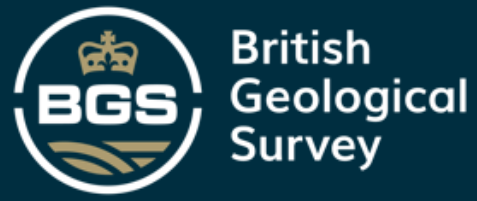
E PETAVRATZI

The role of the circular economy in securing critical raw materials



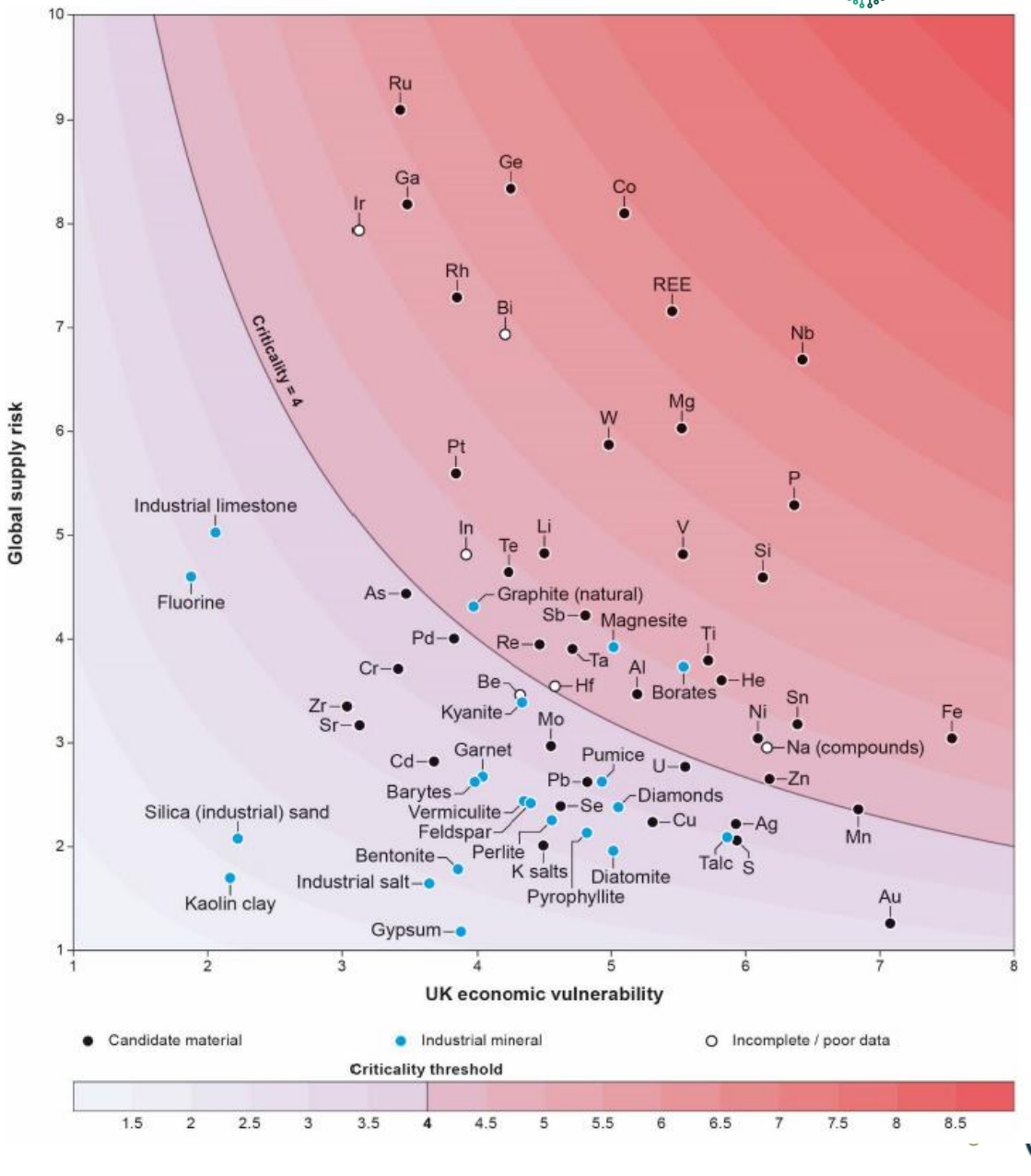
Aims & objectives

UK Critical Minerals Intelligence Centre

- Support the UK in securing adequate and timely supplies of the critical minerals required to reduce national security risks, achieve transition to net zero, deliver economic prosperity, and create supply chain opportunities for UK businesses;
- By providing authoritative, impartial and independent up-to-date data, information and analysis on supply-demand, stocks and flows of critical minerals essential to the UK economy, inform decision-making by government and industry, including recommendations for targeted interventions;
- CMIC is a key part of the UK Government's approach for Critical Minerals

UK critical minerals list

- UK criticality assessment carried out in 2024
- Quantitative assessment based on available datasets such as global trade data
- Represents a ‘snapshot in time’ and does not take account of potentially growing demand
- List of 34 critical minerals for the UK
- These minerals are crucial for the economic prosperity, national security and ongoing technological development of the UK, but have a significant risk of supply disruption.



Foresight studies

https://ukcmic.org/reports/cmic.html

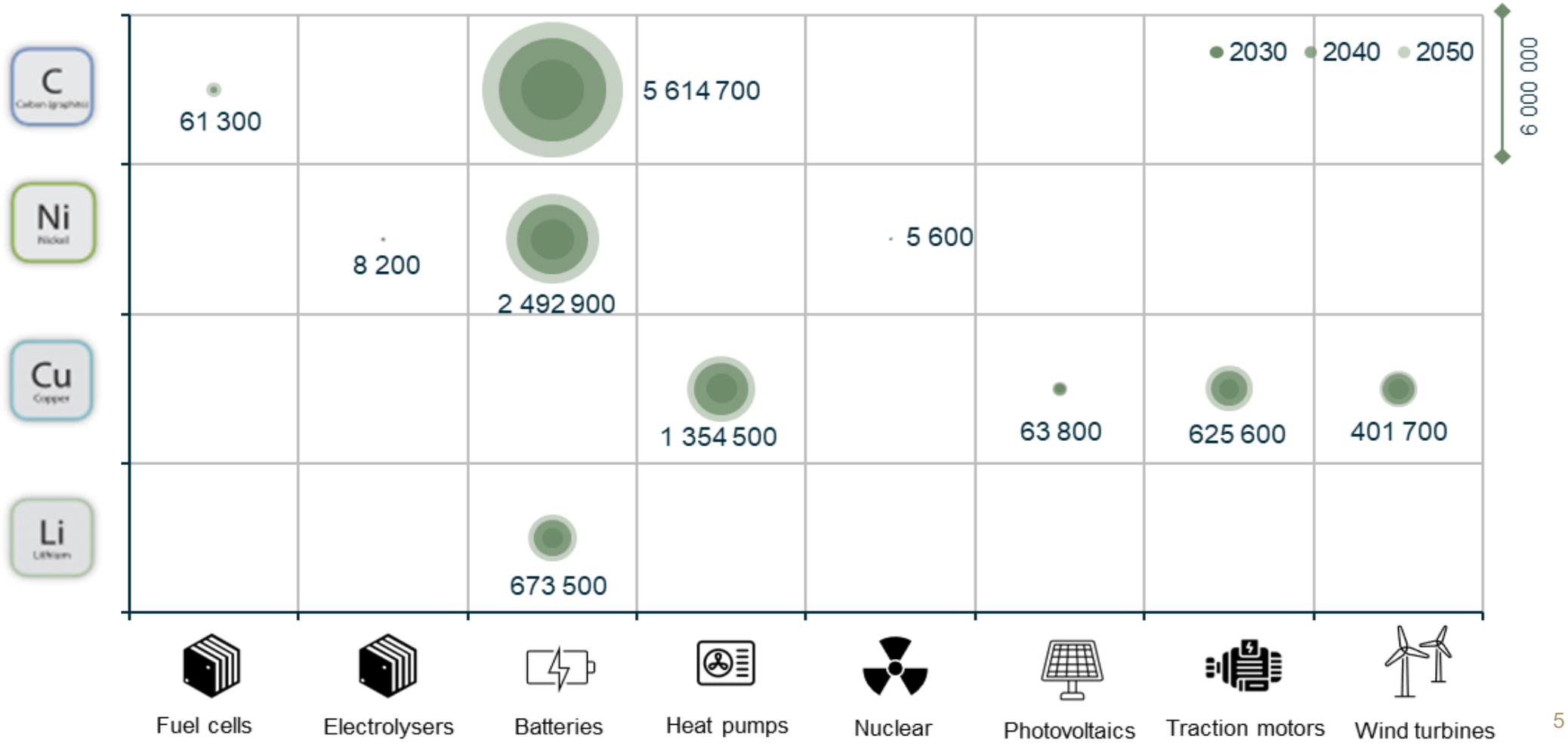
Batteries
Wind turbines
Traction motors
Fuel cells
Electrolysers
Photovoltaics
Nuclear
Heat pumps

Elements included in the foresight assessment
Critical minerals - 2024 assessment

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Lanthanides	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Actinides	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og
			La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
			Ac	Th	Pa	U	Np	Pu	Am	Cm	Cf	Es	Fm	Md	No	Lr	Rf

Results – Cumulative demand

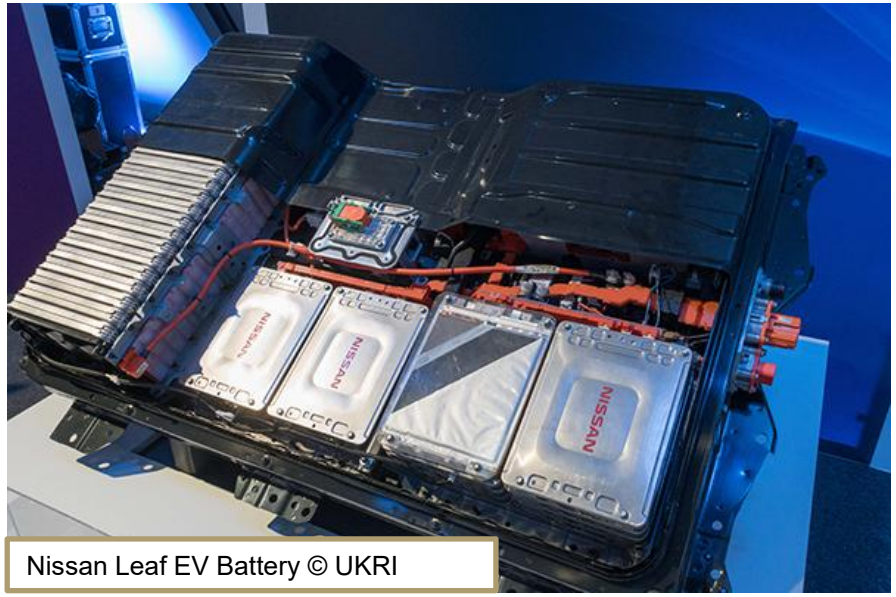
Cumulative UK demand in **million tonnes**



Stocks and Flows Modelling

Introduction

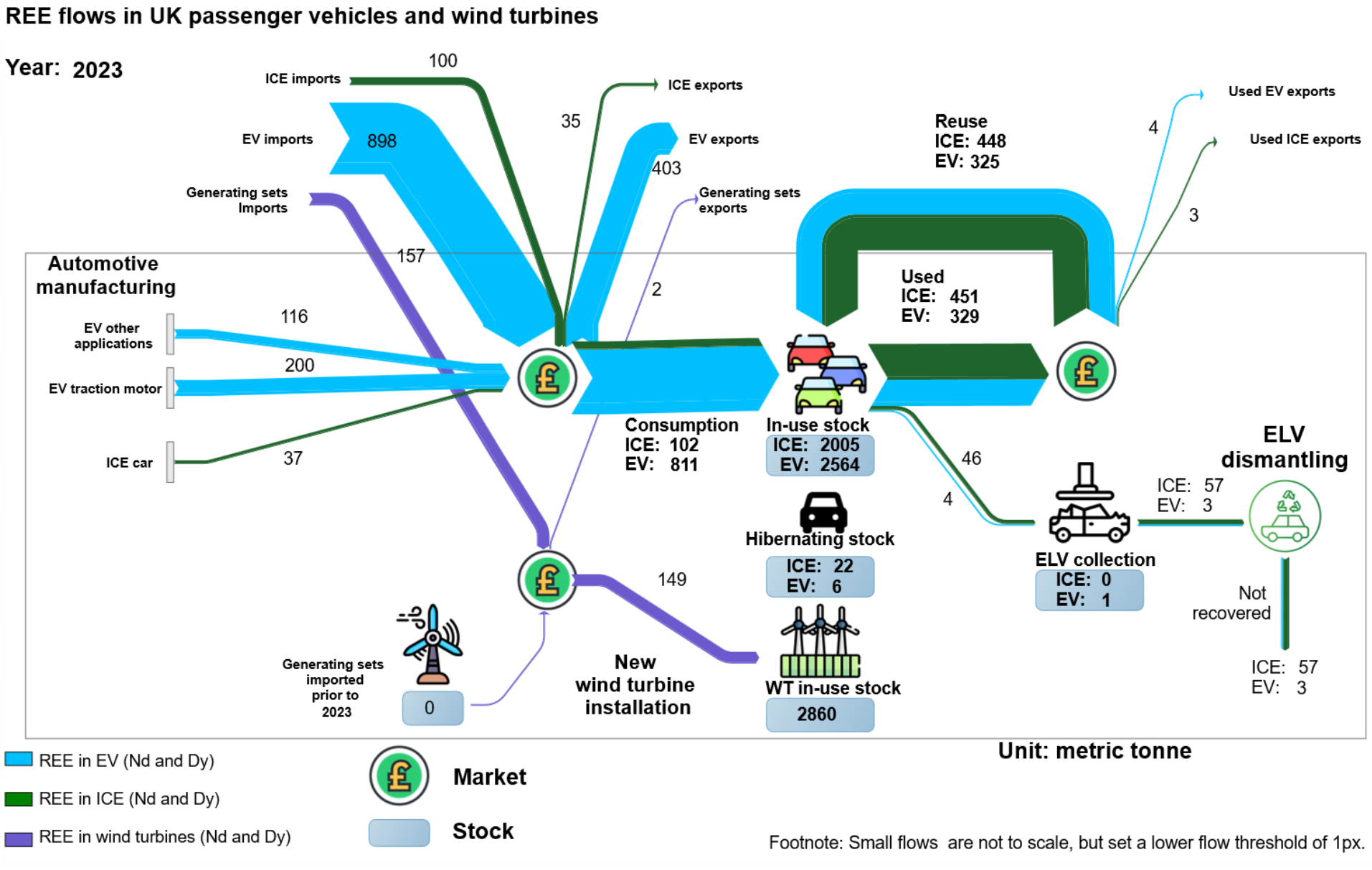
- As the adoption of electric vehicles (EV), and wind turbines continues to rise, the accumulation of batteries and magnets is increasing.
- A growing need for effective end-of-life resource management.
- End-of-life motors in EV and generators in wind turbines contain permanent magnets with significant amounts of rare earths.
- End-of-life rechargeable lithium-ion batteries (LIB) found in EV contain significant amounts of cobalt (Co), nickel (Ni) and manganese (Mn), which can provide feedstock to new battery manufacture.



Nissan Leaf EV Battery © UKRI


Onshore wind turbines © UKRI

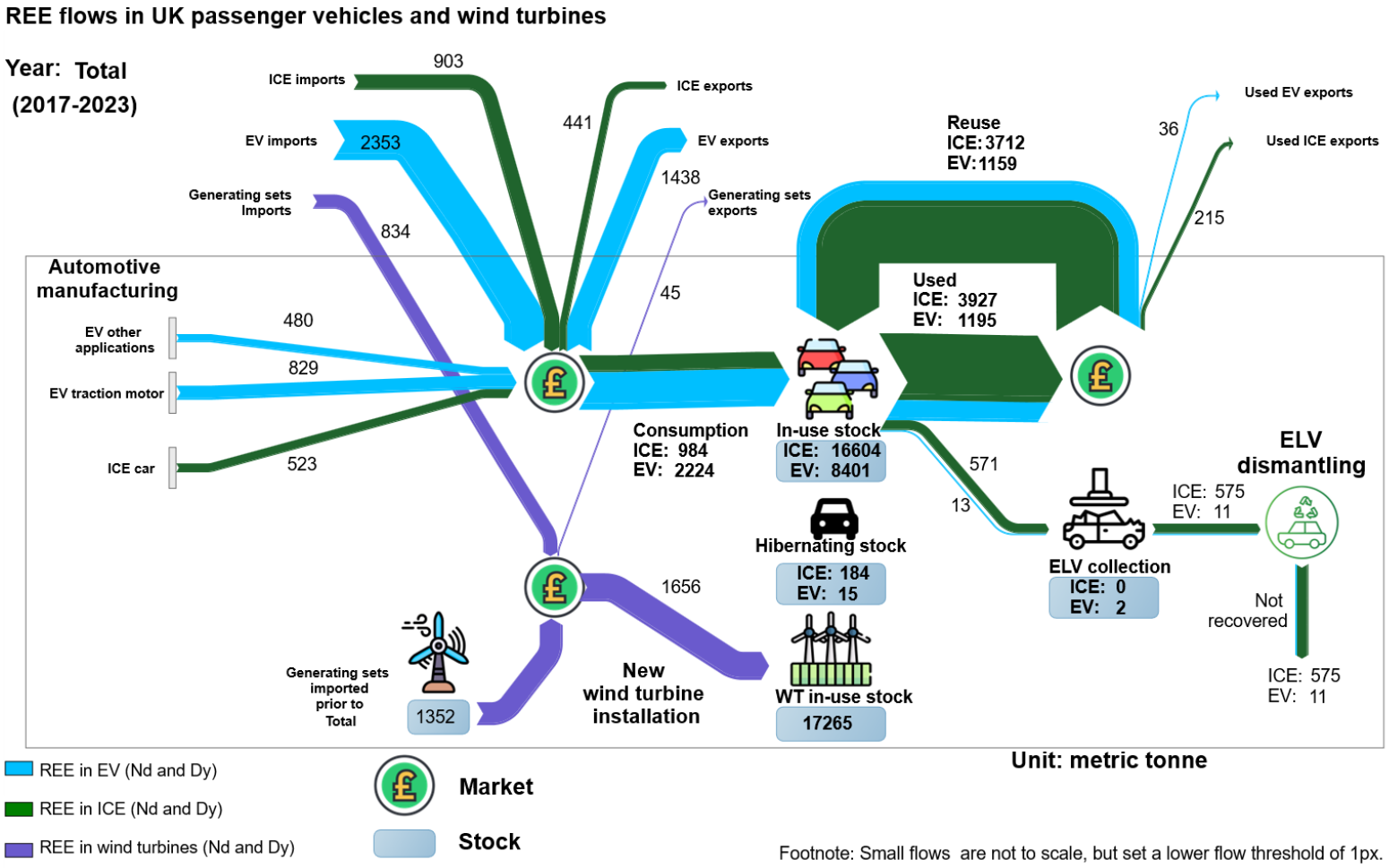
Historic flows of REE - 2017 to 2023



Footnote: Small flows are not to scale, but set a lower flow threshold of 1px.

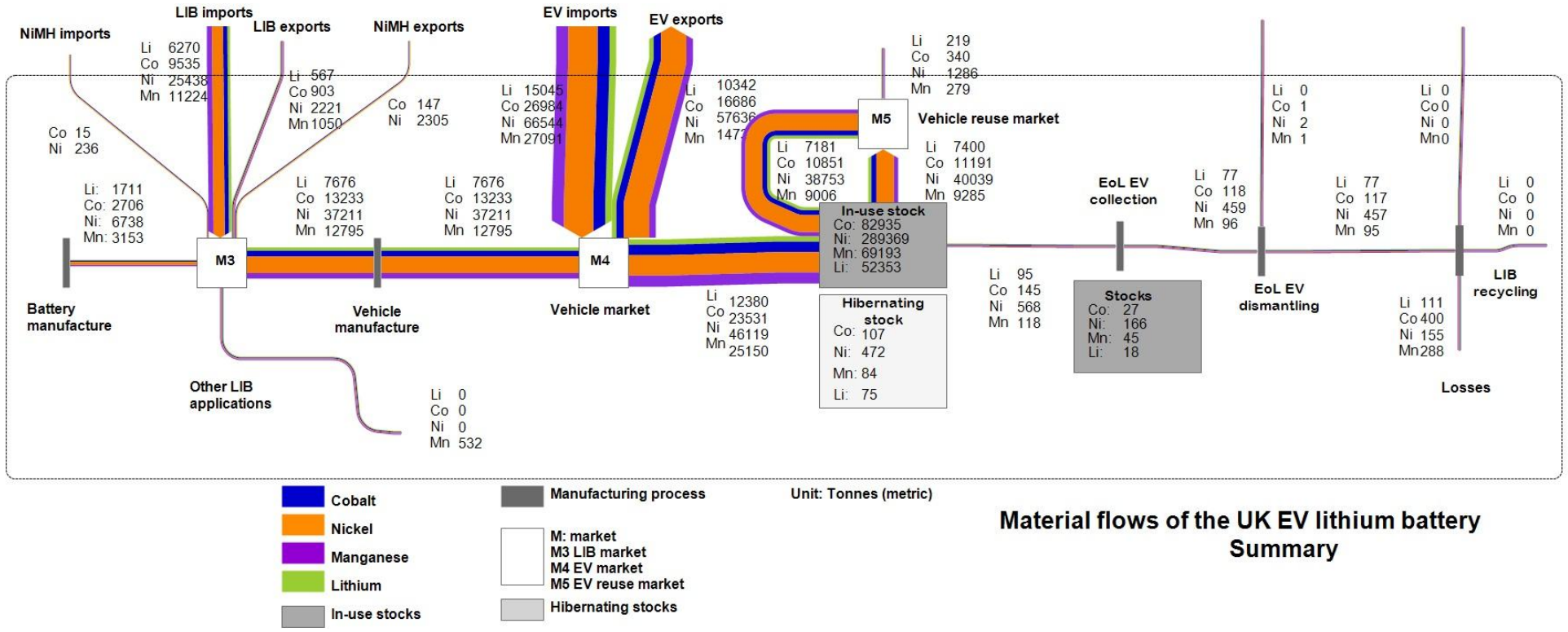
Integrated model - REE

- A stocks and flows model that tracks Nd, Dy for EV traction motors, in other EV components and in ICE cars.
- Models have been developed for years 2017 to 2023.
- Life extension through reuse of vehicles is strong both for the EV and ICE markets.
- From 2017-2023, roughly 575 tonnes of Nd & Dy from ICE and 11 tonnes of Nd, Dy from EV have been lost during shredding as magnets are not currently recovered



Integrated model- LIB

- Integrated model provides the sum of stock and flows between 2017 and 2023.
- Import reliance quite high for EV and LIB.
- In-use stocks have increased rapidly for all Battery raw materials
- These stocks will
- Reuse of EV significant and influence the end-of-life material availability.
- From 2017 around 110t Li, 400t Co, 155t of Ni and 288t of Mn have been wasted due to lack of recovery capacity.



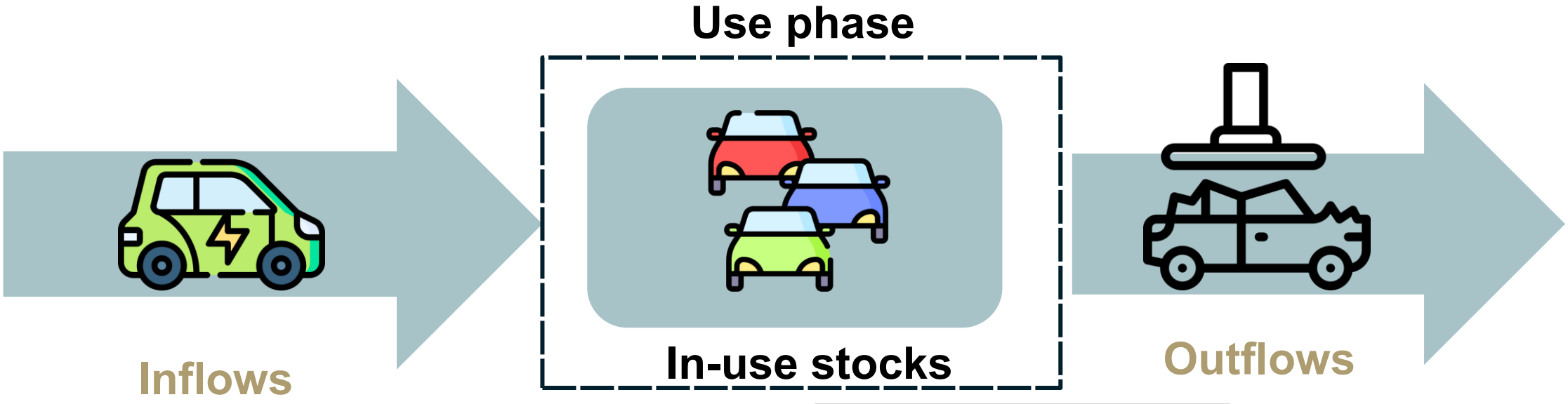
Material flows of the UK EV lithium battery Summary

Future projections overview

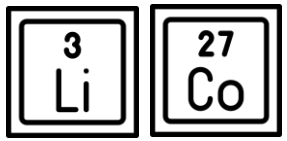
Methodology – Stock-driven approach

System boundary: Stocks and flows of Li & Co in battery electric vehicles (BEVs) in the UK between 2010 and 2050

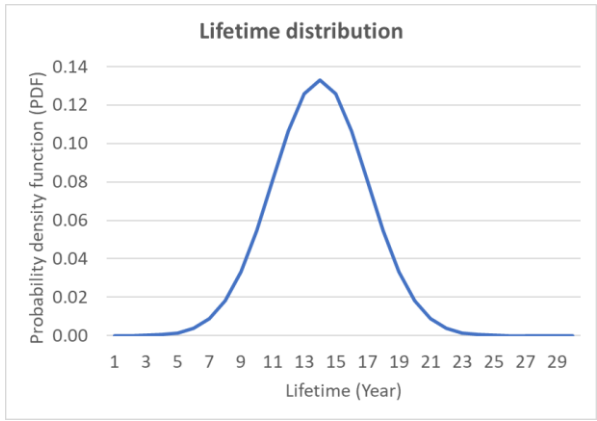
- **Methodology – Stock-driven approach**



Number of Products
Underpinning Scenarios
Market share (%)* material intensity (kg/kWh)



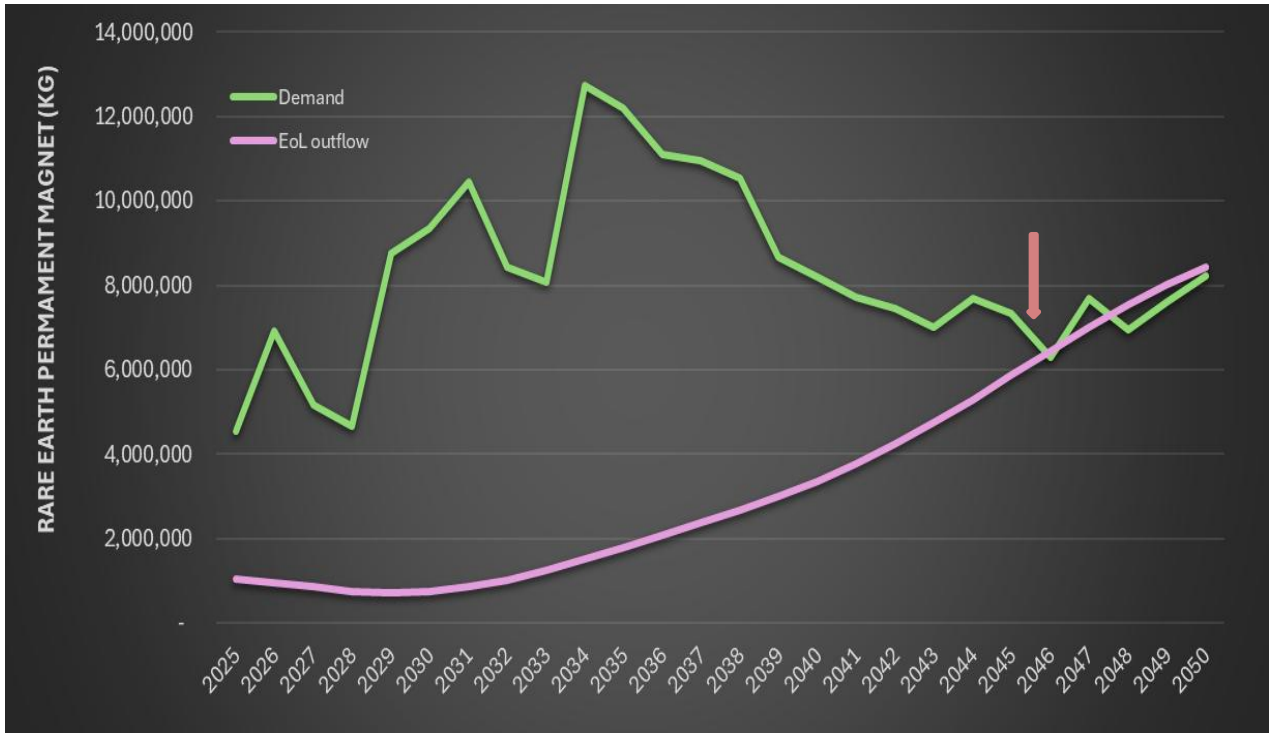
Average battery energy density (kWh)*
material intensity (kg/kWh)

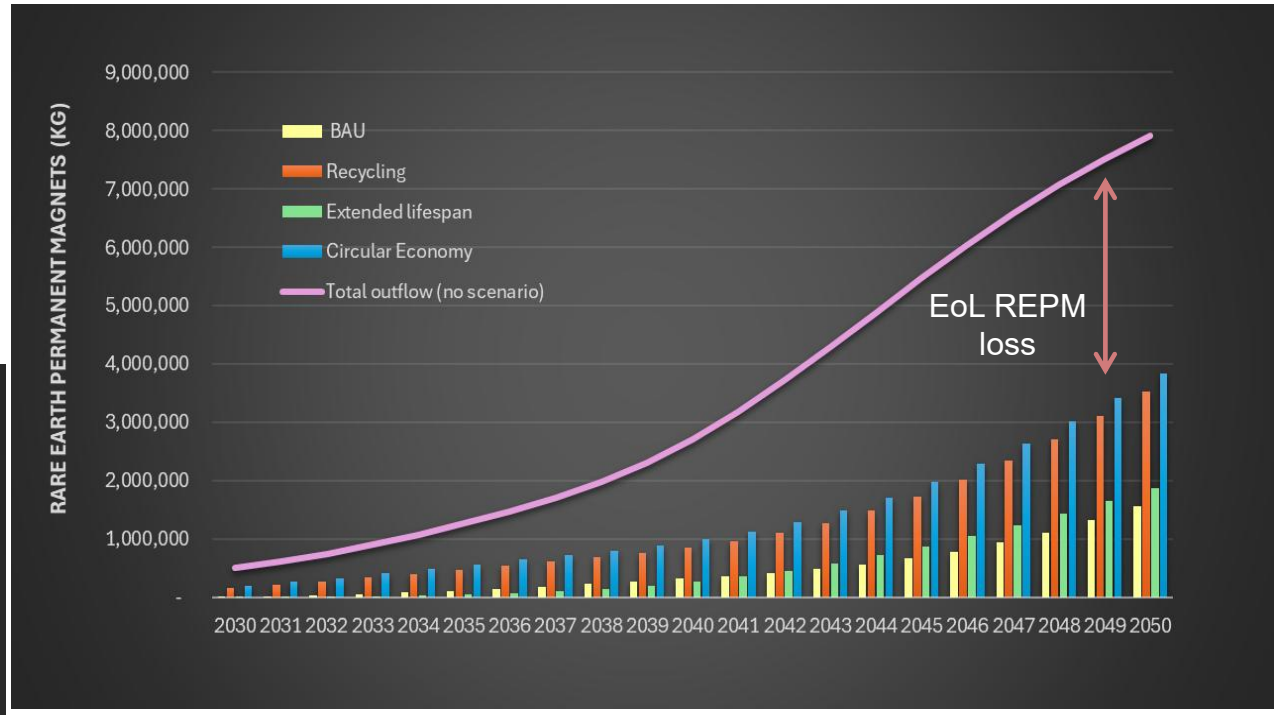


Assumption: normal distribution	
Mean	Standard deviation
14	3
Kamran, Raugei & Hutchinson (2021)	

UK demand and end-of-life potential for REEs in permanent magnets

- By mid-2040 the rare earth permanent magnets in EoL EV, ICE and Wind Turbines equal the UK demand.
- However, between 2025 and 2040, sourcing of material from overseas markets and reliance on primary supply is essential.

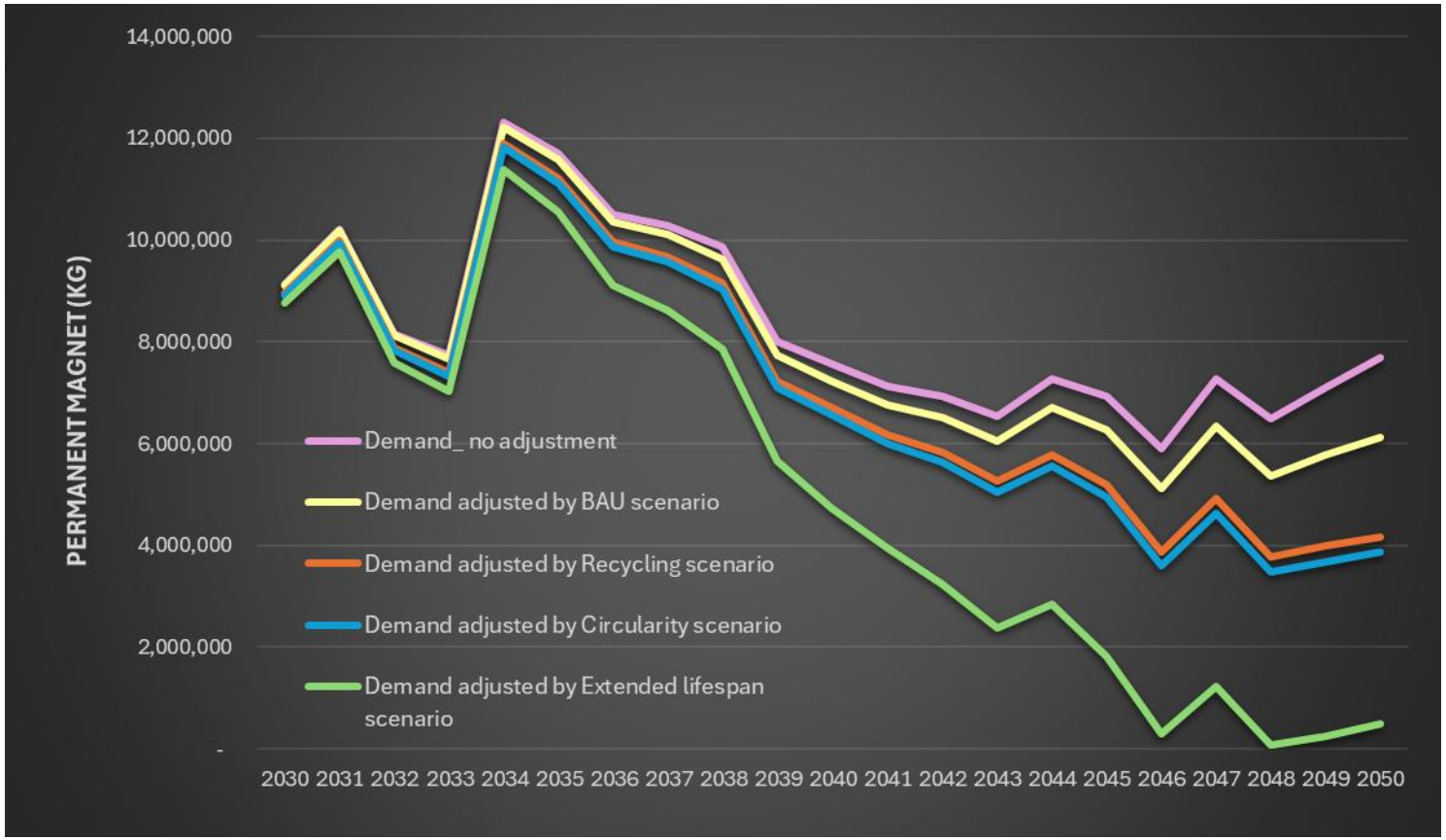




In reality, we are likely to be able to recover less REPM from EoL, unless technological and supply chain challenges are overcome! Reliance on primary REES will continue in such a future.

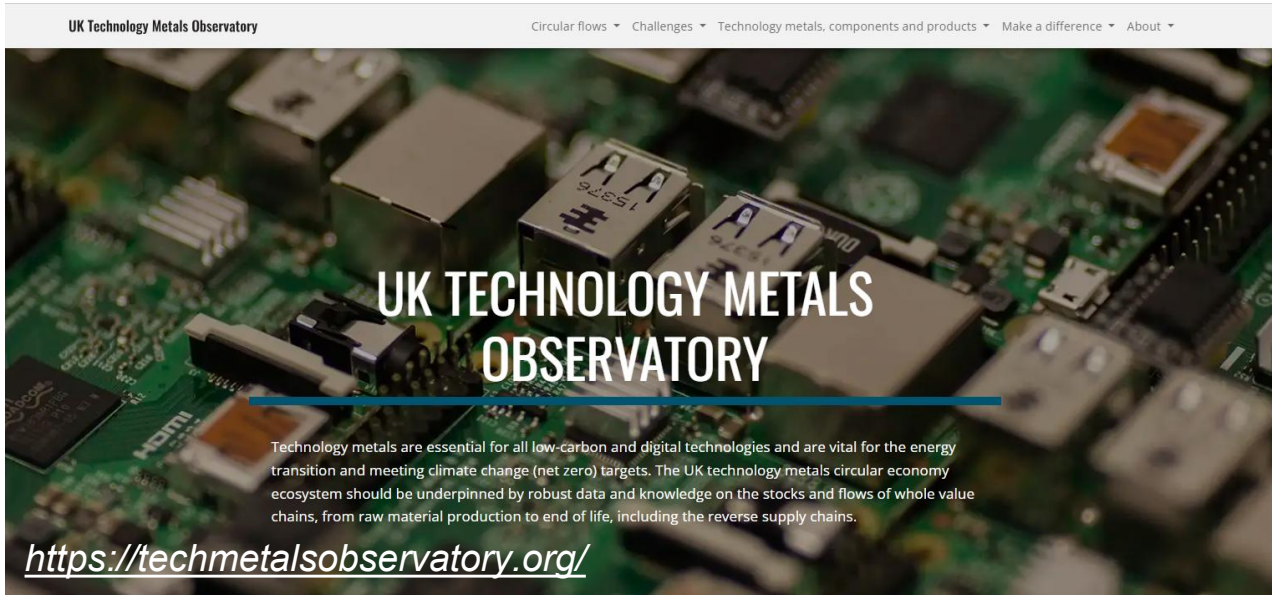
Demand reduction for rare earth permanent magnets (UK)

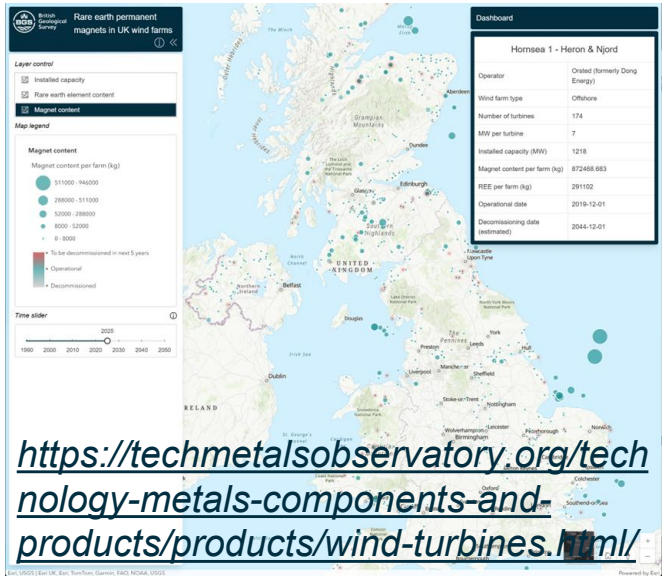
- Different interventions will influence REPM demand in different ways.
- The **life extension** scenario is the **most successful** for reducing REPM demand, followed by the recycling scenario and circularity scenarios.
- From 2035 onwards the impact of any of the circular economy scenarios on demand reduction becomes obvious.
- More **aggressive recycling and circularity targets** can have even higher impacts on demand reduction.



Key takeaways

- **Limited Scope of Current Models:** Our existing data and models focus only on specific signature applications. However, material demand is significantly higher when considering the broader product landscape. Similarly, end-of-life volumes are likely to be underestimated.
- **Need for Broader Application Coverage:** Expanding the scope to include a wider range of applications is essential for enabling intelligent, evidence-based decision-making.
- **Defence Sector – A Major Gap:** The defence sector remains largely unexplored, despite its potential relevance to material flows and strategic demand.
- **Importance of Ongoing Monitoring:** Continuous tracking of material flows and forward-looking analysis is critical to anticipate future trends and risks.
- **Significant Data Gaps:** There are substantial gaps in available data. Efforts to generate new and improved datasets are urgently needed, yet funding for such activities is currently lacking.
- **Technological Advancements Required:** Innovations in dismantling and recovery technologies for REPMs and batteries are necessary to improve circularity and resource efficiency.
- **Reverse Supply Chain & Policy Integration:** Key elements such as reverse supply chain actors, capacity building, economic modelling, and policy development must be integrated—they are all critical pieces of the puzzle.
- **Life Extension – An Overlooked Strategy:** Extending product lifespans is a powerful way to reduce material demand, yet it is often overlooked in policy frameworks.


UK Technology Metals Observatory
Circular flows
Challenges
Technology metals, components and products
Make a difference
About
UK TECHNOLOGY METALS OBSERVATORY
Technology metals are essential for all low-carbon and digital technologies and are vital for the energy transition and meeting climate change (net zero) targets. The UK technology metals circular economy ecosystem should be underpinned by robust data and knowledge on the stocks and flows of whole value chains, from raw material production to end of life, including the reverse supply chains.
https://techmetalsobservatory.org/


Rare earth permanent magnets in UK wind farms
Layer control
Installed capacity
Rare earth element content
Magnet content
Map legend
Magnet content
Magnet content per farm (kg)
Time slider
Dashboard
Hornsea 1 - Heron & Njord
Operator
Orsted (formerly Dong Energy)
Wind farm type
Offshore
Number of turbines
174
MW per turbine
7
Installed capacity (MW)
1218
Magnet content per farm (kg)
872468.683
REE per farm (kg)
291102
Operational date
2019-12-01
Decomissioning date (estimated)
2044-12-01
https://techmetalsobservatory.org/technology-metals-components-and-products/products/wind-turbines.html/