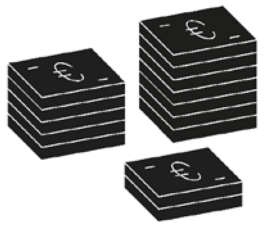
REE4EU-Integrated High Temperature Electrolysis (HTE) and Ion Liquid Extraction (ILE) for a Strong and Independent European Rare Earth Elements Supply Chain

- H2020-SPIRE07-2015. Recovery Technologies of Minerals and Metals
- 1 October 2015 – 4 years
- 14 Partners: **RTOs:** SINTEF, tecnalia Inspiring Business, cea, Université Toulouse III Paul Sabatier

SMEs: LCM less common metals, A3i Inovertis, idener, PNO, cefic, AVERE The European Association for Electromobility

Industry: Elkem A Bluestar Company, VAC Vacuumschmelze, STENA, SNAM Floridienne



- EC funding: € 7 522 491.-
- Private investment: € 1 541 281.-
- Leverage factor: 0.2 points

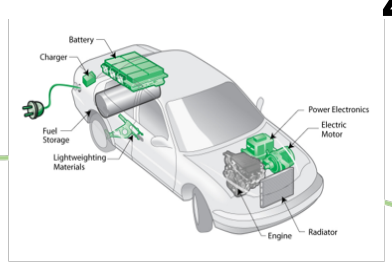
REE4EU's Project Case

1. The EU/ SPIRE needs

EU needs: secure the supply of REE (CRM imported 97% from China)

SPIRE needs: Valorization and re-use of waste streams, including recycling of post-consumer waste streams

SPIRE goal: 20% less primary non-renewable raw materials usage



Raw material → REA producer → RE-Product manufacturing → End user → Waste collector

In-process waste

2. The Project Solution

REE4EU is now developing, validating and demonstrating in **2 industrially relevant Pilots** an innovative **cost effective** RE-extraction and a novel direct **RE alloy production route**. It will allow the recovery of **90% RE from in-process wastes** and **20%** RE from **abundantly available EoL** waste streams, i.e. **permanent magnets** and **batteries** from HEV. The recovered REE will be re-used to manufacture high quality permanent magnets →**closed-loop recycling**

3. Value to Customers

Customers currently depends nearly **100%** on the **export** from **China**. When REE4EU solution will be available at industrial scale, customers will be able to **diversify** their **supply sources**, and buy REE from a **stable EU source**, **high environmental standards** and with a **fixed** and **reasonable price**. They will also be able to assess the potential of recovering REE from their specific waste streams or EoL products to **valorise** the EU **secondary resources** and get better incomes from it

4. How will this happen?

REE4EU will develop the **know-how** and **demonstrate** the concept on a **pilot** level. **Exploitation** on industrial scale either by the **consortium** or **technology transfer** to other potential **stakeholders** is needed. EU **investors** may need **incentives** that can de-risk their investment, e.g. waste recycling tax, environmental quota, etc

Key Expected Sustainability Impacts of *REE4EU*

Indicator	Baseline	Expected Impact	
Global Warming Potential (mainly CO_2 emission reduction)*	CO_2eq from mine to REO= 31 tCO_2/tNd[1] ----------	50% savings	
	CO_2eq from REO to REM= 23 tCO_2/tNd ----------	ca. the same+EU average renewable (29%, 2015)	
	CO_2eq from GHG (PFC)= 666 tCO_2/tNd[2] ----------	100% savings	
	TOTAL: 720 tCO_2/tNd ----------	38.5 tCO_2/tREM	
Fossil energy intensity*	Energy mine to REO (Nd)= 118 kWh/kg Nd →82 tCO_2eq/tNd[1]	50% savings	EU average renewable → 29% (in 2015)
	Electrolysis step= 12.5 kWh/kgNd → 8.7tCO_2eq/tNd ----------	Ca. same	
	TOTAL: 130.5 kWh/kg Nd → 91.35 tCO_2eq/tNd ----------	71.5 kWh/kg Nd 50 tCO_2eq/tNd	
Total material consumption*	Critical materials used from primary sources	Closed loop recycling 100% savings	
	Currently RE recycling rate 1%, mostly from pre-consumer materials	90% recovery from in-process waste	
		20% recovery from EoL products	
Economic added value	Non existing in Europe	Minimum recovery 0.2 kton/yr →5.4 mEUR/yr	
		10% of the value of Europe's exports contain RE → ca. 174 billion € in 2016 (external exports)	
Environmental	Many steps using high toxic solvents	Less steps, reduction of toxic solvents	

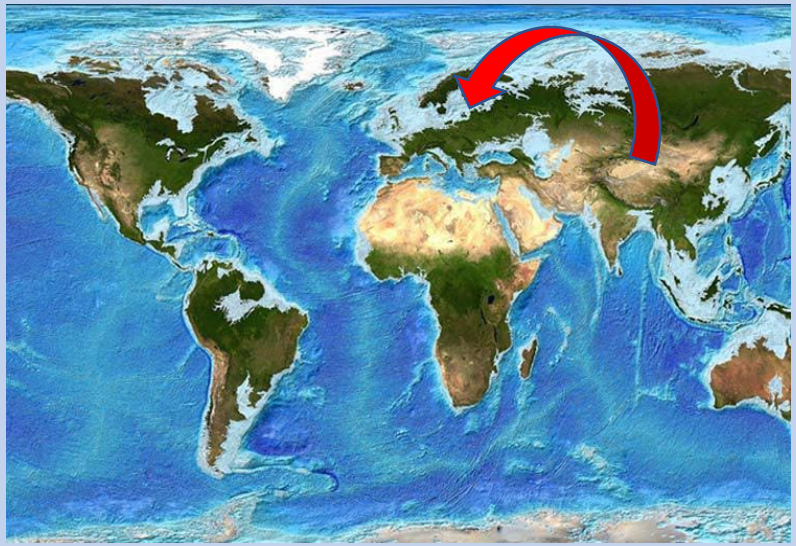
*Core SPIRE indicator

1) Bayan Ob; 2) Average PFC continuous released estimated to be of ca. 7%

Outputs or learning from REE4EU

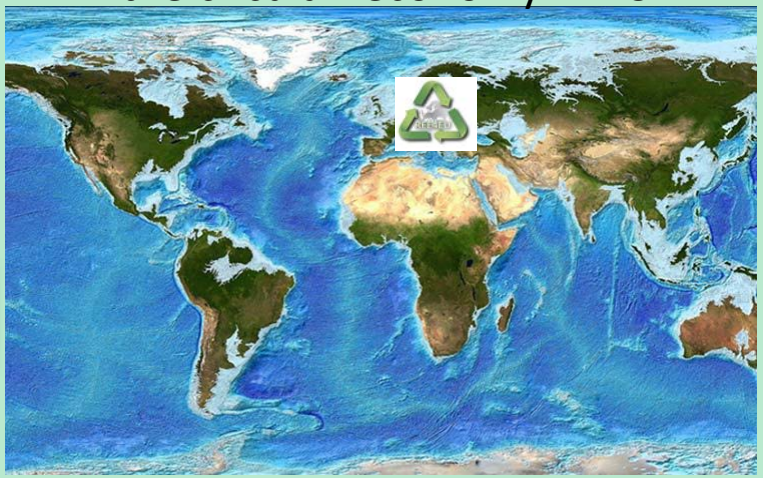
- Technology applicable to the extraction of other valuable **critical materials** from other waste streams, i.e. **Co** from **Li-ion battery waste**
- REE4EU covers the whole value chain, down to the **RE metal production** →closed loop recycling for the highest value RE-application (PM)
- Stakeholder analysis for the whole value chain of RE-containing materials →info on innovators and potential business drivers
- Detail market analysis →info on the availability and potential of RE-containing EoL products in EU
- From the pilot trials REE4EU will provide REAL data on emissions of GHG during RE metal production →environmental safe solution

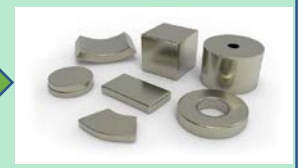
Currently: our strategic European technologies depend nearly 100% on REE export from China



RE Recycling in Europe for the development of GREEN TECHNOLOGIES

Future: Industrial scale recycling plant based on REE4EU will reduce the REE risk of supply and develop the circular economy in EU





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