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Management of the Rare Earth Elements (REE) in the global economy: Neodymium case study

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This study provides an overview of using rare earth elements (REEs) in global economy based on the permanent magnets consuming mainly a mixture of neodymium (Nd), praseodymium (Pr) and dysprosium (Dy), and cerium (Ce), as well as gadolinium (Gd) in much lower quantities. Actually the segment of the magnet market is the largest rare earth market (REM) by volume and will continue to outperform other market segments. In the report on „Rare Earths, Outlook to 2030" presented in Green Car Congress on the 3 February 2021 and developed by Roskill Commodity Research forecast, acquired in June 2021 by Wood Mackenzie, the leading global research, consultancy, and data analytics business powering the natural resources industry, Roskill forecasts that rare earth magnet applications will account for ~40% of total demand by 2030, raising the potential for a tight supply-demand balance for key magnetic REEs.
The supply of rare earths on the US, Europe, Japan and Chinese markets is presented and discussed.

Rare Earths

According to Arafura Rare Earths Limited, an Australian mineral exploration company focusing on REEs, headquartered in Perth (ARE, 2022), rare earths (REs) are critical materials and essential to many important products in modern society. Demand for REs is caused by the following trends (ARE, 2022a):

- Transition towards more renewable energy
- Advances in consumer electronic technology
- Low emission technology concepts
- Evolution in automotive and future mobility trends

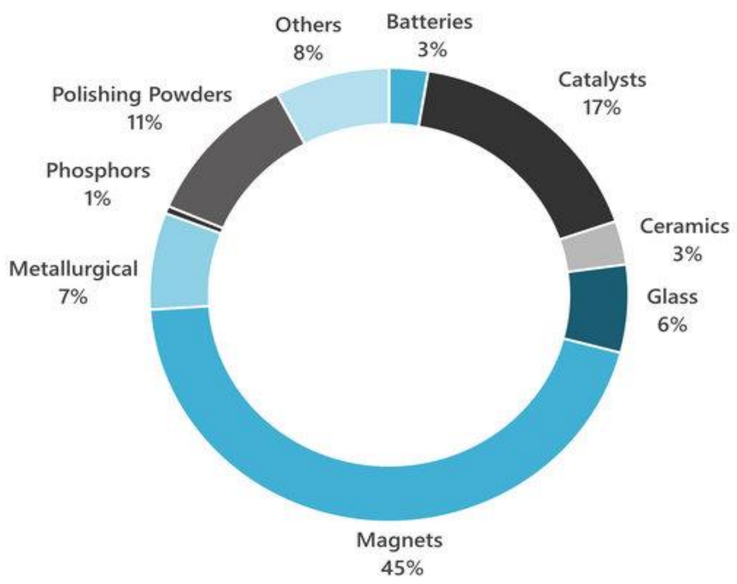

Fig. 1. REO Market by applications in years 2022 (ARE, 2022a)

NdFeB Magnet Materials – A Rapidly Growing Market

According to ARE (2022a) permanent NdFeB magnets, with typical content up to 30% NdPr metal (from NdPr oxide), has an influence on the automotive products and wind power energy generation industry, among others. Moreover. important uses of NdFeB magnets include also: e-bikes, consumer electronics, and robotics (ARE, 2022a), air-conditioners and wind power generators (Baba et al. 2013). Most significantly demand for NdPr oxide, in the automotive sector, according to ARE (2022a), is driving force of growth for permanent magnet electric motors used in hybrid EVs (HEV) and battery EVs (BEV).

Rare-earth magnets are a key material in energy saving and digital equipment such as hard disk drives (HDDs), high-efficiency air conditioners, hybrid vehicles, and wind power generators.

The magnet market segment is the largest rare earth market by volume and will continue to outpace other market segments and is expected to account for 40-50% of the Rare Earth Oxides (REO) market by the end of the decade. The REO market segment application respectively in years 2022 is shown in Figure 1 (ARE, 2022a).

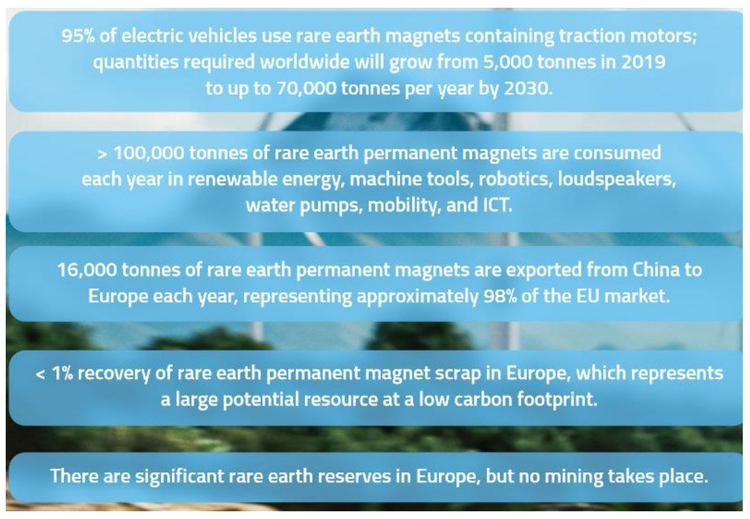

Fig. 2. ERMA Cluster Rare Earth Magnets and Motors: key facts presented in the Rare Earth Magnets and Motors Cluster of the European Raw Materials Alliance Report

European Raw Materials Alliance (ERMA)

The objectives of the ERMA Cluster are „to secure access to sustainably produced magnet rare earths at competitive costs from primary and recycled sources; to make Europe a global leader in rare earth metal, alloys and magnet production; and to sustain and expand Europe's global leadership in electric motor and generator design. A two-fold approach was followed, that is, to identify promising investment cases as well as to recognize regulatory issues that hinder the growth of the sector in Europe" (ERMA, 2021) presented in Figure 2.

Demand

According to Arafura Rare Earths Limited (ARE, 2022b) rare earths remain critical in various applications with future demand expected to remain strong driven by the clean energy economy through e-mobility and wind power. Global consumption of rare earths reached 164,000 tonnes of TREO in 2022 and is forecast to increase to 231,000 tonnes by 2032.

China will continue to dominate global markets, strengthen its supply chain and increase the use of rare earths in e-mobility with expected strong growth for NdPr (Neodymium-Praseodymium) oxide (non-separated oxide of neodymium and praseodymium) in Neodymium Iron Boron (NdFeB) magnets used in electric vehicle (EV) traction motors (ARE, 2022). NdPr supply and demand forecast, and Forecast NdFeB magnet consumption by segment, presented in Figure 3, has been developed by Wood Mackenzie for Arafura Rare Earths Limited (ARE, 2022). NEODYMIUM and praseodymium – or NdPr for short – has been labelled one of the "biggest blind spots of today's global commodity market" (PRELCT, 2020).

For rare earth elements demand, more than 18-fold increases are expected for annual demand in 2050 compared with 2020, and cumulative demand of neodymium and dysprosium are 1.6–3.3% and 1.4–2.8% of their reserves respectively. Recycling will play an important role after 2050 as a secondary supply of metal for Chinese wind power, and lacks noteworthy impacts on short-term future outlooks (Ren, K. et al. (2021), Bridging energy and metal sustainability: Insights from China's wind power development up to 2050, Energy, Vol. 227, 120524

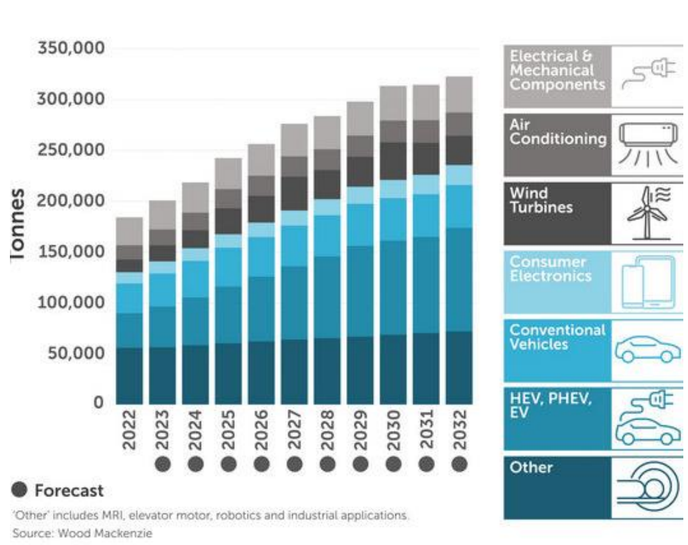

Fig. 3. Forecast NdFeB magnet consumption by segment

Global consumption of sintered NdFeB magnets in 2022 was 184,000 tonnes. NdFeB magnet consumption is forecast to grow by 5.8% per annum in the foreseeable future with demand reaching 322,000 tonnes in 2032. Use of NdFeB magnets in EVs is forecast to account for 32% of total demand by 2032 (see Figure 3). In addition to the discussion about Rare earth demand, specially Neodymium demand from magnet applications, see "Global rare earths strategic planning outlook in 2023" presented in Wood Mackenzie report (WM, 2023).

Conclusion

Rare earths used in NdFeB magnets represent the single largest segment by application, accounting for 45%.
The use of NdFeB magnets in the automotive, wind turbines and factory automation sectors are the biggest growth applications for NdPr oxide demand.

The supply of rare earths has become an increasingly geopolitical issue in the US, Europe and Japan, with Chinese market dominance seen as a supply risk for critical elements including neodymium (Nd), praseodymium (Pr) and dysprosium (Dy)
Global reserves of Nd is the second-most-abundant REE after cerium (Ce).

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