



Os desafios das cadeias de suprimentos de materiais críticos para a transição energética

(The challenges facing critical materials supply chains for energy transition)

**Jack Bedder, David Merriman, Erik Sardain e [Márcio Goto](#)
Project Blue – ago.2023**



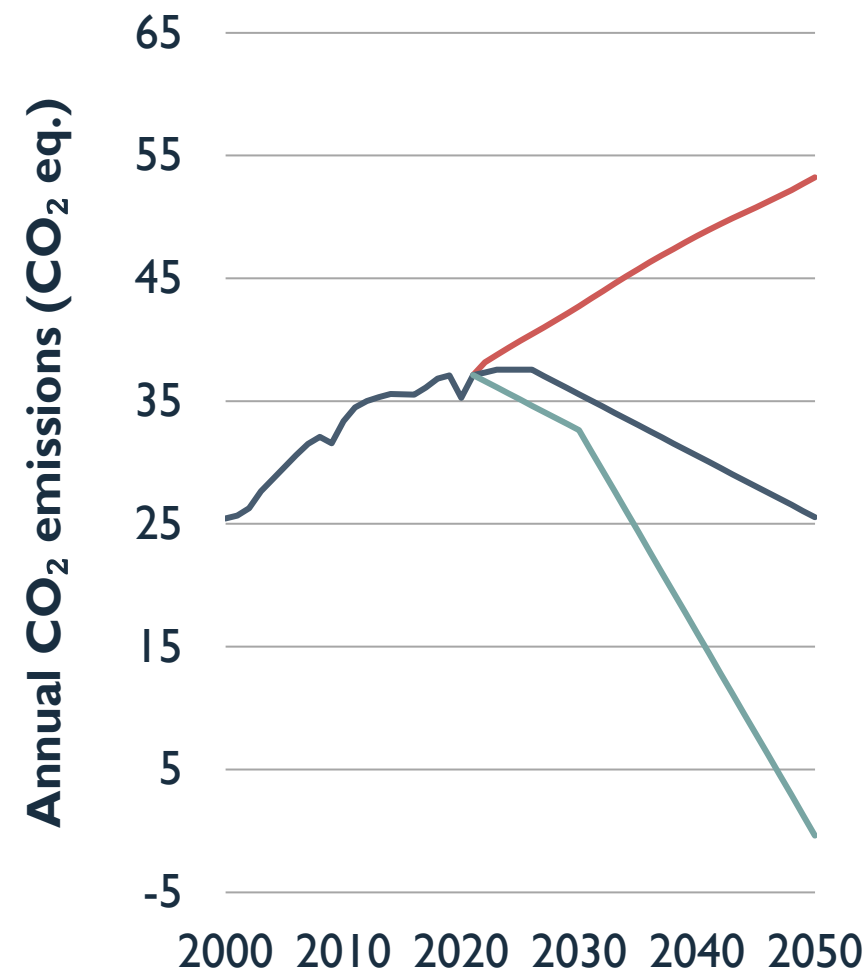
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Net zero is now a global imperative...and **energy transition** the key pathway



	Red scenario	Blue scenario	Green scenario
Assumptions	Limited climate policies.	Current climate policies.	Pledges & targets met.
CO ₂ impact	Warming reaches >4°C by 2050.	Warming sits at 2-3°C by 2050.	Warming limited to ~1.5°C by 2050.
Enablers	A scale back of climate priorities and enabling technologies.	A steady rollout of renewables supported by new technologies.	Mass electrification, hydrogen economy and CCUS buildout.



Net zero is now a global imperative...and **energy transition** the key pathway



China has pledged to reach peak carbon emissions by 2030 and **aims to reach “carbon neutrality” before 2060.**



The Biden administration officially committed to cut **GHG** emissions in half by 2030 and to **reach net zero emissions by 2050.**



The Fit for 55 package should cut emissions by **60% by 2030** and the **EU** aims **to achieve net zero emissions by 2050.**



Energy transition requires **critical materials**

Wind turbines
need **9x**
metals than
gas-fired plants.



Wind turbines
account for
~**6%** of global
energy supply.



Solar needs **7x**
metals than
gas-fired plants.



Solar accounts
for ~**4%** of
global energy
supply.














Each EV needs
6x metals than
an ICE car.



EVs account
for ~**13%** of
passenger
vehicle sales.



Energy transition requires critical materials. The usual suspects are essential...

											
Al	●	●	●	●	●	●	●	●	●	●	●
Co	●	●	●		●	●	●	●		●	
Cu	●	●	●	●	●	●	●	●	●	●	●
Fe	●	●	●		●	●	●	●	●	●	●
Gra	●	●	●		●	●	●			●	
Li	●	●	●			●			●		
Mn	●	●	●		●	●	●			●	●
Ni	●	●	●		●	●	●	●	●	●	●
REE		●	●		●			●			●
Sn	●	●	●		●	●			●		

XX - materials reported by Project Blue



Energy transition sectors monitored and analysed by Project Blue



Aerospace



Electricity
Networks



ICT



Steel and
alloys



Automotive



Energy
Storage



Magnets &
motors



Wind
power



Batteries



Hydrogen
Economy



Solar
power

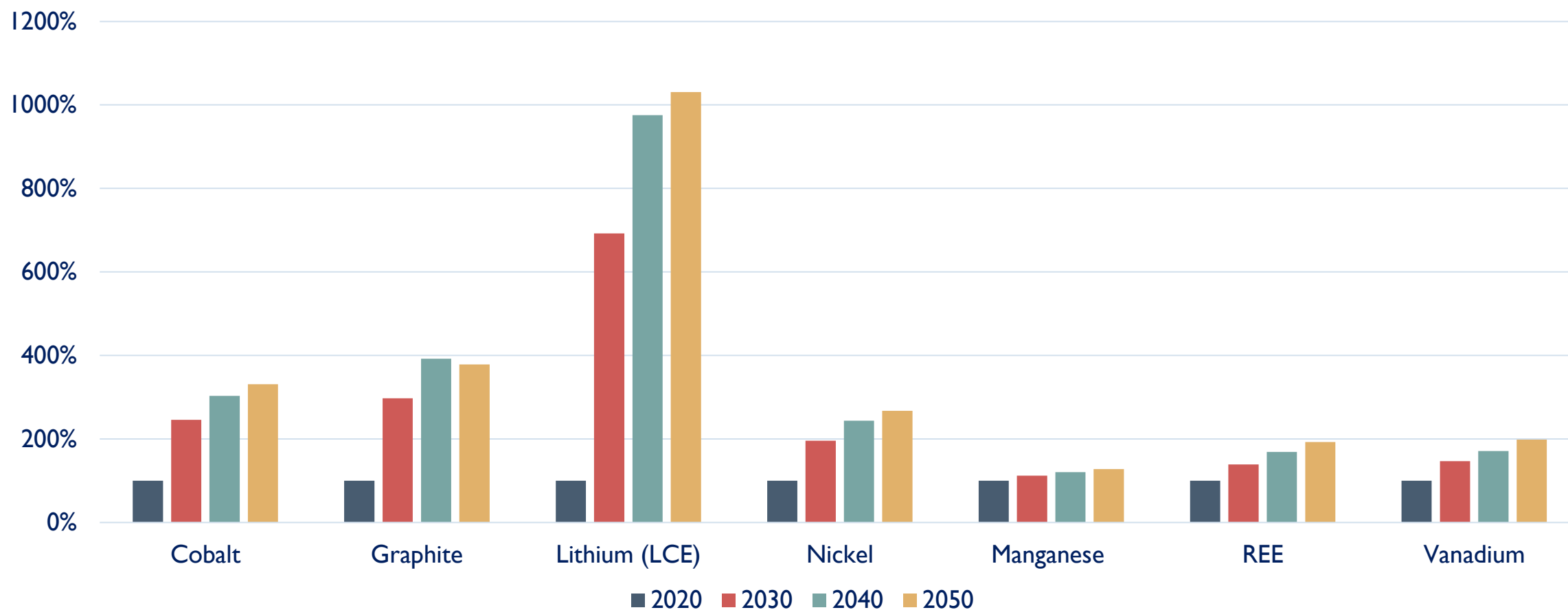


Other
renewables















Energy transition requires critical materials. The usual suspects are needed at scale & quickly...

Project Blue estimates of market growth for EV and ESS materials



Energy transition requires critical materials. The unusual suspects are also essential

												
Bo	●	●	●		●	●	●	●		●		
Cr	●	●	●	●	●	●	●	●	●	●	●	●
F	●	●	●		●	●	●			●		
Mo	●	●	●		●	●	●	●	●	●	●	●
Nb	●	●	●			●			●			
Sb	●	●	●	●	●	●	●	●	●	●	●	●
Si	●	●	●		●	●	●			●	●	●
Ta	●	●	●		●	●	●	●	●	●		●
Ti		●	●		●			●				●
V	●	●	●		●	●			●			

XX - materials reported by Project Blue



Mineral content kg/vehicle Steel and aluminum not included.

 Electric Vehicle  Gas Car



EVs can contain more than a mile of copper wiring inside the stator to convert electric energy into mechanical energy.

11.2 kg

24.5 kg
Manganese

13.3 kg
Cobalt

8.9 kg
Lithium

Rare Earths
0.5 kg

● **0.1 kg**
● **0.1 kg**
Zinc

● **0.3 kg**
● **0.3 kg**
Others

39.9 kg
Nickel

22.3 kg

53.2 kg
Copper

66.3 kg
Graphite



Graphite is the anode material in a lithium-ion battery and is the single largest component by weight.



The engine in gas cars is heavier compared to EVs. A Civic's engine weighs around 184 kg while a Chevy Bolt's motor only weighs 76 kg.

elements.visualcapitalist.com



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Source: IEA
The values are for the entire vehicle including batteries and motors.
The intensities for an electric car are based on a 75 kWh NMC (nickel manganese cobalt) 622 cathode and graphite-based anode.



Energy transition requires critical materials. Can we overcome the **numerous barriers**...

Investment

We are in the midst of a (cyclical) CAPEX drought.

Planning & permitting

It takes over a decade to “turn on” a mine.

Technical challenges

Specifically rising costs and environmental impacts.

Geopolitical tensions

**Sino-US decoupling?
Rising spheres of influence?**

...with solutions?

New sources of capital, and trillions of dollars of investment in assets, infrastructure and people.

More joined up thinking from policy makers so that we can mine the metals to meet government targets.

A combination of new technologies, material intensity reduction & substitution, and recycling.

?

[Project Blue View: A tale of two strategies: How do USA and EU critical material sourcing strategies differ?](#)



More specifically...

Recent market trends and the outlook for electric vehicles (EV's) and battery demand and technology choices

- How have **recent EV sales** performed?
- What expectations are there for **EV penetration by 2033**?
- What **cathode chemistries** will take us forward?

What will be the impact on raw material requirements in batteries?

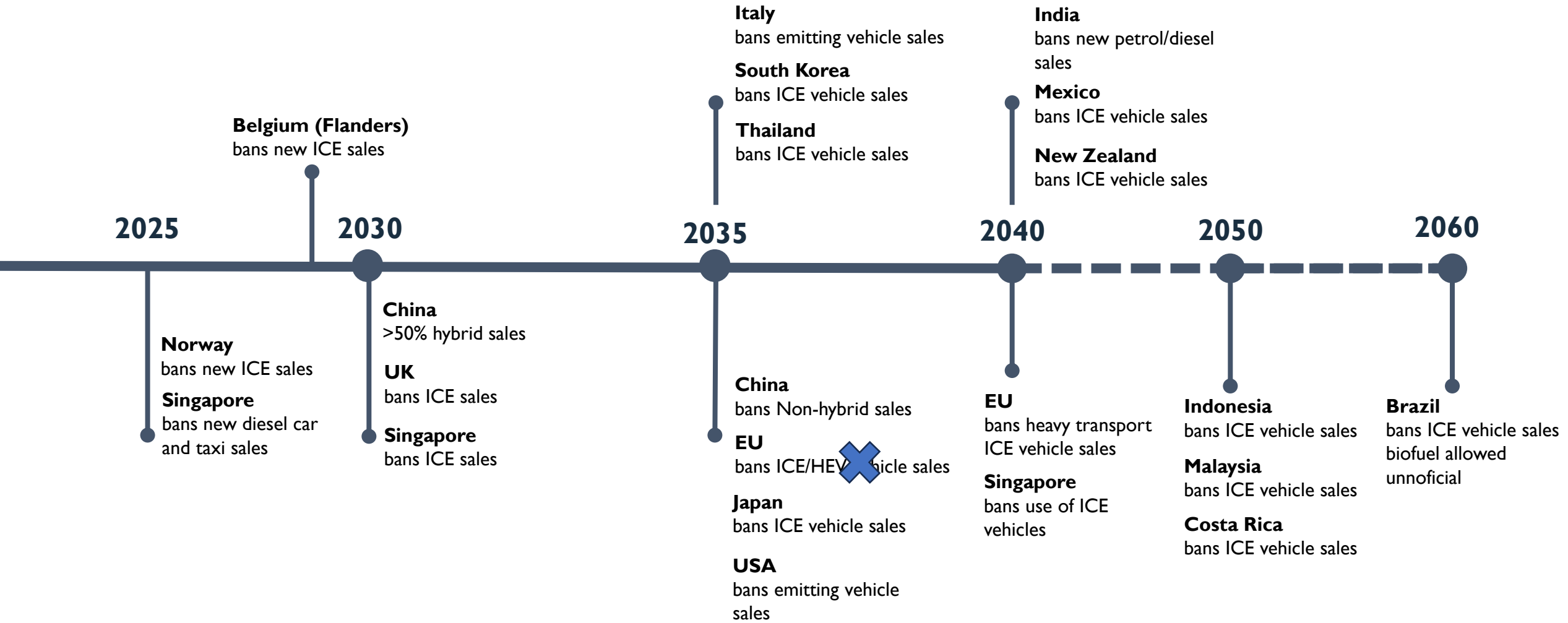
- How will **raw material** markets cope with rising demand?
- What **other factors could impact material availability** for end-users?

Beyond the battery – Rare Earths

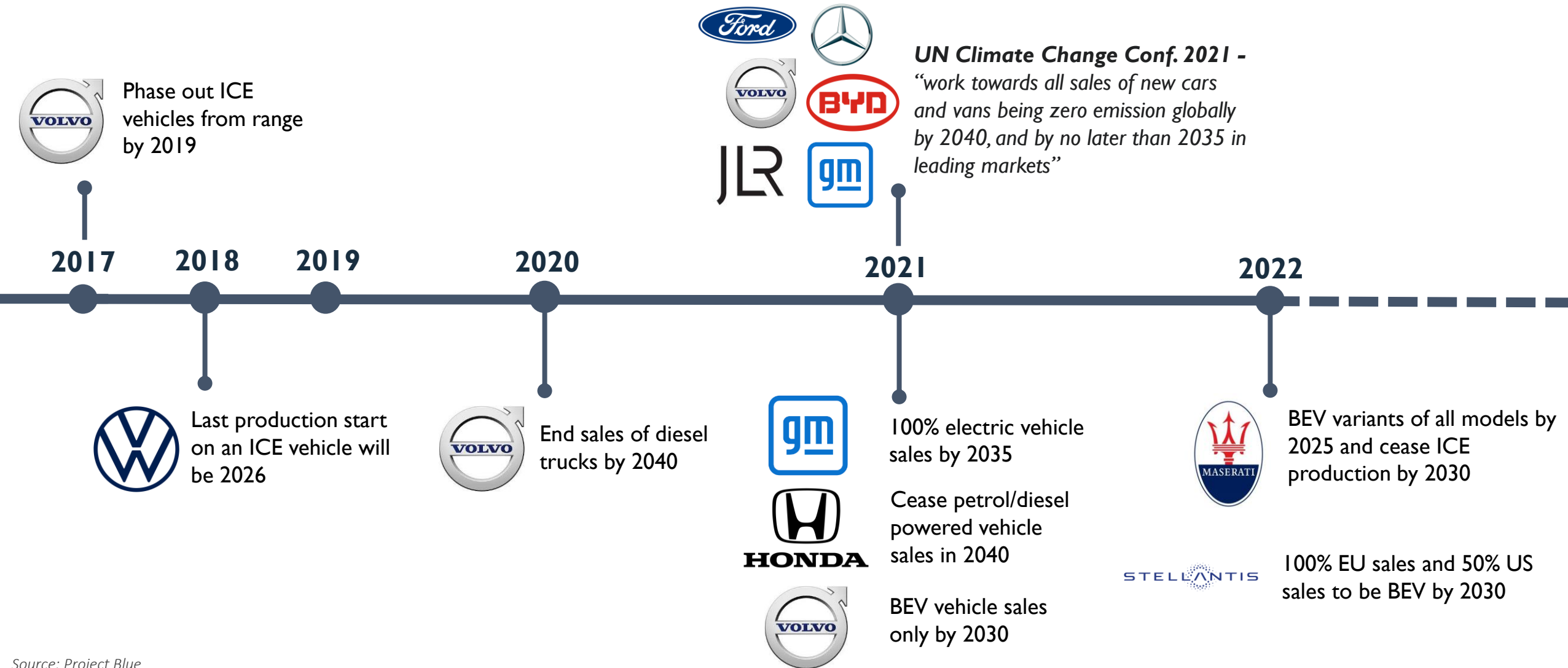
- How is the **rare earths industry** expected to react?
- Can HREE use be mitigated?



Automotive outlook – Government support



Automotive outlook – Manufacturer support



Source: Project Blue



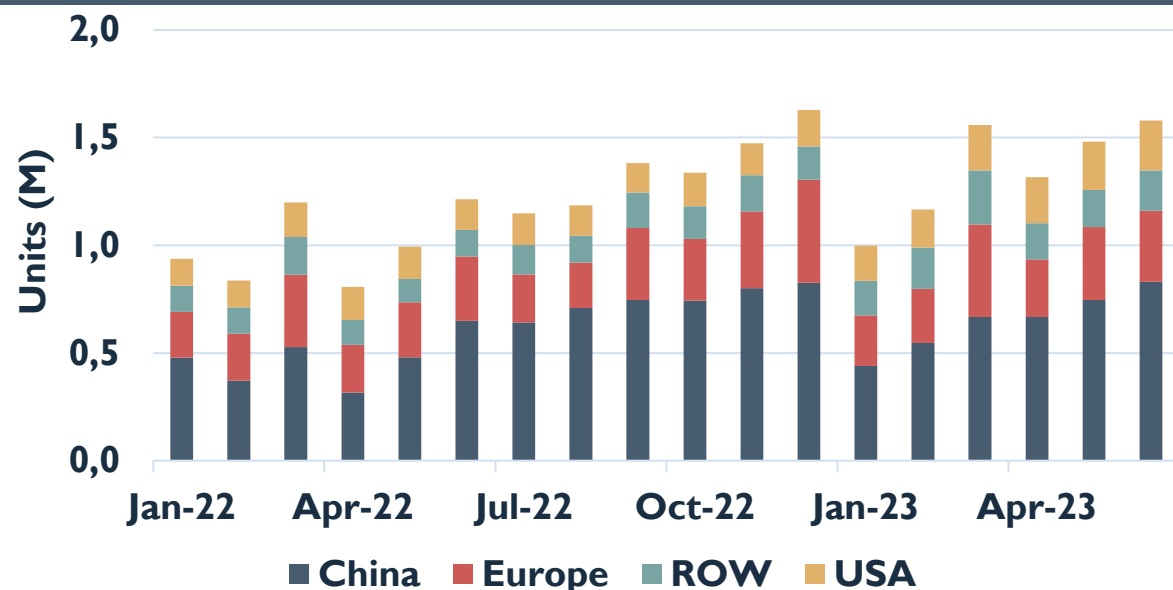
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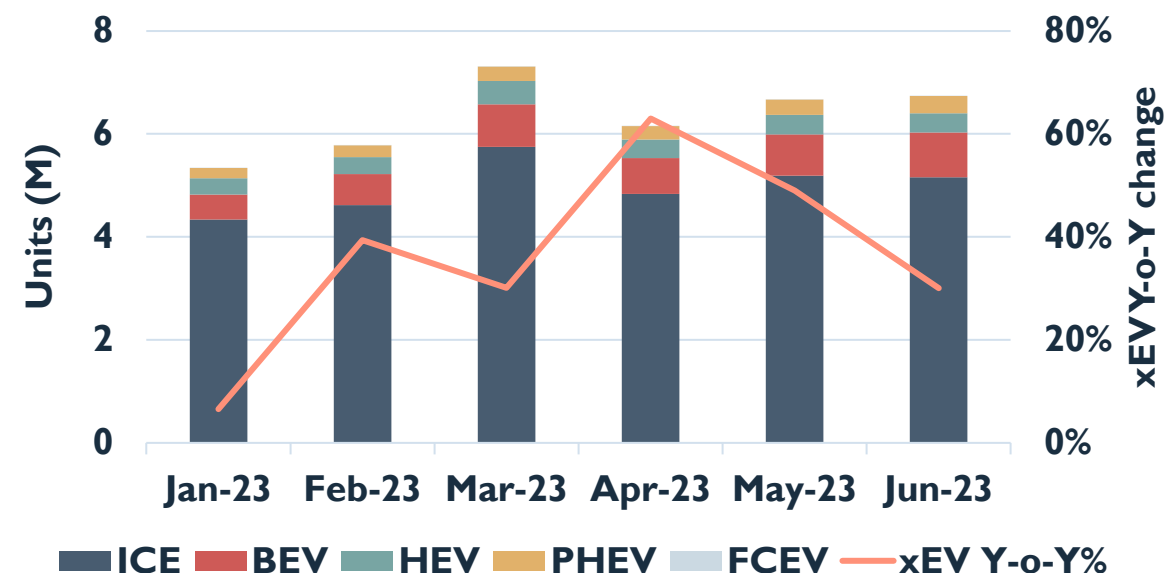
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Automotive outlook – Recent sales

xEV sales by region



Passenger vehicle sales by powertrain



China represents 48% xEV sales in H1 2023, falling from 55% in H2 2022, though up from 46.7% in H1 2022

US sales have consistently gained market share >15% in H1 2023, compared to 11% in H2 2022

January 2023 hit the brakes on electric vehicle growth, though sales have rebounded quickly into Q2.

Y-o-Y growth remains robust, averaging 36% each month in H1 2023 for xEV models

Source: Marklines, Project Blue

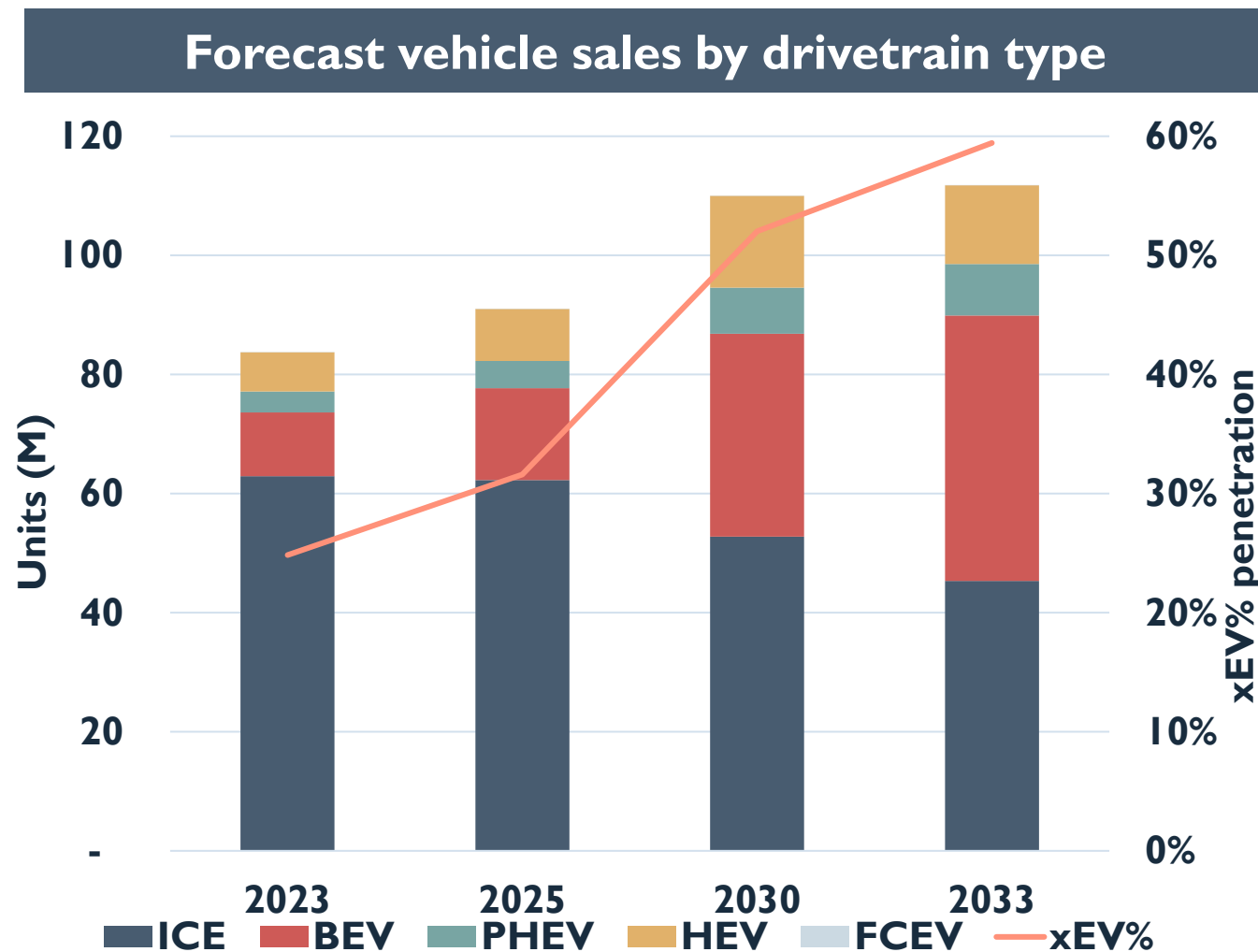


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Automotive outlook – Sales forecast



2030



>34M BEV sales units



>50% xEV market penetration



-28% Reduction in ICE sales (from 2023)

Source: Project Blue



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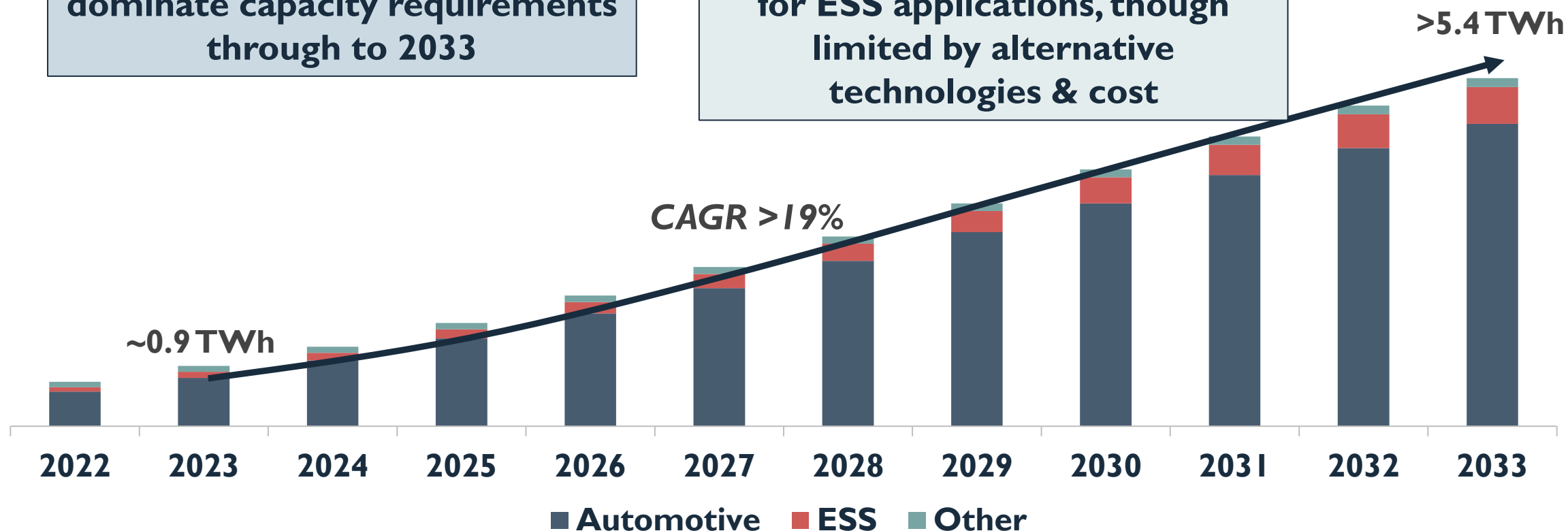
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Ten-year outlook: Li-ion batteries

Forecast Li-ion battery demand (GWh)

Automotive applications will dominate capacity requirements through to 2033

Rapid growth in capacity demand for ESS applications, though limited by alternative technologies & cost



Source: Project Blue

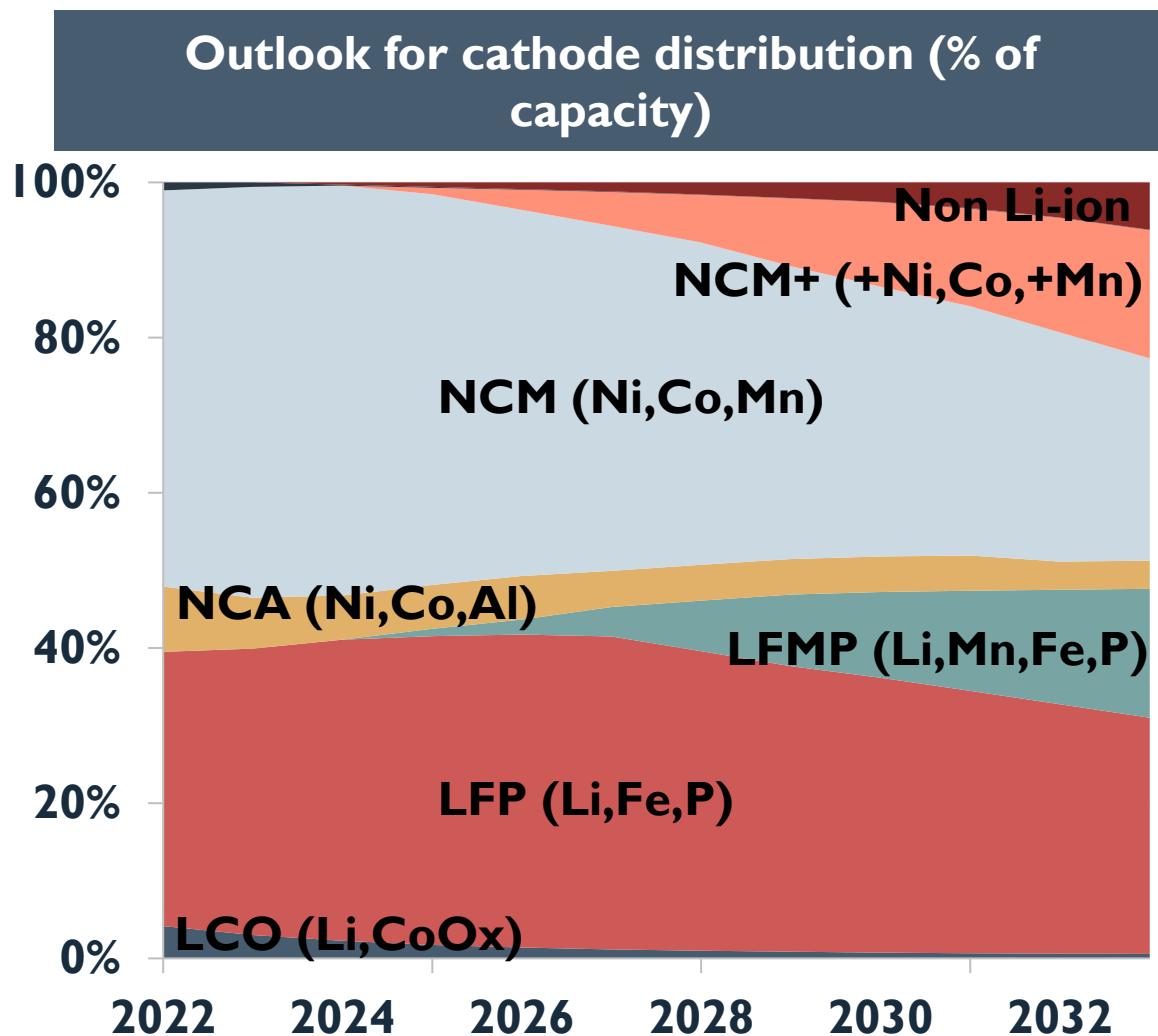


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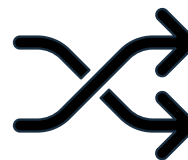


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Cathode choices – Further diversification of cathode chemistries to meet requirements



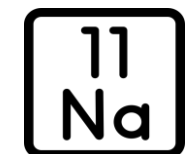
NCM/NCMA to remain dominant chemistry



Increase in LFP/LFMP market share replacing low-med Ni NCM/NCA cathodes



NMX, LMNO, LMRO next-gen high energy density materials building market share in mid-late 2020s



Na-ion and other alternatives build minor market share, predominantly in stationary ESS, but increasingly in specific motive end-uses (two-wheelers)

Source: Project Blue



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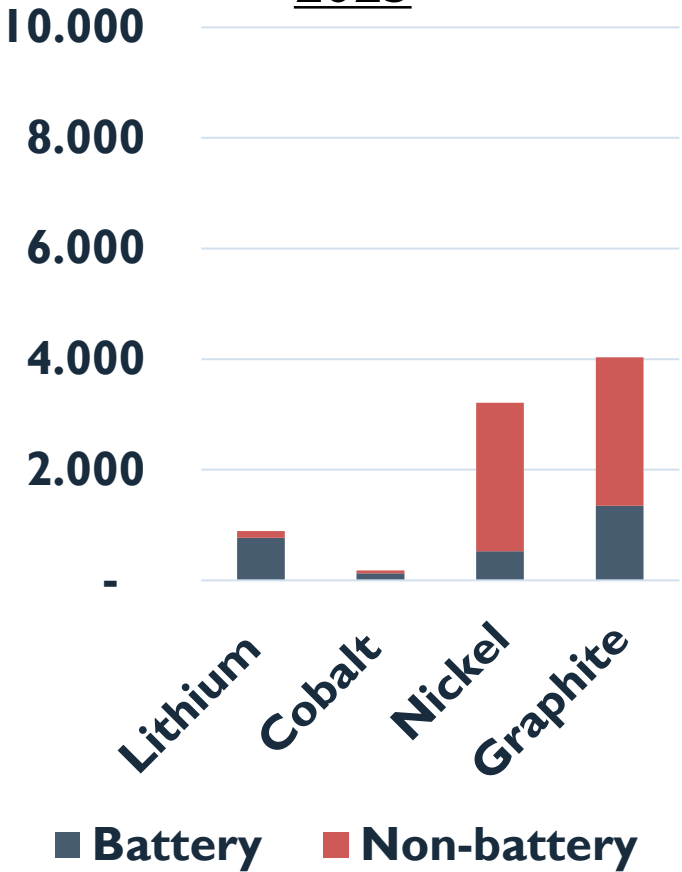


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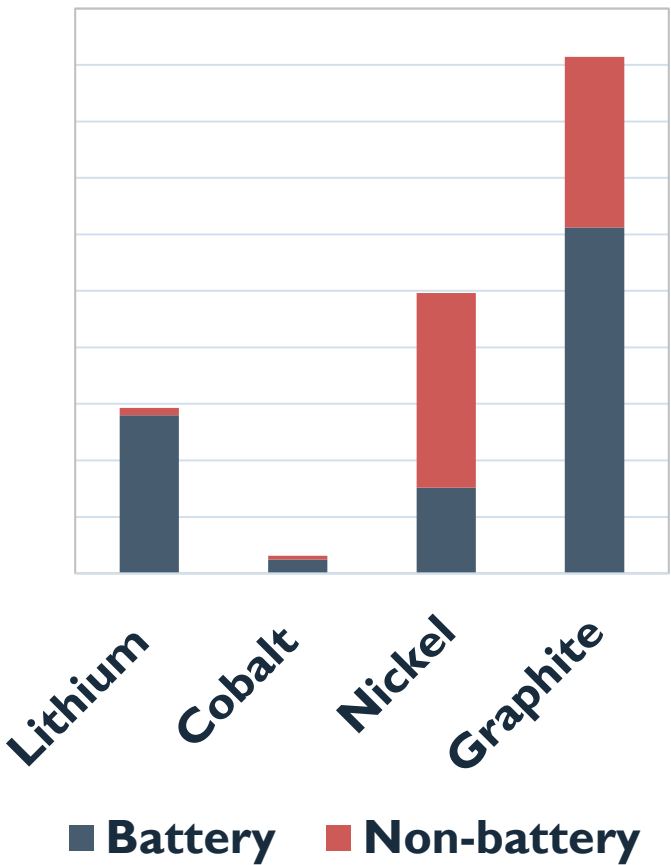
Impact on raw materials

Demand for key Li-ion battery materials (k.ton)

2023



2033



+262%



+188%



+92%



+353%



HOW MANY MINES DO WE NEED?

As the lithium ion battery revolution gains momentum, **Benchmark** forecasts just how many mines need to be built to keep up with the exceptional volumes of demand for key raw materials expected by 2035.



■ 2022 Supply Vs 2035 Demand

Average Mine/Plant Size

No. of Mines/Plants Needed

Lithium



74

Cobalt



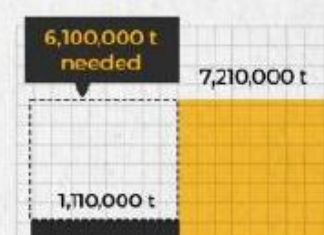
62

Nickel



72

Natural Graphite

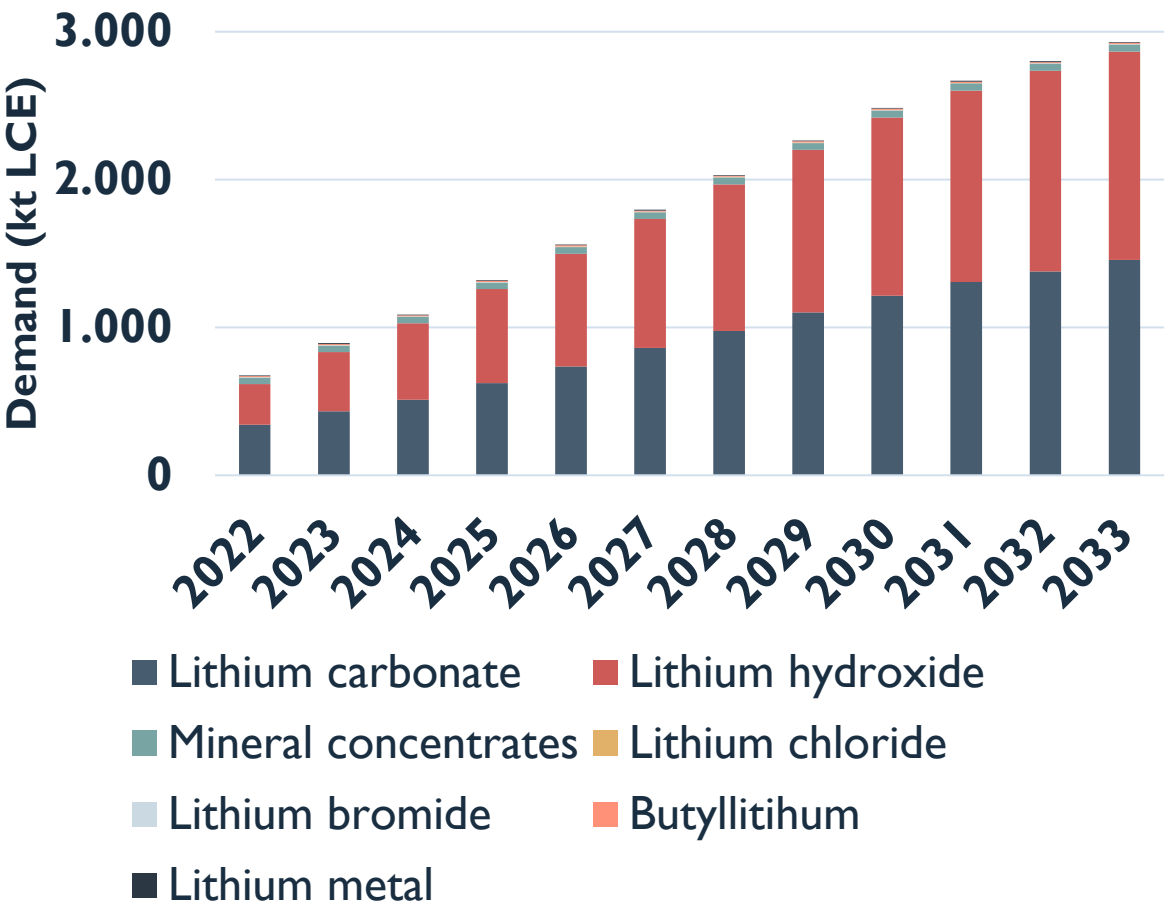


97

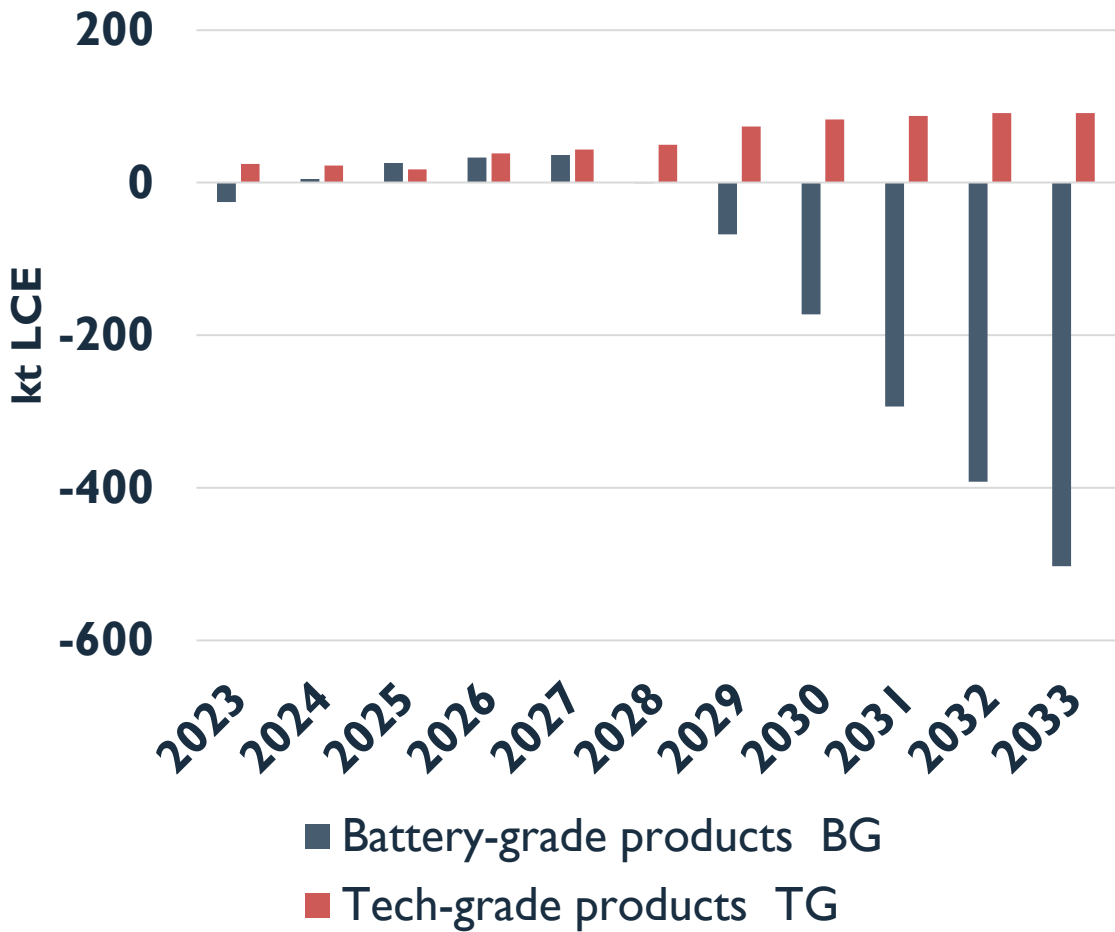


Raw material impacts – Lithium

Lithium demand by product

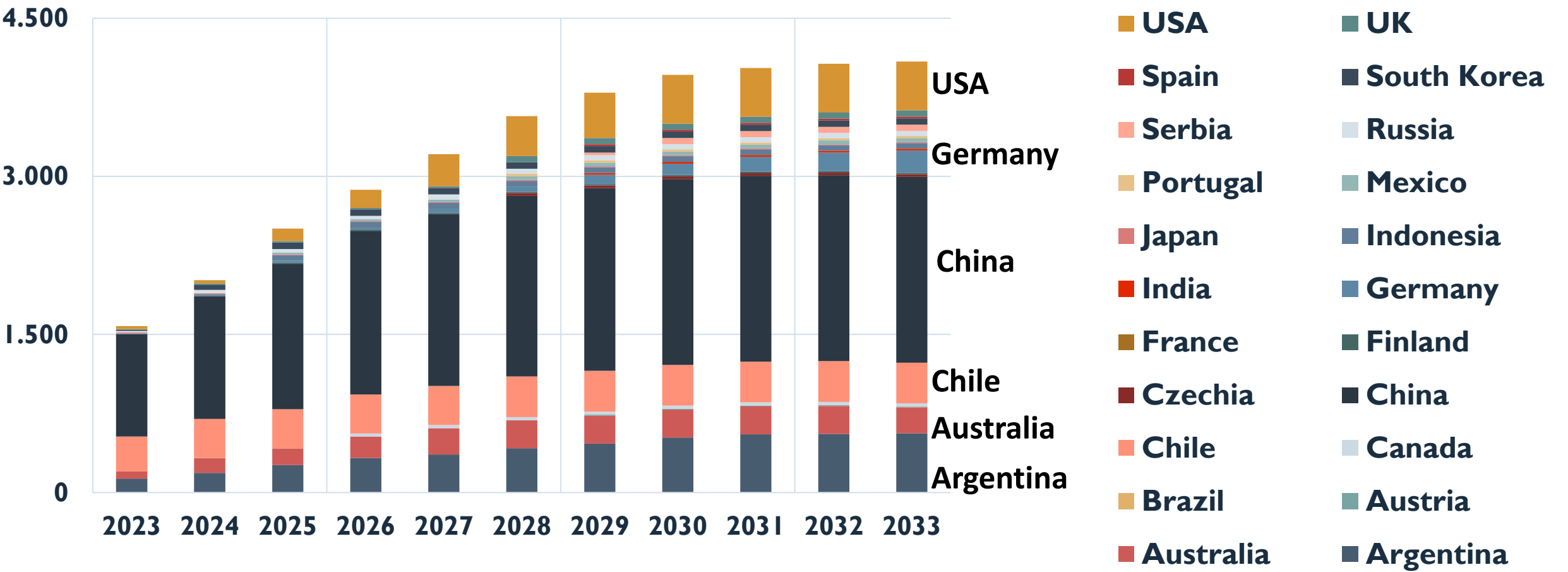


Lithium market balance



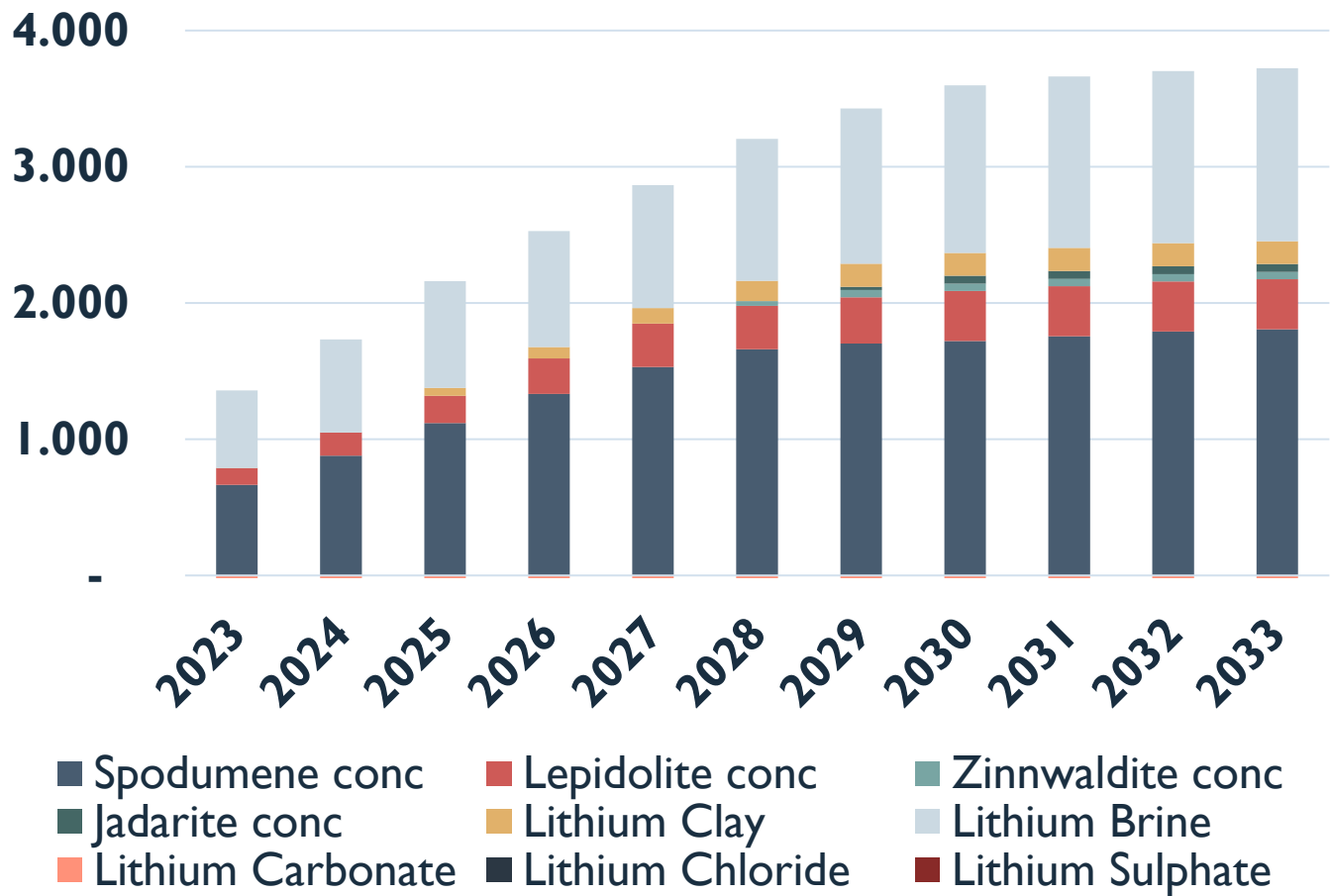
Raw material impacts – Lithium

Refined lithium production by country (kt LCE)



Raw material impacts – Lithium

Refined lithium capacity by feedstock (kt LCE)



Diversification of lithium feedstocks



Deteriorating grade/quality brine assets, reliant on DLE technology

Lithium mine supply

2023

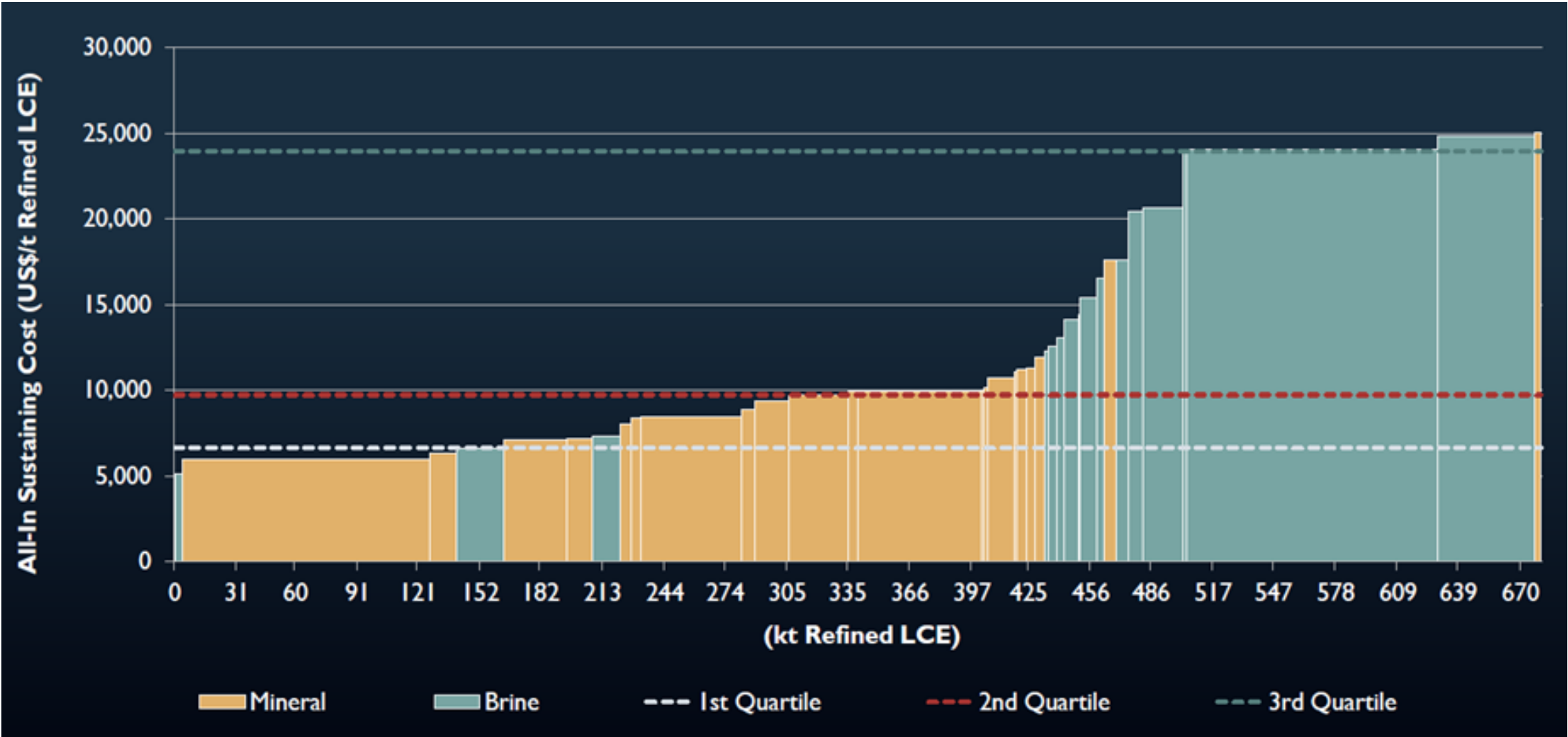
>90% from 3 countries

2033

>90% from 14 countries

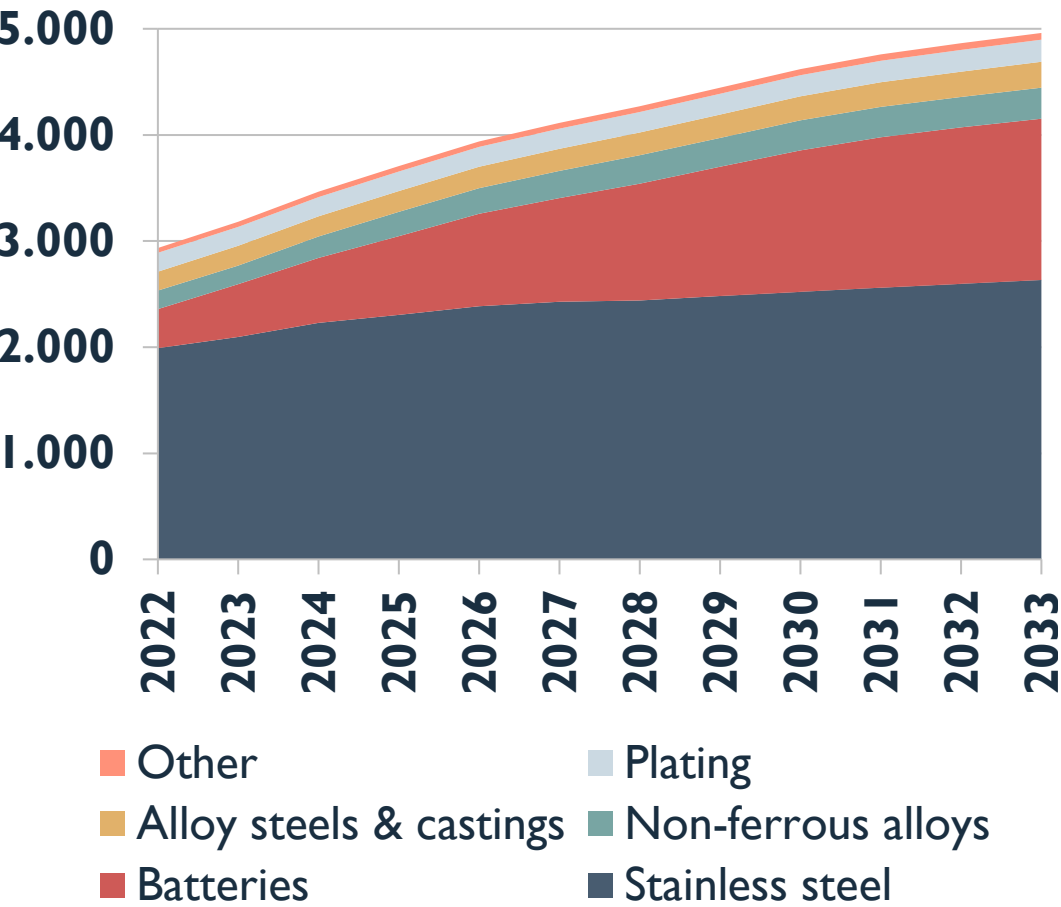


Raw material impacts – Lithium mineral production became the lowest cost route in 2022

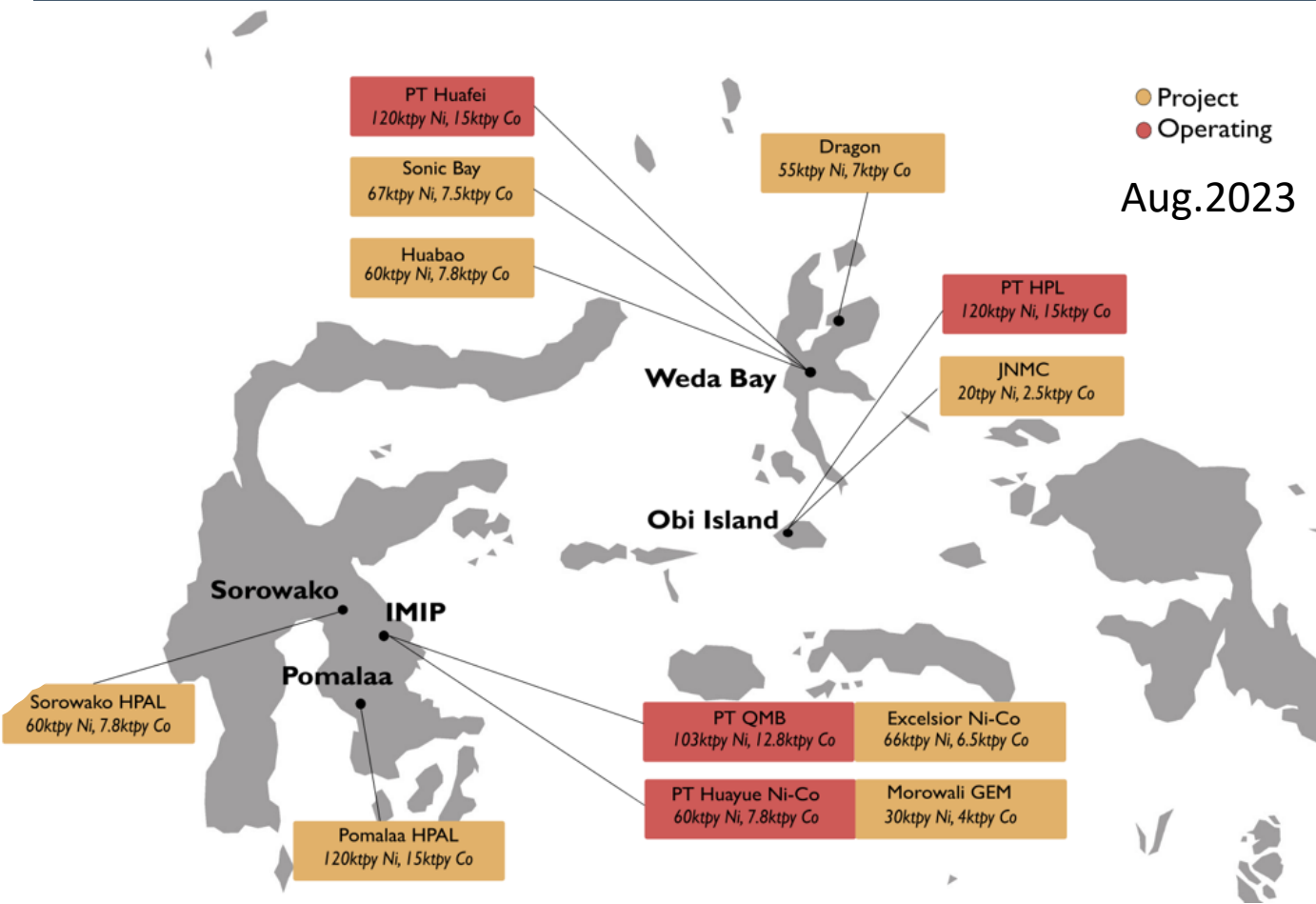


Raw material impacts – Nickel

Primary nickel demand by end-use sector (kt Ni)

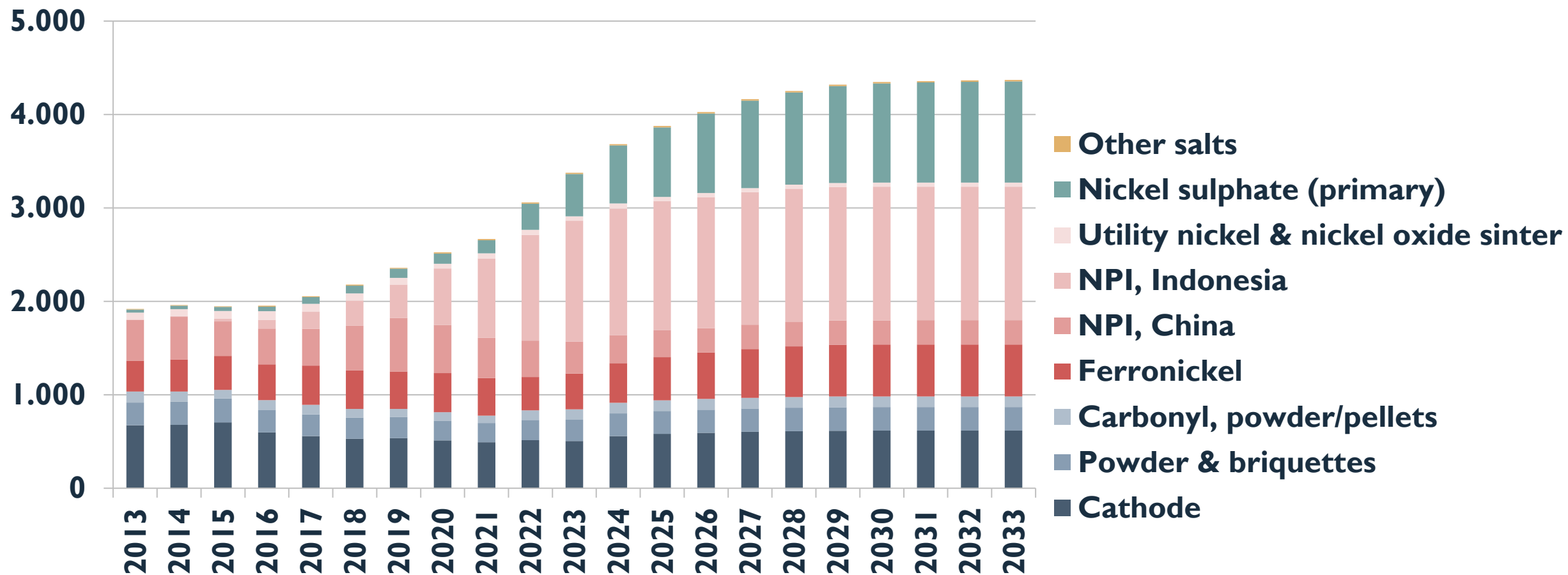


Indonesian HPAL operations and developments



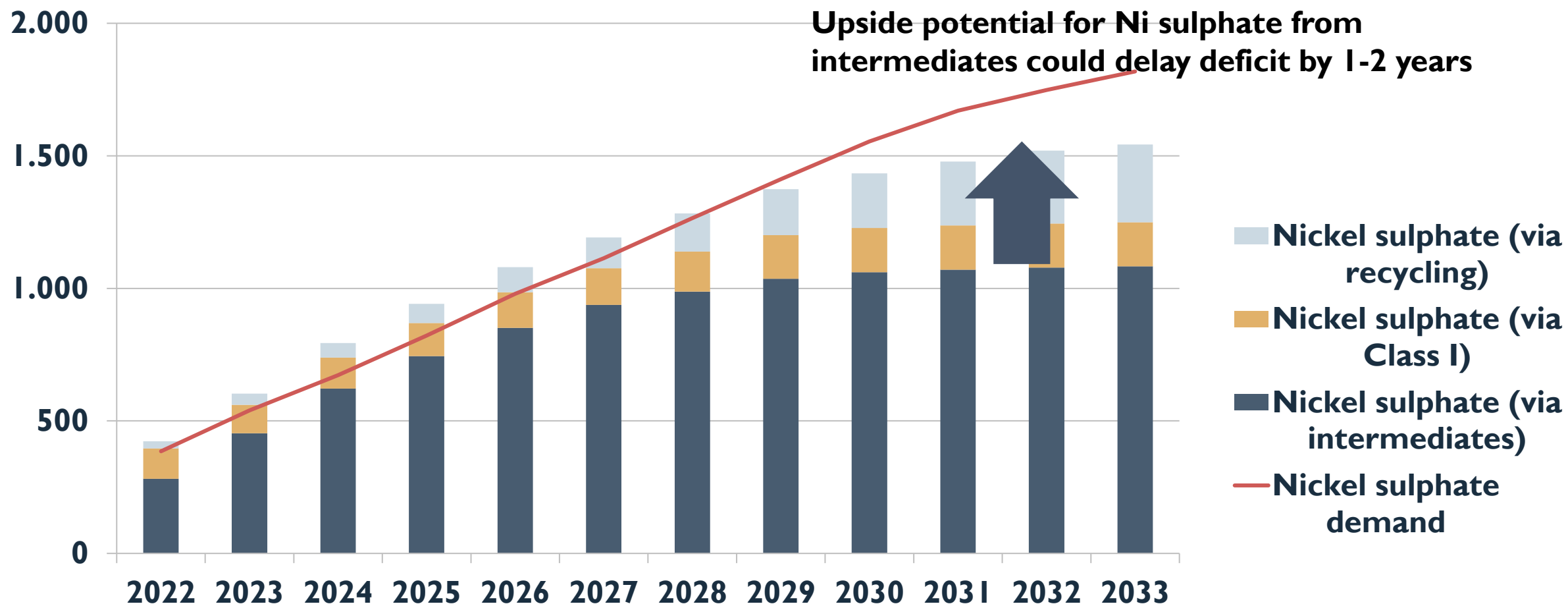
Raw material impacts – Nickel

Refined (first product) nickel supply by product (kt Ni)



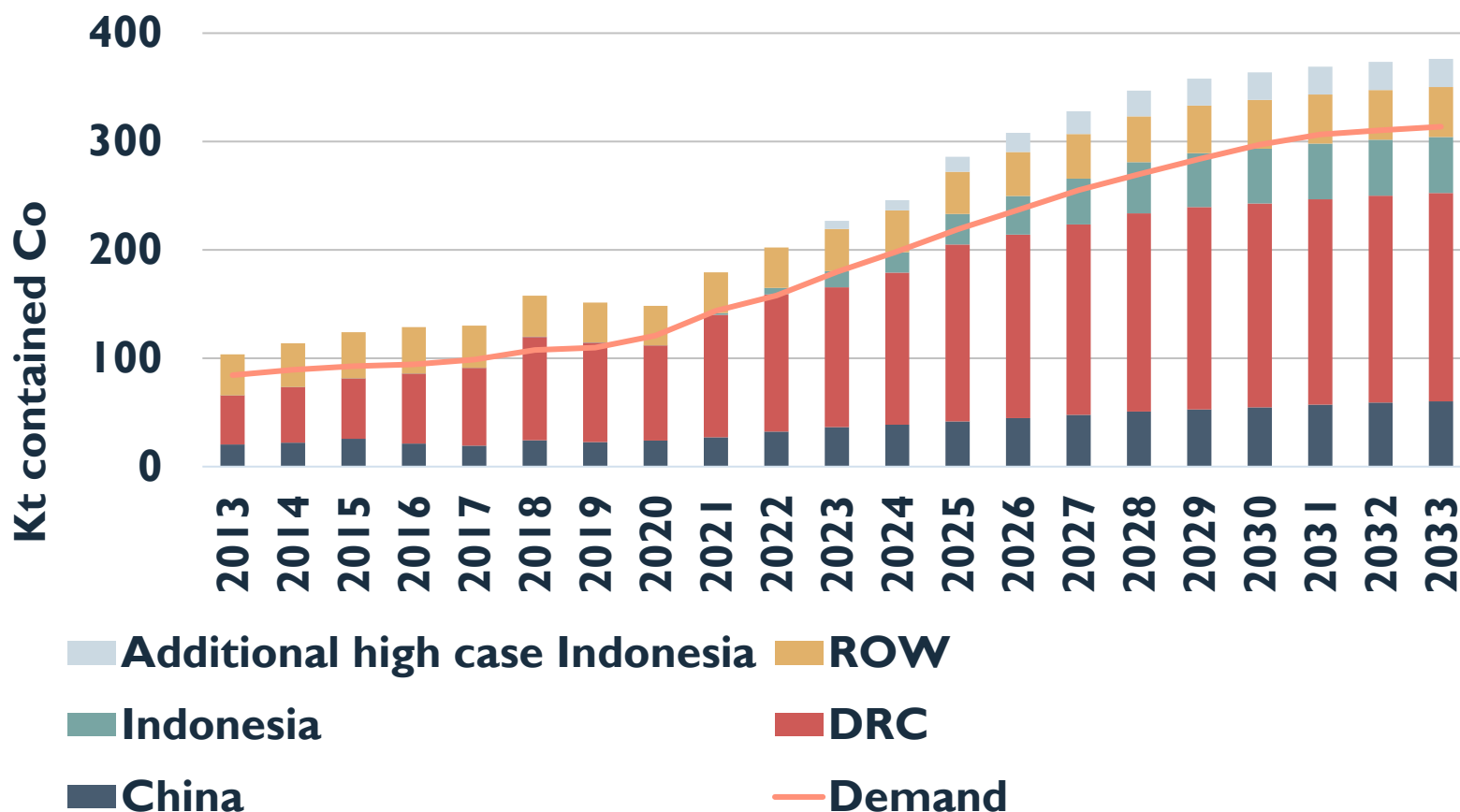
Raw material impacts – Nickel

Nickel sulphate supply by source and demand (kt Ni)



Raw material impacts – Cobalt - In what ways could ESG regulations impact markets?

The cobalt intermediates market looks to be comfortably supplied – but only if all Co units are viable



With DRC projects set to come onstream (cobalt hydroxide) and Indonesian HPAL ramping up (MHP) there looks set to be sufficient cobalt intermediates to meet booming demand.

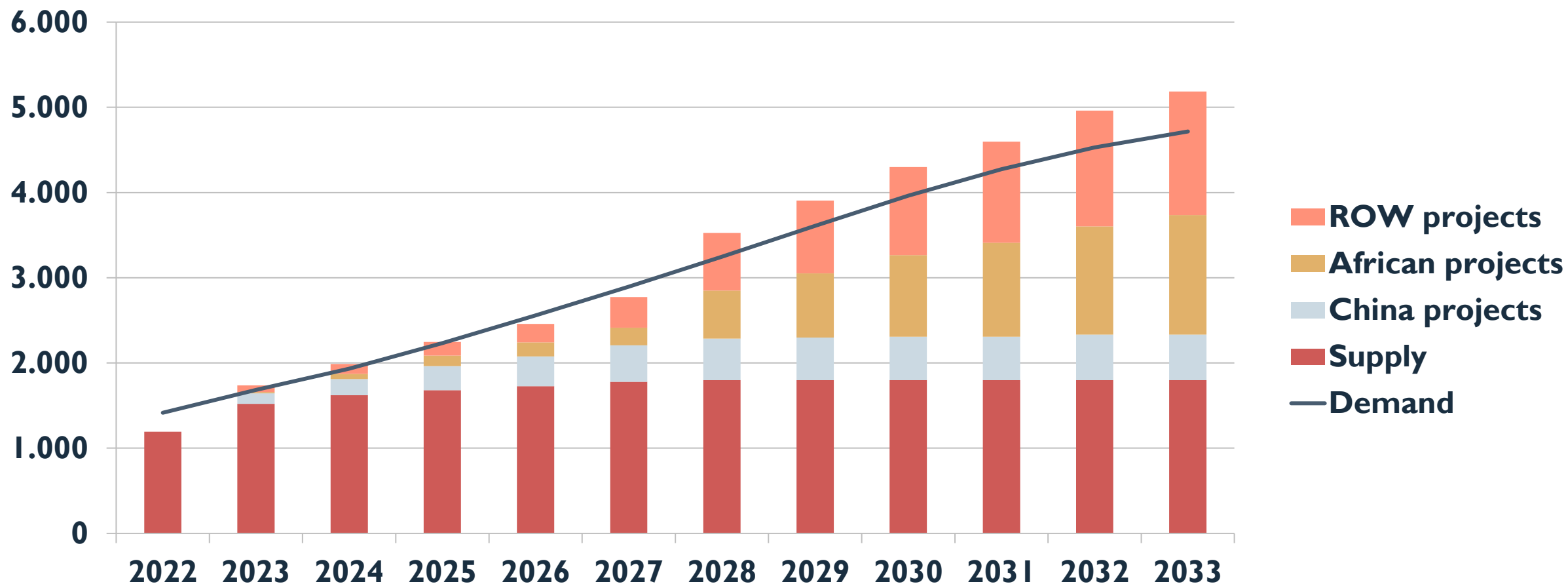
There are enough cobalt units to go around but only if OEMs continue to accept material from DRC, Indonesia and China.

Any imposition of ESG-type restrictions on material from these countries would see huge deficits appear in the cobalt market.



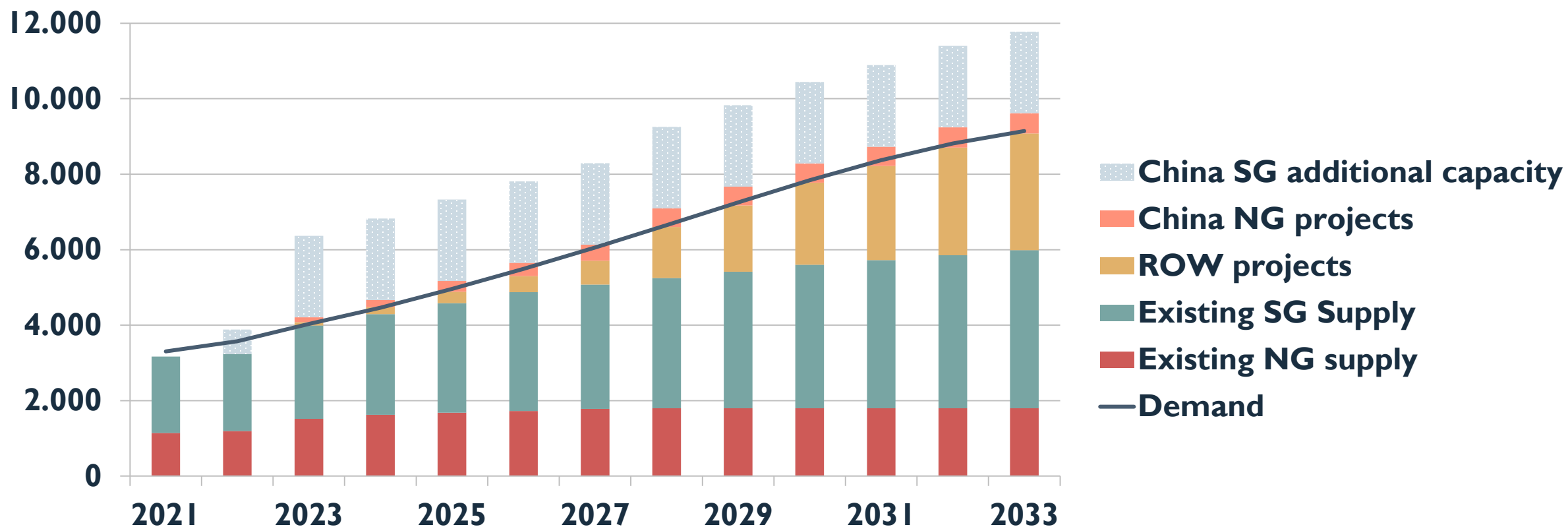
Raw material impacts – Graphite

Outlook for natural graphite supply and demand (kt)



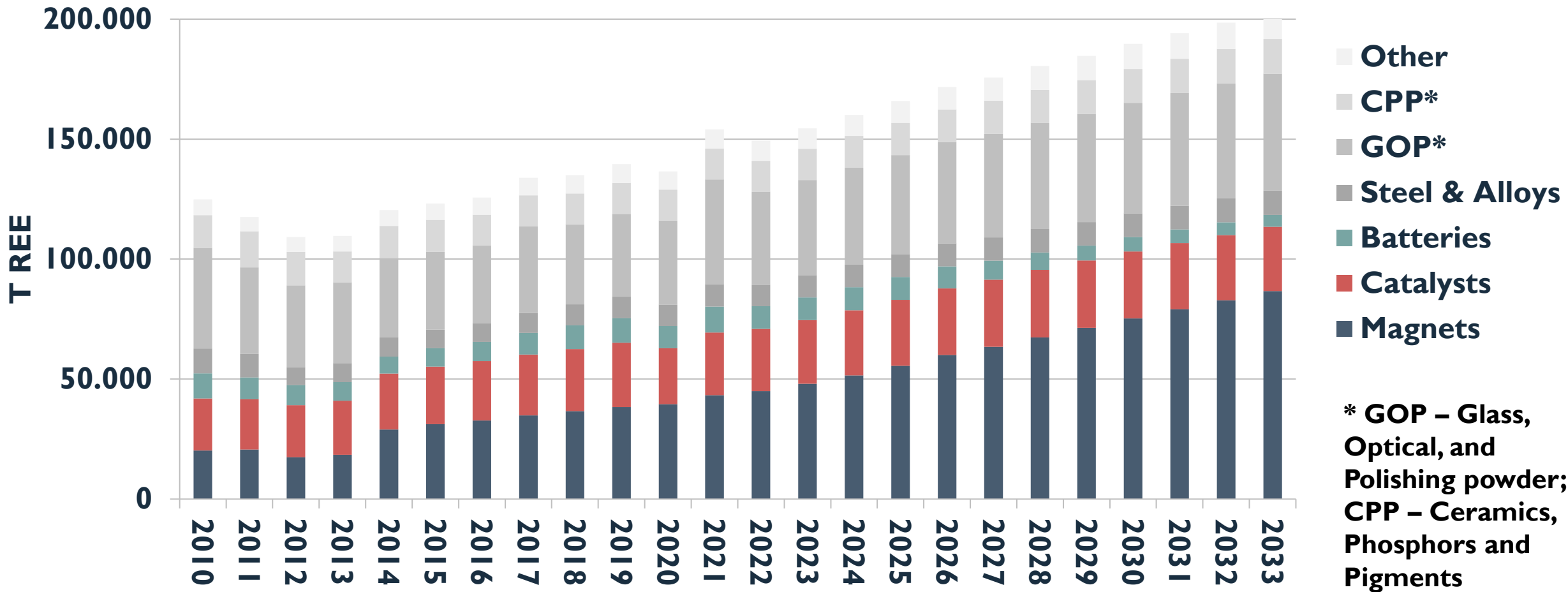
Raw material impacts – Graphite

Outlook for graphite supply and demand (kt)



Rare Earths – Powering the EV revolution

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



Rare Earths – Powering the EV revolution

2023



~95%

Permanent magnet motor (PM/PMSM)



~2.3kg

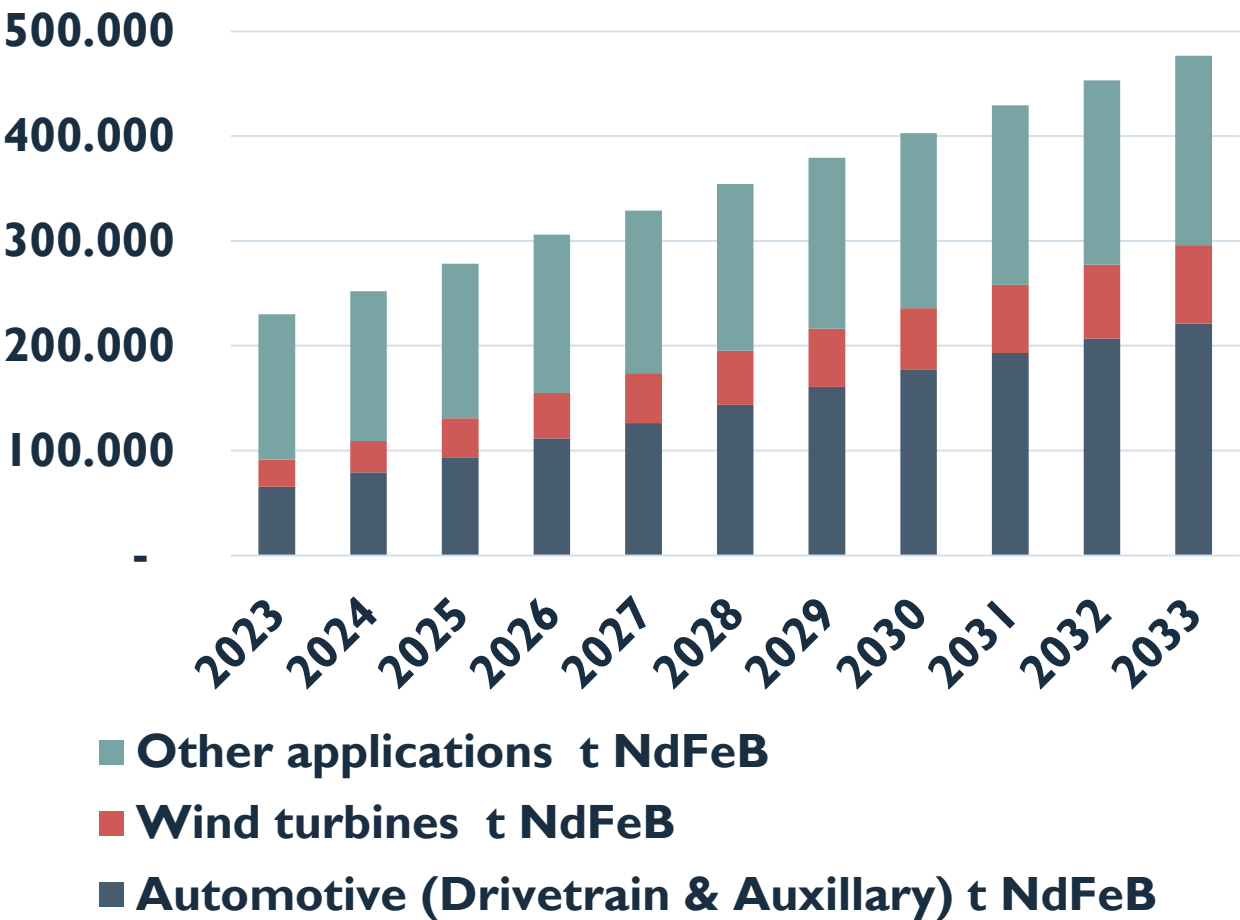
NdFeB per BEV model



~20%

Material loss (swarf)

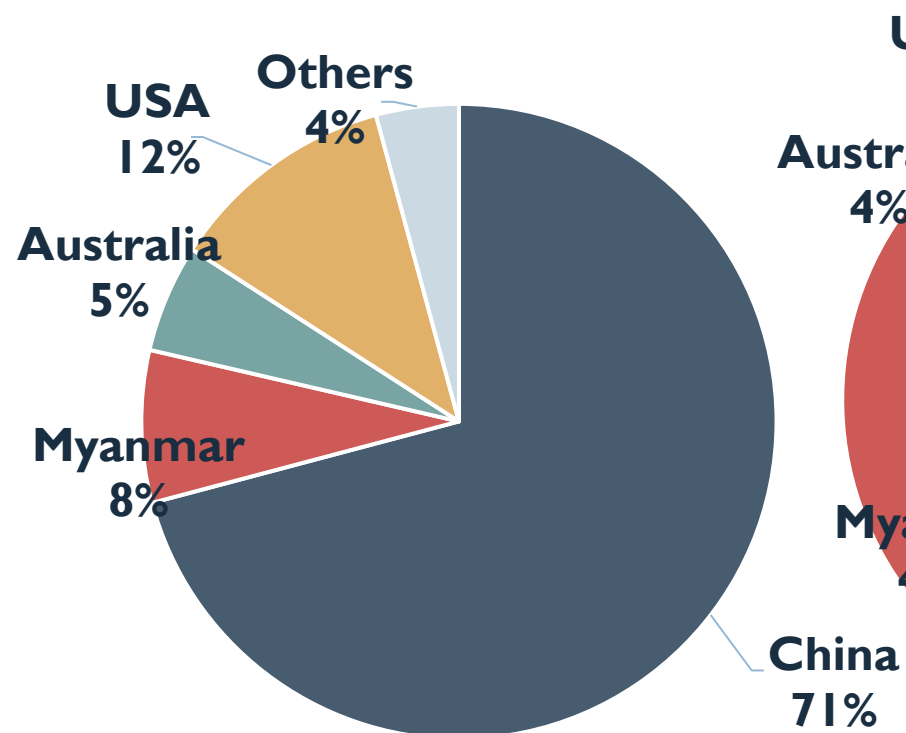
NdFeB demand by end-use (t NdFeB)



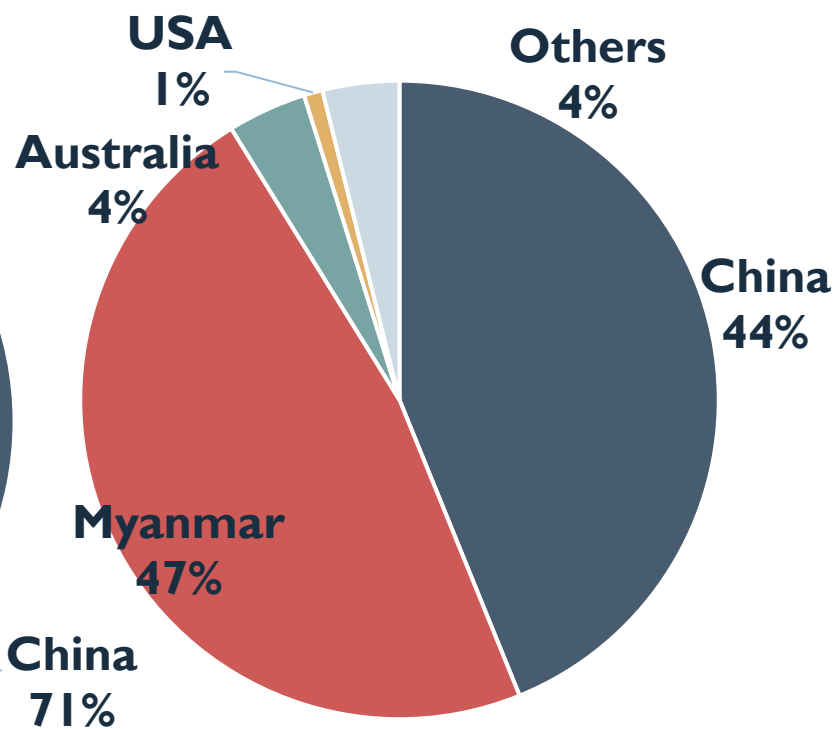
Rare Earths – Powering the EV revolution

2023

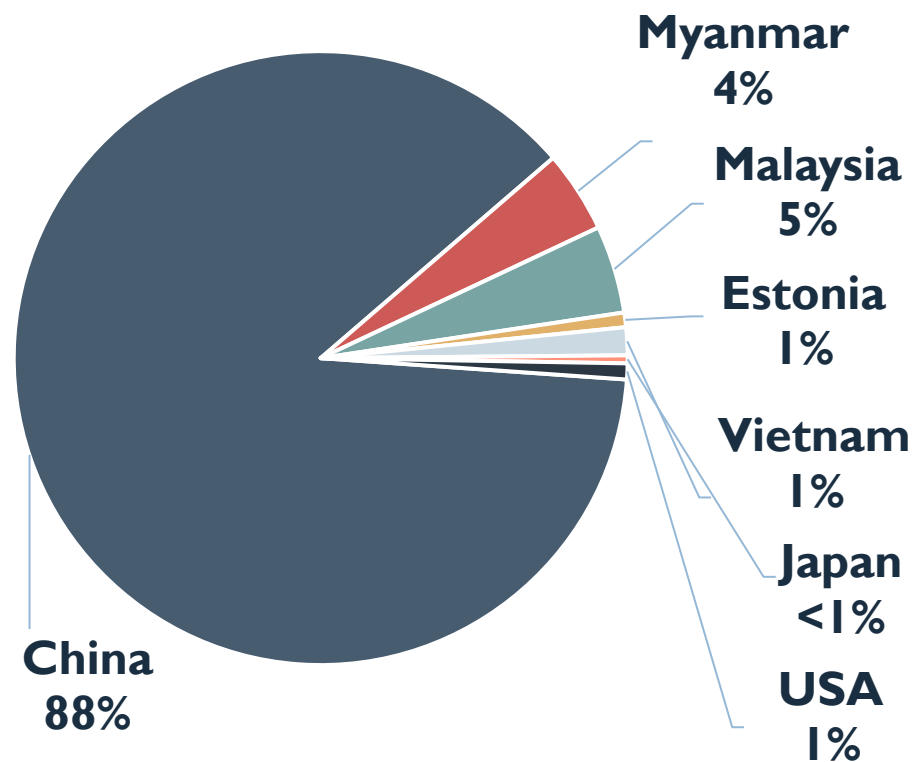
Mine supply – Light rare earth



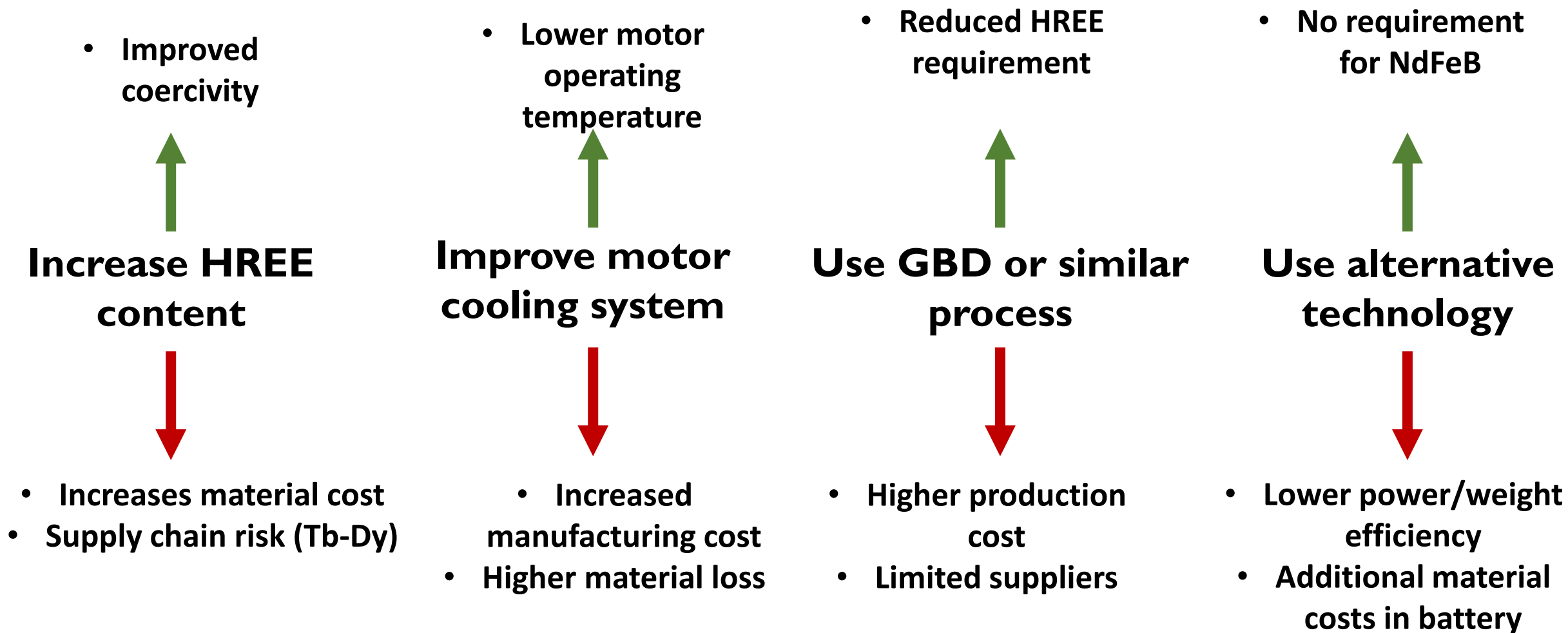
Mine Supply - Heavy rare earth



Refined rare earth supply



Rare Earths – Motor developments present balancing act for HREE and Nd-Pr demand



Why could steel industry de-carbonisation be long and difficult?

The steel industry accounts for about **7% of total carbon emissions globally** and **15% in China**, levels which must be cut to meet the targets set by various regulatory authorities.

The **BF (blast furnace)** route accounts for about **70%** of the world steel production with wide differences between countries.

When it comes to emissions, an average BF generates about 2 t of CO₂ per tonne of steel compared with 0.5 t for an **only-scrap EAF (Electric Arc Furnace)**.

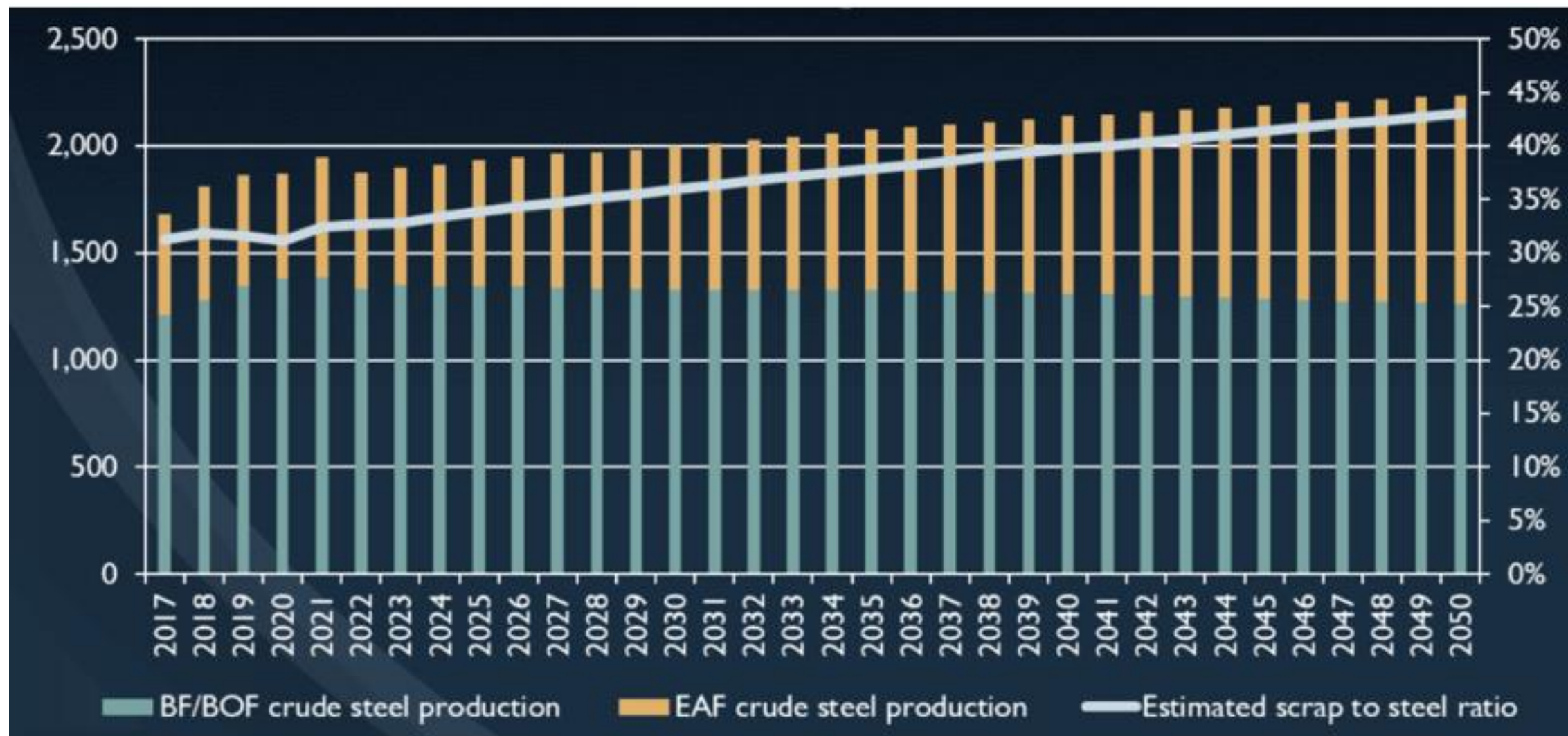


Why not replace BF's with EAFs?

1. **Economics** – BF's already in operation, and with long remaining lifetime - EAFs need to be installed
2. **Size matters** – downsizing of industries
3. **Steel quality** – not removable impurities from scrap feed – scrap-only EAF does not allow it to produce the steel quality required for certain products such as automotive sheets
4. **Scrap availability** - Developed economies can generate large quantities of scrap metal, but this is not the case for countries such as China.
5. **DRI (Direct Reduced Iron) availability** - A full de-carbonisation would imply using 'green' hydrogen as a reducing agent, e.g., produced through a renewable source of energy



Crude steel production (Mt) and estimated scrap to steel ratio





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Márcio Goto - Cel e Whats: +11 99 726 4466
marcio.goto@projectblue.com
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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

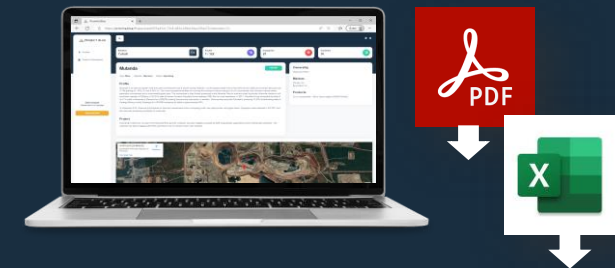
Our market service offering:

- 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



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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.



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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

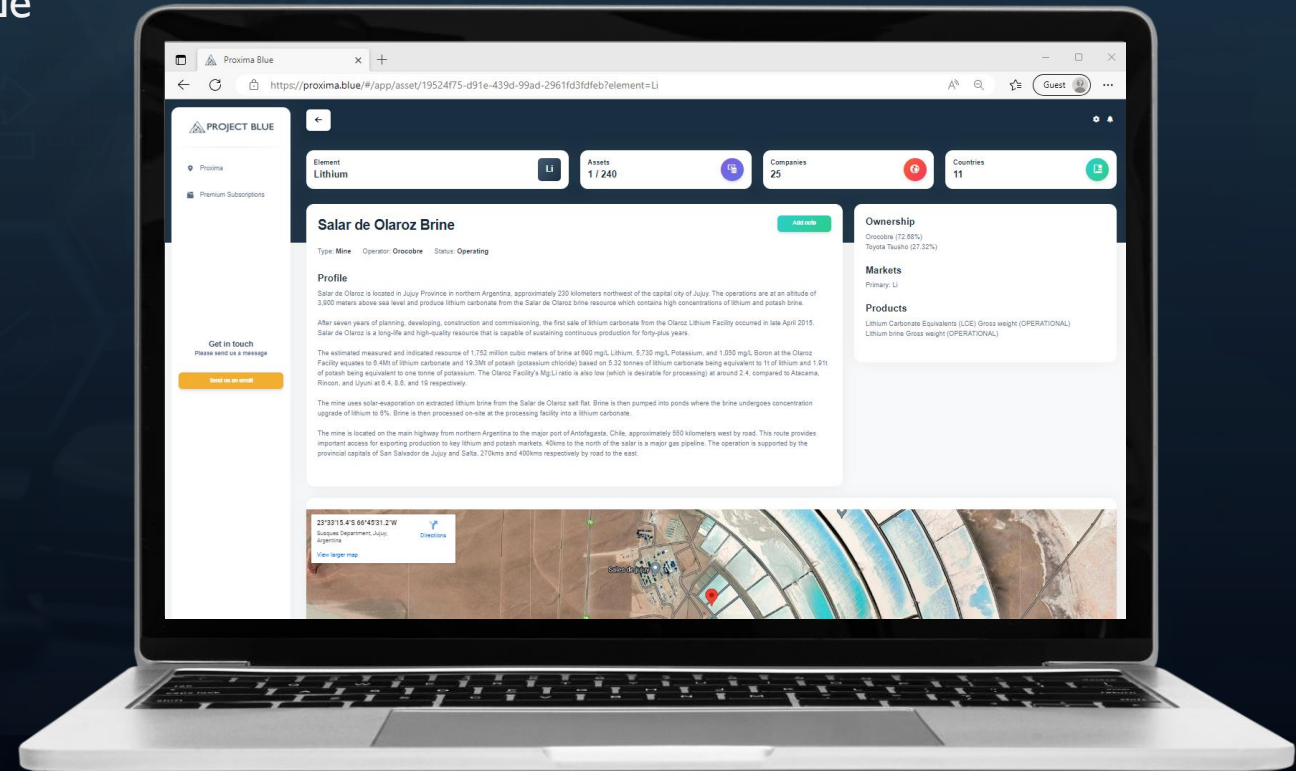
Competing assets and opportunities.

✓ Map

Supply chain linkages, deals and flows.

✓ Notifications

Receive alerts when there is market activity.





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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



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Events

Global 2023 networking events:

 **Critical Materials Forum**
CAPE TOWN 2023

 Investec, Foreshore
 Tuesday 7 February
 13:30 - 17:00

...in association with
 **Investec**


www.projectblue.com

 **Critical Materials Forum**
NEW YORK 2023

 The Cornell Club
 Thursday 15 June
 16:30 - 19:30

...in association with
 **mmta**
Minor Metals Trade Association


www.projectblue.com

 **Critical Materials Forum**
PERTH 2023

 DoubleTree by Hilton,
Perth Waterfront
 Thursday 10 August
 14:00 - 18:00

...in association with
 **Critical Minerals**
Association


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 **Critical Materials Forum**
SYDNEY 2023

 Hilton Sydney
 Wednesday 16 August
 14:00 - 18:00

...in association with
 **Critical Minerals**
Association


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 **Critical Materials Forum**
LONDON 2023

 Burlington House, Piccadilly
 Tuesday 10 October
 15:00

...in association with
 **mmta**
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 **Critical Materials Forum**
JOHANNESBURG 2023

 Investec, Sandton
 October
 TBC

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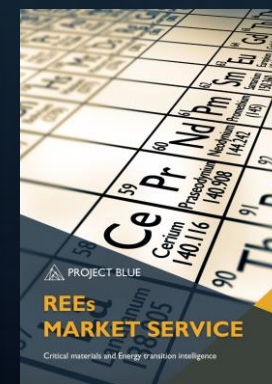
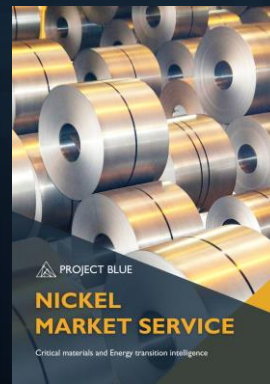
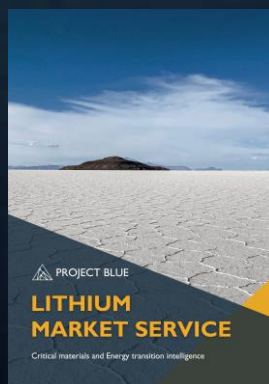
EV & Li-ion battery research suite

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





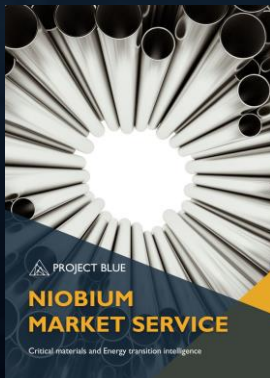
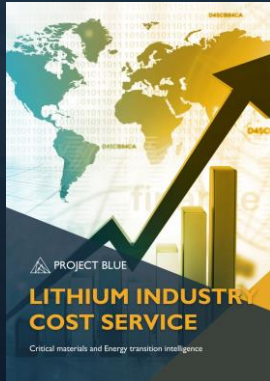
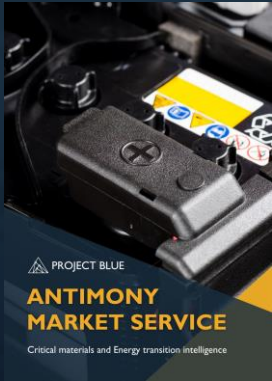
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Additional battery material coverage

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

Our EV and battery research leadership



David Merriman, Li, REEs



Dr Jack Bedder, Co,V



Alison Saxby, Graphite



Leslie Liang, China, REEs



Dr Nils Backeberg, Mn



Jack Anderson, Ni



Steven Seget, Li-ion



Dominic Wells, Costs & ESG



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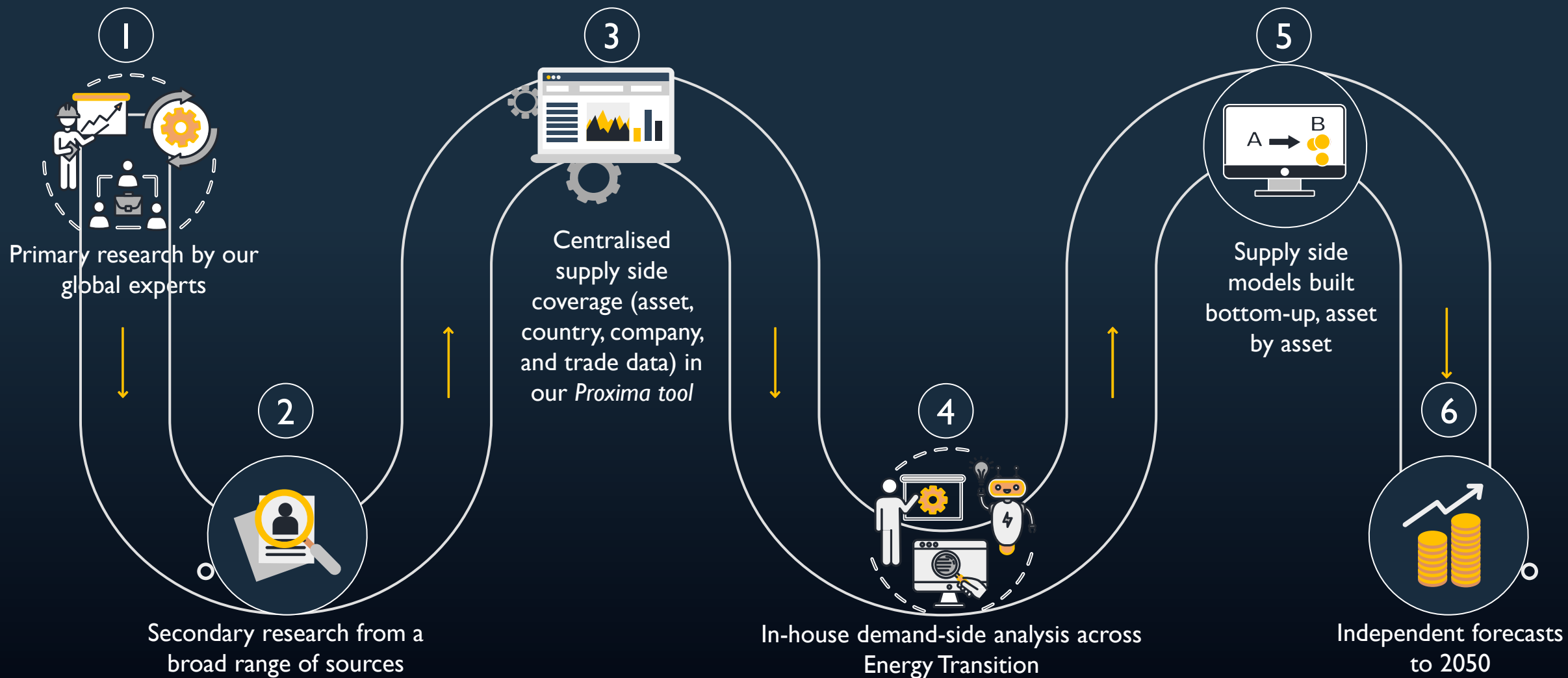
Why choose Project Blue?

- 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.



PROJECT BLUE

Our approach





VIII ENCONTRO DE EXECUTIVOS DO SETOR MINERAL



Márcio Goto - Cel e Whats: +11 99 726 4466

marcio.goto@projectblue.com

www.projectblue.com

Realização:

