RENEWABLE ENERGY AND CLEAN TECHNOLOGY

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INDUSTRY BRIEF

Energy Stat: China's Dominance in Rare Earths - How Is This Supply Chain Security Challenge Being Addressed?

Amid an unprecedentedly busy year of elections on both sides of the Atlantic, here is one of the few things that practically all of the parties can agree on these days: economic nationalism is here to stay. This very much includes a whole-of-government focus on supply chain security. While there are differences of opinion about how governments should or should not promote electric mobility, politicians with anti-EV views are even more opposed to the notion of being reliant on China for strategic materials. Case in point: lithium, about which we wrote this past February in collaboration with our Canadian colleagues Brian MacArthur and David Quezada. Today, alongside Frederic Bastien, also from Canada, we will discuss rare earth metals, for which the overriding concern is, similarly, China. Although China's dominance in rare earths has diminished over the past decade, it remains far and away the largest player, hence the push in Washington and Brussels to promote diversification of the supply mix. While tariffs can be at least somewhat effective in keeping away Chinese EVs or solar modules, the fact of the matter is that most of the rare earths are, well, rare, and it can be difficult to argue with geology. There are, however, creative "carrots" that are bolstering domestic supply chains. This report concludes by highlighting some relevant stocks.

Rare earths 101: what are they, and how are they used?

Let's start with a brief chemistry lesson: rare earths are 17 elements on the periodic table, most of them found in what's known as the f-block of the table. Not all of them are truly rare — cerium, for example, is more abundant in the earth's crust than copper — but the sparse availability of economically viable ore deposits means that mining takes place in a small number of locations. The reason for China's historical dominance in this market is that it is mainly sourced as a byproduct of large-scale iron ore mining operations in the provinces of Inner Mongolia and Sichuan.

The table below shows the five most abundant rare earths and some of the end markets where they are used commercially, taking advantage of their catalytic, magnetic, and luminescent properties. There is a very broad range of applications, most of which are *not* directly energy-related. Probably the best-known product category made with rare earths — permanent magnets — is commonly used in electronics. Zooming in on energy, the most common application is catalysts for fluid catalytic cracking units at refineries. Growing applications in energy transition technologies include solid oxide fuel cells, coatings for LED light bulbs, and powertrains for electric vehicles. There is also an important military angle: looking at the U.S. armed forces, for example, an F-35 fighter jet requires 900 pounds of rare earths; an Arleigh Burke-class DDG-51 destroyer needs 5,200 pounds, and a Virginia-class submarine needs 9,200 pounds.

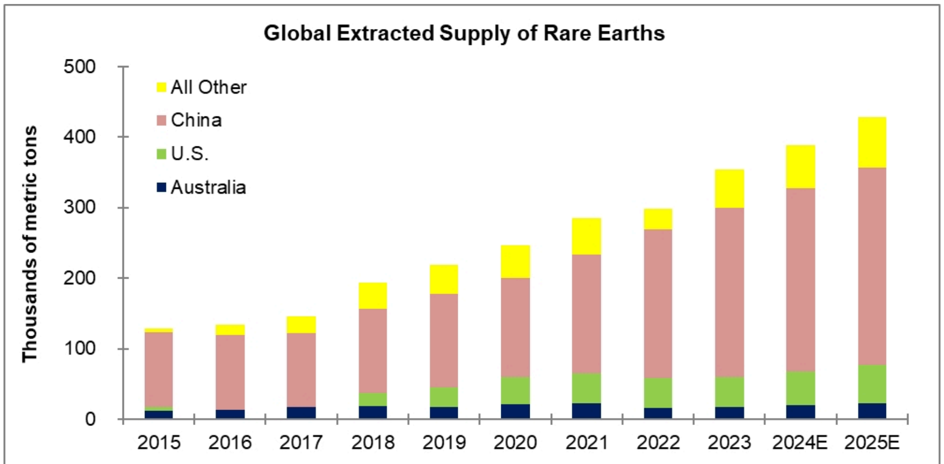
Selected Applications of Rare Earths

Cerium	Neodymium	Lanthanum	Yttrium	Scandium
Aircraft engines	Electric powertrains	Battery electrodes	Aircraft engines	Aerospace alloys
Glass and ceramics	Glass and ceramics	Camera lenses	Camera lenses	Dentistry
Refinery catalysts	Lasers	Glass	Fuel cells	Light bulbs
	Magnets	Refinery catalysts	Light bulbs	
			Spark plugs	
			Superconductors	

Source: BBC News, Raymond James research

It is no longer 90%, but China is still dominant in mining rare earths.

In 2023, global extracted supply of rare earths totaled 354,000 metric tons, with China accounting for 68% of that. This is down from 82% in 2015 and a staggering 98% in 2005. Is China "losing share?" In relative terms, yes, that is what the percentages show. But, to be clear, the size of the pie is expanding — the global market has nearly tripled since 2015 — so this is *not* a situation where Country A (or Company A) needs to fight competitors in a zero sum game. Notice, by the way, the fairly consistent pace of growth in recent years, including through COVID. This consistency is helped by the broad range of applications discussed earlier.



Source: Energy Institute, Raymond James research

The U.S. has been the second-largest supply source since 2019 — admittedly, a very distant second. All of this comes from MP Materials' Mountain Pass mine in California, the only large-scale rare earth mine that is currently operating in North America. Australia had been the third-largest during the period 2019-22, but interestingly enough it was leapfrogged in 2023 by… Myanmar. For a country embroiled in outright civil war, successful development of any mining operations might seem like a stretch. It is certainly true that Myanmar's mines are poorly regulated and rife with environmental and human rights abuses. The bulk of the mines are located in Kachin state, bordering China's Yunnan province, and it is unsurprising that Chinese investment plays a big role here.

Global Extracted Supply of Rare Earths (thousands of metric tons)

	2000	2005	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024E	2025E
Australia				3	12	14	17	19	18	21	23	16	17	20	22
China	73	119	89	94	105	105	105	120	132	140	168	210	240	259	280
% of Total	95%	98%	92%	90%	82%	79%	72%	62%	60%	57%	59%	70%	68%	67%	65%
U.S.				3	6			18	28	39	43	43	43	48	54
All Other	4	3	8	4	6	15	24	37	41	47	51	30	54	62	71
World	77	122	97	104	129	133	146	193	218	247	285	299	354	389	428
% Change						4%	9%	32%	13%	13%	15%	5%	19%	10%	10%

Source: Energy Institute, Raymond James research

There are three early-stage supply sources to watch: Brazil, Canada, and Vietnam.

It is important to emphasize that China is less dominant when it comes to the underlying reserves, with 40% of the worldwide total at year-end 2023: 44 out of 110 million tons. China has a shorter-than-average reserve life, suggesting that its current production rate is ultimately unsustainable. At 183 years, China's reserve life compares to the global average of 314 years. The U.S. is at only 42 years, but on the other hand, Brazil is at a whopping 263,000 years. Brazil has 21 million tons of reserves but almost no current production. Vietnam presents a very similar story: 22 million tons of reserves but almost no current production. Perhaps the most exotic place with reserves is Greenland, though to state the obvious, we are *not* holding our breath for rare earth mining in the middle of the North Atlantic.

In the context of North American supply security, a big question mark is Canada. While Canada has very little reserves (less than one million tons), there is an estimated 15 million tons of unbooked resources, according to Natural Resources Canada. The agency reports that pre-commercial work is currently taking place in six provinces and territories.

Could Beijing play political games with rare earths? History indicates that it would *not* be easy.

The concern in Washington and Brussels about China's dominance in this market arises from the hypothetical scenario of a future crisis in which Beijing would attempt to use its control over rare earths for geopolitical leverage. A Chinese invasion of Taiwan is what usually comes to mind, though other scenarios are also possible. Is there any historical precedent for this? Yes, but the one and only time it happened was all the way back in 2010. That year, Beijing cut the export quota for rare earths by 40%. The ostensible reason was environmental, but the move was widely seen as a protectionist tactic. Moreover, China also imposed a de facto ban on rare earth sales to Japan in the wake of a boat incident in disputed waters. China maintained the restrictions until 2015, after it lost a case in the World Trade Organization. So, did the restrictions work as China had intended? According to a subsequent study by the Greenberg Center for Geoeconomic Studies, the short answer is: *no*.

First, there was spotty compliance with the restrictions, as Chinese companies continued to export restricted rare earths, albeit covertly. The "smuggling" amounted to an estimated 15-30% of the official quota. Second, as rare earth prices rose, alternative supplies came on the market

— hence, the production ramp-up in the U.S., Australia, and elsewhere. The lesson is that the longer supply is restricted, the more economic incentive there is to invest in new mining capacity. Third, demand destruction also occurred, as companies found innovative ways to reduce their usage of rare earths. For example, Hitachi and Mitsubishi in Japan cut down on usage of dysprosium in their production of magnetics.

Beyond mining… will the U.S. and Europe become significant players in *processing* rare earths?

Let's think back to the Mountain Pass mine. What's counterintuitive about this site is that all of the output historically has been shipped to China for processing. This means that the U.S. exports raw rare earths but imports processed rare earths. According to the U.S. Geological Survey, the U.S. imported $190 million of rare earth compounds and metals in 2023, of which 72% came from China. Needless to say, this is a very modest dollar amount in the grand scheme of things. To clarify, here we are referring specifically to U.S. industries that use rare earths in their manufacturing operations, as opposed to imports of finished products containing rare earths. The reason is fairly straightforward: the U.S. has only limited manufacturing capacity vis-a-vis the high-tech products that we described earlier. Electronics and various industrial goods are simply not produced in the U.S. on the scale that they are in China itself and/or its Asian neighbors.

In any case, conversations in Washington about the fact that the U.S. lacks domestic capacity to process rare earths have been taking place for quite a while. This is part of the broader, and (unusually) bipartisan, agenda of economic nationalism. In 2019, the Trump administration declared the entire rare earth supply chain to be eligible for funding via the Defense Production Act. In 2021, the Biden administration published a domestic manufacturing strategy, echoing the same message: "The United States imports substantially greater quantities of rare earth elements in value-added products… Implicit in this trade phenomenon is the gradual decline in value-creation, innovation, research and human capital development." In 2022, the Inflation Reduction Act created the Advanced Manufacturing Production Credit (Section 45X) for domestic manufacturing of a wide range of clean tech hardware, including several types of rare earths. In 2024, the Department of Defense published its first-ever national defense industrial strategy, with rare earths prominently mentioned. Cumulatively during the Biden administration, the DOD has awarded $439 million in funding for domestic rare earth projects, both upstream and downstream: what's known as a "mine to magnets" approach. That said, it will take time for production capacity to scale up in response to the cash flowing from Uncle Sam: as with all infrastructure development, this is a proverbial marathon rather than a sprint. Most recently, in August 2024, the Biden administration began considering the concept of setting a price floor for certain critical minerals as a way of providing further support for domestic production, though it is unclear how such a policy would work in practical terms.

Essentially the same point applies to the EU, with the European Commission reporting 98% dependence on Chinese rare earth supply. In this context, the commission in 2020 launched the European Raw Materials Alliance, which aims to promote domestic capabilities to extract, design, manufacture, and recycle strategic materials. Thus far, EU funding for actual projects has been slim — this is the key difference versus the U.S. approach — but we will be watching the extent to which the EU's Net-Zero Industry Act, approved in early 2024, may provide a boost.

What about recycling rare earths?

Similar to lithium and some other EV-related materials, recycling of rare earths is a nascent part of the value chain: the global recycling rate is only around 1%. In principle, the concept makes a lot of sense: less need for mined resources translates into less supply risk (geological and political) as well as less environmental impact. However, this is easier said than done: before recycling can be scaled up, specialized recycling facilities must be built, and feedstock collection needs to be optimized. While we are *not* holding our breath for fighter jets in the local recycling bin, electronic waste offers the most straightforward roadmap to cost-effective collection. As far as the recycling process itself, there are several options — copper salts, organic acids, and hydrometallurgy — all of which have their advantages and drawbacks.

Given how nascent it is, the companies focused on recycling are typically private. For our readers who have interest in private companies, we note that our database of approximately 900 private companies in every vertical of clean tech includes the following pure-plays: Cyclic Materials (Canada), MagREEsource (France), RarEarth (Italy), and Noveon Magnetics (U.S.)… let us know if you would like a copy.

How can investors get exposure to the rare earth market?

Almost by definition, rare earths comprise a relatively small market (in the context of metals and mining). The number of players is sizable, though not to the extent of, for example, the lithium value chain. Below is a list of some players that our readers may want to learn more about.

American Rare Earths (Australia, ARR.AX / ARRNF) is an exploration-stage mining company with four projects: La Paz in Arizona, Searchlight in Nevada, and Beaver Creek and Halleck Creek in Wyoming. The company's focus is Halleck Creek, where a scoping study in March 2024 pointed to 7.5 million tons of total rare earth oxides, including neodymium and praseodymium. The Halleck Creek resource base also benefits from low radioactivity. Development activity at Halleck Creek is supported by a grant from the Wyoming Energy Authority.

Australian Strategic Materials (Australia, ASM.AX / ASMMF) opened its processing facility in South Korea in 2022, with an initial focus on neodymium iron boron and titanium metal alloys. For the time being, the company purchases raw rare earths from third-parties, but the eventual goal is to vertically integrate by developing the Dubbo mining site in New South Wales, Australia. The company anticipates reaching a final investment decision for Dubbo in early 2026.

Electrified Materials Corp. (U.S., pending ticker: EMCO), which is in the process of going public via a SPAC transaction with AI Transportation Acquisition, is in the early stages of scaling up its capacity to recycle battery materials and rare earths. For the time being, this business is the American Metals division of American Resources (U.S., AREC). There is a partnership with ReElement Technologies, also a division of American Resources, which uses chromatography to refine critical mineral-containing resources into technical-grade products. For its part, ReElement Technologies is working with the wind developer EDP Renewables to recycle neodymium-based permanent magnets from decommissioned wind turbines, and with an (unnamed) major U.S. automaker to recycle rare earths from EV motors.

Leading Edge Materials (Canada, LEM.V, LEMIF) is an exploration-stage mining company that is involved in a graphite project, nickel-and-cobalt project, and rare earth project - all of which are located, rather unusually, in the European Union. The rare earth project - Norra Karr in Sweden - is particularly rich in dysprosium and terbium.

Lindian Resources (U.S., LIN.AX) is an exploration-stage mining company with a focus on the Kangankunde project in Malawi. The estimated resource base is 5.6 million tons of total rare earth oxides. High-grade, near-surface mineralization supports a straightforward open-pit mining operation. Another advantage is that the concentrate product and tailings are expected to contain low levels of radioactive materials and other impurities.

Lynas Rare Earths (U.S., LYC.AX / LYSDY) is a vertically integrated player and the largest one outside China. Mining takes place in Western Australia, and there is a processing facility in Malaysia. Two other processing facilities are in development: one in Western Australia and one in Texas. The latter, supported by a U.S. Department of Defense contract, is expected to start up in late 2025 or early 2026.

MP Materials (U.S., MP) operates Mountain Pass, which, as noted earlier, is the only large-scale mining site in North America. The business model is currently mining-centric, but vertical integration is underway via construction of a processing facility in Texas. This facility, supported by a U.S. Department of Defense contract, will produce alloys and magnets. Production of precursor materials is set to start in late 2024, followed by finished magnets in late 2025. The company has a long-term agreement with General Motors to supply components for EV powertrains.

Neo Performance Materials (Canada, NEO.TO / NOPMF) produces advanced materials derived from rare earths and other rare metals. The company operates in three segments. Magnequench provides bonded neodymium-iron-boron magnetic powders and magnets. Chemicals and Oxides, the largest segment by revenue, provides environmental emissions control catalysts, lanthanide element products, and water purification products. Rare Metals reclaims and refines high-value niche metals, including rare earths, and their compounds. The company has a multinational footprint, with production facilities across Asia, Europe, and North America. These include a rare earth separation plant in Estonia, the only such facility in Europe, and an under-construction sintered rare earth permanent magnet manufacturing plant that is supported by a €19 million grant from the EU's Just Transition fund.

NioCorp Developments (U.S., NB) is primarily an exploration-stage mining company whose Elk Creek project in Nebraska is focused on scandium, niobium, and titanium (the latter two, to be clear, are *not* rare earths). A feasibility study in 2022 pointed to 633,000 tons of total rare earth oxides. Alongside the upstream development effort, the company plans to do a limited amount of on-site processing and is also considering opportunities to recycle rare earth magnets.

Tactical Resources (Canada, RARE.V / USREF) is primarily an exploration-stage mining company whose Peak project in Texas is co-located with the Sierra Blanca quarry, which currently produces ballast material. The company has an agreement with the quarry that allows access and a right of first purchase option vis-a-vis rare earth tailings. Interestingly, this site is only two miles away from another rare earth project, Round Top, which is described below. Alongside the upstream development effort, the company is involved in R&D pertaining to metallurgical chemistry for rare earth processing.

USA Rare Earth (U.S., ticker to be determined), which is in the process of going public via a SPAC transaction with Inflection Point Acquisition Corp. II, is developing a vertically integrated business. The first phase (1,200 tons per year) of the company's processing facility in Oklahoma is expected to start up in 2025, en route to reaching 4,800 tons per year in 2028. In addition, the company holds an 80% interest in the exploration-stage Round Top mining project in Texas, which is prospective for rare earths along with uranium and beryllium; the remaining 20% is owned by Texas Mineral Resources (U.S., TMRC).

Company Citations

Company Name	Ticker	Exchange	Closing Price	RJ Rating	RJ Entity
Neo Performance Materials Inc.	NEO.T	TSX	C$7.70	MO2	Raymond James Ltd.

Prices are as of the most recent close on the indicated exchange. See Disclosure section for rating definitions. Stocks that do not trade on a U.S. national exchange may not be registered for sale in all U.S. states. NC=not covered.

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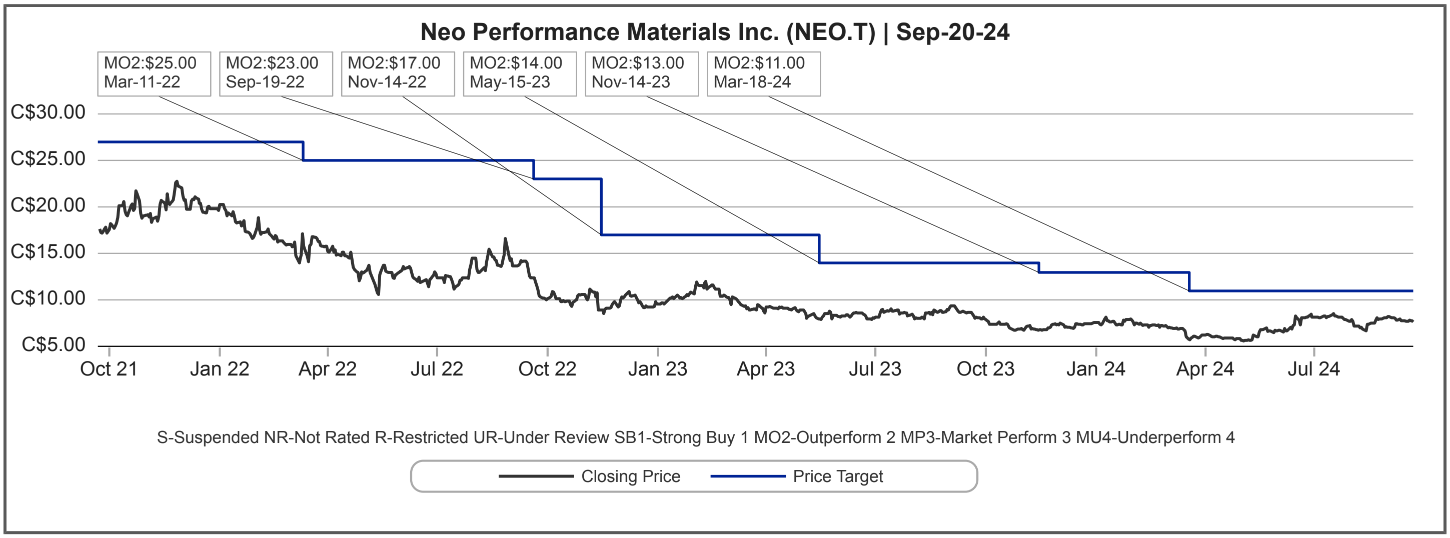

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Neo Performance Materials Inc.
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Neo Performance Materials Inc.
Commodity Price Risk:
As a manufacturer of rare earths, Neo is susceptible to volatility in rare earth pricing. Each of Neo's segments has pricing exposure, while C&O and Rare Metals have the option of selling rare earths and metals in their natural form, which can increase or decrease margins as prices fluctuate. To mitigate this risk, Neo has pricing pass-through arrangements in place and is continually investing in R&D to create more value-add solutions for customers.
Geopolitical Risk:
Operating in many nations leaves Neo exposed to political risks resulting in changes in trade, regulation, and currency. Tensions continue to rise between China and the United States and trade wars have impacted several industries in China. To date, REEs have not been the latest topic of scrutiny from the US, but they have been proposed. Neo's strong customer ties and global production facilities give it a degree of flexibility in the event REEs became targeted.
Currency Risk:
Neo reports in US dollars while operating globally in several countries, making the company susceptible to changes in each country's currency. Neo does not hedge against the Chinese renminbi, the Japanese yen, and the Euro.
Legal Risk:
Legal risk mainly pertains to intellectual property and patent protection. Neo heavily relies on trade secrets for certain aspects of its technology, which are difficult to protect. However, Neo intends to focus on patented products and applications related to auto catalysts, water treatment and bonded magnetic powders. The segment most as risk for patent litigation is C&O, which as of 2Q18 was defending against patent litigations in China, Germany, and the UK. Since litigation is ongoing, we consider the related costs as regular business expenses. Management has provided, using its best estimate, provisions for the ongoing legal action.
Environmental Risk:
Neo's C&O and Rare Metals segments are subject to numerous global and domestic laws, regulations and permits, including those pertaining to environmental permitting and licensing, air quality, water usage, pollution, waste management and the handling, storage and disposal of hazardous or radioactive materials. In July 2017, Neo's JAMR and ZAMR facilities were subject to increased environmental regulation which resulted in the closure of the ZAMR facility pending the implementation of a new wastewater treatment system. Neo's Silmet facility is another key

area subject to large environmental risks as the facility has been around for over 70 years and deals with radioactive materials. Neo takes every effort to remain compliant with laws in each jurisdiction of operations including China, Canada, Thailand, the US, and Europe.

Customer Concentration Risk:

Each operating segment supplies materials to a limited number of key customers. Losing a key customer could have a material adverse effect on the segment's future performance. One of Neo's core strengths is the ability to manage and build lasting relationships with its customers. More often than not, the firm is collaborating with its customers to create products specifically for them. Furthermore, the majority of Neo's customers have long standing histories with the firm as a result of the intricate processes for certification and ever changing industry standards which has created a bond that new competitors cannot easily break.

Regulatory Risk:

China is the largest producer and exporter of rare earth products, leaving the company vulnerable to the country's policy around rare earths and trade. The government has implemented several environmental and protectionist policies on rare earths in the past, including quotas, licenses, taxes, and export controls. As with others in the industry, Neo is subject to quotas on production of rare earths which place constrains on supply as the Chinese government continues to enact increasingly stringent policies. Neo has ample experience in dealing with China and its policies after establishing operations there in 1994. Management understands the environment in which the firm operates and has a long track record of managing risk.

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	Coverage Universe Rating Distribution*				Investment Banking Relationships			
	RJA		RJL		RJA		RJL	
Strong Buy and Outperform (Buy)	568	59%	163	75%	100	18%	37	23%
Market Perform (Hold)	370	39%	51	24%	31	8%	4	8%
Underperform (Sell)	20	2%	2	1%	1	5%	0	0%
Total Number of Companies	958	100%	216	100%	132		41	

** Columns may not add to 100% due to rounding.*

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