA's view, the availability of rare earth element ore is not a problem, between MP Materials, Chemours, and Lynas Rare Earths. Rather, the processing stages (oxide to separation to alloying) create production vulnerabilities. DLA has not announced the purchase of specific magnet grades. [redacted][386]

Although this stockpile is a welcome corrective to current supply chain vulnerabilities, the proposed quantities are small in relation to essential civilian and overall U.S. demand.[387] A disruption of the NdFeB magnet supply chain could cause an essential civilian shortfall of more than ten times DoD's annual peacetime consumption.[388] Demand, including by critical infrastructure sectors, is only expected to grow. The Department recommends that the Administration support further national stockpile purchases of NdFeB magnet block and constituent materials including neodymium, praseodymium, and dysprosium. The Department also suggests that the Administration explore whether to include a commercial buffer for select essential civilian and critical infrastructure sectors, which could strengthen supply chain resiliency in the event of disruptions caused by non-market forces.

[redacted]

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[383] "National Defense Stockpile Market Impact Committee Request for Public Comments on the Potential Market Impact of the Proposed Fiscal Year 2023 Annual Materials Plan," Federal Register, September 9, 2021, https://www.federalregister.gov/documents/2021/09/09/2021-19415/national-defense-stockpile-market-impact-committee-request-for-public-comments-on-the-potential.

[384] As previously mentioned, NdFeB magnets are shaped to meet product requirements. Stockpiling unshaped magnet block is prudent as it can be cut to meet specific end-use demands. However, each magnet block can only produce one grade of magnet, which requires the purchase of magnet blocks at multiple grades based on end-use demand. Stockpiling rare earth oxides may be preferable as they can be refined into metals, alloyed, and manufactured into magnets and obviate the need to consider magnet shape and grade requirements. That said, the United States currently does not possess the requisite downstream capacity to turn rare earth oxides into NdFeB magnets so any stockpile of rare earth oxides would need to be processed overseas until domestic capacity is established.

[385] NdFeB magnets typically contain about 30 percent rare earths, with combined neodymium and praseodymium content ranging from 19 to 29.5 percent depending on magnet grade and the remaining rare earths percentage composed of dysprosium or terbium. Based on the potential acquisition of neodymium and praseodymium the proposed National Defense Stockpile could produce up to about 1,980 tons of NdFeB magnet, not accounting for dysprosium or terbium requirements or material losses in the production process, in addition to the one hundred tons of rare earth magnet block.

[386] Meeting between the Defense Logistics Agency and the Department of Commerce, (Virtual Meeting, November 23, 2021).

[387] At a minimum, 2020 automobile sector demand was 3,300 tons of total U.S. demand of 16,100 tons. "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

[388] "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100 Day Reviews Under Executive Order 14017," The White House, June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

[redacted] DoD has requested $253 million in new appropriations for the National Defense Stockpile Transaction Fund in the President's Budget Request for Fiscal Year 2023. These funds build towards the $1 billion funding goal established by the June 2021 White House Report "*Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100 Day Reviews under Executive Order 14017*."[389]

9.4.3 Bolster Domestic Demand

Cooperation and Information Sharing Between Producers and Consumers

The Department recommends that the Administration establish a forum under a lead U.S. Government agency to encourage information exchange and cooperation between emerging NdFeB magnet producers throughout the supply chain and NdFeB magnet end-users. As previously discussed, ensuring consistent domestic commercial demand is critical to the development of a U.S. NdFeB magnet industry. Industry stakeholders have cited uncertainty over both potential sources of domestic supply and consistent demand for domestic magnets as risks to the emerging U.S. NdFeB magnet value chain. This forum would provide additional assurance of domestic supply and demand, for example by promoting private sector offtake agreements using DPA Title VII. Japan's use of JOGMEC to establish definitive offtake agreements between overseas producers and Japanese consumers is a successful model the U.S. Government could emulate.[390] [391] Ongoing private sector efforts such as the recent agreements between General Motors and MP Materials and Vacuumschmelze are encouraging, but the U.S. Government should facilitate further cooperation.

This forum could also provide a platform to resolve other issues relevant to the NdFeB magnet industry. For example, industry participants could discuss whether developing a market in futures and derivatives based on neodymium or other rare earths could increase price transparency and reduce price volatility or provide additional access to capital markets that could be used to finance capital-intensive projects. The Chinese rare earths industry is already considering such a marketplace.[392] [redacted][393]

[389] Ibid.
[390] For an example, *see* "Sojitz and JOGMEC enter into Definitive Agreements with Lynas Including Availability Agreement to secure supply of Rare Earths products to Japanese Market," Japan Oils, Gas, and Metals National Corporation, March 30, 2011, https://www.jogmec.go.jp/english/news/release/release0069.html.
[391] JOGMEC's offtake agreement with Lynas Rare Earths enabled Lynas Rare Earths to survive a slump in rare earth element prices in the mid-2010s. JOGMEC-style actions and definitive offtakes more generally could be mechanisms to counteract price volatility in the rare earths market. Sonali Paul, "Japanese shore up cash-strapped rare earths miner Lynas," Reuters, March 13, 2015, https://finance.yahoo.com/news/japanese-shore-cash-strapped-rare-085926334.html.
[392] "China's SHFE speeds up RE futures research," Argus Media, October 21, 2019, https://www.argusmedia.com/en/news/1999255-chinas-shfe-speeds-up-re-futures-research.
[393] *See* Appendix F, "U.S. NdFeB Magnet Industry: Company Profiles."

Recycling and Reprocessing

The Department recommends that the Administration take legislative action to establish regulations and, working in collaborative with the private sector, voluntary consensus standards to promote the recovery, recycling, and reuse of NdFeB magnets. In particular, labelling requirements for end-of-life products would ensure recyclers know NdFeB magnet specifications. Uncertainty over magnet specifications is a significant barrier to recycling, so labelling would facilitate recycling.

The Department also recommends that the Administration leverage existing programs and assets to increase the demand for recycling. DLA runs a Strategic Material Recovery and Reuse Program, which allows the recovery of strategic and critical materials from excess materials made available by other Federal agencies.[394] Through this program, DLA mitigated germanium shortfalls and recovered alloys from turbine engines.[395] DLA could potentially recover rare earth magnets from hard disk drives under this authority from the more than 4,000 U.S. Government-owned data centers and thereby generate a source of recyclable end of life material for recycling firms.[396] Leveraging U.S. Government-owned data centers would also give federal authorities an opportunity to lead private industry in secure destruction of the devices containing NdFeB magnets without damaging the magnets. As noted above, private entities often shred their data devices; they may be more willing to follow secure destruction practices identified by the U.S. Government. In addition, Federal agencies could direct any Federally-owned end-of-life electric vehicles or wind turbines using NdFeB magnets to recycle contained magnets.

Finally, the Department recommends that the Administration evaluate whether removing and processing tailings sites, for example of heavy mineral sands and coal tailings, could ameliorate environmental concerns at site locations.[397] [398] If removing heavy mineral sands and coal tailings would improve environmental indicators at site locations, the Environmental Protection Agency should assess whether environmental cleanup funds such as its Superfund program could be used to repurpose these sites. Monazite, produced as a byproduct of heavy mineral sands operations and traditionally considered a waste material, and coal tailings are potential rare earth element

[394] "Strategic Material Recovery and Reuse Program," Defense Logistics Agency Strategic Materials, n.d., https://www.dla.mil/HQ/Acquisition/StrategicMaterials/RRSMRP/.
[395] Ibid.
[396] "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100 Day Reviews Under Executive Order 14017," The White House, June 2021, https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.
[397] Heavy mineral sands operations produce monazite as a byproduct. Monazite was historically considered a waste material due to its radioactive content. As a result, monazite was blended into sand and reburied. Removing and processing monazite could therefore be conceptualized as reusing existing waste material. Meeting between Energy Fuels and the Department of Commerce, (Virtual Meeting, March 1, 2022).
[398] Multiple private and public sector actors are actively seeking to clean up coal mine byproduct waste while extracting rare earth elements. *See* Austyn Gaffney and Dane Rhys, "In coal country, a new chance to clean up a toxic legacy," Washington Post, May 19, 2022, https://www.washingtonpost.com/climate-solutions/2022/05/19/coal-mining-waste-recycling/.

feedstocks. As a result, removing and processing tailing sites could provide an additional source of rare earths and increase the resilience of the U.S. NdFeB magnet value chain.

Domestic Content Requirements

In Executive Order 14057, "Catalyzing Clean Energy Industries and Jobs through Federal Sustainability", the Biden Administration mandated that all federal agencies buy electric vehicles (in total about 600,000 car and trucks) by 2035 and that all 300,000 federal buildings be powered by wind, solar, or nuclear energy by 2030.[399] In addition, greatly expanded offshore wind energy is a major aspect of the Administration's efforts to accelerate the United States' clean energy economy and fight climate change. To support a vibrant and resilient green technology supply chain, federal procurement rules should specify that, to the extent possible, the electric vehicles purchased use domestically produced NdFeB magnets, and that the wind turbines supplying energy to federal facilities use domestically produced NdFeB magnets (for those using NdFeB magnets). The Department of Interior is sponsoring an offshore wind lease sale that includes lease provisions to promote the use of domestic materials.[400] These provisions should cover NdFeB magnets. In addition, electric vehicles and wind turbines might be procured by state or local governments or with state or local funding, and such content requirements could expand to these purchases. Domestic content requirements could mirror those of defense applications, which already have non-Chinese content requirements, and thereby include U.S. allies. Ensuring that requirements are structured to include magnets produced by U.S. allies is important to guarantee U.S. Government demand is adequately supported. To minimize disruption to U.S. procurement, content requirements can be phased-in and waived if insufficient quantities of eligible NdFeB magnets are available.

Consumer Rebates

Consumer rebates are another mechanism to incentivize the domestic production of NdFeB magnets. The Department recommends that the Administration develop and implement a tax rebate for consumers who purchase electric vehicles that are certified to contain U.S. or U.S. ally origin content. This rebate would help compensate automobile manufacturers for the increased cost of using domestic or ally produced NdFeB magnets. Such a rebate need not be limited to NdFeB magnets but could include U.S. or U.S. ally origin content batteries as well.

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[399] "Fact Sheet: President Biden Signs Executive Order Catalyzing America's Clean Energy Economy Through Federal Sustainability," The White House, December 8, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/08/fact-sheet-president-biden-signs-executive-order-catalyzing-americas-clean-energy-economy-through-federal-sustainability/.
[400] "Fact Sheet: Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs," The White House, March 29, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/.

9.4.4 Support Medium- to Long-term Industry Development and Resiliency

Research into Reducing the Use of Rare Earth Elements

The Department recommends that the Administration continue to fund research that seeks to reduce rare earth element content, and especially heavy rare earth element content, in NdFeB magnets, develop NdFeB magnet substitutes, and avoid the use of magnets, including NdFeB magnets, in end-use products. This includes support for research on MQ3 magnets, which could reduce or eliminate heavy rare earth contents, more efficient NdFeB magnets, potential non-NdFeB magnets such as iron-nitride magnets, and assemblies that obviate the need for NdFeB magnets in applications such as electric vehicle motors and wind turbine generators.[401] Reducing rare earth element content would help alleviate projected rare earths shortages and increase supply chain resiliency by reducing dependence on China.

Human Capital Development

The Department recommends that the Administration use applicable programs to support the development of human capital as required by the nascent U.S. NdFeB magnet industry. The collapse of the U.S. NdFeB magnet industry in the 1990s hollowed out industry-specific knowledge and skills, such that the United States' stock of NdFeB magnet-related human capital is limited. Current and potential domestic producers indicated that finding qualified and experienced manufacturing engineers and scientists is an important constraint on their operations. Some firms also indicated that finding qualified and experienced production line workers is an issue. The U.S. Government, state governments, and local authorities should work with industry, labor, and educational institutions to develop skills relevant to NdFeB magnet production by creating and expanding training programs and scholarships. For example, the Department of Labor's Employment and Training Administration funding opportunities, such as the Strengthening Community Colleges Training Grant, could be used to establish and enhance educational programs that teach NdFeB magnet-related skills.[402]

In addition, eligible entities should be encouraged to apply for the Economic Development Administration's Public Works and Economic Adjustment Assistance programs.[403] For example, higher education institutions or local governments in distressed communities (including coal communities) could apply for grants to develop and strengthen training facilities related to

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[401] [redacted] Meeting between Turntide Technologies and the Department of Commerce, (Virtual Meeting, February 17, 2022).

[402] For current Employment and Training Administration funding opportunities, *see* "Funding Opportunities," U.S. Department of Labor, n.d., https://www.dol.gov/agencies/eta/grants/apply/find-opportunities.

[403] *See* "PWEAA2020 FY 2020 EDA Public Works and Economic Adjustment Assistance Programs Including CARES Act Funding," Grants.gov, last modified April 1, 2022, https://www.grants.gov/web/grants/view-opportunity.html?oppId=321695.

NdFeB magnet manufacturing, such as materials science.[404] Supporting the development of human capital related to the NdFeB magnet value chain would help grow a robust domestic NdFeB magnet industry and by extension enhance the resiliency of end-use product supply chains, including electric vehicles and offshore wind turbines.

9.4.5 Continue to Monitor the NdFeB Magnet Value Chain

The Department recommends that the Administration continue to monitor the NdFeB magnet value chain to ensure that U.S. and ally firms are not adversely impacted by non-market factors or unfair trade actions, such as intellectual property violations or dumping. As previously discussed, the U.S. NdFeB magnet industry disappeared in the 1990s and early 2000s in part because of Chinese policies such as tax rebates and subsidies as well as intellectual property infringement. To ensure that the nascent U.S. NdFeB magnet industry survives, the U.S. Government should remain cognizant of the health of the industry and the effects of Chinese competition. The Department and the Supply Chain Trade Task Force should periodically assess the health of the U.S. and global NdFeB magnet value chain to determine whether additional actions should be undertaken to counterbalance non-market factors or unfair trade practices.

[404] Some planned NdFeB magnet industry participants are located in areas that may qualify as distressed communities, while others are situated in places that could qualify as coal communities, such as Kentucky and Tennessee. Training facilities in these areas could be particularly useful for developing a local pipeline for talent.

Tracking Number: 21-0080428

DECISION FOR THE SECRETARY

Approval of the content in the proposed NdFeB Magnet U.S. Department of Defense 232 Notification Letter

_X_ I approve the content in the proposed DoD notification letter.

____ I do not approve the content in the proposed DoD notification letter.

____ I approve as amended the content in the proposed DoD notification letter.

____ I would like to discuss this issue.

Signature: ____________________ Date: 9/21/2021

UNITED STATES DEPARTMENT OF COMMERCE
Secretary of Commerce
Washington, D.C. 20230

September 21, 2021

The Honorable Lloyd J. Austin III
The Secretary of Defense
1000 Defense Pentagon
Washington, DC 20301

Dear Mr. Secretary:

I am writing to notify you that I am initiating an investigation into the effects of the import of neodymium-iron-boron and neodymium (NdFeB) magnets on the national security of the United States. I am taking this action pursuant to Section 232 of the Trade Expansion Act of 1962, as amended (19 U.S.C. § 1862). Section 232 requires that notice be provided to the Secretary of Defense upon initiation of an investigation.

During the course of the investigation, Department of Commerce staff will consult with their counterparts in the Department of Defense regarding any methodological and policy questions that arise during the investigation. The investigation report will include information provided by the Department of Defense regarding the national defense requirements for NdFeB magnets.

My point of contact for this investigation is Kevin Coyne, Director of the Office of Technology Evaluation, Bureau of Industry and Security, at Kevin.Coyne@bis.doc.gov or (202) 482-2313.

I look forward to our collaboration on this important issue.

Sincerely,

Gina M. Raimondo

details found through registering at the web link above. To request additional accommodations, please email *bdelaviez@usccr.gov* at least 10 days prior to the meeting.

Members of the public are invited to make statements during the open comment period of the meeting or submit written comments. The comments must be received in the regional office approximately 30 days after each scheduled meeting. Written comments may be emailed to Barbara Delaviez at *ero@usccr.gov*. Persons who desire additional information may contact Barbara Delaviez at 202–539–8246.

Records and documents discussed during the meeting will be available for public viewing as they become available at *www.facadatabase.gov*. Persons interested in the work of this advisory committee are advised to go to the Commission's website, *www.usccr.gov*, or to contact the Eastern Regional Office at the above phone number or email address.

Agenda

Oct. 5, Nov. 2, Nov. 4, Nov. 9, and Nov. 16; 12:00 p.m. (ET)

- Rollcall
- Planning Meeting: Oct. 5
- Briefings on Water Affordability/Accessibility: Nov. 2, Nov. 4, Nov. 9, Nov. 16
- Next Steps and Other Business
- Open Comment
- Adjournment

Dated: September 21, 2021.

David Mussatt,

Supervisory Chief, Regional Programs Unit.

[FR Doc. 2021–20809 Filed 9–24–21; 8:45 am]

BILLING CODE P

DEPARTMENT OF COMMERCE

Bureau of Economic Analysis

Agency Information Collection Activities; Submission to the Office of Management and Budget (OMB) for Review and Approval; Comment Request; Services Surveys: BE–185, Quarterly Survey of Financial Services Transactions Between U.S. Financial Services Providers and Foreign Persons

The Department of Commerce will submit the following information collection request to the Office of Management and Budget (OMB) for review and clearance, in accordance with the Paperwork Reduction Act of 1995 (PRA), on or after the date of publication of this notice. We invite the general public and other Federal agencies to comment on proposed and continuing information collections, which helps us assess the impact of our information collection requirements and minimize the public's reporting burden. Public comments were previously requested via the **Federal Register** on May 26, 2021, during a 60-day comment period. This notice allows for an additional 30 days for public comments.

Agency: Bureau of Economic Analysis, Department of Commerce.

Title: Quarterly Survey of Transactions between U.S. Financial Services Providers and Foreign Persons.

OMB Control Number: 0608–0065.

Form Number(s): BE–185.

Type of Request: Regular submission, extension of a current information collection.

Number of Respondents: 2,860 annually (715 filed each quarter; 580 reporting mandatory data, and 135 that would file exemption claims or voluntary responses).

Average Hours per Response: 10 hours is the average for those reporting data and one hour is the average for those filing an exemption claim. Hours may vary considerably among respondents because of differences in company size and complexity.

Burden Hours: 24,140 hours annually.

Needs and Uses: The data are needed to monitor U.S. trade in financial services, to analyze the impact of these cross-border services on the U.S. and foreign economies, to compile and improve the U.S. economic accounts, to support U.S. commercial policy on trade in services, to conduct trade promotion, and to improve the ability of U.S. businesses to identify and evaluate market opportunities. The data are used in estimating the trade in financial services component of the U.S. international transactions accounts (ITAs) and national income and product accounts (NIPAs).

Affected Public: Business or other for-profit organizations.

Frequency: Quarterly.

Respondent's Obligation: Mandatory.

Legal Authority: International Investment and Trade in Services Survey Act (Pub. L. 94–472, 22 U.S.C. 3101–3108, as amended), and Section 5408 of the Omnibus Trade and Competitiveness Act of 1988.

This information collection request may be viewed at *www.reginfo.gov*. Follow the instructions to view the Department of Commerce collections currently under review by OMB.

Written comments and recommendations for the proposed information collection should be submitted within 30 days of the publication of this notice on the following website *www.reginfo.gov/public/do/PRAMain*. Find this particular information collection by selecting "Currently under 30-day Review—Open for Public Comments" or by using the search function and entering either the title of the collection or the OMB Control Number 0608–0065.

Sheleen Dumas,

Department PRA Clearance Officer, Office of the Chief Information Officer, Commerce Department.

[FR Doc. 2021–20945 Filed 9–24–21; 8:45 am]

BILLING CODE 3510–06–P

DEPARTMENT OF COMMERCE

Bureau of Industry and Security

[Docket No. 210902–0176]

RIN 0694–XC083

Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets

AGENCY: Bureau of Industry and Security, Office of Technology Evaluation, U.S. Department of Commerce.

ACTION: Notice of request for public comments.

SUMMARY: On September 21, 2021, the Secretary of Commerce (Secretary) initiated an investigation to determine the effects on the national security from imports of neodymium-iron-boron (NdFeB) permanent magnets (sometimes referred to as neodymium magnets, neo magnets, or rare earth magnets). This investigation has been initiated under section 232 of the Trade Expansion Act of 1962, as amended. While the Department is interested in any information related to this investigation that the public can provide, this notice identifies particular issues of significance.

DATES: Interested parties are invited to submit written comments, data, analyses, or other information pertinent to the investigation to the Department of Commerce's (Department) Bureau of Industry and Security by November 12, 2021. The due date for filing comments is November 12, 2021.

ADDRESSES: *Submissions:* You may submit comments, identified by docket number BIS 2021–0035 or RIN 0694–XC083, through the *Federal eRulemaking Portal: http://www.regulations.gov*. To submit comments via *https://*

www.regulations.gov, enter docket number BIS–2021–0035 on the home page and click "search." The site will provide a search results page listing all documents associated with this docket. Find a reference to this notice and click on the link entitled "Comment Now!" (For further information on using *https://www.regulations.gov,* please consult the resources provided on the website by clicking on "How to Use This Site.")

FOR FURTHER INFORMATION CONTACT: David Boylan, Industrial Studies Division, Bureau of Industry and Security, U.S. Department of Commerce, (202) 482–0194, *NdFeB232@bis.doc.gov.*

For more information about the section 232 program, including the regulations and the text of previous investigations, please see *www.bis.doc.gov/232.*

SUPPLEMENTARY INFORMATION:

Background

On September 21, 2021, the Secretary initiated an investigation under section 232 of the Trade Expansion Act of 1962, as amended (19 U.S.C. 1862), to determine the effects on the national security from imports of NdFeB permanent magnets. Numerous critical national security systems rely on NdFeB permanent magnets, including fighter aircraft and missile guidance systems. In addition, NdFeB permanent magnets are essential components of critical infrastructure, including electric vehicles and wind turbines. The magnets are also used in computer hard drives, audio equipment, and MRI devices. If the Secretary finds that NdFeB permanent magnets are being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security, the Secretary shall so advise the President in her report on the findings of the investigation.

Written Comments

This investigation is being undertaken in accordance with part 705 of the National Security Industrial Base Regulations (15 CFR parts 700 to 709) ("NSIBR"). Interested parties are invited to submit written comments, data, analyses, or information pertinent to this investigation to the Department's Office of Technology Evaluation no later than November 12, 2021.

The Department is particularly interested in comments and information directed to the criteria listed in § 705.4 of the NSIBR as they affect national security, including the following:

(i) Quantity of or other circumstances related to the importation of NdFeB permanent magnets;

(ii) Domestic production and productive capacity needed for NdFeB permanent magnets to meet projected national defense requirements;

(iii) Existing and anticipated availability of human resources, products, raw materials, production equipment, and facilities to produce NdFeB permanent magnets;

(iv) Growth requirements of the NdFeB permanent magnets industry to meet national defense requirements and/or requirements for supplies and services necessary to assure such growth including investment, exploration, and development;

(v) The impact of foreign competition on the economic welfare of the domestic NdFeB permanent magnets industry;

(vi) The displacement of any domestic NdFeB permanent magnets production causing substantial unemployment, decrease in the revenues of government, loss of investment or specialized skills and productive capacity, or other serious effects;

(vii) Relevant factors that are causing or will cause a weakening of our national economy; and

(viii) Any other relevant factors, including the use and importance of NdFeB permanent magnets in critical infrastructure sectors identified in Presidential Policy Directive 21 (Feb. 12, 2013) (for a listing of those 16 sectors see *https://www.dhs.gov/cisa/critical-infrastructure-sectors*).

Requirements for Written Comments

The *https://www.regulations.gov* website allows users to provide comments by filling in a "Type Comment" field, or by attaching a document using an "Upload File" field. The Department prefers that comments be provided in an attached document. The Department prefers submissions in Microsoft Word (.doc) or Adobe Acrobat (.pdf). If the submission is in an application format other than those two, please indicate the name of the application in the "Type Comment" field. Please do not attach separate cover letters to electronic submissions; rather, include any information that might appear in a cover letter in the comments themselves. Similarly, to the extent possible please include any exhibits, annexes, or other attachments in the same file (as part of the submission itself) rather than in separate files. Comments will be placed in the docket and open to public inspection, except information determined to be confidential as set forth in § 705.6 of the NSIBR. Comments may be viewed on *https://www.regulations.gov* by entering docket number BIS–2021–0035 in the search field on the home page.

Material submitted by members of the public that is properly marked business confidential information and accepted as such by the Department will be exempted from public disclosure as set forth in § 705.6 of the NSIBR. All filers using the portal should use the name of the person or entity submitting comments as the name of their files, in accordance with the instructions below. Anyone submitting business confidential information should clearly identify the business confidential portion at the time of submission, file a statement justifying nondisclosure and referring to the specific legal authority claimed, and also provide a non-confidential version of the submission in a separate file.

For comments submitted electronically containing business confidential information, the file name of the business confidential version should begin with the characters "BC." Any page containing business confidential information must be clearly marked "BUSINESS CONFIDENTIAL" on the top of that page. The corresponding non-confidential version of those comments must be clearly marked "PUBLIC." The file name of the non-confidential version should begin with the character "P." The "BC" and "P" should be followed by the name of the person or entity submitting the comments or rebuttal comments. Any submissions with file names that do not begin with a "BC" or "P" will be assumed to be public and will be made publicly available through *http://www.regulations.gov.*

The Bureau of Industry and Security does not maintain a separate public inspection facility. Requesters should first view the Bureau of Industry and Security web page, which can be found at *https://efoia.bis.doc.gov/* (see the link to the Index of Documents under the "Electronic FOIA" heading on the web page). If requesters cannot access the website, they may call 202–482–0795 for assistance. The records related to this assessment are made accessible in accordance with the regulations published in part 4 of title 15 of the Code of Federal Regulations (15 CFR 4.1 *et seq.*).

Matthew S. Borman,

Deputy Assistant Secretary for Export Administration.

[FR Doc. 2021–20903 Filed 9–24–21; 8:45 am]

BILLING CODE 3510–33–P

THE EFFECT OF IMPORTS OF NEODYMIUM-IRON-BORON (NdFeB) PERMANENT MAGNETS ON THE NATIONAL SECURITY

U.S. Department of Commerce
Bureau of Industry and Security
Office of Technology Evaluation

Business Confidential Comment Summaries

BIS-2021-0035

Contents

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THE EFFECT OF IMPORTS OF NEODYMIUM-IRON-BORON (NdFeB) PERMANENT MAGNETS ON THE NATIONAL SECURITY

U.S. Department of Commerce
Bureau of Industry and Security
Office of Technology Evaluation

Appendix C: Public Comment Summaries

BIS-2021-0035

Contents

Entity Name: ALL Magnetics Inc

Date Received: 10/5/21
Date Posted: 10/7/21
Type of Entity: U.S. Business
Criteria Covered:
i:☒ **ii:**☐ **iii:**☒ **iv:**☐ **v:**☒ **vi:**☐ **vii:**☐ **viii:**☐

Executive Summary:
All Magnetic sees the production of NeoMagnets, or NdFeB Magnets, in the United States as a National Security Risk. This is because the U.S. has not produced NeoMagnets since 1993. Due to this, the U.S. lacks the infrastructure for rare earth mining and processing. China however has excelled in this infrastructure, with their plating technology being stronger, and their Wire EDM costing 200% less than the United States.

ALL Magnetics Inc's main arguments are as follows:

- NdFeB magnets are a US National Security Risk, not to mention the amount of production for public sector goods that rely on magnets
- All the rare earth mining and processing infrastructure is gone. Mountain Pass is not even moving the needle. The hydrogen dispersion mixers are gone. The roller hearth Kilns are gone. The Magnetically Oriented Presses are gone. The alloying furnaces are gone.
- Assuming the United States had government funding with no corruption (mutually exclusive) it will take the US 8 to 10 years just to break even on the rare earth processing technology that the Chinese have developed.
- NdFeB Magnets are 60-80% FeO. More Iron/Steel processing factories are needed, from which we get the best sources of FeO

Entity Name: Eminence Speaker LLC

Date Received: 10/26/21
Date Posted: 10/27/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☐ iii:☐ iv:☐ v:☒ vi:☐ vii:☐ viii:☒

Executive Summary:

Eminence Speaker LLC is a U.S. company which focuses on the manufacturing of professional audio loudspeakers. Their products rely heavily on neodymium magnets, which have recently seen a spike in price and shipping. This has created challenges for the company, as well as other businesses who rely heavily on these magnets. Eminence faces more challenges, as the U.S. government will possibly place an additional 25% special tariff on the import of neodymium magnets.

Eminence Speaker LLC's main arguments are as follows:

- the costs of neo magnets are continuing to rise. This is further exacerbated by exorbitant freight costs associated with shipping neodymium magnets into the USA from China

- There is a movement in the USA to manufacture neodymium magnets, but no one is really going from mine to magnet, at least not for several years. Even then, the prices will continue to be exorbitant due to environmental standards that the Chinese don't have to face.

- Many others could be vitally challenged by USA based tariffs for these products and will make the USA loudspeaker industry far less competitive than our Italian and other European counterparts.

Entity Name: MagnetoDynamics LLC

Date Received: 10/27/21
Date Posted: 10/28/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☒ iii:☐ iv:☒ v:☐ vi:☐ vii:☐ viii:☒

Executive Summary:

Very little progress has been seen when it comes to generating a robust internal supply chain for high performance RE magnets. The lack of magnet manufacturing for weapon systems in the United States, such as JDAM, has been a continuous concern for some, including MagnetoDynamics LLC. However, the U.S. is not the only country having their RE magnet manufacturing decimated by Chinese production; both European and Japanese industries have suffered the same fate. A short-term solution would be to work with Japan to secure sufficient RE magnet products to address military requirements and build up US manufacturing surrounding magnets. In the long-term, if a smaller scale production is economically justified, then the processes can slowly be scaled up.

MagnetoDynamics LLC's main arguments are as follows:

- the US was in a strong position in both the mining and concentration of RE elements as well as the manufacturing of magnets based on them, however with the closure of the Mountain Pass mine in 2002 and the decaying profitability of US magnet manufacture with competition in China, the manufacturing chain crumbled quickly.
- The creation of a supply chain for military applications has always seemed to be the focus before, but since the quantity of magnets used is small by comparison to other applications a supply chain just for that would not be economically viable. To have a robust supply chain it will need to address the needs of major magnet users in a wide variety of products made in the US and therefore be done cost effectively when compared with imports from China.
- The US really has no substantial manufacturing capability left so it will have to be re-created rather than retained. There are RE magnet manufacturing companies in the US but they are small privately owned businesses.
- Another business which may or may not be making any significant quantity of sintered product is Urban Mining – however their initial business model was to recycle RE magnets, which have a much lower material cost than the alloys used for virgin production, using technology developed at the University of Birmingham in the UK. Even with lower material cost it is unlikely that magnets they make will be profitable – and the owners may just be looking for someone to buy them out because it has taken so long to get to production (8 years) and they have sunk a lot of money into the business.
- An interesting short-term solution, which would be to work with Japan to secure sufficient RE magnet product to address military requirements and at the same time develop US metal, alloy and magnet manufacture based on concentrates or pure oxides / fluorides from US mines like MP and USRE
- Longer term, if smaller scale production seems to be economically justified the processes can be scale up or replicated for higher volume production. This would also stimulate R+D into these subjects which has also faded

Entity Name: MagnetoDynamics LLC

Date Received: 10/27/21
Date Posted: 10/28/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☒ iii:☐ iv:☐ v:☐ vi:☐ vii:☐ viii:☐

Executive Summary:

It is strategically important that the United States does not have a RE magnet supply chain. The Department of Congress only received 3 responses regarding the topic. Therefore, either there messaging was ineffective, or people just did not care. Instead, the U.S. needs a sintered RE magnet plant which is capable 5000 tons of production and all the supporting supply chain, to support the manufacture.

MagnetoDynamics LLC's main arguments are as follows:

- Last month (Sept 2021) the Department of Congress launched an investigation of the NdFeB magnet supply chain to protect strategic businesses and asked for public contributions.
- The U.S. has been practically non-existent since the closure of Mountain Pass and the sale by MQ of the ex-Ugimag magnet production facility 18 years ago.
- Supply chain steps which would be supported in a RE magnet plant capable of 5000 tons would be – mining, separation, oxide production and metal making.

Entity Name: Tridus International

Date Received: 10/28/21
Date Posted: 11/1/21
Type of Entity: U.S. Business
Criteria Covered:
i:☒ **ii:**☐ **iii:**☒ **iv:**☐ **v:**☐ **vi:**☒ **vii:**☐ **viii:**☐

Executive Summary:

Tridus International (Tridus) is a California based supplier of NdFeB magnets which are produced in China. Implementing Section 232 tariffs on NdFeb Magnets would harm the company, and a numerous amount of American NdFeB magnet users. This is because the American magnet's consumer group is growing quickly. If Section 232 action is taken to reduce the imports of NdFeB magnets, then the reduction of imports must be filled by a domestic sourcing to keep American consumers happy, which is currently non-existent in the United States.

Tridus International's main arguments are as follows:

- Tridus has been supplying NdFeB magnets in the United States for more than 30 years, we supply NdFeB magnets to a wide variety of industries and our customers employ thousands of Americans; from engineers that design energy efficient electric motors to factory workers that build permanent magnet devices.
- One of the main growth drivers is the battery electric vehicle (BEV). BEVs rely on electric motors for propulsion and most BEV powertrain designs rely on NdFeB magnets.
- While there are numerous American magnet buyers, there is no domestic magnet producer. North American NdFeB magnet buyers must purchase their sintered NdFeB magnets from Japanese, German or Chinese producers.
- It could be argued that Section 232 action would encourage domestic NdFeB magnet production, but achieving commercial scale production would take years to accomplish
- In addition to harming American magnet buyers, it is easy to imagine Tridus customers deciding to off-shore electric motor production as the supply of imported NdFeB magnets is restricted and un-proven domestic entities develop NdFeB production capabilities.
- It is in our national security interest to foster and encourage a domestic NdFeB supply chain, but imposing Section 232 tariffs when our domestic supply chain is not ready would do more harm than good.

Entity Name: Individual (John Ormerod)

Date Received: 10/29/21
Date Posted: 11/1/21
Type of Entity: Individual
Criteria Covered:
i:☒ ii:☐ iii:☐ iv:☒ v:☐ vi:☐ vii:☐ viii:☐

Executive Summary:

John Ormerod knows that imported NdFeB magnets have an adverse effect on the U.S. National Security. If the United States ever wants to begin producing the magnets domestically, this will be a challenge which needs to be looked at through the full supply chain, from mine to OEM magnet user. This will be a challenge and needs to be looked at through the full supply chain (see attachment) from mine to OEM magnet user. This would include reviewing REE separation, reduction to metal, alloy making, magnet making, supporting infrastructure, and OEM magnet users.

John Ormerod's main arguments are as follows:

- Since we have zero domestic production of sintered NdFeB magnets and as already stated they are critical components in several defense systems, imported NdFeB have an adverse effect on U.S. National Security
- REE separation: there is no commercial scale REE separation capability in the US. However, MP Materials is planning to establish the capability at their Mountain Pass mine in the next 18 months.
- Reduction to metal: No US commercial capability.
- Alloy making: The preferred method is strip casting. Again, no commercial capability in the US.
- OEM magnet user: This probably is the most critical point. Realize a plant to produce 5,000 to 10,000 tons of sintered NdFeB is in the range of $50 to $100 million investment. In my opinion the operating costs will be higher than Chinese prices levels. Therefore, the magnet buyer has to accept a premium for domestically produced materials

Entity Name: Spontaneous Materials

Date Received: 11/2/21
Date Posted: 11/4/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☒ iii:☒ iv:☐ v:☐ vi:☒ vii:☐ viii:☐

Executive Summary:

Stanley Trout, Ph.D. in Metallurgy and Material Sciences, sees magnet production making its way back into the United States for domestic military sourcing soon. Before returning the process back to America, a few processing steps that are currently missing in the U.S. need to be taken care of. This includes 1) separating rare earth ores to make oxides, 2) reducing the oxides to make metals, 3) casting alloys and 4) magnet processing. Other suggestions/proposals need to be considered as well, such as how often should the facility be running, who should be employed there and working on the projects, and so much more. The goal with returning to the domestic market should be to create new business models, and not repeat previous ones used, since they failed.

Spontaneous Materials's main arguments are as follows:

- If someone or some group would like to restart the US magnet industry, don't follow what was done previously. It was a lousy business model. Chasing profitability month by month or quarter by quarter will just lead back to sending factories and technology overseas to the countries with the lowest labor rates. We have seen this movie already and do not like the ending.
- I'd suggest running it more as a not-for-profit business that isn't as susceptible to the ups and downs of the business cycle. It would provide a way to keep the technology at home.
- Don't be guilty of inconsistent support or interest in this industry. Being the focus of attention can be nice, but it really isn't helpful if it is temporary. Just as it would be irresponsible to only pay attention to a child on its birthday and Christmas, and to completely ignore the child the rest of the year, temporary attention really isn't going to help this industry survive in the long term
- military applications domestic sourcing is likely on its way to becoming mandatory, but it represents a small percentage of overall demand for permanent magnets. Other users, like the automotive and motor industries are many times larger; however, their buyers are more concerned about price and less concerned about the country of origin
- A modest proposal is to establish a centrally located facility that can address all four of the missing pieces of the production puzzle. The second part of my proposal is that this plant should only be run a few weeks a year, unless there is an emergency requiring more output. The plant should be operated by young engineers, to optimize the longevity of the processing knowledge and the availability of people who can be called back to run the plant fulltime in the event of a national emergency. This is a crucial part of the proposal.

Entity Name: Alliance LLC

Date Received: 11/2/21
Date Posted: 11/4/21
Type of Entity: U.S. Business
Criteria Covered:
i:☒ ii:☒ iii:☒ iv:☐ v:☐ vi:☐ vii:☐ viii:☐

Executive Summary:

NeoMagnets are a vital component in everyday life, being seen in almost all vehicles and highly technological devices. Unfortunately, there are no North American manufacturers that produce NdFeB from virgin raw materials. Implementing the 232 tariffs would place an additional burden on the American consumer's who are already feeling the pain of higher prices on virtually every good they buy. Therefore, Alliance LLC believes domestic production of NdFeB magnets are necessary.

Alliance LLC's main arguments are as follows:

- NdFeB magnets are a vital component in almost every high technology device and are heavily used in automotive, consumer electronics, sound systems, electric motors. Unfortunately, there are no North American manufacturers that produce NdFeB from virgin raw materials.
- Imported NdFeB magnets are in almost all cases purchased by manufacturers who make their products in the United States. Adding an additional tariff on NdFeB magnets (HTS code 8505.11.0070) will be passed on from the importers to their customers who will in turn pass them onto the US taxpayer.
- 232 tariffs could cause US manufacturers to be at an even greater disadvantage when competing against non-US producers of products such as electric motors and sensors.
- As for domestic production of NdFeB required for US Defense and US Government procurement, these magnets are already made in the US via fabrication entirely from non-Chinese origin. The companies who make them are large top quality world class manufacturers such as MCE.

Entity Name: Arnold Magnetic Technologies

Date Received: 11/09/2021
Date Posted: 11/18/21
Type of Entity: U.S. Business
Criteria Covered:
i:☒ **ii:**☒ **iii:**☒ **iv:**☐ **v:**☐ **vi:**☐ **vii:**☒ **viii:**☐

Executive Summary:
Arnold Magnetic Technologies recognizes the growing concern with the fragility of Rare Earth Magnet Neodymium Iron Boron (Neo) production capabilities in the United States. Neo is contained in critical components of myriad defense programs. Arnold Magnetic Technologies is deeply engaged with downstream magnetic assemblies in multiple defense platforms that rely on Neo materials. Presently, there are no commercial production scale Neo capabilities in the United States. Arnold Magnetic Technologies seeks DoD support and supplemental funding to restore and strengthen Neo production capacity within the United States. DFARS legislative updates, specifically on 252.225-7052, places restriction on Neo materials that have been "melted or produced" in China. This policy, guiding the industrial base to a worthy end-state, has generated extensive interest in establishing compliant supply chains in the United States. This paper outlines the ongoing discussion for the reader and focuses specifically on Neo capabilities.

Arnold Magnetic Technologies's main arguments are as follows:

- Arnold Magnetic Technologies can provide quantity data through secure channels within DoD.
- Domestic production and productive capacity needed for NdFeB permanent magnets to meet projected national defense requirements; Floatation Process, Spiral and Hydro Process, Separation Process, Oxide, Metal, Milling, Pressing, and Sintering
- Equipment need by the magnet producers after receipt of the blended alloys in powder form would be the following. -Jet or Ball mills for powder refinement
- MP Materials produces approximately 15% of the global supply of rare earths, currently in the form of an intermediate product—rare earth concentrate—that requires further processing in Asia (China and Australia?). MP Materials has relaunched its onsite processing facilities, forming the basis for a renewed, self-sufficient U.S. rare earth industry.
- Arnold Magnetic Technologies could support manufacturing capability stateside. Capability will sustain previously funded levels of capacity, as US-based manufacturing operations will source more materials from the new US processing facilities versus sourcing overseas.

Entity Name: Vital Metals Ltd And Cheetah Resources Corp

Date Received: 11/10/2021
Date Posted: 11/17/21
Type of Entity: Foreign Business
Criteria Covered:
i:☐ ii:☒ iii:☐ iv:☒ v:☒ vi:☐ vii:☐ viii:☐

Executive Summary:
Cheetah's business is guaranteeing the supply of responsibly sourced feedstock to the rare earth element supply chain independent of China. Four of the rare earths supplied by Cheetah Resources, including neodymium, are used in neodymium magnets. Cheetah mines and concentrates rare earths in the NWT, Canada and is completing a hydrometallurgical processing facility in Saskatchewan, Canada, to produce a mixed rare earth concentrate. Cheetah and its parent company, Vital Metals Ltd., have arrangements to sell their product to Europe and the United States. They are one of two producers of rare earths, including neodymium in North America and the only North American producer that does not sell their product to China directly or indirectly.

Vital Metals Ltd And Cheetah Resources Corp's main arguments are as follows:

- Cheetah Resources Corp. ("Cheetah") opened Canada's first rare earth metals mine in the Northwest Territories, Canada in 2021.
- Cheetah's sister company, Vital Metals Canada Inc., uses the concentrate to produce rare earth carbonate from its Rare Earth Extraction plant in Saskatoon, Saskatchewan, Canada. First feed into the plant is scheduled to commence December 2021, with first product produced June 2022. The mixed rare earth carbonate will contain Neodymium.
- We are concerned about actual and potential US trade actions that could hurt our ability to sell our rare earth concentrate and carbonate to the US market. Neodymium-containing rare earth carbonate products are essential to US Security and are a critical mineral. We suspect that domestic production is well below domestic demand and that present and future quantities and circumstances of REE imports do not threaten to impair the national security as defined in Section 232.
- We also understand that under section 232 the term "national security" can be interpreted more broadly to include the general security and welfare of certain industries, beyond those necessary to satisfy national defense requirements, which are critical to the minimum operations of the economy and government. We further understand that the Department Phone Number: 1 867-920-7273 (RARE) Corporation Number: 1179310-1 P.O. Box 1919 Yellowknife, Yellowknife NT X1A 2P4 relies on Presidential Policy Directive 21; Critical Infrastructure Security and Resilience to identify 16 critical infrastructure sectors, many of which rely on Neodymium-containing rare earth carbonate products

Entity Name: Individual (Anonymous)
Date Received: 11/10/2021
Date Posted: 11/17/21
Type of Entity: Individual
Criteria Covered:
i:☐ ii:☐ iii:☐ iv:☒ v:☒ vi:☐ vii:☐ viii:☐

Executive Summary:

An expert for a major electronics manufacturer in the United States stated that he believes the U.S. government should not impose tariffs or additional regulations on NdFeB magnets. These tariffs and regulations will endanger the U.S. competitiveness in this industry. The US commercial interests are in no danger of losing access to Chinese NdFeB magnets. Imposing these actions could lead to punitive actions against the US and so benefit our European competitors.

Anonymous' main arguments are as follows:

- The tariffs and regulations will endanger the competitiveness of US manufactures that integrate permanent magnets in their products and there will be a net negative impact on US jobs.
- It does not require a lot of well-paid people to manufacture magnets: but if US corporations lost business due a tariff effort, then many well-paying jobs in the downstream industries could be threatened. This is especially true of the American automotive industry, especially with their EV goals.
- China has invested in creating the most sophisticated NdFeB supply chain in the world. They are processing >80% of the worlds rare earth minerals to metals and over 90% of the worlds rare earth metals to magnets.
- The idea that the US is going to snap its fingers and create an NdFeB magnet industry in time to compete in the EV race is a fantasy. The idea that this could be hastened by tariffs and adversarial trade actions is dangerous to US industry competitiveness, US jobs, and and America's Climate goals

Entity Name: Arelec

Date Received: 11/11/2021
Date Posted: 11/17/21
Type of Entity: Foreign Business
Criteria Covered:
i: ☒ **ii:** ☒ **iii:** ☒ **iv:** ☒ **v:** ☒ **vi:** ☒ **vii:** ☒ **viii:** ☒

Executive Summary:
ARELEC is a company specializing in products and components based on permanent magnets. We achieve a turnover in 2021 of 16M € in various fields such as automotive, energy, electrical industry, pharmaceutical equipment, packaging. Products manufactured by ARELEC range from furnishing equipment, targets for magnetic sensors and rotors for electric motors. In Lon’s, France, the company's headquarters bring together the design office, sales forces and a plasto-magnet and magnetic elastomer manufacturing workshop. In Megrine, Tunisia, a manufacturing workshop completes our manufacturing resources

Arelec’s main arguments are as follows:

- Many other products could be delivered to United States by our customers.
- No direct exportation from ARELEC to US national defense requirements known today
- ARELEC can design application using permanent magnets as motors, sensors, actuators and holding solutions, measure magnetic performance of our products, produce permanent magnet component, and manage magnet supply chain
- Needed investment of 4,5M€ in ARELEC to guaranty: =>cash flow financing due to raw material increase =>R&D and manufacturing investment Arelec is member of a French consortium about sintered NdFeB recyclability. Arelec is interested to add sintered NdFeB process to his production capacity.
- High level of competition on the western NdFeb permanent magnets market due to Chineses competitors. The ability of our Chinese competitors increases a lot in the last 10 years. They are now able to enter in competition in some specific market
- ARELEC is targeting to keep and develop his productions and activities. The international competition reduces the margin level and so impact directly ARELEC investment capacity
- Availability of Raw material from China at a stable price
- Arelec provides magnet to pharmaceutical industry. They are use as rotors and mixer for medicine’s machines and vaccine’s machines.

Entity Name: Cccme, Cemia, Acrei

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☒ ii:☒ iii:☒ iv:☐ v:☐ vi:☐ vii:☐ viii:☐

Executive Summary:
CCCME, CEMIA, ACREI and their member companies believe imports of NdFeB permanent magnets industry from China do not threaten to impair U.S. national security of the U.S. industry. Instead, Chinese imports are a beneficial complement to the U.S. NdFeB permanent magnets industry and help improve the competitiveness of U.S. NdFeB permanent magnets industry companies, accelerate the development of the U.S. NdFeB permanent magnets industry, and reduce the purchase cost for U.S. Consumers. The CCCME, CEMIA, and their member companies hope that the United States will carefully assess the impact of any determination made because of this investigation, and avoid any harm caused by any trade barrier.

Cccme, Cemia, Acrei's main arguments are as follows:

- Import of NdFeB magnets shall be considered as beneficial supplement to relevant industries of the United States, as it helps to enhance the competitiveness of American enterprises, meets the needs for the American domestic market, and contributes to the sustainable development and profit maximization
- China's NdFeB exports to the U.S. have long been dominated by low and mid-range products, manufacturers are mainly small and medium sized enterprises
- Alternatives that can be made in the United States include Ferrite permanent magnet and Samarium Cobalt magnet
- Chine exports of NdFeB will not affect U.S. national and industrial security
- The U.S. has first mover advantage of intellectual property rights in the core technologies of NdFeB
- In terms of manufacturing, Rare Earths America has purchased NdFeB magnet manufacturing facility, owned and operated in North Carolina
- Section 232 tariffs will have many negative affects including damage to U.S. downstream manufacturing companies, affects stable supply in the U.S. domestic market, and also affects the interest's groups and investment interest in the country

Entity Name: Japan Electronics And Information Technology Industries Association (JEITA)

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☒ ii:☐ iii:☐ iv:☒ v:☒ vi:☐ vii:☒ viii:☐

Executive Summary:
The Japan Electronics and Information Technology Industries Association (JEITA) is Japan's leading IT and electronics association. Neodymium magnets are essential in a wide range of electronic equipment using cutting-edge technologies, including fighter planes, guided missile systems, business machines, and medical equipment. While the United States has the Mountain Pass rare earth mine in operation in California and various other rare-earth element (REE) mines either under development or scheduled for operation, it does not have the production capacity to engage in the separation, refinement, and alloying necessary to produce neodymium magnets from the excavated REEs.

Japan Electronics And Information Technology Industries Association (JEITA)'s main arguments are as follows:

- The Japan Electronics and Information Technology Industries Association (JEITA) is Japan's leading IT and electronics association. Our members comprise 390 large and medium-ranked companies working in areas from consumer electronic equipment, industrial electronic equipment, semiconductors, and electronic components to software.
- Neodymium magnets are essential in a wide range of electronic equipment using cutting-edge technologies, including fighter planes, guided missile systems, business machines, and medical equipment. They are also a critical metal in policies for the transition from fossil fuel to renewable energies like electric vehicles (EVs) and wind power generation.
- The "100-Day Reviews under Executive Order 14017" released by the White House in June 2021 reports that only China currently has active capacity in all the processes (mining and mineral processing, separation and refinement, electrolysis, alloying, magnet production, and processing) necessary for production of neodymium magnets.
- While the United States has the Mountain Pass rare earth mine in operation in California and various other rare-earth element (REE) mines either under development or scheduled for operation, it does not have the production capacity to engage in the separation, refinement, and alloying necessary to produce neodymium magnets from the excavated REEs.
- Further, the REE production process produces large amounts of impurities, wastewater, and exhaust air, and production of neodymium magnets requires various other metals in addition to the neodymium (Nd) and dysprosium (Dy) and emits radioactive materials.
- If the U.S. government sets sufficiently high tariffs on neodymium magnet imports, this could well incentivize domestic neodymium production
    - Until domestic production capacity is sufficiently established, however, tariffs will simply push up the cost of neodymium magnet imports for U.S. manufacturers producing EVs, wind power generators, computer HDDs, and missile guidance systems, etc.
- In March 2021, the leaders of Quadrilateral Security Dialogue members the United States, Australia, India, and Japan agreed to establish a working group on cutting-edge technologies with the aim of breaking their dependence on imports from China, announcing that they would investigate rebuilding semiconductor and rare earth supply chains.

Entity Name: Urban Mining Company

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☒ iii:☒ iv:☒ v:☒ vi:☒ vii:☐ viii:☒

Executive Summary:
Urban Mining Company (UMC), the only domestic producer of neodymium iron boron permanent magnets. Department of Defense (DoD) demand for rare earth permanent magnets is variously estimated at between 2% and 10% of total domestic demand. UMC is uniquely well-positioned to avoid bottlenecks in raw materials and other input items to produce NdFeB magnets. Current global demand for NdFeB magnetic materials is around 170,000 tons of material per year, or about $20 billion. This demand is expected to at least double within the next decade.

Urban Mining Company's main arguments are as follows:

- Urban Mining Company (UMC), the only domestic producer of neodymium iron boron permanent magnets, encourages continued investigation and action by the Department of Commerce pursuant to section 232 of the Trade Expansion Act of 1962 to ensure these critical items are available for national defense and other essential functions in the face of foreign activities to disrupt and dominate the rare earth permanent magnet supply chain
- UMC projects that it will be capable of producing sufficient volumes of NdFeB permanent magnets to meet national defense requirements upon full commercialization of the San Marcos facility.
    - Department of Defense (DoD) demand for rare earth permanent magnets is variously estimated at between 2% and 10% of total domestic demand. UMC, which is planning to produce up to 2,000 metric tons of NdFeB magnets per year domestically at its San Marcos facility, can easily support DoD's demand, if necessary.
- UMC is uniquely well-positioned to avoid bottlenecks in raw materials and other input items to produce NdFeB magnets. Whereas traditional magnet manufacturing has relied on extensive supply chains from mine-to-magnet, UMC's revolutionary M2M® technology offers closed-loop capabilities that remove a potential source of vulnerability and instability.
- Current global demand for NdFeB magnetic materials is around 170,000 tons of material per year, or about $20 billion. This demand is expected to at least double within the next decade. Due to failures in the production chain and increased geopolitical risk with China, data shows demand will outpace supply as early as 2026.
- Risk mitigation is especially important in the rare earth markets because of the geopolitical climate and supply pressures resulting from growing demand and price volatility.
- By the early 1990s, there were four major NdFeB magnet mills in the United States (Crucible, Hitachi, Magnequench, and Ugimag) that were all closed and exported out of the U.S. by 2005. This caused thousands of Americans to lose their jobs and the U.S. to lose valuable technology that has not been recoverable until the establishment of UMC.
- For decades, the U.S. government and others have attempted to develop substitutes for NdFeB magnets. To date, none of these substitution efforts have successfully reduced demand. As the most powerful permanent magnets available, NdFeB magnets will have an important part in our future, especially as electric vehicles replace fossil fuel-driven vehicles in the coming decades.

Entity Name: Air-Conditioning, Heating, And Refrigeration Institute (AHRI)

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☒ ii:☐ iii:☐ iv:☒ v:☒ vi:☐ vii:☒ viii:☒

Executive Summary:
Our member companies have grave concerns about the possibility of tariffs being placed on essential products for human health, safety, and comfort, many of which contain NdFeB magnets. While AHRI and its members appreciate the foundational reasoning of the investigation, we strongly believe that it is against the interests of U.S. consumers and workers to impose tariffs on NdFeB magnets. There is no ready substitute for NdFeB magnets. Tariffs on NdFeB magnets or imported products that contain these magnets will not address any national security issues and would only hurt consumers in this time of rising temperatures, higher prices and supply chain disruptions. We believe the solution is instead to invest in R&D in a North American NdFeB mining and processing industry.

Air-Conditioning, Heating, And Refrigeration Institute (AHRI)'s main arguments are as follows:

- Our member companies have grave concerns about the possibility of tariffs being placed on essential products for human health, safety, and comfort, many of which contain NdFeB magnets.
    - Further, there is no ready substitute for NdFeB magnets. Tariffs on NdFeB magnets or imported products that contain these magnets will not address any national security issues and would only hurt consumers in this time of rising temperatures, higher prices and supply chain disruptions.
- The HVACR and water heating industry represents a sector of critical infrastructure that would be injured by Section 232 tariffs on NdFeB magnets or NdFeB magnet-containing products.
- While AHRI and its members appreciate the foundational reasoning of the investigation, we strongly believe that it is against the interests of U.S. consumers and workers to impose tariffs on NdFeB magnets. Many products manufactured in the U.S. require key inputs that must be imported from other countries. In this case, the supply of NdFeB is concentrated in China.
    - Therefore, we believe the solution to this problem is to diversify the supply by investing in research and development (R&D) of a North American NdFeB magnet mining and processing industry.
- In summary, we believe the solution is to not impose tariffs on NdFeB magnets or products that contain them. Doing so would not save American jobs or protect national security, rather it would simply hurt competitiveness, increase prices of essential goods, and cause production stoppages at North American facilities.
    - We believe the solution is instead to invest in R&D in a North American NdFeB mining and processing industry.
    - Should the Department of Commerce decide to move forward with Section 232 tariffs on NdFeB magnets, contrary to the recommendation of AHRI, we request that it allow for an exemption to the HVACR and water heating industry so that the access to critical products for U.S. consumers will not be hindered.

Entity Name: Motor & Equipment Manufacturers Association (MEMA)

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☒ ii:☐ iii:☐ iv:☐ v:☐ vi:☐ vii:☒ viii:☒

Executive Summary:
MEMA represents over 900 vehicle suppliers that develop innovative technologies and manufacture and remanufacture original equipment (OE) and aftermarket components and systems for use in passenger cars and commercial trucks. Neo-magnets are critical inputs used in certain vehicle components and systems. U.S.-based manufacturers rely on neo-magnets and neodymium because there are few alternatives available to achieve the level of quality, performance, and durability required for these essential vehicle components and systems – several of which are safety-critical – needed for electrified and advanced technology vehicles. In sum, MEMA urges the Department of Commerce and BIS to not recommend the imposition of any Section 232 actions against neo-magnets – both standalone neo-magnets and finished goods with neo-magnets embedded.

Motor & Equipment Manufacturers Association (MEMA)'s main arguments are as follows:

- MEMA represents over 900 vehicle suppliers that develop innovative technologies and manufacture and remanufacture original equipment (OE) and aftermarket components and systems for use in passenger cars and commercial trucks.
- Since 2012 – driven in large part by federal greenhouse gas emissions and fuel efficiency rules – vehicle suppliers have invested billions of dollars in the U.S. establishing more manufacturing facilities and innovation centers that conduct research, testing and development.
- Now, more than ever, the vehicle industry is at an inflection point as it moves towards an economy-wide net-zero emissions future with new propulsion technologies – including battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell electric vehicles (FCEVs), and advanced internal combustion engines (ICE).
- Neo-magnets are critical inputs used in certain vehicle components and systems. Different vehicle suppliers may process neodymium materials in various ways – depending on their products. Importantly, many of the electric power steering motors and related components are incorporated into electric vehicles.
- As is common knowledge, the primary source of this rare earth material is China. Anecdotally, our members have indicated that the costs of these materials continue to increase, and capacity is expected to be further constrained as demand for neo-magnets rises.
- U.S.-based manufacturers rely on neo-magnets and neodymium because there are few alternatives available to achieve the level of quality, performance, and durability required for these essential vehicle components and systems – several of which are safety-critical – needed for electrified and advanced technology vehicles.
- MEMA members continue to struggle with shortages, allocation shortfalls, extended lead times, unreliable deliveries, and exorbitant price increases for a wide range of raw materials and components.
- In sum, MEMA urges the Department of Commerce and BIS to not recommend the imposition of any Section 232 actions against neo-magnets – both standalone neo-magnets and finished goods with neo-magnets embedded.

Entity Name: Trade Pacific PLLC

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: U.S. Business
Criteria Covered:
i:☒ **ii:**☐ **iii:**☐ **iv:**☐ **v:**☒ **vi:**☒ **vii:**☒ **viii:**☒

Executive Summary:
MMI was founded in 1976 in Castle Rock, Colorado and has grown to become a large distributor of magnets and magnetic devices for commercial, industrial, and consumer uses. MMI is concerned that if Section 232 duties or quotas are placed on neodymium magnets, its business will suffer serious hardship without advancing any national security interest. The reality that any Section 232 action could (1) ensnare magnets with no security application and (2) that there is presently no U.S. production should inform any reports or recommendations from BIS.

Trade Pacific PLLC's main arguments are as follows:

- On behalf of Master Magnetics Inc. ("MMI"): MMI was founded in 1976 in Castle Rock, Colorado and has grown to become a large distributor of magnets and magnetic devices for commercial, industrial, and consumer uses. MMI employs 106 people at 4 facilities in the USA. MMI imports ceramic, alnico, samarium cobalt, and neodymium raw material magnets and assemblies thereof.
- Magnets have been MMI's core product since it was founded and this business generates $25-30 million in annual revenue. MMI is concerned that if Section 232 duties or quotas are placed on neodymium magnets, its business will suffer serious hardship without advancing any national security interest.
- In addition, MMI imports neodymium magnets because there is no U.S. production. Over time, the manufacturing of various magnet material decreased in the United States to the point that there is no meaningful production of which MMI is aware.
- The reality that any Section 232 action could (1) ensnare magnets with no security application and (2) that there is presently no U.S. production should inform any reports or recommendations from BIS.
- First and as mentioned above, BIS should explore further how to focus any 232 duties or quotas only on those neodymium magnets with security or critical infrastructure applications. If the intervention is not focused on those goods that implicate national security, then the benefits of the intervention would also be diminished.
- Second, if BIS is unable to identify general categories of magnets with security implications due to the challenge of drawing distinctions between low-technology and high-technology magnets, then BIS should confirm that an exclusion process will be available so specific companies can seek exclusion from 232 duties for specific products.
- Third, considering that there is no U.S. production presently, the time before any measures to be implemented should align with the time for investments in U.S. production of neodymium magnets to result in product availability. It will take at least three to four years before it could serve any meaningful share of the U.S. market.
- Japan and other countries possess neodymium manufacturing. Measures to incentivize supply chains with those trading partners would advance the national security concern without the associated damage to consumer prices caused by blanket Section 232 duties.

Entity Name: Usa Rare Earth LLC

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☒ iii:☒ iv:☐ v:☒ vi:☐ vii:☒ viii:☒

Executive Summary:
USA Rare Earth is a U.S.-based company establishing a fully vertically integrated mine-to-magnet supply chain for sintered NdFeB rare earth permanent magnets in the United States. Currently, the U.S. lacks a commercial-scale capability to process rare earth permanent magnets used in the automotive, aerospace, defense and electronics industries. USA Rare Earth is strongly capitalized to restore the operations of the NdFeB magnet manufacturing system it acquired from Hitachi Metals America, Ltd. in April 2020. USA Rare Earth supports the following pieces of legislation: The Rare Earth Magnet Manufacturing Production Tax Credit Act of 2021, H.R. 503315, Reclaiming American Rare Earths Act (RARE Act), H.R. 268816, and Build Back Better Act, H.R. 5376 - RULES COMMITTEE PRINT 117–1717, Section 31401.

Usa Rare Earth LLC's main arguments are as follows:

- USA Rare Earth is a U.S.-based company establishing a fully vertically integrated mine-to-magnet supply chain for sintered NdFeB rare earth permanent magnets in the United States. In 2020, our company acquired the only neodymium magnet plant in the Americas, formerly owned and operated by Hitachi Metals in North Carolina.
- We are committed to keeping this national strategic asset inside the U.S., and we plan to bring it back into operation during 2022 for the first time since 2015.
- Currently, the U.S. lacks a commercial-scale capability to process rare earth permanent magnets used in the automotive, aerospace, defense and electronics industries.
    - USA Rare Earth is strongly capitalized to restore the operations of the NdFeB magnet manufacturing system it acquired from Hitachi Metals America, Ltd. in April 2020. The company announced in May 2021 it completed a $50 million Series C Funding Round through which the Company's wholly owned subsidiary, USA Rare Earth Magnets, is fully funded to recommission the magnet manufacturing system.
- Prior to commercial production at the Round Top Mine, USA Rare Earth will acquire third-party alloy feedstock to bring the magnet plant into production during 2022. The Company anticipates producing 1,200 tonnes of NdFeB magnets during its initial partial year of production while ramping up to full productions of 2,400 tonnes of NdFeB magnets utilizing non-China sources of rare earth feedstock material.
- Once in production, the Round Top mine will be one of three rare earths producers located outside of China. At the top of the range is USA Rare Earth's Round Top project with a basket price of marketed rare earths of more than $95/kg (based on March 2021 China export prices) compared with basket prices of $20/kg to $30/kg for current producers in China and elsewhere. This pricing difference reflects the more valuable and significant demand for NdFeB magnet-quality rare earth elements.
- The Rare Earth Magnet Manufacturing Production Tax Credit Act of 2021, H.R. 503315, would establish a $20 per kilogram Production Tax Credit ("PTC") for the production of rare earth magnets that are manufactured in the U.S., and an enhanced credit of $30.00 per kilogram for

rare earth magnets manufactured in the U.S. and for which all component rare earth material is produced domestically.

- USA Rare Earth also supports the Reclaiming American Rare Earths Act (RARE Act), H.R. 268816, as it would create new business expensing incentives for the upstream production of rare earth elements. The legislation would provide permanent full business expensing for qualified property which is substantially involved in the mining, reclaiming, or recycling of rare earth elements and certain critical minerals from deposits in the United States.
- Lastly, the Build Back Better Act, H.R. 5376 - RULES COMMITTEE PRINT 117–1717, Section 31401 Manufacturing Supply Chain Resilience, if enacted, would appropriate $5 billion to the Department of Commerce to support the reliance of supply chains by providing grants, loans, and loan guarantees to maintain and improve manufacturing supply chain resiliency

Entity Name: Delegation of the European Union to the United States of America

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Foreign Government
Criteria Covered:
i:☐ ii:☐ iii:☐ iv:☐ v:☐ vi:☐ vii:☐ viii:☒

Executive Summary:
The current US administration continues to launch US Section 232 national security investigations, for what appears to be industrial policy reasons. The EU wants to recall that, with regard to the critical material sector (which includes permanent magnets), the EU and the US have agreed during the first inaugural meeting of the EU-US Trade and Technology Council on 29 September 2021 to work together on advancing respective supply chain resilience and security of supply in this key sector. The EU would also like to recall that no exception in the WTO's General Agreement on Tariffs and Trade ("GATT") can justify unilateral measures, such as import restrictions, taken by a developed country for the purpose of protecting a domestic industry against foreign competition.

Delegation of the European Union to the United States of America's main arguments are as follows:

- The current US administration continues to launch US Section 232 national security investigations, for what appears to be industrial policy reasons. The proliferation of such investigations and possible actions under the guise of national security to protect certain industrial sectors against foreign competition is of great concern to the EU.
- The EU wants to recall that, with regard to the critical material sector (which includes permanent magnets), the EU and the US have agreed during the first inaugural meeting of the EU-US Trade and Technology Council on 29 September 2021 to work together on advancing respective supply chain resilience and security of supply in this key sector.
- The EU is an important trading partner for the US: in 2020, US imports of neodymium magnets from the EU constituted the third most important source of US imports representing around 15% of the total. As a result, the EU constitutes a reliable source of input, with a significant potential to further increase in the coming years, which would contribute towards a more stable and diversified sourcing of such important inputs for US and EU industries.
- The EU would also like to recall that no exception in the WTO's General Agreement on Tariffs and Trade ("GATT") can justify unilateral measures, such as import restrictions, taken by a developed country for the purpose of protecting a domestic industry against foreign competition.
    - The EU continues to believe that trade distortive actions based on national security cannot provide a lasting solution for any industry-based sector, including US neodymium magnets producers.
- Without prejudice to its WTO rights, the EU also wishes to underline that the Department of Commerce's analysis of national security must be narrowly tailored to focus on real and direct threats to national security.
- The EU wishes to emphasise the need for both the EU and US to advance their ongoing existing strands of cooperation for this strategic product. The US supply chain review recalls that the EU and the US have already an extensive cooperation for several initiatives and, as mentioned above, can further develop this within the EU and US Trade and Technology Council.

Entity Name: Lynas Rare Earths Ltd

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Foreign Business
Criteria Covered:
i:☐ ii:☐ iii:☐ iv:☐ v:☒ vi:☐ vii:☒ viii:☐

Executive Summary:
Lynas is the world's largest producer of separated rare earth products outside of China. China's successful 'Made in China' policy has resulted in nearly all viable, non-Chinese rare earth manufacturing being insourced to China. A magnet maker outside China who sources rare earths oxide, metal or alloy from inside China pays 13-20% more for raw rare earth material than a magnet maker located inside China. For a magnet manufacturing plant to be economically viable/competitive on the global stage, it must have access to magnet by-products, particularly swarf.

Lynas Rare Earths Ltd's main arguments are as follows:

- Lynas is the world's largest producer of separated rare earth products outside of China. Lynas produces separated Light Rare Earth (LRE) products and a mixed Heavy Rare Earth (HRE) compound (SEG+) to a globally diverse set of strategic customers.
- China's successful 'Made in China' policy has resulted in nearly all viable, non-Chinese rare earth manufacturing being insourced to China. China now has an overwhelmingly dominant position in the magnet industry with, according to external research has 94% market share; while Japan has 5% and the E.U. 1%.
    - However, Japan remains a leader in high performance magnets.
- The Chinese state sponsored rare earths sector supports domestic activities and champions.
    - A magnet maker outside China who sources rare earths oxide, metal or alloy from inside China pays 13-20% more for raw rare earth material than a magnet maker located inside China.
- For a magnet manufacturing plant to be economically viable/competitive on the global stage, it must have access to magnet by-products, particularly swarf.
    - While it is technically feasible to build an SX system to extract and separate discrete rare earth materials from swarf – and this is done at some facilities overseas - a dedicated factory is yet another cost penalty to be absorbed by the non-Chinese producer.
- In order for the U.S. to catalyze a domestic NdFeB magnet manufacturing industry -- an industry which currently does not commercially exist -- the U.S. Government must consider a whole of government strategy, including:
    - Grants (e.g., direct payments), subsidies (e.g., favorable tax treatment for the investment in or production of rare earth products, including downstream metal and magnet making) and other incentives
    - Mandating domestic purchasing of ethically and sustainably produced goods/practices throughout the rare earth supply chain
    - Mandating a minimum of domestically sourced content
    - Providing subsidies/rebates on materials sourced from outside China and processed into magnets outside China

Entity Name: U.S. Chamber Of Commerce

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☐ ii:☐ iii:☐ iv:☐ v:☐ vi:☐ vii:☒ viii:☒

Executive Summary:
NdFeB permanent magnets are essential inputs used in electric vehicle motors, medical equipment, wind turbines, and elements of defense systems, among other products. While we support the Biden administration's efforts to reduce U.S. reliance on imports of critical materials from foreign adversaries and secure domestic and allied sources of strategic minerals, we do not view tariffs or quantitative restrictions as effective tools to address these concerns. Domestic production of NdFeB permanent magnets — as well as rare earth components — is nearly non-existent. Imposing tariffs or quotas would be extremely disruptive in the short term under these circumstances.

U.S. Chamber Of Commerce's main arguments are as follows:

- NdFeB permanent magnets are essential inputs used in electric vehicle motors, medical equipment, wind turbines, and elements of defense systems, among other products.
- While we support the Biden administration's efforts to reduce U.S. reliance on imports of critical materials from foreign adversaries and secure domestic and allied sources of strategic minerals, we do not view tariffs or quantitative restrictions as effective tools to address these concerns.
- Domestic production of NdFeB permanent magnets — as well as rare earth components — is nearly non-existent. Imposing tariffs or quotas would be extremely disruptive in the short term under these circumstances.
- The Chamber strongly supports that approach and urges the administration to prioritize further progress on that front, to include domestic production of these strategic minerals as well as production in the territory of allied nations.
- The Chamber questions the efficacy of Section 232 import restrictions as a useful tool in this regard. In addition to the unintended consequences already cited, the imposition of tariffs or quotas could lead companies to offshore production of devices made with these magnets.

Entity Name: Government of Japan

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Foreign Government
Criteria Covered:
i:☒ ii:☐ iii:☐ iv:☐ v:☒ vi:☐ vii:☐ viii:☒

Executive Summary:
The U.S. trade relationship with Japan, an ally, contributes not only to the economic prosperity and the international competitiveness of the U.S., but also to its national security. Imports of neodymium magnets and the products using them from Japan have never posed a threat to the national security of the United States. On the contrary, as an important ally and partner of the U.S., Japan has profoundly contributed to the resilience of the entire U.S. supply chain. It's to be noted that it is practically difficult to completely eliminate neodymium magnets manufactured in specific countries and the products using them from the supply chain.

Government of Japan's main arguments are as follows:

- The U.S. trade relationship with Japan, an ally, contributes not only to the economic prosperity and the international competitiveness of the U.S., but also to its national security. Establishing stable supply relationships between the U.S. and Japan of neodymium magnets and products using them also supports the national security of the United States.
- In the investigation on neodymium magnets under Section 232 of the Trade Expansion Act, we acknowledge that the U.S. has expressed its concerns about
    - (1) the fact that numerous critical national security systems rely on neodymium magnets, including fighter aircraft and missile guidance systems.
    - (2) the fact that neodymium magnets are essential components of critical infrastructure, including electric vehicles and wind turbines.
    - The facts above show the high demand in the U.S. supply chain for Japan's high-grade neodymium magnets and products using them. In this regard, Japan has deeply contributed to the U.S. economy, including its economic security, as an important supplier of neodymium magnets and products using them.
- Imports of neodymium magnets and the products using them from Japan have never posed a threat to the national security of the United States. On the contrary, as an important ally and partner of the U.S., Japan has profoundly contributed to the resilience of the entire U.S. supply chain.
- It's to be noted that it is practically difficult to completely eliminate neodymium magnets manufactured in specific countries and the products using them from the supply chain.
- It should also be noted that any trade measures should be consistent with the WTO Agreement, as trade restrictive measures may lead to a decline in the industrial competitiveness of U.S. users of neodymium magnets and their products.

Entity Name: National Electrical Manufacturers Association

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☐ ii:☐ iii:☐ iv:☐ v:☐ vi:☒ vii:☒ viii:☒

Executive Summary:
NEMA represents more than 300 pro-growth American companies employing over 300,000 U.S. workers in more than 6,100 facilities covering every state. NEMA opposes tariffs on neodymium-iron-boron permanent magnets (neodymium magnets). NEMA supports the domestic neodymium magnet industry, though the processing capacity needed to make these magnets is extremely limited in the U.S. The tariffs will not only impact electroindustry manufacturers' supply chains but may also impact their customers' supply chains and the broader U.S. industrial and infrastructure base.

National Electrical Manufacturers Association's main arguments are as follows:

- NEMA represents more than 300 pro-growth American companies employing over 300,000 U.S. workers in more than 6,100 facilities covering every State
- NEMA opposes tariffs on neodymium-iron-boron permanent magnets (neodymium magnets). NEMA supports the domestic neodymium magnet industry, though the processing capacity needed to make these magnets is extremely limited in the U.S.
- Attempting to raise a domestic industry through tariffs is not an effective approach. The tariffs will not only impact electroindustry manufacturers' supply chains but may also impact their customers' supply chains and the broader U.S. industrial and infrastructure base.
- Neodymium magnets and imported goods that are embedded with those magnets are key to the functionality of hundreds of products and responsible for thousands of U.S. jobs throughout the supply chain.
- NEMA strongly supports the Administration's goals of electrification and infrastructure improvement. Achievements in these areas will not be feasible unless American manufacturers can source vital components for infrastructure products. Products that use these magnets provide power density levels unattainable with traditional materials dramatically reducing power usage.
- Tariffs on the components or finished goods that embed neodymium magnets will be counterproductive to the U.S. economy and lead to further supply chain challenges and higher prices at U.S. factories and on consumers.

Entity Name: Autos Drive America

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☒ ii:☐ iii:☐ iv:☐ v:☐ vi:☐ vii:☐ viii:☒

Executive Summary: Autos Drive America recognizes geopolitical and potential shortage issues in the NdFeB permanent magnet supply chain but argues that concerns are best addressed through R&D incentives, production incentives, and public-private workforce education initiatives rather than tariffs or quantitative import restrictions. Their member companies and suppliers rely on NdFeB magnets embedded in components, and anticipate increasing magnet use because of electric vehicle production.

Autos Drive America's main arguments are as follows:

- "Our member companies and their suppliers rely on the availability of neodymium-iron-boron permanent magnets as part of other components used in their U.S. automotive production." Their members "purchase the components that rely on the magnets critical to their function from U.S. suppliers as well as suppliers based in Japan, Germany, Canada, among others."
- While "our member companies use limited amounts of neodymium magnets in their current U.S. production" they point to concerns "that shortages will soon develop as production of electrified vehicles, including hybrid and battery electric vehicles, dramatically increases." NdFeB magnets "create electric motors that are more efficient allowing for better range capabilities in electric vehicles."
- "The nearly nonexistent U.S. production of neodymium magnets prohibits electric motor manufacturers from sourcing the minerals in the United States. Achieving commercial-scale production of NdFeB would take several years to achieve."
- They oppose tariffs and quotas and suggest that, "Incentives dedicated for funding of research and development, production facilities, and public-private partnerships to promote education and job training pathways could be ways to attract the investment needed to create the needed production capacities in the United States."

Entity Name: Semi
Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☒ ii:☐ iii:☐ iv:☐ v:☐ vi:☐ vii:☐ viii:☒

Executive Summary: SEMI emphasizes the ubiquity of permanent magnets in semiconductor manufacturing equipment and ancillary OEM equipment. They claim that U.S.-based manufacturers rely mostly on Japanese-produced magnets that use Australian rare earths. Semi is concerned that tariffs would hurt sourcing options and costs for the semiconductor industry. They also provided information from a member company on that firm's consumption of NdFeB magnets (see below).

Semi's main arguments are as follows:

- NdFeB magnets "are found in almost every [semiconductor manufacturing equipment] tool, as well as "ancillary OEM equipment such as vacuum pumps, heat exchangers, small motors, and purchased robots."
- "Most magnets used by [semiconductor manufacturing equipment] manufacturers in the U.S. are sourced from Japan, using mostly Australian rare earth exports for the manufacturing of these magnets."
- "Due to the commodity nature of the market, an interruption from China, the world's dominant commodity exporter, could create market panic despite other sources."
- One of their members consumed 15 tonnes of NdFeB magnets for magnetrons, magnetic coupling on build to print robots and motion components, and sensors, up 50% from 2020, with demand forecasted to rise 40% in 2022. 95% of these (sintered) magnets came from Japan, with ore originating in Australia, China, and unspecified recycling; less than 5% came from China. All dysprosium used in magnets comes from China. This consumer estimates North American magnets are 5 years away.

Entity Name: National Foreign Trade Council

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☐ **ii:**☐ **iii:**☐ **iv:**☐ **v:**☐ **vi:**☐ **vii:**☐ **viii:**☒

Executive Summary: National Foreign Trade Council argues strongly against the application of tariffs on NdFeB permanent magnets, which would impact sourcing and final product costs, and discourage production of goods containing NdFeB magnets which includes critical infrastructure. They suggest funding R&D, subsidizing domestic production, and workforce training initiatives.

National Foreign Trade Council's main arguments are as follows:

- They noted that NdFeB magnets are essential components of critical infrastructure: electric motors, permanent magnet motors, monitors and sensors including in MRIs, computer chip manufacturing, computer hard drives and audio equipment, and wind turbines
- They argue tariffs would adversely impact sourcing and final product costs, and thereby discourage assembly and manufacturing of products containing NdFeB magnets.
- They favor incentives, such as "dedicated funding for research and development, subsidies for production facilities, and public-private partnerships to promote educational and job training pathways to domestic manufacturing jobs."

Entity Name: Embassy of Canada
Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Foreign Government
Criteria Covered:
i:☐ ii:☐ iii:☒ iv:☐ v:☐ vi:☐ vii:☐ viii:☒

Executive Summary: The Embassy of Canada emphasizes that Canada is an essential security partner of the U.S., based on U.S. policy and law. They also note that the U.S. and Canada finalized a joint action plan January 9, 2020 on critical minerals collaboration. As a result, any U.S. action should conclude imports of NdFeB magnets from Canada are not a national security threat and be consistent with WTO and CUSMA commitments. They also outline the current state of the NdFeB magnet supply chain in Canada, and emphasize that Canadian companies can be part of a resilient supply chain for the U.S.

Embassy of Canada's main arguments are as follows:

- Canada is a trusted defence and security partner of the United States, as well as a secure, responsible source of critical minerals. Canada is working with the United States to establish diversified critical mineral supply chains through the Canada-U.S. Joint Action Plan for Critical Minerals Cooperation. Canada and the United States are engaged in ongoing discussions on critical minerals…through the National Technology and Industrial Base working group.
- Clean energy technology will increase demand, such that "From 2020 to 2030, global annual demand for magnet rare earth oxides…is forecasted to increase by 150%, requiring more than a two-fold increase in global production."
- There is current business cooperation between U.S. and Canadian firms. USA Rare Earth has partnerships with Canadian companies Search Minerals and Geomega, and Canadian companies have applied to Department of Defense (DoD) REE production procurement opportunities.
- Their submission included an overview of the Canadian market. In terms of mining, Cheetah Resources opened Canada's first REE mine in 2021, the Nechalacho Rare Earth project. Cheetah aims to produce 470 tonnes/year of neodymium/praseodymium and 940 tonnes/year by 2025, which would represent over 25% of neodymium not sourced or processed in China. Cheetah will send the rare earth concentrate to its extraction plant in Saskatchewan, with the first mixed rare earth carbonate to be produced in June 2022. Cheetah's parent company, Vital Metals, has a definitive offtake agreement with Norway-based REEtec to separate the mixed rare earth oxides, and has signed a Memorandum of Understanding with Ucore Rare Metals, which is developing a separation facility in Alaska. In addition to Cheetah, "there are approximately a dozen advanced stage exploration projects across the country. Canada has some of the largest known reserves and resources (measured and indicated) of rare earths in the world, estimated at approximately 14M tonnes of rare earth oxides."
- Separation projects are also underway: In August 2020 Saskatchewan announced $31 million in funding to develop a processing and separation facility, expected to be operational by 2024.
- There are at least two Canadian magnet producers: "Neo Performance Materials has global operations, and produces magnetic powders and magnets, specialty chemicals, metals, and alloys critical to the performance of current and especially emerging technologies. Neo's Magnequench is a global leader in bonded NdFeB magnetic powders and magnets." Jobmaster Magnets Canada Inc. builds rare earth magnets of Chinese origin.

Entity Name: Mp Materials Corp

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: U.S. Business
Criteria Covered:
i:☒ **ii:**☒ **iii:**☒ **iv:**☒ **v:**☒ **vi:**☐ **vii:**☒ **viii:**☒

Executive Summary: MP is the largest rare earth materials producer outside of China. MP wants to restore the full rare earth supply chain to the US by producing REE concentrated, separated REEs, and NdFeB magnets. MP notes that US dependence on foreign and especially Chinese imports is a national security issue given the use of NdFeB magnets in defense and critical commercial applications. The US must establish commercially viable capabilities across the full supply chain. The US government must support private sector actors, and NdFeB customers must recognize resiliency and sustainability as important values. They cite current legislation making US magnets eligible for tax credits, global sustainability standards to allow environmental and social factors to be incorporated into the marketplace, patent sharing between the US and Japan, and ensuring remedies do not hurt US manufacturing or the magnet industry.

Mp Materials Corp's main arguments are as follows:

- NdFeB magnets contain about 1/3 neodymium. They are engineered products used in numerous applications (listed). US production of separated REEs has been constrained and domestic production of sintered NdFeB magnets is almost non-existent. China produces 80% of the world's separated REEs and 90% of the NdFeB magnets. China is the only country with capabilities throughout the supply chain. Bar Japan, allies' capability to produce NdFeB alloys and magnets is limited. Most magnet imports are embedded in downstream goods. Chinese dominance is due to magnet material capacity, subsidies of the cost of capital, tax and trade schemes that advantage domestic producers, and substandard environmental and labor conditions that disadvantage other producers. China has consolidating its domestic REE materials industry, which will enable more centralized control by state owned enterprises. Chinese NdFeB producers, along with the Japanese, hold key patents. Bar Japan, allies' capability to produce NdFeB alloys and magnets is limited. Most magnet imports are embedded in downstream goods.
- US producers currently cannot support either defense or commercial needs. Defense needs are small enough that they cannot support economically viable NdFeB magnet production. However, one modern large-scale facility can meet nearly the defense and civilian demand combined.
- In addition to no separation or magnet production capacity, the US has limited human capital capacity. Investment in the workforce is critical for NdFeB materials capacity. MP is a significant employer and will grow as it moves downstream.
- In 2020 MP's Mountain Pass produced 38,500 metric tons of rare earths, representing 15% of global production. MP is implementing a three stage strategy across the NdFeB supply chain: 1) producing REE concentrate (completed), 2) separating REEs (2022), and 3) producing metal, alloy, and magnets (ASAP). MP has significantly increased production of REE concentrate at its mine since 2017. Mountain Pass' 7% REE content (versus .1 to 4% for most global deposits) provides MP with a leading cost position. MP believes Mountain Pass is the world's cleanest REE

facility, because of the ore composition and production process. There is currently no production of separated REEs in the US, so MP exports its concentrate to China. However, MP expects to achieve a 2023 production rate of 20,000 metric tons of separated REO per year, including 6,075 metric tons of separate neodymium-praseodymium oxide per year. MP is retrofitting an existing processing facility to make separate rare earth oxides more reliably with a smaller environmental footprint. In stage 3, MP plans to use the separated REEs to manufacture NdPr metal, alloy, and magnets in the US through a merger, JV, or greenfield investment. They plan to announce the site of an initial magnet facility by the end of 2021.

Entity Name: Australian Government

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Foreign Government
Criteria Covered:
i:☐ ii:☐ iii:☒ iv:☐ v:☐ vi:☐ vii:☐ viii:☒

Executive Summary: The Australian Government notes that it is a close strategic and economic partner of the U.S., citing the USAFTA, ANZUS, and its inclusion in the U.S. NTIB. They note that they are the fourth-largest producer of rare-earth elements including those used in NdFeB permanent magnets, and are making substantial investments in rare earth mining and processing operations. They argue that Australia's strength in the upstream portions of the NdFeB magnet supply chain make it an ideal partner for established Japanese and Korean magnet producers and a nascent downstream U.S. industry, and emphasize they also want to establish a secure and resilient NdFeB magnet supply chain.

Australian Government's main arguments are as follows:

- Australia is the world's fourth-largest producer of rare-earth elements, including NdPR which are used in permanent magnets, and has the world's sixth-largest resource base.
- Australia is developing rare earth recovery and processing operations which can significantly expand supplies of neodymium and praseodymium (NdPr) oxides. They provided an overview of six current projects that will add mining capacity to the rare earth supply chain. As part of these efforts the Australian Government established a $1.4 billion Critical Minerals Facility to provide finance to advanced critical minerals projects where private finance is limited.
- Australia will continue to rely on stable and secure global supply chain partnerships for downstream metal and magnet-making to support end-use markets. Their ability as a reliable and market-oriented producer of upstream materials is an ideal complement to a developing U.S. downstream magnet industry.
- In terms of specific companies, Lynas' Advanced Materials Plant in Malaysia is the most advanced global facility for producing a mixed rare-earth oxide and the largest facility outside of China. It is the leading supplier of NdPr products to the Japanese market. In Australia, Lynas' Mt Weld mine and nearby rare earths processing will provide feedstock for its proposed separation plant in the United States. This will support the development of a domestic U.S. rare earth magnet supply chain.

Entity Name: Business Alliance For Customs Modernization

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☐ ii:☐ iii:☐ iv:☐ v:☐ vi:☐ vii:☐ viii:☐

Executive Summary: The Business Alliance for Customs Modernization wants to ensure that if the Department of Commerce finds NdFeB permanent magnet imports negatively affect national security any measures should give U.S. consumers of magnets time to adjust to new incentives.

Business Alliance For Customs Modernization's main arguments are as follows:

- BACM members have identified NdFeB permanent magnets as critical components in their products. U.S. production currently relies on imported NdFeB magnets, given the lack of suitable domestic suppliers. If imports of NdFeB permanent magnets impair U.S. national security, U.S. producers of goods who rely on imported magnets should be able to access a product exclusion program. U.S. producers who rely on imported NdFeB magnets need time to adjust to any new incentive (e.g., an incentive to source domestically in the form of an additional duty imposed on imports).

Entity Name: United States Magnetic Materials Association (USMMA)
Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☒ ii:☒ iii:☒ iv:☐ v:☐ vi:☐ vii:☐ viii:☐

Executive Summary: USMMA supports the investigation and hopes it can lead to a healthy domestic industrial base. They note the importance of NdFeB magnets to national security and that the current upstream portions of the supply chain from ore to metal are dominated by China. U.S. national security can be met by non-Chinese magnet producers in the UK, Germany, and Japan. Domestic production is hindered by the reticence of Hitachi to grant production licenses and the need for a viable business plan.

United States Magnetic Materials Association (USMMA)'s main arguments are as follows:

- USMMA gave a brief description of the supply chain from ore to concentrate, oxide, metal, alloy and then magnet. They noted that the steps from ore to metals are reliant on Chinese sources, but that there is substantial non-Chinese NdFeB alloy and magnet production. Rare earth alloys and magnets are produced in the United Kingdom, Germany, and Japan. These manufacturers can and do provide magnets to the US. They noted many magnets are imported by distributors, and/or cut, ground and finished domestically, which masks dependence on China.
- Current and projected national defense requirements for sintered NdFeB magnets are and can be filled by non-Chinese foreign producers in the UK, Japan, and Germany. However, the Department of Defense must encourage a culture of compliance to current laws governing high performance magnet production amongst its contractors. The distributor/fabricator model, in which Chinese magnet blocks are cut to size by a U.S. distributor, can mask Chinese dependence. DoD's prime contractors will need to be vigilant in flowing down domestic production requirements of the Specialty Metals Clause (10 U.S.C. 2533b) to the subcontract level to ensure that magnet producers are not using alloys melted or magnets produced (sintered or bonded) outside of qualifying countries.
- There is no current domestic capacity to produce NdFeB magnets, that is to melt alloys and sinter powder. They emphasize that the knowledge produce magnets exists, and that pressing and sintered NdFeB magnets is similar to other high-performance magnets. However, without a Hitachi license or viable business case no production will occur.

Entity Name: Energy Fuels Resources (Usa) Inc

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☐ iii:☒ iv:☒ v:☐ vi:☐ vii:☐ viii:☐

Executive Summary: Energy Fuels Resources supports the investigation and immediate action to ensure a sustainable domestic NdFeB permanent magnet supply chain, including processing upstream materials. The rare earth element carbonate that Energy Fuels Resources produces is used in the production of national security items including NdFeB magnets. Energy Fuels is planning to move downstream to separation and potentially metalization in conjunction with partners.

Energy Fuels Resources (Usa) Inc's main arguments are as follows:

- The White Mesa Mill operated by Energy Fuels is the only operating domestic uranium mill. It is a major producer of a high purity mixed REE carbonate extracted and purified from Monazite ore. Monazite is a high-value mineral with greater percentages of neodymium, praseodymium, and other heavy REEs than Bastnasite mined in California. Energy Fuels currently purchases Monazite from The Chemours Company's heavy mineral sand (HMS) operation in Offerman, Georgia and processes this Monazite at the White Mesa Mill. They also have a strategic agreement with Hyperion Metals for a new HMS mine in Tennessee.
- They expect to sell most or all the REE Carbonate to a separation facility in Europe (Estonia), as there currently are no downstream REE processing facilities in North America. However, Energy Fuels is evaluating the installation of REE Separation and other downstream REE capabilities at the White Mesa Mill in the coming years. Doing so will incentivize downstream domestic production of value-added products in critical sectors.
- To make magnets and other advanced REE materials, REE Oxides must be made into REE metals and alloys. Energy Fuels is evaluating the potential to perform REE metal-making and/or alloying at the White Mesa Mill or elsewhere in Utah. Energy Fuels has already had discussions with end-users, including major automobile manufacturers and magnet-makers, regarding partnering on the manufacturing of rare earth magnets.

Entity Name: Niron Magnetics Inc

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☒ iii:☐ iv:☐ v:☐ vi:☐ vii:☐ viii:☒

Executive Summary: Niron Magnetics Inc. is commercializing a rare earth free permanent magnet from Iron Nitride, which can substitute for several grades of sintered and bonded NdFeB magnets in a variety of applications. They are currently partnering with General Motors and Marquette University in a Department of Energy-funded project to use their magnets in electric vehicles. Niron noted NdFeB magnets are critical to national defense and noted a number of defense-related applications and programs. Niron advocates for additional government funding to accelerate the development of Iron Nitride as a substitute to NdFeB magnets.

Niron Magnetics Inc's main arguments are as follows:

- NdFeB magnets are critical to the national defense supply chain. Multiple military systems require high performance magnets. Aerospace systems like AMRAAM missiles use NdFeB magnets in fin actuators. Both manned and unmanned aircraft use Neodymium magnets in motors, generators, and actuators, including the F-35 Joint Strike Fighter, the MQ-1 Predator UAV, and MQ-9 Reaper UAV. Land-based military systems such as the HMMWV and the M1-A1 Abrams Tank use NdFeB magnets in drive motors and electrical generators. Precision munitions such as the Javelin Missile and Excalibur Artillery Shell use NdFeB magnets in fin actuators. Naval systems also use NdFeB magnets in motors and actuators, such as the Phalanx Close-in Weapons Support system.
- Niron provided market data from 2016 indicating that industrial applications (e.g. generators, actuators) are the largest portion of the market, followed by transportation (e.g. electric vehicles) and buildings (e.g. HVAC systems). Aerospace and defense applications are the smallest volume, because of specialized applications and performance requirements. Alternatives to NdFeB magnets must be dual use.
- Niron Magnetics is commercializing Iron Nitride, a high performance, rare earth free permanent magnet that can substitute for several grades of sintered and bonded NdFeB magnets. This technology emerged from research at the University of Minnesota and was funded in part by ARPA-E. Niron's permanent magnets have remanences higher than, but coercivities lower than, most grades of sintered NdFeB magnets. They are positioned to substitute for NdFeB magnets in applications that require large magnetic flux density but are not heavily loaded, i.e. are subjected to demagnetization fields greater than approximately half the remanence. Their data suggest Niron's magnets exhibit superior temperature stability when compared to Neodymium magnets up to operating temperatures of 200 °C.
- Niron's magnets can substitute for NdFeB magnets in many applications, included in a table in the submission. They are currently partnering with General Motors and Marquette University in a DoE project to develop rare earth free electric vehicle motors. Further government funds are needed to reduce time to market and capacity expansion.

Entity Name: General Motors Company
Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: U.S. Business
Criteria Covered:
i:☐ ii:☐ iii:☒ iv:☐ v:☐ vi:☐ vii:☐ viii:☒

Executive Summary: General Motors notes that NdFeB magnets and rare earth elements are critical to electric vehicle production. Current electric vehicle product networks are global in nature, with upstream and midstream production distributed around the world. As a result, GM opposes tariffs and advocates for the use of incentives for production along the supply chain, workforce training initiatives, and collaboration with U.S. allies.

General Motors Company's main arguments are as follows:

- NdFeB magnets and rare earths play an important role in GM's strategic vision, because rare earth elements are one of the most important, high-cost, and potentially supply-constrained components for EV drive trains. NdFeB magnets in drive trains use the energy stored in the battery to propel the vehicle. Rare earth elements are critical to achieving magnetic properties that enable desired motor performance and increased coercivity, which improves a magnet's tolerance to high temperatures. These magnets have the highest performance of any magnet used for automotive applications. They come at a cost premium but have the necessary robustness to temperature while yielding the highest torque. Demand for rare earths is likely to increase over the next ten years, with an increasing share consumed by electric vehicles.
- EV drive unit supply chains are necessarily global in nature, as much of the "upstream" raw materials and "midstream" processing capabilities are distributed around the world and dominated by non-US suppliers. Other jurisdictions are shaping the EV supply chain: The European Commission allocated $3 billion to support the development of EV and battery materials, manufacturing, and recycling, while China has devoted more than $50 billion to vehicle electrification initiatives. GM is actively working to secure supply of rare earth elements and on-shore the related magnet manufacturing footprint. GM recently signed a non-binding Memorandum of Understanding with GE Renewable Energy to evaluate opportunities to improve supplies of rare earth materials, among others, for electric vehicles and renewable energy equipment
- Tariffs would raise costs for EV manufacturers and incentivize foreign production. Instead, GM suggests the following recommendations. They advocate for domestic policy incentives for mineral mining, extraction, and processing, as well as EV component production including magnets at the federal, state, and local level. Incentives should focus on known reserves and processes as well as research and innovation in new extraction and refining/processing methods. GM also advocates collaboration with U.S. allies like Canada and Australia, which possesses significant rare earth reserves, the capability to process these elements, and other advantages that can complement and support EV production in the U.S. Finally, GM notes a domestic workforce with the necessary skills is critical for the EV value chain. U.S. federal, state, and local policy actions and incentives can help attract, develop, and retain a skilled workforce.

Entity Name: American Automotive Policy Council

Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Trade/Manufacturer/Industry Association
Criteria Covered:
i:☐ **ii:**☐ **iii:**☒ **iv:**☐ **v:**☐ **vi:**☐ **vii:**☐ **viii:**☒

Executive Summary: Neodymium magnets are an important and critical component of electric motors used in Electric Vehicles (EVs). AAPC and members are opposed to actions that will directly or indirectly result in adding costs to the manufacture of EVs in the United States, including higher tariffs. They advocate industry collaboration on initiatives like a domestic action plan, incentives, and working with global, asset-rich allies to diversify and support local sourcing and processing of rare earths and critical minerals.

American Automotive Policy Council's main arguments are as follows:

- Neodymium magnets are a critical technology for the future of Electric vehicles (EVs). They are key subcomponents of the most efficient electric drive motors. Although not an essential input for all types of EV electric vehicle motors, they are important in increasing efficiency and range.
- The US automotive industry is expected to increase localization of EV components including electric drive motors, in part because of USMCA rules of origin. Some automakers are looking to reduce the use of rare earth magnets. However, the US auto industry alone is expected to utilize millions of NdFeB magnets and EVs are forecast to consume 25% of NdFeB magnets in 2030.
- China is the largest source of neodymium (58%) followed by the US (16%), Burma (12.3%), and Australia (7%). China is also the largest rare earths processor and manufacturer, with Japan, the EU, and the UK also manufacturing. US rare earth processing and magnet manufacturing is underdeveloped.
- Given status of the NdFeB magnet supply chain and importance of NdFeB magnets to EVs, it is important to ensure that actions do not raise EV manufacturing costs, which would undermine US government efforts aimed at incentivizing EV production and consumption.

Entity Name: Individual (James Smith)
Date Received: 11/12/2021
Date Posted: 11/17/21
Type of Entity: Individual
Criteria Covered:
i:☐ ii:☐ iii:☒ iv:☐ v:☐ vi:☐ vii:☐ viii:☐

Executive Summary: There is a national security strategic imperative to reestablish rare earth magnet production capability from mine to magnets. Many defense systems employ NdFeB magnets, the main supplier of which is China, which is the only great power challenging the US for global economic and strategic military influence. US capability will need to be reconstructed from the ground up, and government partnerships should include environmental issues and forward thinking research techniques.

James Smith's main arguments are as follows:

- There is a national security strategic imperative to reestablish rare earth magnet production capability from mine to magnets. Many defense systems employ NdFeB magnets, the main supplier of which is China, which is the only great power challenging the US for global economic and strategic military influence.
- US capacity will have to be reconstructed, because it is nonexistent. There are resources that can be drawn to restore a small capability, including human capital.
- We should also be forward facing and address new challenges, for instance the environmental challenges caused by the NdFeB magnet supply chain. These issues should be included in any government partnerships use to recreate a mine.
- The metallurgy and physics understanding needed to further improve not just magnet performance but soft magnetic materials and machine design techniques to exploit such gains must also be included in government partnerships.

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OMB Control Number: 0694-0120
Expiration Date: June 30, 2022

Section 232 Investigation into Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets

SCOPE OF ASSESSMENT

The U.S. Department of Commerce, Bureau of Industry and Security (BIS), Office of Technology Evaluation (OTE), is conducting a survey of the U.S. Neodymium-Iron-Boron (NdFeB) Permanent Magnet industry. The survey results will be used to support an ongoing investigation on the effect of imports of NdFeB Permanent Magnets on the U.S. national security initiated under Section 232 of the Trade Expansion Act of 1962, as amended.

The principal goal of this survey is to assist the U.S. Department of Commerce in determining whether NdFeB Permanent Magnet imports are being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security. Information collected will include: organization and facility information, production, feedstock and resale purchases, sales, employment, capital expenditures, research and development, intellectual property, national defense & critical infrastructure, and competition/challenges. The resulting data will provide the U.S. Department of Commerce detailed NdFeB Permanent Magnet industry information that is otherwise not publicly available and needed to effectively conduct this Section 232 investigation.

RESPONSE TO THIS SURVEY IS REQUIRED BY LAW

A response to this survey is required by law (50 U.S.C. Sec. 4555). Failure to respond can result in a maximum fine of $10,000, imprisonment of up to one year, or both. Information furnished herewith is deemed confidential and will not be published or disclosed except in accordance with Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. Sec. 4555). Section 705 prohibits the publication or disclosure of this information unless the President determines that its withholding is contrary to the national defense. Information will not be shared with any non-government entity, other than in aggregate form. The information will be protected pursuant to the appropriate exemptions from disclosure under the Freedom of Information Act (FOIA), should it be the subject of a FOIA request.

Notwithstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB Control Number.

BURDEN ESTIMATE AND REQUEST FOR COMMENT

Public reporting burden for this collection of information is estimated to average 12 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information to BIS Information Collection Officer, Room 6883, Bureau of Industry and Security, U.S. Department of Commerce, Washington, D.C. 20230, and to the Office of Management and Budget, Paperwork Reduction Project (OMB Control No. 0694-0120), Washington, D.C. 20503.

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General Instructions	
A.	Your organization is required to complete this survey of the U.S. NdFeB Permanent Magnet industry, which can be downloaded from the BIS website: https://www.bis.doc.gov/ndfeb-232 If you are unable to download the survey document, at your request, BIS survey support staff will e-mail the Excel survey template directly to you. For your convenience, a PDF version of the survey and required drop-down content is available on the BIS website to aid internal data collection. **DO NOT SUBMIT** the PDF version of the survey as your response to BIS. Should this occur, your organization will be required to resubmit the survey in the requested Excel format.
B.	Respond to every question. Surveys that are not fully completed will be returned for completion. Use the comment boxes to provide any information to supplement responses provided in the survey form. Make sure to record a complete answer in the space provided, even if the space does not appear to expand to fit all of the information. **DO NOT CUT AND PASTE RESPONSES WITHIN THIS SURVEY OR PASTE IN RESPONSES FROM OUTSIDE THE SURVEY**. Survey inputs should be completed by typing in responses or by using a drop-down menu. The use of cut and paste can corrupt the survey template. If your survey response is corrupted as a result of cut and paste response, your survey will be rejected and your organization must immediately resubmit the survey.
C.	**Do not disclose any U.S. Government (USG) classified information in this survey form.**
D.	Upon completion of the survey, final review, and certification, **transmit the survey document via e-mail to**: NdFeB232@bis.doc.gov
E.	Questions related to the survey should be directed to BIS survey support staff at NdFeB232@bis.doc.gov E-mail is the preferred method of contact. You may speak with a member of the BIS survey support staff by calling (202) 482-0194.
F.	For questions related to the overall scope of this Section 232 Investigation, contact NdFeB232@bis.doc.gov or: Jason D. Bolton Program Manager, Industrial Studies BIS/Export Administration/Office of Technology Evaluation 1401 Constitution Avenue, NW, Room 1093 Washington, DC 20230 **DO NOT** submit completed surveys to Mr. Bolton's postal or personal e-mail address. All surveys must be submitted electronically to: NdFeB232@bis.doc.gov
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Definitions

Term	Definition
Authorizing Official	An executive officer of the organization or business unit or another individual who has the authority to execute this survey on behalf of the organization.
Bonded NdFeB Magnet	A magnet comprised of NdFeB powder bound by a matrix of polymer produced via compression, injection or calendaring.
Capital Expenditures	Investments made by an organization in buildings, equipment, property, and systems where the expense is depreciated. This does not include expenditures for consumable materials, other operating expenses, and salaries associated with normal business operations.
Critical Infrastructure	Sectors whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health and safety, or any combination thereof.
Customer	Any organization (external or internal entity) for which your organization manufactures/processes any product comprised of NdFeB Permanent Magnets or related products.
Defense-related Sales/Activities	Any product or service that your organization produces that is ultimately used by the U.S. Government for defense purposes, whether by the armed services, the Department of Defense, or any other U.S. Government entity.
Development	The design, simulation, and testing of a prototype, including experimental software or hardware systems, to validate technological feasibility or concept of operation in order to reduce technological risk, or provide test systems prior to production approval.
Distributor	An independent selling agent who has a contract to sell the products of a manufacturer.
Dysprosium Oxide (Dy_2O_3)	The commonly produced form of dysprosium oxide.
Exports	Shipments to destinations outside the United States.
Facility	A building or the minimum complex of buildings or parts of buildings that conducts NdFeB Permanent Magnet or related products production, in which an organization operates to serve a particular function, producing revenue, and incurring costs for the company. A facility may produce an item of tangible or intangible property or may perform a service. It may encompass a floor or group of floors within a building, a single building, or a group of buildings or structures. Often, a facility is a group of related locations at which organization employees work, together constituting a profit-and-loss center for the company, and it may be identified by a unique DUNS number.
Feedstock	A raw material used to supply a machine or industrial process. In the context of NdFeB Permanent Magnet production, feedstock refers to the raw materials utilized in both sintered and bonded NdFeB Permanent Magnet production.
Finisher	Finishing in the context of NdFeB Permanent Magnet production refers to the milling, cutting, and coating of magnet blocks or other related products.
Full Time Equivalent (FTE) Employees	Employees who work for 40 hours in a normal work week. Convert part-time employees into "full time equivalents" by taking their work hours as a fraction of 40 hours.
Global Headquarters	A location that serves as the organization's hub of worldwide operations with all global branches or divisions reporting to it.
Harmonized Tariff Schedule (HTS)	A 10-digit numbering system that classifies a good based on its name, use, and/or the material used in its construction. The number provides Customs and Border Protection (CBP) with a standardized method of tracking all merchandise imported into the United States and sets out the tariff rates and statistical categories.
Imports (Value)	Values reported should be landed, duty-paid values at the U.S. port of entry, including ocean freight and insurance costs, brokerage charges, and import duties (i.e., all charges except inland freight in the United States).
NdFeB Alloy	The NdFeB precursor materials from which sintered and or bonded NdFeB magnets are produced.
NdFeB Magnet	The final sintered or bonded magnet form (often coated to protect from corrosion), ready for use in a particular end product.
NdFeB Permanent Magnet Related Products	Any products directly or indirectly used in the production of NdFeB Permanent Magnets, including REE mining, carbonates, oxides, metals, and/or alloys.
NdFeB Powder	The NdFeB precursor material from which sintered and or bonded magnets may be produced.
NdPr Oxide (aka Didymium Oxide)	Combined form of neodymium (75%) and praseodymium (25%) oxide commonly used by NdFeB manufacturers instead of neodymium and/or praseodymium oxide.
Neodymium Oxide (Nd_2O_3)	The commonly produced form of neodymium oxide.
Non-U.S. Facility	A facility that is physically located outside of the United States.
Organization	A company, firm, laboratory, or other entity that owns or controls one or more U.S. establishment or facility capable of designing, manufacturing, or distributing NdFeB Permanent Magnets or related products.
Pilot Production	A new line of production established to determine whether new processes/products used to manufacture NdFeB Permanent Magnets or related products will be economically efficient and profitable.
Praseodymium Oxide (Pr_6O_{11})	The commonly produced form of praseodymium oxide.
Production	The process of transforming inputs (raw materials, semi-finished goods, subassemblies, ideas, information, knowledge) into goods or services.
Rare Earth Elements (REE)	The lanthanide series of chemical elements, plus scandium and yttrium. For the purposes of this collection, the primary focus is REEs used in NdFeB permanent magnet manufacturing.
Research & Development	Basic and applied research in the engineering sciences, as well as design and development of prototype products and processes. Efforts that an organization conducts towards innovating, introducing and/or improving products and processes.
Sales	All reported and unreported sales of NdFeB permanent magnets or related products, including sales to end-users, producers, financial entities, intermediaries, traders, distributors, et al.
Single Source	An organization that is designated as the only accepted source for the supply of parts, components, materials, or services, even though other source with equivalent technical know-how and production capability may exist.
Sintered NdFeB Magnet	A fully dense magnet produced via the sintering process (i.e., pulverizing ingots in a magnetic field then hot treating in a sintering furnace).
Sole Source	An organization that is the only source for the supply of parts, components, or services. No alternative U.S. or non-U.S. based suppliers exist other than the current supplier.
Supplier	An entity from which your organization obtains inputs, which may be goods or services. A supplier may be another organization with which you have a contractual relationship, or it may be another facility owned by the same parent organization.
Terbium Oxide (Tb_4O_7)	The commonly produced form of terbium oxide.
Total Rare Earth Oxides (TREO)	The collective of all rare earth oxides combined.
United States	The "United States" or "U.S." includes the 50 states, Puerto Rico, the District of Columbia, Guam, the Trust Territories, and the U.S. Virgin Islands.

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1. Organization Information

A.	Provide the following information for your organization. Please select "Other" for "State/Province" if located outside of the U.S.	
	Organization Name	
	Street Address	
	City	
	State/Province	
	ZIP Code	
	Country of Global Headquarters	
	U.S. Point of Contact Name	
	U.S. Point of Contact Email	
	U.S. Point of Contact Phone	

B. Is this organization owned, in whole or in part, by any Non-U.S. entity? Indicate Yes/No, then identify the entities below, if applicable.
List entities with at least 5% ownership. **Include only direct relationships**.

Entity Name	Global Headquarters Street Address	Global Headquarters City	Global Headquarters State/Province	Global Headquarters Country	Ownership %

C. Please provide your organization's CAGE, DUNS, and or NAICS code(s) if applicable. Blank entries will be considered as "Not Applicable".

Commercial and Government Entity (CAGE) Code(s)		Data Universal Numbering System (DUNS) Code(s)		NAICS (6-digit) Code(s)	
Find CAGE codes at:		Find DUNS numbers at:		Find NAICS codes at:	
https://cage.dla.mil/		https://www.dnb.com/duns-		https://www.census.gov/naics/	

D. Identify the activities in the NdFeB Permanent Magnet supply chain that your organization currently performs. **Please do not include standby/idle, closed, or future facilities in this section.**

Activity	Number of U.S. Facilities	Number of Non-U.S. Facilities
Mining and Concentration of Rare Earth (RE) Minerals		
Processing of Rare Earth (RE) Minerals into Carbonates		
Separation of Rare Earth (RE) Carbonates into Oxides		
NdFeB Metal Production		
NdFeB Alloy Production		
Sintered NdFeB Permanent Magnet Production		
Bonded NdFeB Permanent Magnet Production		
Importer/Reseller/Distributor of NdFeB Permanent Magnets		
Finishing/Fabrication of NdFeB Permanent Magnets (e.g. Milling, Cutting, and Coating)		
Integration of NdFeB Permanent Magnets into Assemblies/Systems		
Recycling/Reclamation of Rare Earth Elements (REE) from Waste or Non-Traditional Feedstocks		
Recycling/Reclamation of NdFeB Permanent Magnets from Waste or Non-Traditional Feedstocks		
End User of NdFeB Permanent Magnets		
Other (Specify Here)		

Comments:

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2a. Production Facilities

Identify all of your organization's production facilities with **NdFeB Permanent Magnet related operations** including facilities that are on standby/idle and closed. If your organization does not currently operate any NdFeB Permanent Magnet related production facilities, indicate "No" and proceed to part B. Provide the **LOCATION** (U.S. and Non-U.S.) of the facility, indicate all operations at each facility using the drop down menus, and specify any changes that may impact that facility over the next five years. If a given facility has more than one operation, list each operation at the facility and the given operation's capacity on separate lines. Note, only list facilities that **produce NdFeB Permanent Magnets or related products. Do not list any distribution, value-add/finishing, or resale facilities** Once completed, please proceed to Part B.

Yes

A.

	Facility Name	Location: City	Location: State/Province (Select "Other" if outside the U.S.)	Location: Country	Facility Operation: Operation Type	Facility Operation: Facility Operating Status	Facility Operation: Average Annual Operating Cost (Cost of Goods Sold + Operating Expenses) ($ Thousands USD)	Facility Capacity: Total Facility Capacity (Metric Tons (MT))	Facility Capacity: Average Capacity Utilization Rate (Last Full Year of Operation)	Facility Capacity: Time to Reach 100% Capacity Utilization (in days)	Facility Capacity: Cost to Reach 100% Capacity Utilization ($ Thousands USD)	Outlook: Do you anticipate any significant changes in this particular operation in the next five years?	Outlook: If yes or unknown, provide a brief explanation.
1					Mining and Concentration of Rare Earth (RE) Minerals	Operating						Yes	
2					Processing of Rare Earth (RE) Minerals into Carbonates	Standby/Idle						No	
3					Separation of Rare Earth (RE) Carbonates into Oxides	Closed						Unknown	
4					NdFeB Metal Production								
5					NdFeB Alloy Production								
6					Sintered NdFeB Permanent Magnet Production								
7					Bonded NdFeB Permanent Magnet Production								
8					Recycling/Reclamation of Rare Earth Elements (REE) from Waste or Non-Traditional Feedstocks								
9					Recycling/Reclamation of NdFeB Permanent Magnets from Waste or Non-Traditional Feedstocks								
10													
11													
12													
13													
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16													
17													
18													
19													
20													
Comments:													

If your organization plans to operate and or fund new NdFeB Permanent Magnet and or related product production facilities in **2022-2026**, please answer the following: What is the operation type for the facility, the initial expected capacity, the final expected capacity, the expected start date, the primary challenge to start (if applicable), the estimated total cost to reach full production, and the previously allocated funds to reach full production (e.g. the amount previously spent on upgrading equipment, purchasing land/capital/labor, etc. to reach full production). If your organization does not plan to operate or fund new production facilities between 2022-2026, indicate "No" and proceed to the next section. Note, **only list facilities that will produce NdFeB Permanent Magnets or related products. Do not list any distribution, value-add/finishing, or resale facilities** Once completed, please proceed to the next section.

Yes

B.

	Facility Name	Location: City	Location: State/Province (Select "Other" if outside the U.S.)	Location: Country	Facility Operation: Operation Type	Facility Operation: Initial Non-Pilot Expected Facility Capacity (Metric Tons (MT))	Facility Operation: Full Non-Pilot Expected Facility Capacity (Metric Tons (MT))	Start Factors: Expected Start Date	Start Factors: Primary Challenge to Start (If applicable)	Start Factors: Estimated Total Cost to Reach Full Production ($ Thousands USD)	Start Factors: Previously Allocated Funds to Reach Full Production ($ Thousands USD)	Explain
1					Mining and Concentration of Rare Earth (RE) Minerals				NdFeB Price			
2					Processing of Rare Earth (RE) Minerals into Carbonates				High Investment Costs			
3					Separation of Rare Earth (RE) Carbonates into Oxides				Lack of Skilled Labor			
4					NdFeB Metal Production				Lack of or Declining Domestic Demand			
5					NdFeB Alloy Production				High Operating Costs			
6					Sintered NdFeB Permanent Magnet Production				COVID-19 Pandemic			
7					Bonded NdFeB Permanent Magnet Production				Other			
8					Recycling/Reclamation of Rare Earth Elements (REE) from Waste or Non-Traditional Feedstocks							
9					Recycling/Reclamation of NdFeB Permanent Magnets from Waste or Non-Traditional Feedstocks							
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20												
Comments:												

Comments:

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2b. Distribution and Finishing Facilities

Identify all of your organization's distribution and finishing facilities with **NdFeB Permanent Magnet related operations** including facilities that are on standby/idle and closed. If your organization is an end-user of NdFeB Permanent Magnets, please indicate "No" and proceed to the next section. If your organization does not currently operate any NdFeB Permanent Magnet related distribution or finishing facilities, indicate "No" and proceed to part B. Provide the **LOCATION** (U.S. and Non-U.S.) of the facility, indicate all operations at each facility using the drop down menus, and specify any changes that may impact that facility over the next five years. If a given facility has more than one operation, list each operation at the facility and the given operation's capacity on separate lines. Note, only list facilities that **distribute and or finish NdFeB Permanent Magnets or related products. Do not list any production facilities** Once completed, please proceed to Part B.

Yes

A.

		Location			Facility Operation			Facility Capacity		Outlook	
	Facility Name	City	State/Province (Select "Other" if outside the U.S.)	Country	Operation Type	Facility Operating Status	Average Annual Operating Cost (Cost of Goods Sold + Operating Expenses) ($ Thousands USD)	Total Facility Capacity (Metric Tons (MT))	Average Capacity Utilization Rate (Last Full Year of Operation)	Do you anticipate any significant changes in this particular operation in the next five years?	If yes or unknown, provide a brief explanation.
1					Importer/Reseller/Distributor of NdFeB Permanent Magnets	Operating				Yes	
2					Finishing/Fabrication of NdFeB Permanent Magnets (e.g. Milling, Cutting, and Coating)	Standby/Idle				No	
3					Integration of NdFeB Permanent Magnets into Assemblies/Systems	Closed				Unknown	
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
Comments:											

If your organization plans to operate and or fund new NdFeB Permanent Magnet or related product distribution and finishing facilities in **2022-2026**, please answer the following: What is the operation type for the facility, the initial expected non-pilot capacity, the final expected non-pilot capacity, the expected start date, and the primary challenge to start (if applicable). If your organization does not plan to operate or fund new distribution facilities between 2022-2026, indicate "No" and proceed to the next section. Note, **only list facilities that will distribute and or finish NdFeB Permanent Magnets or related products. Do not list any production facilities** Once completed, please proceed to the next section.

Yes

B.

		Location			Facility Operation			Start Factors		
	Facility Name	City	State/Province (Select "Other" if outside the U.S.)	Country	Operation Type	Initial Non-Pilot Expected Facility Capacity (Metric Tons (MT))	Full Non-Pilot Expected Facility Capacity (Metric Tons (MT))	Expected Start Date	Primary Challenge to Start (If applicable)	Explain
1					Importer/Reseller/Distributor of NdFeB Permanent Magnets				NdFeB Price	
2					Finishing/Fabrication of NdFeB Permanent Magnets (e.g. Milling, Cutting, and Coating)				High Investment Costs	
3					Integration of NdFeB Permanent Magnets into Assemblies/Systems				Lack of Skilled Labor	
4									Lack of or Declining Domestic Demand	
5									High Operating Costs	
6									COVID-19 Pandemic	
7									Other	
8										
9										
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20										
Comments:										

Comments:	

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3a. U.S. Production

Indicate if your organization produced (or plans to produce) NdFeB Permanent Magnets or related products between **2017-2021** (and **2022-2026 expected**) **in the United States**. If your organization only distributed and or finished the following products, indicate "No" and proceed to the next section.

Has your organization produced, is currently producing, and or plans to produce NdFeB Permanent Magnets or related products **in the United States**? If "No", please proceed to the next section.	Yes	**Do not include facilities that solely distribute, import, export, and or finish NdFeB Permanent Magnets. Only include facilities that produce NdFeB Permanent Magnets and or related products.**

A. Mining and Concentration of Rare Earth (RE) Minerals

Select "No" if category is not relevant to your operations

Unit of Measurement (Specify Here if Other)

	Actual Production of TREO					Economic Viability (2021 Only)		Estimated Production of TREO				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Rare Earth Oxides (TREO) Total Production (U.S. Facilities)												
(% of Rare Earth Elements (REE) contained in TREO)								(% of Rare Earth Elements (REE) contained in TREO)				
1 Neodymium												
2 Dysprosium												
3 Praseodymium												
4 Terbium												
5 Cerium												
6 Other Rare Earth Element (REE) (Specify Here)												
7 Other Rare Earth Element (REE) (Specify Here)												
Total:	**0%**	**0%**	**0%**	**0%**	**0%**			**0%**	**0%**	**0%**	**0%**	**0%**

Comments:

B. Recycling/Reclamation of Rare Earth Elements (REE) from Waste Material/Non-Traditional Feedstocks

Select "No" if category is not relevant to your operations

Unit of Measurement (Specify Here if Other)

	Actual Production from Waste Material/Feedstock					Economic Viability (2021 Only)		Estimated Production from Waste Material/Feedstock				
	2017	2018	2019	2020	2021	Average Cost per Unit to Recycle ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Primary Waste Material/Feedstock Utilized Total REE Production (U.S. Facilities) (Specify Here)												
(% of Rare Earth Elements (REE) contained in Waste Material/Feedstock)								(% of Rare Earth Elements (REE) contained in Waste Material/Feedstock)				
1 Neodymium												
2 Dysprosium												
3 Praseodymium												
4 Terbium												
5 Cerium												
6 Other Rare Earth Element (REE) (Specify Here)												
7 Other Rare Earth Element (REE) (Specify Here)												
Total:	**0%**	**0%**	**0%**	**0%**	**0%**			**0%**	**0%**	**0%**	**0%**	**0%**

Comments:

C. Processing of Rare Earth (RE) Minerals into Carbonates

Select "No" if category is not relevant to your operations

Unit of Measurement (Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (U.S. Facilities)												
1 Neodymium Carbonate												
2 Dysprosium Carbonate												
3 Neodymium-Praseodymium Carbonate												
4 Praseodymium Carbonate												
5 Terbium Carbonate												
6 Cerium Carbonate												
7 Other REE Carbonates (Specify Here)												

Comments:

D. Separation of Rare Earth (RE) Carbonates into Oxides

Select "No" if category is not relevant to your operations

Unit of Measurement (Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (U.S. Facilities)												
1 Neodymium Oxide												
2 Dysprosium Oxide												
3 Neodymium-Praseodymium Oxide												
4 Praseodymium Oxide												
5 Terbium Oxide												
6 Cerium Oxide												
7 Other REE Oxides (Specify Here)												

Comments:

E. NdFeB Metal Production

Select "No" if category is not relevant to your operations

Unit of Measurement (Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (U.S. Facilities)												
1 Neodymium Metal												
2 Dysprosium Metal												
3 Neodymium-Praseodymium Metal												
4 Praseodymium Metal												
5 Terbium Metal												
6 Cerium Metal												
7 Other REE Metals (Specify Here)												

Comments:

F. NdFeB Alloy Production

Select "No" if category is not relevant to your operations

Unit of Measurement (Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (U.S. Facilities)												
1 NdFeB Alloy Containing Dysprosium												
2 NdFeB Alloy Containing Praseodymium												
3 NdFeB Alloy Containing Terbium												
4 NdFeB Alloy Containing Cerium												
5 NdFeB Alloy Containing other REEs												
6 NdFeB Alloy Containing other Non-REEs (Specify Here)												

Comments:

G. NdFeB Permanent Magnet Production

Select "No" if category is not relevant to your operations

Unit of Measurement (Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce/Recycle ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (U.S. Facilities)												
1 Sintered NdFeB Permanent Magnets												
2 Bonded NdFeB Permanent Magnets												
3 Other Magnets (Specify Here)												

Comments:

Comments:

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3b. Non-U.S. Production

Indicate if your organization produced (or plans to produce) NdFeB Permanent Magnets or related products between **2017-2021** (and **2022-2026 expected**) **outside the United States**. If your organization only distributed and or finished the following products, indicate "No" and proceed to the next section.

Has your organization produced, is currently producing, and or plans to produce NdFeB Permanent Magnets or related products **outside the United States**? If "No", please proceed to the next section.	Yes	**Do not include facilities that solely distribute, import, export, and or finish NdFeB Permanent Magnets. Only include facilities that produce NdFeB Permanent Magnets and or related products.**

A. Mining and Concentration of Rare Earth (RE) Minerals

Select "No" if category is not relevant to your operations		
Unit of Measurement		(Specify Here if Other)

	Actual Production of TREO					Economic Viability (2021 Only)		Estimated Production of TREO				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Rare Earth Oxides (TREO) Total Production (Non-U.S. Facilities)												
(% of Rare Earth Elements (REE) contained in TREO)								(% of Rare Earth Elements (REE) contained in TREO)				
1 Neodymium												
2 Dysprosium												
3 Praseodymium												
4 Terbium												
5 Cerium												
6 Other Rare Earth Element (REE) (Specify Here)												
7 Other Rare Earth Element (REE) (Specify Here)												
Total:	**0%**	**0%**	**0%**	**0%**	**0%**			**0%**	**0%**	**0%**	**0%**	**0%**

Comments:

B. Recycling/Reclamation of Rare Earth Elements (REE) from Waste Material/Non-Traditional Feedstocks

Select "No" if category is not relevant to your operations		
Unit of Measurement		(Specify Here if Other)

	Actual Production from Waste Material/Feedstock					Economic Viability (2021 Only)		Estimated Production from Waste Material/Feedstock				
	2017	2018	2019	2020	2021	Average Cost per Unit to Recycle ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Primary Waste Material/Feedstock Utilized Total REE Production (Non-U.S. Facilities) (Specify Here)												
(% of Rare Earth Elements (REE) contained in Waste Material/Feedstock)								(% of Rare Earth Elements (REE) contained in Waste Material/Feedstock)				
1 Neodymium												
2 Dysprosium												
3 Praseodymium												
4 Terbium												
5 Cerium												
6 Other Rare Earth Element (REE) (Specify Here)												
7 Other Rare Earth Element (REE) (Specify Here)												
Total:	**0%**	**0%**	**0%**	**0%**	**0%**			**0%**	**0%**	**0%**	**0%**	**0%**

Comments:

C. Processing of Rare Earth (RE) Minerals into Carbonates

Select "No" if category is not relevant to your operations		
Unit of Measurement		(Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (Non-U.S. Facilities)												
1 Neodymium Carbonate												
2 Dysprosium Carbonate												
3 Neodymium-Praseodymium Carbonate												
4 Praseodymium Carbonate												
5 Terbium Carbonate												
6 Cerium Carbonate												
7 Other REE Carbonates (Specify Here)												

Comments:

D. Separation of Rare Earth (RE) Carbonates into Oxides

Select "No" if category is not relevant to your operations		
Unit of Measurement		(Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (Non-U.S. Facilities)												
1 Neodymium Oxide												
2 Dysprosium Oxide												
3 Neodymium-Praseodymium Oxide												
4 Praseodymium Oxide												
5 Terbium Oxide												
6 Cerium Oxide												
7 Other REE Oxides (Specify Here)												

Comments:

E. NdFeB Metal Production

Select "No" if category is not relevant to your operations		
Unit of Measurement		(Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (Non-U.S. Facilities)												
1 Neodymium Metal												
2 Dysprosium Metal												
3 Neodymium-Praseodymium Metal												
4 Praseodymium Metal												
5 Terbium Metal												
6 Cerium Metal												
7 Other REE Metals (Specify Here)												

Comments:

F. NdFeB Alloy Production

Select "No" if category is not relevant to your operations		
Unit of Measurement		(Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (Non-U.S. Facilities)												
1 NdFeB Alloy Containing Dysprosium												
2 NdFeB Alloy Containing Praseodymium												
3 NdFeB Alloy Containing Terbium												
4 NdFeB Alloy Containing Cerium												
5 NdFeB Alloy Containing other REEs												
6 NdFeB Alloy Containing other Non-REEs (Specify Here)												

Comments:

G. NdFeB Permanent Magnet Production

Select "No" if category is not relevant to your operations		
Unit of Measurement		(Specify Here if Other)

	Actual Production					Economic Viability (2021 Only)		Estimated Production				
	2017	2018	2019	2020	2021	Average Cost per Unit to Produce/Recycle ($ USD)	Capacity Utilization Needed to Remain Profitable	2022	2023	2024	2025	2026
Total Production (Non-U.S. Facilities)												
1 Sintered NdFeB Permanent Magnets												
2 Bonded NdFeB Permanent Magnets												
3 Other Magnets (Specify Here)												

Comments:

Comments:

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4a. Sourcing/Feedstock Purchases

Did your organization purchase **feedstocks/materials** which were used to produce NdFeB Permanent Magnets or related products between 2017-2021 (and 2022-2026 expected)? If yes, answer the following questions below for each of your organization's suppliers. If no, please proceed to the next section. If your organization has more than fifteen suppliers, rank them by value of purchases over the 2017-2026 period (greatest to least). **For 2022-2026, limit your responses to signed contracts and memorandums of understanding (MOUs). Do not include speculative/desired feedstock purchases**. Note, **do not include any purchases which were intended for resale or further processing (see section 4b)** (i.e. purchases which do not include value-add activities).

Yes

A. Processing of Rare Earth (RE) Minerals into Carbonates
(Purchases of Total Rare Earth Oxides and Waste Material)

Select "No" if category is not relevant to your operations

Unit of Measurement

(Specify Here if Other)

Total:

TREO Content (% of REE contained in TREO) or (% of Rare Earth Elements (REE) contained in Waste Material/Feedstock)

	Supplier Name	Country of Purchase (Location of Feedstock)	Feedstock Type	Other Specify (If Applicable)	Single/Sole Source?	10-Digit HTSUS Code (If Known)	Top Factor Influencing Purchase	Dysprosium	Neodymium	Praseodymium	Terbium	Cerium	Other (Specify Here)	Other (Specify Here)	2017 Volume	2017 Value ($ Thousands USD)	2018 Volume	2018 Value ($ Thousands USD)	2019 Volume	2019 Value ($ Thousands USD)	2020 Volume	2020 Value ($ Thousands USD)	2021 Volume	2021 Value ($ Thousands USD)	2022 Volume	2022 Value ($ Thousands USD)	2023 Volume	2023 Value ($ Thousands USD)	2024 Volume	2024 Value ($ Thousands USD)	2025 Volume	2025 Value ($ Thousands USD)	2026 Volume	2026 Value ($ Thousands USD)
1			Total Rare Earth Oxides (TREO)		Single Source		Financial Consideration																											
2			Waste Material		Sole Source		Technical Specification																											
3			Other		Neither		Relationship																											
4							Delivery																											
5							Other																											
6																																		
7																																		
8																																		
9																																		
10																																		
11																																		
12																																		
13																																		
14																																		
15																																		

Comments:

B. Separation of Rare Earth (RE) Carbonates into Oxides

Select "No" if category is not relevant to your operations

Unit of Measurement

(Specify Here if Other)

Total:

	Supplier Name	Country of Purchase (Location of Feedstock)	Feedstock Type	Other Specify (If Applicable)	Single/Sole Source?	10-Digit HTSUS Code (If Known)	Top Factor Influencing Purchase	2017 Volume	2017 Value ($ Thousands USD)	2018 Volume	2018 Value ($ Thousands USD)	2019 Volume	2019 Value ($ Thousands USD)	2020 Volume	2020 Value ($ Thousands USD)	2021 Volume	2021 Value ($ Thousands USD)	2022 Volume	2022 Value ($ Thousands USD)	2023 Volume	2023 Value ($ Thousands USD)	2024 Volume	2024 Value ($ Thousands USD)	2025 Volume	2025 Value ($ Thousands USD)	2026 Volume	2026 Value ($ Thousands USD)
1			Neodymium Carbonate		Single Source		Financial Consideration																				
2			Dysprosium Carbonate		Sole Source		Technical Specification																				
3			Neodymium-Praseodymium Carbonate		Neither		Relationship																				
4			Praseodymium Carbonate				Delivery																				
5			Terbium Carbonate				Other																				
6			Cerium Carbonate																								
7			Other REE Carbonates																								
8			Other																								
9																											
10																											
11																											
12																											
13																											
14																											
15																											

Comments:

C. NdFeB Metal Production

Select "No" if category is not relevant to your operations

Unit of Measurement

(Specify Here if Other)

Total:

	Supplier Name	Country of Purchase (Location of Feedstock)	Feedstock Type	Other Specify (If Applicable)	Single/Sole Source?	10-Digit HTSUS Code (If Known)	Top Factor Influencing Purchase	2017 Volume	2017 Value ($ Thousands USD)	2018 Volume	2018 Value ($ Thousands USD)	2019 Volume	2019 Value ($ Thousands USD)	2020 Volume	2020 Value ($ Thousands USD)	2021 Volume	2021 Value ($ Thousands USD)	2022 Volume	2022 Value ($ Thousands USD)	2023 Volume	2023 Value ($ Thousands USD)	2024 Volume	2024 Value ($ Thousands USD)	2025 Volume	2025 Value ($ Thousands USD)	2026 Volume	2026 Value ($ Thousands USD)
1			Neodymium Oxide		Single Source		Financial Consideration																				
2			Dysprosium Oxide		Sole Source		Technical Specification																				
3			Neodymium-Praseodymium Oxide		Neither		Relationship																				
4			Praseodymium Oxide				Delivery																				
5			Terbium Oxide				Other																				
6			Cerium Oxide																								
7			Other REE Oxides																								
8			Other																								
9																											
10																											
11																											
12																											
13																											
14																											
15																											

Comments:

D. NdFeB Alloy Production

Select "No" if category is not relevant to your operations

Unit of Measurement

(Specify Here if Other)

Total:

	Supplier Name	Country of Purchase (Location of Feedstock)	Feedstock Type	Other Specify (If Applicable)	Single/Sole Source?	10-Digit HTSUS Code (If Known)	Top Factor Influencing Purchase	2017 Volume	2017 Value ($ Thousands USD)	2018 Volume	2018 Value ($ Thousands USD)	2019 Volume	2019 Value ($ Thousands USD)	2020 Volume	2020 Value ($ Thousands USD)	2021 Volume	2021 Value ($ Thousands USD)	2022 Volume	2022 Value ($ Thousands USD)	2023 Volume	2023 Value ($ Thousands USD)	2024 Volume	2024 Value ($ Thousands USD)	2025 Volume	2025 Value ($ Thousands USD)	2026 Volume	2026 Value ($ Thousands USD)
1			Neodymium Metal		Single Source		Financial Consideration																				
2			Dysprosium Metal		Sole Source		Technical Specification																				
3			Neodymium-Praseodymium Metal		Neither		Relationship																				
4			Praseodymium Metal				Delivery																				
5			Terbium Metal				Other																				
6			Cerium Metal																								
7			Flouride																								
8			Ferroboron																								
9			1001 Steel																								
10			Other REE Metals																								
11			Waste Material																								
12			Other																								
13																											
14																											
15																											

Comments:

E. Sintered NdFeB Magnet Production

Select "No" if category is not relevant to your operations

Unit of Measurement

(Specify Here if Other)

Total:

	Supplier Name	Country of Purchase (Location of Feedstock)	Feedstock Type	Other Specify (If Applicable)	Single/Sole Source?	10-Digit HTSUS Code (If Known)	Percent of Recycled Material (Enter 0% if Unknown)	Top Factor Influencing Purchase	2017 Volume	2017 Value ($ Thousands USD)	2018 Volume	2018 Value ($ Thousands USD)	2019 Volume	2019 Value ($ Thousands USD)	2020 Volume	2020 Value ($ Thousands USD)	2021 Volume	2021 Value ($ Thousands USD)	2022 Volume	2022 Value ($ Thousands USD)	2023 Volume	2023 Value ($ Thousands USD)	2024 Volume	2024 Value ($ Thousands USD)	2025 Volume	2025 Value ($ Thousands USD)	2026 Volume	2026 Value ($ Thousands USD)
1			NdFeB Alloy Containing Dysprosium		Single Source			Financial Consideration																				
2			NdFeB Alloy Containing Praseodymium		Sole Source			Technical Specification																				
3			NdFeB Alloy Containing Terbium		Neither			Relationship																				
4			NdFeB Alloy Containing Cerium					Delivery																				
5			NdFeB Alloy Containing other REEs					Other																				
6			NdFeB Alloy Containing other Non-REEs																									
7			NdFeB Powder																									
8			Ferroboron																									
9			1001 Steel																									
10			Waste Material																									
11			Other																									
12																												
13																												
14																												
15																												

Comments:

F. Bonded NdFeB Magnet Production

Select "No" if category is not relevant to your operations

Unit of Measurement

(Specify Here if Other)

Total:

	Supplier Name	Country of Purchase (Location of Feedstock)	Feedstock Type	Other Specify (If Applicable)	Single/Sole Source?	10-Digit HTSUS Code (If Known)	Percent of Recycled Material (Enter 0% if Unknown)	Top Factor Influencing Purchase	2017 Volume	2017 Value ($ Thousands USD)	2018 Volume	2018 Value ($ Thousands USD)	2019 Volume	2019 Value ($ Thousands USD)	2020 Volume	2020 Value ($ Thousands USD)	2021 Volume	2021 Value ($ Thousands USD)	2022 Volume	2022 Value ($ Thousands USD)	2023 Volume	2023 Value ($ Thousands USD)	2024 Volume	2024 Value ($ Thousands USD)	2025 Volume	2025 Value ($ Thousands USD)	2026 Volume	2026 Value ($ Thousands USD)
1			NdFeB Alloy Containing Dysprosium		Single Source			Financial Consideration																				
2			NdFeB Alloy Containing Praseodymium		Sole Source			Technical Specification																				
3			NdFeB Alloy Containing Terbium		Neither			Relationship																				
4			NdFeB Alloy Containing Cerium					Delivery																				
5			NdFeB Alloy Containing other REEs					Other																				
6			NdFeB Alloy Containing other Non-REEs																									
7			NdFeB Powder																									
8			Ferroboron																									
9			1001 Steel																									
10			Waste Material																									
11			Other																									
12																												
13																												
14																												
15																												

Comments:

Comments:

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4b. NdFeB Permanent Magnet Purchases

Did your organization purchase NdFeB Permanent Magnets or NdFeB Permanent Magnet Blocks between 2017-2021 (and 2022-2026 expected)? If yes, answer the following questions below for each of your organization's suppliers. If no, please proceed to the next section. If your organization has more than twenty suppliers, rank them by value of purchases over the 2017-2026 period (greatest to least). **For 2022-2026, limit your responses to signed contracts and memorandums of understanding (MOUs). Do not include speculative/desired purchases**Note, **do not include any feedstock purchases listed in section 4a in this section.**	Yes

A.

NdFeB Permanent Magnet Distribution and Finishing

Unit of Measurement | (Specify Here if Other)

	Supplier Name	Country of Purchase (Location of Product)	Type of Magnet Purchased	Single/Sole Source?	10-Digit HTSUS Code (If Known)	Operation Type	Total: Top Factor Influencing Purchase	2017 Volume	2017 Value ($ Thousands USD)	2018 Volume	2018 Value ($ Thousands USD)	2019 Volume	2019 Value ($ Thousands USD)	2020 Volume	2020 Value ($ Thousands USD)	2021 Volume	2021 Value ($ Thousands USD)	2022 Volume	2022 Value ($ Thousands USD)	2023 Volume	2023 Value ($ Thousands USD)	2024 Volume	2024 Value ($ Thousands USD)	2025 Volume	2025 Value ($ Thousands USD)	2026 Volume	2026 Value ($ Thousands USD)
1			Sintered NdFeB Permanent Magnets	Single Source		Importer/Reseller/Distributor of NdFeB Permanent Magnets	Financial Consideration																				
2			Bonded NdFeB Permanent Magnets	Sole Source		Finishing/Fabrication of NdFeB Permanent Magnets (e.g. Milling, Cutting, and Coating)	Technical Specification																				
3			Other	Neither		Integration of NdFeB Permanent Magnets into Assemblies/Systems	Relationship																				
4							Delivery																				
5							Other																				
6																											
7																											
8																											
9																											
10																											
11																											
12																											
13																											
14																											
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16																											
17																											
18																											
19																											
20																											

Comments:

Comments:

BUSINESS CONFIDENTIAL - Per Section 705(d) of the Defense Production Act

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5. Sales

Did your organization sell NdFeB Permanent Magnets or related products in general, as a finisher, and or end-user between 2017-2021 (and 2022-2026 expected)? If yes, answer the following questions below for each of your organization's customers. If no, please proceed to the next section. If your organization has more than fifteen customers, rank them by value of sales over the 2017-2026 period (greatest to least). **For 2022-2026, limit your responses to signed contracts and memorandums of understanding (MOUs). Do not include speculative/desired sales** . Note, **do not include intra-company transfers or list any material that was internally consumed** (i.e. Only include sales to other entities outside of your organization).	Yes	DFARS 225.7018, 10 U.S.C. 2533c: https://www.federalregister.gov/documents/2019/04/30/2019-08485/defense-federal-acquisition-regulation-supplement-restriction-on-the-acquisition-of-certain-magnets

A. Total Rare Earth Oxides (TREO) & Other REE Waste Material/Feedstocks

Select "No" if category is not relevant to your operations

Unit of Measurement

	Customer Name	Country of Sale	Direct End Use (If Known)	10-Digit HTSUS Code (If Known)	Top Factor Influencing Sale	TREO Content (% of REE contained in TREO): Dysprosium	Neodymium	Praseodymium	Terbium	Cerium	Total: Other (Specify Here)	(Specify Here)
1			Automotive - Traction		Financial Consideration							
2			Automotive - Speakers		Technical Specification							
3			Automotive - Motors & Sensors		Relationship							
4			Automotive - Other		Delivery							
5			Consumer Appliances		Other							
6			Consumer Electronics									
7			Wind Power Generators									
8			Aerospace & Defense									
9			Medical									
10			Industrial - Pumps & Compressors									
11			Industrial - Other									
12			Power Tools									
13			Oil & Gas									
14			Other									
15			Unknown									

	(Specify Here if Other)																		
2017	2017	2018	2018	2019	2019	2020	2020	2021	2021	2022	2022	2023	2023	2024	2024	2025	2025	2026	2026
Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)

Comments:

B. Rare Earth (RE) Carbonates

Select "No" if category is not relevant to your operations

Unit of Measurement

	Customer Name	Country of Sale	Type of REE Carbonate	Other Specify (If Applicable)	Direct End Use (If Known)	10-Digit HTSUS Code (If Known)	Percent of Cerium Content (Enter 0% if Unknown or Not Applicable)	Total: Top Factor Influencing Sale
1			Neodymium Carbonate		Automotive - Traction			Financial Consideration
2			Dysprosium Carbonate		Automotive - Speakers			Technical Specification
3			Neodymium-Praseodymium Carbonate		Automotive - Motors & Sensors			Relationship
4			Praseodymium Carbonate		Automotive - Other			Delivery
5			Terbium Carbonate		Consumer Appliances			Other
6			Cerium Carbonate		Consumer Electronics			
7			Other REE Carbonates		Wind Power Generators			
8			Other		Aerospace & Defense			
9					Medical			
10					Industrial - Pumps & Compressors			
11					Industrial - Other			
12					Power Tools			
13					Oil & Gas			
14					Other			
15					Unknown			

	(Specify Here if Other)																		
2017	2017	2018	2018	2019	2019	2020	2020	2021	2021	2022	2022	2023	2023	2024	2024	2025	2025	2026	2026
Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)

Comments:

C. Rare Earth (RE) Oxides

Select "No" if category is not relevant to your operations

Unit of Measurement

	Customer Name	Country of Sale	Type of REE Oxide	Other Specify (If Applicable)	Direct End Use (If Known)	10-Digit HTSUS Code (If Known)	Percent of Cerium Content (Enter 0% if Unknown or Not Applicable)	Total: Top Factor Influencing Sale
1			Neodymium Oxide		Automotive - Traction			Financial Consideration
2			Dysprosium Oxide		Automotive - Speakers			Technical Specification
3			Neodymium-Praseodymium Oxide		Automotive - Motors & Sensors			Relationship
4			Praseodymium Oxide		Automotive - Other			Delivery
5			Terbium Oxide		Consumer Appliances			Other
6			Cerium Oxide		Consumer Electronics			
7			Other REE Oxides		Wind Power Generators			
8			Other		Aerospace & Defense			
9					Medical			
10					Industrial - Pumps & Compressors			
11					Industrial - Other			
12					Power Tools			
13					Oil & Gas			
14					Other			
15					Unknown			

	(Specify Here if Other)																		
2017	2017	2018	2018	2019	2019	2020	2020	2021	2021	2022	2022	2023	2023	2024	2024	2025	2025	2026	2026
Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)

Comments:

D. NdFeB Metals

Select "No" if category is not relevant to your operations

Unit of Measurement

	Customer Name	Country of Sale	Type of REE Metal	Other Specify (If Applicable)	Direct End Use (If Known)	10-Digit HTSUS Code (If Known)	Percent of Cerium Content (Enter 0% if Unknown or Not Applicable)	Total: Top Factor Influencing Sale
1			Neodymium Metal		Automotive - Traction			Financial Consideration
2			Dysprosium Metal		Automotive - Speakers			Technical Specification
3			Neodymium-Praseodymium Metal		Automotive - Motors & Sensors			Relationship
4			Praseodymium Metal		Automotive - Other			Delivery
5			Terbium Metal		Consumer Appliances			Other
6			Cerium Metal		Consumer Electronics			
7			Flouride		Wind Power Generators			
8			Ferroboron		Aerospace & Defense			
9			1001 Steel		Medical			
10			Other REE Metals		Industrial - Pumps & Compressors			
11			Waste Material		Industrial - Other			
12			Other		Power Tools			
13					Oil & Gas			
14					Other			
15					Unknown			

	(Specify Here if Other)																		
2017	2017	2018	2018	2019	2019	2020	2020	2021	2021	2022	2022	2023	2023	2024	2024	2025	2025	2026	2026
Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)

Comments:

E. NdFeB Alloys

Select "No" if category is not relevant to your operations

Unit of Measurement

	Customer Name	Country of Sale	Type of REE Alloy	Other Specify (If Applicable)	Direct End Use (If Known)	10-Digit HTSUS Code (If Known)	Percent of Cerium Content (Enter 0% if Unknown or Not Applicable)	Total: Top Factor Influencing Sale
1			NdFeB Alloy Containing Dysprosium		Automotive - Traction			Financial Consideration
2			NdFeB Alloy Containing Praseodymium		Automotive - Speakers			Technical Specification
3			NdFeB Alloy Containing Terbium		Automotive - Motors & Sensors			Relationship
4			NdFeB Alloy Containing Cerium		Automotive - Other			Delivery
5			NdFeB Alloy Containing other REEs		Consumer Appliances			Other
6			NdFeB Alloy Containing other Non-REEs		Consumer Electronics			
7			NdFeB Powder		Wind Power Generators			
8			Ferroboron		Aerospace & Defense			
9			1001 Steel		Medical			
10			Waste Material		Industrial - Pumps & Compressors			
11			Other		Industrial - Other			
12					Power Tools			
13					Oil & Gas			
14					Other			
15					Unknown			

	(Specify Here if Other)																		
2017	2017	2018	2018	2019	2019	2020	2020	2021	2021	2022	2022	2023	2023	2024	2024	2025	2025	2026	2026
Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)

Comments:

F. NdFeB Permanent Magnets

Select "No" if category is not relevant to your operations

Unit of Measurement

	Customer Name	Country of Sale	Type of Magnet	Magnet Grade	Direct End Use (If Known)	DFARS 225.7018, 10 U.S.C. 2533c Compliant?	10-Digit HTSUS Code (If Known)	Percent of Cerium Content (Enter 0% if Unknown or Not Applicable)	Total: Top Factor Influencing Sale
1			Sintered NdFeB Permanent Magnets	N20-N29	Automotive - Traction	Yes			Financial Consideration
2			Bonded NdFeB Permanent Magnets	N50+	Automotive - Speakers	No			Technical Specification
3			Other	N20M-N29M	Automotive - Motors & Sensors	Unknown			Relationship
4				N50M+	Automotive - Other				Delivery
5				N20H-N29H	Consumer Appliances				Other
6				N50H+	Consumer Electronics				
7				N20SH-N29SH	Wind Power Generators				
8				N50SH+	Aerospace & Defense				
9				N20UH-N29UH	Medical				
10				N50UH+	Industrial - Pumps & Compressors				
11				N20EH-N29EH	Industrial - Other				
12				N50EH+	Power Tools				
13				N20AH-N29AH	Oil & Gas				
14				N50AH+	Other				
15				Unknown	Unknown				

	(Specify Here if Other)																		
2017	2017	2018	2018	2019	2019	2020	2020	2021	2021	2022	2022	2023	2023	2024	2024	2025	2025	2026	2026
Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)	Volume	Value ($ Thousands USD)

Comments:

G. Semi-Finished & Finished Products Containing NdFeB Permanent Magnets (2022-2026 Only)

Select "No" if category is not relevant to your operations

	Direct End Use	Primary Customer Name	Primary Finished or Semi-Finished Product Sold	Type of Magnet Contained Within	Percent of Value Attributed to Magnet(s) Contained Within	Percent of Cerium Content (Enter 0% if Unknown or Not Applicable)	10-Digit HTSUS Code (If Known)	Top Factor Influencing Sale	Magnet Substitutes Available? (If yes, proceed to the right)	Substitute Magnet Type (Specify Below)	Advantages	Disadvantages	If a sufficient and reliable domestic source of NdFeB permanent magnets were available, would you still utilize the listed substitute?	Explain
1	Automotive - Traction			Sintered NdFeB Permanent Magnets				Financial Consideration	Yes		Better Performance	Reduced Performance	Yes	
2	Automotive - Speakers			Bonded NdFeB Permanent Magnets				Technical Specification	No		Better Quality	Worse Quality	No	
3	Automotive - Motors & Sensors			Other				Relationship	Not Applicable		Cheaper	More Expensive		
4	Automotive - Other							Delivery	Unknown		Ample Supply	Limited Supply		
5	Consumer Appliances							Other			Secure Sourcing	Sole-Sourced/Insecure Supply		
6	Consumer Electronics										Proximity to Customer	Proximity to Customer		
7	Wind Power Generators										Other	Other		
8	Aerospace & Defense													
9	Medical													
10	Industrial - Pumps & Compressors													
11	Industrial - Other													
12	Power Tools													
13	Oil & Gas													
14	Other													
15	Other													

Will your organization's demand for NdFeB permanent magnets increase over the next ten years? If yes, indicate if all of this demand can be satisfied by current and or anticipated capacity or if substitutes are necessary. If no, please proceed to the next section.

Comments:

Comments:

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6. Employment

Record the total number of full time equivalent (FTE) employees and contractors for the **2017 to 2021 (and expected for 2022-2026)** period for your organization employed at the locations listed in sections 2a and 2b. Estimates are acceptable. **Note, if your organization was instructed to respond "No" to both 2a and 2b, please input "End-User" in the comment box at the bottom of the page and proceed to the next section.**

A.		Past					Current	Expected			
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
	FTE Employees & Contractors										

Record the number of workers by occupation employed at the locations listed in sections 2a and 2b for **2021 only**. Estimates are acceptable.

B.	Occupation		Number of Employees
	Manufacturing Engineers, Scientists, R&D		
	Production Line Operations		
	Testing and Quality Control		
	Information Technology/Computing		
	Sales, Administrative, and Management		
	Other	(Specify Here)	
		Total:	**0**

C.	Issue		Timeframe	Primary Occupation Affected	Explain
	Attracting Workers to Location		Ongoing, Expected to Continue	Manufacturing Engineers, Scientists, R&D	
	Employee Turnover		Past Only (Resolved)	Production Line Operations	
	Finding Experienced Workers		Expected In Future	Testing and Quality Control	
	Finding Qualified Workers		No or Not Applicable	Information Technology/Computing	
	Finding U.S. Citizens			Sales, Administrative, and Management	
	Significant Portion of Workforce Retiring			Other	
	Other	(Specify Here)		None	
	Other	(Specify Here)			

D.	Describe any significant changes in the recruitment, hiring and/or retention of human capital	

E.	If you plan to shut down a facility, do you reasonably anticipate being able to hire or rehire workers?		Explain:	

Comments:	

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7. Capital Expenditures

A.	Has your organization conducted **NdFeB Permanent Magnet product related capital expenditures (CapEx)** from 2017-2021 (and or expects to for 2022-2026)?	Yes	If no, proceed to the next section.

B. Record your organization's CapEx dollar expenditures and type of CapEx for the 2017-2021 (2022-2026 estimates) period. Estimates are acceptable

Record $ in Thousands, e.g. $12,000.00 = survey input of $12

			Past					Current	Future			
			2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1	Total CapEx		**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
2	Machinery, Equipment, and Vehicles											
3	IT, Computers, Software											
4	Land, Buildings, and Leasehold Improvements											
5	Other	(Specify Here)										
6	Other	(Specify Here)										

C. Provide your organization's CapEx funding sources for **2021 only**. Estimates are acceptable. U.S. and Non-U.S. Industry refers to joint ventures or other partnerships with your organization (does not include bonds, IPOs, or other funding sources). In addition, please provide any relevant CapEx projects that your organization is currently conducting (or plans to conduct by 2026).

Source of Funding		CapEx Project(s) Explain:
Internal/Self-Funded		
DOE-Related (Including CMI & AMES)		
DOD-Related		
Other USG-Related		
State/Local Government		
U.S. Industry		
Non-U.S. Industry		
Non-U.S. Government		
Other (Specify Here)		
Total:	**0%**	

D.

From 2017-2021, did your organization experience any major change(s) in CapEx related to NdFeB Permanent Magnet related products?	
If Yes, identify the reasons for these change(s):	
For 2022-2026, does your organization anticipate any major change(s) to CapEx related to NdFeB Permanent Magnet related products?	
If Yes, identify the reasons for these change(s):	

E. In order to produce NdFeB Permanent Magnets and or related products, are there significant CapEx costs associated with production? If yes, please answer the following below. If no, please proceed to the next section. (Note, only provide CapEx for the step(s) of the process chain that your organization participates in).

Mining and Concentration of Rare Earth (RE) Minerals

	Equipment	Equipment Producer Name	Equipment Producer Country	Single/Sole Source	Average lead time to acquire (in days)	Difficulties to Acquire (If Applicable)	Primary Resolution (If Applicable)	Criticality	Average cost to acquire ($ Thousands USD)	Comments
1				Single Source		Cyber Security Incident	Designed Input	4 - Little to no impact on production		
2				Sole Source		Disease/Quarantine	Developed Captive Capability	3 - Partial impact on production		
3				Neither		Equipment Outage	Identified Another Supplier	2 - Significant impact on production		
4						Financial Constraint	Stockpiling	1 - Critical to production (cannot produce without)		
5						Labor Disruption	Substituted Input			
6						Regulatory/Environmental Restrictions	Waited Until Disruption Passed			
7						Other	Other			
8						None	None			
9										
10										

Recycling/Reclamation of Rare Earth Elements (REE) from Waste Material/Non-Traditional Feedstocks

	Equipment	Equipment Producer Name	Equipment Producer Country	Single/Sole Source	Average lead time to acquire (in days)	Difficulties to Acquire (If Applicable)	Primary Resolution (If Applicable)	Criticality	Average cost to acquire ($ Thousands USD)	Comments
1				Single Source		Cyber Security Incident	Designed Input	4 - Little to no impact on production		
2				Sole Source		Disease/Quarantine	Developed Captive Capability	3 - Partial impact on production		
3				Neither		Equipment Outage	Identified Another Supplier	2 - Significant impact on production		
4						Financial Constraint	Stockpiling	1 - Critical to production (cannot produce without)		
5						Labor Disruption	Substituted Input			
6						Regulatory/Environmental Restrictions	Waited Until Disruption Passed			
7						Other	Other			
8						None	None			
9										
10										

Processing of Rare Earth (RE) Minerals into Carbonates

	Equipment	Equipment Producer Name	Equipment Producer Country	Single/Sole Source	Average lead time to acquire (in days)	Difficulties to Acquire (If Applicable)	Primary Resolution (If Applicable)	Criticality	Average cost to acquire ($ Thousands USD)	Comments
1				Single Source		Cyber Security Incident	Designed Input	4 - Little to no impact on production		
2				Sole Source		Disease/Quarantine	Developed Captive Capability	3 - Partial impact on production		
3				Neither		Equipment Outage	Identified Another Supplier	2 - Significant impact on production		
4						Financial Constraint	Stockpiling	1 - Critical to production (cannot produce without)		
5						Labor Disruption	Substituted Input			
6						Regulatory/Environmental Restrictions	Waited Until Disruption Passed			
7						Other	Other			
8						None	None			
9										
10										

Separation of Rare Earth (RE) Carbonates into Oxides

	Equipment	Equipment Producer Name	Equipment Producer Country	Single/Sole Source	Average lead time to acquire (in days)	Difficulties to Acquire (If Applicable)	Primary Resolution (If Applicable)	Criticality	Average cost to acquire ($ Thousands USD)	Comments
1				Single Source		Cyber Security Incident	Designed Input	4 - Little to no impact on production		
2				Sole Source		Disease/Quarantine	Developed Captive Capability	3 - Partial impact on production		
3				Neither		Equipment Outage	Identified Another Supplier	2 - Significant impact on production		
4						Financial Constraint	Stockpiling	1 - Critical to production (cannot produce without)		
5						Labor Disruption	Substituted Input			
6						Regulatory/Environmental Restrictions	Waited Until Disruption Passed			
7						Other	Other			
8						None	None			
9										
10										

NdFeB Metal Production

	Equipment	Equipment Producer Name	Equipment Producer Country	Single/Sole Source	Average lead time to acquire (in days)	Difficulties to Acquire (If Applicable)	Primary Resolution (If Applicable)	Criticality	Average cost to acquire ($ Thousands USD)	Comments
1				Single Source		Cyber Security Incident	Designed Input	4 - Little to no impact on production		
2				Sole Source		Disease/Quarantine	Developed Captive Capability	3 - Partial impact on production		
3				Neither		Equipment Outage	Identified Another Supplier	2 - Significant impact on production		
4						Financial Constraint	Stockpiling	1 - Critical to production (cannot produce without)		
5						Labor Disruption	Substituted Input			
6						Regulatory/Environmental Restrictions	Waited Until Disruption Passed			
7						Other	Other			
8						None	None			
9										
10										

NdFeB Alloy Production

	Equipment	Equipment Producer Name	Equipment Producer Country	Single/Sole Source	Average lead time to acquire (in days)	Difficulties to Acquire (If Applicable)	Primary Resolution (If Applicable)	Criticality	Average cost to acquire ($ Thousands USD)	Comments
1				Single Source		Cyber Security Incident	Designed Input	4 - Little to no impact on production		
2				Sole Source		Disease/Quarantine	Developed Captive Capability	3 - Partial impact on production		
3				Neither		Equipment Outage	Identified Another Supplier	2 - Significant impact on production		
4						Financial Constraint	Stockpiling	1 - Critical to production (cannot produce without)		
5						Labor Disruption	Substituted Input			
6						Regulatory/Environmental Restrictions	Waited Until Disruption Passed			
7						Other	Other			
8						None	None			
9										
10										

NdFeB Permanent Magnet Production

	Equipment	Equipment Producer Name	Equipment Producer Country	Single/Sole Source	Average lead time to acquire (in days)	Difficulties to Acquire (If Applicable)	Primary Resolution (If Applicable)	Criticality	Average cost to acquire ($ Thousands USD)	Comments
1				Single Source		Cyber Security Incident	Designed Input	4 - Little to no impact		
2				Sole Source		Disease/Quarantine	Developed	3 - Partial impact on		
3				Neither		Equipment Outage	Identified	2 - Significant impact		
4						Financial Constraint	Stockpiling	1 - Critical to production (cannot produce without)		
5						Labor Disruption	Substituted Input			
6						Regulatory/Environmental Restrictions	Waited Until Disruption Passed			
7						Other	Other			
8						None	None			
9										
10										

Recycling/Reclamation of NdFeB Permanent Magnets from Waste or Non-Traditional Feedstocks

	Equipment	Equipment Producer Name	Equipment Producer Country	Single/Sole Source	Average lead time to acquire (in days)	Difficulties to Acquire (If Applicable)	Primary Resolution (If Applicable)	Criticality	Average cost to acquire ($ Thousands USD)	Comments
1				Single Source		Cyber Security Incident	Designed Input	4 - Little to no impact on production		
2				Sole Source		Disease/Quarantine	Developed Captive Capability	3 - Partial impact on production		
3				Neither		Equipment Outage	Identified Another Supplier	2 - Significant impact on production		
4						Financial Constraint	Stockpiling	1 - Critical to production (cannot produce without)		
5						Labor Disruption	Substituted Input			
6						Regulatory/Environmental Restrictions	Waited Until Disruption Passed			
7						Other	Other			
8						None	None			
9										
10										

Comments:

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8. Research & Development/Intellectual Property

A.	Has your organization conducted **NdFeB Permanent Magnet product related research and development (R&D)** from 2017-2021 (and or expects to for 2022-2026)?	Yes	If no, proceed to part D below.

B. Record your organization's R&D dollar expenditures and type of R&D expenditure for the 2017-2021 (2022-2026 estimates) period. Estimates are acceptable.

Record $ in Thousands, e.g. $12,000.00 = survey input of $12

		Past					Current	Future			
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
1	Total R&D Expenditures	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
2	Basic Research										
3	Applied Research										
4	Product/Process Development										

From 2017-2021, did your organization experience any major change(s) in R&D expenditures related to NdFeB Permanent Magnet related products?		
If Yes, identify the reasons for these change(s):		
For 2022-2026, does your organization anticipate any major change(s) to R&D expenditures related to NdFeB Permanent Magnet related products?		
If Yes, identify the reasons for these change(s):		

C. Provide your organization's R&D funding sources for **2021 only**. Estimates are acceptable. U.S. and Non-U.S. Industry refers to joint ventures or other partnerships with your organization (does not include bonds, IPOs, or other funding sources). In addition, please provide any relevant R&D projects that your organization is currently conducting (or plans to conduct by 2026).

Source of Funding		R&D Project(s) Explain:
Internal/Self-Funded		
DOE-Related (Including CMI & AMES)		
DOD-Related		
Other USG-Related		
State/Local Government		
U.S. Industry		
Non-U.S. Industry		
Non-U.S. Government		
Other (Specify Here)		
Total:	**0%**	

D.	Did your organization own or use NdFeB Permanent Magnet related intellectual property (IP) from 2017-2021 (and or expects to for 2022-2026)? For original inventors, date of acquisition refers to when the IP was issued from a regulatory agency. For licensees, date of acquisition refers to when access to the IP was approved. Note, **only provide IP which is critical (can not produce without) to the production of NdFeB Permanent Magnets or related products**		If no, proceed to the next section.

E. Record the following: The serial number of the IP your organization utilizes, the organization which owns the IP, and the date of acquisition (can include anticipated acquisition dates).

IP Number	Name of IP Owner	Country of IP Owner	Date of Acquisition	Cost of Acquisition ($ Thousands USD)	Comments

Has your organization encountered difficulties in obtaining NdFeB Permanent Magnet related IP? If yes, please explain below.		

Comments:	

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9. National Defense/Critical Infrastructure

A.	Since 2017, has your organization directly or indirectly supplied NdFeB Permanent Magnets or related products for incorporation into U.S. critical infrastructure sectors? If no, proceed to part C. If yes, proceed to part B.	Yes
	For 2022-2026, does your organization plan to directly or indirectly supply NdFeB Permanent Magnets or related products for incorporation into U.S. critical infrastructure sectors? If no, proceed to part C. If yes, proceed to part B.	Yes

B. For 2017-2021, rank the top three critical infrastructure sectors your organization directly or indirectly supplies with NdFeB Permanent Magnets and or related products. Please do the same for 2022-2026. Once complete, proceed to Part C.

Definitions of each sector may be found at: https://www.cisa.gov/critical-infrastructure-sectors

Critical Infrastructure Sector	(2017-2021)	(2022-2026)
Chemical Sector		
Commercial Facilities Sector		
Communications Sector		
Critical Manufacturing Sector		
Dams Sector		
Defense Industrial Base Sector		
Emergency Services Sector		
Energy Sector		
Financial Services Sector		
Food and Agriculture Sector		
Government and Facilities Sector		
Healthcare and Public Health Sector		
Information Technology Sector		
Nuclear Reactors, Materials, and Waste Sector		
Transportation Systems Sector		
Waste and Wastewater Systems Sector		

C.	How have current market conditions involving the subject product categories affected your ability to meet current U.S. Critical Infrastructure requirements? Please explain below. If not applicable, proceed to part D.	Yes
D.	How have current market conditions involving the subject product categories affected your ability to meet current U.S. Defense requirements? Please explain below. If not applicable, proceed to part E.	Yes
E.	Is your organization ensuring that its sales are compliant with DFARS 225.7018, 10 U.S.C. 2533c? Indicate when your organization began this effort (or plans to) and please explain below. Definition/Terms may be found at: https://www.federalregister.gov/documents/2019/04/30/2019-08485/defense-federal-acquisition-regulation-supplement-restriction-on-the-acquisition-of-certain-magnets	

Comments:	

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10. Competition/Challenges

A.	Does your organization struggle to compete against imports and or exporting abroad? Do you expect the same/similar conditions to persist in the future?				
	Are any of the input conditions below hindering your organization's ability to compete on price?				

Input Condition	Percentage of total operating costs (Estimates Acceptable)	Would changing current government regulations/incentives significantly improve your organization's ability to compete on price?	If Yes, specify the regulation/incentive below	Explain
Electricity		Yes		
Environmental Regulations		No		
Export Licensing/Regulations		Not Applicable		
Labor				
Sourcing Feedstock Material				
Taxes				
Transportation Costs				
VAT Taxes, Tariffs, and other Trade Duties				
Other (Specify Here)				
Total:	**0%**			
What single change (and to which portion of the NdFeB Permanent Magnet supply chain) would most significantly improve cost competitiveness by 2026? Please explain to the right.				
Comments:				

B. Does your organization currently participate in any cooperative production, sourcing, information sharing, and or other agreements with other firms/governments both inside and outside of the United States? Do you intend to participate in the future/continue participation? If yes, answer the following questions below. If no, please proceed to Part C. | Current Participation |

Country	Partner Organization Name	Anticipated/Past Start Date (If Applicable)	Anticipated/Past End Date (If Applicable)	Explain
Comments:				

C. Is your organization looking to expand its operations domestically (or internationally) between 2022-2026? If yes, answer the following questions below. If no, please proceed to part D. Note, **limit market share responses to only activities that your organization performs (i.e. do not provide responses on the market as a whole or in general)**. | Yes |

Country	Current market share (Estimates acceptable)	Anticipated change in market share 2022-2026	Primary challenge to increasing market share (If Applicable)	Explain
		Increase	Domestic Competition	
		Decrease	Environmental regulations/remediation	
		No Change	Export controls/ITAR & EAR	
		Unknown	Financing/credit availability	
			Foreign Competition	
			Input availability	
			Labor availability/costs	
			Quality of inputs	
			Taxes	
			Trade disputes/tariffs	
Comments:				

D. Identify the primary challenges/issues affecting your competitive position in the overall [U.S. and non-U.S.] subject product markets. Rank the leading 5 most significant challenges (1 being the most important issue/impact; 2 being the next most important issue/impact, etc.). Explain your response.

	Challenge/Issue		Challenge Experienced?	Rank Top 5	Explain
1	Aging equipment, facilities, or infrastructure		Yes		
2	Aging workforce		No		
3	Counterfeit parts				
4	Cyber security				
5	Domestic competition				
6	Environmental regulations/remediation				
7	Export controls/ITAR & EAR				
8	Financing/credit availability				
9	Foreign competition				
10	Government acquisition process				
11	Government purchasing volatility				
12	Government regulatory burden				
13	Healthcare				
14	Industrial espionage - domestic				
15	Industrial espionage - foreign				
16	Input availability				
17	Intellectual property/patent infringement				
18	Labor availability/costs				
19	Natural disasters (including disease/quarantine)				
20	Obsolescence				
21	Pension costs				
22	Proximity to customers				
23	Proximity to suppliers				
24	Qualifications/certifications				
25	Quality of inputs				
26	R&D costs				
27	Reduction in USG demand				
28	Taxes				
29	Trade disputes/tariffs				
30	Worker/skills retention				
31	Other	(specify)			
32	Other	(specify)			
Comments:					

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11. Certification

The undersigned certifies that the information herein supplied in response to this questionnaire is complete and correct to the best of his/her knowledge. It is a criminal offense to willfully make a false statement or representation to any department or agency of the United States Government as to any matter within its jurisdiction (18 U.S.C. 1001 (1984 & SUPP. 1197)).

Once your organization has completed this survey, save a copy and submit it via email to NdFeB232@bis.doc.gov. Be sure to retain your survey for your records and to facilitate any necessary edits or clarifications.

Organization Name	
Organization's Internet Address	
Name of Authorizing Official	
Title of Authorizing Official	
E-mail Address	
Phone Number and Extension	
Date Certified	

In the box below, provide any additional comments or any other information you wish to include regarding this survey assessment.

How many hours did it take to complete this survey?	

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Appendix E: Global NdFeB Magnet Production: A Firm-Level Perspective

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A.1 Overview

This Appendix will discuss the global market conditions for the NdFeB magnet value chain. In particular, it focuses on five important current and potential industry producers outside of the United States: Australia, Canada, China, the European Union, and Japan. For each country or region, participation in the main market segments (mining, processing of carbonates/separation of oxides, metallization/alloying, magnet production) plus recycling and substitution is described. The major firms involved in production, often multinationals with global operations, will also be discussed.

The countries or regions discussed in this section were selected because of their current importance in the NdFeB magnet value chain, the role of domiciled firms in the NdFeB magnet value chain, and the significance of each country or region's prospective activities for U.S. reliance on NdFeB magnet imports. Table 7 provides a review of market share by country for the consolidated market segments of mining, separation, metallization, and alloying/magnet manufacture. China has the largest share of global production, by a large margin, at every step of the NdFeB magnet value chain. [redacted][1] Australia is the third largest miner after China and the United States, and the Australian firm Lynas Rare Earths is responsible for Malaysia's seven percent share of the refined oxide market. Japan is the second largest alloy and magnet producer (seven percent in 2020), and its firms produce metals, alloys, and magnets in Japan, Southeast Asia, and China. [redacted][2] The European Union has plans for significant growth in rare earth mining and magnet production, and seeks to grow its relatively small share of the oxide separation, alloying, and magnet production markets. [redacted]

[1] Adamas Intelligence, "Rare Earth Magnet Market Outlook to 2030," 2020.
[2] Ibid.

[redacted][3] Finally, Canada also plans to establish rare earth mining and separation capacity, in addition to Canadian firms such as Neo Performance Materials who maintain global capacity in multiple steps of the magnet value chain.

Table 7: Market Share by Country, 2021 for Mining and 2020 for Other Steps

Country	Mining[4]	Separation[5]	Metal refining[6]	Magnet alloy manufacturing[7]
China	60%	89%	90%	92%
U.S.	15%	-	-	<1%
Myanmar (Burma)	9%	-	-	-
Australia	8%	-	-	-
Madagascar	1%	-	-	-
India	1%	1%	-	-
Russia	1%	-	-	-
Thailand	3%	-	~3%	-[8]
Malaysia	-	7%	-	-
Estonia	-	1%	~2%	-
Japan	-	-	-	7%
Vietnam	>1%	-	~3%	1%
Laos	-	-	~2%	-
Germany	-	-	-	<1%
Slovenia	-	-	-	<1%
Finland	-	-	-	<1%
U.K.	-	-	<1%	-
Other countries	1%	2%	<1%	<1%

Source: "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022; Daniel Cordier, "Rare Earths: Mineral Commodity Summaries 2022," U.S. Geological Survey, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.

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[3] Ibid.
[4] For 2021 estimates of rare earth mine output by country, *see* Daniel Cordier, "Rare Earths: Mineral Commodity Summaries 2022," U.S. Geological Survey, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.
[5] Calculated based on current understanding of where concentrate from specific producers is separated (for example, output from Lynas' Mount Weld mine in Australia is separated at its facility in Malaysia and heavy rare earths mined in Myanmar are transported to China for further processing). "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[6] Current hypothesis based on expert consultation. "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[7] "Rare earth magnet market outlook to 2030," Adamas Intelligence, August 2020.
[8] In 2019, Thailand accounted for about eight percent of bonded NdFeB powders. Neo Magnequench (a subsidiary of Neo Performance Materials) manufactures bonded magnetic powders at its facility in Korat, Thailand. "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

A.2 Australia

Australia is a major participant in the upstream NdFeB magnet value chain with significant rare earths reserves and mining operations. Australian firms have also built or plan to build rare earth separation plants in Malaysia, the United Kingdom, and the United States. To encourage domestic production, in 2021 the Australian government established the $1.4 billion Critical Minerals Facility to provide financing when private sector finance is inadequate and the $860 million Modern Manufacturing Initiative to encourage additional private investment. As of November 2021, $34 million had been allocated to domestic critical minerals projects.[9] Australia has no domestic metallization or magnet production capacity and indicates that although it is interested in potential domestic rare earths alloy production it will continue to rely on Japan, South Korea, and prospectively the United States to turn its rare earth oxides into metals, alloys, and magnets.[10]

Australia has four million tons of rare earths reserves, with 2021 mine production of approximately 22,000 tons (eight percent of global production).[11] Lynas Rare Earths, Australia's most prominent rare earths miner, initiated production in 2011 as a result of Japanese investment designed to diversify Japan's sources of rare earths away from China.[12] Lynas Rare Earths is now the leading supplier of neodymium-praseodymium (NdPr, sometimes referred to as didymium) to the Japanese market.[13] Indeed, Japan has priority supply rights until 2038, including clauses to prioritize the needs of Japanese customers.[14] [15]

Lynas Rare Earths' main source of rare earths is Mt. Weld in Western Australia.[16] In fiscal year 2021, Lynas Rare Earths' rare earth oxide production was 15,761 tons, of which NdPr production needed for NdFeB magnets account for 5,461 tons.[17] In 2020 Lynas Rare Earths announced plans for a rare earths separation facility in Australia.[18] In 2021 Lynas Rare Earths advanced plans for another rare earths separation facility in the United States that is partially

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[9] Comments of the Australian Government to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[10] Ibid.
[11] Rare earths include elements not used in NdFeB magnets. Daniel Cordier, "Rare Earths: Mineral Commodity Summaries 2022," U.S. Geological Survey, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.
[12] Brian Daigle and Samantha DeCarlo, "Rare Earths and the U.S. Electronics Sector: Supply Chain Developments and Trends," U.S. International Trade Commission Working Paper ID-075, June 2021, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.
[13] "2021 Annual Report," Lynas Rare Earths, Ltd., 2021, https://wcsecure.weblink.com.au/pdf/LYC/02434182.pdf.
[14] Cecilia Jamasmie, "Japan secures rare earth supply for longer through Lynas funding", Mining.com, June 27, 2019, https://www.mining.com/japan-secures-rare-earth-supply-for-longer-through-lynas-funding/.
[15] "2021 Annual Report," Lynas Rare Earths, Ltd., 2021, https://wcsecure.weblink.com.au/pdf/LYC/02434182.pdf.
[16] Brian Daigle and Samantha DeCarlo, "Rare Earths and the U.S. Electronics Sector: Supply Chain Developments and Trends," U.S. International Trade Commission Working Paper ID-075, June 2021, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.
[17] "2021 Annual Report," Lynas Rare Earths, Ltd., 2021, https://wcsecure.weblink.com.au/pdf/LYC/02434182.pdf.
[18] Ibid.

funded under DPA Title III, [redacted].[19] In addition to Lynas Rare Earths, other Australian firms are exploring potential mining operations.[20] At least five Australian mining projects are currently in pre-construction or feasibility stages.[21] Iluka Resource's expanded Eneabba project in Western Australia, Arafura Resources' Nolans Rare Earth Project in the Northern Territory, and Australian Strategic Materials' Dubbo Project in New South Wales, are the nearest to commercialization and should be commissioned by 2024.[22] [23]

Australia's current rare earths separation capacity is entirely dependent on Lynas Rare Earths but will diversify given planned facilities. Lynas Rare Earths maintains a rare earths refinery in Malaysia, which is currently operating under a three-year license that is valid until early March 2023.[24] Lynas Rare Earths' Malaysian separation facility is currently the only large-scale separation site outside of China, with about seven percent of the 2020 oxide separation market.[25] In April 2022, Iluka Resources announced the construction of a rare earths separation facility in Australia after obtaining a $913 million low-interest loan from the Australian government.[26] The facility, which is expected to begin production in 2025, will have an annual capacity of 5,500 tons of NdPr, although average annual production is estimated at 2,700 tons.[27] Iluka Resources will also produce dysprosium and terbium oxides, with capacity of about 750 tons per year.[28] Arafura Resources also plans to begin to separate individual oxides from its Nolans Project starting in 2025, with full production of 4,400 tons per year beginning in 2027.[29] In May 2022, Arafura Resources announced a non-binding memorandum of understanding with South Korean

[19] "DoD Announces Rare Earth Element Award to Strengthen Domestic Industrial Base," Department of Defense, February 1, 2021, https://www.defense.gov/News/Releases/Release/Article/2488672/dod-announces-rare-earth-element-award-to-strengthen-domestic-industrial-base/.
[20] Brian Daigle and Samantha DeCarlo, "Rare Earths and the U.S. Electronics Sector: Supply Chain Developments and Trend," U.S. International Trade Commission Working Paper ID-075, June 2021, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.
[21] Comments of the Australian Government to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[22] Ibid.
[23] For Iluka Resources this refers to an expanded facility, as it has produced rare earths concentrates since 2020. "Overview," Iluka Resources, n.d., https://iluka.com/engage/eneabba.
[24] "Lynas Malaysia Operating Licence Renewed for Three Years," Lynas Rare Earths, February 27, 2020. https://lynasrareearths.com/wp-content/uploads/2020/02/200227-Lynas-Malaysia-Operating-Licence-Renewed-for-Three-Years-2034990.pdf.
[25] I.M.S.K. Illankoon et al., "Constraints to Rare Earth Elements Supply Diversification: Evidence from an Industry Survey," Journal of Cleaner Production (331), January 10, 2022, https://doi.org/10.1016/j.jclepro.2021.129932.
[26] The loan was $1.25 billion Australian dollars and the exchange rate was 0.75 U.S. dollars to the Australian dollar on April 4, 2022. "Transforming Australia's critical minerals sector," Export Finance Australia, April 4, 2022, https://www.exportfinance.gov.au/newsroom/transforming-australia-s-critical-minerals-sector.
[27] "Iluka Resources Limited: Eneabba Rare Earths Refinery – Final Investment Decision," Iluka Resources, April 3, 2022, https://www.iluka.com/getattachment/bf86791e-7a5b-40cd-a38f-0fd6185fdc24/eneabba-rare-earths-refinery-final-investment-(1).aspx.
[28] Ibid.
[29] "Arafura and Hyundai Motor Company Sign Non-Binding MoU for Neodymium and Praseodymium Offtake," Arafura Resources, May 19, 2022, https://wcsecure.weblink.com.au/pdf/ARU/02523015.pdf.

automobile firm Hyundai, which provides a framework for a binding offtake agreement to supply 1,000 to 1,500 tons of NdPr for use in NdFeB magnets over a seven year period starting in 2025.[30] It is not clear what firm will process Arafura Resources' NdPr into magnets.

Some Australian firms are also establishing downstream capacity in the NdFeB magnet value chain. Australian Strategic Materials plans to produce rare earth metals in South Korea using its Australian-mined rare earths.[31] The company acquired 95 percent of its former South Korean joint venture partner ZironTech in 2020.[32] One hundred percent of its planned Dubbo Project's neodymium oxide will be processed into metal at the South Korean plant.[33] The metallization plant will be located in the Ochang Foreign Investment Zone in Chungcheongbuk-do, South Korea, with an initial capacity of 5,200 tons per annum by mid-2022 and full capacity of 16,000 tons per annum by the end of 2024.[34] [35] Australian Strategic Materials recently announced a five year cooperation agreement with the Korean Mine Rehabilitation and Resource Corporation, a state agency responsible for national resource security.[36] This agreement is meant to ensure a secure supply of minerals and metals for South Korean industry and to facilitate the development of a South Korean strategic stockpile of critical metals.[37] Australian Strategic Materials has also entered into an offtake agreement for 2,800 tons per annum of NdFeB alloy with a South Korean consortium, which includes a proposed NdFeB magnet manufacturing facility in South Korea.[38]

Australian firms also operate rare earths projects outside of Australia. For example, Peak Rare Earths operates the Ngualla project in Tanzania, with 18.5 million tons of rare earths reserves with an estimated grade of 4.8 percent or approximately 887,000 tons of rare earth oxides.[39] The Ngualla project will focus on the extraction of neodymium and praseodymium once construction of the mine and concentration facility are completed. Rare earth concentrate will be shipped to the United Kingdom, where Peak Rare Earths also plans to construct a facility to separate the concentrate into rare earth oxides with annual output of 9,900 to 11,600 tons. The separation

[30] Ibid.
[31] David Woodall, "New Technologies and Manufacturing ASM – Independent Supplier of Critical Metals," Australian Strategic Materials, December 2020.
[32] "ASM Completes Acquisition of Ziron Tech," Australian Chamber of Commerce in Korea, December 1, 2020, https://austchamkorea.org/2020/12/01/asm-completes-acquisition-of-ziron-tech/.
[33] "Annual Report 2021," Australian Strategic Materials, 2021, https://asmd.irmau.com/site/PDF/40ea7ebd-4c56-44de-a0e2-869eda3d3f11/AnnualReporttoshareholders.
[34] "ASM signs MoU with South Korean provincial government for metals plant location," Australian Strategic Materials, March 9, 2021, https://asm-au.com/asm-signs-mou-with-south-korean-provincial-government-for-metals-plant-location/.
[35] "Scoping study demonstrates feasibility of ASM Korean metals plant," Australian Strategic Materials, March 2, 2021, https://asm-au.com/scoping-study-demonstrates-feasibility-of-asm-korean-metals-plant/.
[36] "ASM signs Joint Statement of Cooperation on Critical Metals with KOMIR (KORES)," Australian Strategic Materials, December 14, 2021, https://asm-au.com/asm-signs-joint-statement-of-cooperation-on-critical-metals-with-komir-kores/.
[37] Ibid.
[38] "ASM signs $US250m framework agreement with South Korean consortium for 20% in Dubbo Project and offtake from Korean Metals Plant," Australian Strategic Materials, July 21, 2021, https://asm-au.com/asm-signs-us250m-framework/.
[39] "2021 Annual Report," Peak Rare Earths, 2021, https://wcsecure.weblink.com.au/pdf/PEK/02440680.pdf.

facility is expected to cost $165 million.[40] Peak Rare Earths was recently partially acquired (19.9 percent stake) by China's Shenghe Group.[41] [42]

A.3 Canada

Although Canada's current contribution to the NdFeB magnet value chain is limited, it has significant prospective capacity to be a producer of rare earths and plans to enter the separation market.

Dozens of advanced stage exploration projects and one current mining operation in Canada seek to leverage Canada's estimated 14 million tons of total rare earth oxides.[43] Cheetah Resources, a subsidiary of Vital Metals, opened Canada's first rare earths mine in 2021. This is a bastnaesite deposit with 1.46 percent rare earth oxides.[44] Cheetah Resources will initially produce about 470 tons per year of NdPr oxide, and by 2025 will produce at least 5,000 tons of rare earth oxides, including 940 tons per year of NdPr.[45] [46] In addition, the Canadian firm Neo Performance Materials operates the only separation facility in Europe [redacted] [47] Neo Performance Materials also owns [redacted] production facilities in China.[48]

Canada is seeking to establish domestic separation facilities. In August 2020, the Government of Saskatchewan announced $23 million in funding to establish a processing and separation facility,

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[40] Ibid.
[41] Min Zhang and Twinnie Siu, "Shenghe Resources plans to buy stake in Australia's Peak Rare Earths," Reuters, February 11, 2022, https://www.reuters.com/article/china-rareearth-shenghe-peak-rare-earths-idINKBN2KG11T.
[42] The Shenghe Group also has a minority stake in U.S. mining firm MP Materials. *See* Mary Hui, "A Chinese rare earths giant is building international alliances worldwide," Quartz, February 19, 2021, https://qz.com/1971108/chinese-rare-earths-giant-shenghe-is-building-global-alliances/.
[43] Comments of the Embassy of Canada to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[44] Comments of Vital Metals Ltd. and Cheetah Resources Corp. to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[45] Comments of the Embassy of Canada to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[46] Comments of Vital Metals Ltd. and Cheetah Resources Corp. to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[47] "MD&A," Neo Performance Materials, 2021, https://www.neomaterials.com/wp-content/uploads/2022/03/NPM-12.31.2021-MDA.pdf.
[48] Ibid.

which is expected to be operational as early as the end of 2022.[49] [50] The Saskatchewan Research Council is currently sourcing rare earth element feedstock for this facility, which can process about 3,000 tons per year.[51]

Finally, Canadian firm Geomega Resources is seeking to recycle magnet production waste and end-of-life magnets using its own proprietary production technology.[52] In January 2021, Geomega Resources announced the completion of its pilot plant to confirm the validity of its recycling technology.[53] Geomega Resources' recycling demonstration plant in Saint-Bruno-de-Montarville, Quebec, has yet to be completed.[54]

A.4 China

As detailed earlier, China is the global leader in the NdFeB magnet value chain. China's dominance of the value chain can be attributed to government policy, the country's significant reserves of rare earths, and the relative abundance of low-cost labor. Starting in the 1980s, the Chinese government established policies, including tax rebates, subsidies, and research and development funding for mining technology, to increase its share of the global rare earths market.[55] For example, in 1985 rare earth exports became eligible for tax reimbursements.[56] As a result of these policies, China's rare earths production doubled from 1985 to 1990.[57] Having expanded its market share, in the 2000s the government turned its focus to increasing the capacity of downstream value chain production of alloys, powders, and NdFeB magnets.[58] China's downstream capacity expansion influenced other countries' decisions to close processing facilities.[59] China placed restrictions on foreign investment in the early 1990s while maintaining

[49] The $23 million dollar funding figure was calculated by converting the value of the $31 million Canadian award to U.S. dollars at August 2020 prices, which were about 0.75 Canadian dollars to the U.S. dollar. Comments of the Embassy of Canada to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[50] "Saskatchewan to Create Canada's First Rare Earth Processing Facility at SRC," Government of Saskatchewan, August 27, 2020, https://www.saskatchewan.ca/government/news-and-media/2020/august/27/ree-facility.
[51] Ibid.
[52] "Sustainable and Innovative Extraction, Separation and Recycling Technologies for Rare Earth Element (REE) and other critical metals," Geomega Resources, n.d., https://geomega.ca/company-profile/.
[53] "Geomega successful completes rare earths pilot plant testing," Geomega Resources, January 12, 2021, https://www.globenewswire.com/news-release/2021/01/12/2156976/0/en/Geomega-Successfully-Completes-Rare-Earths-Pilot-Plant-Testing.html.
[54] "Geomega provides REE recycling demo plant update," Geomega Resources, March 28, 2022, https://geomega.ca/geomega-provides-ree-recycling-demo-plant-update/.
[55] "Tech Companies Depend on China for Rare Earths. Can that Change?" The Wall Street Journal, May 4, 2021, https://www.youtube.com/watch?v=T7pusAWBCoE.
[56] Yuzhou Shen, Ruthann Moomy, and Roderick G. Eggert, "China's public policies towards rare earths, 1975-2018," Mineral Economics 33: 127-151, January 7, 2020, https://doi.org/10.1007/s13563-019-00214-2.
[57] Ibid.
[58] Ana-Cristina Balgar, "Implications and Challenges of China's Supremacy on the Global Rare Earths Market," Global Economic Observer 9 (1): 55-68, 2021, http://www.globeco.ro/wp-content/uploads/vol/split/vol_9_no_1/geo_2021_vol9_no1_art_007.pdf.
[59] Yuzhou Shen, Ruthann Moomy, and Roderick G. Eggert, "China's public policies towards rare earths, 1975-2018," Mineral Economics 33: 127-151, January 7, 2020, https://doi.org/10.1007/s13563-019-00214-2.

its export tax reimbursement policy, which contributed to the expansion of its global rare earth element market share to 85 percent.[60] Having established downstream capacity, China cancelled its export tax reimbursement in 2005 and imposed export taxes on downstream products in 2007 to maintain a wholly domestic supply chain.[61] A particular barrier for foreign NdFeB magnet producers is the application of a 13 percent value added tax (VAT) refund on exported finished magnets that is not applied to exported magnet feedstock.[62] As a result, foreign magnet firms, which almost certainly rely on Chinese feedstocks of oxides, metals, and/or alloys, will produce magnets that are at least 13 percent more expensive than their Chinese counterparts. In addition to favorable tax policies and subsidies, China has invested heavily in research and development of rare earth elements, even founding labs focused specifically on rare earth separation techniques.[63] Public policies aided the development of and maintain China's ongoing dominance of the global NdFeB magnet value chain.

Factor endowments also facilitated China's domination of the global NdFeB magnet value chain. China maintains about 37 percent of global rare earth reserves.[64] Chinese rare earth reserves are concentrated in Inner Mongolia, which is rich in light rare earths, and southern China, which has significant heavy rare earths deposits.[65] The largest light rare earths deposit, Bayan Obo, accounts for more than 40 percent of China's known rare earths reserves and half of its production.[66] Sichuan is also rich in rare earth elements.[67] In addition to rare earths reserves, China's relatively low-cost labor contributes to lower production costs. DoE estimates that in general, labor costs in China range from 18 to 50 percent of U.S. labor costs and should be on the higher end of that range for the NdFeB magnet value chain given the specialization required to produce NdFeB magnets.[68]

From 2017, when the Chinese government consolidated the upstream NdFeB magnet value chain, until 2021, there were six major Chinese enterprises operating in the rare earths mining and separation market: China Minmetals, Aluminum Corporation of China, China Northern Rare Earth Group High-Tech, Xiamen Tungsten, China Southern Rare Earth Group, and Guangdong

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[60] Ibid.
[61] Ibid.
[62] Comments of Noveon to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[63] Marc Humphries, "Rare Earth Elements: The Global Supply Chain," Congressional Research Service, December 16, 2013, https://sgp.fas.org/crs/natsec/R41347.pdf.
[64] Annie Fixler and Louis Gilbertson, "China Consolidates Rare Earth Supply Chain," Foundation for the Defense of Democracies, November 5, 2021, https://www.fdd.org/analysis/2021/11/05/china-consolidates-rare-earth-supply-chain.
[65] Comments of Arnold Magnetics to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[66] "Projects: Banyan Obo Rare Earth Mine," NS Energy, n.d., https://www.nsenergybusiness.com/projects/bayan-obo-rare-earth-mine/.
[67] Yuzhou Shen, Ruthann Moomy, and Roderick G. Eggert, "China's public policies towards rare earths, 1975-2018," Mineral Economics 33: 127-151, January 7, 2020, https://doi.org/10.1007/s13563-019-00214-2.
[68] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

Rare Earth Industry Group.[69] Each of these enterprises covered different parts of the upstream magnet value chain and together controlled almost one hundred percent of the mining and separation markets in China.[70] On December 23, 2021, three of these – China Minmetals, Chinalco Rare Earth and Metals, and China Southern Rare Earth group – announced their merger into a new state-controlled organization called China Rare Earth Group, which will produce about 70 percent of China's total rare earths output.[71] This new organization will be a particularly important producer of heavy rare earths such as dysprosium and terbium, of which China has a near monopoly and which are critical components of NdFeB magnets when used in high-temperature applications.[72] [73] China Rare Earth Group may acquire two other major Chinese rare earths firms, Xiamen Tungsten and Guangdong Rare Earth Industry Group, which would further consolidate the Chinese industry into two major rare earths firms.[74]

China North Rare Earth Group High-Tech (CNREG) is China's other major – and currently the world's largest – rare earths producer.[75] When the Chinese industry was initially consolidated in 2017, it held over 50 percent of the rare earths concentrate and separation quotas.[76] It is valued at $29.6 billion with a separated oxide capacity of 80,000 tons per year and a metallization capacity of 10,000 tons per year.[77] In September 2021, CNREG and Anhui Earth-Panda Advance Magnetic Material announced a NdFeB alloy facility with an annual output of 8,000 tons to start production in late 2022.[78] [79] Together with Qingdao Zhonggat, CNREG also plans to operate further down the NdFeB magnet value chain by developing a more efficient NdFeB magnet motor.[80]

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[69] Yuzhou Shen, Ruthann Moomy, and Roderick G. Eggert, "China's public policies towards rare earths, 1975-2018," Mineral Economics 33: 127-151, January 7, 2020, https://doi.org/10.1007/s13563-019-00214-2.
[70] Ibid.
[71] Sun Yu and Tom Mitchell, "China Merges 3 Rare Earth Miners to Strengthen Dominance of Sector," Financial Times, December 23, 2021, https://www.ft.com/content/4dc538e8-c53e-41df-82e3-b70a1c5bae0c.
[72] Tom Daly, "Minmetals confirms China rare earths merger, creating new giant," Reuters, December 22, 2021. https://www.reuters.com/world/china/minmetals-unit-confirms-china-rare-earths-merger-2021-12-22/.
[73] Comments of USA Rare Earth to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[74] Sun Yu and Tom Mitchell, "China Merges 3 Rare Earth Miners to Strengthen Dominance of Sector," Financial Times, December 23, 2021, https://www.ft.com/content/4dc538e8-c53e-41df-82e3-b70a1c5bae0c.
[75] Ibid.
[76] Yuzhou Shen, Ruthann Moomy, and Roderick G. Eggert, "China's public policies towards rare earths, 1975-2018," Mineral Economics 33: 127-151, January 7, 2020, https://doi.org/10.1007/s13563-019-00214-2.
[77] CNREG dwarfs current and potential U.S. firms. MP Materials, the largest U.S. rare earths producer, has a valuation of $8.7 billion as of April 15, 2022. Based on the Department's survey of the U.S. NdFeB magnet industry, in 2026 the United States is forecast to produce fewer than [redacted] of separated rare earth oxides and barely [redacted] of rare earth metals.
[78] "China Northern Rare Earth, Earth Panda to Build 8,000 Mt/Year High-Performance NdFeB Alloy Flakes Project," Shanghai Metals Market News, September 2, 2021, https://news.metal.com/newscontent/101587169/China-Northern-Rare-Earth,-Earth-Panda-to-Build-8,000-MtYear-High-Performance-NdFeB-Alloy-Flakes-Project/.
[79] The Department's U.S. NdFeB magnet industry survey projects total U.S. rare earth alloy production at [redacted] by 2026.
[80] "Northern Rare Earth and Qingdao Zhongjiate Plan to Jointly Invest in the Project of Rare Earth Permanent Magnet High Efficiency Motor," Shanghai Metals Market News, March 28, 2022,

In addition to the two main rare earths producers, there are numerous Chinese NdFeB magnet manufacturers – by one count, 160 in 2019.[81] [82] Ten of these firms produced over 5,000 tons each in 2019.[83] [redacted][85]

[redacted][86] [redacted][87] [redacted] Chinese magnet manufacturers generally dwarf non-Chinese firms in production capacity but continue to invest in additional capacity. For example, JL Mag is constructing a facility in Baotou that will bring its total capacity to 23,000 tons.[88]

Industry participants indicate that some Chinese firms produce lower quality magnets while others produce magnets comparable in quality to German and Japanese magnets.[89] Indeed, some Chinese magnet producers have licensed Japanese intellectual property from Hitachi to produce sintered NdFeB magnets, including the following firms since 2013: Advanced Technology and Materials, Anhui Earth-Panda Advance Magnetic Material, Beijing Jingci Magnet, Beijing Zhong Ke San Huan High-Tech, Ningbo Jinji Strong Magnetic Material, Ningbo Yunsheng, Thinova Magnet, and Yantai Zhenghai Magnetic Material.[90] As discussed in subsequent sections, a group of Chinese firms led by Ningbo Ketian Magnet is attempting use the Chinese courts to

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https://news.metal.com/newscontent/101790107/Northern-rare-earth-and-Qingdao-Zhongjiate-plan-to-jointly-invest-in-the-project-of-rare-earth-permanent-magnet-high-efficiency-motor/.

[81] In addition to Chinese magnet manufacturers, foreign firms, such as Neo Performance Materials and Hitachi, operate production facilities in China.

[82] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.

[83] Ibid.

[84] "Rare earth magnet market outlook to 2030," Adamas Intelligence, August 2020.

[85] Ibid.

[86] This only accounts for direct imports and does not point to magnet manufacturers of embedded magnets.

[87] [redacted]

[88] "Field investigation of Jinliyong Magnetic bonding Baotou "High performance rare Earth permanent Magnet material Base Project" will form a blank production capacity of 23000 tons/year of high performance rare earth permanent magnet materials," Shanghai Metals Market, January 12, 2022, https://news.metal.com/newscontent/101724148/field-investigation-of-jinliyong-magnetic-bonding-baotou-%22high-performance-rare-earth-permanent-magnet-material-base-project%22-will-form-a-blank-production-capacity-of-23000-tonsyear-of-high-performance-rare-earth-permanent-magnet-materials/.

[89] Meeting between Arnold Magnetics and the Department of Commerce, (Virtual Meeting, December 6, 2021).

[90] "Sintered NdFeB Magnets," Hitachi Metals, n.d., https://www.hitachi-metals.co.jp/e/pdf/pi20131202ec.pdf.

compel Hitachi to license its sintered NdFeB magnet patents, which may result in even wider de jure technological diffusion among Chinese manufacturers.[91]

China is also active in NdFeB magnet recycling, which contributes to the country's overall production capacity for magnets. As with magnet producers generally, recycling magnet swarf, or the material lost when shaping magnets in accordance with end-use specifications, is particularly common.[92] NdFeB waste recycling companies are mainly located in Jiangxi, with others in Zhejiang, Jiangsu, and Guangdong.[93] The Chinese government is also encouraging increased end-user magnet recycling: In November 2021, the Ministry of Industry and Information Technology proposed improvements to motor recycling, which will produce an additional 29,000 tons of NdFeB magnets from 2021 to 2025.[94]

Chinese firms have moved to purchase stakes in overseas NdFeB magnet industry participants and expand their own foreign operations, increasing China's control of the global NdFeB magnet value chain. For example, partially state-owned Shenghe Resources is involved in overseas operations across the value chain from rare earths mining to oxide separation and metal refining.[95] Shenghe Resources has taken ownership stakes in firms in Australia, Greenland, the United States, and Vietnam, including U.S. mining firm MP Materials.[96] MP Materials currently sells its rare earth concentrate to Shenghe Resources for further processing.[97] Other Chinese firms are also attempting to invest abroad: in 2020, Australia blocked China's Baogang Group from investing in Australian firm Northern Minerals, which owns a rare earths project in Western Australia.[98] In addition to purchasing stakes in existing firms, Chinese companies are also establishing operations abroad to source rare earths. For example, in 2019 state-owned China Nonferrous Metal Industry announced a non-binding memorandum of understanding to

[91] "Chinese Court Enforces Mandatory Licensing for "Essential Facility" Patents in Antitrust Case," Jones Day, June 2021, https://www.jonesday.com/en/insights/2021/06/chinese-court-enforces-mandatory-licensing-for-essential-facility-patents-in-antitrust-case.
[92] Meeting between Noveon and the Department of Commerce, (Virtual Meeting, November 12, 2021).
[93] "A Quick Look into Rare Earth (Chapter 1)," Shanghai Metals Market, August 10, 2021, https://news.metal.com/newscontent/101563731/A-Quick-Look-into-Rare-Earth-Chapter-I/; "SMM: Predicts that There is Still a Gap between Supply and Demand of Rare Earths in 2022 and Prices will be Consolidated at a High Level," Shanghai Metals Market, January 21, 2022, https://advance.lexis.com/document/index?crid=7737c212-c2ca-466d-bb80-49822132e498&pdpermalink.
[94] "SMM: Predicts that There is Still a Gap between Supply and Demand of Rare Earths in 2022 and Prices will be Consolidated at a High Level," Shanghai Metals Market, January 21, 2022, https://advance.lexis.com/document/index?crid=7737c212-c2ca-466d-bb80-49822132e498&pdpermalink.
[95] "Shenghe Resources Holding Co Ltd," Reuters, last accessed May 19, 2022, https://www.reuters.com/markets/companies/600392.SS; Mary Hui, "A Chinese rare earths giant is building international alliances worldwide," Quartz, February 19, 2021, https://qz.com/1971108/chinese-rare-earths-giant-shenghe-is-building-global-alliances/.
[96] Mary Hui, "A Chinese rare earths giant is building international alliances worldwide," Quartz, February 19, 2021, https://qz.com/1971108/chinese-rare-earths-giant-shenghe-is-building-global-alliances/.
[97] "Form 10-K," MP Materials, February 28, 2022, https://d18rn0p25nwr6d.cloudfront.net/CIK-0001801368/77b2894e-b746-43c5-938a-a3f524823baa.pdf.
[98] Brad Thompson, "Chinese group blames Australia for barring stake in African lithium mine," Financial Review, April 27, 2020, https://www.afr.com/companies/mining/china-group-blames-australia-for-barring-stake-in-african-lithium-mine-20200426-p54n8h.

work as a contractor on a rare earths project in Madagascar with rights to purchase 3,000 tons of rare earth products.[99] Similarly, in April 2021 state-backed China Rare Metals and Rare Earth signed a non-binding memorandum of understanding with Australian firm Ionic Rare Earths to accelerate production of and establish a framework to invest in or purchase products produced by Ionic Rare Earths at its Makuutu Rare Earth Project in Uganda.[100] China's outbound investments appear directed at developing a network of overseas operations to guarantee a stable supply of rare earth feedstocks.[101]

A.5 European Union

The European Union (EU) is currently a relatively minor participant in the NdFeB magnet value chain, though planned investments will increase capacity in the coming years. From 2016 to 2018, the EU consumed an estimated 4,734 tons per year of rare earth elements and 683 tons per year of rare earth metals and interalloys, most of which were sourced from China.[102] In 2019, these Chinese feedstocks were utilized for EU production of approximately 500 tons of NdFeB magnets.[103] In the same year, EU production capacity for NdFeB magnets was 1,000 tons per year.[104] In contrast to minimal domestic production, the EU currently imports about 16,000 tons of NdFeB magnets per year from China.[105] [106] In order to reduce this dependence on China, the EU is actively working to develop its currently nonexistent mining capacity. Further downstream, the EU also plans to expand its currently limited separation and magnet production capacity, including alloys. By 2030, the EU plans to increase production to 7,000 tons per year, which would add an estimated 5,000 direct jobs.[107]

Various firms are actively exploring potential commercial mining sites in Sweden, Spain, and Germany, with estimated deposits of 333,000, 36,000, and 10,000 tons respectively.[108] Other firms are exploring commercial projects in Greenland (approximately 1.5 million tons of rare

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[99] "China's CNMC agrees to work on Madagascar rare earth project," Reuters, June 24, 2019, https://www.reuters.com/article/us-china-rareearths-madagascar-idUSKCN1TP1H3.
[100] "IonicRE signs MoU with CHINALCO for Potential Investment, Offtake and Mine Development," Ionic Rare Earths, April 7, 2021, https://ionicre.com.au/wp-content/uploads/post/210407i.pdf.
[101] Mary Hui, "A Chinese rare earths giant is building international alliances worldwide," Quartz, February 19, 2021, https://qz.com/1971108/chinese-rare-earths-giant-shenghe-is-building-global-alliances/.
[102] Cynthia El Latunussa et al., "Study on the EU's list of critical raw materials (2020): Critical raw materials factsheets," European Commission, September 16, 2020, https://op.europa.eu/en/publication-detail/-/publication/8dabb4c1-f894-11ea-991b-01aa75ed71a1/language-en/format-PDF/source-259044582.
[103] Roland Gaus et al., "Rare Earth Magnets and Motors: A European Call for Action," European Raw Materials Alliance, September 2021, https://erma.eu/app/uploads/2021/09/01227816.pdf.
[104] Ibid.
[105] Ibid.
[106] Rare earth elements comprise approximately 30 percent of the total content of NdFeB magnets, which explains why imports of magnets are larger in volume than rare earth elements or rare earth metals.
[107] Roland Gaus et al., "Rare Earth Magnets and Motors: A European Call for Action," European Raw Materials Alliance, September 2021, https://erma.eu/app/uploads/2021/09/01227816.pdf.
[108] Cynthia El Latunussa et al., "Study on the EU's list of critical raw materials (2020): Critical raw materials factsheets," European Commission, September 16, 2020, https://op.europa.eu/en/publication-detail/-/publication/8dabb4c1-f894-11ea-991b-01aa75ed71a1/language-en/format-PDF/source-259044582.

earth reserves).[109] Due to the relatively low grade of deposits at these sites, some industry players are skeptical that EU mining projects will be commercially viable, especially if rare earths prices fall back to 2019 price levels.[110] [111] In addition to traditional mining projects, there are plans to extract rare earths from unconventional feedstocks. For example, starting in 2027 state-owned Swedish mining firm LKAB plans to extract 2,000 tons of rare earths a year from iron ore mining tailings in Lulea, Sweden.[112]

The EU's limited capacity to separate rare earth oxides comes from Neo Performance Materials, a Canadian firm, that has a plant in Estonia that produces about 1.6 percent of global output.[113] Neo Performance Materials purchases mixed rare earth carbonates from Russia, in addition to Australia, China, and the United States, then separates neodymium from other rare earth elements.[114] The neodymium is then sold to European customers or sent to Neo Performance Material's magnetic powders plant in Thailand.[115]

[redacted][116] [117] EU alloy makers operate in Germany and Slovenia but rely on imported processed materials.[118]

Vacuumschmelze, a German firm, is the EU's major producer of NdFeB magnets, although it controls less than one percent of the global market.[119] Vacuumschmelze and U.S. automotive firm General Motors announced a non-binding memorandum of understanding to build a U.S. NdFeB magnet production facility with production to start in 2024.[120] [redacted]

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[109] Note that Greenland has special status vis-à-vis Denmark and Norway is not part of the European Union.
[110] Prices for neodymium oxide and metal more than tripled between 2019 and year-end 2021. See Section 8.3.4, "Prices and Price Volatility," for more infomation on prices and price volatility.
[111] Meeting between Neo Performance Materials and the Department of Commerce, the Department of Defense, and the U.S. Geological Survey, (Virtual Meeting, November 30, 2021).
[112] "LKAB chooses Lulea for the circular industrial park for phosphorus and rare earth elements," LKAB, May 3, 2022, https://www.lkab.com/en/news-room/press-releases/lkab-chooses-lulea-for-the-circular-industrial-park-for-phosphorus-and-rare-earth-elements/.
[113] I.M.S.K. Illankoon et al., "Constraints to Rare Earth Elements Supply Diversification: Evidence from an Industry Survey," Journal of Cleaner Production (331), January 10, 2022, https://doi.org/10.1016/j.jclepro.2021.129932.
[114] "MD&A," Neo Performance Materials, 2021, https://www.neomaterials.com/wp-content/uploads/2022/03/NPM-12.31.2021-MDA.pdf.
[115] Ibid.
[116] "Rare earth magnet market outlook to 2030," Adamas Intelligence, August 2020.
[117] [redacted]
[118] Cynthia El Latunussa et al., "Study on the EU's list of critical raw materials (2020): Critical raw materials factsheets," European Commission, September 16, 2020, https://op.europa.eu/en/publication-detail/-/publication/8dabb4c1-f894-11ea-991b-01aa75ed71a1/language-en/format-PDF/source-259044582.
[119] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[120] "General Motors and Vacuumschmelze (VAC) Announce Plans to Build a New Magnet Factory in the U.S. to Support EV Growth," General Motors, December 9, 2021, https://investor.gm.com/news-releases/news-release-details/general-motors-and-vacuumschmelze-vac-announce-plans-build-new.

[redacted] In addition to Vacuumschmelze, there are several smaller European NdFeB magnet makers: Magnetfabrik Schramberg of Germany is licensed by Hitachi to sell sintered NdFeB magnets under older patents, while Magnetfabrik Bonn of Germany, Magneti Ljubljana of Slovenia, and Magnet e Motion of the Netherlands also manufacture NdFeB magnets.[121]

The EU has also sought to expand recycling and substitution capabilities. HyProMag, a United Kingdom-headquartered and Canadian-owned startup, recently announced a German subsidiary which will help develop the EU's recycling capacity.[122] HyProMag extracts and demagnetizes NdFeB alloy from magnets in scrap equipment using technology developed at the University of Birmingham in the United Kingdom. The European Commission has also funded projects to test recycling methods, such as REE4EU, which brought together a consortium of fourteen companies to test new rare earths recycling methods, including for NdFeB magnets.[123] This project concluded in 2019 and it is unclear whether commercialization will occur.

In addition to specialized firms, EU-headquartered end-users of NdFeB magnets are also looking into substitution technologies. Daimler, one of the world's largest automobile manufacturers, has pursued research to decrease the use of dysprosium in the NdFeB magnets it uses and indicates that dysprosium use could drop to as low as 2.5 percent by weight from the typical 8.5 to 11 percent by weight.[124] [125] BMW has also used hybrid motors to decrease the amount of NdFeB magnets in the motor by 30 to 50 percent from standard designs, which implies a reduction in magnet content by 0.3 to one kg per motor.[126]

A.6 Japan

Japan is a key participant in the NdFeB magnet value chain, currently the second largest producer of NdFeB magnets and alloy after China, accounting for seven percent of global

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[121] "Sintered NdFeB Magnets," Hitachi Metals, n.d., https://www.hitachi-metals.co.jp/e/pdf/pi20131202ec.pdf.
[122] "Mkango Announces HyProMag Expansion into Germany," GlobeNewsWire, November 15, 2021, https://www.globenewswire.com/news-release/2021/11/15/2333784/0/en/Mkango-Announces-HyProMag-Expansion-Into-Germany.html.
[123] "The Project," REE4EU, n.d., https://www.ree4eu.eu/the-project/.
[124] Claudiu C. Pavel et al, "Role of substitution in mitigating the supply pressure of rare earths in electric road transport applications," Sustainable Materials and Technologies (12): 62-72, July 2017, https://doi.org/10.1016/j.susmat.2017.01.003.
[125] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[126] Claudiu C. Pavel et al, "Role of substitution in mitigating the supply pressure of rare earths in electric road transport applications," Sustainable Materials and Technologies (12): 62-72, July 2017, https://doi.org/10.1016/j.susmat.2017.01.003.

production.[127] Japanese firms are mainly involved in the downstream metallization, alloying, magnet production, and recycling steps of the NdFeB magnet value chain. Japan's direct participation in upstream segments of the NdFeB magnet value chain is limited because it has no proven domestic sources of rare earth elements. Japanese-headquartered firms are not directly involved in rare earths mining, the processing of rare earth carbonate, or the separation of rare earth oxides, and instead purchase feedstocks from Australian or Chinese producers. However, the state-owned Japan Oils, Gas, and Metals National Corporation (JOGMEC), which is in charge of ensuring stable supplies of oils, natural gases, and nonferrous metals and mineral resources, has supported overseas projects at upstream steps of the value chain and established definitive offtake agreements between foreign producers and Japanese consumers.[128] [129] For example, in 2011 JOGMEC and Japan's Sojitz Corporation entered into a definitive agreement with Lynas Rare Earths to provide $250 million in loans and equity in return for 8,500 tons of rare earths products.[130] JOGMEC has provided financing for a diverse range of additional rare earths projects, including in Canada, Kazakhstan, and Namibia.[131]

Although Japan's domestic sources of rare earth elements appear minimal, in 2013, high rare earths content deep sea mud was discovered in the western North Pacific Ocean near Japan's Minamitorishima Island.[132] Researchers estimated the most promising area might have 1.2 million tons of rare earth oxides.[133] The Japan Agency for Marine Earth Science and Technology is looking to develop an engineering system for exploring and retrieving these deep sea rare earth element resources.[134] However, it could take many years to successfully mine these deposits because they are found in water depths as great as 6,000 meters.[135]

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[127] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf.
[128] "Overview," Japan Oils, Gas, and Metals National Corporation, n.d., https://www.jogmec.go.jp/english/about/about001.html.
[129] For an example, *see* "Sojitz and JOGMEC enter into Definitive Agreements with Lynas Including Availability Agreement to secure supply of Rare Earths products to Japanese Market," Japan Oils, Gas, and Metals National Corporation, March 30, 2011, https://www.jogmec.go.jp/english/news/release/release0069.html.
[130] Ibid.
[131] "Starting rare earth production in Kazakhstan," Sumitomo Corporation, November 5, 2012, https://www.sumitomocorp.com/en/jp/news/release/2012/group/20121105_2; "JOGMEC Signs Memorandum of Agreement for Rare Earth in Canada," Japan Oils, Gas, and Metals National Corporation, March 3, 2010, https://www.jogmec.go.jp/english/news/release/release0043.html; "Namibia Critical Metals and JOGMEC Conclude Agreement to Develop the Lofdal Heavy Rare Earth Project," Accesswire, January 27, 2020, https://www.accesswire.com/574171/Namibia-Critical-Metals-and-JOGMEC-Conclude-Agreement-to-Develop-the-Lofdal-Heavy-Rare-Earth-Project.
[132] Yutaro Takaya et al., "The tremendous potential of deep-sea mud as a source of rare-earth elements," Scientific Reports 8: 5763, April 10, 2018, https://doi.org/10.1038/s41598-018-23948-5.
[133] Ibid.
[134] Josh Lewis, "Toyo enlists Singaporean offshore engineering player for 'world first' deep-sea mineral extraction system," Upstream, September 10, 2021, https://www.upstreamonline.com/energy-transition/toyo-enlists-singaporean-offshore-engineering-player-for-world-first-deep-sea-mineral-extraction-system/2-1-1065462.
[135] Roku Goda, "Japan's dream to produce rare earths still stuck in the mud," The Asahi Shimbun, January 22, 2020, https://www.asahi.com/ajw/articles/13053341.

After China sharply restricted rare earth exports in 2010, Japan made considerable investments in alternative feedstock sources.[136] [redacted][137] As mentioned earlier, JOGMEC provided financing to the Australian firm Lynas Rare Earths to develop mining and processing facilities in Australia, in return for preferential supply terms.[138] To that end, Japanese policy was instrumental in enabling Lynas Rare Earths to survive the difficult market conditions in the mid-2010s when China eased export restrictions and rare earth element prices slumped.[139] Japanese firms have also expressed interest in developing Vietnam's 22 million tons of rare earths reserves.[140] Several firms, including Toyota, announced in 2010 investments to increase mining production in Vietnam, but these ventures have not materialized and production was barely 1,000 tons in 2020.[141] Similarly, in 2009 Toyota established a subsidiary to refine Indian rare earths and in 2015 announced it would separate rare earth oxides from feedstock purchased from the state-owned Indian Rare Earths Limited.[142] In 2021 India controlled about one percent of the rare earths mining market and in 2020 contributed about one percent to global rare earths separation.[143]

Japanese firms, including the leading companies TDK, Shin-Etsu, and Hitachi, are mainly involved in the downstream metallization, alloying, magnet production, and recycling stages of NdFeB magnet production, for which they hold important patent portfolios.[144] These firms mainly produce NdFeB magnets in Japan but have facilities throughout Southeast Asia as well as

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[136] Kristen Vekasi, "Politics, markets, and rare commodities: Responses to Chinese rare earth policy," Japanese Journal of Political Science 20 (1): 2-20, 2019, https://doi.org/10.1017/S1468109918000385.
[137] Kazuaki Kobayashi, "Trusted Supply-Chain for Rare Earths in the Age of Carbon Neutrality," Ministry of Economy, Trade, and Industry, n.d.
[138] Cecilia Jamasmie, "Japan secures rare earth supply for longer through Lynas funding," Mining.com, June 27, 2019, https://www.mining.com/japan-secures-rare-earth-supply-for-longer-through-lynas-funding/.
[139] Sonali Paul, "Japanese shore up cash-strapped rare earths miner Lynas," Reuters, March 13, 2015, https://finance.yahoo.com/news/japanese-shore-cash-strapped-rare-085926334.html.
[140] Brian Daigle and Samantha DeCarlo, "Rare Earths and the U.S. Electronics Sector: Supply Chain Developments and Trends," U.S. International Trade Commission Working Paper ID-075, June 2021, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.
[141] Ibid.
[142] "Toyota Tsusho Inks Rare Earths Contract with Indian State Corporation," Toyota Tsusho Corporation, December 10, 2015, https://www.toyota-tsusho.com/english/press/detail/151210_002928.html.
[143] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022; Daniel Cordier, "Rare Earths: Mineral Commodity Summaries 2022," U.S. Geological Survey, 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022.pdf.
[144] Bain Capital announced in April 2021 that it was acquiring Hitachi Metals from the Hitachi Group. In November 2021 Hitachi announced that the deal would be finalized in the fiscal year ending in March 2023. The sale does not appear to have been finalized as of May 2022, and industry participants have expressed uncertainty about the possibility of acquisition. Masumi Suga, "Hitachi to Sell Metal Unit to Bain Group for $3.5 Billion," Bloomberg, April 28, 2021, https://www.bloomberg.com/news/articles/2021-04-28/hitachi-agrees-to-sell-metal-unit-to-bain-group-for-3-5-billion; Meeting between USA Rare Earth and the Department of Commerce, (Virtual Meeting, December 10, 2021); Notification of the Status of Progress in the Tender Offer for Share of Subsidiary, and Change in the Timing of Recognition of Extraordinary Gain on Unconsolidated Basis and Other Income on Consolidated Basis," Hitachi, November 30, 2021, https://www.hitachi.com/New/cnews/month/2021/11/f_211130.pdf.

in China.[145] [redacted] [146] TDK produces magnets for the automotive, ICT, and industrial sectors, with segment sales of about $2 billion or 16.1 percent of its overall business in 2020.[147] [148] TDK acquired Showa Denko's magnet alloy business in 2018.[149] TDK also owns a rare earths metal facility which produces NdPr and dysprosium in Vietnam, established by Showa Denko.[150] [151] The primary production facilities for Shin-Etsu's NdFeB magnets are in Japan (Fukui Prefecture) and Vietnam, with additional production facilities in Malaysia and the Philippines.[152] Shin-Etsu also operates rare earth refinement and NdFeB magnet production plants in Vietnam, established in the 2010s.[153] Hitachi produces NdFeB magnets in China and the Philippines, and plans to expand these facilities.[154] [redacted] [155] Finally, Daido Electronics also produces an unknown amount of NdFeB magnets in Japan.[156]

In concert with shifting some sourcing outside of China, Japan has also cultivated research and development into NdFeB magnet substitutes and recycling. [redacted] [157] These

[145] Shinichirou Morimoto et al, "Scenario assessment of neodymium recycling in Japan based on substance flow analysis and future demand forecast," Journal of Material Cycles and Waste Management (23): 2120-2131, August 12, 2021, https://doi.org/10.1007/s10163-021-01277-6; Comments of Shin-Etsu Chemical Co. Ltd. to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[146] Comments of TDK Corporation to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[147] In 2020, the U.S. dollar was worth between 103 and 112 Japanese yen. The Department converted TDK's segment sales of 220 billion yen to U.S. dollars by taking the midpoint (107.5).
[148] "Annual Report 2020," TDK, 2020, https://www.tdk.com/system/files/wwwtdkcom_ir_ir_library_annual_pdf_2020_all.pdf.
[149] "TDK acquires R&D business sector for magnet alloy from Showa Denko K.K. to complement TDK's neodymium magnets," TDK, November 27, 2018, https://www.tdk.com/en/news_center/press/20181127_01.html.
[150] Brian Daigle and Samantha DeCarlo, "Rare Earths and the U.S. Electronics Sector: Supply Chain Developments and Trends," U.S. International Trade Commission Working Paper ID-075, June 2021, https://www.usitc.gov/publications/332/working_papers/rare_earths_and_the_electronics_sector_final_070921_2-compliant.pdf.
[151] "SDK Subsidiary Completes Rare Earth Metal Plant in Vietnam," Showa Denko, November 5, 2010, https://www.showa-denko.com/news/sdk-subsidiary-completes-rare-earth-metal-plant-in-vietnam/.
[152] "Annual Report 2021," Shin-Etsu Chemical Co., Ltd., 2021, https://www.shinetsu.co.jp/wp-content/uploads/2021/07/Annual-Report-2021-for-viewing.pdf.
[153] Ibid.
[154] "The Hitachi Metals Group Report 2021," Hitachi, 2021, https://www.hitachi-metals.co.jp/e/ir/pdf/ar/2021/2021_all_a4.pdf.
[155] "Rare earth magnet market outlook to 2030," Adamas Intelligence, August 2020.
[156] *See* "Daido Electronics," Daido Electronics, last accessed May 5, 2022, http://www.daido-electronics.co.jp/english/.
[157] [redacted] Department of Defense, written communication, May 16, 2022.

efforts reduce magnet cost and increase supply chain resiliency because dysprosium and terbium are even more expensive than neodymium and praseodymium and China controls an even greater percentage of the market.[158] These technologies selectively diffuse dysprosium along the grain boundaries in sintered magnets ("grain boundary diffusion"), which yields similar coercivity while reducing dysprosium usage by 20 to 60 percent.[159] [redacted][160]

Other Japanese manufacturers are actively researching how to reduce rare earths content in NdFeB magnets. In 2016, Honda announced that it had developed in partnership with Daido Electronics a NdFeB magnet without dysprosium or terbium, which it planned to use in its Freed hybrid electric vehicles.[161] Honda had previously partnered with Japan Metals and Chemicals to reuse rare earths in batteries. In February 2018, Toyota revealed that it had developed a magnet with 50 percent less neodymium and no terbium or dysprosium, which it expected to commercialize in the first half of the 2020s.[162] Finally, in September 2021, Nissan announced that it had started testing a recycling process to recover rare earth compounds from electric vehicle magnets, with potential commercialization by the mid-2020s.[163]

[158] "Rare Earth Permanent Magnets: Supply Chain Deep Dive Report," Department of Energy, February 24, 2022, https://www.energy.gov/sites/default/files/2022-02/Neodymium%20Magnets%20Supply%20Chain%20Report%20-%20Final.pdf; Comments of USA Rare Earth to Request for Public Comments, "Section 232 National Security Investigation of Imports of Neodymium-Iron-Boron (NdFeB) Permanent Magnets," 86 Fed. Reg. 53277, November 12, 2021.
[159] Ibid.
[160] Kazuaki Kobayashi, "Trusted Supply-Chain for Rare Earths in the Age of Carbon Neutrality," Ministry of Economy, Trade, and Industry, n.d.
[161] Lindsay Brooke, "Honda's new e-motor magnet aims to mitigate China rare-earth monopoly," SAE International, July 17, 2016, https://www.sae.org/news/2016/07/hondas-new-e-motor-magnet-aims-to-mitigate-china-rare-earth-monopoly.
[162] "Toyota Develops New Magnet for Electric Motors Aiming to Reduce Use of Critical Rare-Earth Element by up to 50%," Toyota, February 20, 2018, https://global.toyota/en/newsroom/corporate/21139684.html.
[163] "Nissan and Waseda University in Japan testing jointly developed recycling process for electrified vehicle motors," Nissan Motor Corporation, September 3, 2021, https://global.nissannews.com/en/releases/release-e502610b72cdc20c7a5ee23758433a8c-nissan-waseda-university-in-japan-testing-jointly-developed-recycling-process-for-ev-motors.

Appendix F: U.S. NdFeB Magnet Industry: Company Profiles

Table of Contents

A.1 Overview

This Appendix presents profiles of those firms that are expected to be major participants in the U.S. NdFeB magnet industry to better illuminate the plans, requirements, and challenges U.S. firms face in establishing production.[1] [redacted] These profiles emphasize information on current and planned facilities, including location, start date, and capacity, planned facilities' fixed costs, future production volumes, employment, and challenges. Profiles are presented in alphabetical order.

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[1] Unless otherwise stated, data in Appendix F, "U.S. NdFeB Magnet Industry: Company Profiles," are based on the Department's survey of the U.S. NdFeB magnet industry, as described in Section 3.3, "Information Gathering and Data Collection Activities." All projected production figures reflect estimates firms submitted to the Department and may therefore be overoptimistic.

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Appendix G: NdFeB Magnet Substitutes: Niron Magnetics

Niron Magnetics is seeking to commercialize iron-nitride magnets as a substitute for NdFeB magnets.[1] Iron-nitride is a high magnetization compound that has been known for many years, but which has yet to be commercialized because of the difficulties involved in manufacturing.[2] Researchers at the University of Minnesota, funded by the Advanced Research Projects Agency – Energy's (ARPA-E) Rare Earth Alternatives in Critical Technologies (REACT) Program, were the first to produce an iron-nitride magnet prototype. Niron Magnetics, [redacted] continues to develop these magnets and has formed its own patent portfolio.[3] In 2021, Niron Magnetics raised $23 million in its latest funding round.[4] [redacted][5]

Iron-nitride magnets, made of iron and nitrogen powder, have several attractive qualities and may become a viable alternative to NdFeB magnets. [redacted][6] [redacted][8] [redacted].[9] [redacted][10] [redacted][11] [redacted][12]

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[1] [redacted]
[2] Meeting between Niron Magnetics and the Department of Commerce, (Virtual Meeting, January 7, 2022).
[3] Ibid.
[4] Ibid.
[5] Ibid.
[6] Ibid.
[7] Ibid.
[8] "Niron Magnetics: Summary of Environmental Life Cycle Analysis," Niron Magnetics, November 25, 2021.
[9] Ibid.
[10] Meeting between Niron Magnetics and the Department of Commerce, (Virtual Meeting, January 7, 2022).
[11] Ibid.
[12] Ibid.

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[13] Ibid.

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