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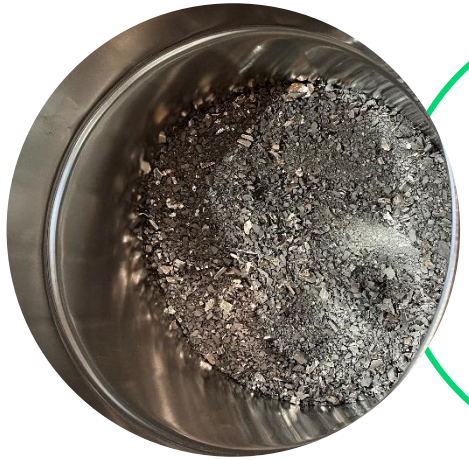
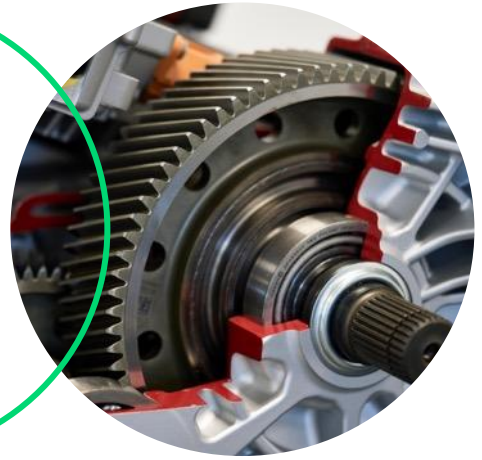
Leading Magnet Recycling and the Circular Economy of Rare Earths

Circular Republic
Knorr-Bremse Circular Technology Award 2026

Step Change in Magnet Recycling

COMMERCIALIZING RECYCLING RARE EARTH PERMANENT MAGNETS TO PRODUCE HIGH PURITY, SEPARATED MAGNET RARE EARTH OXIDES





Mixed grades of waste permanent magnets and swarf from existing metal, alloy and magnet supply chain

- ✓ Any composition of NdFeB magnet
- ✓ Compatible with oxidized material
- ✓ Coated magnets acceptable

Recycled separated high-purity (>99.5%) grade magnet REOs from domestic advanced manufacturing

- ✓ Nd_2O_3
- ✓ Pr_6O_{11}
- ✓ $(NdPr)_2O_3$
- ✓ Dy_2O_3
- ✓ Tb_4O_7
- ✓ Ho_2O_3

High spec permanent magnets for net zero carbon technologies such as EV motors and off-shore wind turbines

- ✓ Products for any grade of magnet
- ✓ Full specification flexibility
- ✓ Recovery rate of 95% plus

China is focused on selling only finished magnets or further downstream products; Rare earth alloys and oxides are in critically short supply for western production

China Rare Earth Export Restrictions

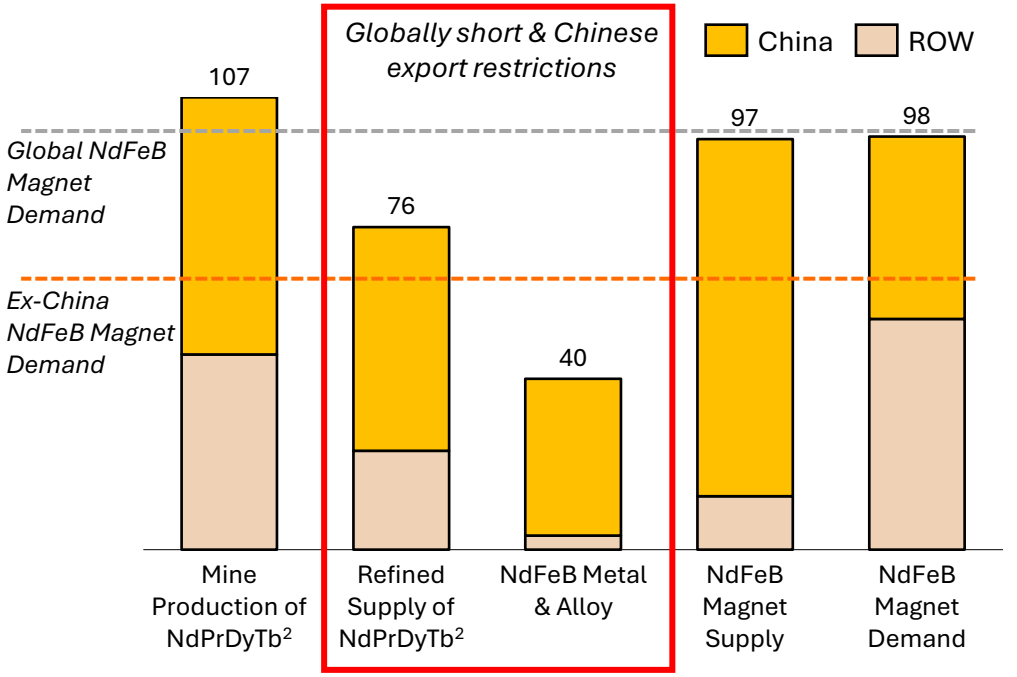
Export of RE ores & concentrates **banned**; in recent years China has ramped up production using **mining quotas** – leaving industry to digest the excess.(Including export restrictions on all RE separation to magnet production technology and machinery)

	IP Restricted	Export Control on 7 REEs	No VAT Rebate
Ores & Concentrates			
Oxides	IP Restricted	Export Control on 7 REEs	No VAT Rebate
Metals	IP Restricted	Export Control	VAT Rebate[3]
Magnets	Incentivized	No restrictions	VAT Rebate[3] (on magnets)
End-Use Products			

Export Control

- **On April 4, 2025**, China imposed export restrictions on **7 rare earth elements and magnets used in defense**, energy, and automotive sectors
- Restrictions apply to **Dy, Tb, Sm, Gd, Lu, Sc, Y** – and requires companies to secure special export licenses to export these minerals and magnets
- On June 11, 2025, it was reported that **China plans to put a six-month limit on rare earth export licenses for US automakers and manufacturers, giving China leverage for future trade tensions**

2028 Estimated Global NdFeB Magnet Value Chain (kt REO)

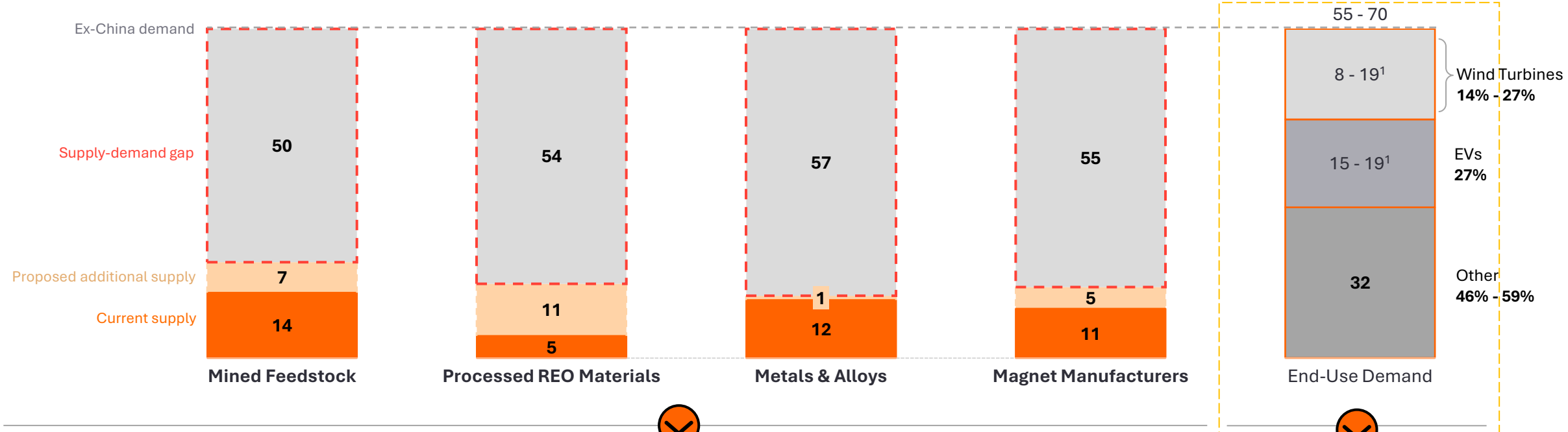


While China possesses extensive magnet production capabilities and has curtailed production expansion outside its borders through technology and machinery export restrictions, there is ***no substantial medium-term supply, consequently there is a significant supply/demand gap*** *in global magnet production.* ***Producers outside of China*** *must either compete with* ***Chinese export prices, with VAT rebates, or rely on incentives to bolster local production.***

1. Sources: Wood Mackenzie Global rare earths investment horizon outlook – December 2023, Project Blue; Does a detachment from the Chinese rare earth market threaten the global energy transition? (19/10/2023), Announcement No.18 of 2025 of the Ministry of Commerce and the General Administration of Customs of the People's Republic of China (4 April 2025). 2 . Represents total forecasted mined and refined production of Nd, Pr, Dy, and Tb; used in other applications in addition to NdFeB magnets.
3. VAT rebate, provides for the recovery of input taxes paid. It allows qualifying businesses in China to claim back VAT paid on purchases of goods or services related to the business' provision of VAT taxable goods.

Ex-China demand for Permanent Magnet Supply – needs new REO capacity

Ex-China NdPrDyTb Gap in NdFeB Value Chain Supply 2028 (Kt REO)



11 - 12	22 - 24	26 - 32	10 - 11
Gap in # of Average Mines (Projected supply vs. demand in 2028)	**Gap in # of Average REO Separation Manufacturers** (Projected supply vs. demand in 2028)	**Gap in # of Average Metals & Alloys Manufacturers** (Projected supply vs. demand in 2028)	**Gap in # of Average Magnet Manufacturers** (Projected supply vs. demand in 2028)

Other Demand:
- Defence Applications
- Electrical Components
- Mechanical Components
- Air Conditioning

1. International Energy Agency (IEA) forecasted rare earth elements (REE) magnet demand in year 2028 https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer
2. Gap in number of mines or manufacturers needed based on IEA forecasted REE magnet demand in year 2028

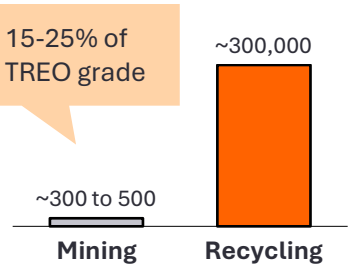
Sources: Argus Direct, WoodMac, US Department of Defense, InspiREs, International Energy Agency, Company Investor Presentations and Financial Reports

Magnet Recycling vs Mine Supply:

HIGHER FEEDSTOCK GRADE CONTRIBUTES TO HIGHER RETURNS WITH LOWER RISK

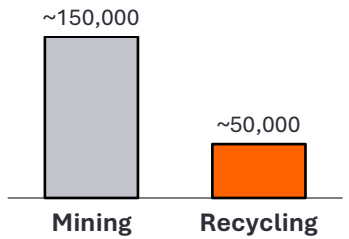
Higher Returns

Grade of magnet REOs (ppm)



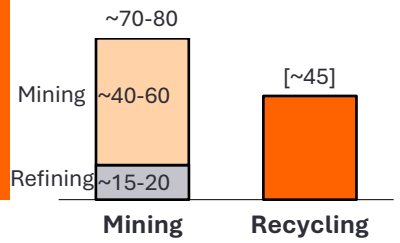
- Higher grades mean a substantial reduction in feedstock processing requirement per tonne of REO

CAPEX[1] Intensity ($ per tonne produced)



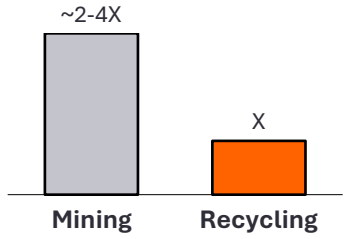
- Lower amount of feedstock to process results in lower CAPEX and footprint per tonne NdPrDyTb
- Lower risk of a CAPEX overrun due to smaller scale and relatively simpler scope

OPEX[1] ($/kg REO)



- Lower feedstock volume and higher grade translates into lower reagent, energy, labor and maintenance costs
- Energy and reagent costs depend on the recycling technology used

Working Capital



- In mining, large volume of material undergoes processing steps at multiple facilities across the world, incurring significant time and logistical cost
- Recycling has relatively quicker inventory/sales cycles

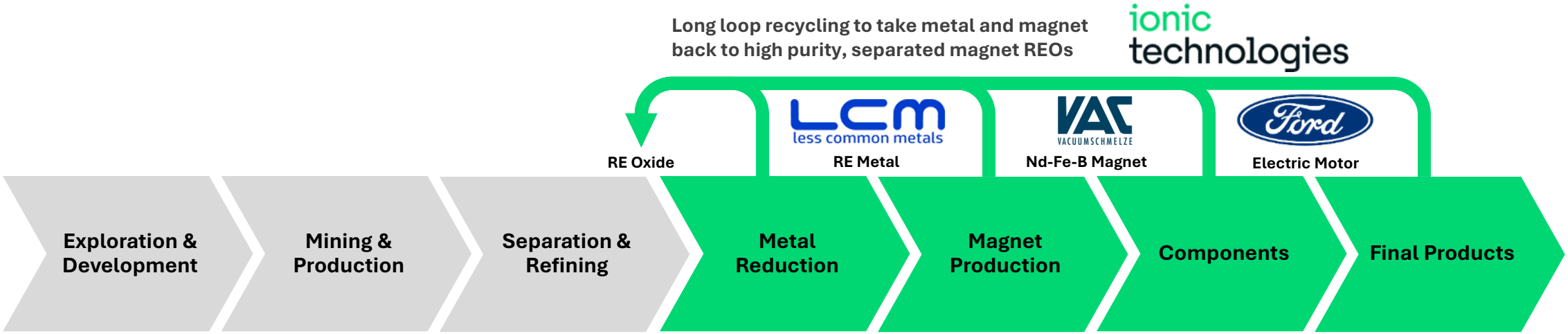
Lower Risks

Permitting and Social License	Permitting for a mine often involves extensive land clearance and displacement of population. Permitting for recycling facility is relatively simple
Environmental Footprint	LCA (Life Cycle Analysis) completed demonstrating 60% lower CO_2 footprint reduction compared to existing mining operations, no radionuclides
Time/Speed of Development	Unlike mining, recycling has relatively shorter supply chain and thus the speed of development is faster
Government Support & Incentives	Significant support for recycling by UK, US, EU, Brazilian government (multiple peers got grants), smaller grant, higher appetite for govt. investment
Integration within the Supply Chain	Direct relationship with metal, alloy, magnet makers and OEMs: results in de-risking of operations and access to their swarf, waste
OEM Support	Significant OEM support for the sector, as many pledge their commitment to circular economy initiatives
Licence to Operate Risk	Licence to Operate risks in mining jurisdictions can be higher compared to recycling facility embedded within advanced manufacturing countries (UK, US, EU)

1. Indicative numbers based on preliminary analysis – actual number depends on the facility, process, feedstock, power costs, reagents used etc. Basis informed by Belfast Commercial magnet recycling feasibility study announced 18 November 2024. Mining examples taken from a cross section of development projects. 2. LCA announced to ASX on 13 March 2025.

Overview & Technology

RECYCLING OFFERS A STEP CHANGE TO UNLOCK LOW CAPEX ALTERNATIVE SUPPLY CHAIN SOLUTIONS FOR IMMEDIATE MAGNET REO SOURCES TO CREATE INSULATED, SOVEREIGN CAPABILITY FOR WESTERN END USERS ACROSS DEFENCE, ENERGY TRANSITION AND ADVANCED MANUFACTURING



Ionic Technologies is 100% owned by ASX listed Ionic Rare Earths Limited (ASX: IXR)

Technology provides a hydrometallurgical 'long loop' recycling method to produce individually separated rare earth oxides (NrPr, Dy and Tb) at >99.5% purity

Developing a domestic supply chain now for the UK in a model that can be rapidly replicated in other western markets

Technology can be used on other rare earths – notably medium and heavy RE "upcycling"

Rapid Progression to Commercialisation

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Technical Developer Accelerator Program

QUEEN'S UNIVERSITY BELFAST

ADVANCED PROPULSION CENTRE UK

UKRI Innovate UK

Scale-Up Readiness Validation & CLIMATES

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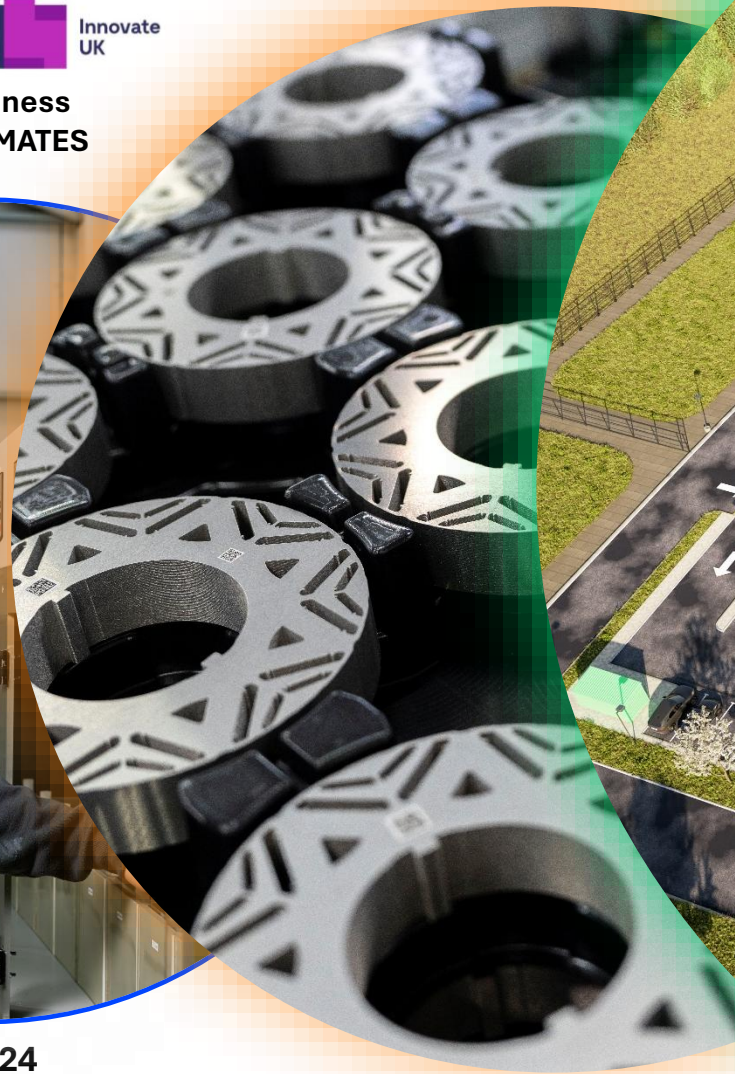
DRIVE35 Collaborate CirculaREEconomy



2022
Lab Scale

2022
Pilot Scale

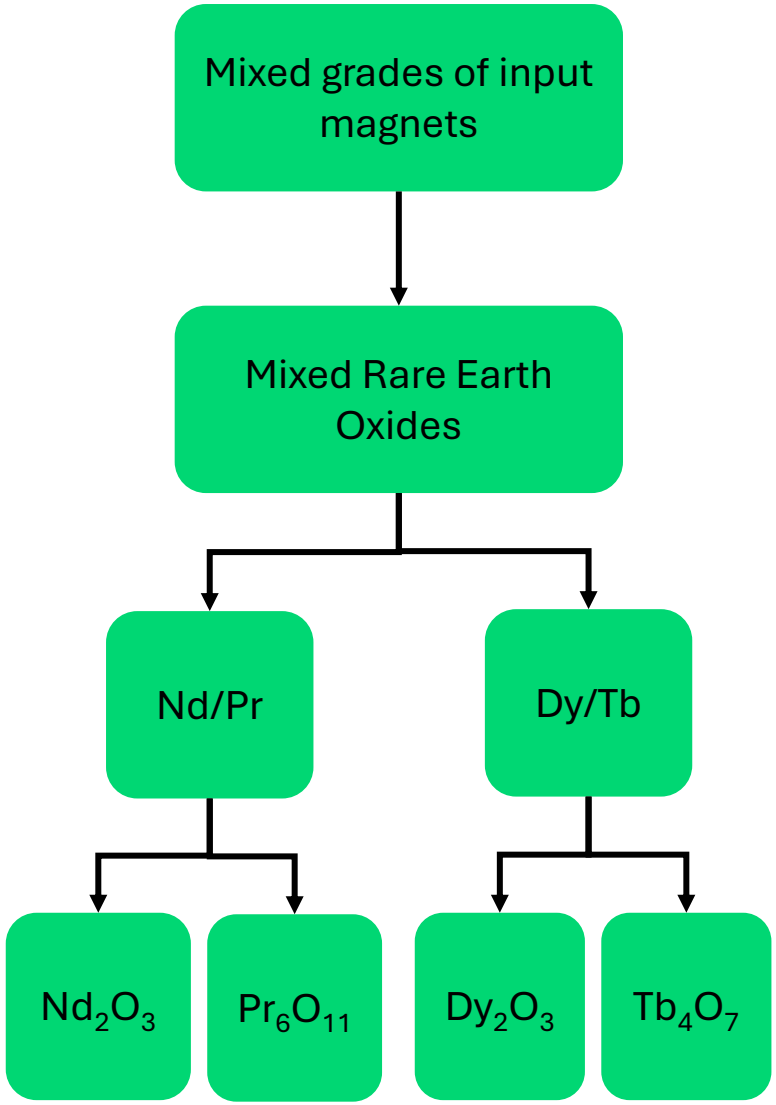
2023/24
Demonstration Plant
10tpa REO capacity

2025/28
Supply Chain Validation

2027/28
Commercial Plant[1]
400tpa REO capacity

1. Facility Render, planned construction expected to be completed late 2027, subject to financing and approval being received.

Long-Loop Recycling Competitive Advantage



- ✓ Unlike most recycling technologies, Ionic Technologies can accommodate all grades and oxidation states, and high variability in end-of-life magnet composition.
- ✓ Ionic Technologies produce a high purity Mixed REO, and can incorporate similar material from third parties, using 3 advanced pre-treatment routes
- ✓ Targeted light/heavy separation, supported by ionic liquids, enables highly efficient solvent extraction, producing NdPr appropriate for all magnet applications
- ✓ **The proven capability to produce high purity separated REOs (99.5% plus) enables the highest specification of magnets to be produced**

Process overview

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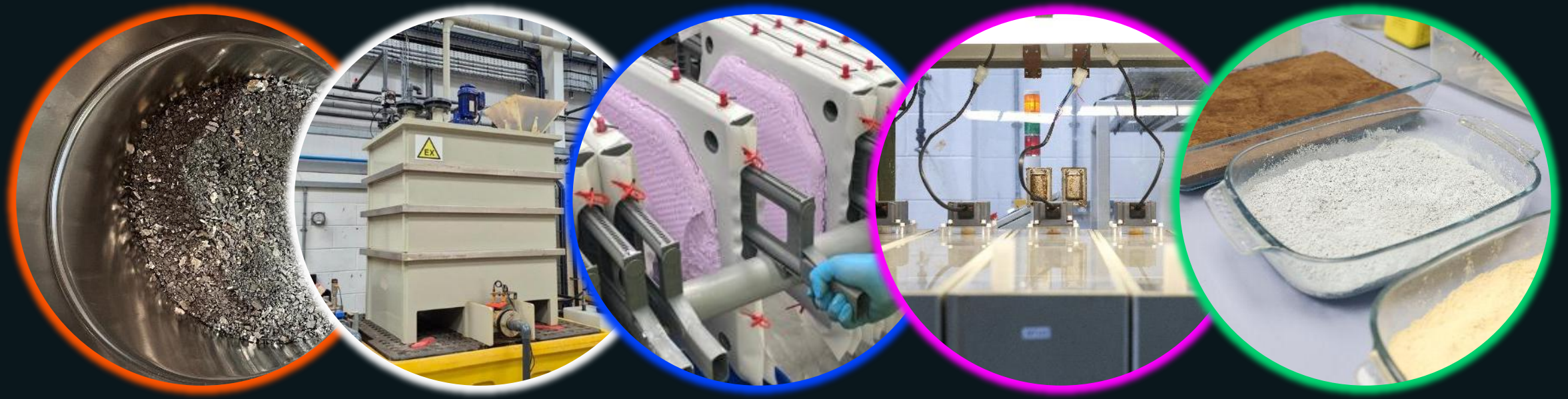
Magnet crushing / grinding

Digestion

Separate base metals (Fe, Mn, Al, Ni, Cu, B)

Nd, Pr, Dy, Tb solvent separation

Individual oxides precipitation



Crushed magnets

Magnet Digestion tank being operated

Mixed Rare Earth Oxide cake from filter press

Solvent Extraction circuit

Terbium, Neodymium and Dysprosium Oxides

Ionic Technologies Demonstration Plant

- The UK Demonstration Plant is operational
- 30 tonnes per annum magnet capacity, yielding 10 tonnes per annum Rare Earth Oxides
- UK Government support of circa £5million for delivery and demonstration projects
- Collaborations with numerous key stakeholder organisations including Ford, LCM, Bentley, Wrightbus and VAC

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Ford

LCM less common metals

VAC VACUUMSCHMELZE

MINVIRO

GKN POWDER METALLURGY

BGS British Geological Survey

Materials Processing Institute

WRIGHT

BENTLEY

emr

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UKRI Innovate UK

Management Team

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Tim Harrison

Managing Director / CEO

Overseeing Ionic Technologies' magnet recycling business, leveraging over 20 years of expertise in mineral processing and hydrometallurgy across all stages of project development.

Brett Lynch

Chairman

With a strong background in managing multi-million-dollar mining and mining related operations globally, he focuses on driving value and advancing the company's goals.

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Thomas Kelly

Director of Operations

Leader of the UK based subsidiary business, stakeholder engagement and operations. An experienced operational leader in chemical and engineering industries.

Dr Fergal Coleman

Head of Technology

Specialising in ionic liquids and inorganic chemistry. With extensive experience in R&D, process scale-up, and commercialisation, he leads the development of our magnet recycling process.

Tracy Baker

Finance Manager & Company Secretary

Tracy brings extensive experience in finance and administration to Ionic Technologies. She oversees the company's financial management.

Julien Lehoux

Project Manager

Julien is responsible for delivering feasibility studies, managing research projects, reporting on technical developments, and leading plant-related projects.

Curtiss Danks

Demo Plant Manager

Leading operational activities for the Magnet Recycling Demonstration Plant in Belfast, working closely with his team of technicians.

Life Cycle Analysis – Saving a finite resource, minimizing emissions

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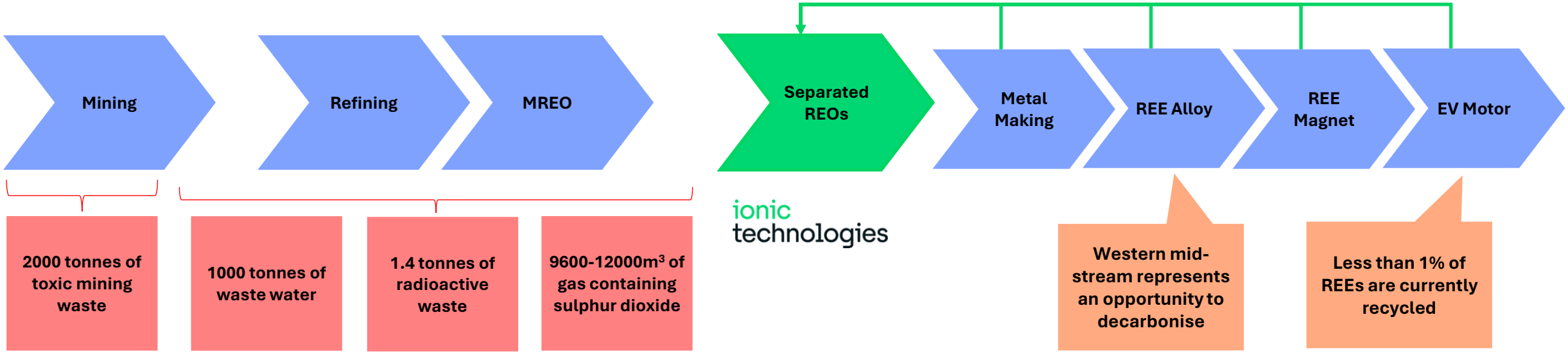
LONG-LOOP RECYCLING OF RARE EARTHS REPRESENTS A STEP CHANGE IN RECYCLING PRACTICES AND ENVIRONMENTAL IMPACT

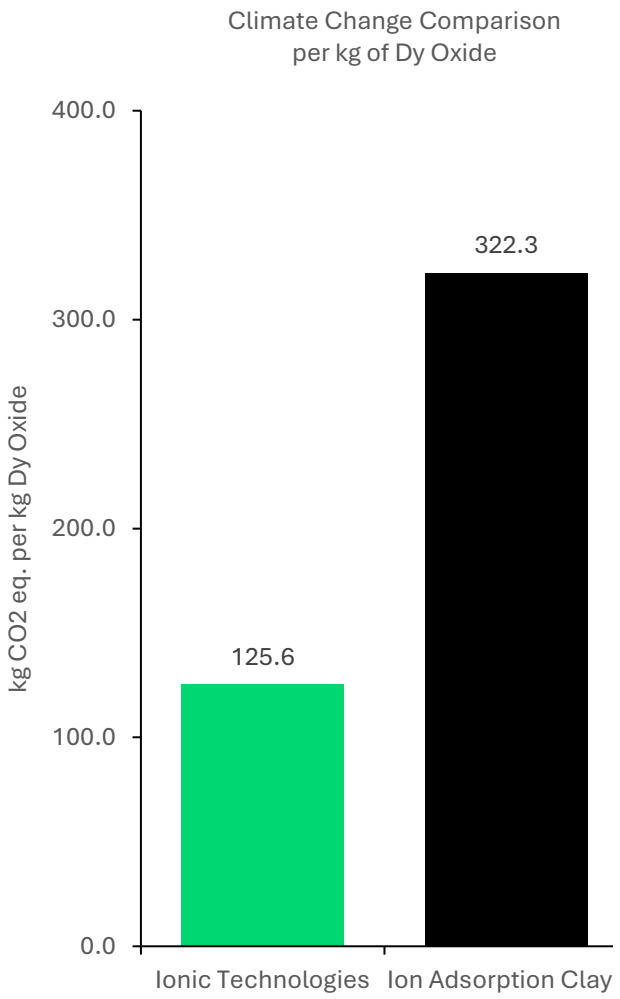


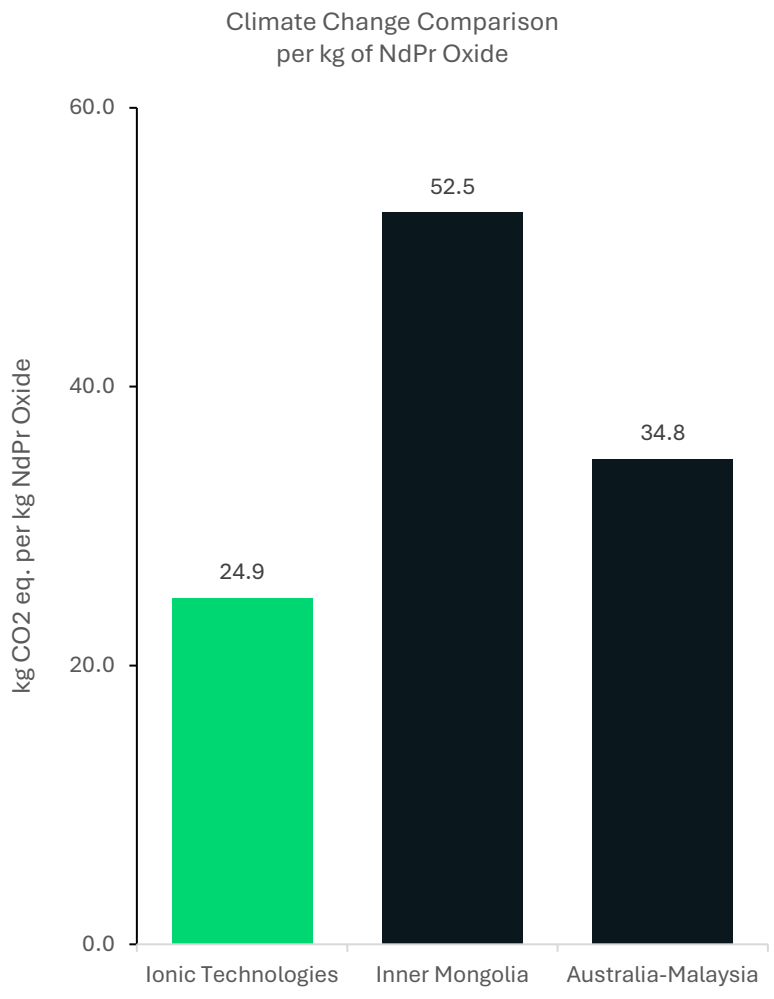
Per each tonne of REEs generated

- ✓ Ionic Technologies long-loop process eliminates emissions and wastes associated with primary sourcing
- ✓ Zero radioactive waste is generated via long-loop recycling
- ✓ Significant volumes of water are saved by recycling REEs
- ✓ As Western energy production is decarbonised, there is a growing opportunity to reduce CO_2 in the magnet supply chain
- ✓ A tiny proportion of REE material is currently recycled; the potential to economically recover this material relies on robust long-loop recycling

Adapted from "2023, How to build a circular economy for rare-earth elements, Yong Geng, Joseph Sarkis & Raimund Bleischwitz"

Life Cycle Analysis – Product Carbon Footprint





- ✓ Reduction in CO_2 compared to conventional primary REE supply
- ✓ Secondary REE material is interchangeable with primary material
- ✓ No radioactive waste
- ✓ No sulfur dioxide
- ✓ No toxic waste
- ✓ Minimal water consumption
- ✓ Recovery of a finite resource

✓ 61% CO_2 reduction on Dysprosium Oxide (Dy_2O_3)

✓ Up to 53% CO_2 reduction on NdPr Oxide ($(NdPr)_2O_3$)

creem
CircularReeconomy

DRIVE 35 Collaborate

- ✓ Commenced 01 September 2025
- ✓ 36 Months Project
- ✓ £11million Project
- ✓ Leading Collaborate project, part of the UK Government's DRIVE35 launch
- ✓ Partners Ionic Technologies with UK industry leaders at each stage of a circular REE supply chain
- ✓ Quantifies/reduces CO_2 and costs
- ✓ Supports renewables and defence businesses
- ✓ Compliments UK's existing REE capacity

Department for Business & Trade · ADVANCED PROPULSION CENTRE UK · BGS British Geological Survey · emr · Ford · ionic technologies · LCM less common metals · WRIGHT

Demonstrating Capability leading High Performance Supply Chains

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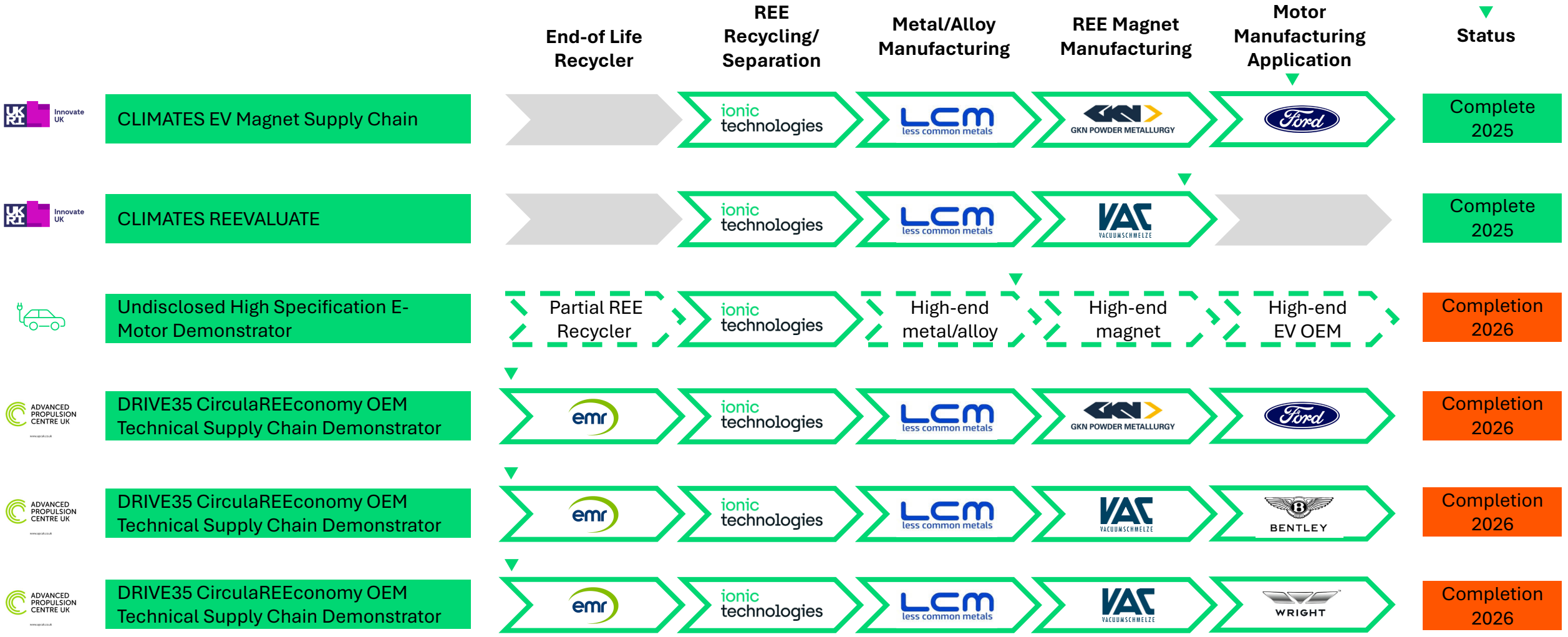
MULTIPLE TECHNICAL DEMONSTRATORS COMPLETED WITH MULTIPLE FEEDSTOCKS AND MULTIPLE E-MOTOR OEM OFF-TAKERS



✓ Multiple additional projects being planned with European supply chain partners for 2026/27.

Supply Chain Partnerships

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SUPPLY CHAIN PARTNERSHIPS FORMING AS WESTERN ECONOMIC VULNERABILITY TO RARE EARTH ELEMENTS (REE) GROWS

	End-of Life Recycler	Metal/Alloy Manufacturing	REE Magnet Manufacturing	Motor Manufacturing Application/ Traders/Others
Memorandum of Understanding	emr	LCM less common metals	JSLINK	VIRIDIS MINING & MINERALS TRONOX TRADIUM
Announced Supply Chain Production	emr	LCM less common metals	VAC VACUUMSCHMELZE GKN POWDER METALLURGY	Ford BENTLEY WRIGHT

Commercial Plant – Key Metrics

FEASIBILITY STUDY COMPLETED IN 2024, DETAILS A 1200 TPA MAGNET – 400 TPA RARE EARTH OXIDE RECYCLING FACILITY IN BELFAST

Overview of commercial plant

- Planned commercial plant would represent a 40-fold increase in production capacity (400tpa) from the demonstration plant (10tpa)

- Modular process design with two 200 tpa production lines, allowing for scale-up flexibility and parallel operation

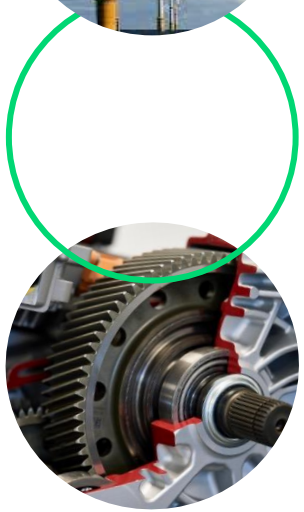
Economics summary from feasibility study

$NPV_{7.5}$ (post-tax) **US$ 502m**	IRR (post-tax) **43.6%**
CAPEX of **£ 85m** with a payback of **2.4 years**	Life of operation **20 years**
Lifetime EBITDA **US$ 1.78b**	Lifetime Net Revenue **US$ 2.12b**
OPEX (excluding EOL magnets and swarf) **$27.68/ kg REO**	Annual Throughput **1200 tpa of magnets/swarf**

Annual Output : **400 tpa of REOs (350 tpa NdPr Oxide, 37 tpa Dysprosium oxide, 13 tpa Terbium Oxide)**

1. Feasibility Study announced 18 November 2024, which contains a set of assumptions and qualification related to commercialisation of the technology in Belfast, UK.

Summary



- ✓ Ionic Technologies offers a sustainable, traceable route to process end-of-life REE permanent magnets and pre-consumer material
- ✓ Long-loop recycling offers the only method to enable Western supply of all REEs needed for e-motors
- ✓ REEs produced via Ionic Technologies are all above the standard 99.5% purity standard for REEs used in permanent magnets for offshore wind turbines
- ✓ European regulation and global geo-political uncertainty are creating a market for European domestic recycling and REE production
- ✓ European REE production and mid-stream manufacturing capacity are extremely limited, with investment in the sector historically stifled by Chinese pricing
- ✓ Ionic Technologies are developing a first-of-kind 1200tpa magnet feedstock/400tpa Rare Earth Oxide production facility in Belfast to be operational in 2027/28.

Key Contacts

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