PASSENGER
FOR SUSTAINABLE AND EFFICIENT RE-FREE MAGNETS

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

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INTELLIGENCE BULLETIN DELIVERED BY
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INTELLIGENCE BULLETIN #1

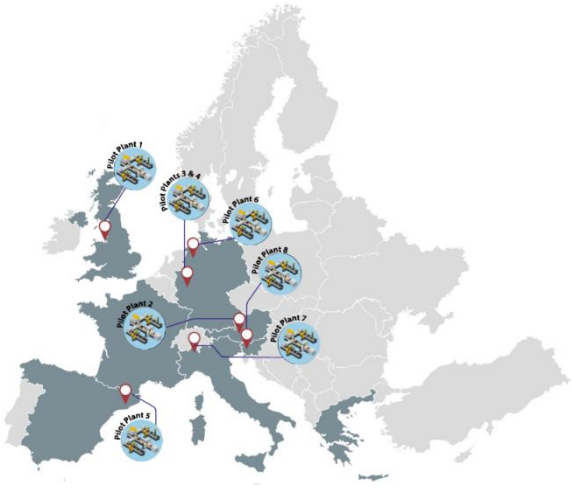
Strategic Intelligence Bulletins aim to enrich strategic and managerial decisions and to engage stakeholders based on partners networks.

PASSENGER APPROACH : GUIDELINES FOR PILOTS AND SELECTION OF MATERIALS

PASSENGER will develop substitution pilots for critical and scarce raw materials to address an aspect of high economical, technological, social and environmental relevance. The solution for the EU dependency on rare-earths and for permanent magnets will avoid bottlenecks in the material supply-chain and will reduce the environmental impact. PASSENGER alternatives will be based on widely available resources and innovative technologies all focused to an industrial orientation involving key end users and SMEs/LEs from 8 EU countries.

1. THE 8 SUBSTITUTION PILOTS

The 8 innovative pilot activities developed in PASSENGER will cover the complete value chain and will guarantee implementation across the EU after the project is finished. These innovative pilot actions on the substitution of Nd-Fe-B-based magnets, the fabrication of new grades of magnets and the validation of new products (4 integration pilots) will be covered.



Pilots will include production of fully dense Mn-Al-C magnets, production of bonded Mn-Al-C magnets, production of fully dense ferrite magnets and production of bonded ferrite magnets. Some major milestones will be achieved related to pilots planned:

PILOT ACTION 1. Steps:

- Fabrication of MnAlC powder
- Fabrication of a MnAlC-based compound for bonding technologies
- Fabrication of Mn-Al-C bonded magnets
- Fabrication of fully dense Mn-Al-C magnets

Result: Complete substitution of traditional RE magnets with new Mn-Al-C magnets

PILOT ACTION 2. Steps:

- Fabrication of improved ferrite powder
- Fabrication of a ferrite-based compound for bonding technologies
- Fabrication of improved ferrite bonded magnets
- Fabrication of improved ferrite sintered magnets

Result: Partial substitution of traditional RE magnets with improved Sr-ferrite magnets

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PILOT ACTION 3. Steps:

- Implementation of PASSENGER magnets in gearboxes and actuators
- Complete substitution with PASSENGER magnets in e-scooters, e-bikes and e-motorbikes
- Substitution with PASSENGER magnets in e-cars: sensing, gearshifts, drive- and brake-by-wire, active suspension controls, headlights range adjustment and battery management
- Substitution with PASSENGER magnets in the rotor of a pump motor

Result: Integration and validation of the newly developed RE-free magnets

The three main Pilot Actions will each be divided into different steps and implemented in eight different Pilot Plants across Europe.

PILOT PLANTS:

PILOT PLANT #1

Pilot activities lead by LCM

➔ In the Pilot Plant 1, LCM will lead the up-scaled fabrication of the Mn-Al-C alloy by casting. LCM will then supply the newly produced as-cast alloy to METALPINE, who will proceed with gas-atomization.

PILOT PLANT #2

Pilot activities lead by Metalpine

➔Metalpine's gas-atomisation will provide quasi-spherical particles with a controllable particle size distribution (< 100 microns) by varying the processing parameters (gas pressure and ratio of gas to metal mass flow).

➔The quasi-spherical shape and the possibility of controlling the particle size will be important for the optimised fabrication of fully dense magnets by hot-deformation that will be led by WILO.

➔The casting of Mn-Al-C alloy followed by crushing and milling will result in irregular shape particles of about 100 microns. These characteristics will be suitable for the fabrication of magnets by IMA and KOLEKTOR.

PILOT PLANT #3&4

Pilot activities lead by Barlog Plastics

➔In these pilot plants, BARLOG will prepare compounds (PM/polymer) based on the powders provided by LCM (Mn-Al-C powder from crushed alloy), METALPINE (Mn-Al-C gas-atomized powder) and ILPEA (ferrite powder). In order to consider the influence of particle size, BARLOG will also test the previous powder materials after milling by MBN and ILPEA, respectively.

➔The compounds will then be supplied to IMA and KOLEKTOR for testing them in the fabrication of PASSENGER's magnets, followed by upscaled production.

PILOT PLANT #5

Pilot activities lead by Ingenieria Magnetica Aplicada SA

➔IMA will fabricate PASSENGER's novel Mn-Al-C and improved ferrite magnets by an injection moulding technique. It will be applied to the automotive sector but it can also be extended to other sectors with a high demand for magnets for sensing and motors applications.

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PILOT PLANT #6

Pilot activities lead by Wilo SE

➔PASSENGER's novel permanent magnets, fabricated by IMA, KOLEKTOR and WILO, will then be integrated into functional prototypes and tested under operating conditions. Building upon TUDA's work, Wilo will apply in PASSENGER its patent related to the invention of a permanent magnet rotor for an electrical machine, with a soft magnetic core and a number of circumferentially arranged permanent magnets (a pseudo magnetic pole being created in the iron core in the circumferential direction between two adjacent permanent magnets).

PILOT PLANT #7

Pilot activities lead by Industrie ILPEA

➔PASSENGER will fabricate ferrite powder precursors with enhanced PM properties and enlarged coercivity to compensate for losses when decreasing temperature. The project will apply Ilpea's expertise in controlling both the content of Fe_2O_3 during the synthesis of the ferrite material and the sintering parameters. The interplay of the tuneable synthesis process and the microstructural refinement achieved by ball milling has been demonstrated by JSI and IMDEA as a key factor to enhance the magnetic properties of ferrites.
➔ILPEA (Sr-ferrite producer) will work with JSI (expert on the study and characterization of ferrites) and IMDEA and MBN (both working together for translation of the flash-milling method to industrial processing of ferrite powder.

PILOT PLANT #8

Pilot activities lead by Kolektor Group

➔Casting of Mn-Al-C alloy followed by crushing and milling will result in irregular shape particles of about 100 microns. These characteristics will be suitable for the fabrication of magnets by IMA and KOLEKTOR.

Moreover, the validation pilots for commercial applications will be applied to **electromobility sector** with three application areas (e-scooter, e-bikes and e-motorbikes and e-cars) and, due also to the rapid integration in the market and the relevance of the application, the **sector of pump motors**.

E-SCOOTERS E-BIKES E-MOTORBIKES E-CARS MOTOR PUMPS

2. THE PERMANENT MAGNETS SELECTION

Combining key premises to guarantee achievement of a sustainable permanent magnet solution for Europe with absence of any critical raw elements and, moreover, use of constituent elements widely available in Europe; sufficiently mature development of the materials and the proposed technologies (TRL>4) providing a solid basis for a successful transition from the lab to the industrial production through the creation of innovative pilot plants in PASSENGER's time frame is assured. The choice of PMs will be based on realistic projects results and patents

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(proven at TRL 4-5) achieved by the partners in successful EU projects, with envisioned up-scaling, low cost and environmental impact approach:

- **Improved Strontium ferrite (Sr-ferrite).** The manufacture of improved hard ferrites, while avoiding the use of critical materials as proposed by PASSENGER, will enable a sustainable partial substitution of bonded rare earth-based magnets based on elements available in Europe. PASSENGER's powder producer (ILPEA) has a long time trajectory fabricating and commercializing Sr-ferrite powder, with a continuous supply of the constituent materials. Accordingly, the sourcing is guaranteed for the development of PASSENGER's improved ferrite.
- **Manganese-Aluminum-Carbon (Mn-Al-C) and related technologies**. The PASSENGER companies that will work in the fabrication of the alloy will be LCM and METALPINE. They will identify the best suppliers for these elements among their existing suppliers (and/or new ones on the basis of reliability, location and fair price). Sourcing for the required elements (Mn, Al and C) will consider two aspects:

ASPECT 1) European countries have some of the largest reserves of the minerals (e.g., Ukraine with 140,000 tonnes of manganese in 2018, about 10% of the world's supply, Norway with 1,4m tonnes of aluminium in 2018 and Iceland with 870,000 tonnes of aluminium in 2018.

ASPECT 2) Mn and C are fundamental constituents in powder metallurgy steels, moving an enormous market sector on a global basis and counting with a strong European presence in the manufacture sector. Additionally, Fe-Mn-Al-C structural steels are used in automotive, armour and mining industry due to their lightweight and structural resistance properties.

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