Critical Raw Materials for Electric Vehicles

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Rare earth elements for Electric Vehicles
PGM savings from BEV deployment

29th April 2022 - webinar

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Rare earth elements for EVs

E-motors using Permanent Magnets

Rare earths / Permanent magnets are NOT essential for EV e-motors! but “nice to have”

A common misunderstanding:

Forbes

ENERGY

The Future Of EVs Depend On Rare Earths. Should The U.S. Still Delegate To China?

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I write about the global energy business.

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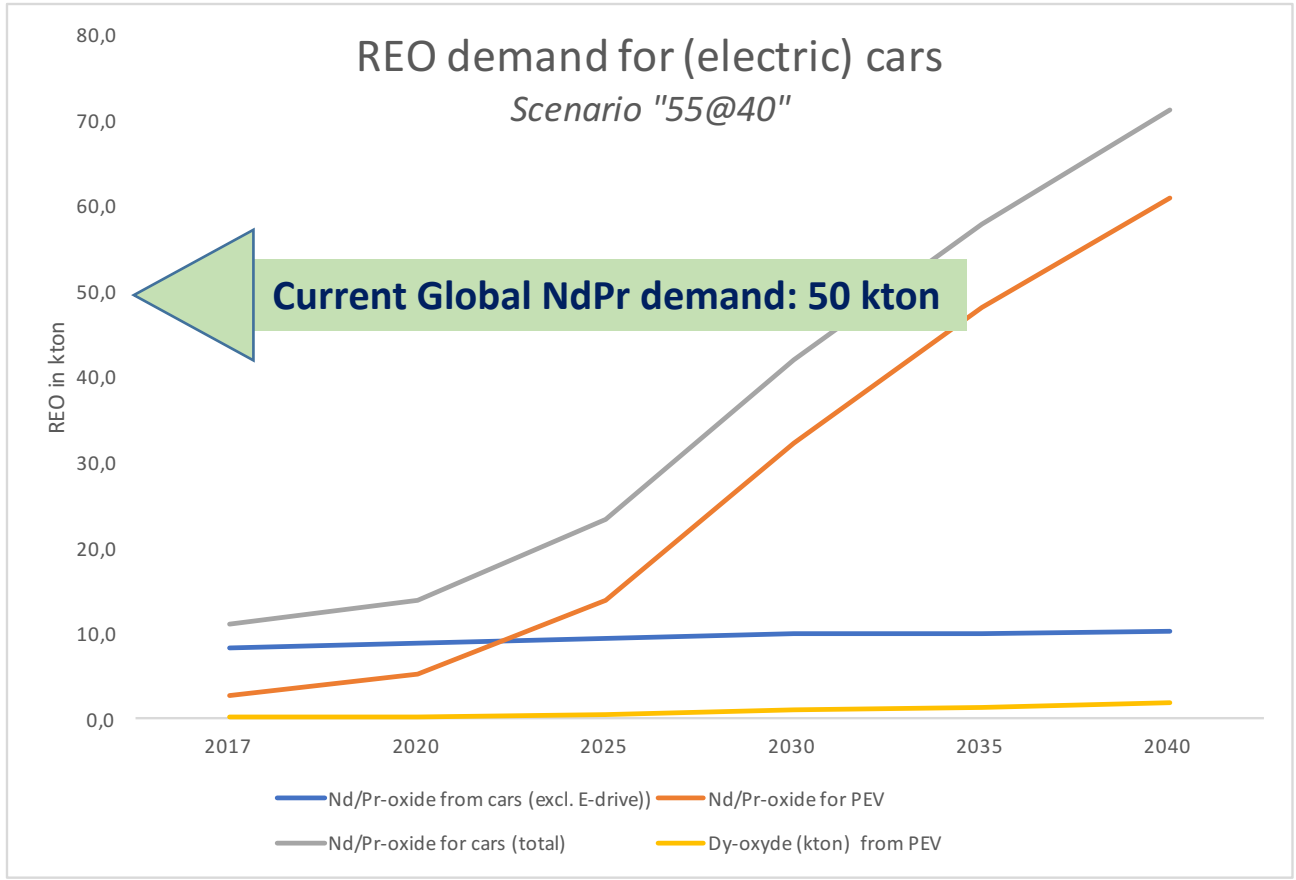
Feb 6, 2022, 05:00pm EST

- Permanent magnet motors are more efficient than induction motors, especially at lower speeds. Permanent magnet motors are also smaller and lighter. However, induction motors are efficient at high speeds.
- Permanent magnetic motors are more expensive to produce as they contain rare earth metals. Mining for these metals is often harmful to ecosystems and very costly.
- OEMs can not afford to put all eggs in the Chinese rare earth basket and have or are developing alternatives. Many have said they have scrapped, plan to eliminate, or are scaling down rare earths in electric vehicles.
- Prices of neodymium oxide more than doubled during a nine-month rally in 2021; the U.S. Department of Commerce said in June it is considering an investigation into the national security impact of neodymium magnet imports.

Impact of rapid EV deployment on REO demand Especially Neodymium / Praeseodimium

- EV growth is projected to accelerate and may reach 50% or higher market share by 2030
- PM demand for electric drive trains will dominate the use of Rare Earths in cars and have become the largest application area for PMs
- In a PM motor dominated market, RE demand will outstrip current global supply by 2030



The imbalance of the Rare Earths supply and demand

- **<u>Rare earths are mined as a mix</u>** and the strong growth in PMs has resulted in an imbalance of supply and demand for the different rare earths.
- Over-supply of Cerium, Lanthanum and other Rare Earths has grown to 50,000 tons of Rare Earth Oxides (REOs) or 25% of total supply in 2016 and will continue increase.
- Permanent Magnets utilise 35% of RE volume but >90% of value.

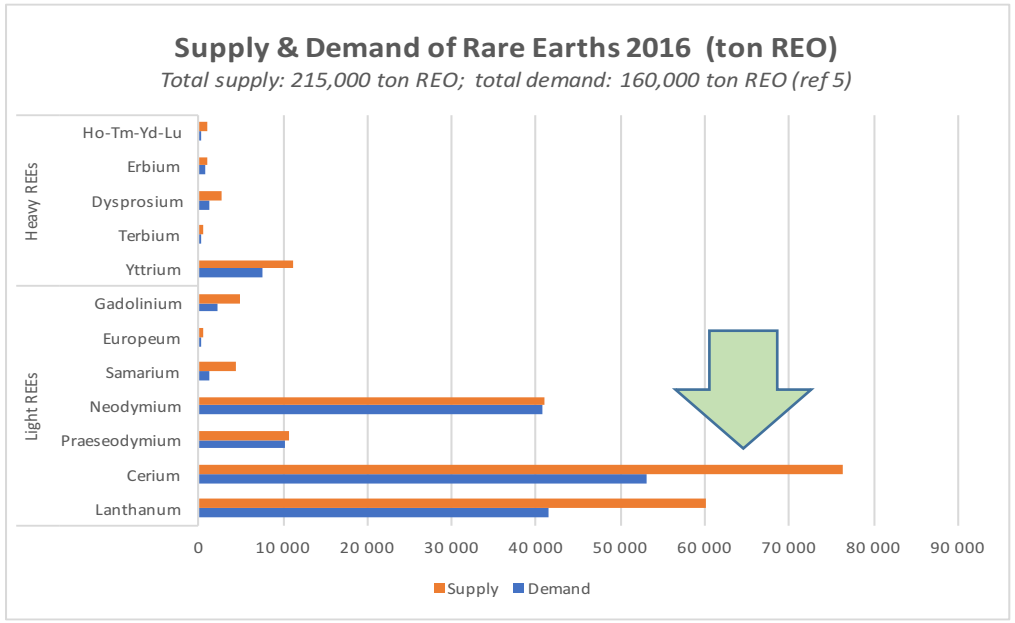
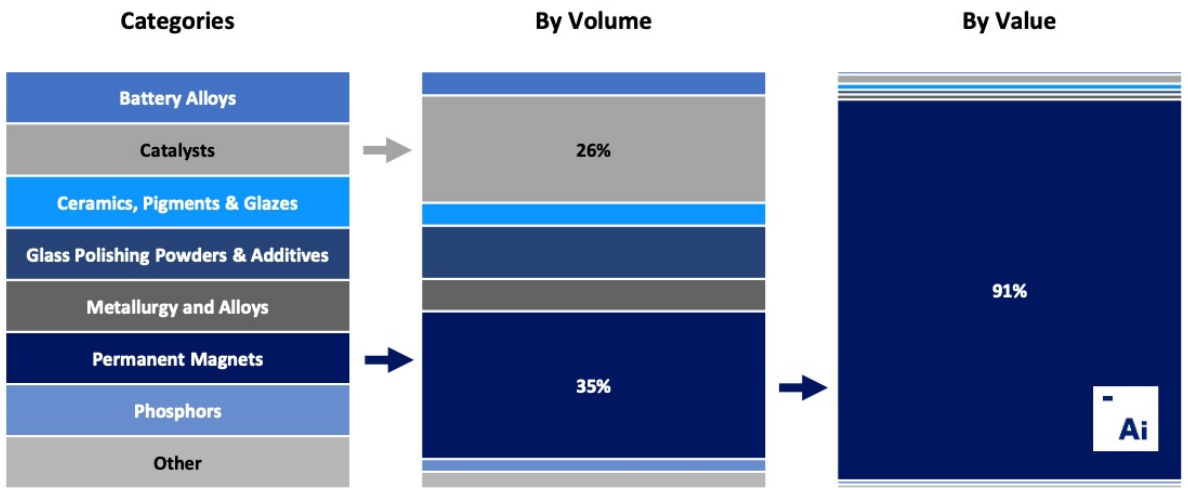


Figure 3: Permanent magnets and catalysts are the largest rare earth demand drivers



Source: Adamas Intelligence

Rare earths not necessary and better avoided for EVs

- Rare earth market is not very transparent
- Shortages of Nd magnets are already predicted: 60 kton by 2030, 206 kton by 2035 or 1/3 of the total market
- Rare earths shortage for magnets by 2030 equal tot total Chinese production 2021, PM rare earth market (Nd/Pr/Dy) to triple by 2035
- **BUT the – always higher than expected – EV growth will only increase supply risks**
- **PMs are very important for off-shore windturbines !!**
- **Recycling PM/RE from cars is VERY COMPLEX, from windturbines very EASY**

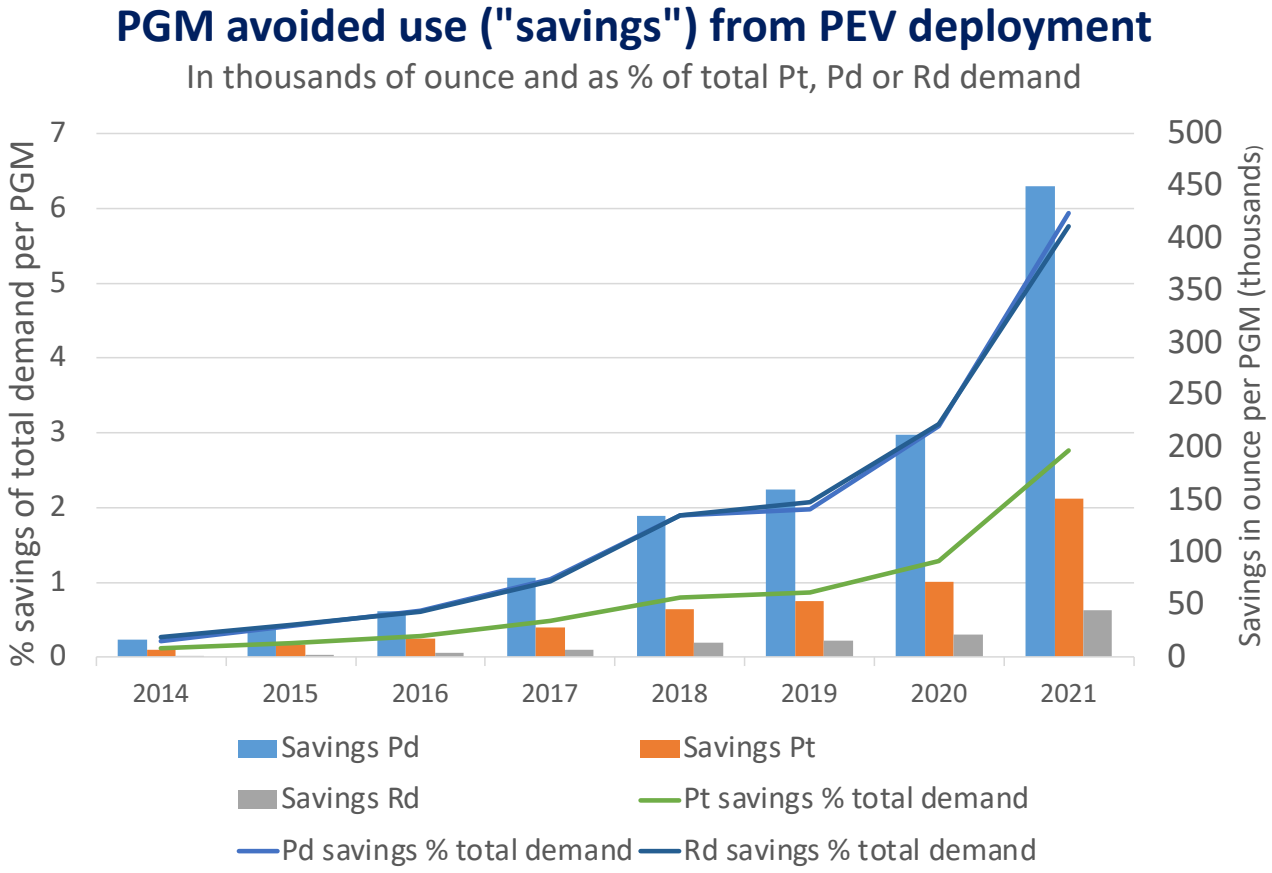
Market forecast: Adamas Intelligence (April 2022)

PGM savings from BEV deployment

Palladium – Platinum – Rhodium

Transition to BEV will transform PGM industry

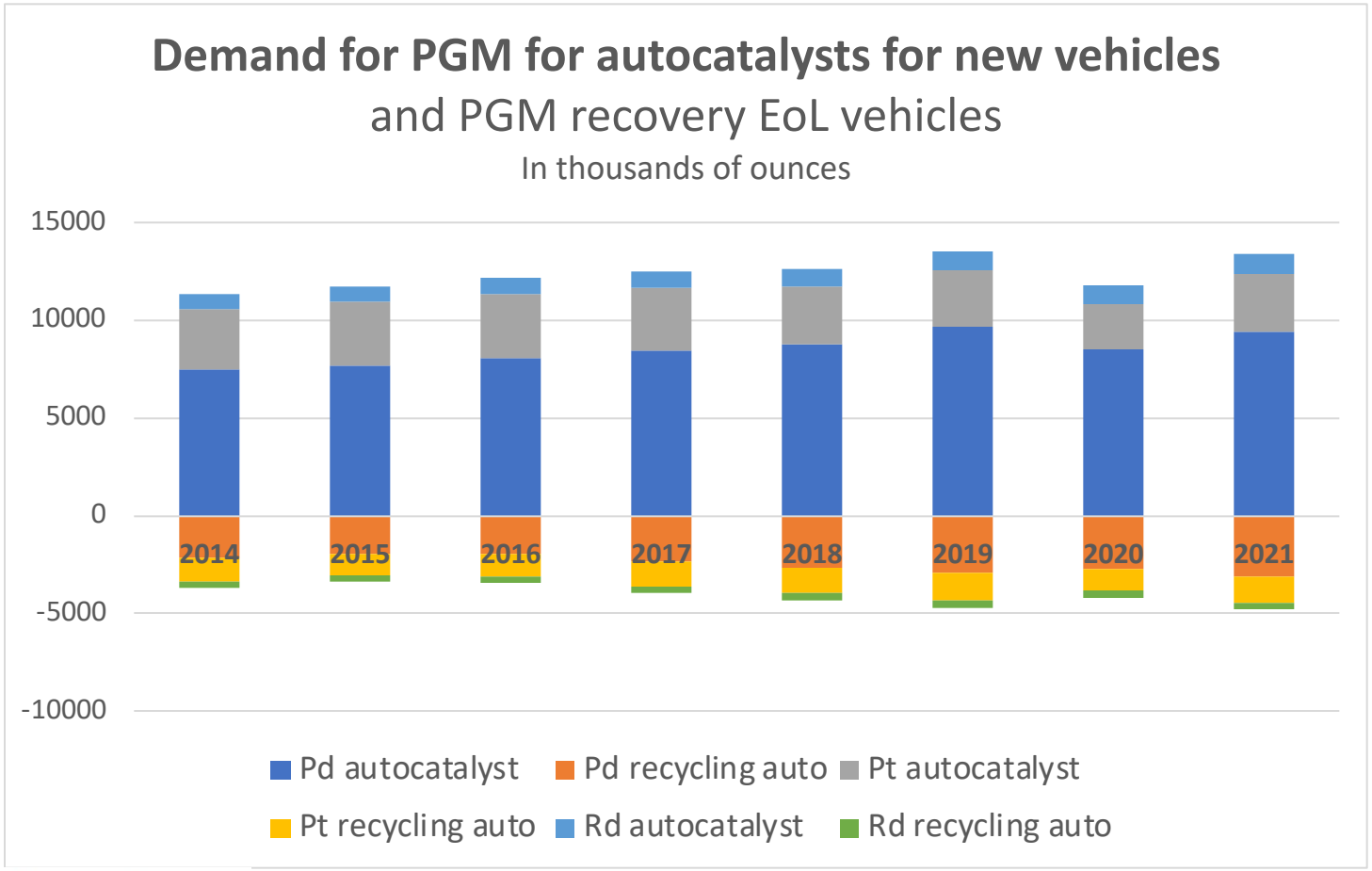
PGM mining has significant environmental and social impacts as well as geopolitical risks



- BEV in 2021 have reduced the total net demand for PGM with 6%, for Pt this is 3%
- Pd and Rh are used primarily for gasoline cars and Pt for diesel cars and trucks, the shift from diesel to gasoline cars (Europe) will increase the demand for Pd/Rh autocatalysts.

Autocatalyst demand determines the PGM market

BEV growth will reduce PGM demand while PGM from recycling will increase the coming decade



- **Over 80% of net Palladium and Rhodium demand is for autocatalyst**
- Around 50% of net Platinum demand is for autocatalyst
- The use of PGM for catalyst has been increasing (till 2019)
- **Recycling of autocatalysts yields around 35-40% of required PGM for catalyst**
- Fuel cells require significant amount of PGM per vehicle