

Global Rare Earths

Lowering earths price forecasts, yet 2024 appears the year of recovery

Industry Overview

NdPr price bottomed, recovery expected from 2Q24

We lower our NdPr price forecast from 2024 to 2027 by an average 23% (Exhibit 8) driven by softer-than-expected NdPr demand growth from wind turbines, EVs, as well as industrial products, such as air conditioners, elevators, and consumer electronics in China. We now forecast NdPr prices to average at US\$66/kg (vs US\$110/kg prior) in 2024, and US\$83/kg in 2025 (vs US\$120/kg prior). We believe rare earth prices have bottomed in 1Q24E at US\$55/kg and demand looks set to recover from here. We remain attracted to the long-term growth of rare earth materials driven by the growth of EV and wind turbines. Our long-term NdPr price remains unchanged at US\$85/kg (nominal).

Spot NdPr price 20% below 10-year average

NdPr price declined by 40% in 2023 from US\$101/kg in early Jan 2023 to US\$62/kg in late-Dec 2023. The weakness in NdPr prices was due to continued surplus in the China rare earths market. 21% increase in 2023 China refining quota and significant increase in rare earth concentrate imports led to 11% YoY increase in China NdPr production in 2023. Weak demand from industrial products and wind turbines moved the market into a surplus. NdPr price continued to decline in 1Q24, with spot of US\$49/t 20% below 10-year average of US\$61/kg. The spot price is also below the US\$50/kg cash cost of the world's largest and integrated NdPr producer China Northern Rare Earths. We believe the spot has bottomed and will recover from here given cost support and demand recovery.

Wind turbines and EV remain key main growth drivers

We believe the growth in EV and wind turbines will continue to drive rare earths demand in the next decade. We forecast NdPr demand to grow by a CAGR of 7.4% from 2023 to 2030, mainly on growth in wind turbines and EV. We estimate a CAGR of 19.0% in NdPr demand from EV between 2023 (10.4kt) and 2030 (34kt), and a CAGR of 13% in NdPr demand from wind turbines from 2023 (10kt) to 2030 (24kt) driven by new wind capacity growth and continued penetration of direct-drive wind turbines. We estimate only 13% of 2023's NdPr demand from EV and 12% from wind, while the rest 75% from other segments, including electronics, industrials, and ICE cars. However, we see EV's share of total NdPr demand to increase to 26% in 2030 and wind's share to increase to 18%.

China's rare earths monopoly expected to continue

We believe China will continue to be the monopoly in the global rare earths industry. We expect rare earths supply from China to continue to grow through increased mining and refining quotas coupled with further expansions in downstream capacity. 90% of global NdPr is produced from China, with the remaining 10% from Lynas. MP will gradually ramp up its NdPr production from 2024 after the completion of its light rare earths' separation facility in 2023. Combining MP's and Lynas' NdPr production of 19ktpa in 2026, we expect China's dominance in NdPr production to reduce to 80%. We expect the NdPr price to continue to be largely influenced by rare earths supply and demand in China.

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NdPr: Neodymium and Praseodymium

VAT: Value Added Tax

ICE: Internal Combustion Engine

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Refer to important disclosures on page 15 to 16.

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Global rare earths - supply and demand

Global NdPr supply and demand

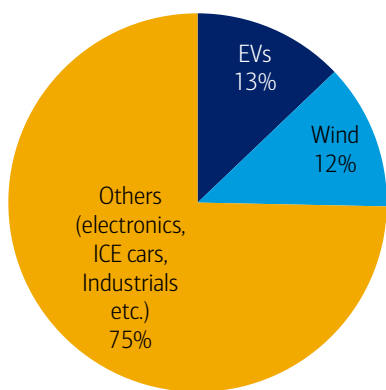
Global demand for rare earth materials and NdFeB magnets will continue to accelerate on structural shift to green economy. The growth in EV and wind turbines will continue to drive rare earths demand in the next decades. We forecast NdPr demand to grow a CAGR of 7.4% from 2023 to 2030, primarily driven by growth in wind turbines and EV. We forecast a CAGR of 19.0% in NdPr demand growth from EV between 2023 to 2030 and a CAGR of 13.0% from wind turbines.

Long-term demand remains attractive

We estimate c.75% of 2023's NdPr demand is from other segments, including electronics, industrials, and ICE cars, while 13% from EV and 12% from wind. However, we forecast demand from EV as % total NdPr demand to grow to 26% by 2030 and wind to 18%.

Exhibit 1: 2023 NdPr demand by segment

We estimate c.75% of 2023's NdPr demand is from other segments, incl. electronics, industrials, and ICE cars, while 13% from EV and 12% from wind

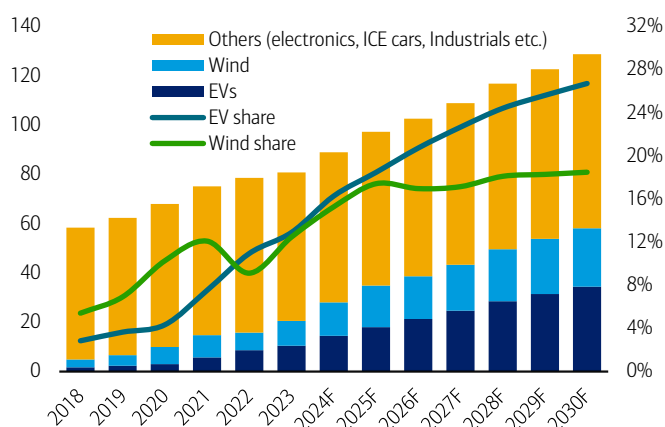


Source: BofA Global Research estimates

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Exhibit 2: NdPr demand growth LHS (kt) and RHS (%) EV and wind's share

However, we forecast EV's share of total NdPr demand to increase to 26% and wind to increase to 18% of the total demand in 2030



Source: BofA Global Research estimates

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New EV growth and NdPr required

BofA auto team forecasts new EV (BEV and PHEV) to grow by CAGR of 19% from 12mn units of new EVs in 2023 to 39mn units of new EVs by 2030. We forecast each incremental EV would require 0.896kg of NdPr. Consequently, we forecast NdPr demand from EV is expected to record a CAGR of 19% from 10.4kt in 2023 to 34kt in 2030 - Exhibit 3. We forecast NdPr demand from EV to increase to 27% of total NdPr demand in 2030 from 13% in 2023.

Wind demand growth and NdPr required

2023 - difficult year for wind turbines growth

Wind turbine pricing hit a new low in China in 4Q23 led to deferred wind installations. Less than half of the 2022 orders in China were executed in 2023, consequently backlogs built up into 2024 and 2025.

The global offshore wind industry experienced cancellations of offtake agreements, projects delays, and challenged financials. According to WoodMac, governments have announced more than 200 offshore wind targets globally to support nearly 300GW ex-China development to 2030. Offshore wind projects have been taken longer than the initial targets, so WoodMac believes revised targets are required in the next few years.

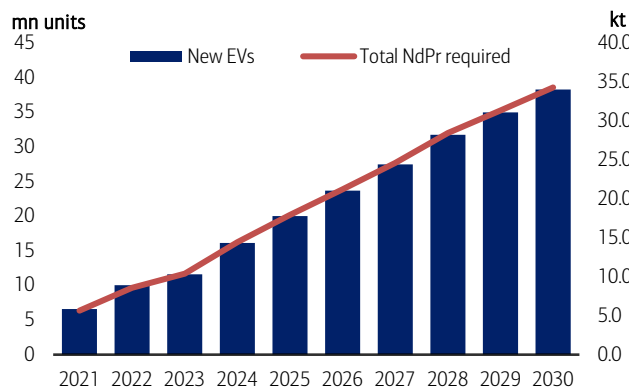
Wind turbines demand expected to come back from 2024

According to WoodMac, total new wind capacity is likely to post a CAGR of 8.3% over 2023-30. We expect NdPr demand to grow by a CAGR of 13% over 2023-30 driven by

new wind capacity growth and continued penetration of direct-drive wind turbines especially for the offshore wind capacity (Exhibit 4). We forecast NdPr demand from wind turbines to increase to 18% of total NdPr demand in 2030 from 12% in 2023.

Exhibit 3: New EVs LHS (mn units) and NdPr demand RHS (kt)

We forecast NdPr demand from EV to grow by a CAGR of 19% from 10.4kt in 2023 to 34kt in 2030

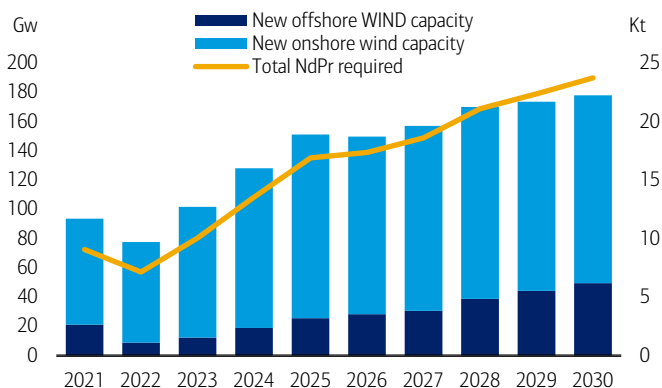


Source: BofA Global Research estimates

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Exhibit 4: New wind capacity LHS (GW) and NdPr demand RHS (kt)

We expect NdPr demand from wind turbines to grow by a CAGR of 13% from 2023 to 2030



Source: BofA Global Research estimates, Wind capacity from WoodMac

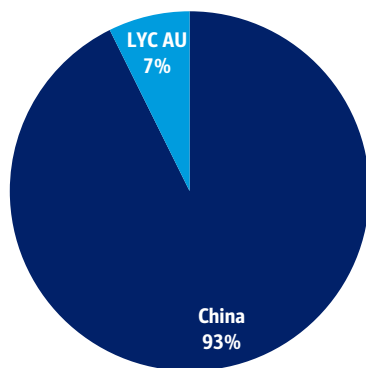
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Global rare earths supply

90% of global NdPr is produced from China, while the rest 10% is from Lynas operating in Australia and Malaysia. We think MP will gradually ramp up of its NdPr production from 2024 after the completion of the light rare earths' separation facility in 2023. Combining MP's and Lynas' NdPr production of 19ktpa, we expect China's dominance in NdPr production to reduce to 80% in 2026. We forecast 9% increase on average every year from 2023 to 2030 for China's mining and refining quota. Around one quarter of NdPr supply comes from scrap in China. We continue to forecast close to 25% of NdPr supply from scrap in the next few years.

Exhibit 5: 2023 NdPr split by country

We estimate around 93% of global NdPr is produced from China

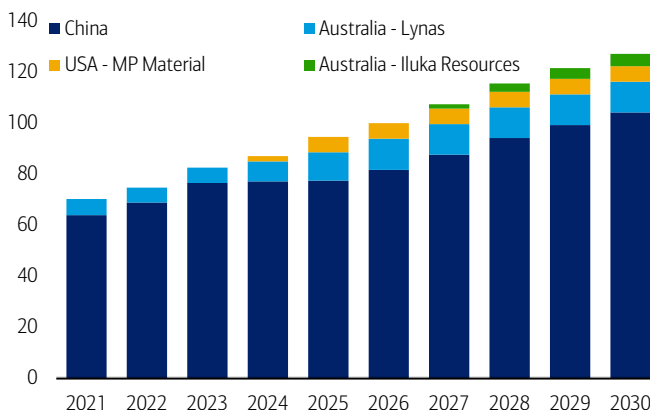


Source: BofA Global Research estimates

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Exhibit 6: Global NdPr supply by country

Combining MP's and Lynas' NdPr production of 19ktpa, we expect China's dominance in NdPr production to reduce to 80% in 2026



Source: BofA Global Research estimates

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Global NdPr supply and demand model

We believe NdPr price in the near and medium term will continue to be determined by China's rare earths supply and demand. However, in the long term, we think the price will be driven fundamentally by global supply and demand.

Exhibit 7: Global NdPr supply and demand (2021-2030F)

We believe NdPr prices in the near and medium term will continue to be determined by China's rare earths supply and demand. However, in the long term, the price will be driven fundamentally by global supply and demand

NdPr Supply		2021	2022	2023	2024F	2025F	2026F	2027F	2028F	2029F	2030F
Lynas (Ex-China)	kt	6.3	6	6.0	7.8	11.0	12.2	12.0	12.0	12.0	12.0
MP Materials (incl export to China)	kt	6.7	6.8	6.8	6.4	6.0	6.1	7.5	8.8	8.7	8.2
ILU	kt	0	0	0	0	0	1.7	3.3	4.2	4.9	4.9
China (Quota only)	kt	32	35	43	47	51	54	59	63	69	74
Myanmar (Export to China)	kt	3	4	6	4	3	3	3	3	3	2
Scrap (Recycling)	kt	22	24	20	22	24	24	24	25	25	25
Other	kt	0	0	0	0	0	0	0	0	0	0
Total	kt	70.2	74.6	82.5	87.0	94.5	101.6	108.9	116.4	122.1	127.1
NdPr demand											
EVs	kt	5.6	8.6	10.4	14.4	17.9	21.2	24.6	28.4	31.3	34.3
	YoY%	92%	52%	21%	39%	24%	18%	16%	16%	10%	9%
	%total	8%	11%	13%	16%	18%	20%	22%	24%	25%	26%
Wind	kt	9.0	7.1	10.0	13.5	16.9	17.3	18.6	21.1	22.4	23.7
	YoY%	30%	-21%	41%	35%	25%	3%	7%	13%	6%	6%
	%total	12%	9%	12%	15%	17%	17%	17%	18%	18%	18%
Others (electronics, ICE cars, Industrials etc.)	kt	60	63	60	61	63	65	68	70	73	75
	YoY%	4%	4%	-4%	2%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
	%total	80%	80%	75%	69%	65%	63%	61%	59%	57%	56%
Total	kt	75.0	78.4	80.6	89.1	98.1	104.0	111.0	119.7	126.3	133.2
Surplus/deficit	kt	-4.8	-3.8	1.8	-2.1	-3.6	-2.4	-2.1	-3.3	-4.2	-6.1
Growth of NdPr	%	10%	5%	3%	10%	10%	6%	7%	8%	6%	5%
NdPr price forecast	\$/US/kg	92	126	75	66	83	95	100	100	85	87

Source: BofA Global Research estimates

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NdPr price forecast changes

We lower our NdPr price forecast from 2024 to 2027 by 23% on average (Exhibit 6) driven by softer-than-expected NdPr demand growth from wind turbines, EV, as well as industrial and manufacturing products, such as air conditioners, elevators, and consumer electronics in China. We now forecast NdPr price in 2024 to average at US\$66/kg from US\$110/kg prior, and to US\$83/kg in 2025 from US\$120/kg prior. We remain attracted to the long-term growth of rare earths materials driven by the structural shift to green economy. Our long-term NdPr price is unchanged at US\$85/kg (nominal).

Exhibit 8: 2024-2029 NdPr price change forecast US\$/kg (2016-2029E)

We now forecast NdPr price in 2024 to average at US\$66/kg from US\$110/kg prior, and to US\$83/kg in 2025 from US\$120/kg prior

	Spot	2016A	2017A	2018A	2019A	2020A	2021A	2022A	2023A	2024E	2025E	2026E	2027E	2028E	2029E (LT Nominal)
Old	50	38	52	50	45	45	92	124	75	110	120	110	110	85	85
New	50	38	52	50	45	45	92	124	75	66	83	95	100	100	85
% chg		0%	0%	0%	0%	0%	0%	0%	0%	-40%	-31%	-14%	-9%	18%	0%
Spot		50	50	50	50	50	50	50	50	50	50	50	50	50	55
LT (nominal)		85	85	85	85	85	85	85	85	85	85	85	85	85	85

Source: BofA Global Research estimates

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We believe rare earths prices have bottomed in 1Q24E at US\$55/kg and the demand is set to recover from here. We forecast NdPr price to increase to US\$65/kg in 2Q, US\$70/kg in 3Q, and US\$75/kg in 4Q.

Exhibit 9: 2024-2025 quarterly NdPr price forecast change

We believe rare earths price have bottomed in 1Q24E at US\$55/kg and the demand is set to recover from here. We forecast NdPr price to increase to US\$65/kg in 2Q, US\$70/kg in 3Q, and US\$75/kg in 4Q

	Q1'24E	Q2'24E	Q3'24E	Q4'24E	Q1'25E	Q2'25E	Q3'25E	Q4'25E
Old	95	105	120	120	120	120	120	120
New	55	65	70	75	80	80	85	85
% chg	-42%	-38%	-42%	-38%	-33%	-33%	-29%	-29%

Source: BofA Global Research estimates

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Global Rare earths reserves /production

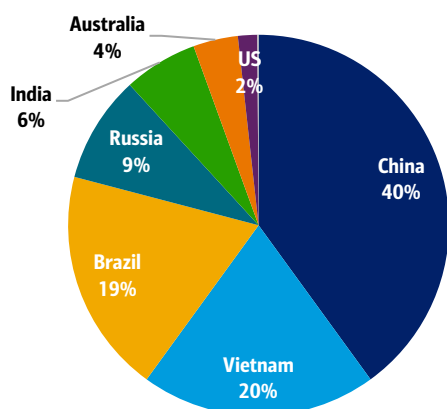
China's dominance in production

"The Middle East has oil. China has rare earth metals" said Deng Xiaoping, the architect of China's economic reform and development when Deng opened China in 1980s. According to US Geological Survey, China accounts for 40% of the global REO reserves in 2023, while ~70% of the global REO (unseparated) is produced from China.

From a downstream perspective, China is home to more than 80% of the world's capacity to process rare earth concentrates or carbonates into materials that manufacturers can use. It would take many years to build enough processing and separation plants to match China's processing capacity of 250kt (annualized 2024 separation quota at 254ktpa). China supplied 80% of the rare earths imported by the US from 2014 to 2017.

Exhibit 10: REO global reserves by country (2023)

China accounts for 40% of the global REO reserves in 2023, while the US and Australia combined comprises 6.0%

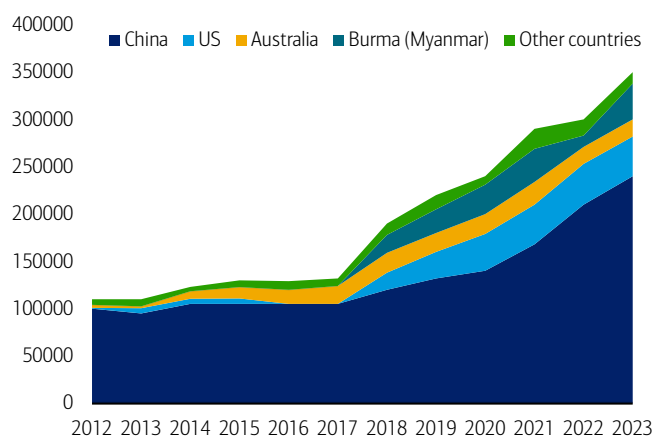


Source: BofA Global Research, US Geological Survey (USGS)

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Exhibit 11: Total REO (unseparated REE) 2023 production by country (tonnes)

~70% of global REO (unseparated) is produced from China



Source: BofA Global Research, US Geological Survey (USGS)

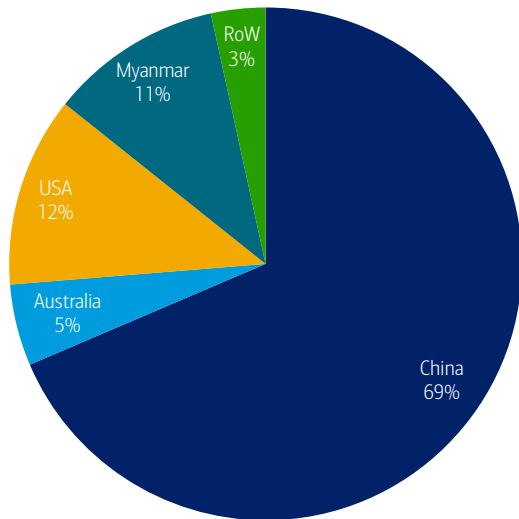
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US (MP) and Australia (LYC): 18% of global REO production

The US and Australia combined comprise 5.0% of the global REO reserves and 18% of the global REO production (LYC AU 5.0% and MP Material 12%). However, either US or Australia has processing / separation plant to produce NdPr as separated REE product in 2022. Currently, Australia's LYC ships rare earths concentrates and carbonate to Malaysia to process and separate. After several years of shipping rare earths concentrates from the US to China to process into NdPr, MP has just completed construction of its own light-REO US-based separation facility targeting NdPr production and sales from 2024.

Exhibit 12: REO global production by producers (2023)

70% of global REO is mined from China, while the US (MP) and Australia (LYC) together comprise 18%

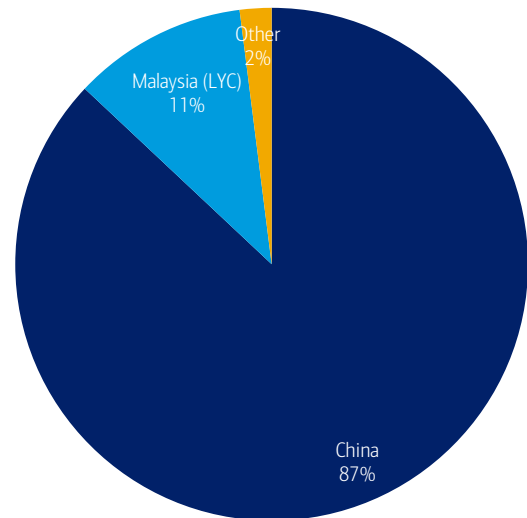


Source: BofA Global Research estimates, US Geological Survey (USGS)

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Exhibit 13: Rare earths processing capacity from mined to separated

China dominates 80-90% of rare earths processing capacity



Source: BofA Global Research estimates

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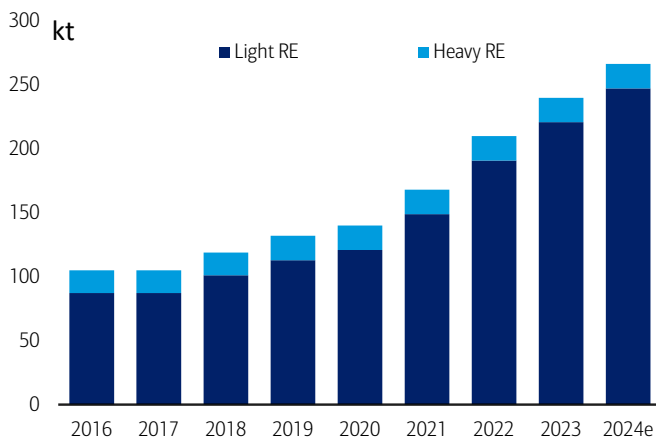
China's rare earths quota and oligopolies

China's mining quota for rare earths is an indication for China's domestic production of rare earths. China's RE mining quota more than doubled in the last five years from 105kt of REO in 2017 to 240kt in 2023. The first six months in 1HCY24 China guided quota is 135kt, which is annualized to 270ktpa, another 12.5% increase YoY. We expect the pace of the growth to continue at be 9.0% YoY on average over the next 10 years.

China's rare earths quota used to be occupied by a few major names. However, consolidation over the last few years led to the quota shared by two major rare earths companies. 70% of 1HCY24's mining quota is allocated to China Northern Rare Earths and the rest 30% to China Rare Earths.

Exhibit 14: China RE mining quota

China's RE mining quota more than doubled over the last five years from 105kt of REO in 2017 to 240ktpa in 2023. The first six months 1HCY24 China guided quota is 135kt, which is annualized to 270ktpa.

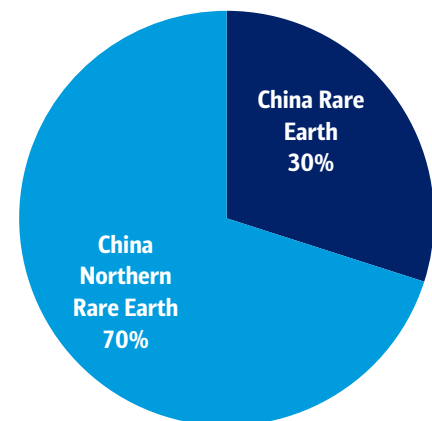


Source: BofA Global Research estimates

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Exhibit 15: China's RE quota allocated to two RE producers in 1HCY24

70% of quota allocated to China Northern Rare Earths, 30% to China Rare Earths



Source: BofA Global Research

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Exhibit 16: Global Rare Earths integrated producers
LYC is the only integrated RE producer outside of China from mined products to separated products, i.e., selling NdPr



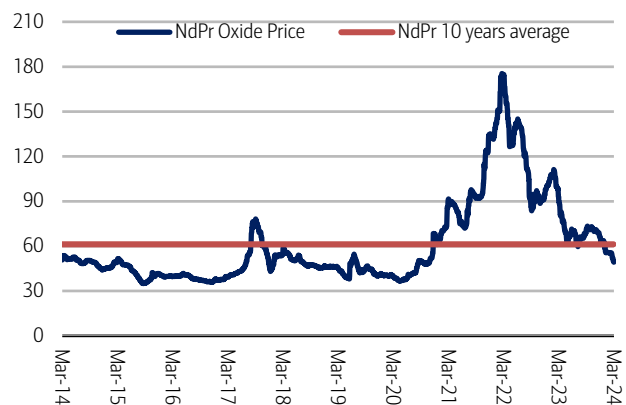
Source: Wood Mackenzie

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Rare earths prices

Exhibit 17: NdPr price US\$/kg (incl VAT)

Spot of US\$49/t is 20% below 10-year average of US\$61/kg.



Source: BofA Global Research, Bloomberg

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Exhibit 18: Terbium oxide price US\$/kg

Spot terbium price at US\$785/kg



Source: BofA Global Research, Bloomberg

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Exhibit 19: Dysprosium oxide price (US\$/kg)

Spot price at US\$279/kg



Source: BofA Global Research, Bloomberg

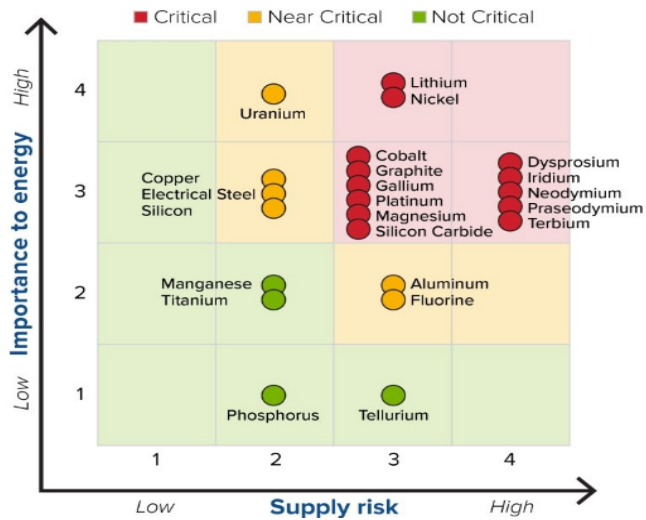
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Rare earths supply vulnerability = Critical minerals

The US Department of Energy (DOE) continues to rank dysprosium and terbium as critical materials. Currently, all heavy RE (HRE) separation occurs in China. LYC is planning to build the first HRE separation plant in the US fully funded by the US Department of Defense (DoD). We forecast the first production of LYC's HRE plant from FY26.

Exhibit 20: Critical Minerals Medium term 2025-2035

Dysprosium, Terbium, Neodymium and Praseodymium have been identified as “critical” minerals in the medium term by the US DoE

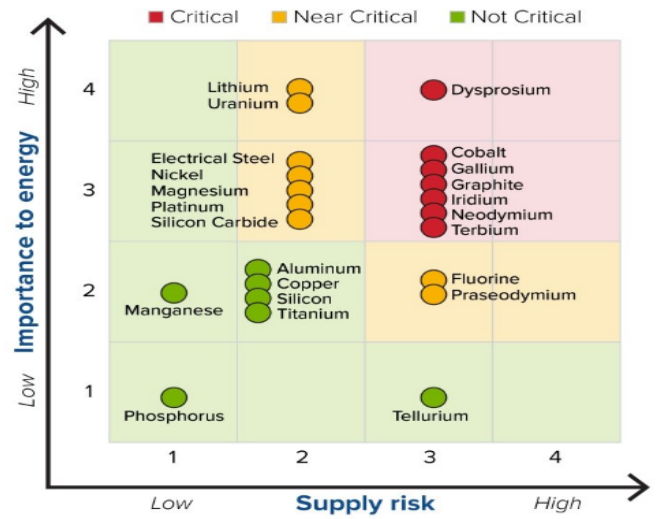
MEDIUM TERM 2025-2035

Source: US Department Energy

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Exhibit 21: Critical Minerals short term 2020-2025

Dysprosium, Terbium, and Neodymium have also been identified as “critical” minerals in the short term by the US DoE

SHORT TERM 2020-2025

Source: US Department Energy

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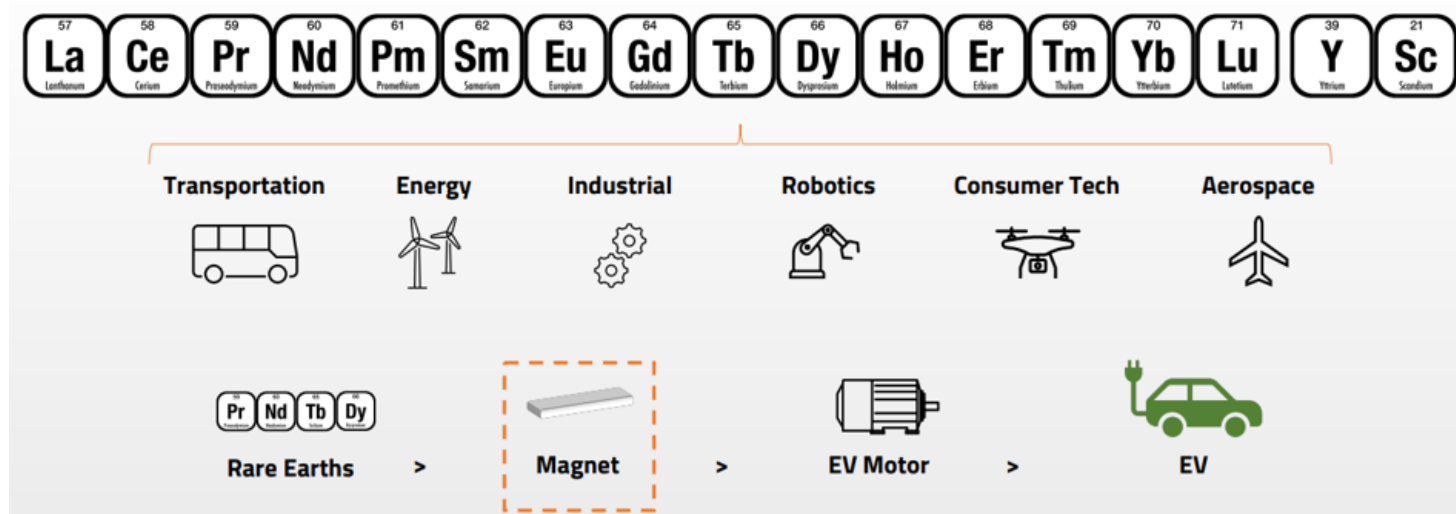
Rare Earths 101

Rare Earth Elements - group of 17 chemical elements

Rare earth elements (REE) are a group of 15-17 elements comprising the lanthanides (atomic numbers 57-71) plus yttrium and scandium. While named rare earths, the geologic deposits are relatively abundant in the earth's crust, but minable concentrations are less common than for most other ores. Some rare earths elements are about the same abundance in the earth's crust as copper or gold. However due to their geochemical properties, rare earth elements are normally dispersed and are never found in high concentrations. The chemical properties of the rare earth elements make them difficult to separate and purify from other mixed elements/chemicals from the ore. In other words, what makes them rare is the ability to find them in concentrations sufficient to support commercial mining operations. Key applications include permanent magnets and catalysts, with future magnet demand heavily linked to future EV production and renewable energy as wind turbines.

Exhibit 22: Rare Earths – The Lanthanide Series

Rare earth elements (REE) are a group of 15-17 elements comprising the lanthanides (atomic numbers 57-71) plus yttrium and scandium. Key applications include permanent magnets and catalysts, with future magnet demand heavily linked to future EV production and renewable energy as wind turbines.



Source: MP Materials website

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Light rare earth (LRE) and heavy rare earth (HRE)

Rare earth elements (REE) are found, mined, and processed together up to the state of rare earth oxide (REO) concentrate. After that, REO needs to be separated through solvent extraction into individual element. Rare earths are separated / categorised into light elements (LREE) (from lanthanum to samarium) and heavy elements (HREE) (from europium to lutetium). The classification is determined by the electron configuration of the atoms of the element. The "heavy" (HREE) are less common and more expensive, while the "lights" (LREE) typically more common and easier to extract, hence lower priced. Cerium (Ce) is the most abundant REE followed by Lanthanum (La), Neodymium (Nd) and Praseodymium (Pr).

China's share of HRE separation is almost near-100%. Most of these separated HREs come from ionic clay minerals found in China and Burma. Dy can be found or recovered from mineral sands. If a fraction of HREs is much smaller than fraction of LREs, it may not be economical to separate small quantities of HREs into individual rare earths. From value and demand (application) perspective, the most important REE are: LRE: Neodymium (Nd), and Praseodymium (Pr) known as NdPr; HRE: Dysprosium (Dy) and Terbium (Tb). NdPr is used mainly to produce permanent magnet (NdFeB), and Dy and Tb normally will add energy efficiency when permanent magnet is performing at high temperature.

Dysprosium (Dy) is a critical rare earth element. However, its supply, consumption, trade, and recycling along its supply chain are still not clearly studied or researched as close to 100% of Dy is produced from China. China is also the major consumer for Dy. Over 2004-19, China domestic Dy demand increased by 16-fold. Due to intensified environmental regulations from China while producing Dy is highly polluted, Dy production in recent years couldn't catch up with supply.

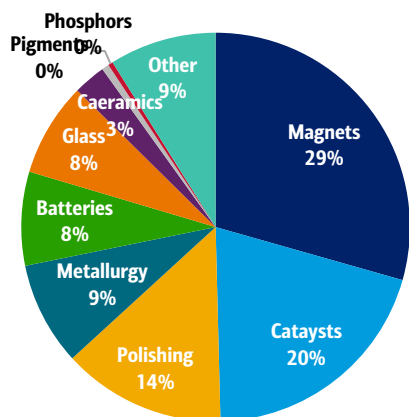
Key applications – “vitamins of modern industry”

Rare earth is a “technology metals” which are almost irreplaceable to the technology in modern world owing to their unique magnetic, phosphorescent, and catalytic properties. Rare earths are essential to industrial and military technologies. The industrial application includes electronics, smartphones, LED lights, Plasma TV, battery technology, electric cars, wind turbines, medical equipment, etc. Military technologies include nuclear power, space, critical defence, etc.

Heavy rare earths such as Dy and Tb are used primarily in sintered magnets to improve the resistance to demagnetization at temperatures above 120 degrees C. While light rare earths now can be produced outside of China such as LYC, access to heavy rare earths is still constrained. China supplied 80% of the rare earths imported by the US from 2014 to 2017. China is home to 80-90% of the world's capacity to process rare earth ores into materials that manufacturers can use. It would take years to build enough processing plants to match China's processing capacity.

Exhibit 23: Rare earths application

Rare earths are most used for magnets and catalysts

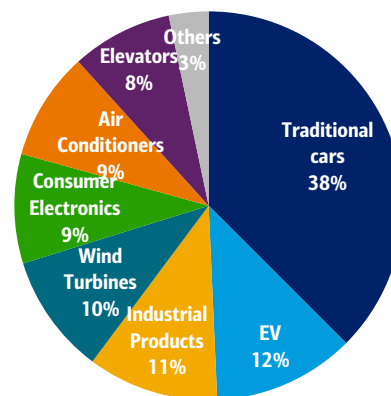


Source: BofA Global Research estimates, company report

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Exhibit 24: NdFeB demand in 2019

Around 10% of demand from Wind and 12% from EV while traditional cars still consume 38% of NdFeB demand in 2019



Source: BofA Global Research

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Appendix - rare earths glossary

RE – Rare earth.

REE – Rare earth element.

LRE – Light rare earth.

HRE – Heavy rare earth.

REO – Rare earth oxide.

Ce – Cerium, a LRE element.

La – Lanthanum, a LRE element.

Nd – Neodymium, a LRE element.

Pr – Praseodymium, a LRE element.

NdPr – Neodymium & Praseodymium, LRE elements.

Dy – Dysprosium, a HRE element.

Tb – Terbium, a HRE element.

NdFeB – Neodymium iron boron

EV Electric Vehicle

ICE Internal Combustion Engine

MP MP Materials

LYC Lynas

NdFeB Neodymium Iron Boron (Magnet)

BEV Battery Electric Vehicle

PHEV Plug in Hybrid Vehicle

REO Rare Earth Oxide

HRE: heavy rare earth

LRE: Light rare earth

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