Challenges of rare earths magnet collection and recycling in e-waste : SICAPERMA project

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Project SICAPERMA (I3-2023-INV2a) ID 101160837

Co-funded by the European Union

SICAPERMA
Sustainable Innovation Investment Catapult for Permanent Magnets

What is SICAPERMA?

Project presentation

Title

Sustainable Innovation investment Catapult for Permanent Magnets

Duration **Oct 2024 – Sep 2027**

Overall Budget **6 244 986 €**

EU Contribution **4 371 482 €**

Co-funded by

I3 Interregional Innovation Investments Instrument

Co-funded by the European Union

Project ID: 101160837 | CALL: I3-2023-INV2A

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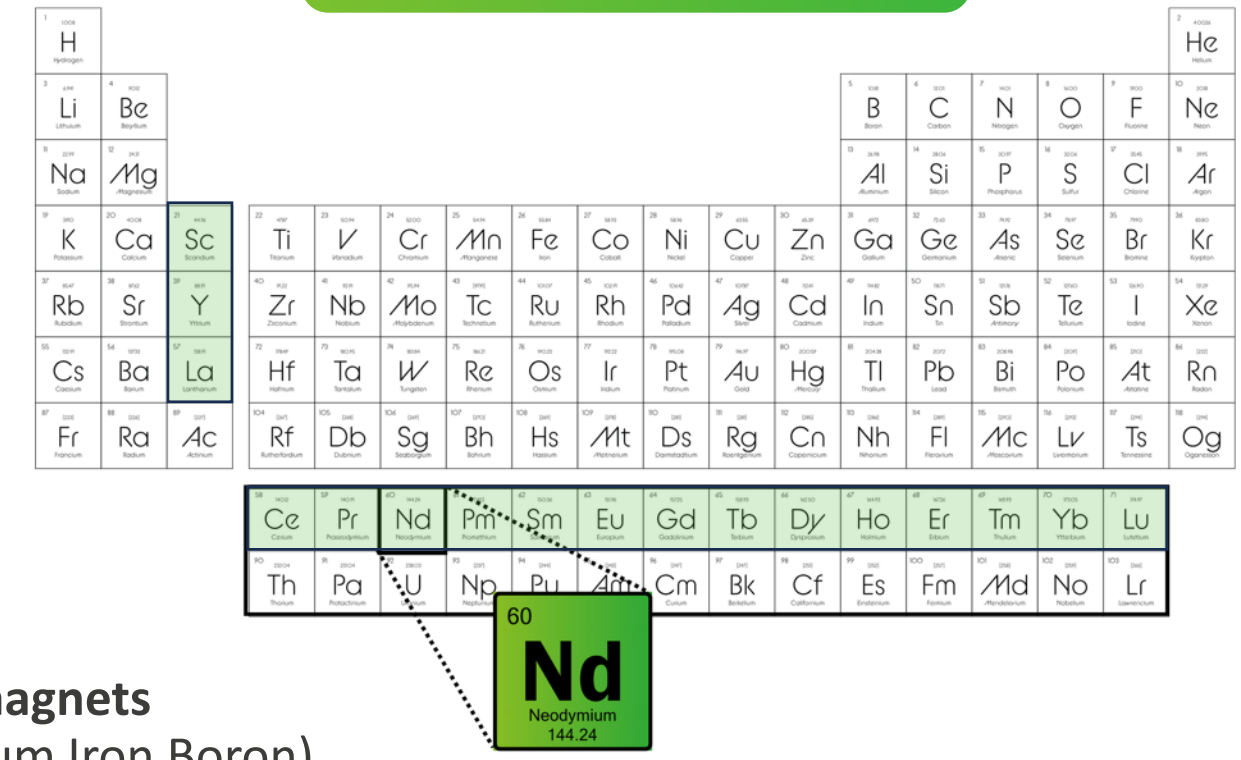
The problem

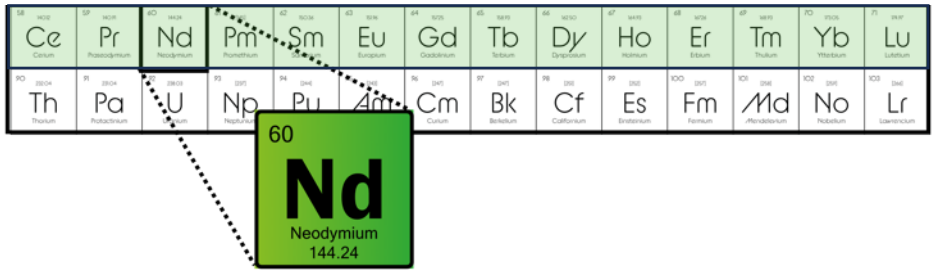


Rare earth elements (REEs) are a group of 17 chemically similar metallic elements (15 lanthanides plus scandium and yttrium) **crucial for high-tech devices**, electric vehicles, and defense systems.

Nd-Fe-B magnets
(Neodymium Iron Boron)

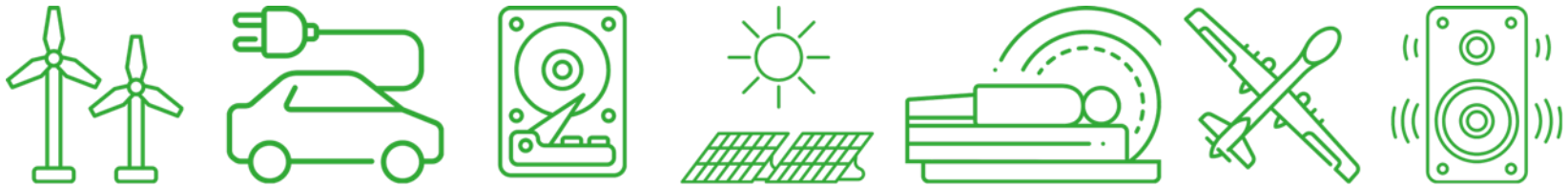
are the strongest type of commercially available permanent magnets, known for exceptional magnetic strength, high coercivity (resistance to demagnetization), and relatively low cost compared to other high-performance magnets.

The problem



Nd-Fe-B magnets
(Neodymium Iron Boron)

And therefore, they are essential to a wide range of modern technologies, including electric motors, sensors, consumer electronics, renewable energy systems, electric vehicles (EVs), medical devices, and defense applications.



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The solution (or part of it)

Consumption and demand

The European Union (EU) is one of the largest consumers of rare-earth magnets, such as neodymium-iron-boron magnets, due to its focus on clean technologies.

Demand will not decrease.

Research and development

Europe is **investing on R&D into technologies for recycling** and replacing rare earth elements, including neodymium and boron.

Reducing dependency

The EU has launched projects and strategies, such as the *European Raw Materials Alliance (ERMA)*, to secure supply, **diversifying** imports, and strengthening the **circular economy**.

Policy initiatives and regulation

The EU has strict regulations on mining and environmental impact, which makes it difficult to extract rare earths locally but **encourages recycling** and efficient use of these materials.

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SICAPERMA VALUE CHAIN

SICAPERMA offers the first specialisation area where Less Developed Regions can become the leaders in EU Resilience: Nd-Fe-B Recycling Technologies

PM COLLECTION

MagREEsource

Greentronics

Universidad de Jaén

TECOS

PILOT 2

Demonstrating Innovative Sintered and Bonded PM Production from Recycled materials

MagREEsource

KOLEKTOR

IMA

NIMP SCIENTIFIC RESEARCH

INTERREGIONAL VALUE CHAIN STRUCTURING

STEP ONE 01

STEP TWO 02

STEP THREE 03

STEP FOUR 04

IMPACT DEPLOYMENT MULTIPLICATOR

PILOT 1

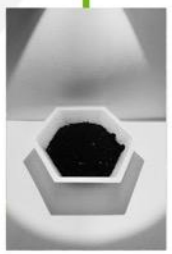
Demonstrating Multi-Stream PM dismantling & Processing Tech

MagREEsource

METALPINE

SLOVENSKÁ AKADÉMIA VIED

SAV



PILOT 3

Demonstrating the integration of Recycled PM into motors and sensors

MP

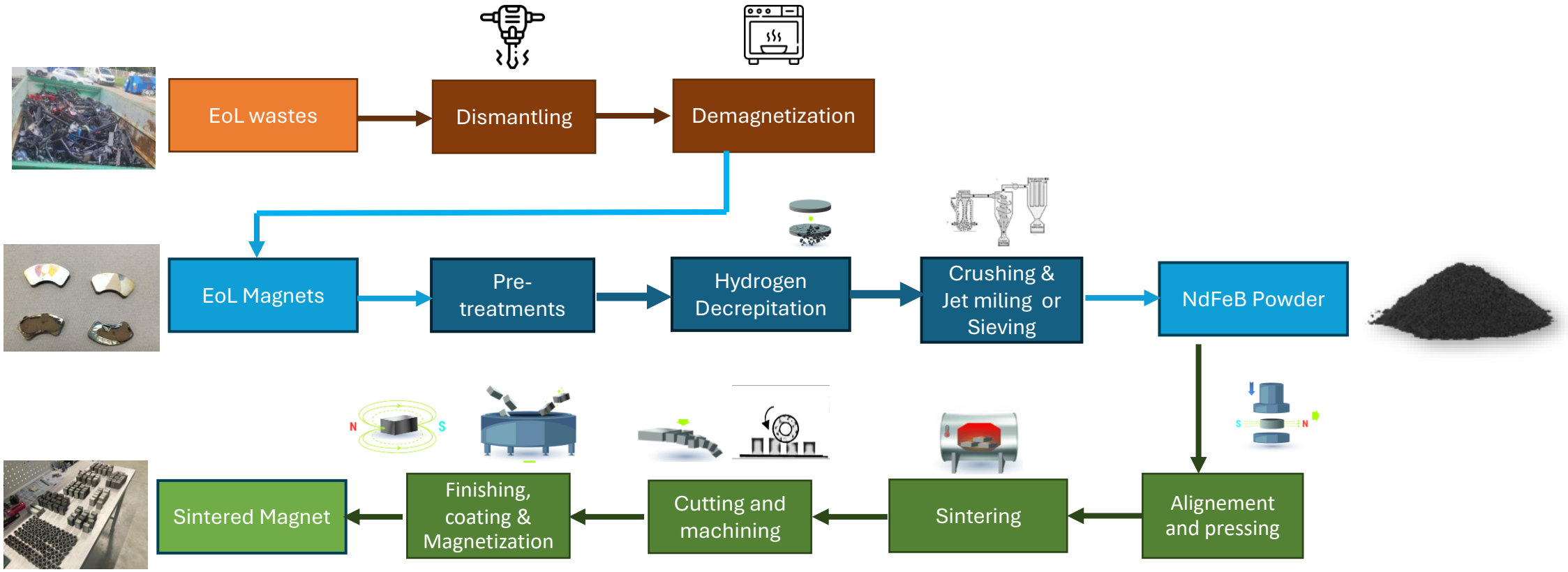
Primum, d.o.o.

RASCO

ETRA

Short loop recycling process

From EoL wastes to 100% recycled NdFeB magnets and powders



Step 1 - PM collection

- **IT & communications equipment**

HDDs, laptops, servers – high magnet density per unit

- **Small household appliances**
- **Electrial & electronic tools**
- **Air-conditionning equipment**

One collection source example

Hard Disc Drives (HDDs)

Step 1 - PM collection

Some challenges

50 tons
of HDDs

150 kg
of PM

Step 1 - PM collection

Some challenges

Certificate of Erasure

Serial No.: S0K364FR
Incident No.:
Date/Time: 2025-12-10 14:28:54
Degaussed: 10230 G (PASS)
Destroyed: N/A SSD: No
User ID: ALEXANDRU
Witness ID: N/A
JPG File:

Serial No.: S0K36KCD
Incident No.:
Date/Time: 2025-12-10 14:30:16
Degaussed: 10230 G (PASS)
Destroyed: N/A SSD: No
User ID: ALEXANDRU
Witness ID: N/A
JPG File:

Serial No.: S0M3LMQV
Incident No.:
Date/Time: 2025-12-10 08:33:24
Degaussed: 10230 G (PASS)
Destroyed: N/A SSD: No
User ID: ALEXANDRU
Witness ID: N/A
JPG File:

Serial No.: 6SLAAHX4
Incident No.:
Date/Time: 2025-12-10 08:35:19
Degaussed: 10230 G (PASS)
Destroyed: N/A SSD: No
User ID: ALEXANDRU
Witness ID: N/A
JPG File:

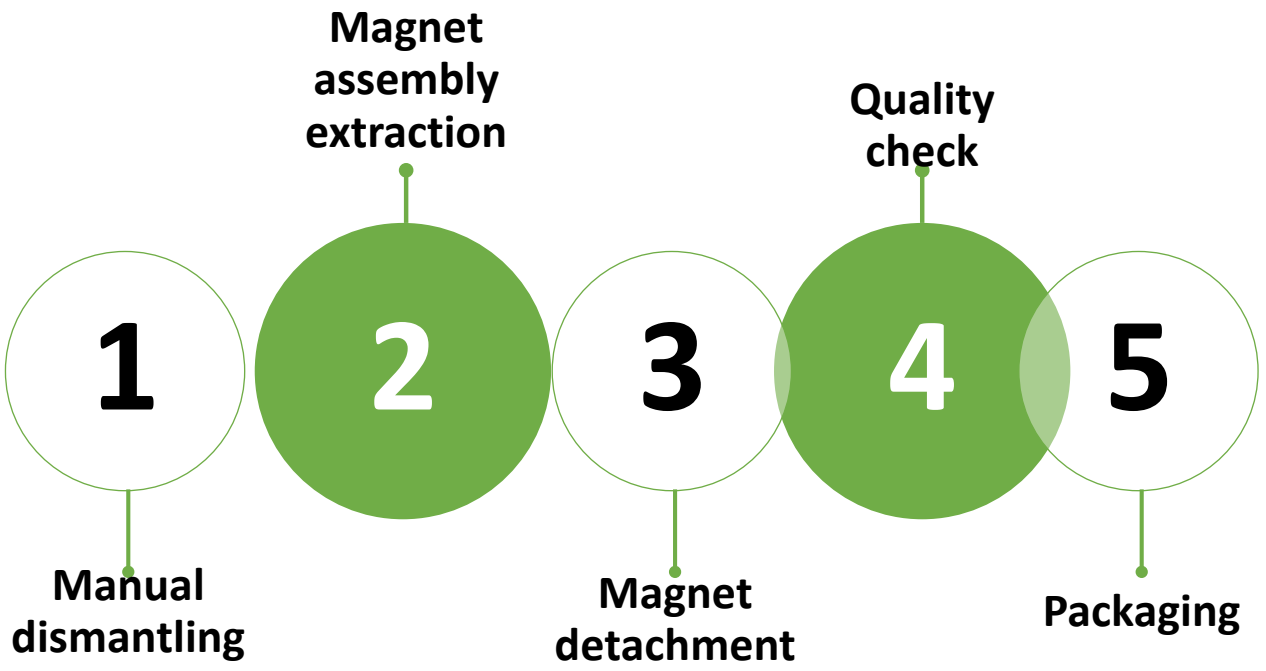
Serial No.: 6SLA8LGT
Incident No.:
Date/Time: 2025-12-10 08:36:52
Degaussed: 10150 G (PASS)
Destroyed: N/A SSD: No
User ID: ALEXANDRU
Witness ID: N/A
JPG File:

Serial No.: 6SLAA7WK
Incident No.:
Date/Time: 2025-12-10 08:37:40
Degaussed: 10230 G (PASS)
Destroyed: N/A SSD: No
User ID: ALEXANDRU
Witness ID: N/A
JPG File:

As there is sensitive data in HDDs, they use to be shredded leaving valuable components out of the loop.

It is important to establish secure lines to recover PM with HDD owners.

Step 2 - Dismantling & Sorting



Tools & method

- Pneumatic gun
- Hand tools
- Heat gun

➔ Precise PM extraction

➔ Equipment design variability

Takeaways

✓ Room for innovation

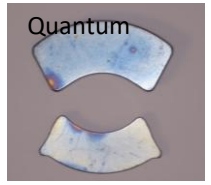
✓ Scalability must be built in

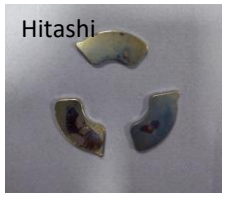
Step 2 - Characterization of End-of-Life magnet

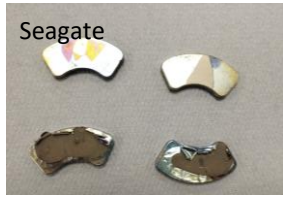
- The EoL magnet characterization is essential to optimize MagREEsource process towards recycling
  - Composition, magnetic grade and impurities are carefully controlled

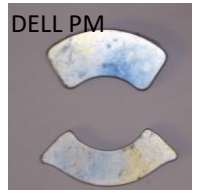
- *Example of the full characterization of HDD EoL magnet sorted by supplier*
  - 9 HDD suppliers studied
  - Magnets with different sizes and geometries
  - Coating : Ni – Cu – Ni, Ni
  - Magnetization : perpendicular to the flat surface
  - Characterization of the composition by X-ray Fluoresence

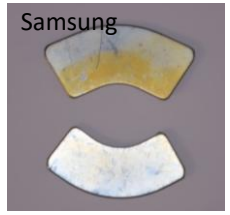
⇒ **Huge range of magnet composition from a single supplier**
⇒ **No direct correlation between supplier magnet and magnet composition**

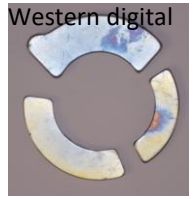






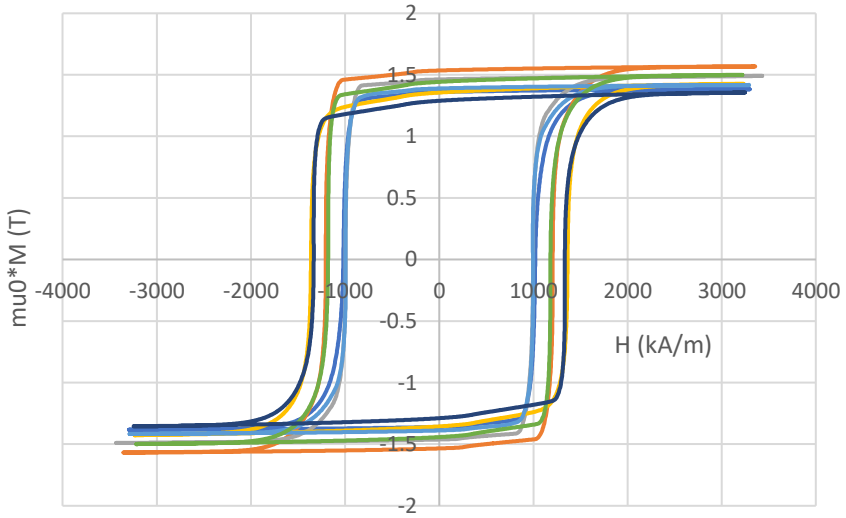




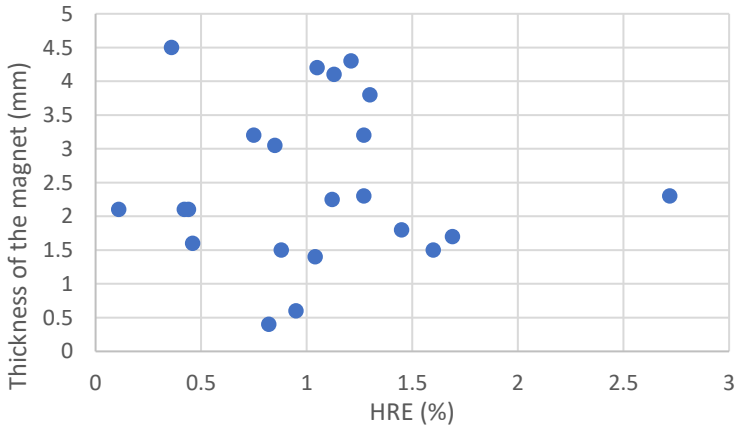


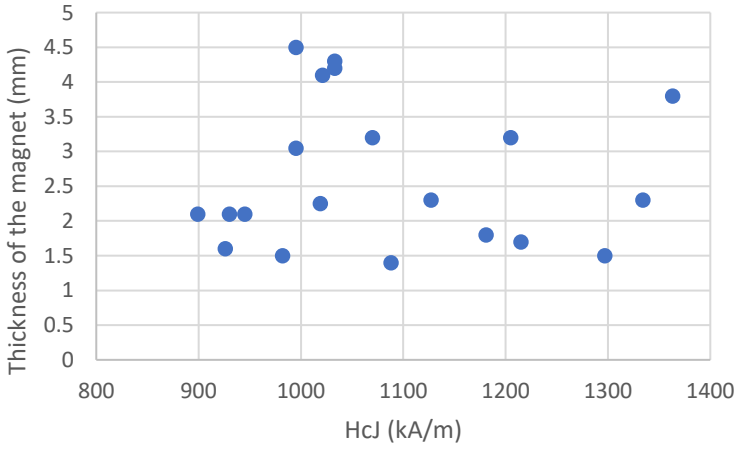
Step 2 - Characterization of End-of-Life magnet

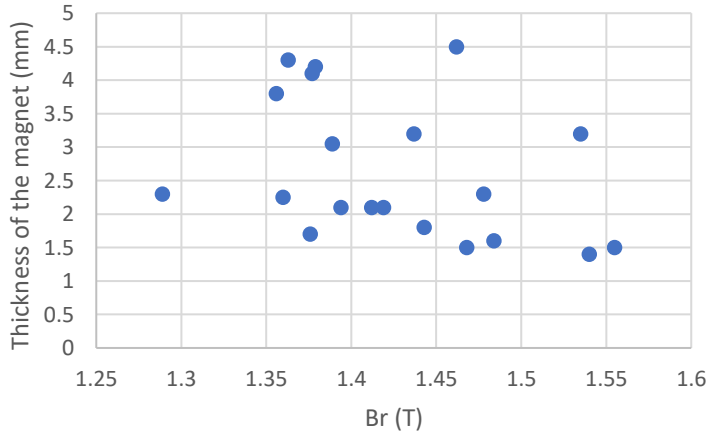
- ⇒ Variety of magnetic performance characteristics from a single supplier: from N42H grade to N52
- ⇒ No direct correlation between magnet supplier and magnet grade
- ⇒ No direct correlation between magnet geometry and magnetic performances
- ⇒ No direct correlation between magnet geometry and composition (Heavy Rare Earth content)



⇒**Even after sorting, batches of HDD magnets represent a heterogeneous collection of magnets, both in terms of magnetic properties and compositions**







Step 3 - Re-Processing of bulk Magnets from EoL HDD magnets

- **Starting material : EoL HDD PM**

Thickness < 2 mm

- **Process based on :**

Hydrogen decrepitation, powder jet milling,
Alignement/pressing, sintering and thermal treatment

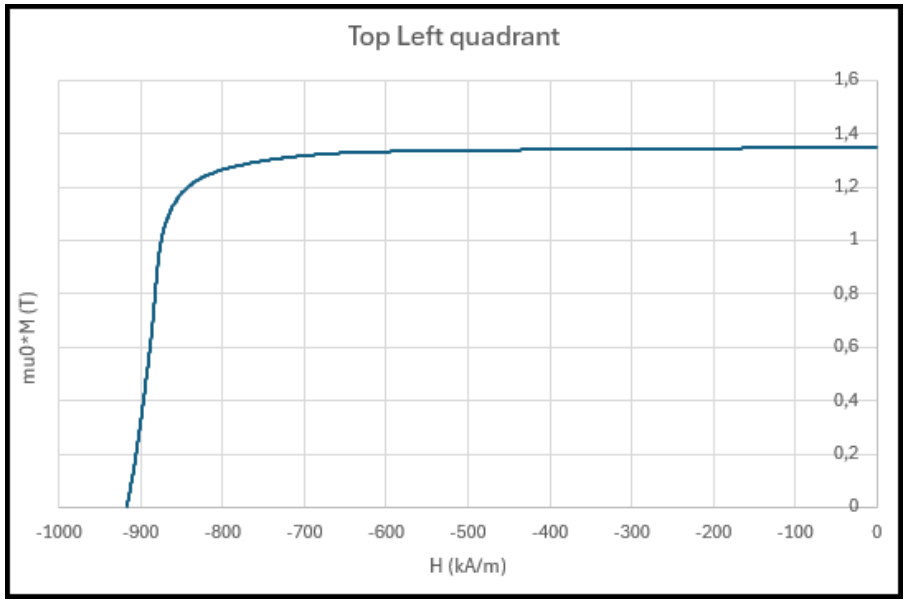
- **Re-Processed Magnet :**

⇒ **N45 magnetic grade**

Demonstration of a successful implementation of the recycling value chain towards the (re)manufacturing of high-quality magnets

Material	Re-processed magnet
Remanence (T)	1.349
Coercivity (kA/m)	917
$(BH)_{max}$ (kJ/m^3)	355

Extrinsic magnetic properties of reprocessed magnet



Demagnetization curves of reprocessed magnet

The path towards sovereignty

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Support collect

Volumes a required to develop European circular loops.

Most components of interest do not have their own WEEE category but need to be extracted from channels.

Support dismantling

Crushing must be **avoid** to recover permanent magnets efficiently. 100% dismantling rates can be achieved for many components: HDDs, e-wheels, electric motor rotors, loudspeakers…

Support automation

Automation is a lever to address small subassemblies, operator **safety** and **time cycle**. It must address variety to ensure **industrial scalability**.

Policy initiatives and regulation

The **WEEE directive** is being revised. **Synergies** with the **CRM Act** must be found to encourage recycling of Rare Earth Permanent Magnets

MagREEsource

Thank you !

RESILIENCE in materials
Circular model and Vertical integration from Metals up to finished Magnets

AUTONOMY in technology
Made-in-EU supply chain for the main technological assets

SUSTAINABILITY by essence
Low Carbon Magnet with 91% reduction of CO_2 emissions

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