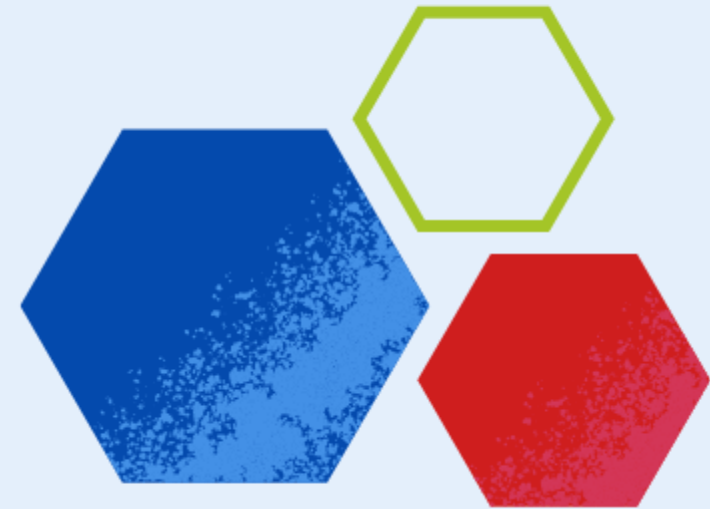




Magellan Project: Building Strategic Synergies Across the Electrical Manufacturing Value Chain

ORANO, Alexandre DAMIENS, CWIEME Berlin 2026



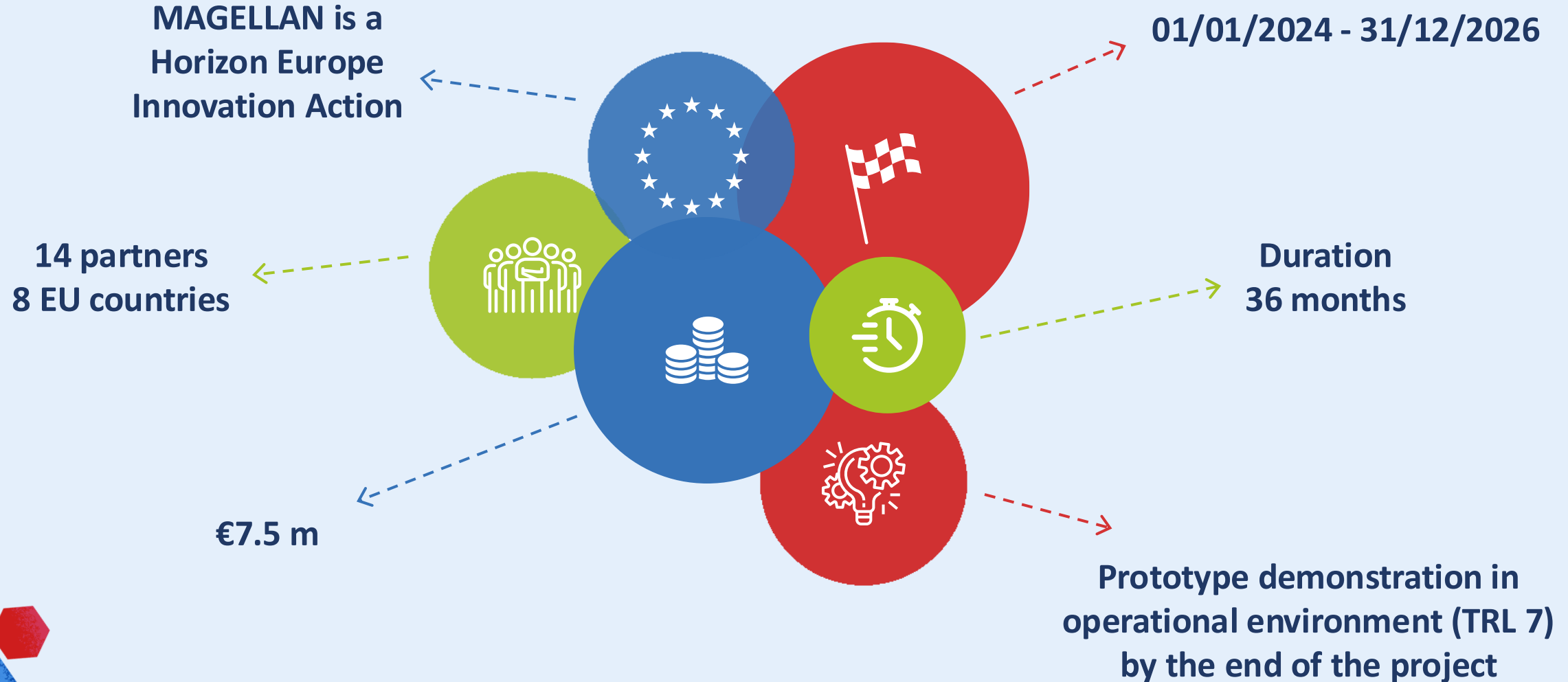
Grant Agreement No:101138260



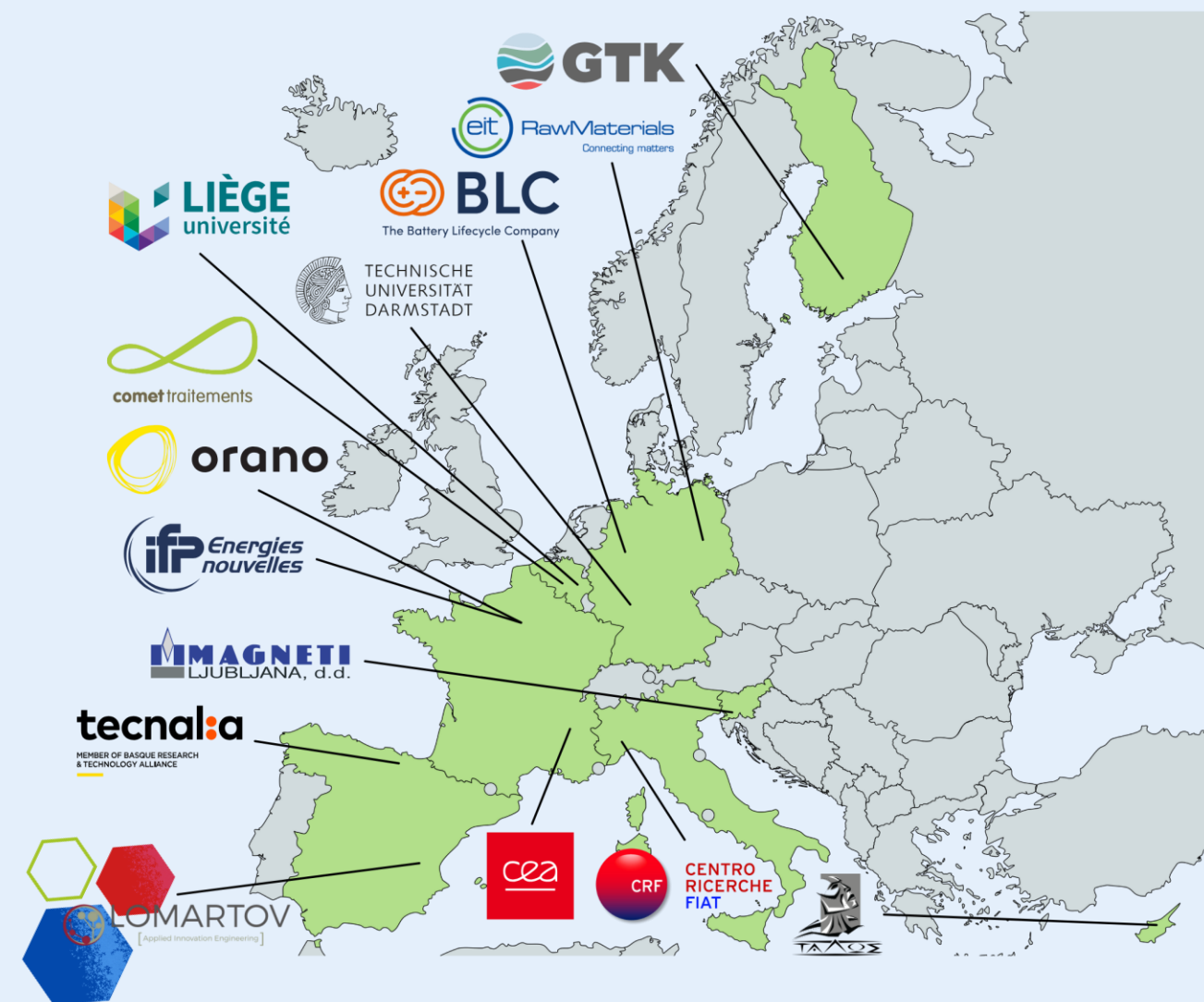
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PROJECT DATA



CONSORTIUM



	Partner	Country
1	ORANO (Coordinator)	France
2	MAGNETI LJUBLJANA	Slovenia
3	CENTRO RICERCHE FIAT SCPA	Italy
4	THE BATTERY LIFECYCLE COMPANY	Germany
5	COMET TRAITEMENTS	Belgium
6	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	France
7	IFP ENERGIES NOUVELLES	France
8	UNIVERSITE DE LIEGE	Belgium
9	FUNDACION TECNALIA RESEARCH & INNOVATION	Spain
10	TECHNISCHE UNIVERSITAT DARMSTADT	Germany
11	GEOLOGIAN TUTKIMUSKESKUS	Finland
12	LOMARTOV SL	Spain
13	RTD TALOS LIMITED	Cyprus
14	EIT RAW MATERIALS GmbH	Germany

SOLUTION

Optimising 3 main steps leading to improvements in the 3 pillars of the **circular economy business model**

USE: Better design of EVTMs

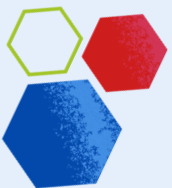
- Facilitate magnet recovery and minimise material loss during reprocessing
- Utilise advanced shaped PMs for improved assembly, avoiding irreversible gluing
- Enhance EVTm performance with better flux distribution and reduced PM mass per kW

MAKE: Better use of REE in the production of magnets

- Increase the sourcing of recycled heavy rare earth elements (HREE) through a short-loop recycling process
- Enhance the use of secondary REE in new high-performance magnets meeting EVTm requirements
- Substitute Neodymium with less critical REE (Ce/La) with supplementary use of HREE

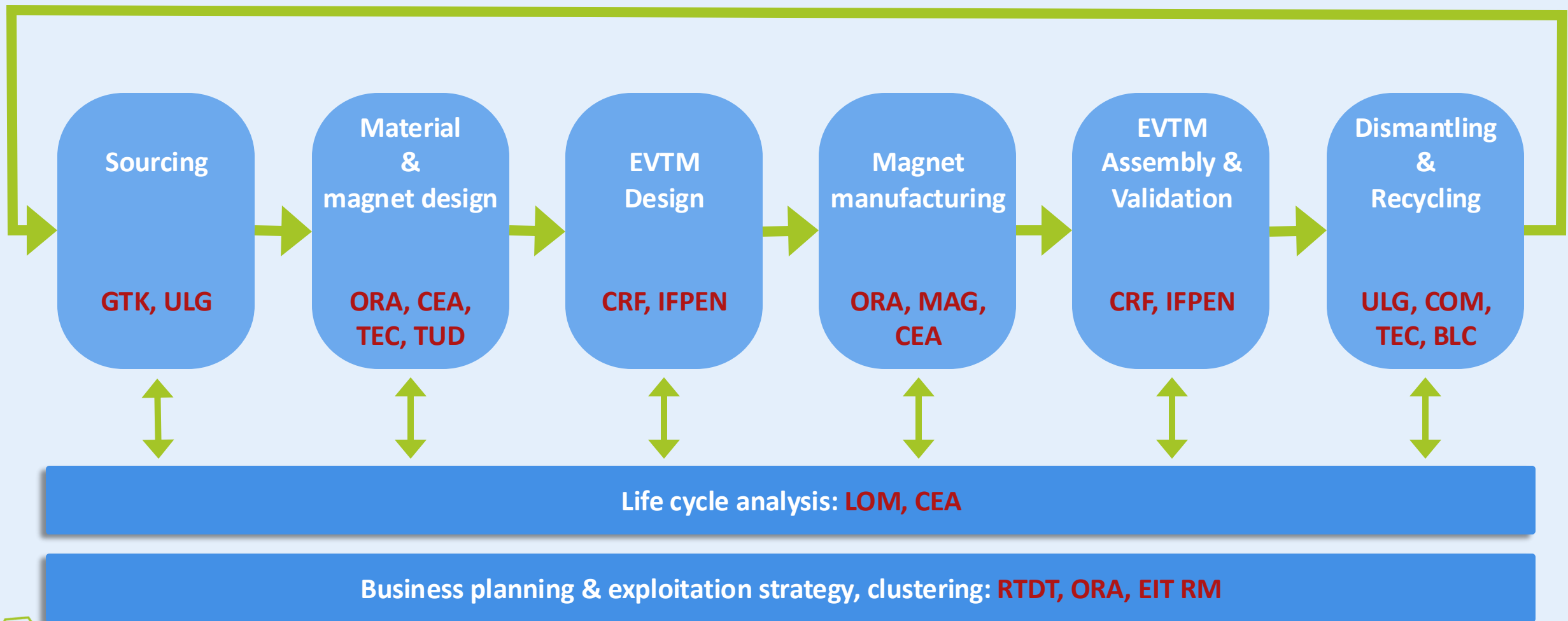
RECOVER: Better recovery, reuse and recycling of REE and PM

- Upscale the magnet-to-alloy route and employ functional recycling to avoid downcycling
- Establish characterisation protocols for directing EoL PMs to their optimal recycling loop
- Promote standardised magnet labelling (composition, size, etc.)

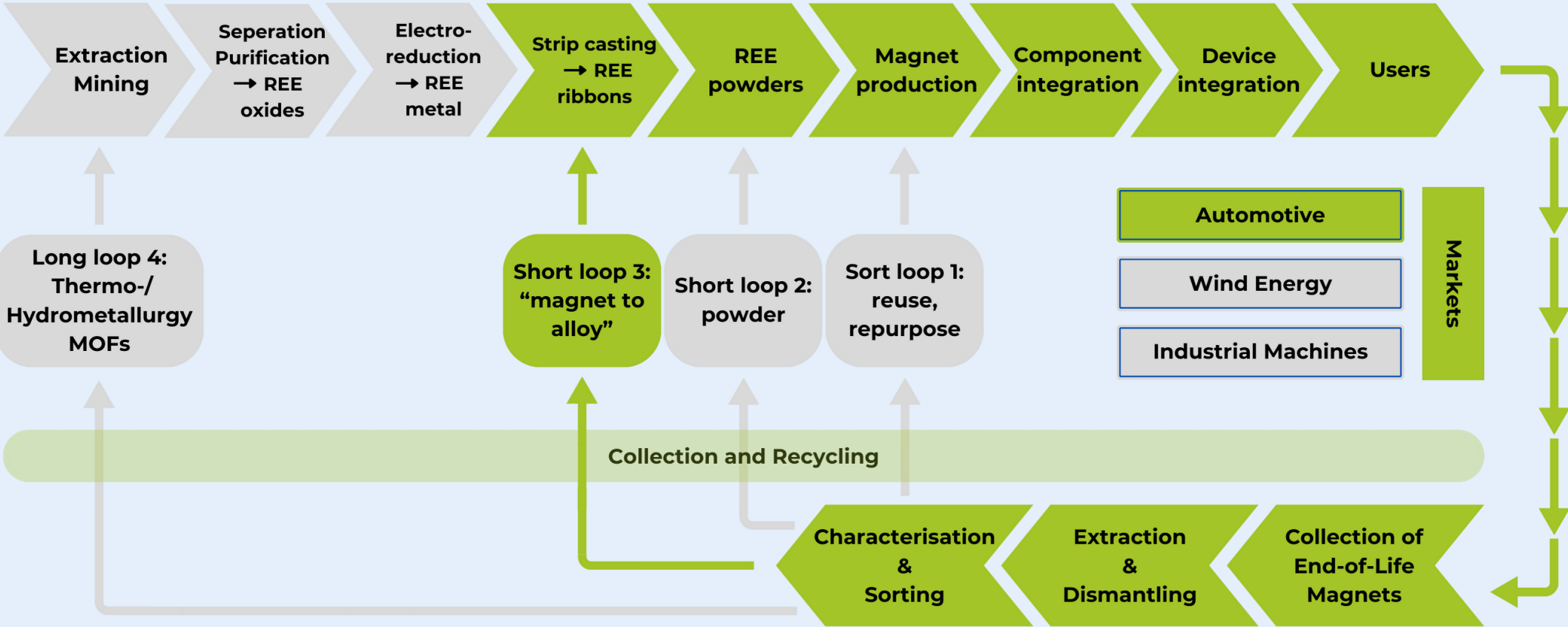


CONSORTIUM

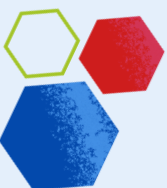
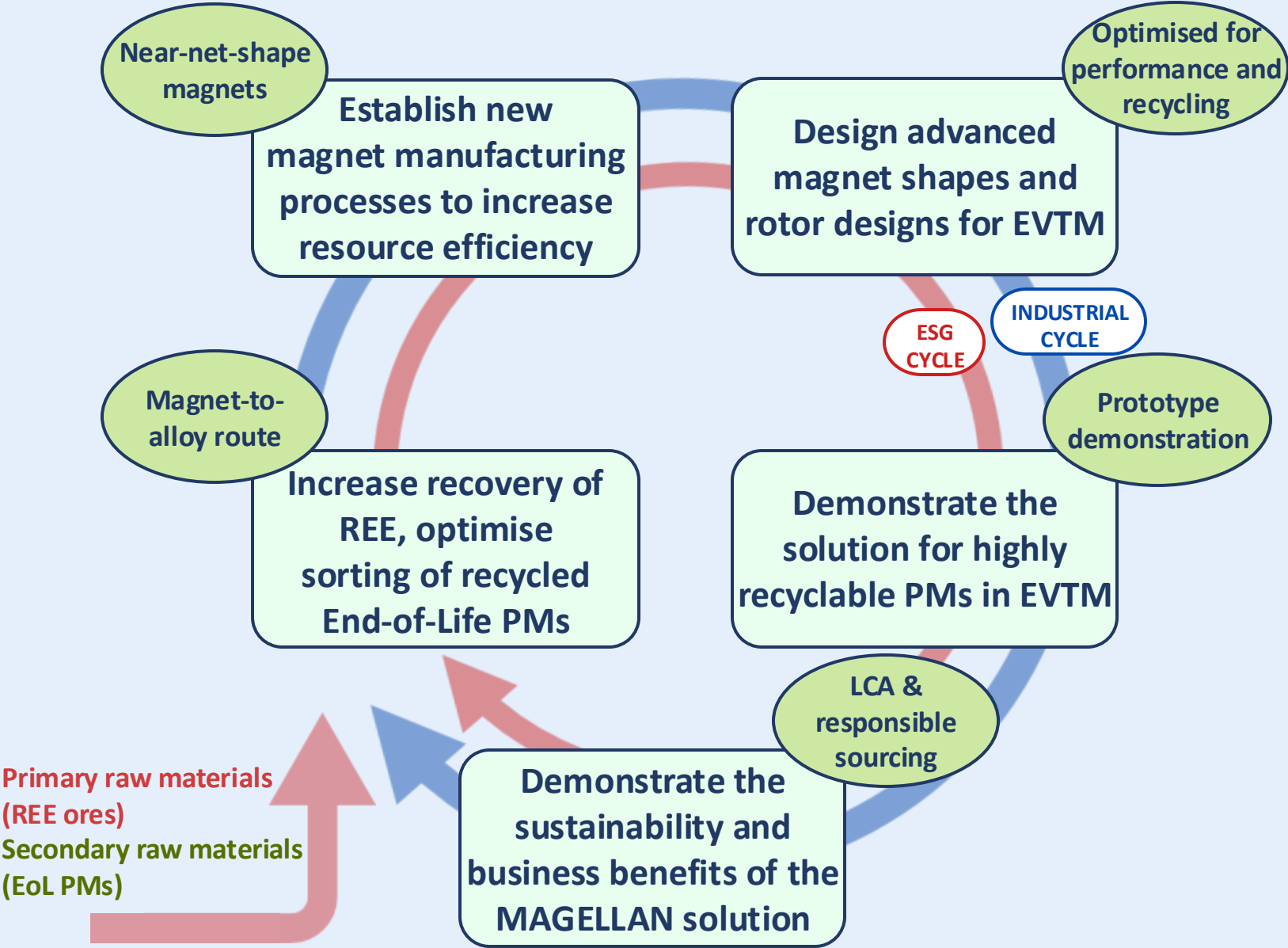
Complementary expertise between academia, research and industry



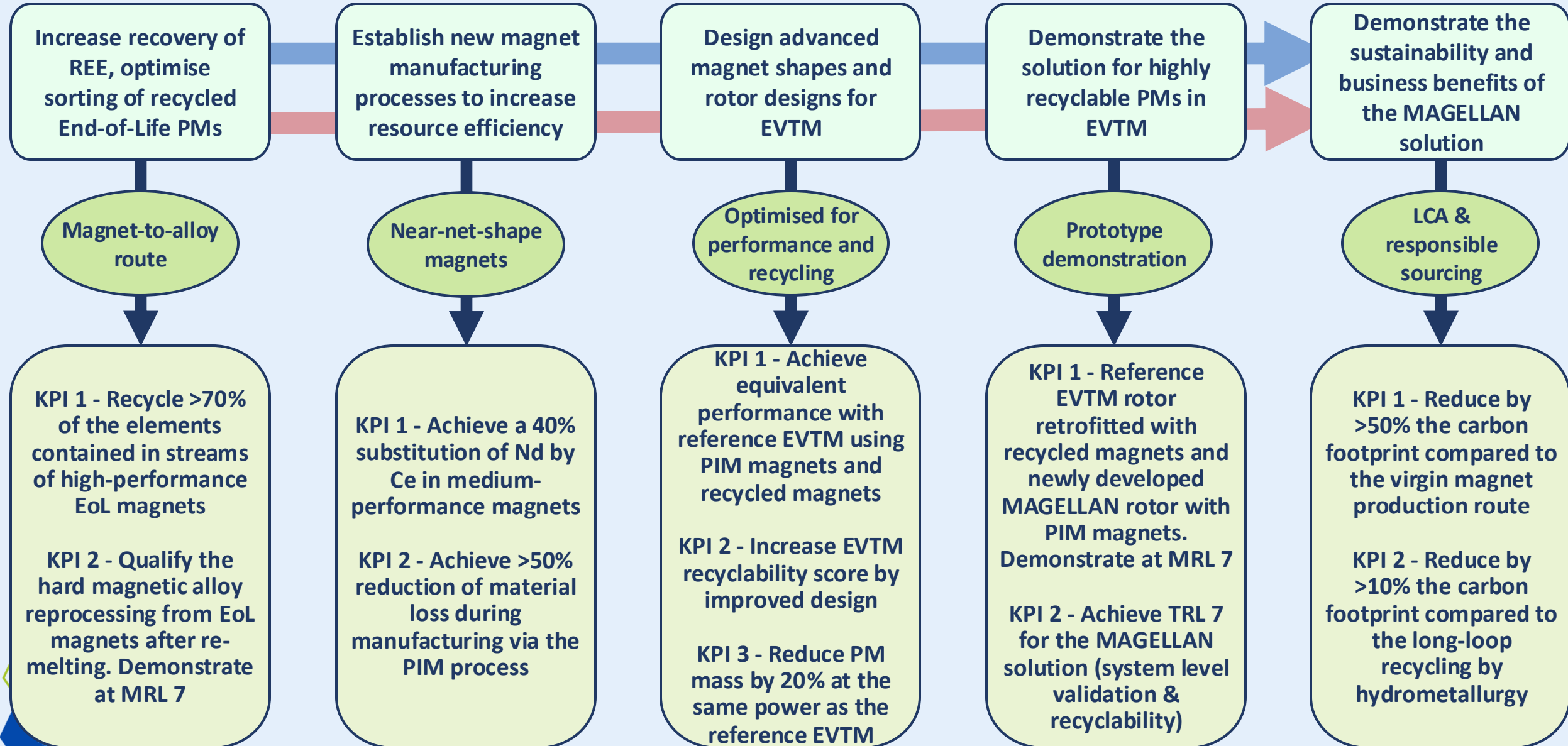
MAGNET-TO-ALLOY ROUTE IN VALUE CHAIN



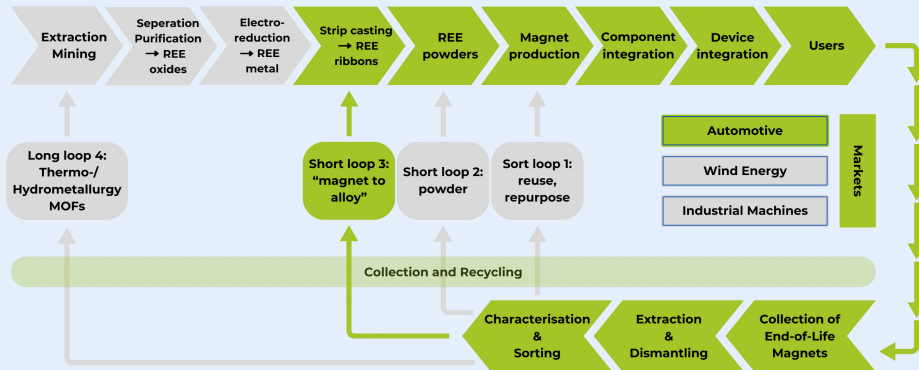
OBJECTIVES



KEY PERFORMANCE INDICATORS



ADVANTAGES OF MAGNET-TO-ALLOY ROUTE



Environmental competitiveness

- ⇒ Conserves up to 70% of the REE in the metallic form, reducing the high energy required for their reduction
- ⇒ Eliminates the need for separation of constituting elements (Nd-Dy-Fe-B), thus avoiding polluting processes

Economic competitiveness

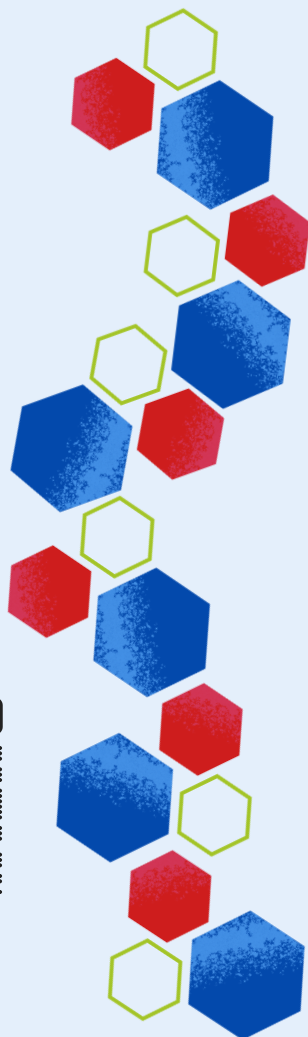
- ⇒ Improves yield, making it more productive
- ⇒ Utilises conventional strip casting equipment already available in magnet manufacturing plants
- ⇒ Enables the incorporation of non-critical primary sources (Ce and La) into different alloys, leveraging cheaper and easier-to-source materials



magELLAN
Magnets in resilient supply chains

**Thank you for
your attention!**

Connect

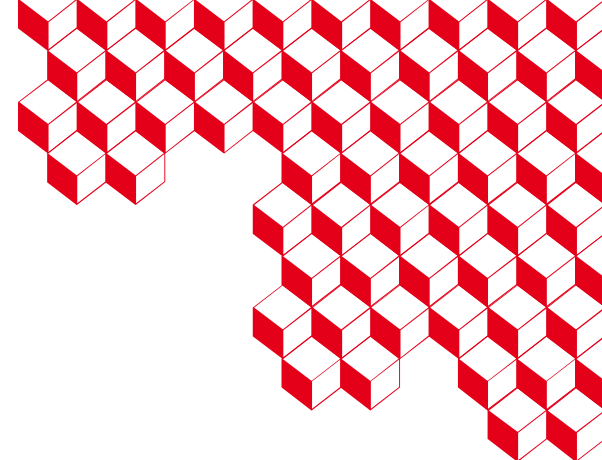


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CEA in Magellan Project

CWIEME

19 May 2026

Benoit Dhien // benoit.dhien@cea.fr

Technology Development & Transfer in Europe

- **CEA** is a Research and Technology Organisation
- Pushing forward technologies **from Labs to Industry**
- By **collaborating** with Industrial **Partners** in Projects
- Committed to building **European R&D**



Low Carbon Energy
(nuclear & renewable)



Digital



Future Healthcare



Defence & Security

CEA Key Figures



+ 20.000

Employees



+ 236

Start-ups



633

Patents

Registered (INPI 2021)



6 Md€

Annual Budget
(Civil & Defence)



+ 700

**Industrial
Partners**



+ 7 200

**Active Patent
Portfolio**



#25

Global Innovators
(Clarivate 2026)

CEA Activities in Magellan Project

- Magnetic alloy casting & grinding
- Producing
 - N38UH shaped magnets
 - by Powder Injection Molding

Shaped magnets are interesting for eco-designing

1. *Easier dismantling and recovery*
2. *Increasing material efficiency*

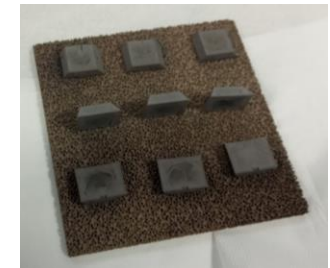
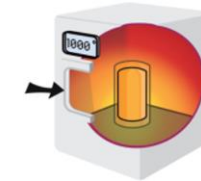
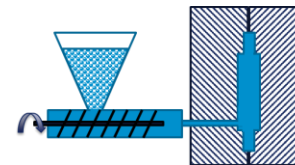
Productive process to make complex shapes



Compounding
powder + binder

Injection
molding

Debinding



Standard powder metallurgy

PIM

Alloying
(strip casting)

Hydrogen
decrepitation

Jet milling

Pressing

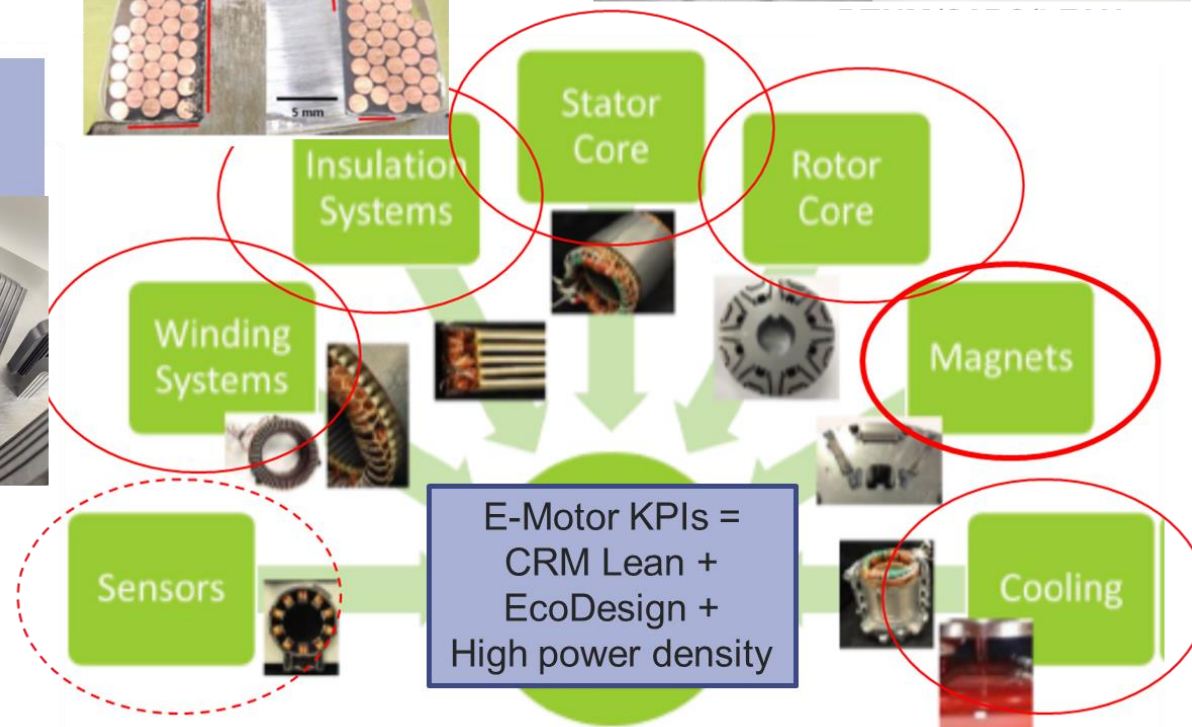
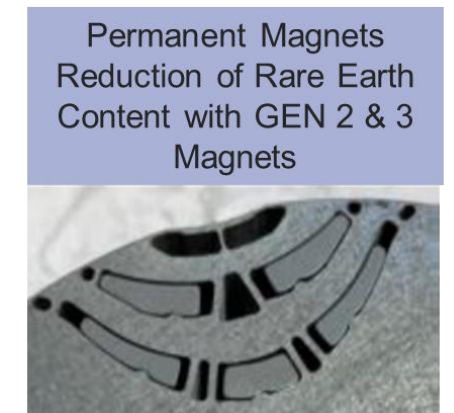
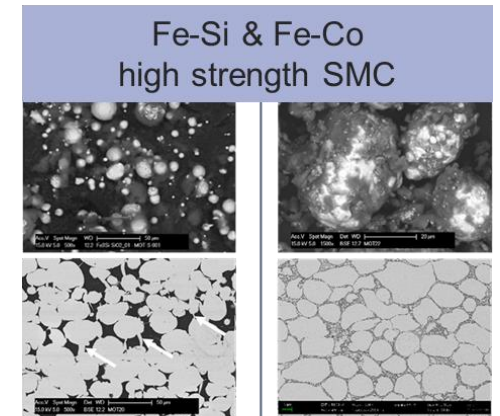
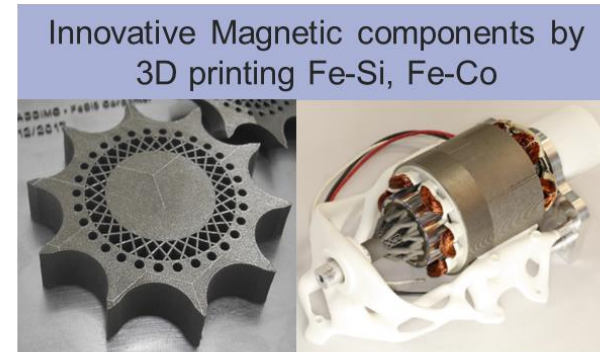
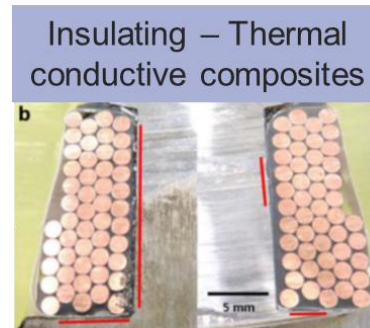
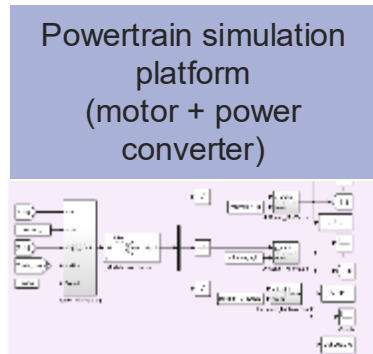
Sintering &
Annealing

Current status
with 1% Dy GBD

- Coercivity: 100%
- Remanence: 98%

E-Motors Materials Developments at CEA

- From materials scale up to powertrain integration (owing to advanced process and simulation)
- Design for performance and circular economy



Rare Earths & Permanent Magnets

*Techno-provider and engineering
for recycling and manufacturing
of high-performance NdFeB Permanent Magnets*



Credits: P. Jayet/CEA-Orano



CWIEME, Berlin
May 2026

Orano is the world expert in nuclear fuel cycle and is embarking on a new era of growth and innovation: the company is opening up to new activities that reflect its purpose and answer some of the challenges of the 21st century

Key Figures (2025)

€ 5.1 bn

of revenue

€ 34.2 bn

order backlog (equivalent to nearly 8 normal years of revenue)

Top 3

in the world
in its key activities

18,000

employees

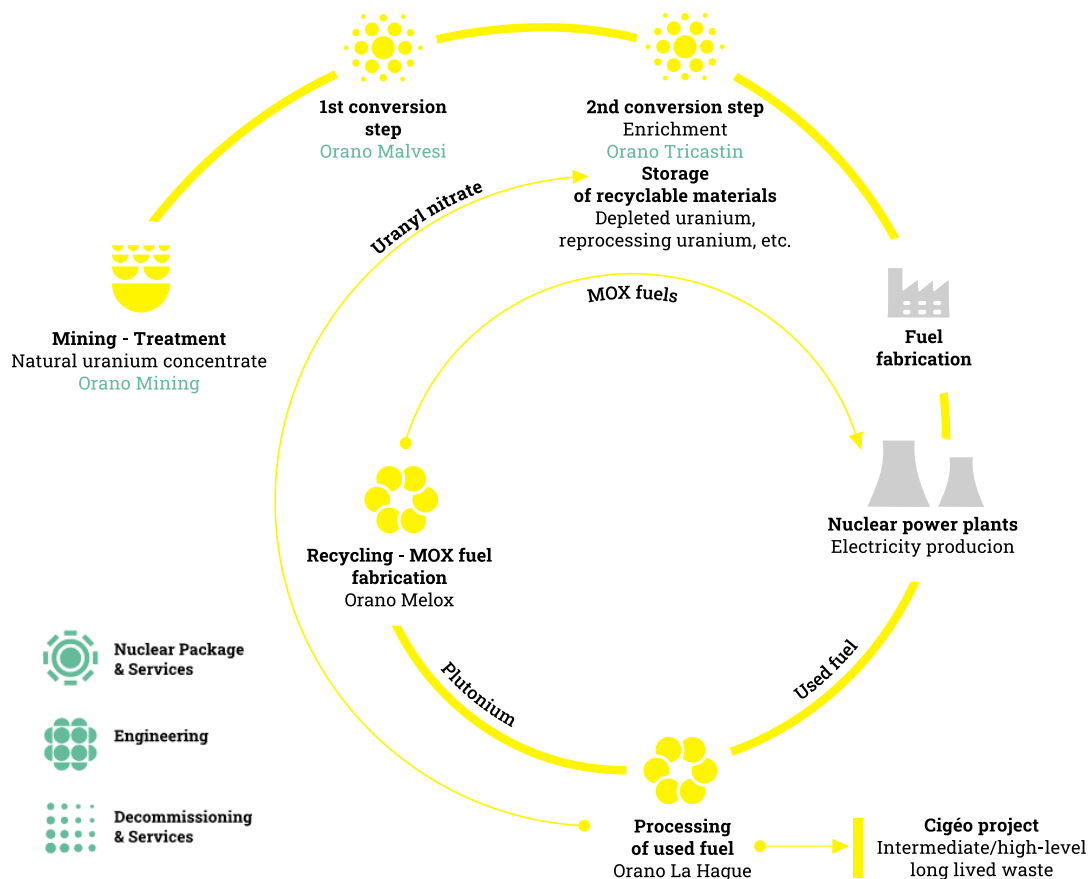
90% *

owned by the
French State



10% owned by Japanese interests

Ensure excellence across the entire fuel cycle to contribute to the production of low-carbon electricity



Invent tomorrow's businesses today



Treatments for cancer via targeted α -therapy



Recycling of strategic materials from EV batteries



Stable isotope production facility



GEN IV molten salt reactors



Am-241 as a fuel for space nuclear batteries

Develop and qualify a process for recycling and manufacturing of high-performance NdFeB permanent magnets

(1) : Electricity generation, Use of resources, Carbon neutrality in 2050, Everyone's health

Orano is implementing an ambitious magnet recycling program based on the considerable know-how acquired in its core business, with the support of its strategic partner CEA



Technical know-how



Hydro-Pyro-Powder metallurgy processes



Processes industrialisation



Industrial production with complex powder in inert atmosphere



MOX fuel production process is similar to permanent magnets' manufacturing process

Recycling know-how

96% of the nuclear fuel used in reactors can be recycled

10% of French nuclear electricity from recycled materials

+38,000 metric tons of fuel processed in 50 years



Orano is the world's expert in nuclear fuel recycling



From R&D to industry

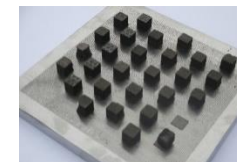
CEA is a key research player, at the service of the French state, its economy and its citizens
Based on an excellent fundamental research, CEA brings solutions in various domains

+60y collaboration with Orano

Originally in the nuclear field, extending to new activities

+15y expertise in magnetic materials and components

High-performance magnetic materials
3D complex shaped magnetic materials
New magnetic components for system optimisation
Rare earth recycling
Critical rare earth reduction



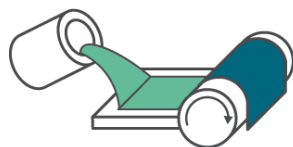
Orano's R&D Work Packages in the manufacturing process of NdFeB sintered permanent magnets

+ Dy Grain Boundary Diffusion

+ Substitution of Nd by Ce

+ Powder Injection Moulding

Used magnets recycling



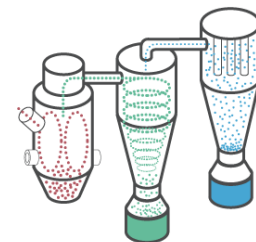
1 Synthesis of the alloy by strip-casting

Used HREE magnets and scraps recycling

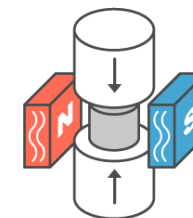


2 Hydrogen decrepitation

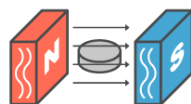
Dy Grain Boundary Diffusion



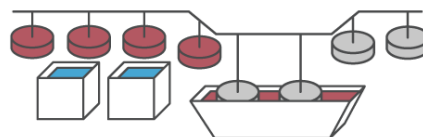
3 Jet-mill to achieve the average grain size and particle size distribution



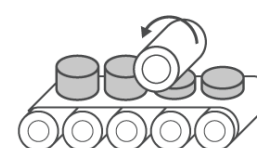
4 Orientation and pressing of the powder



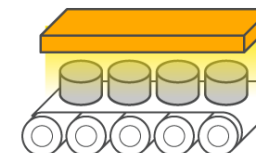
8 Magnetization



7 Surface coating



6 Magnet machining

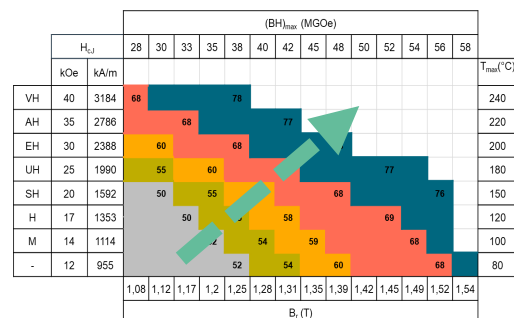


5 Powder sintering and annealing

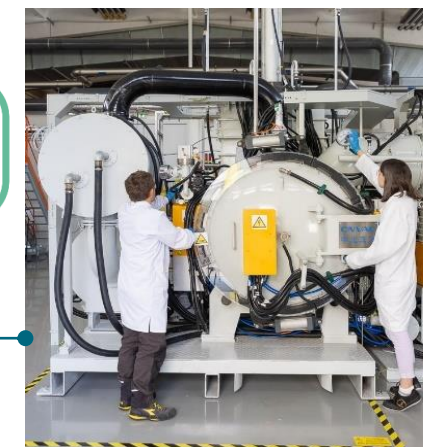
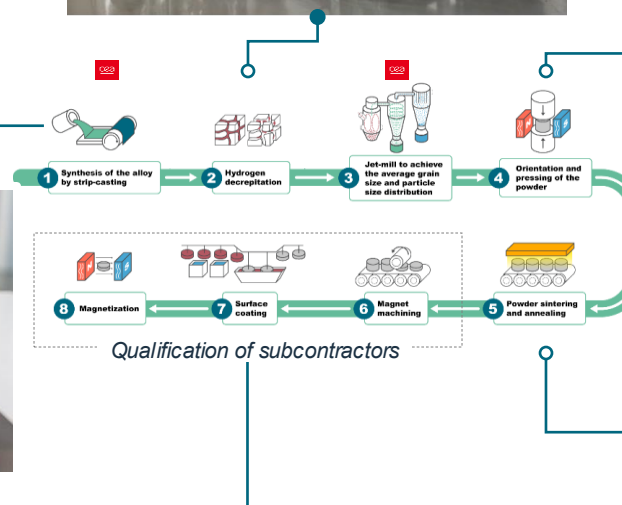
A state-of-the-art 4T pilot line has been inaugurated in September 2025, covering all steps for reaching high-performance, from strip casting to final magnet, next to an advanced characterization facilities

Technologies to improve magnetic performances

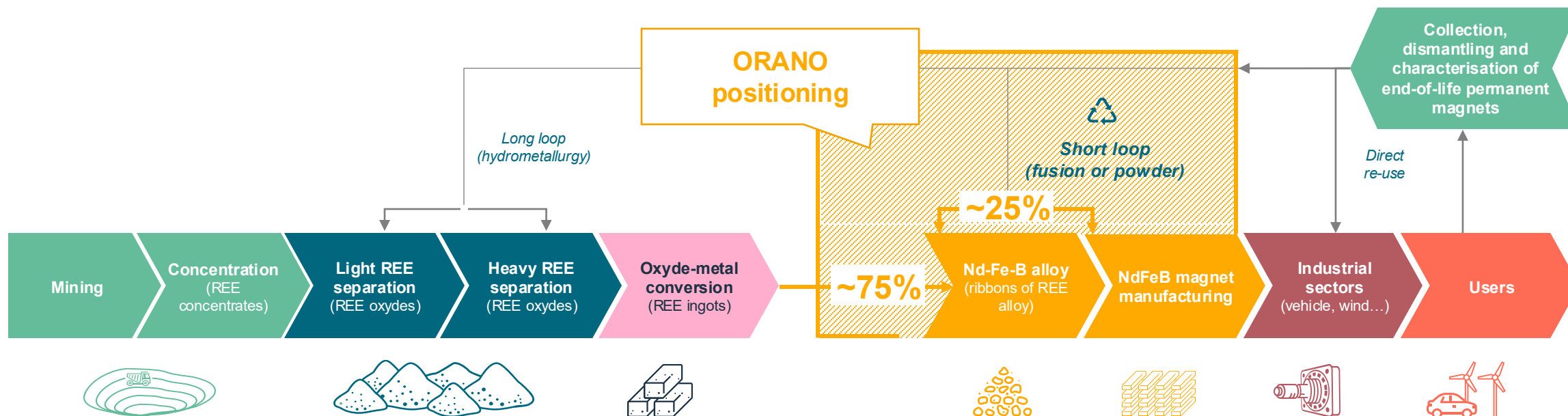
- Strip casting
- Oxygen contamination control
- Reduction of total RE content
- Finer grain size
- Reduction of HRE content
- Grain alignment
- Grain boundary engineering



State-of-the-art process pilot



ORANO program will industrialise an hybrid process for the manufacturing of high-performance magnets incorporating ~25% of secondary raw materials from the short loop



Short loop recycling
in fusion process

Short loop recycling
in powder process

magellan

Co-funded by
the European Union

horizon
europe

MAGNOLIA

FRANCE
RELANCE

bpi france

25%

Recycled content in
future EU REPMs

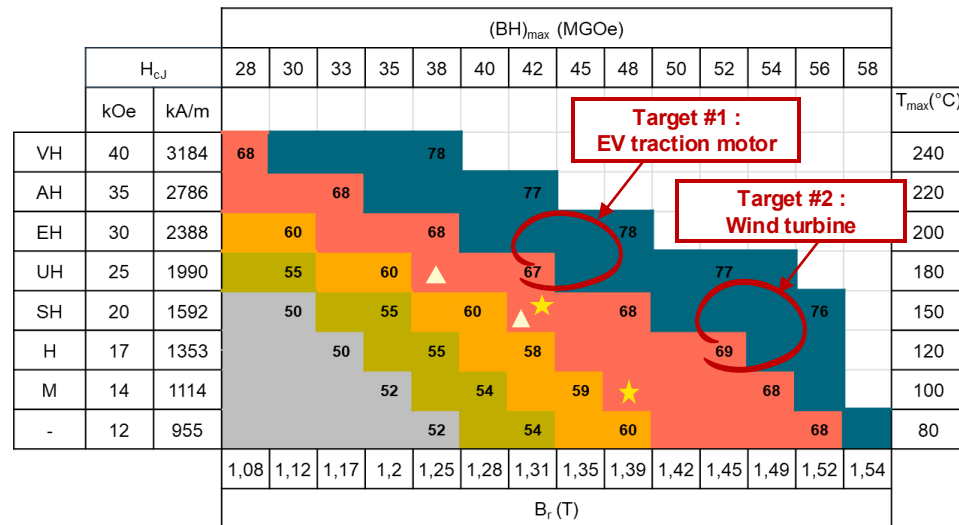
To align with CRMA and cope with high heterogeneity of used magnets' stockpile while meeting stringent requirements

➔ Most adequate positioning, from industrial standpoint, to concretely answer UE's stakes of resilience & circularity

ORANO will reconcile the recycling of used magnets with the high performance of permanent magnets to serve the demanding use cases of 'electric vehicle traction motors' and 'wind turbines'

Unique positioning of the value proposition of ORANO combining both short-loop and high perf.

Orano targets the most demanding applications: electric vehicle traction motors and wind turbines



△ Grade achieved so far with 25% recycled content, before the start of the new process pilot

★ Highest grade achieved so far : N43SH – N43UH, with the new pilot process

○ Targets



The challenges of energy transition command to master the manufacturing of high performance magnets to increase EU's strategic autonomy

Orano's hybrid process is laser-focused on reaching high-performance magnets with ~25% of recycled materials from short-loop

End-of-Life magnets: source of critical materials

- **Technics** → No technical limitation on reaching high % of recycled content
- **Industrial** → Used magnets are today (i) a stock that is not very accessible, although increasing, (ii) with a wide range of compositions and (iii) relatively average magnet grades
- **Quality** → Meet the quality and performance specified
- **Regulation** → CRM Act objective of recycling is set at 25%

EoL Magnets have variable performance and composition and can be sources of contamination (C, O)

C38SH, G48UH,
F45HSH, Dy++,
Ce++, N52M



« **HYBRID recycling approach** - one that preserves the critical microstructure of the magnets, and thereby maintains their essential properties. This is a standalone innovation axis that must be aligned with robust industrial processes, not replace them. »

F. Vial, J. Ormerod, M. Sagawa-san, 2025

Orano is a trusted catalyst to empower a new generation of EU Manufacturers – delivering high performance magnets, circularity and resilience for strategic components and critical materials

Orano, as a qualified techno-provider is driving Europe's magnetic resilience...

From R&D to validation

Phase 1 : done

New pilot process : inaugurated

Phase 2 : confirm results, validate them at pre-industrial scale, with increasing volumes and full repeatability and reproducibility studies

From Validation to Qualification

By 2026–2027, production of high-performance magnets – integrating recycled materials – for qualification campaigns, reaching TRL7 maturity

Oversight by a technical committee gathering key industry stakeholders

Qualification to Market Readiness

Technology, developed with CEA-Liten, available to the market

Supported by a portfolio of advanced technological bricks



... combining patented recycling processes and industrial excellence to empower a new generation of EU manufacturers

Orano empowers the EU to move forward on four interdependent strategic pillars that are key to achieving industrial and technological resilience

Cutting-edge
Process

Key equipment
manufacturers

Advanced
Assets

Primary &
Secondary Materials

A multi-component proposition to answer technical requirements of the most demanding users, the strategic challenges of circularity and resilience, and the strictest regulations.

Reliable and
proven
processes

Design and
process
engineering

A wide
range of
expertise

Knowledge of
supply chain and
market trends



Orano is open for discussion with industrial players willing to develop a magnet factory in Europe based on our techno and processes

Towards high performance and 25% recycling on a pre-industrial scale by 2027, before licensing

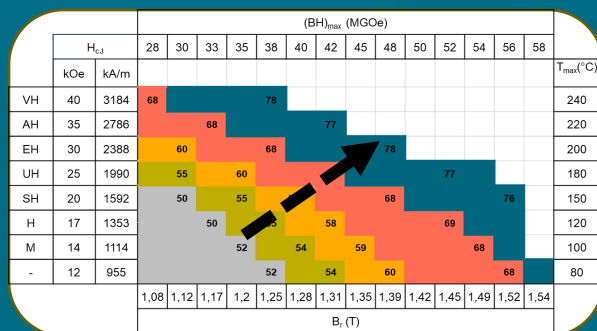
S1 2026

S2 2026

2027

HIGH PERF. MAGNETS

Produce high-performance permanent magnets on the pilot line



HIGH PERF. MAGNETS WITH 25% RECYCLING

Optimize the use of critical raw materials from short loop recycling on the pilot line, while guaranteeing the achievement of high performance

From EoL magnets... → ... to high perf. magnet with 25% recycled content



SCALE-UP OF HIGH PERF., RECYCLING MAGNET

Demonstrate the process's capacity at the pre-industrial scale to produce high-performance magnets incorporating 25% recycled material.





orano

Donnons toute sa valeur au nucléaire