

REE4EU



Rare Earth Recycling for Europe

Closed-loop Permanent Recycling Process at Pilot Scale

Ana Maria Martinez, Project Coordinator



»»» The REE4EU Consortium



- ❑ 4 years project: 1 October 2015 – 30 September 2019
- ❑ Innovation action, TRL= 7
- ❑ 14 Partners, industry-driven consortium
- ❑ Budget: 9 m€ (7.5 m€ EU contribution)

RTOs:



SMEs:



Industry:



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SPIRE Sustainable Process Industry through
Resource and Energy Efficiency



REE4EU



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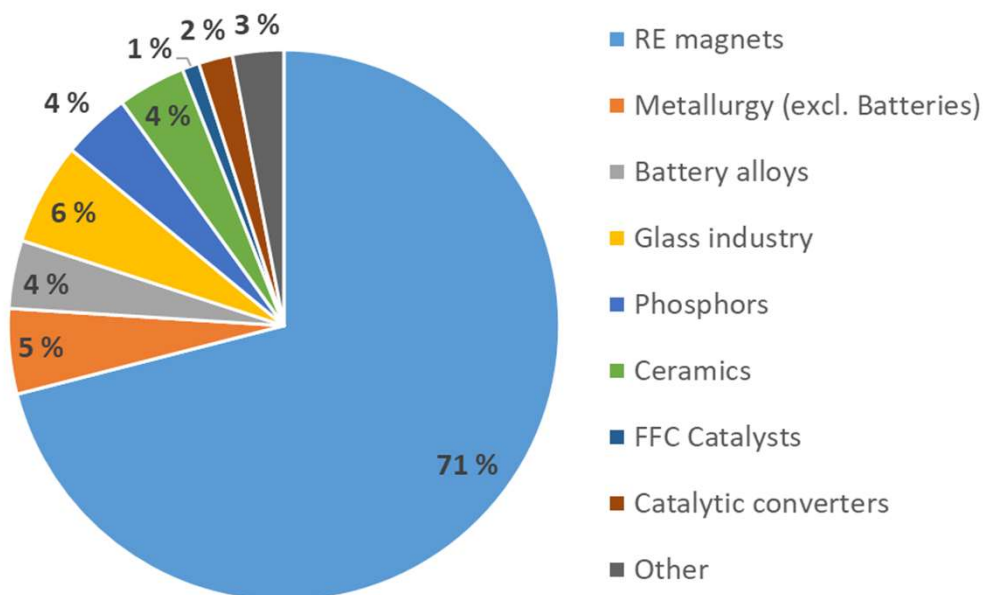
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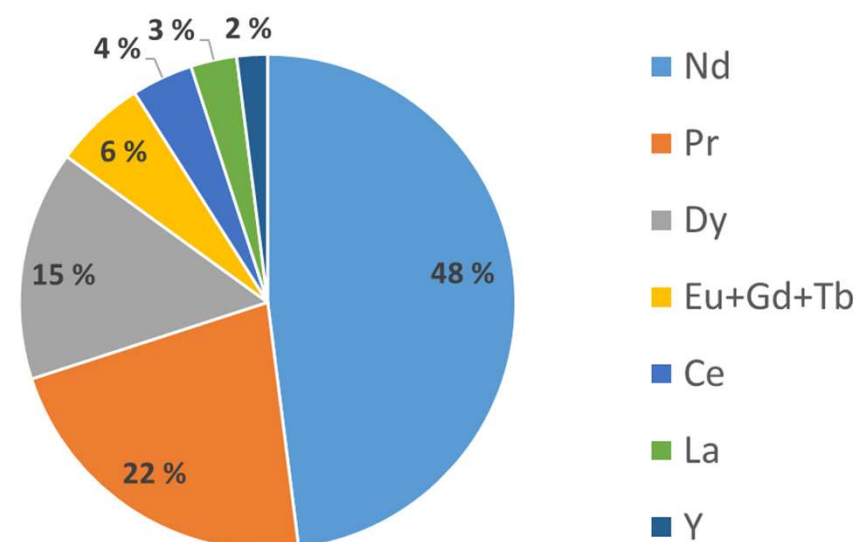
Industrial Consumption of RE by value

By value



The largest share of RE consumption corresponds to RE-based permanent magnets (Nd-based PM)

By element



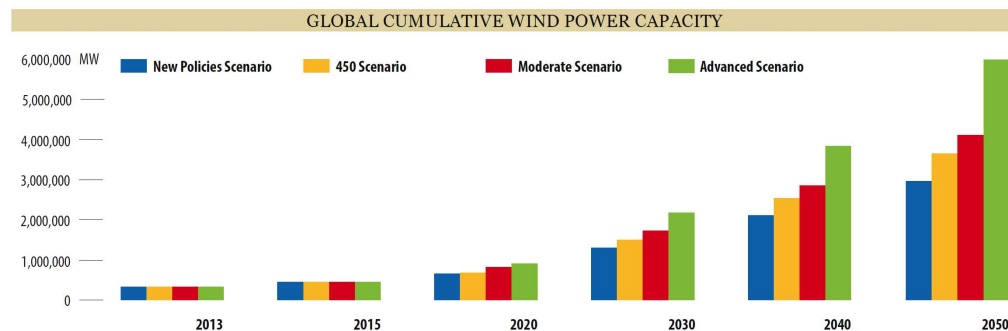
The largest share corresponds to the REE that are used in the PM, i.e. Neodymium, Praseodymium and Dysprosium





Rare Earth Market Drivers-Green Technologies

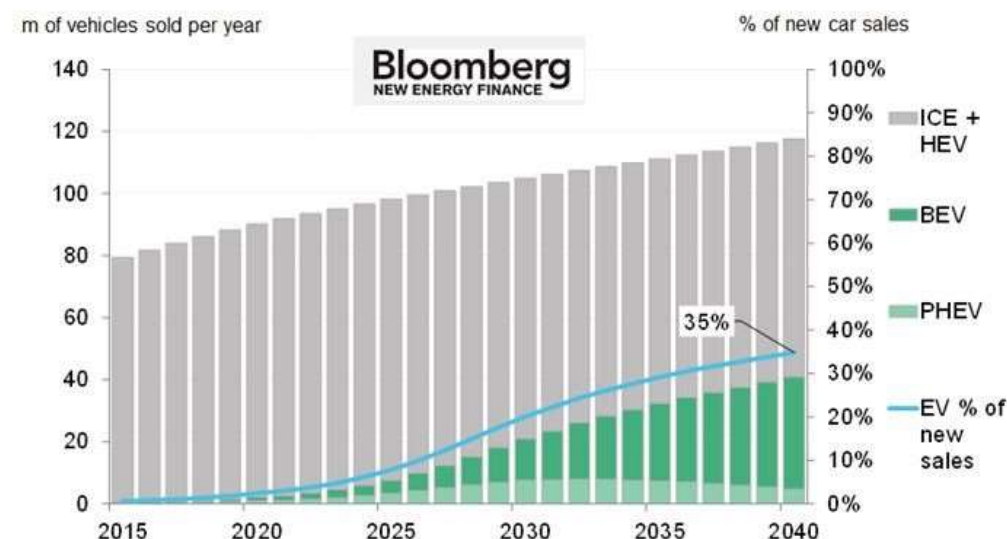
Wind Energy



PM in offshore turbines $\Rightarrow$ 170-230 Kg RE/MW

PM: permanent magnet, where RE= Nd, Pr and Dy

Electric Vehicles

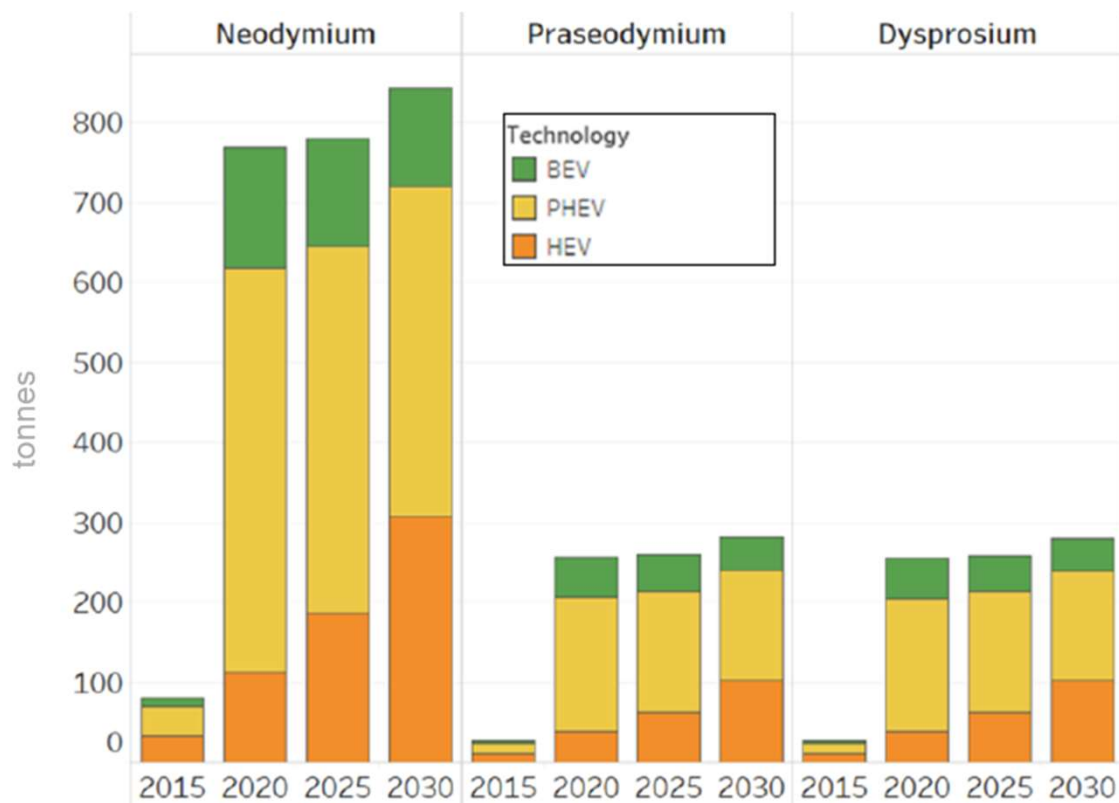


PM in both electric traction motor and generator $\Rightarrow$ 1.5-2 Kg and 0.5 Kg, respectively





Rare Earth Expected demand in E&HEV sector



Demand forecast in the EU

BEV: battery electric vehicle

PHEV: plug-in hybrid electric vehicle

HEV: hybrid electric vehicles

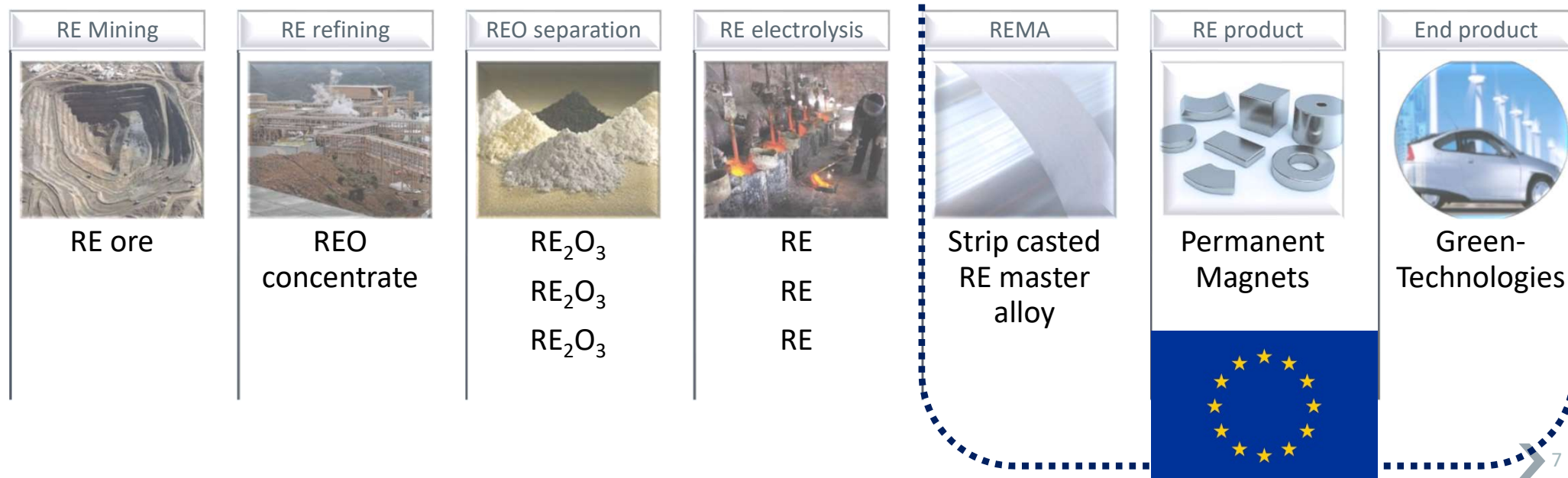


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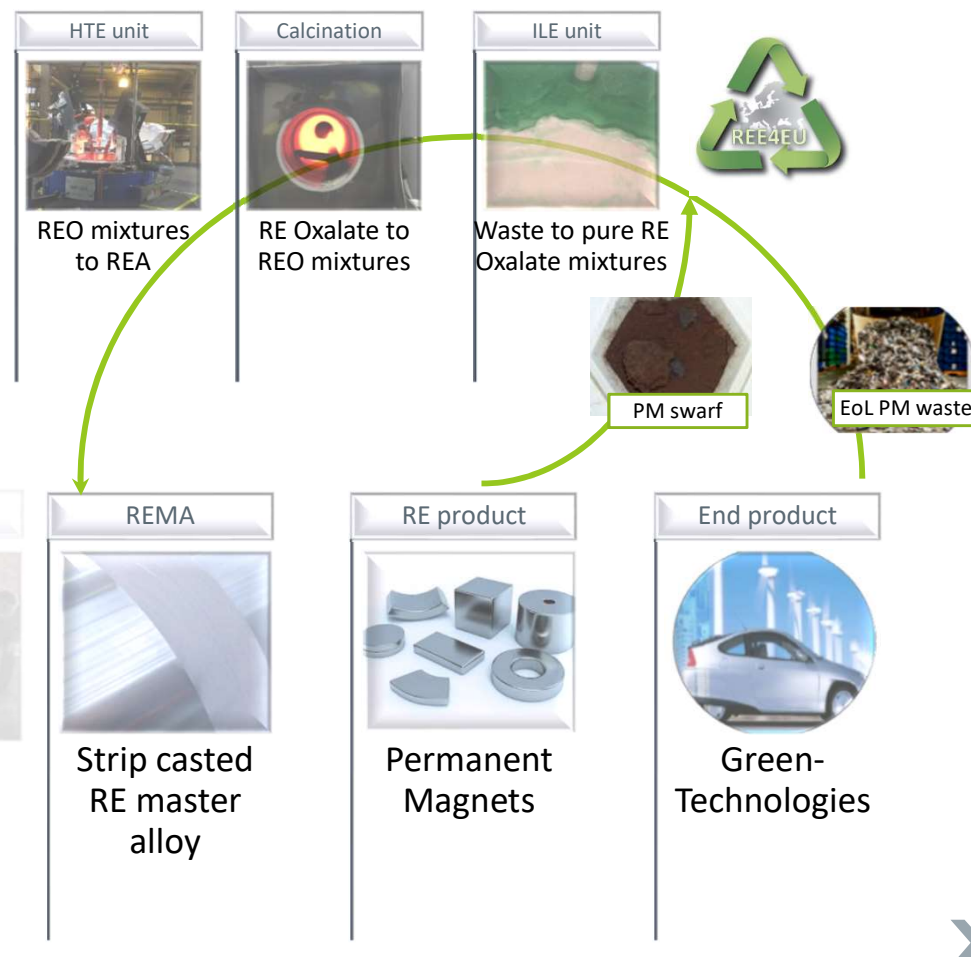


Current Permanent Magnets Value Chain





REE4EU technology - PM value chain in Europe

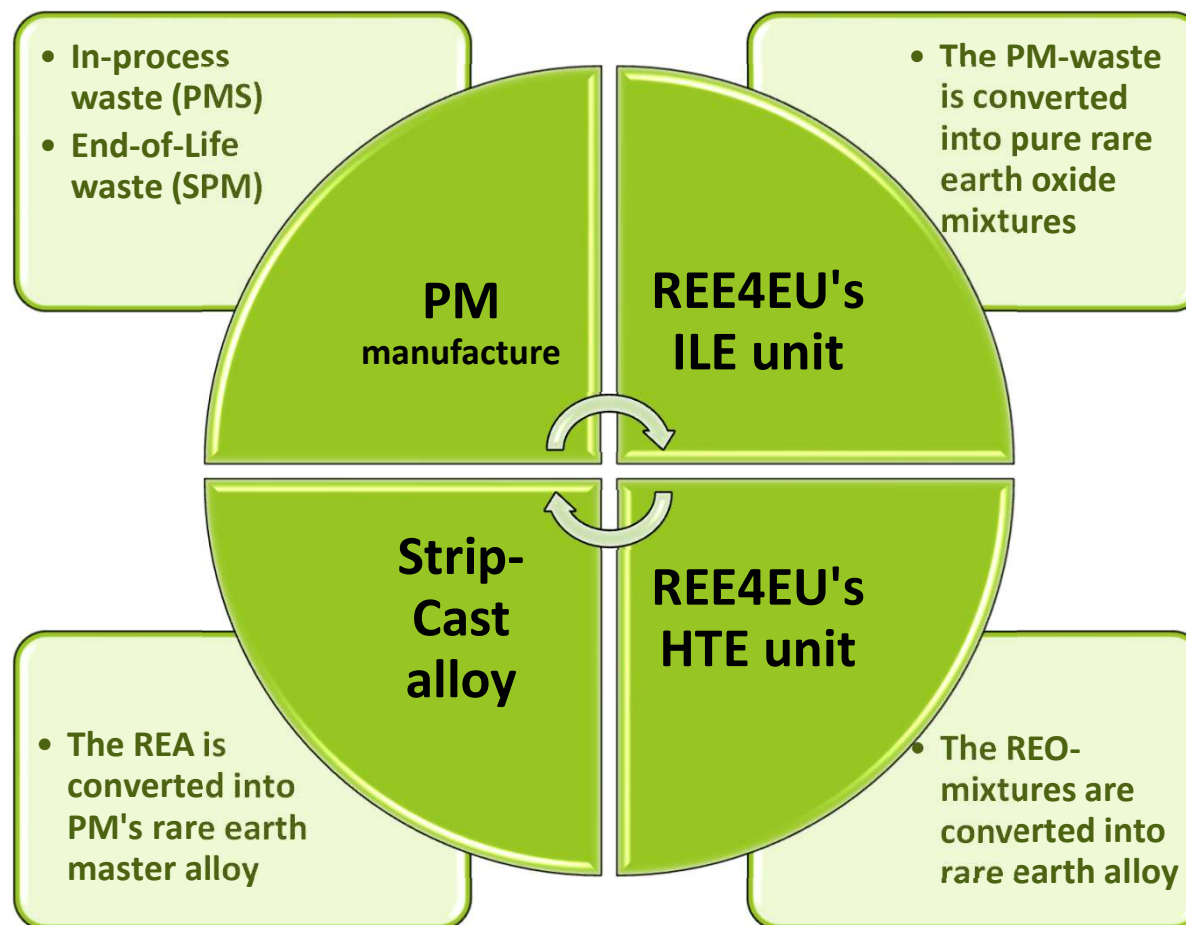


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REE4EU's Closed Loop Permanent Magnet Recycling



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REE4EU Technology

RE-containing
Waste materials



**Permanent
magnet in-
process waste
(swarf)
1.5 tonnes**

**Spent
permanent
magnets
(scrap)
500 kg**

**Replication activities using spent
NiMH battery waste (black mass)**

ILE unit



Waste to pure RE
Oxalate mixtures

Calcination



RE Oxalate to
REO mixtures

HTE unit



REO mixtures
to REA

REMA



Strip casted RE
master alloy

Permanent
magnets



New magnets
to be used in
new products

- ☺ Able to produce RE-alloys from RE-Oxide mixtures in a single step, without separation in the corresponding single RE-oxides.
- ☺ Flexible to any PM-waste composition.
- ☺ Can be applied to other RE-containing wastes.





REE4EU's Ionic Liquid Extraction Unit

- ❑ The PM-waste is converted into pure RE-Oxalates in several steps
- ❑ The spent permanent magnets can be treated as big ingots in special designed reactors thus avoiding the use of metallic powder material, and minimising HSE risks



**300 Kg pure
RE-oxalates**



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REE4EU's High Temperature Electrolysis Unit

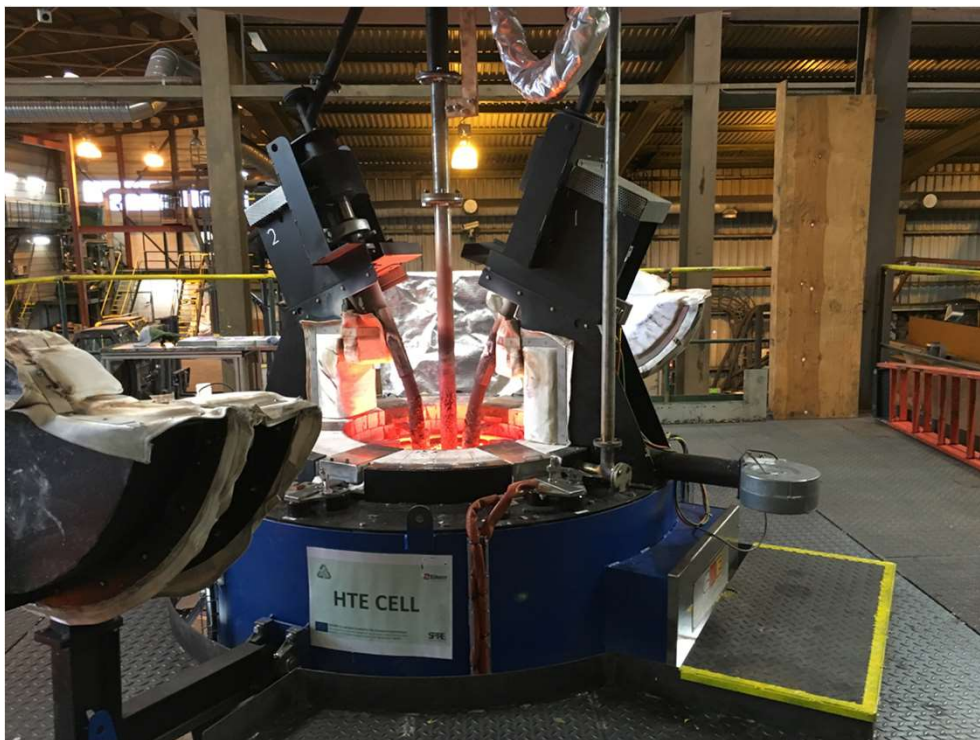


- ❑ The pure RE-Oxalates obtained in the ILE unit are calcined in a rotary kiln.
- ❑ The pure RE-Oxides obtained are treated in the HTE unit





REE4EU's High Temperature Electrolysis Unit

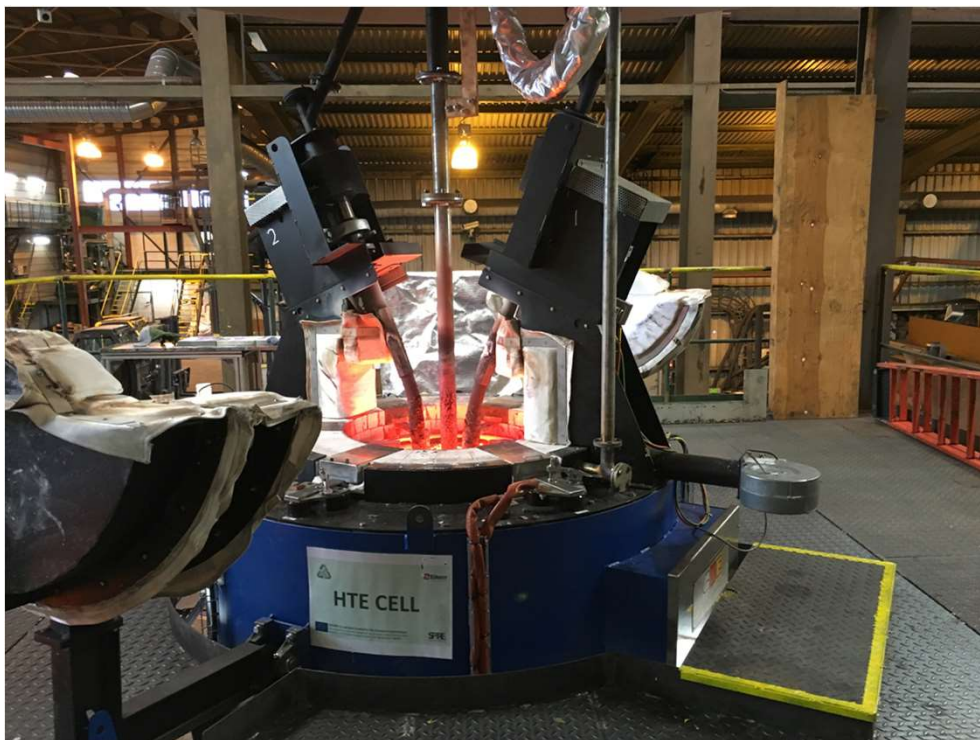


- ❑ The pure RE-Oxides are converted into RE alloys
- ❑ Basis for the REE4EU technology
- ❑ HTE unit is one-of-its-kind: automatic REO feeding and continuous monitoring of the off-gas are two of its advantages
- ❑ Provides **RE-alloy**, suited to be used in the manufacture of new PM





REE4EU's High Temperature Electrolysis Unit

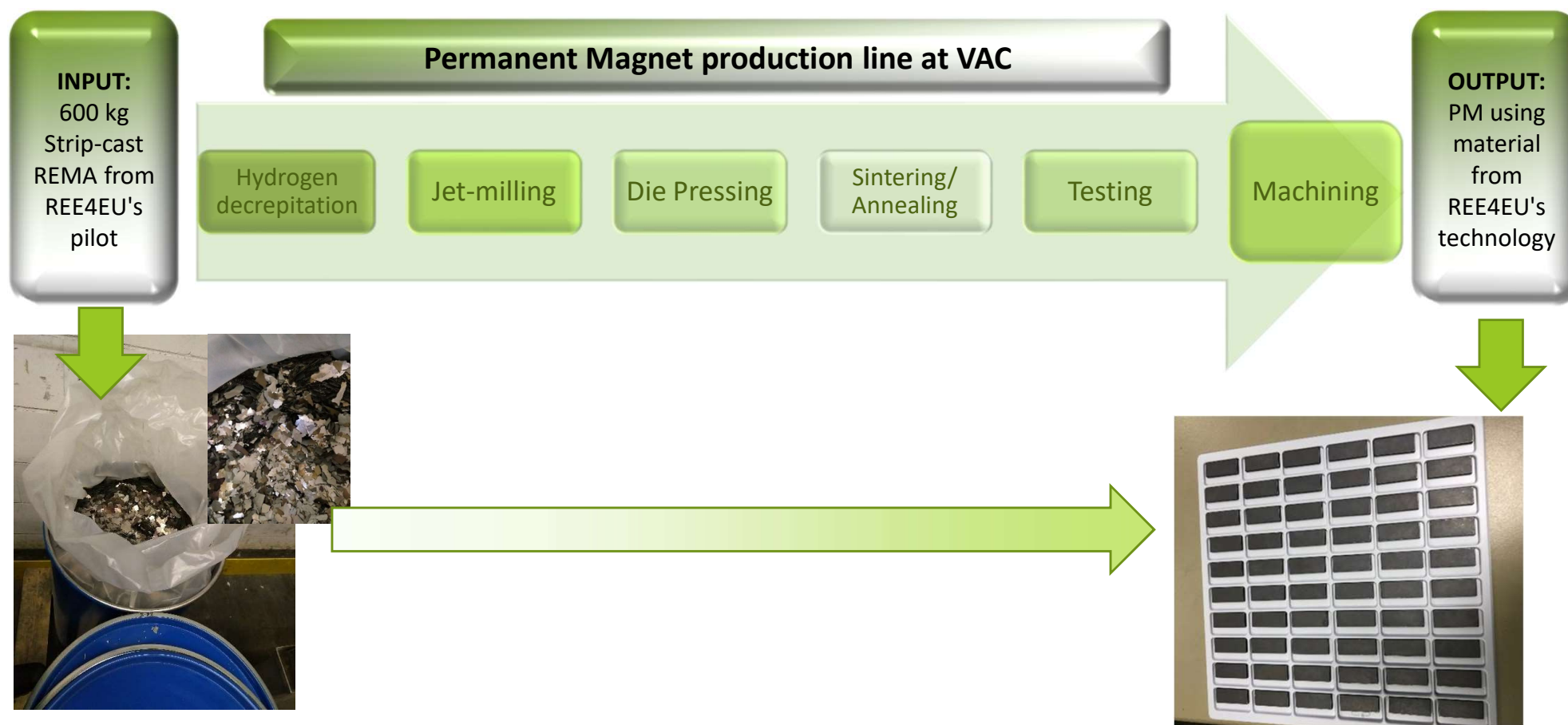


Ca. 100 Kg
REA



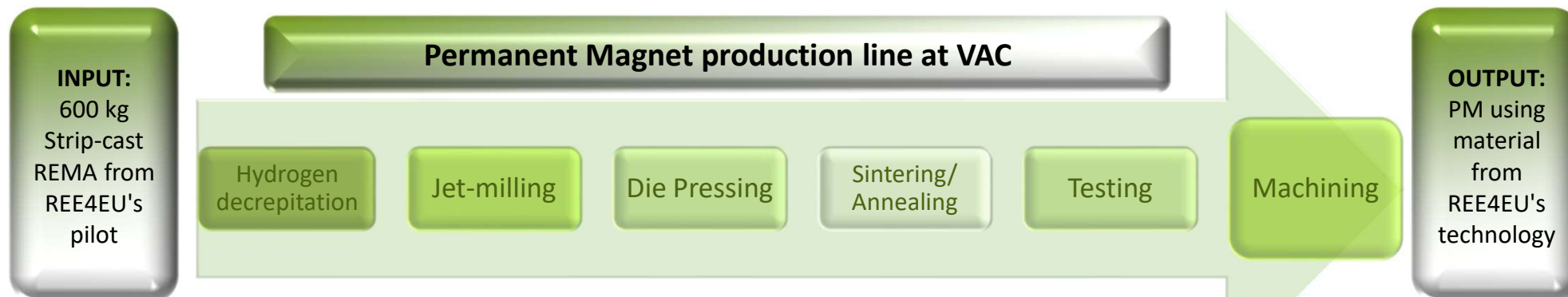


PM Produced using REE4EU's Technology

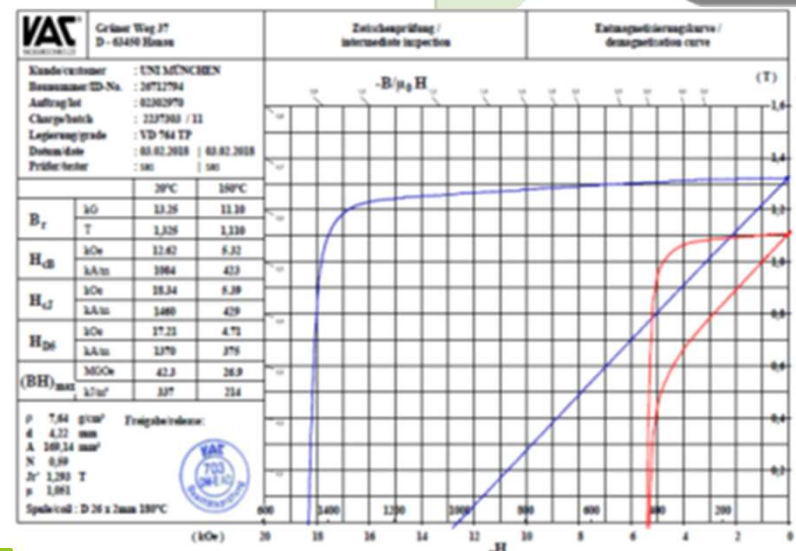
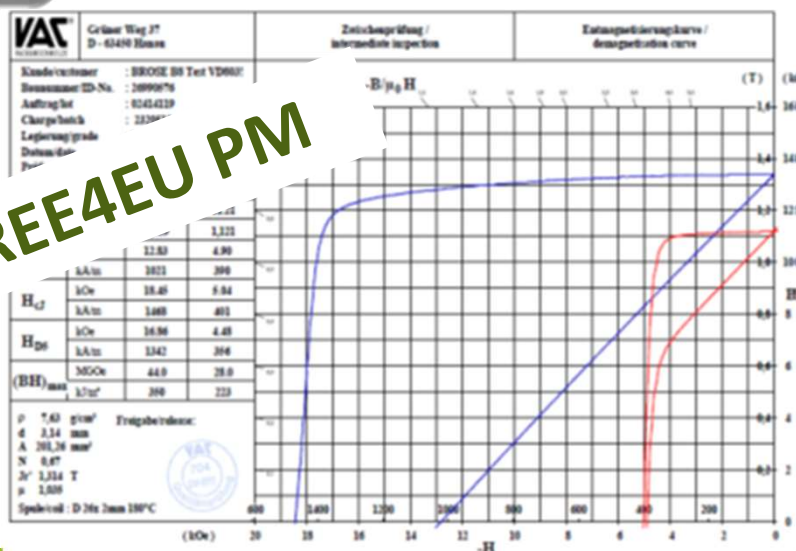




PM Produced using REE4EU's Technology



REE4EU PM



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»»» Acknowledgments

REE4EU project has received funding from the European Union's Horizon 2020 Research and Innovation program under Grant Agreement No 680507



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