# Anisometric permanent hybrid magnets based on inexpensive and non-critical materials

## Informe

Información del proyecto

**AMPHIBIAN**

Identificador del acuerdo de subvención: 720853

Sitio web del proyecto

**DOI**
10.3030/720853

Proyecto cerrado

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Spain

# Periodic Reporting for period 2 - AMPHIBIAN (Anisometric permanent hybrid magnets based on inexpensive and non-critical materials)

**Período documentado:** 2018-07-01 hasta 2019-12-31

## Resumen del contexto y de los objetivos generales del proyecto

Permanent magnets are crucial in modern technology as they allow storing, delivering and converting energy. They are able to transform electrical energy into mechanical and vice versa, which means that improving their performance entails transforming energy in a more efficient and sustainable way.
The best magnets are based on rare-earths (RE), however, their status as a Critical Raw Material (CRM) has brought forward the realization that it is of great strategic, geographic and socio-economic importance to consider alternative magnets that present a reduced amount (or absence) of RE. One of the most sought approaches towards this goal consists on constructing composite magnetic materials magnetically coupled at the interface.
In the framework of the success of a previous European Project (FP7-SMALL-NANOPYME-310516), focused on improving ferrite-based magnets, we developed a low-cost novel approach (Patent P201600092) that exploits the magnetostatic interactions within these composites and that yielded extremely promising results in the form of an experimental proof-of-concept.
The goal of this project is to implement up-scalable and cost-efficient methods for fabrication of ferrite-based dense anisotropic magnets with a 40% enhanced magnetic performance (energy products above 55 kJ/m3) with respect to commercial ferrites. We aim at producing improved magnets that retain the advantages of ferrites –availability, sustainability, cost, recyclability- and which have the potential to substitute currently used RE magnets in the electric power system.
Our targeted application is an electric energy storage device: we will substitute RE magnets by AMPHIBIAN ones in a demonstrator of a flywheel and evaluate its performance against cost, eco-friendliness and resource efficiency criteria.

## Trabajo realizado desde el comienzo del proyecto hasta el final del período abarcado por el informe y los principales resultados hasta la fecha

We will briefly summarize the work carried and the main results obtained thus far towards the completion of each of the main objectives of the project.

Objective 1: Design and Fabricate high-performance anisotropic dense magnets.

Main results at project completion:
• Software package for modeling the compaction process of magnetic particles under the influence of external magnetic field has been developed and tested.
• We have reached in anisotropic hybrid powders containing 40% FeCo nanowires – 60% $SrFe_{12}O_{19}$, we have observed a 47% increase in remanence. This has translated to a 40% increase in energy product in a real magnet with 30% FeCo nanowires – 70% $SrFe_{12}O_{19}$ composition. This innovation has a strong exploitation potential and a demonstrator has been fabricated.
• We have developed novel sintering methods that lead to savings in energy consumption of 30%. The results are in the process of being patented.

Objective 2: Evaluate and assess recyclability, sustainability and life cycle.

• We have achieved a full recovery of the magnetic properties of the MB waste after a defined procedure consisting of milling and annealing steps. We have estimated the costs associated with this recovery at 0.3-0.4 €/kg, thus completing milestone MS3 (Successful recycling at reasonable cost).
• We are reusing the ferrite sprue for manufacturing of magnetic tiles, in collaboration with the Keraben company. The technology is in the process of being patented. This innovation has a strong exploitation potential and a demonstrator has been fabricated.

Objective 3: Up-scale and test the improved hybrid permanent magnets.

• The up-scaling and cost of nanowires based composites has been extensively studied. The development, cost and viability of a pilot plant has been presented, with the aim of fabricating 100 g/month with a 1-3 M€ investment. (WP6)
• Max Baermann have fabricated 50 kg of SrFe12O19-Fe hybrid magnets at a very competitive cost.

Objective 4: Demonstration of substitution in an energy storage device.

• A commercial flywheel based on a novel design is being fabricated. This product needs 0.75 T to operate (instead of 1.2 T as the previous model). This technology has strong exploitation potential as it will be commercialized within 1-2 years after completion of the project
• A novel prototype of a levitation system of a flywheel that can function with ferrites (0.4 T, i.e. the strength of ferrites) has been developed as well and will be presented. This technology has strong exploitation potential as WUP plans to implement a commercial product.

Objective 5: Develop and implement the Exploitation, Dissemination and Communication strategies.

• The dissemination and exploitation plans have been implemented.
• The Data Management Plan is active and currently being deployed, we have published in open access all our scienfific articles and made the corresponding data available.

## Avances que van más allá del estado de la técnica e impacto potencial esperado (incluida la repercusión socioeconómica y las implicaciones sociales más amplias del proyecto hasta la fecha)

The main progress achieved with respect to the two main outputs of the project (improved magnets and rare-earth-free flywheel) is a 40% increase in energy product in ferrite-based magnets, and the patented design of a novel levitation system for a flywheel that operates with ferrites and is completely rare-earth-free.

Improved magnets: The main application of the improved bonded magnets is substitution of REE in automotive components. This substitution may lead to a substantial decrease of REE import dependency. The ferrite based magnets that will substitute REE- magnets contain elements that are abundant within European borders, mitigating the supply risk. Thus, AMPHIBIAN impact will contribute to the EU objectives of: reducing CRM imports, improving resource efficiency, avoid supply bottlenecks and putting Europe at the forefront in raw materials. As a consequence of our developments, we estimate a reducing of the import of rare-earth elements by 1,000 tons in 2024.

Rare-earth-free flywheels: The competitive advantage for the AMPHIBIAN partner WattsUp Power is being the producer of the only ferrite-based flywheel on the market. As energy storage devices, flywheels are linked to the renewable energies sector and initial market studies indicate that the development of a green flywheel can lead to a market share in the flywheel sector between 10-15% (estimated at 3 billion € by 2024). The sector is expected to spectacularly increase by 26% annually (CAGR).

AMPHIBIAN´s impact will ensure the competitiveness of the consortium SMEs in each of their sectors, where they are already well positioned enterprises. WattsUp Power for instance already has experience in translating innovations of a European Project onto the market, and they expect to commercialize AMPHIBIAN´s results by 2021. The ambition will be that EU companies acquire the knowledge and technologies that allows an independent, dominant and strength position respect to foreigner competitors.

The growth of the SMEs of the consortium is already leading to job creation in the companies themselves, and also in associated sectors. Our dissemination and communication strategies have impacted stakeholders and societal awareness, helping raise awareness on the crucial importance of sustainability and resource efficiency, from researchers to policy makers, industries to NGO, citizens to politicians. As a result, AMPHIBIAN partners have become important actors in the raw materials sector and participate in all kinds of events and initiatives.

Our important work on a cross-cutting issues such as gender equality has increased the visiblity of women in science (https://www.youtube.com/watch?v=R3zRfTguKk0&t=4s).


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