PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

BLACK CYCLE
1ST WORKSHOP

NOVEMBER 2021

PASSENGER

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

20	13	8	8
CONSORTIUM MEMBERS	INDUSTRY PARTNERS	EUROPEAN COUNTRIES	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

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

Content preview

01

About us

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

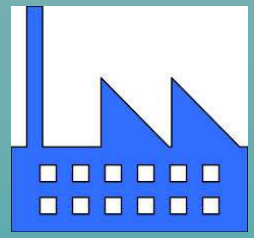
HORIZON 2020

02

Our mission

03

Our goal



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

The Call

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

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

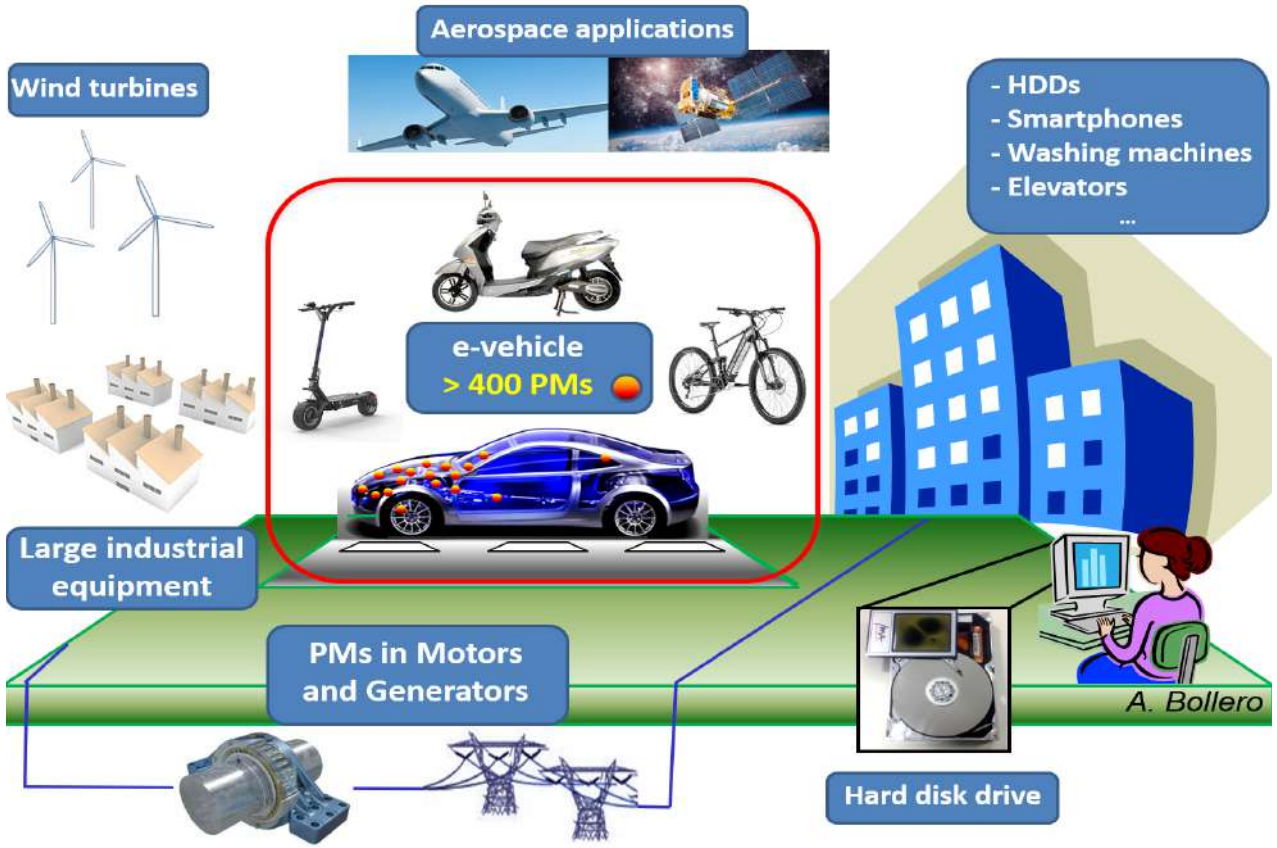
PASSENGER: Specific challenges

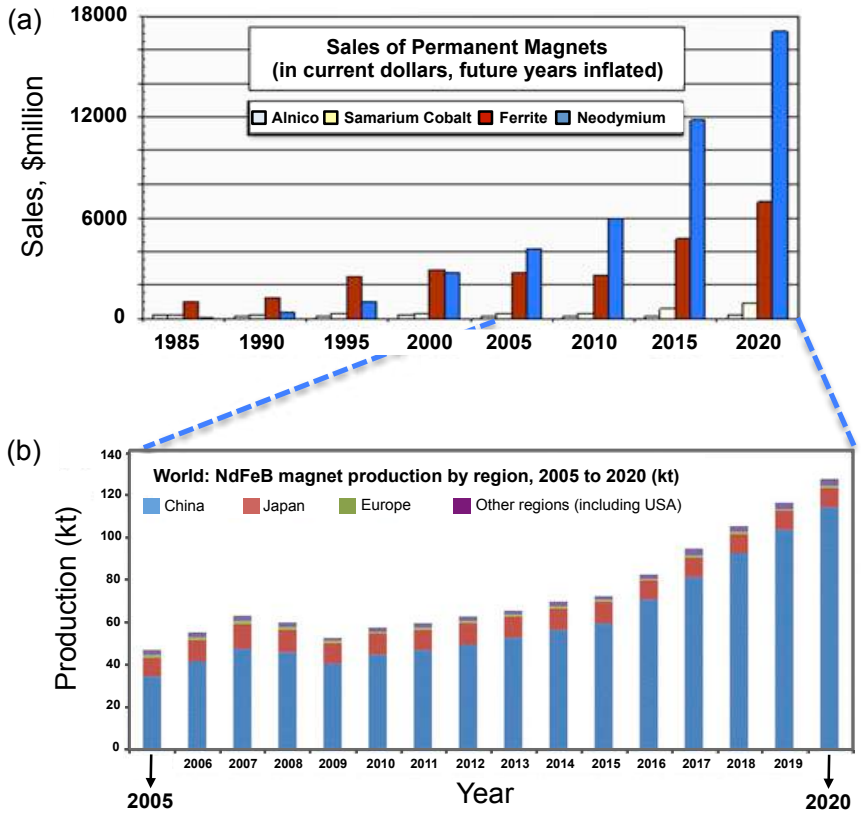
Specific challenge ↓	How *PASSENGER* addresses this specific challenge ↓
Substitution. To use substitution as a way to reduce the EU's consumption of CRMs, lower dependence on imports and reduce adverse environmental impacts.	*PASSENGER* will reduce the dependence on CRMs, specifically REEs, by piloting two previously TRL 4-5 demonstrated permanent-magnet materials: improved strontium ferrites ($SrFe_{12}O_{19}$) and manganese-aluminium-carbides (Mn-Al-C).
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.	*PASSENGER* will scale up two already-demonstrated technologies to produce REE-free permanent magnets as industrial prototypes for application in the e-mobility market.

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

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

The Topic: Permanent Magnets





(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

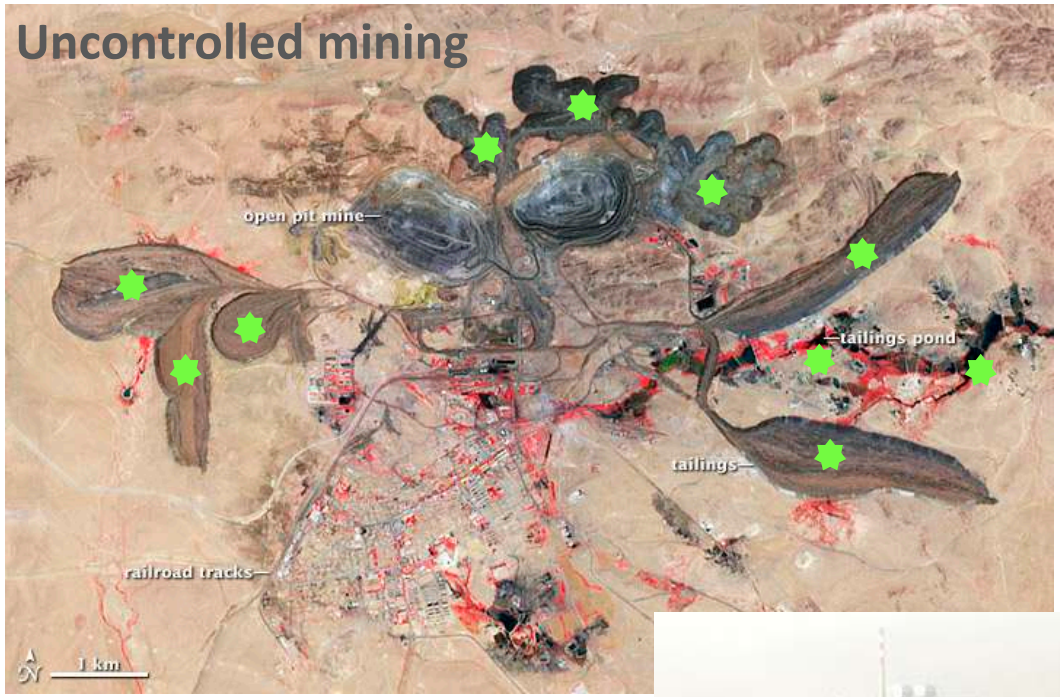
⟺

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

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

BLACK CYCLE
1ST WORKSHOP

The Topic: Permanent Magnets



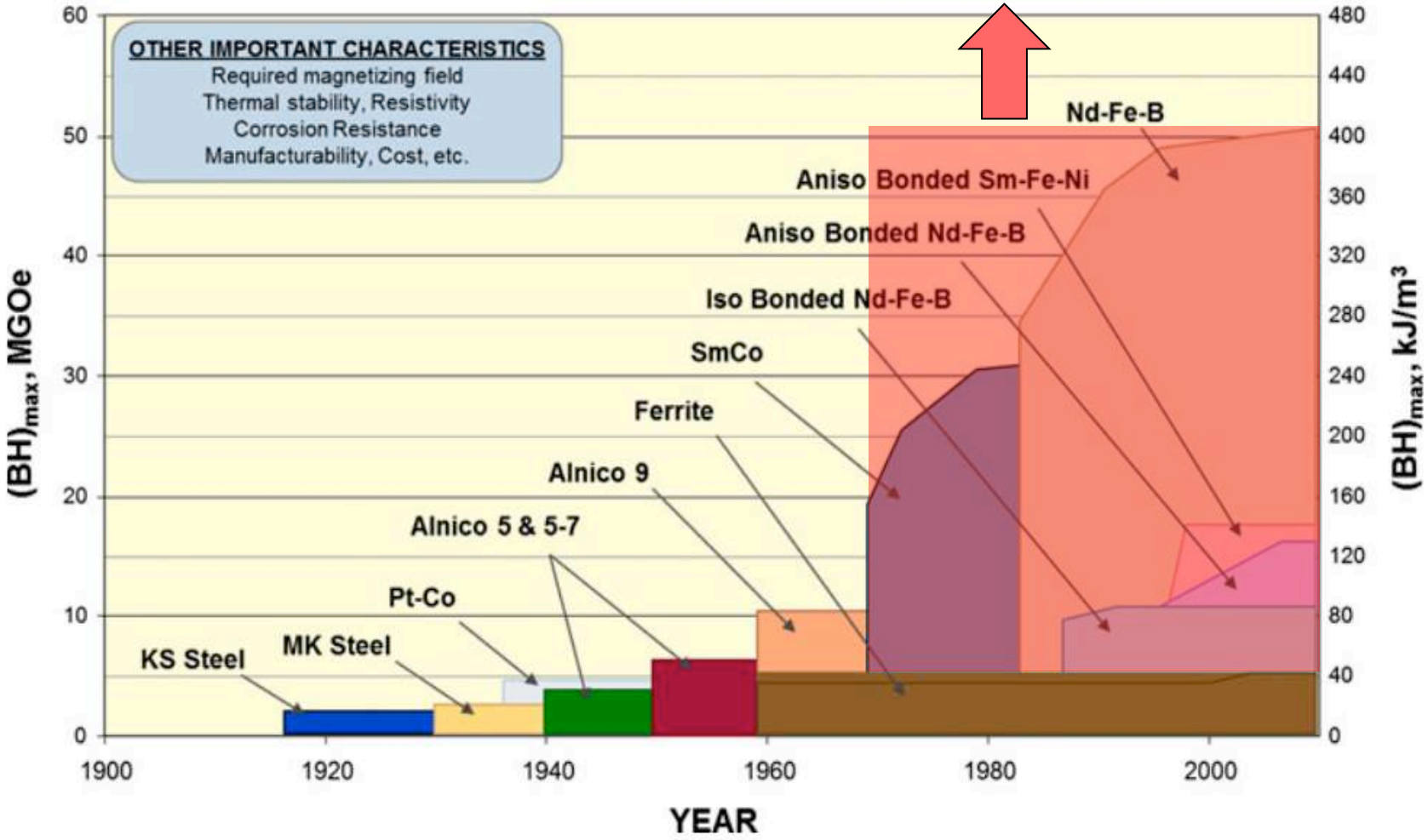
Environmental impact from extraction and refinement of the rare-earth elements

Globalization means ***"WE":***
Impact on You brings Impact on Me

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

The Topic: Permanent Magnets

Complete performance region covered exclusively by rare earth-based magnets



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

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

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

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

Approaches to mitigate dependency on CRMs in PMs

Novel materials

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

Engineering structures

Engineering nanostructures for optimized (reduced) use of CRMs.

Reuse and recycling

Increased sustainability through reuse and recycling.

Exploring new phenomena

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

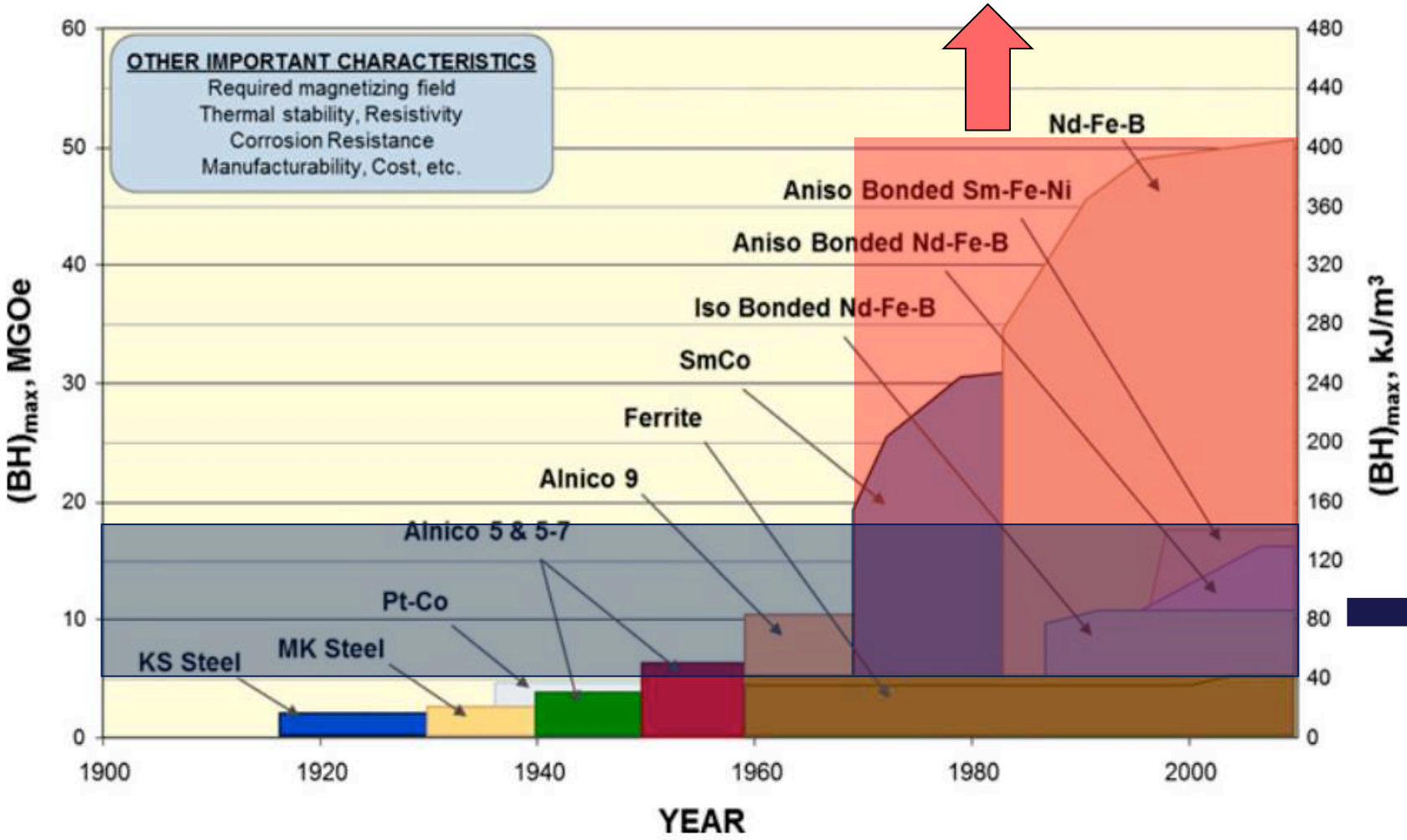
Diversification of PM materials

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

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

The Topic: Permanent Magnets

Rare earth-based magnets



Objective

Substitution

Filling an area currently covered exclusively by REE-based PMs

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

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

Cooking Permanent Magnets

Excellent ingredients

+

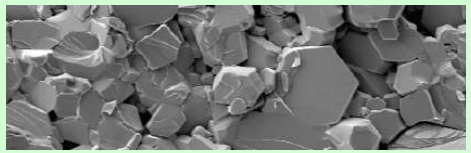
Processing (cooking)

⇒

Delicious dish

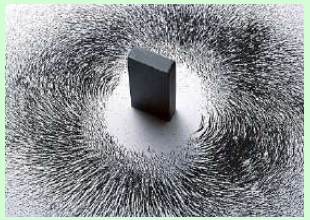
Intrinsic properties

+



Nanostructuring & Phase transformation

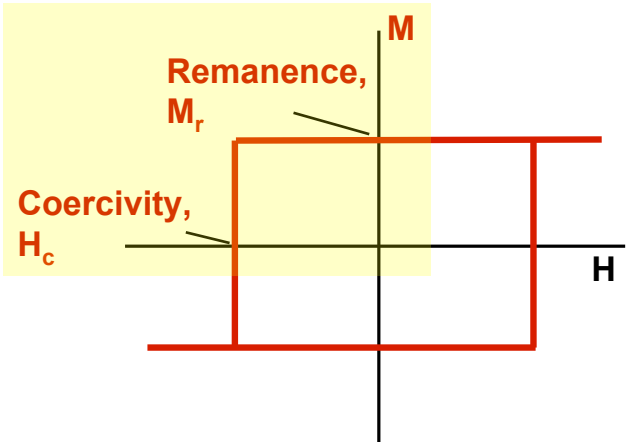
⇒



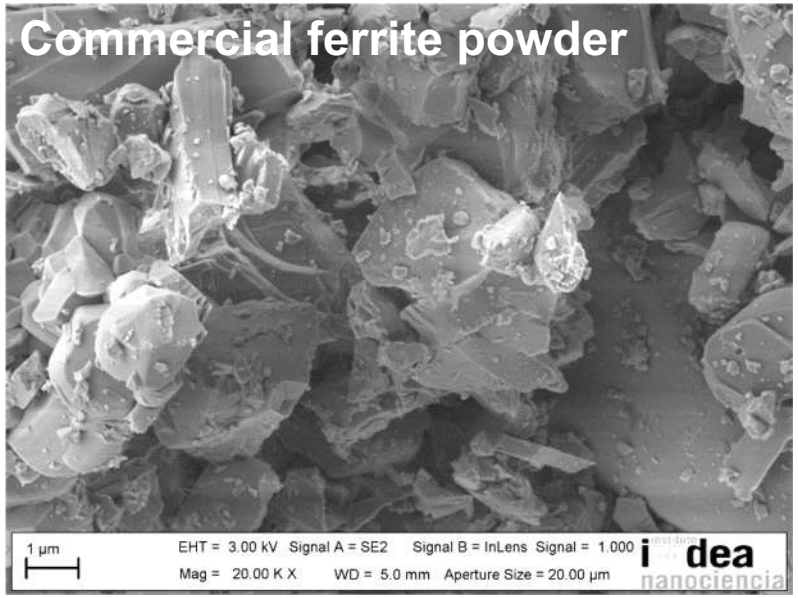
Extrinsic properties

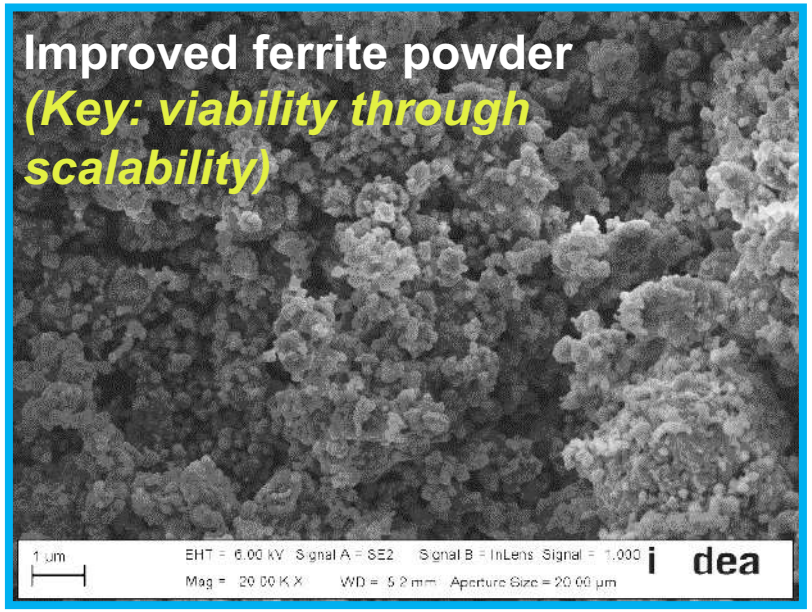
We can control it by proper choice of the preparation/ processing parameters

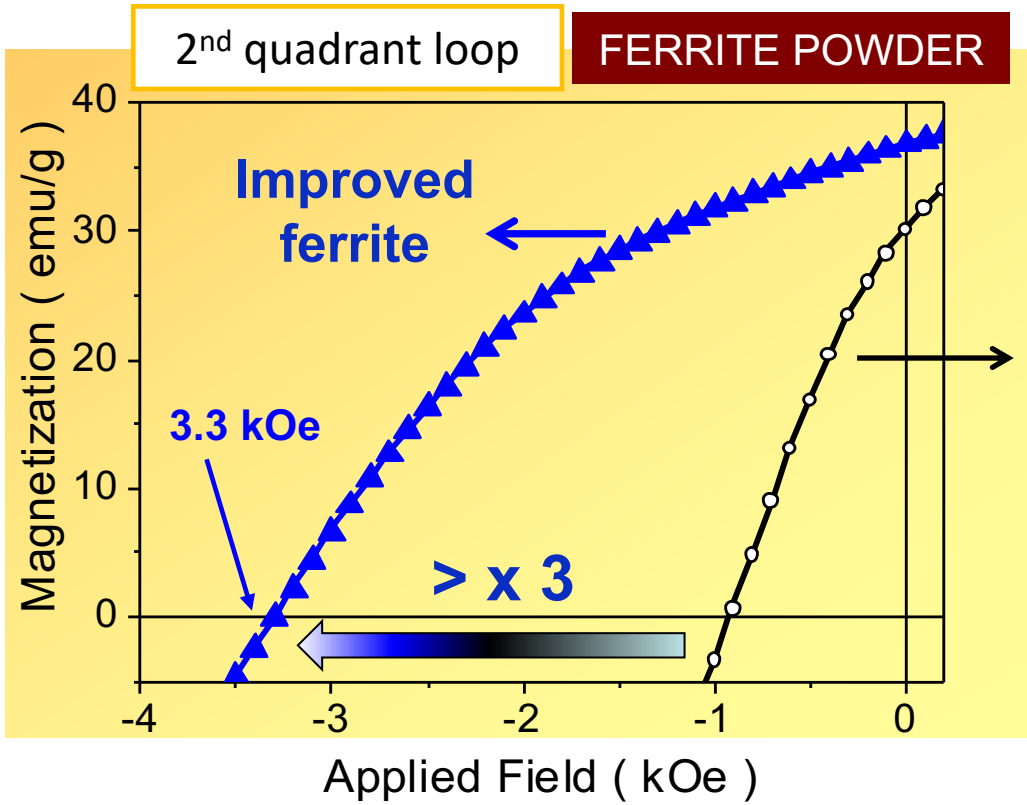
Magnetic response ("*Magnet ID*"):



Cooking Permanent Magnets







Starting material (commercial ferrite)

Do you find good this three-fold increase?

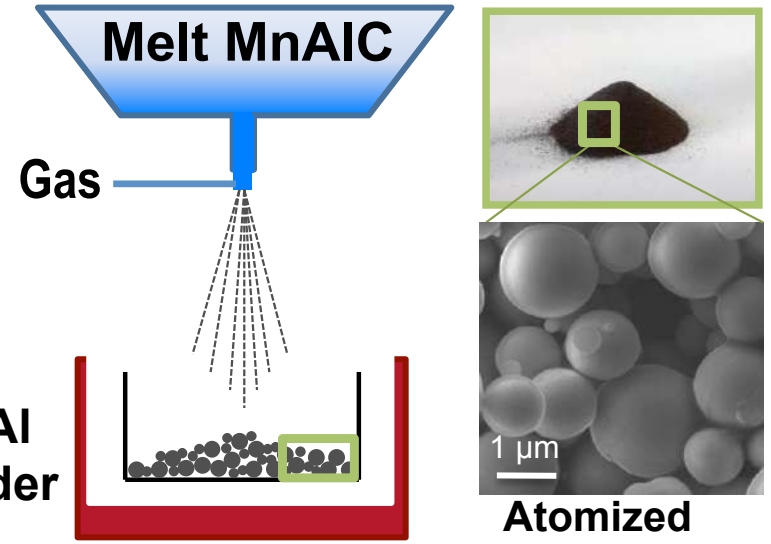
We have already surpass it in ***PASSENGER*** by achieving a coercivity **above 6 kOe** (!!!) → Good PM candidate to improve functionality (e.g. when decreasing operation temperature in motors)

BLACK CYCLE
1ST WORKSHOP

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

+ Incorporation of a New Player: Mn-Al-C

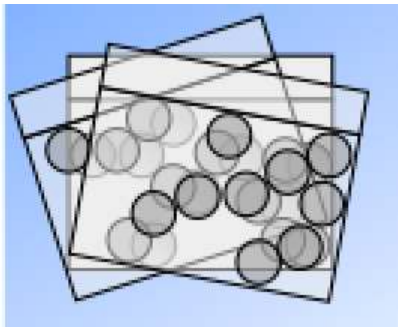
Gas-atomization (synthesis)

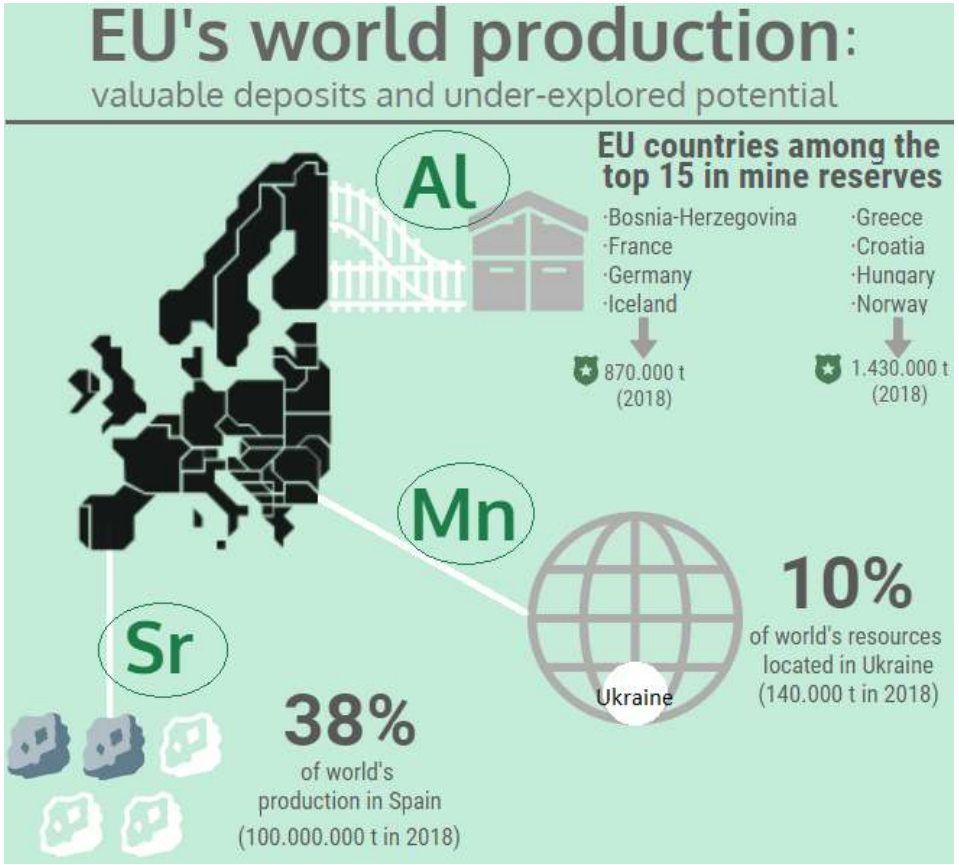


Atomized metallic particles

Flash-milling

nanostructuration
+
controlled phase transformation





- Excellent permanent magnet properties with European resources.
- Possibility of producing low-density magnets with high performance (e.g.: advantage on reduced fuel consumption).
- Synthesis by industrial casting and atomization techniques.
- Magnets fabrication by diverse industrial techniques.

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

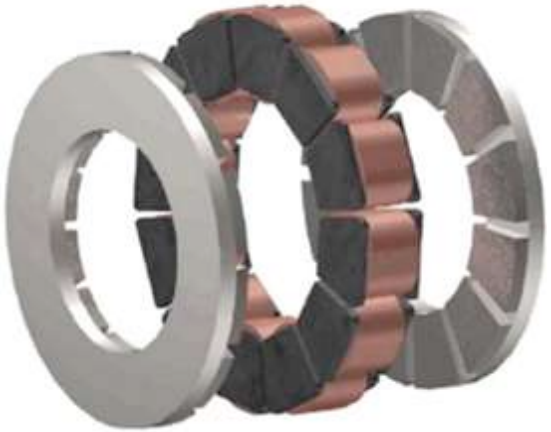
PASSENGER: Specific challenges

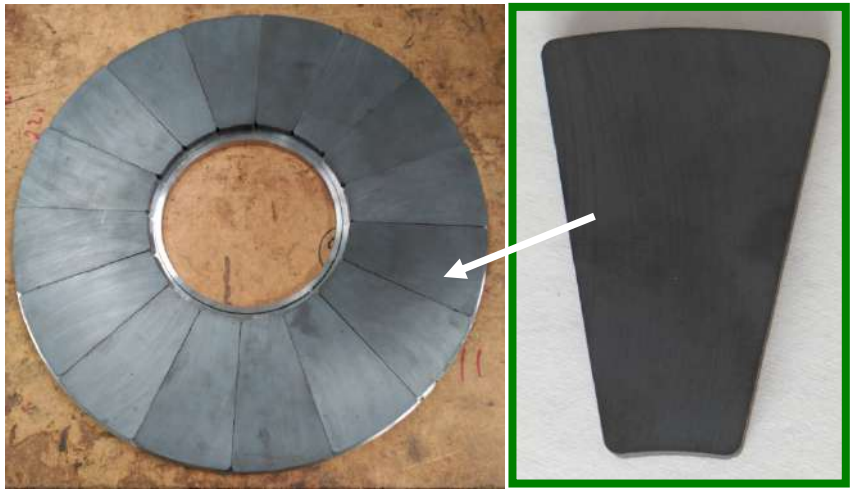
Specific challenge ↓	How *PASSENGER* addresses this specific challenge ↓
Substitution. To use substitution as a way to reduce the EU's consumption of CRMs, lower dependence on imports and reduce adverse environmental impacts.	*PASSENGER* will reduce the dependence on CRMs, specifically REEs, by piloting two previously TRL 4-5 demonstrated permanent-magnet materials: improved strontium ferrites ($SrFe_{12}O_{19}$) and manganese-aluminium-carbides (Mn-Al-C).
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.	*PASSENGER* will scale up two already-demonstrated technologies to produce REE-free permanent magnets as industrial prototypes for application in the e-mobility market.

Is this objective realistic?

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

NANOPYME: prototype





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).

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

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

The Consortium

- 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!*

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

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

The Goal

1 **Fundación IMDEA Nanociencia (IMDEA) Coordinator**
2 Metalpine
3 Fundación ICAMCYL (ICAMCYL)
4 Ingenieria Magnetica Aplicada SL (IMA)
5 MBN Nanomaterialia SPA (MBN)
6 Kolektor Group (KOLEKTOR)
7 Centro Ricerche FIAT SCPA (CRF)
8 EIT Raw Materials GMBH (EIT)
9 Technische Universität Darmstadt (TUDA)
10 Fondation Europeenne de la Science (ESF)
11 Industrie ILPEA spa (ILPEA)
12 OSLV Italia S.R.L. (OSLV)
13 Spanish Association for standardization (UNE)
14 BARLOG Plastics GmbH (BARLOG)
15 MNLT Innovations IKE (MNLT)
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

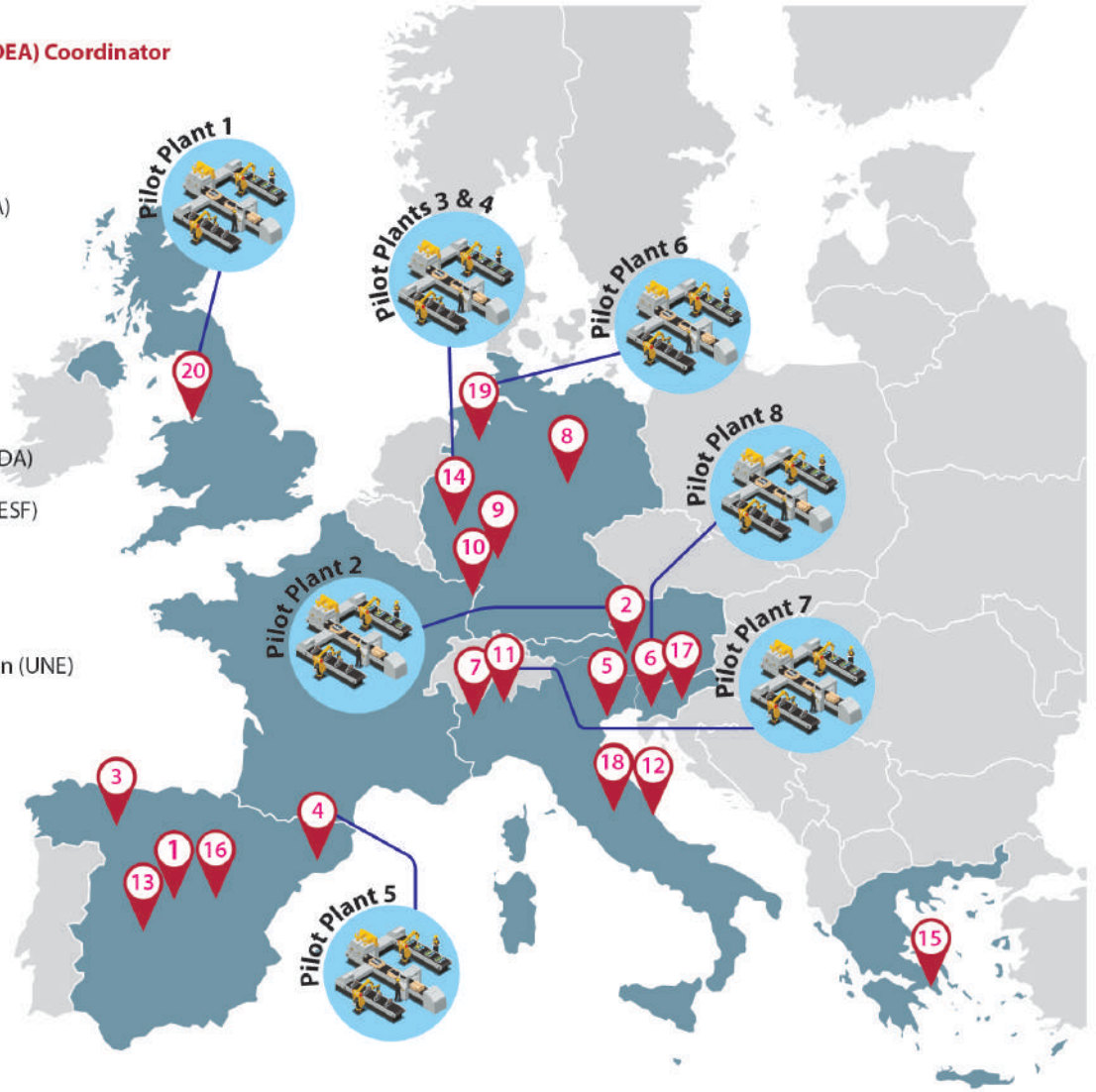
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003914

BLACK CYCLE
1ST WORKSHOP

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

The Goal

1 **Fundación IMDEA Nanociencia (IMDEA) Coordinator**
2 Metalpine
3 Fundación ICAMCYL (ICAMCYL)
4 Ingenieria Magnetica Aplicada SL (IMA)
5 MBN Nanomaterialia SPA (MBN)
6 Kolektor Group (KOLEKTOR)
7 Centro Ricerche FIAT SCPA (CRF)
8 EIT Raw Materials GMBH (EIT)
9 Technische Universität Darmstadt (TUDA)
10 Fondation Europeenne de la Science (ESF)
11 Industrie ILPEA spa (ILPEA)
12 OSLV Italia S.R.L. (OSLV)
13 Spanish Association for standardization (UNE)
14 BARLOG Plastics GmbH (BARLOG)
15 MNLT Innovations IKE (MNLT)
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)



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.

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

BLACK CYCLE
1ST WORKSHOP

The Goal: *From the Lab to the Fab* and to the user

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

instituto imdea nanociencia EXCELENCIA SEVERO OCHOA

TECHNISCHE UNIVERSITÄT DARMSTADT

Institut Jožef Stefan

LCM less common metals

BARLOG GRUPPE

IMA

KOLEKTOR

METALPINE

INDUSTRIE ILPEA

MBN nanomaterialia

MNLT Innovations

UNE Normalización Española

ICAMCYL

Smart Waste Engineering srl

SCIENCE CONNECT YOUR PARTNER IN SCIENCE

eit RawMaterials Connecting matters

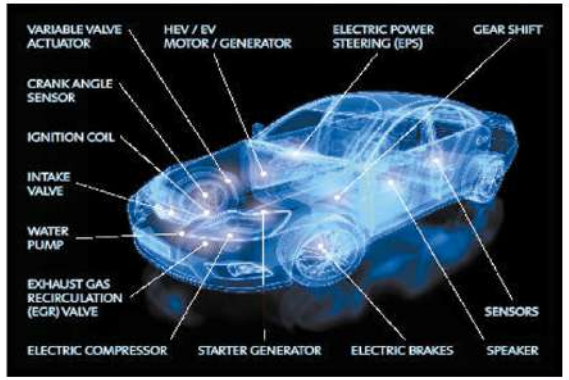
Integration into e-mobility applications
[+ demonstration in pumps (water), actuators…]

wilo

TIZONA MOTORS

OSLV.com

CRF CENTRO RICERCHE FIAT



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

Integration – *some numbers…*

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 profitting 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.

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

PASSENGER: Dimensions

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

Materials synthesis

Magnets production

Sustainability and environmental impact

Magnets integration in products

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

Dissemination

Standardization

Industrial exploitation and commercialization

Communication

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

PASSENGER: Technological objectives

TO1: Producing Mn-Al-C permanent magnets as a REE-free substitute.

TO2: Producing improved Sr-ferrite ($SrFe_{12}O_{19}$) permanent magnets.

TO3: Technology implementation and production upscale (5-10 tonne/yr).

TO4: Validation of *PASSENGER*'s developments across 8 production and manufacturing pilots involving 8 companies, with key end users (4 additional companies involved in 4 integration/validation pilots).

Powder and compounds

MAGNETS

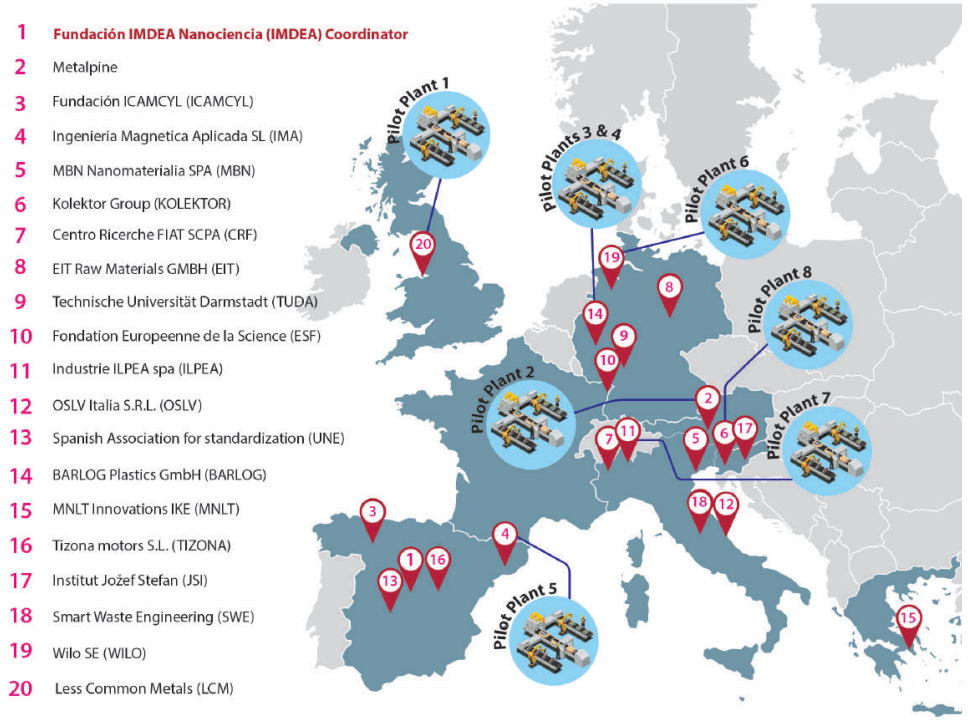
Bonded and Sintered Magnets

INTEGRATION

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

PASSENGER: Environmental objectives

EO1: Developing an eco-design and lifecycle analysis (LCA) of *PASSENGER*'s substitution pilot.

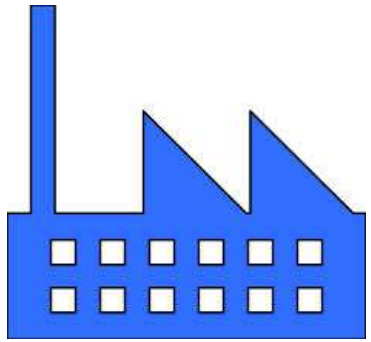


EO2: Including an economic lifecycle cost (LCC) assessment, providing an eco-efficiency analysis.

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

PASSENGER: Environmental objectives

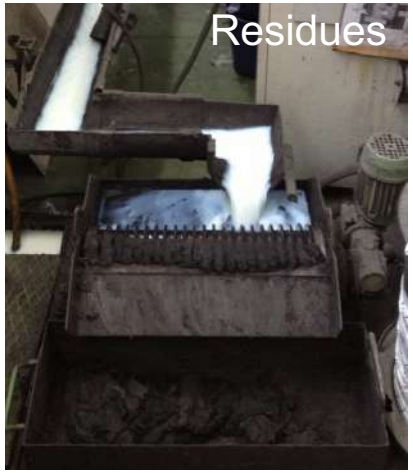
Residues removal → Increased costs + environmentally unfriendly + energetically inefficient



Manufacturing of Magnets

Closing the loop

Sustainability through recycling



Magnetic waste

To avoid:

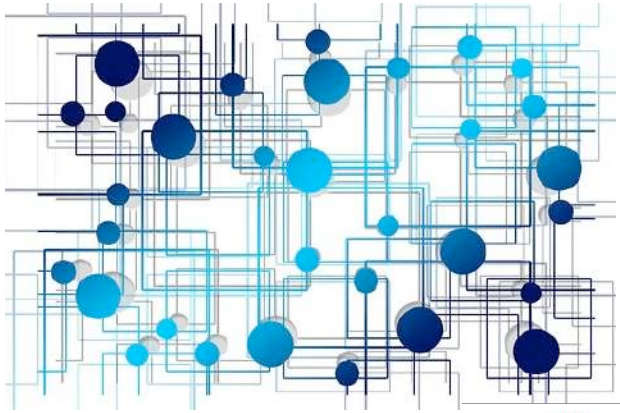
Residues removal by external company

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

PASSENGER: Business objectives

BO1: Quantifying the economics of the different substitution pilots on the premise of a competitive target price per kg. Implement a realistic business plan for the commercialisation of the permanent magnets.

BO2: Transferring the knowledge of integrated substitution solutions on MnAlC and improved ferrite to EU-related projects and platforms. To promote cross-fertilization and clustering activities.



BO3: Exploring policy actions by providing recommendations to national or/and European legislators and advocate for an adaptation of the legislation/directives/new standards where needed, and quantify the social impact of substitution solutions.

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

PASSENGER: Societal objectives

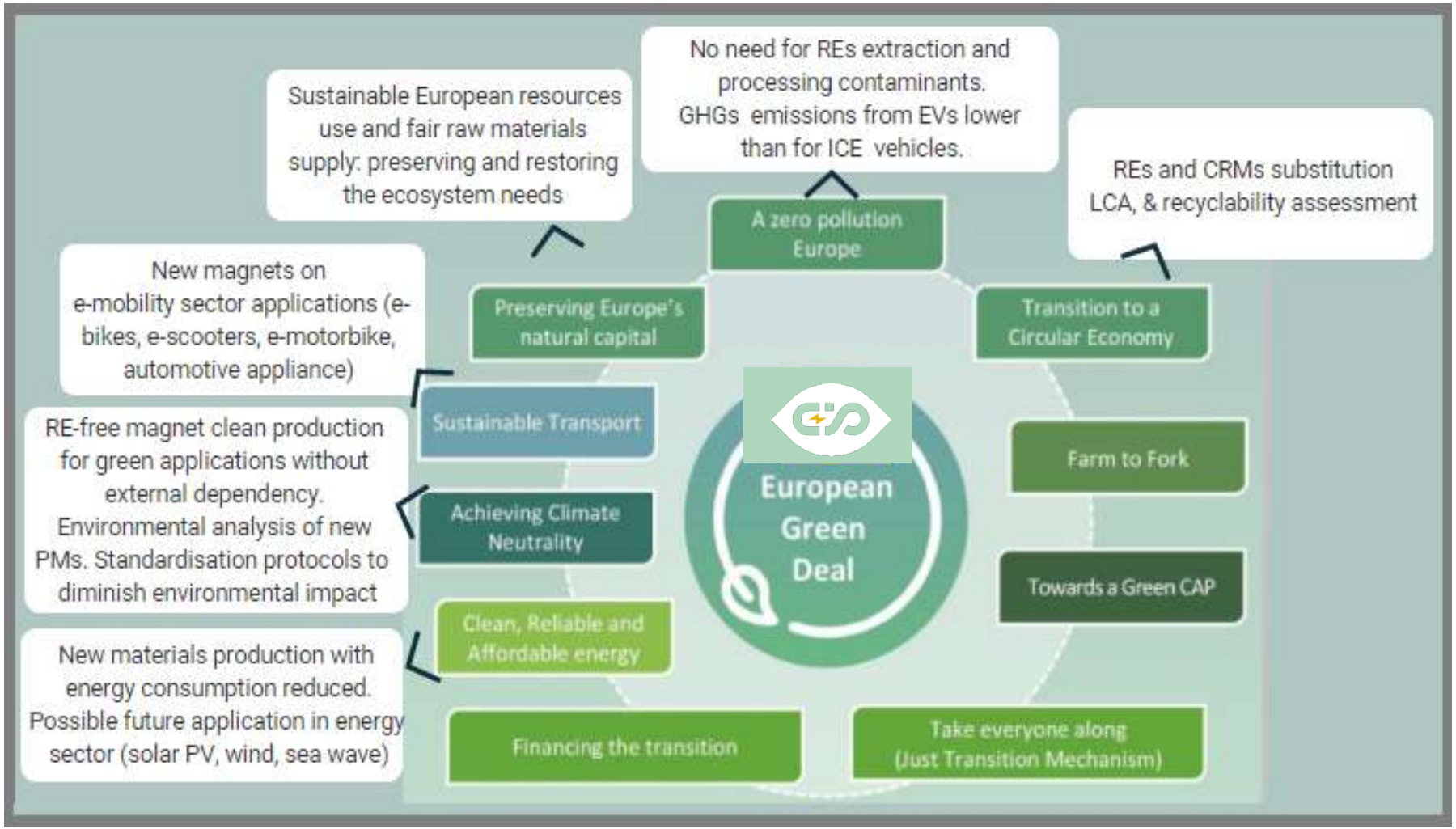
SO1: Raising awareness by communicating findings to the public, university/research/industry, local and national governments and the EC through policy briefs, reports, trainings and a roadshow concept.

SO2: Clustering with related national and H2020 projects, with the EIT KIC raw materials (i.e., lighthouse programmes & zero-waste cluster), non-EU initiatives and global-standards organisations.

We want to know you !

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

PASSENGER – *European Green Deal*



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

PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

BLACK CYCLE
1ST WORKSHOP

Follow us!

PASSENGER website: https://passenger-project.eu/

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

Twitter

https://twitter.com/Passenger_EU

Linkedin

https://www.linkedin.com/company/passenger-eu/

FaceBook

https://www.facebook.com/PassengerEU

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