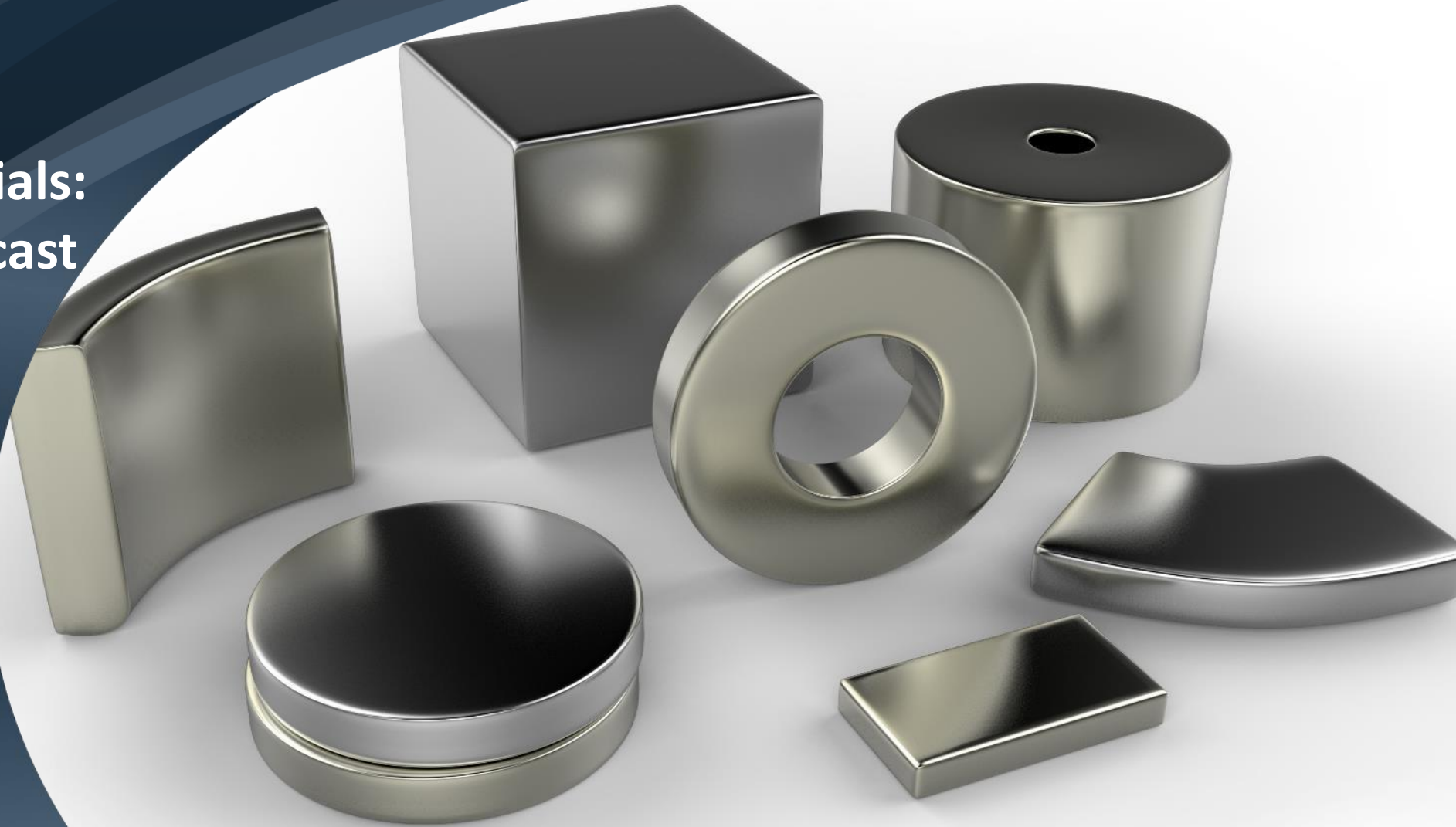




# PROJECT BLUE

**Rare earth materials:  
Market size, forecast  
and supply chain  
outlook**



**David Merriman e [Márcio Goto](#) - nov.2023**



## Forward-looking statements

This document may contain forward-looking statements that are subject to risks and uncertainties. All statements that are not historical facts contained within are forward-looking statements. In some cases, you can identify forward-looking statements by terminology such as “can,” “might,” “believe,” “may,” “estimate,” “continue,” “anticipate”, “intend,” “should,” “plan,” “should,” “could,” “expect,” “predict,” “potential,” or the negative of these terms or other similar expressions.

Forward-looking statements are based on information and assumptions that Project Blue had when those statements are made or its good faith belief as of that time with respect to future events. Forward-looking statements are subject to risks and uncertainties that could cause actual performance or results to differ materially from those in or suggested by the forward-looking statements. Except as required by law, Project Blue undertakes no obligation to update publicly any forward-looking statements after the date of this publication release, or to conform these statements to actual results or changes. While consideration has been taken in preparing the information published in this report, the content is provided without any guarantees, conditions, or warranties as to its accuracy, completeness, or reliability.

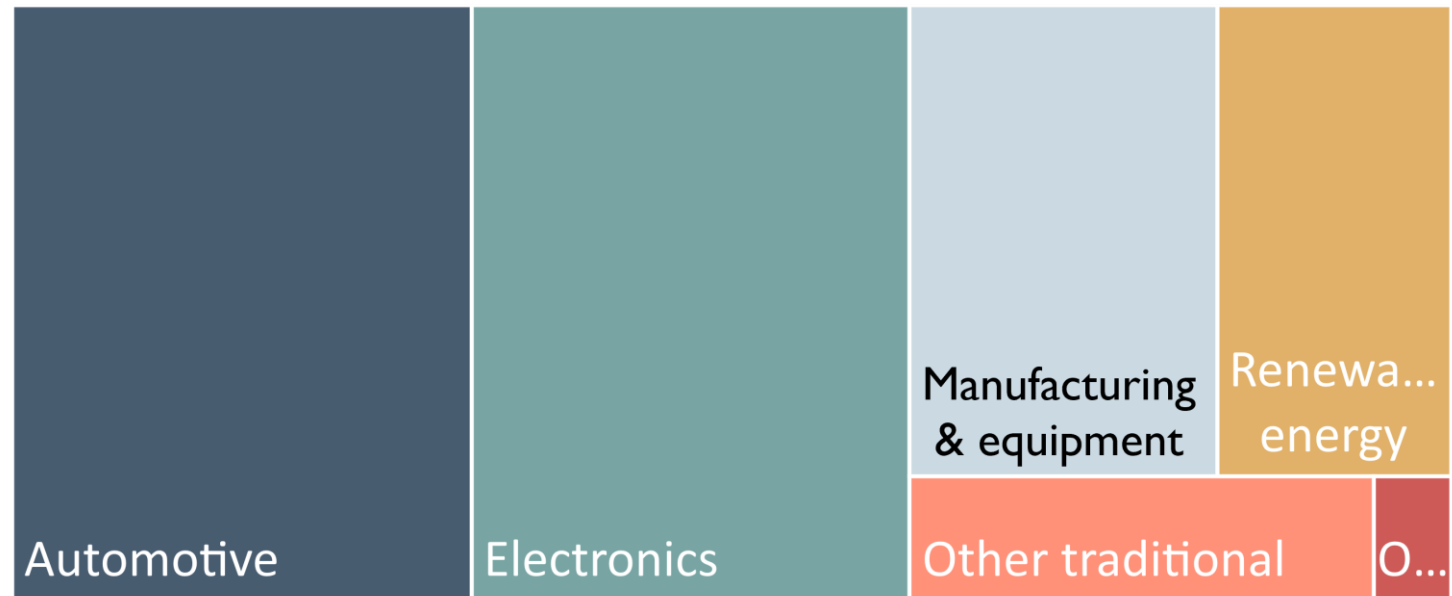
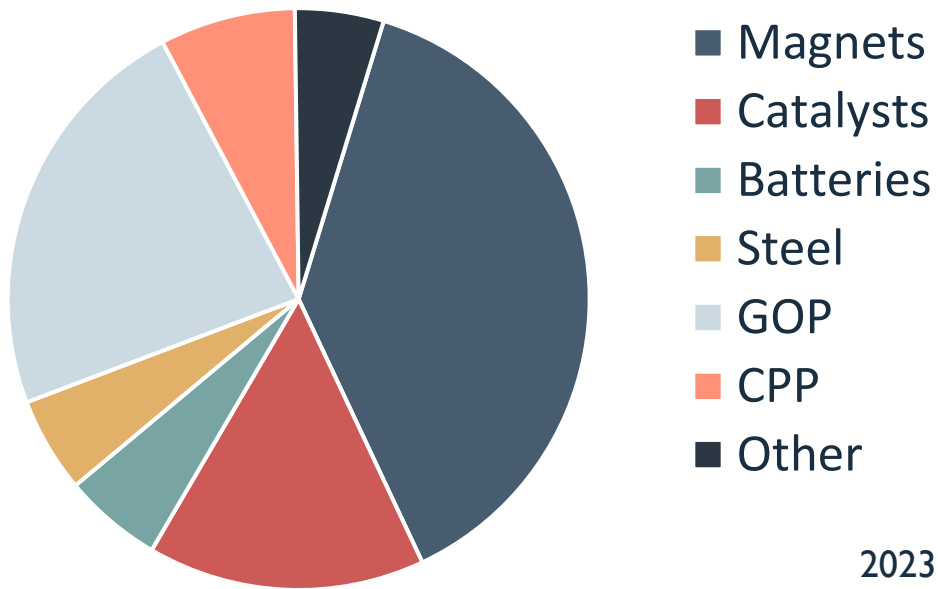
We accept no liability to third parties, howsoever arising. Although reasonable care and diligence has been used in the preparation of this report, we do not guarantee the accuracy of any data, assumptions, forecasts or other forward-looking statements

Why are rare earths important to **energy transition**?



# Why are rare earths important to the **energy transition**?

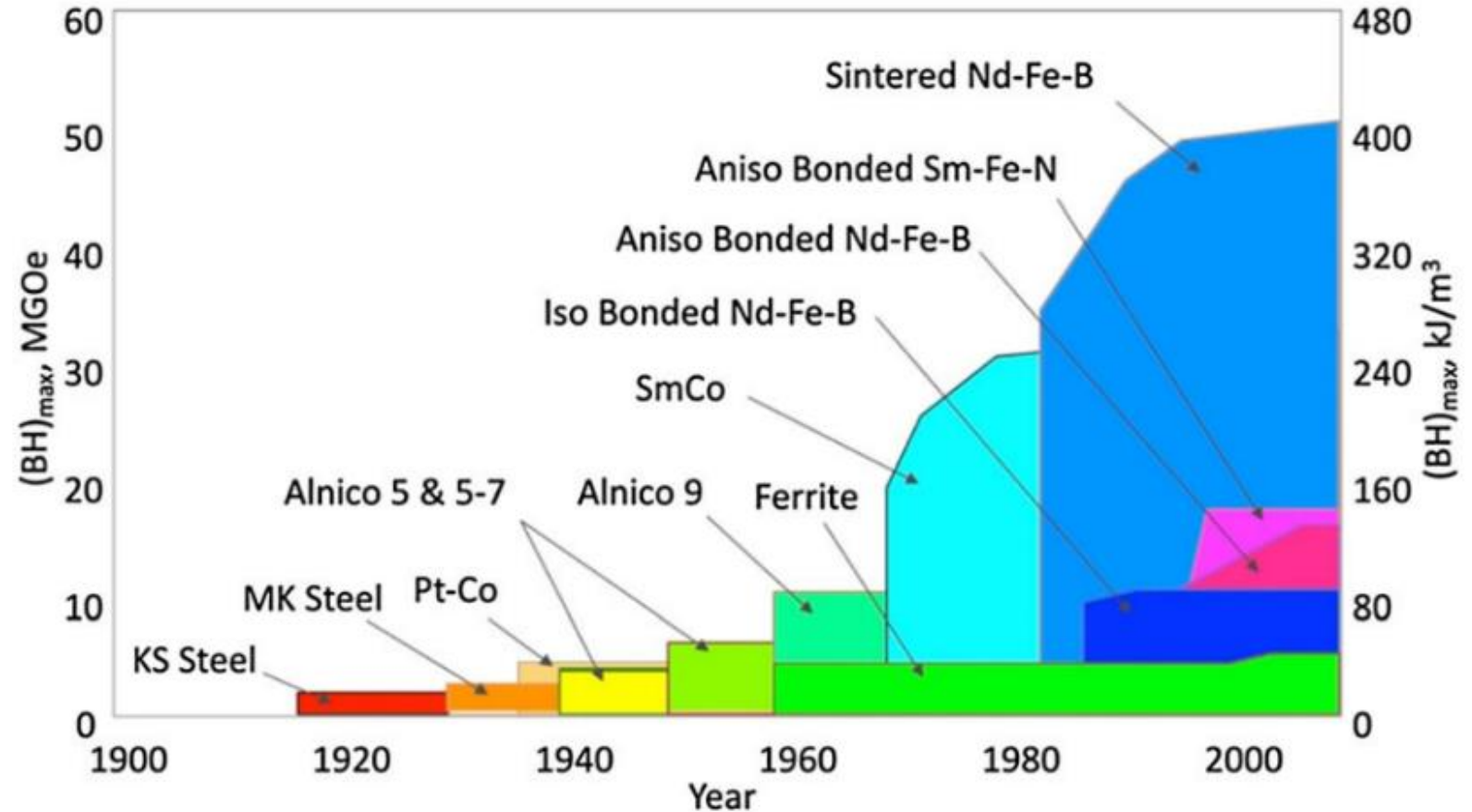
- **Wide variety of end-products to which rare earths provide critical performance capabilities**
- **Permanent magnets, catalysts, metallurgical powders, polishing powders, LED phosphors**
- **Use of rare-earth permanent magnets in EV motors and wind energy turbines has linked the REE industry to the energy transition**



# Why rare earth permanent magnets?

## But why rare earth permanent magnets?

- Which type of rare earth magnet?
- High magnetic strength (maximum energy product,  $(BH)_{\max}$ )
- Allows for high torque to be generated with minimum size and weight
- Able to operate in suitable temperature window (with additives)



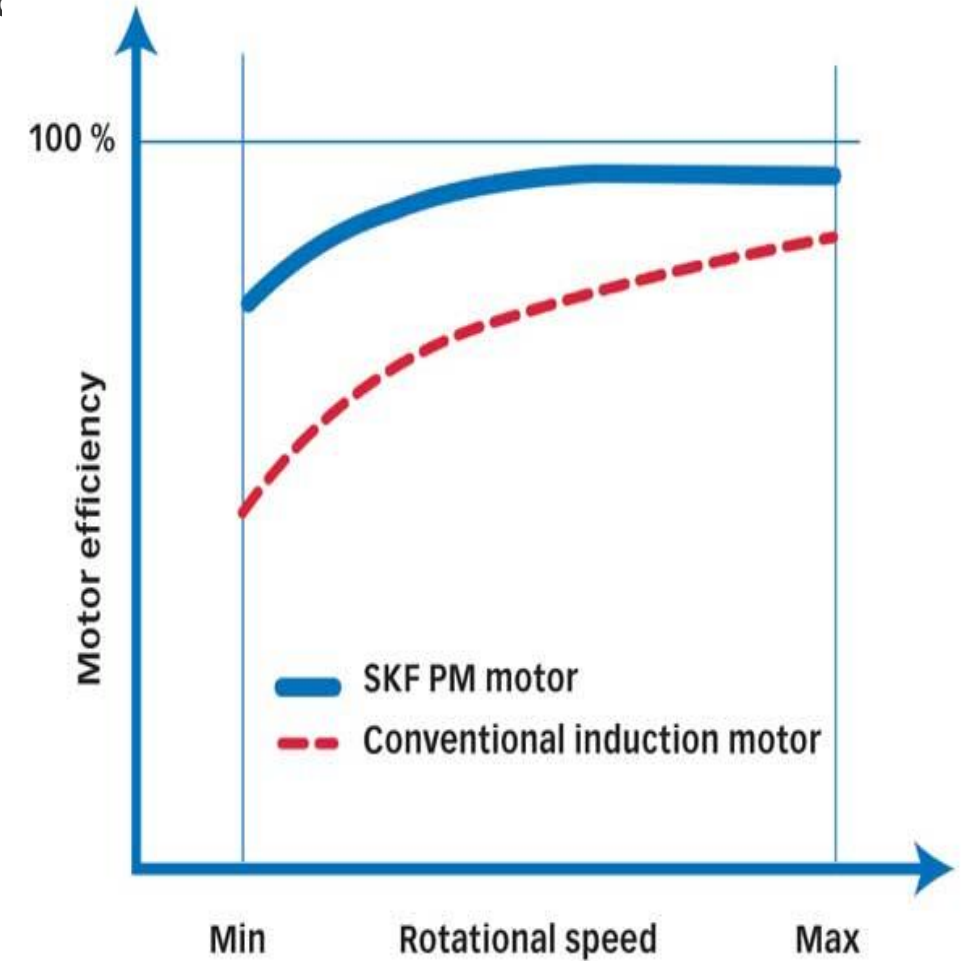
Source: Kramer et al (2012)



# Why rare earth permanent magnets?

## Weight saving and miniaturization crucial for electric vehicle applic

	Nd-Fe-B magnets used (Basis of comparison)	High-performance ferrite magnets used [1] (Equivalent motor performance)	High-performance ferrite magnets used [2] (Equivalent motor size and higher rotation speed)
Motor : "1/8 model"			
<ul style="list-style-type: none"> <li><span style="color: yellow;">■</span> Nd-Fe-B magnets</li> <li><span style="color: teal;">■</span> High-performance ferrite magnets NMF™ -15G</li> </ul>			
Max. output	110 kW	110 kW	105 kW
Max. rotation speed	10,000 rpm	10,000 rpm	15,000 rpm
Thickness in axial direction	1 (ref.)	1.4	1.0
Magnet $B_r$	1 (ref.)	0.37	0.37
Magnet weight	1 (ref.)	1.7	1.2
Motor weight	1 (ref.)	1.3	1.0

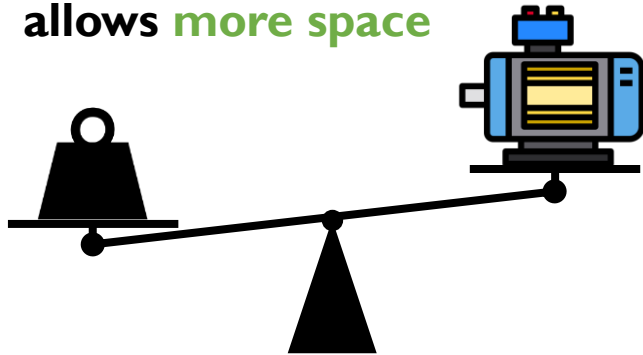


Source: Hitachi Metals (Proterial Ltd)

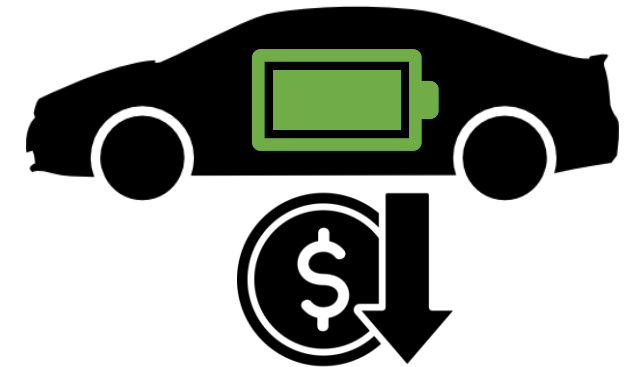


# Why are rare earths important to the **energy transition**?

Smaller, lighter motors reduces vehicle **weight** and allows **more space**



Improved **efficiency** allows a reduction in battery size and weight while achieving the same vehicle range

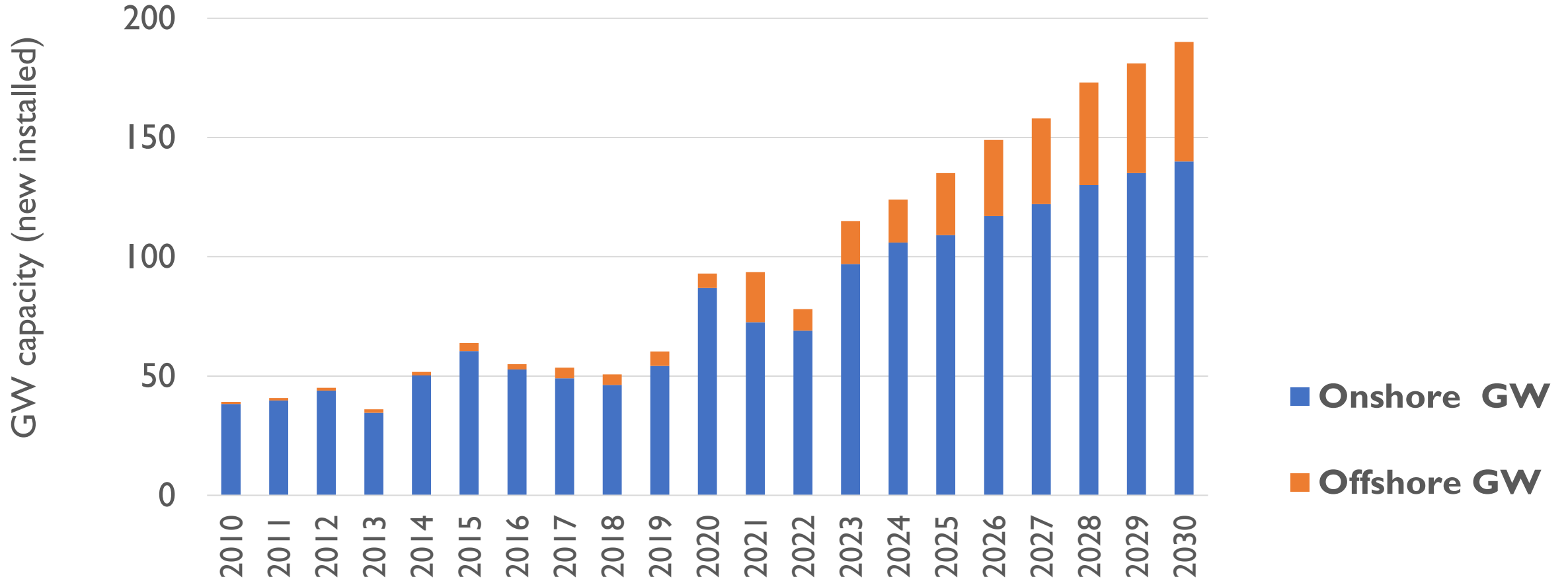


Smaller battery requires less raw materials, allowing cost savings in raw material purchasing or use of alternative battery chemistries



# Why are rare earths important to the **energy transition**?

## Wind energy installations by type, 2010-2030

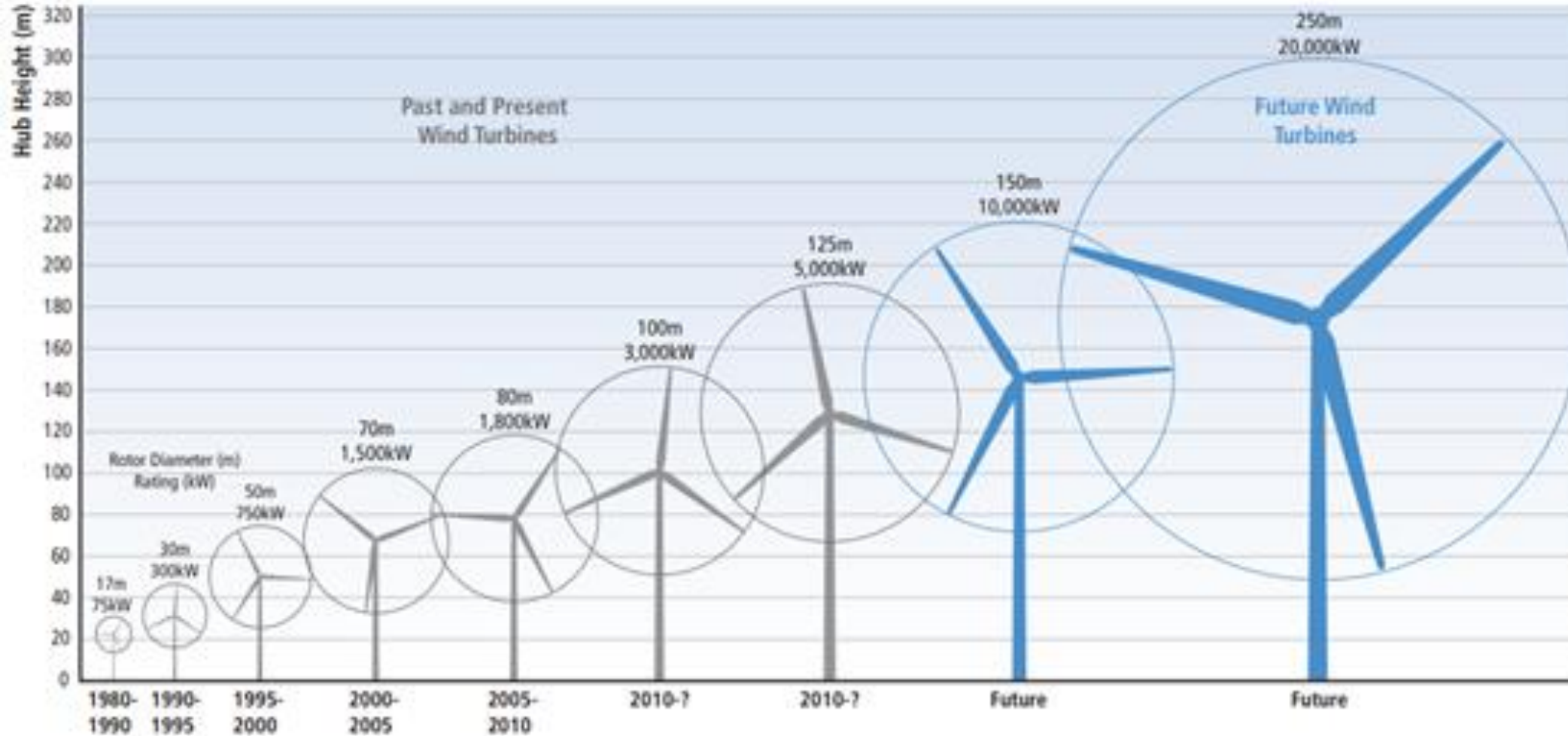


Source: Project Blue, GWEC, Brinckmann





# Why are rare earths important to the **energy transition**?



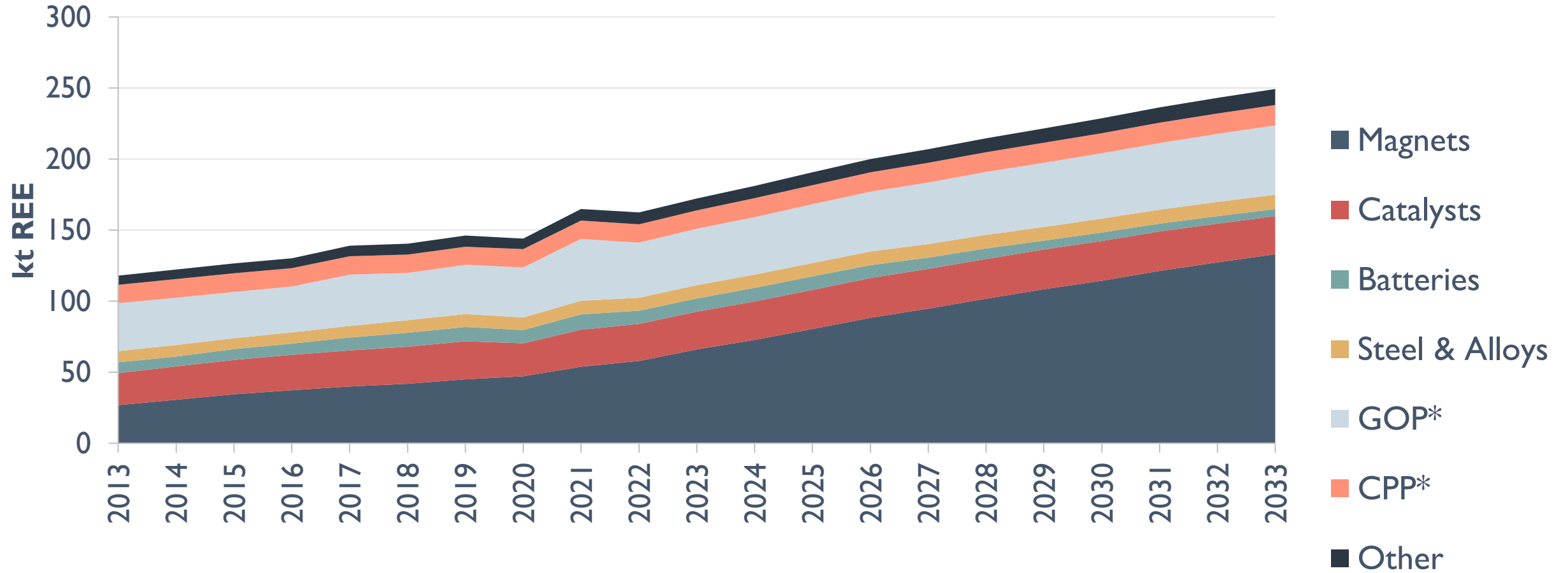
- Synchronous permanent magnet generators (SPMG) are lower weight and smaller, attractive for larger wind turbine designs
- When used in a direct-drive system, the lack of gearbox reduces maintenance costs, further reduces weight and size and improves efficiency.

Source: Project Blue, GWEC, Brinckmann



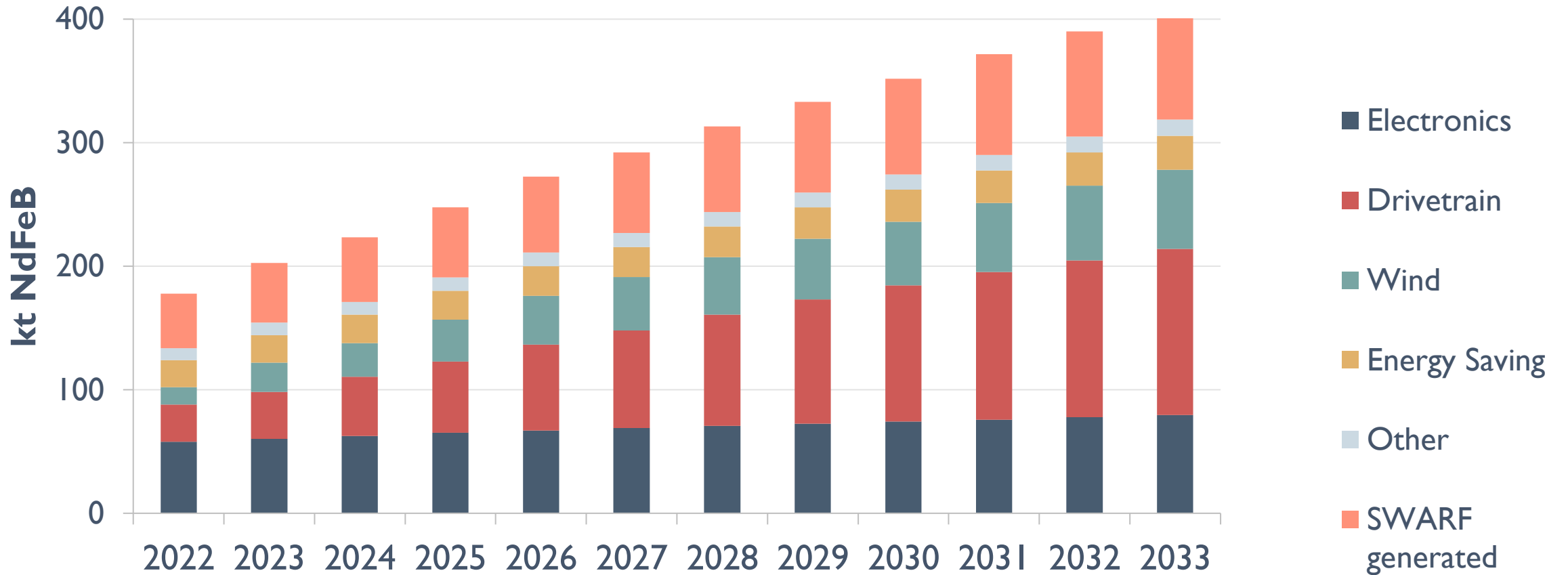
# What will be the impact of the rare earth industry?

Forecast and historical rare earth demand by application (t REE)



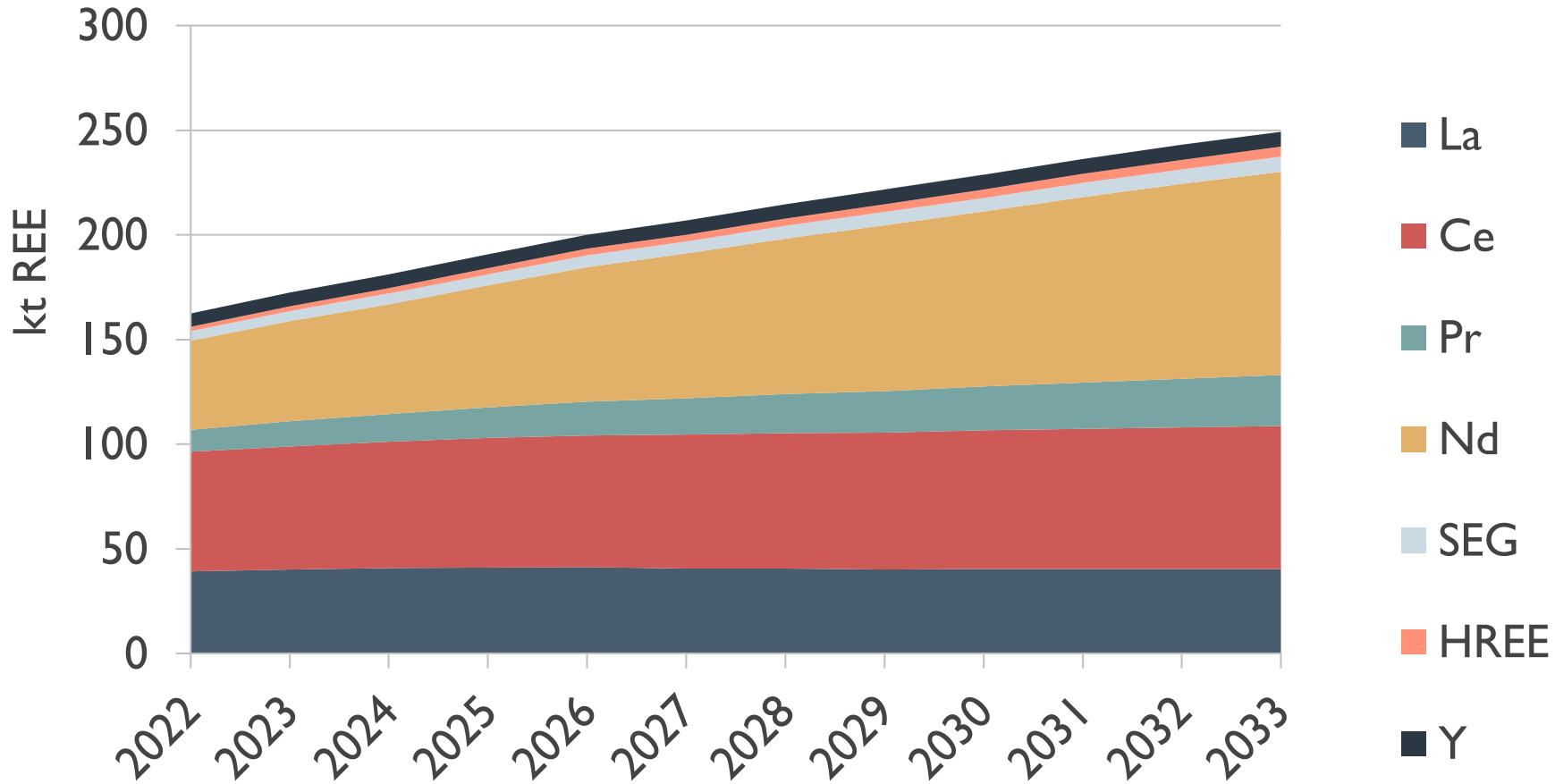
# What will be the impact of the rare earth industry?

## NdFeB demand by end-use sector (kt NdFeB)



# What will be the impact of the rare earth industry?

REE demand by element (kt REE)



2023 → 2033

Nd-Pr: +103% growth

Tb-Dy: +110% growth

Gd: +66% growth

La-Ce: +9.8% growth

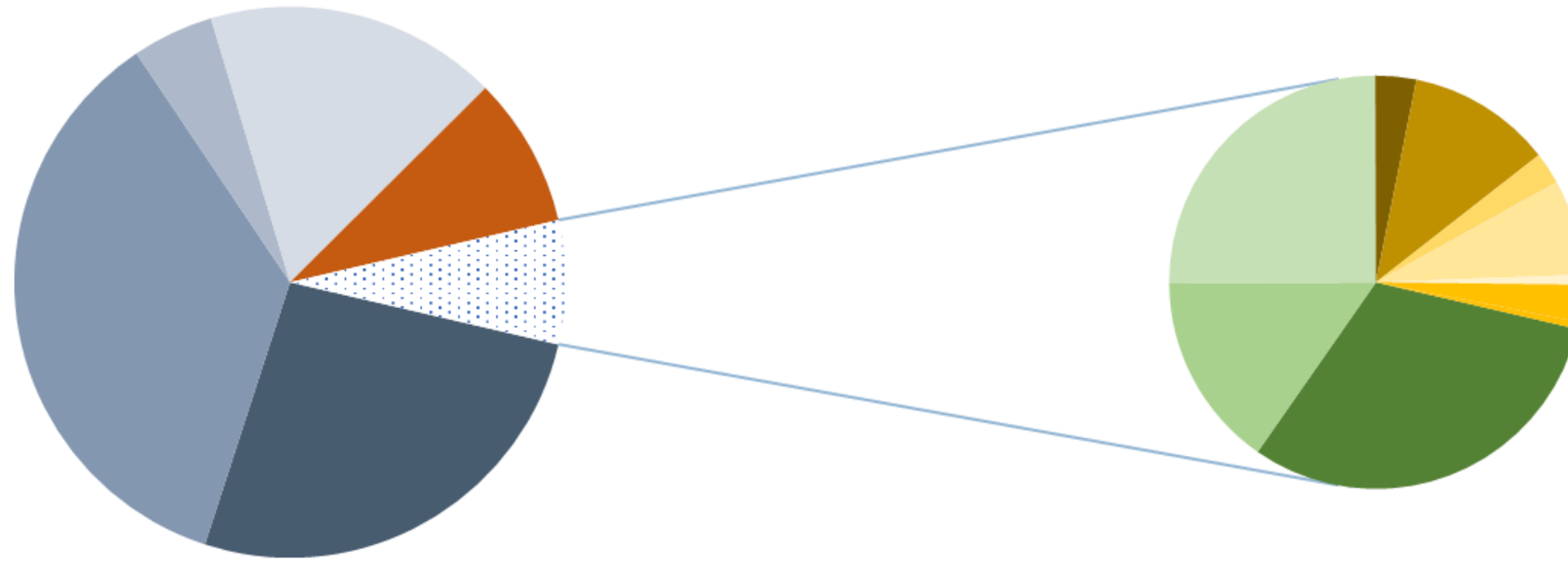


How are electric vehicles restructuring **the rare earth market?**



# How will the market meet supply?

First we need to understand that rare earths come as a package of 15 elements



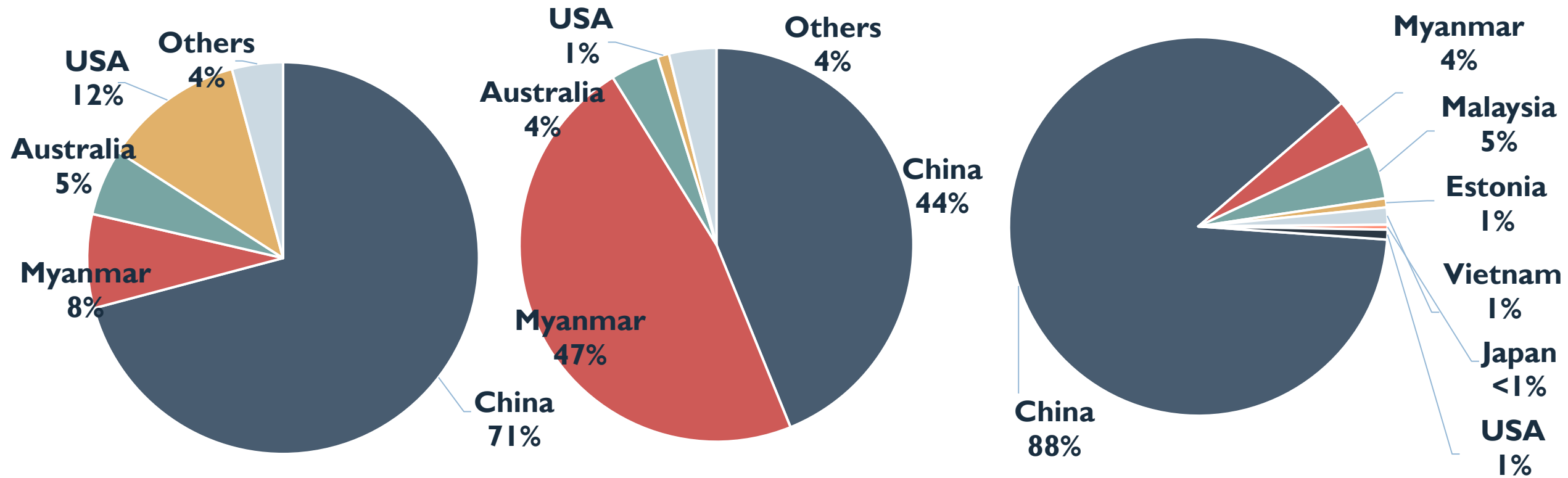
# Rare Earths – China importance in the supply chain

**2023**

**Mine supply – Light rare earth**

**Mine Supply - Heavy rare earth**

**Refined rare earth supply**



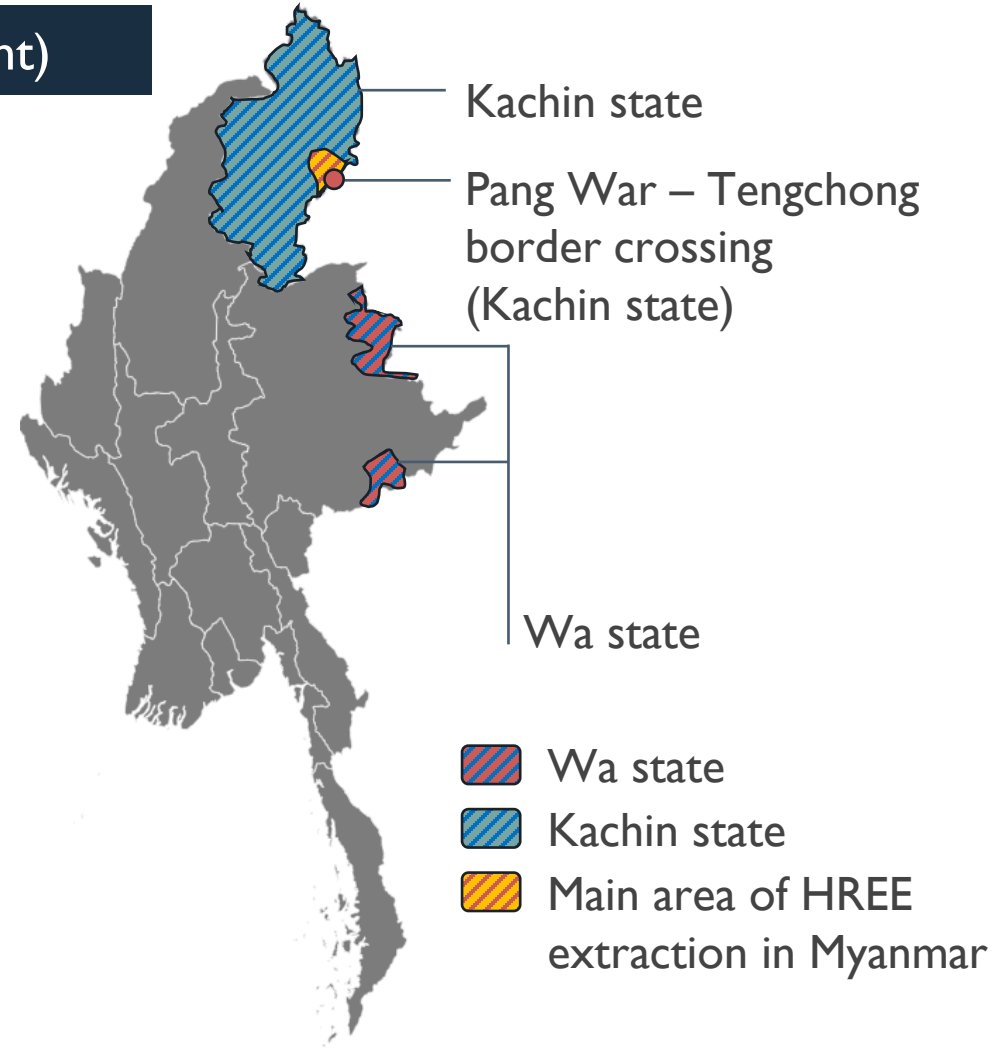
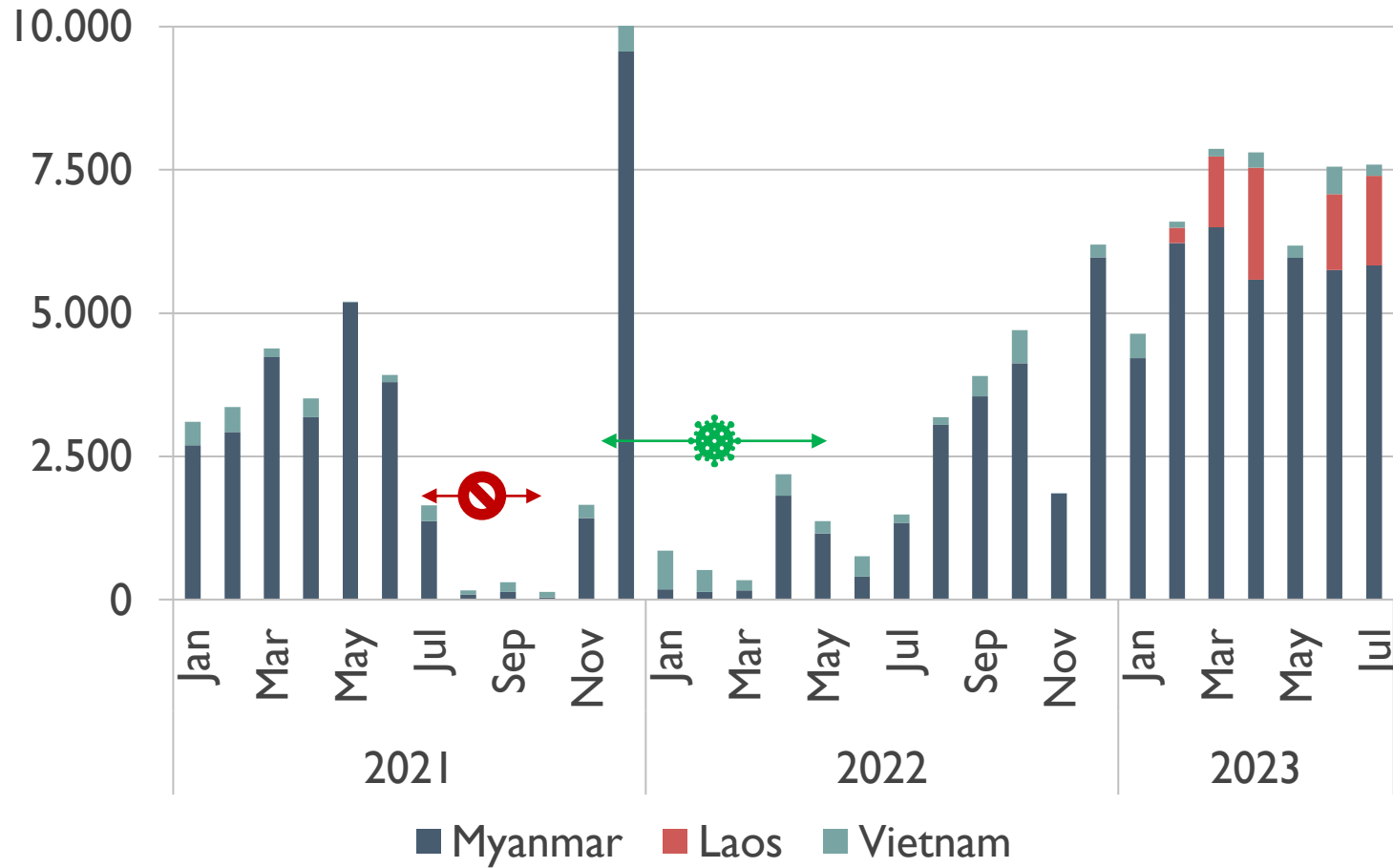
# How will the market meet supply?

Major rare earth minerals					
Mineral	Type	Wt.% REO	Th U	Group	Examples
Bastnasite/Bastnaesite $\text{REECO}_3(\text{F,OH})$	Carbonate	53-79	-	Mostly LREE	Bastnäs (SW), Mountain Pass (USA), Maoniuping (CH), Bayan Obo (CH), Gakara (BU)
Parisite $\text{CaREE}_2(\text{CO}_3)_3(\text{F,OH})_2$	Carbonate	58-63	-	LREE	Mountain Pass (USA), Weishan and Bayan Obo (CH)
Synchysite $\text{CaREE}(\text{CO}_3)_2(\text{F,OH})$	Carbonate	48-52	-	Mostly LREE	Mary Kathleen (AU)
Monazite $(\text{REE, Th, Ca, Sr})(\text{P, Si, S})\text{O}_4$	Phosphate	38-71	Yes	LREE	Bayan Obo (CH), Mt. Weld (AU),
Xenotime $(\text{REE, Zr})(\text{P, Si})\text{O}_4$	Phosphate	43-65	Yes	HREE	Pitinga (BR), Mt. Weld (AU), Lofdal (NMB)
Churchite $\text{REEPO}_4 \cdot 2\text{H}_2\text{O}$	Phosphate	43-56	Yes	Mostly HREE	Mt. Weld (AU), Chuktukon (RU)
Fergusonite $\text{REENbO}_4$	Oxide	43-52	...	Mostly HREE	Bayan Obo (CH), Nechalacho (CA)
Loparite $(\text{Na, REE, Ca})(\text{Ti, Nb})\text{O}_3$	Oxide	28-38	-	LREE	Lovozero (RU)
Gadolinite $(\text{Ce, La, Nd, Y})_2\text{FeBe}_2\text{Si}_2\text{O}_{10}$	Silicate	60	Yes	HREE or LREE	Ytterby (SW)

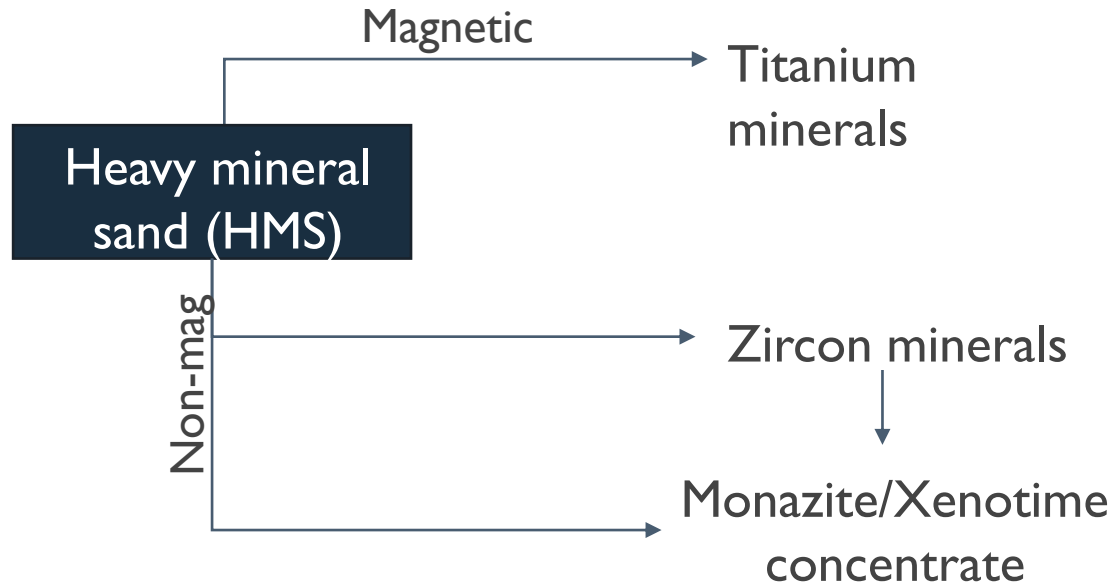


# How will the market meet supply? – IAC (Ionic Adsorption Clay) deposits

Chinese imports of IAC type ores and concentrates (t gross weight)



# How will the market meet supply? - Heavy mineral sand (HMS) operations



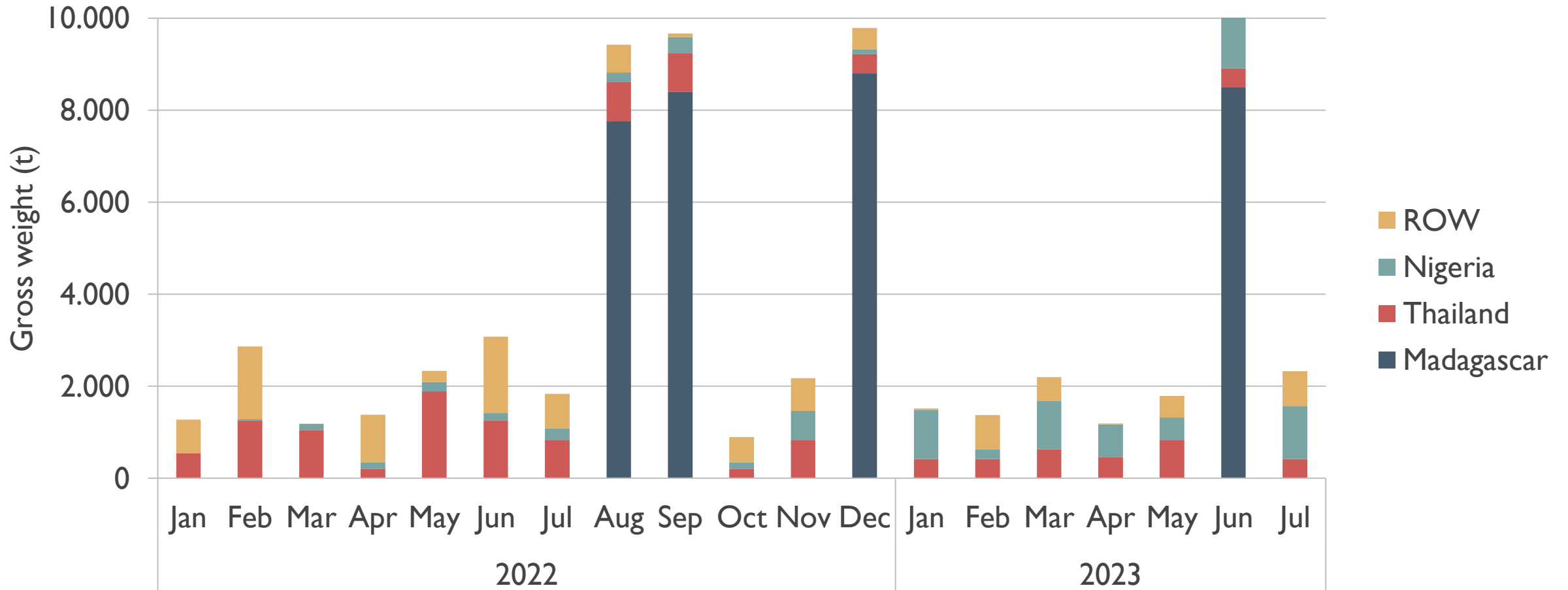
- Monazite and xenotime mineral concentrates provide an attractive Nd-Pr and Dy-Tb content
- Th-U content needs to be addressed at points of concentration, storage and transportation
- Several operations in the USA, Mozambique, Madagascar, Thailand and Australia already in production
- An increasing number of HMS projects in operation are investigating monazite recovery from non-magnetic portion of HMS concentrates

Source: Global Trade Tracker



# How will the market meet supply? - Heavy mineral sand (HMS) operations

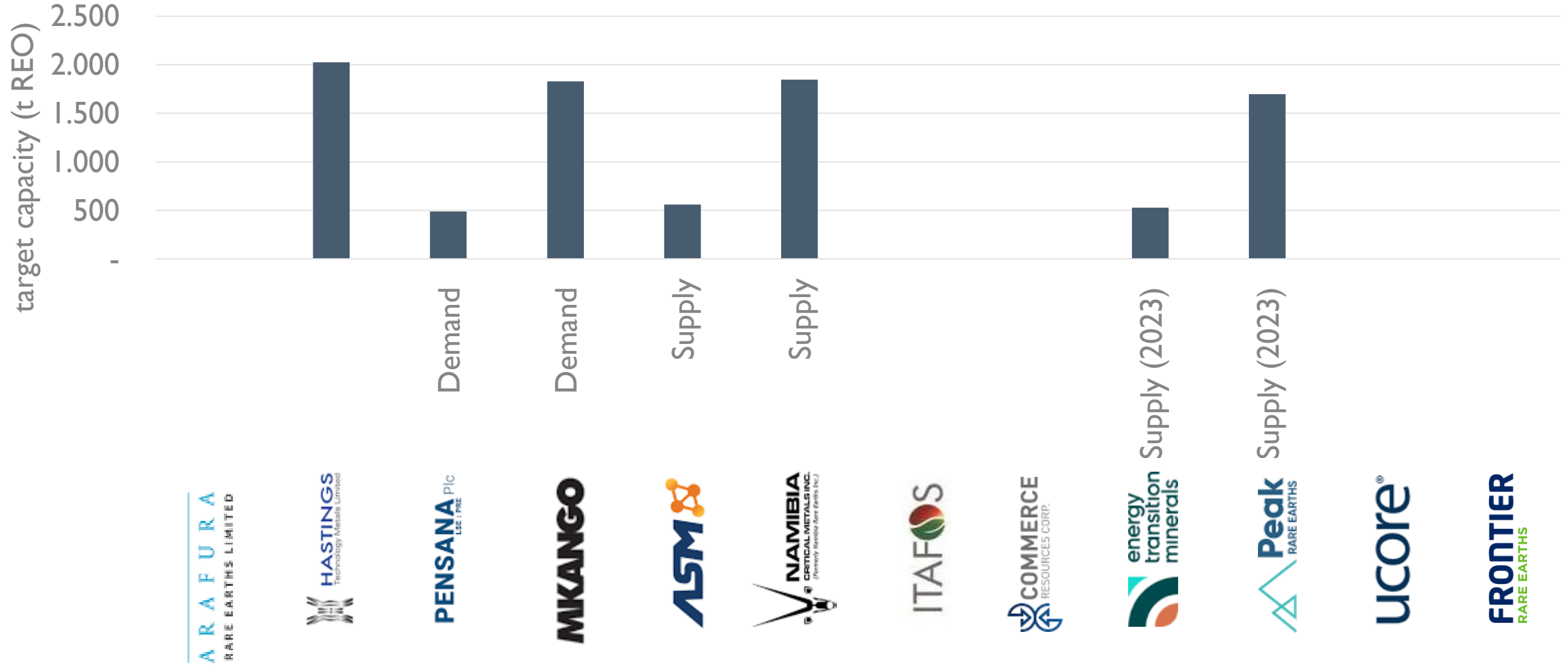
## China imports of monazite from key sources



Source: Global Trade Tracker

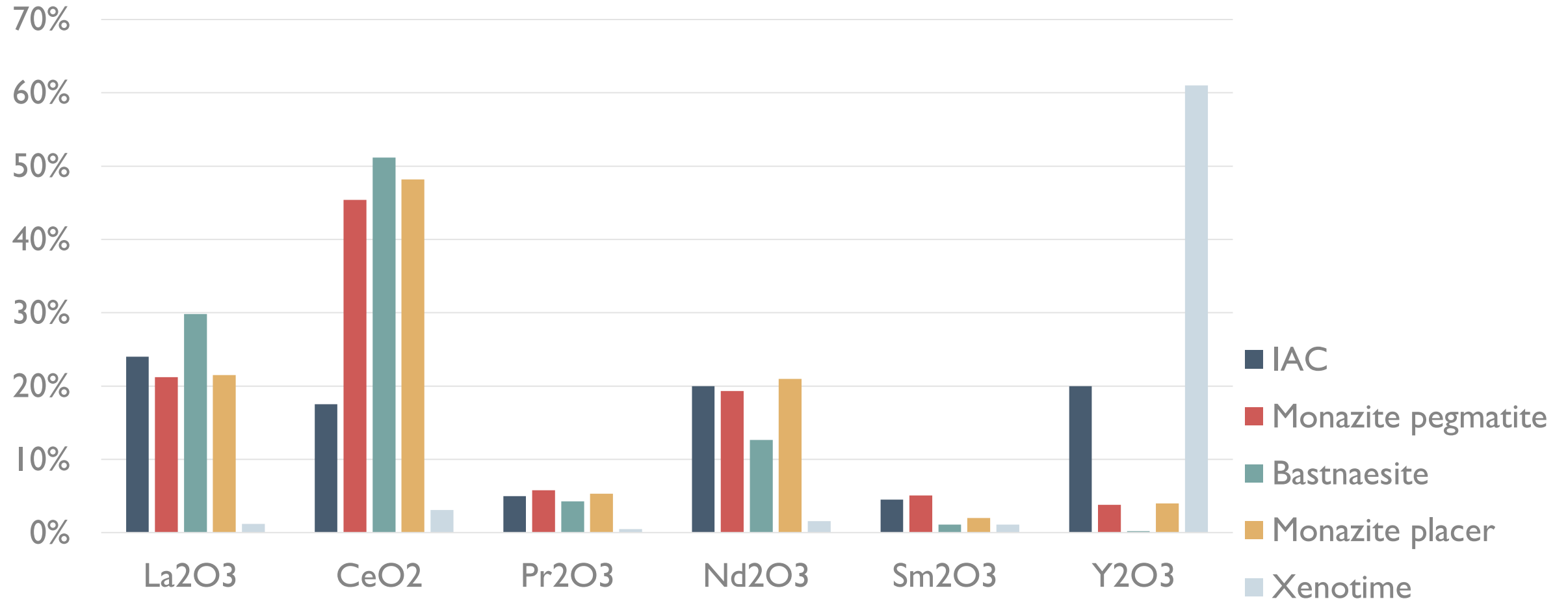


# How will the market meet supply? - Primary rare earth operations



# Recent trade trends - Heavy rare earth projects

## LREE + Y distribution

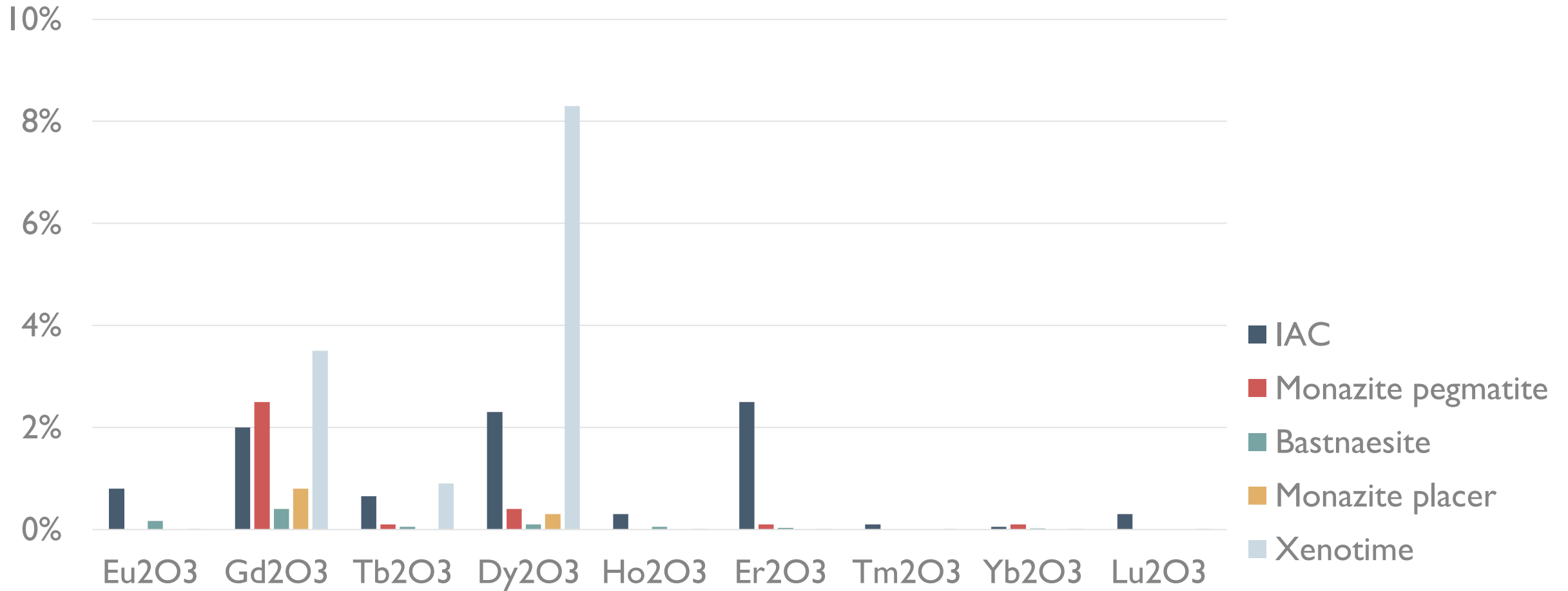


Source: Global Trade Tracker



# Recent trade trends - Heavy rare earth projects

## HREE distribution

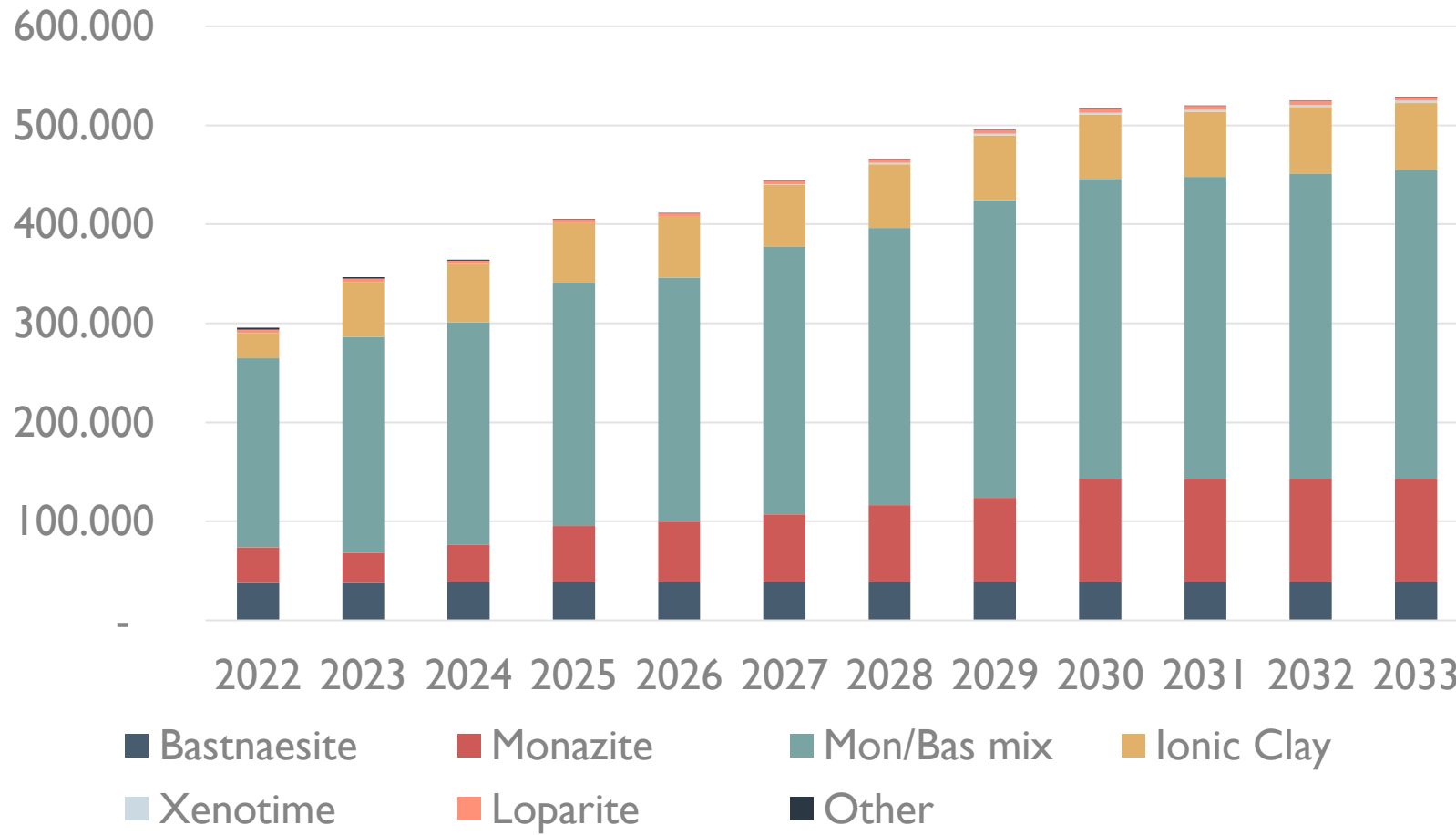


Source: Global Trade Tracker



# How will the market meet supply?

Forecast rare earth production by deposit type (t REE)



- Continued increases to production in China from operations in Inner Mongolia and Sichuan
- Expansions will be required at existing rare earth operations in Australia and North America
- Development of IAC operations in East Asia, South America & Africa
- Increasing feedstock production from HMS operations globally
- Multiple primary rare earth operations will require development in the period to 2033.

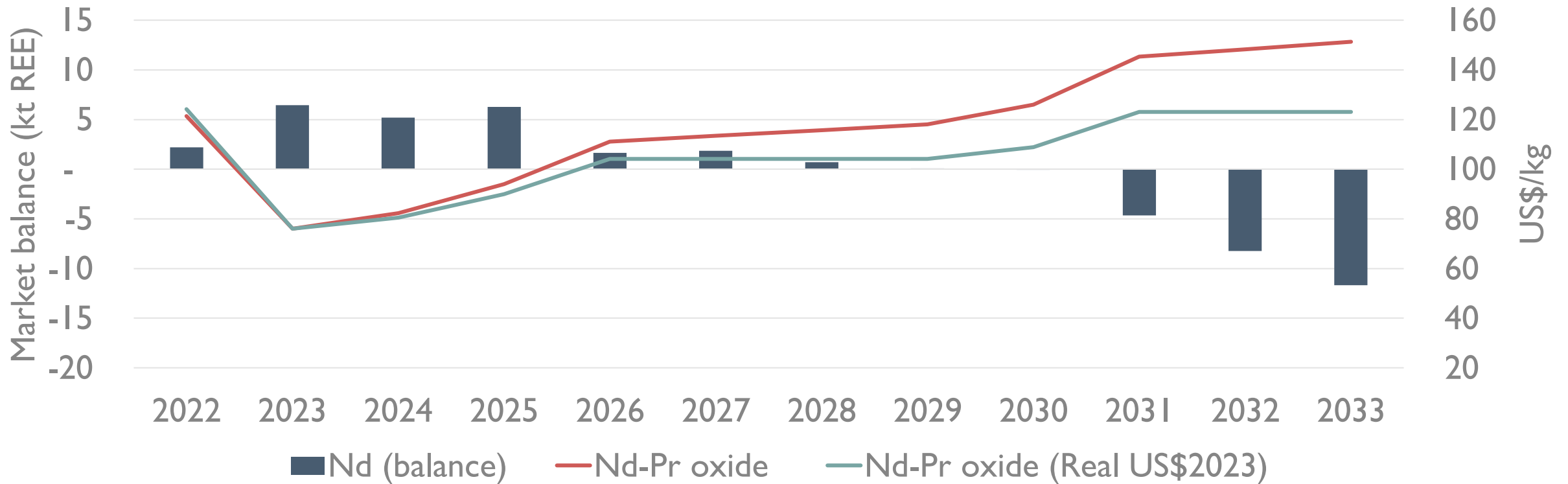


# How will the market react to increasing demand?

Prices maintained below US\$100/kg in short term by increased Chinese production, ROW expansions and 1-2 new producers entering market

Nd-Pr oxide prices maintained between US\$100-110/kg to support current project development

Higher Nd-Pr oxide prices expected to incentivise continued development of new supply. Higher price also incentivises recycling of materials





Márcio Goto - Cel e Whats: +11 99 726 4466  
[marcio.goto@projectblue.com](mailto:marcio.goto@projectblue.com)  
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# PROJECT BLUE

## Subscriptions

### Market Services

Our deep-dive subscription services on specific supply chains provide unrivalled analysis and forecasts on the markets underpinning energy transition.

Designed to:

- Help you understand market dynamics, risks & opportunities
- Provide unbiased outlooks and scenarios to help you make better decisions
- Enable the benchmarking of companies and assets using interactive tools

### Our market service offering:

- Antimony
- Chromium
- Critical Materials Monthly
- Cobalt
- Fluorine
- Gallium
- Graphite
- Iron
- Lithium
- Lithium industry cost service
- Magnesium
- Manganese
- Molybdenum
- Nickel
- Niobium
- Rare Earths
- Salt
- Scandium
- Silicon
- Tantalum
- Tin
- Titanium
- Tungsten
- Vanadium



# PROJECT BLUE

## Market Services



### Market overview

Background (**yearly**): a “101” document covering supply chain structure, geology, processing, product forms, and first use applications.

Analysis (**yearly**): covering historical market developments including production, trade, consumption, costs, and price trends.

ESG: (**yearly**) containing analysis of the most important environmental, social and governance issues facing the supply chain.



### Market analysis tools

Proxima profiles (**online**): explore and understand all key assets, companies, and countries engaged in the supply chain.

Interactive data: (**quarterly**) all the key underlying data required to embed into your workflows.



### Market outlook

Short-term outlook: (**monthly**) key developments over the previous month and our three-month outlook for trends and prices.

Medium-term outlook (**quarterly**): current market trends and our ten-year forecasts for supply, demand, and prices with scenarios.

Long-term outlook (**quarterly**): outlining our view of the market over the energy transition horizon to 2050 with scenarios.



### Market Support

Access (**continuous**): our expert team will be available to discuss key market trends and forecasts.

Notifications (**online**): of key market events will be sent via our online portal.



# PROJECT BLUE

## Proxima (included in Market Services)

Project Blue's **supply chain analytics platform**, designed to help you understand raw material flows and benchmark key assets, companies and countries across the market.

Our customers use Proxima to access the latest data and insight on assets, countries, companies, supply chain linkages, and trade flows.

### Proxima is used for:

#### Supply chain analysis

- Project and company evaluation
- Due diligence
- Risk analysis
- Business Development

#### Filter

Profiles by country, company, status, stage, type, product and more.

#### Find

New prospects, suppliers, and partners.

#### Benchmark

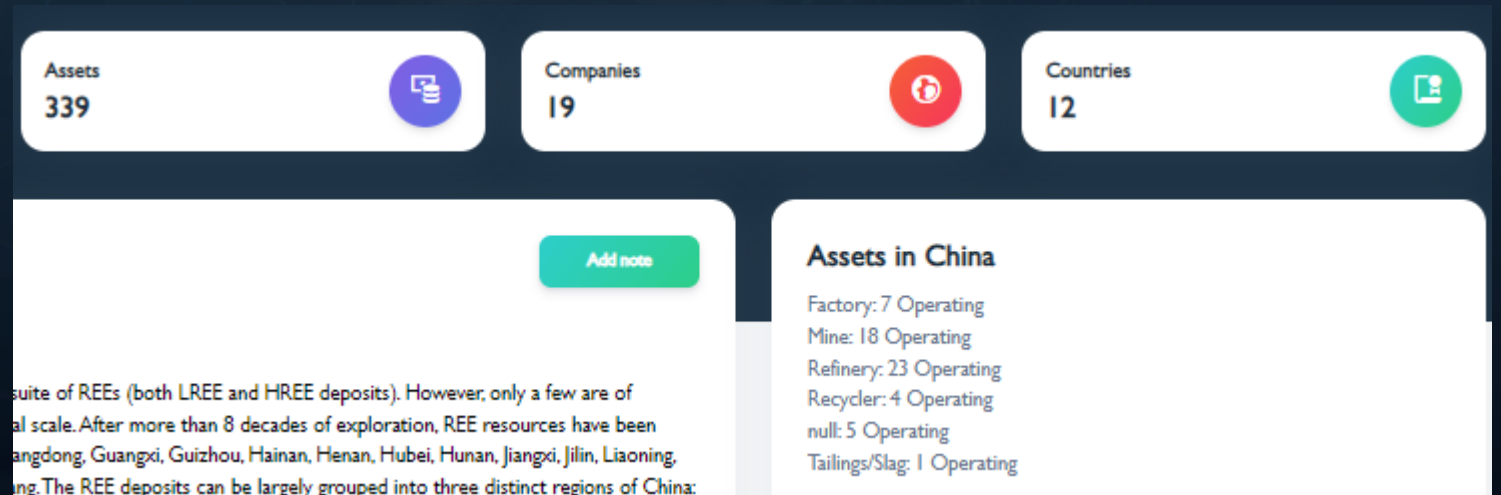
Competing assets and opportunities.

#### Map

Supply chain linkages, deals and flows.

#### Notifications

Receive alerts when there is market activity.





# PROJECT BLUE

## Consulting

Bespoke research for clients across the value chain



Miners and refiners



OEMs



Financial services

Our consulting team provides tailored solutions for our customers and their stakeholders. Our global network and deep knowledge of critical materials and energy transition enables our expert team to help clients gain competitive advantage, make the best decisions, and mitigate risks.



Cost analysis



Market analysis



Financing/investment support



ESG/sustainability analysis



Forecasting services



M&A/market entry support



Feasibility studies



Strategic consulting



Sourcing/offtake strategy



# PROJECT BLUE

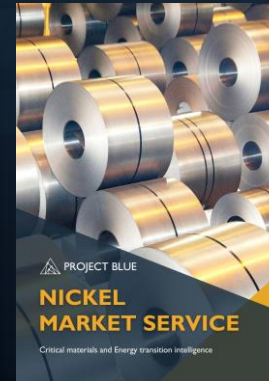
## EV & Li-ion battery research suite

Full coverage of all lithium-ion battery raw materials + REEs as well as midstream coverage of the anode, cathode, precursor and cell landscape and detailed downstream models for portables, power & motive, ESS and automotive.

### Market services:

- Cobalt
- Graphite
- Lithium
- Nickel
- Manganese
- Rare Earths

### Six market service subscriptions covering the whole supply chain





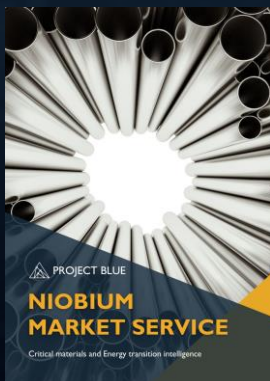
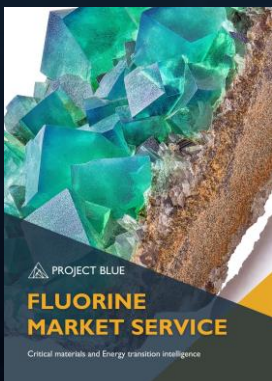
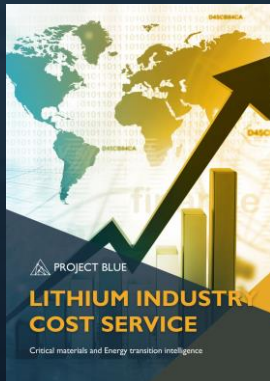
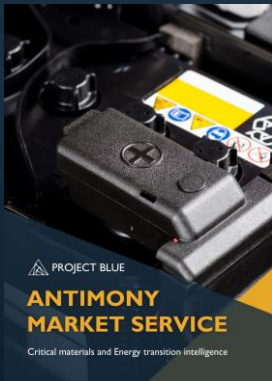
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## Additional battery material coverage

Aside from the key lithium-ion raw materials, an increasing number of metals play a critical role in the battery story. Project Blue has unrivalled coverage across these supply chains.

### Other key battery market services:

- Antimony
- Fluorine
- Lithium industry cost service
- Niobium
- Silicon
- Tin
- Titanium
- Vanadium





# PROJECT BLUE

## Why choose Project Blue?

- Unrivalled breadth of coverage in critical materials – we track 30 critical materials supply chains and, therefore, understand all the key raw material inputs underpinning the global energy transition.
- Complete analysis of the markets we cover – we analyse the whole supply chain, from mine to market, enabling a comprehensive understanding of rapidly evolving industries.
- Analysis you can use – all outputs are fully downloadable via our portal, and our customers benefit from global licenses to our research.
- Dedicated client support from our senior leadership – our research is led by experts in their fields with extensive experience of the markets we cover. Our customers enjoy direct access to our team.
- Keep track of fast-moving supply chains via our Portal and Proxima – stay on top of developments via forecasts delivered monthly/quarterly and regular updates to asset, company and country profiles.



Márcio Goto - Cel e Whats: +11 99 726 4466  
[marcio.goto@projectblue.com](mailto:marcio.goto@projectblue.com)  
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<https://projectblue.com/sign-up>



# Márcio Goto - clientes e parceiros



**PROJECT BLUE**

Análises de Mercado de Materiais Críticos e da Transição Energética



Preços de Aços e Matérias-Primas



**Acerto Limited**

*Agribusiness Intelligence for Latin America*

Preços de Fertilizantes, Fretes e Portos



Preços e Análises de Mercado de Enxofre e Ácido Sulfúrico



**SIMPÓSIO SINDIADUBOS NPK 2023**



**World Copper Conference 2024**



## Estudos de Mercado, Viabilidade e Treinamentos

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