

NOVEMBER 2021

PASSENGER

**Pilot Action for Securing a Sustainable European
Next Generation of Efficient RE-free magnets**

20

CONSORTIUM
MEMBERS

13

INDUSTRY
PARTNERS

8

EUROPEAN
COUNTRIES

8

PILOT PLANS

Duration:
2021 – 2025

Prof. Dr. Alberto Bollero – IMDEA Nanoscience



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003914



Content preview

01

About us



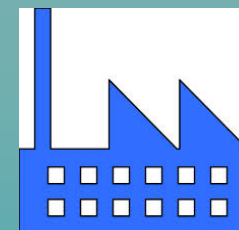
02

Our mission



03

Our goal



Programme:

Horizon 2020 Framework Programme



Work programme part:

Climate action, environment, resource efficiency and raw materials

Call:

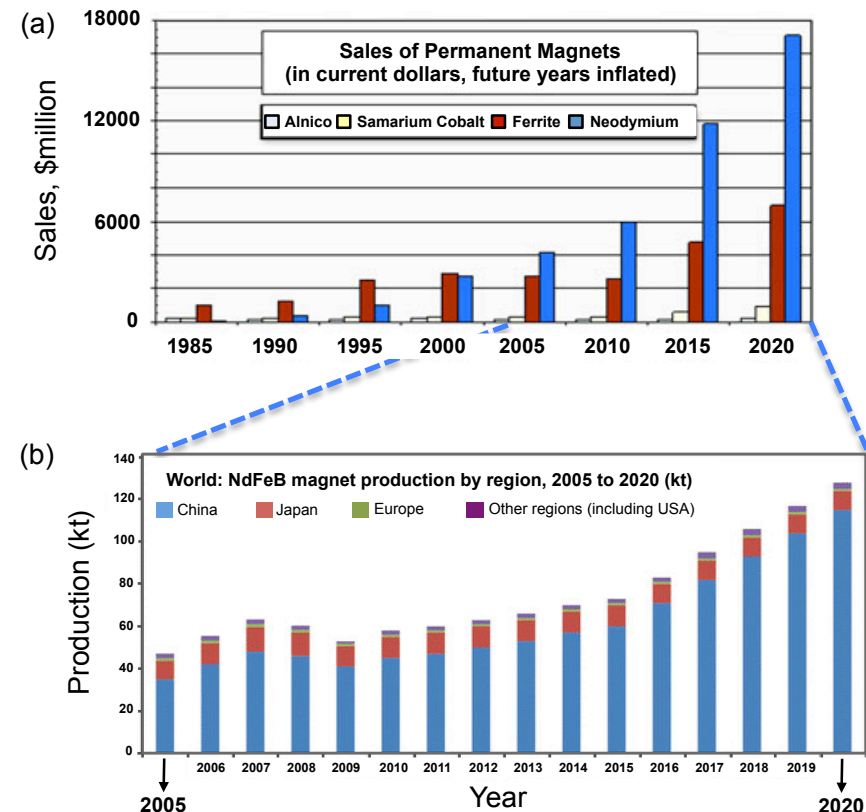
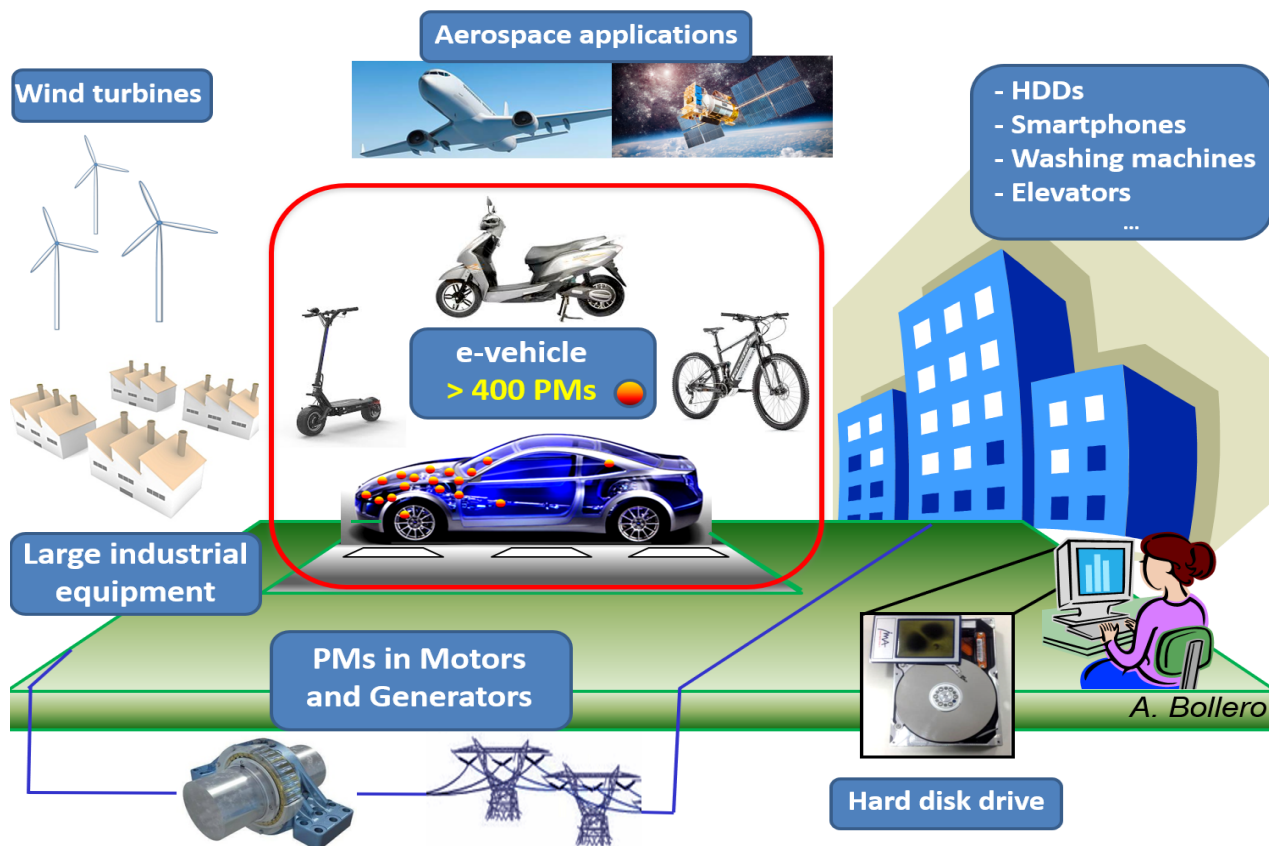
Greening the economy in line with the Sustainable Development Goals (SDGs)
(H2020-SC5-2018-2019-2020)

Topic:

SC5-10-2020: Raw materials innovation actions: exploration and Earth observation in support of sustainable mining
d) Pilots on substitution of critical and scarce raw materials



Specific challenge ↓	How <i>PASSENGER</i> addresses this specific challenge ↓
<p>Substitution. To use substitution as a way to reduce the EU's consumption of CRMs, lower dependence on imports and reduce adverse environmental impacts.</p>	<p><i>PASSENGER</i> will reduce the dependence on CRMs, specifically REEs, by piloting two previously TRL 4-5 demonstrated permanent-magnet materials: improved strontium ferrites (SrFe₁₂O₁₉) and manganese-aluminium-carbides (Mn-Al-C).</p>
<p>Scale up. To scale up promising technologies for raw-materials production or the substitution of CRMs, to demonstrate that raw materials can be produced in an innovative and sustainable way, and to ensure that research and innovation end up on the market.</p>	<p><i>PASSENGER</i> will scale up two already-demonstrated technologies to produce REE-free permanent magnets as industrial prototypes for application in the e-mobility market.</p>



(a) Source: Metall. and Mater. Trans. A, 44A, S2 (2013)

(b) Source: J. Sustain. Metall. 3:122–149 (2017)

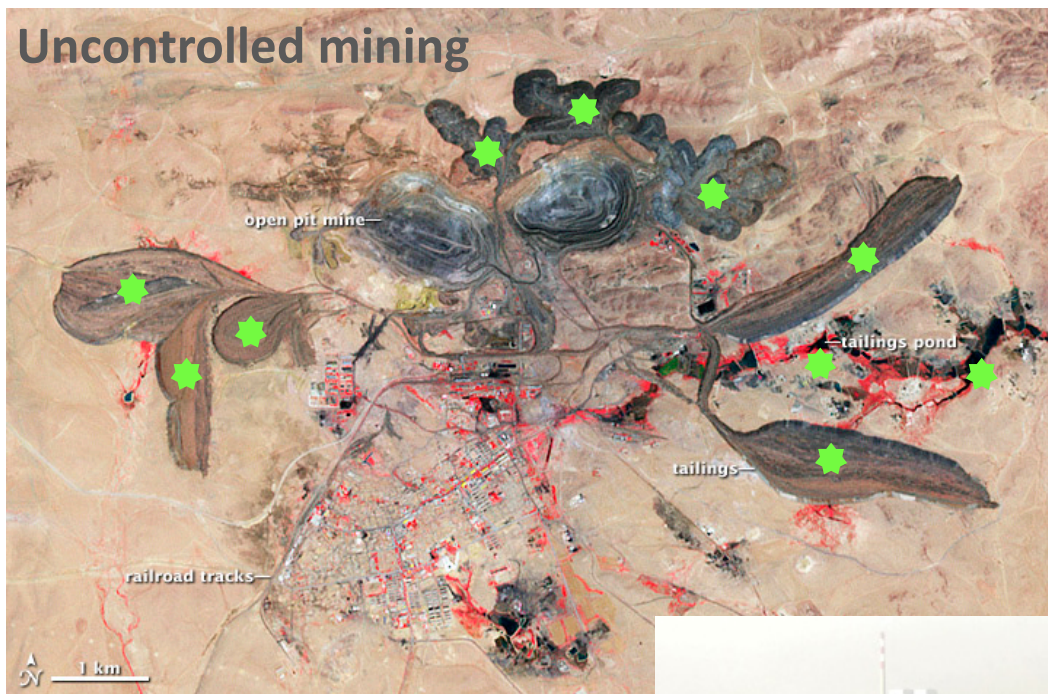
PMs present in a broad spectrum of technological applications



Problem asks for the search of alternatives to controversial REE-based PMs

The Topic: Permanent Magnets

Uncontrolled mining



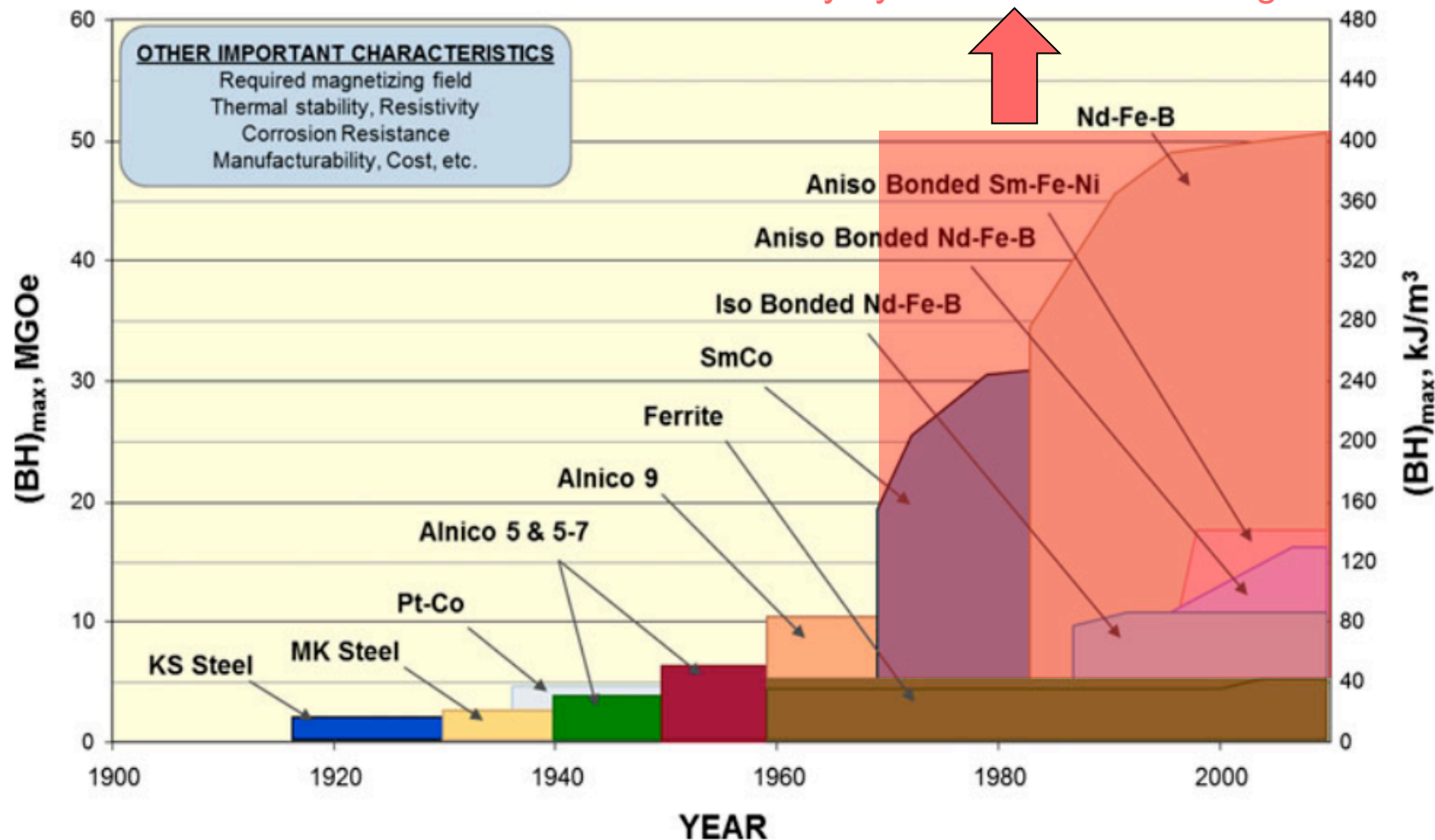
*Environmental impact
from extraction and
refinement of the
rare-earth elements*



Globalization means **“WE”**:
Impact on You brings Impact on Me



Complete performance region covered exclusively by rare earth-based magnets



The historical evolution of permanent magnets shows a huge performance gap between ferrites and rare earth-based magnets (since NdFeB discovery in 1983).

Source: M.J. Kramer, W. McCallum, A. Anderson, and S. Constantinides, JOM 64, 752 (2012).



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Approaches to mitigate dependency on CRMs in PMs

01

Novel materials

New combination of elements to result in novel REE-free magnets

03

Exploring new phenomena

Exploring enhanced/new phenomena (e.g. *nanometer scale*) in existing alloys.

02

Engineering structures

Engineering nanostructures for optimized (reduced) use of CRMs.

04

Diversification of PM materials

Efficient / selective use of the different REE-based materials according to applications.

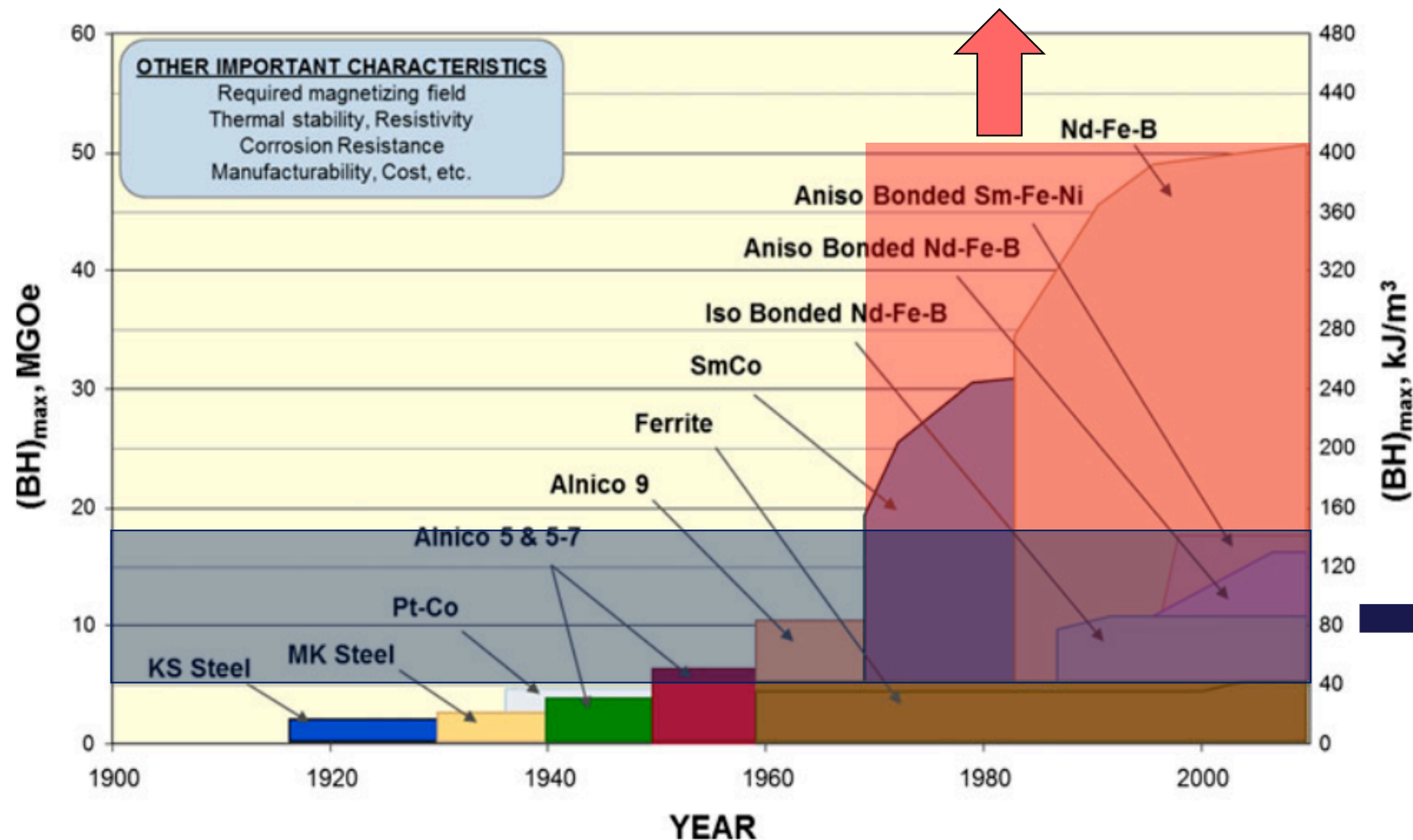
05

Reuse and recycling

Increased sustainability through reuse and recycling.



Rare earth-based magnets



Objective

Substitution

Filling an area currently covered exclusively by REE-based PMs

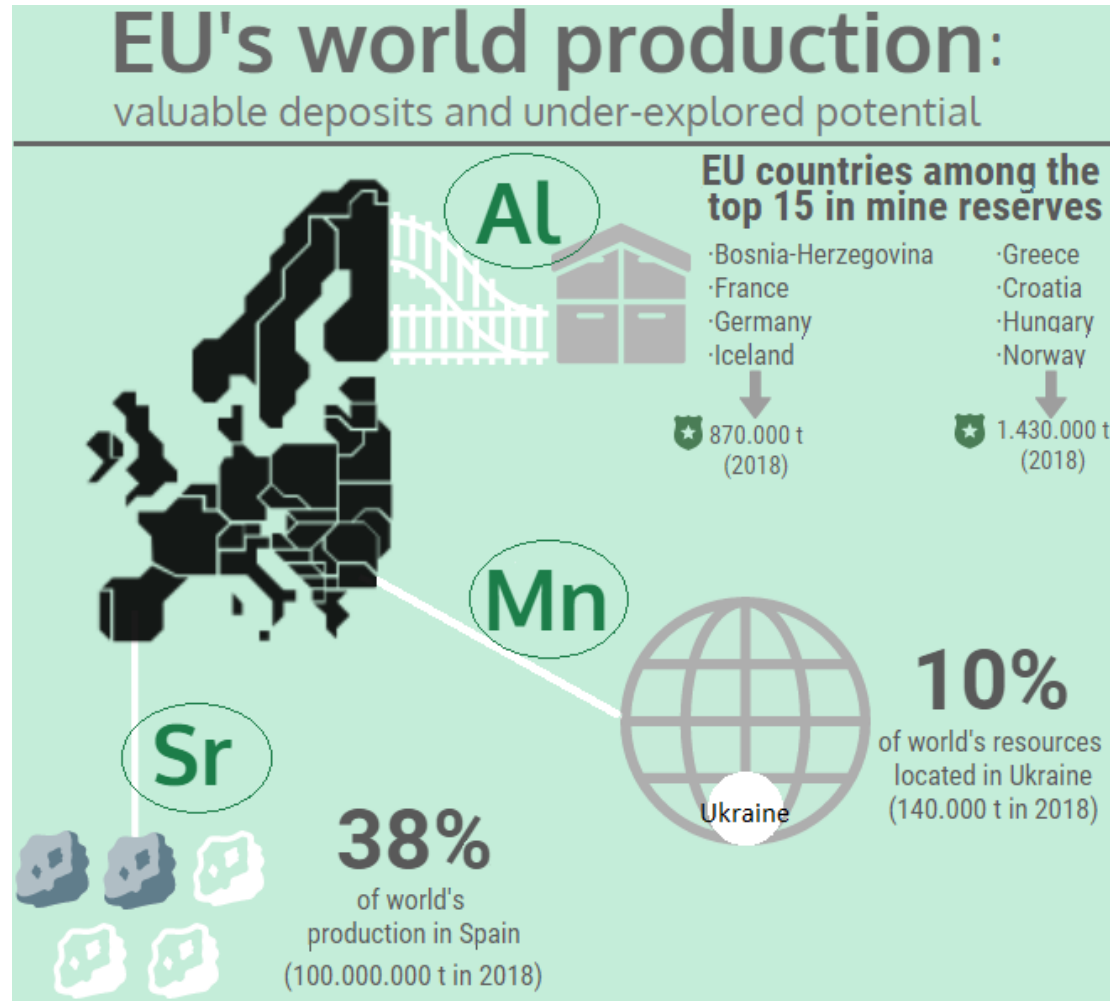
Source: M.J. Kramer, W. McCallum, A. Anderson, and S. Constantinides, JOM **64**, 752 (2012).



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Resources and processes



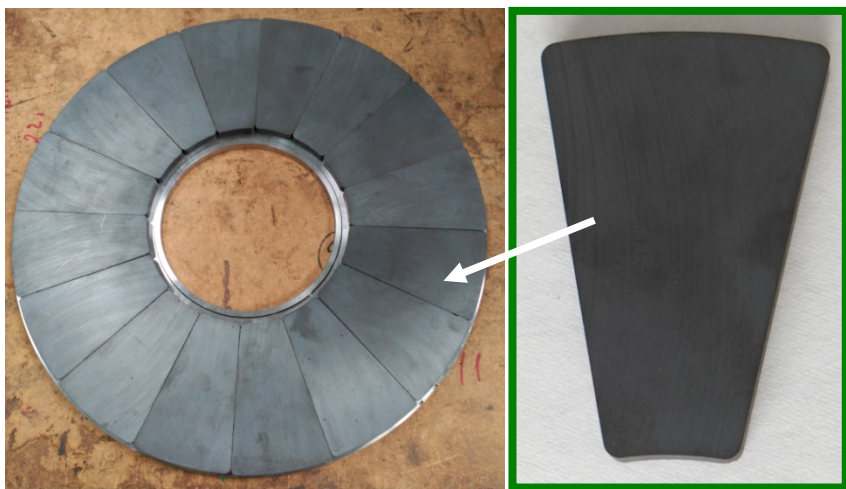
- ⚡ Abundant natural resources available in Europe → Avoidance of external dependency.
- ⚡ No need for rare earths extraction and elements refinement.
- ⚡ Industrial synthesis of material precursors and magnets fabrication with a reduced energy consumption.
- ⚡ Standardization protocols to diminish environmental impact. Recyclability.



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<p>Scale up. To scale up promising technologies for raw-materials production or the substitution of CRMs, to demonstrate that raw materials can be produced in an innovative and sustainable way, and to ensure that research and innovation end up on the market.</p>	<p><i>PASSENGER</i> will scale up two already-demonstrated technologies to produce REE-free permanent magnets as industrial prototypes for application in the e-mobility market.</p>



Is this objective realistic?



Fabrication of rotor with 32 (16x2)
ferrite magnets

Prototype scooter with an electric ferrite-based motor designed and constructed in the frame of the ended EU FP7 “NANOPYME” project (Ref: 310516/ Coordinator: IMDEA Nanociencia).

Prototype with room for improvement:

Better RE-free magnets + optimized design -> Enhanced performance



⚡ Expert partners involved in the different steps of the whole value chain.

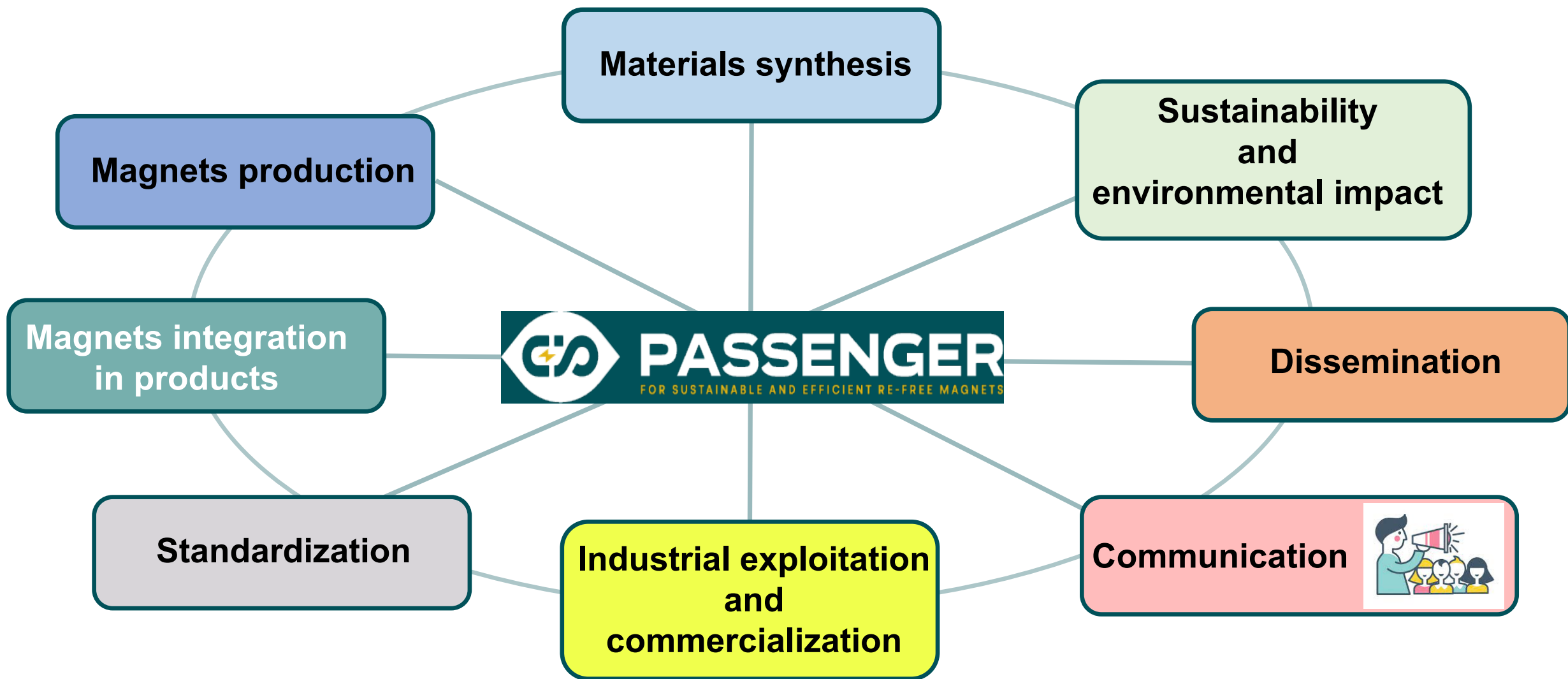
⚡ Possibility of exploring different industrial approaches to achieve efficiency in:

- Production.
- Implementation.
- Sustainability.

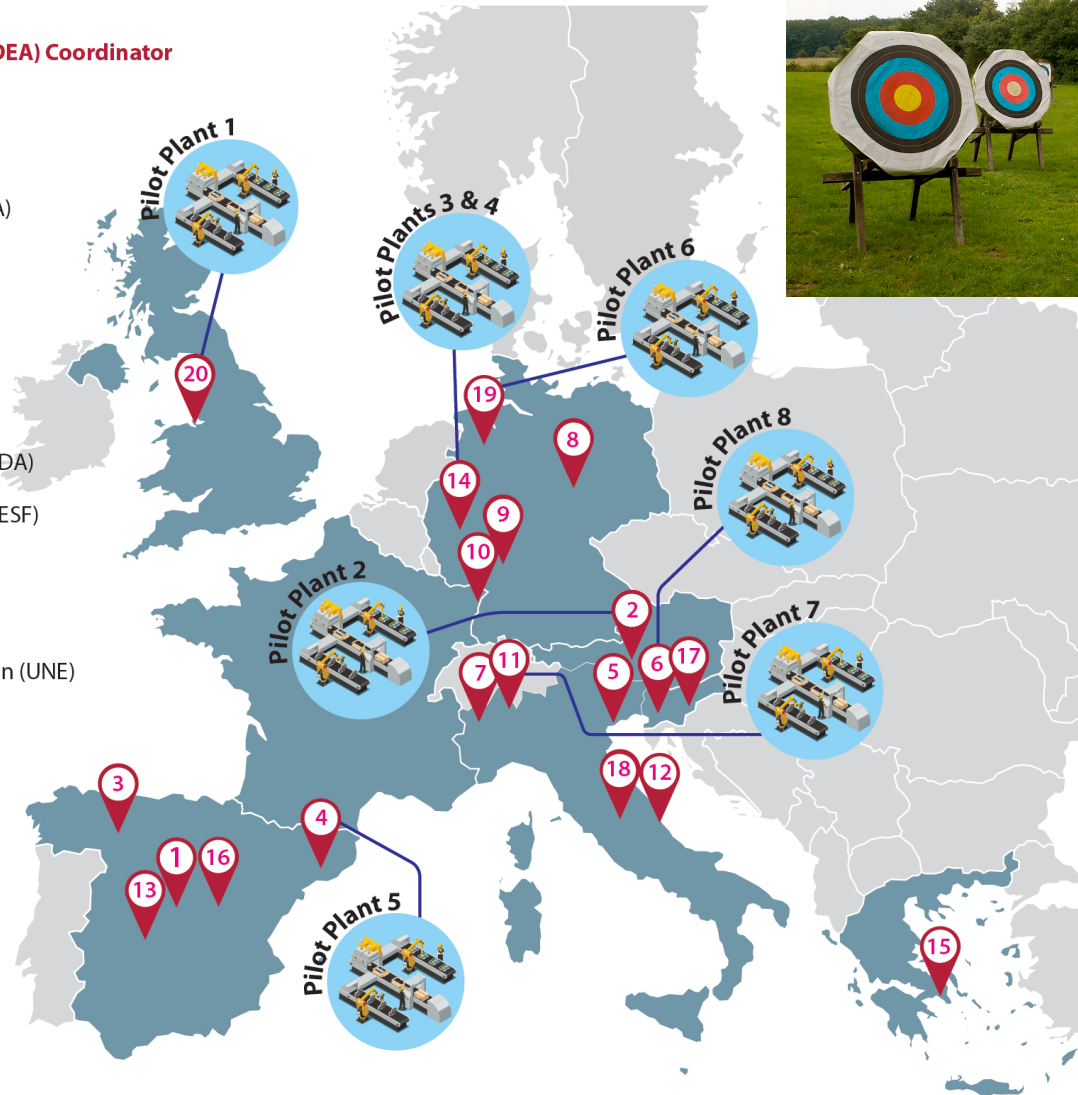
⚡ Guarantee viability of the approach (environmental impact, LCA, LCC...)

⚡ Connect with citizens → *Make worth the investment, effort and achievements!*





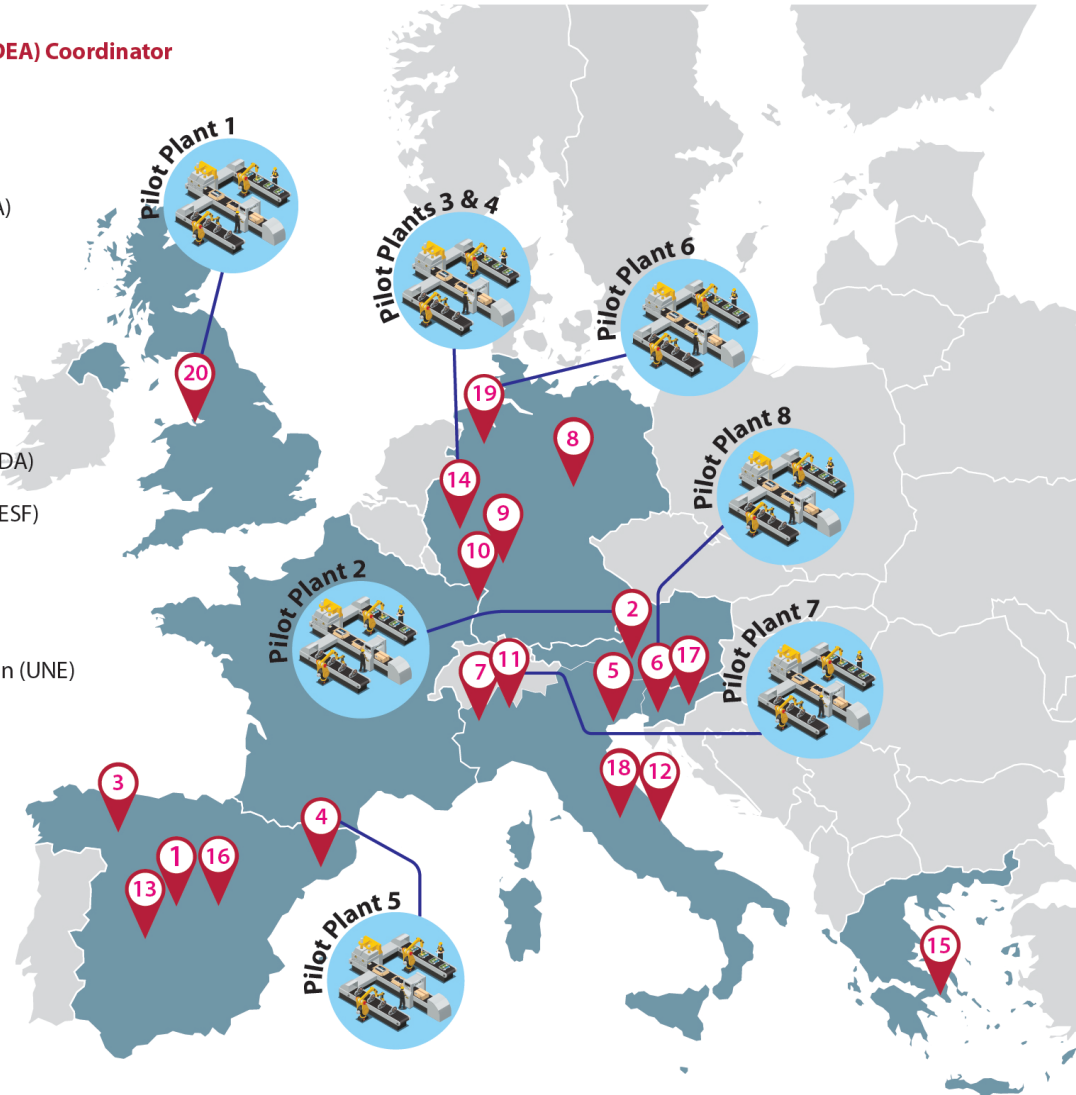
- 1 Fundación IMDEA Nanociencia (IMDEA) Coordinator
- 2 Metalpine
- 3 Fundación ICAMCYL (ICAMCYL)
- 4 Ingeniería Magnética Aplicada SL (IMA)
- 5 MBN Nanomaterialia SPA (MBN)
- 6 Kolektor Group (KOLEKTOR)
- 7 Centro Ricerche FIAT SCPA (CRF)
- 8 EIT Raw Materials GMBH (EIT)
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- 16 Tizona motors S.L. (TIZONA)
- 17 Institut Jožef Stefan (JSI)
- 18 Smart Waste Engineering (SWE)
- 19 Wilo SE (WILO)
- 20 Less Common Metals (LCM)



8 Pilot plants:
*Substitution of rare-earths
in permanent magnets
addressing 3 pilot actions*



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PILOT ACTION 1 [Substitution]:
Complete substitution of bonded Nd-Fe-B by Mn-Al-C magnets.

PILOT ACTION 2 [Substitution]:
Partial substitution of bonded Nd-Fe-B by improved Sr-ferrite magnets.

PILOT ACTION 3 [Integration]:
Integration and validation of Mn-Al-C and improved ferrite magnets.





**BARLOG
GRUPPE**



IMA
KOLEKTOR



*Integration into e-mobility applications
[+ demonstration in pumps (water), actuators...]*



wilo

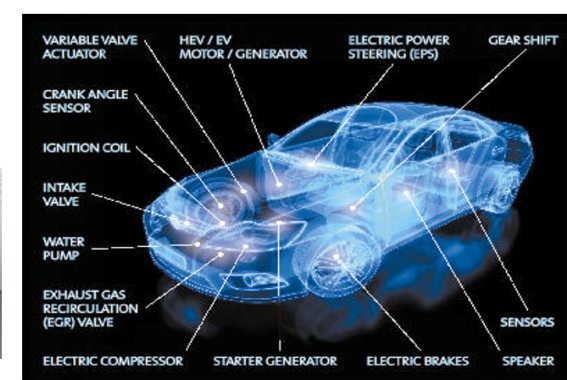


**TIZONA
MOTORS**



OSLV.com

CRF
**CENTRO
RICERCHE
FIAT**





Electric bikes: Excluding China, global e-bike sales are expected to grow from 3.3 million units annually to some 6.8 million units by 2025, with the majority of this growth coming from Europe.

PASSENGER aims to substitute in its entirety the NdDyFeB magnets in e-bikes.



Electric motorbikes: Annual e-motorcycle sales is expected to reach \$6 million by 2023.

PASSENGER aims to substitute in its entirety NdDyFeB in this sector profiting from an optimized motor design.



Electric cars: Uptake of electric vehicles in Europe is increasing fast. A vehicle may use about 400 g Nd-Fe-B PMs for **utilities and accessories** (*these numbers without considering the large use of Nd-Fe-B magnets in the driving motor*) → annual incremental demand of 120 t NdPr oxide and Dy for every 1 million vehicles sold.

Weight is an issue in e-cars and the materials considered in *PASSENGER* have a significantly lower density (about 35%) than Nd-Fe-B.

+ Integration in motor pumps and actuators as key driving sectors to open a new market for PASSENGER's magnets

— Follow us!

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contact: passenger.project@imdea.org
alberto.bollero@imdea.org



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