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

- 1 October 2015 – 4 years
- 14 Partners: RTOs: SINTEF, tecnalia, CEA, Université Toulouse III, Paul Sabatier
  - SMEs: LCM, A3i, idener, PNO, Cefic
  - Industry: Elkem, VAC, STENA, SNAM

- 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

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

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Baseline</th>
<th>Expected Impact</th>
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<tbody>
<tr>
<td><strong>Global Warming Potential</strong> (mainly CO₂ emission reduction)*</td>
<td>CO₂eq from mine to REO = 31 tCO₂/tNd¹</td>
<td>50% savings</td>
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<td>CO₂eq from REO to REM = 23 tCO₂/tNd²</td>
<td>ca. the same + EU average renewable (29%, 2015)</td>
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<td>CO₂eq from GHG (PFC) = 666 tCO₂/tNd³</td>
<td>100% savings</td>
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<td>TOTAL: 720 tCO₂/tNd</td>
<td>38.5 tCO₂/tREM</td>
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<td><strong>Fossil energy intensity</strong>*</td>
<td>Energy mine to REO (Nd) = 118 kWh/kg Nd → 82 tCO₂eq/tNd¹</td>
<td>50% savings</td>
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<td>Electrolysis step = 12.5 kWh/kgNd → 8.7tCO₂eq/tNd²</td>
<td>Ca. same</td>
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<td>TOTAL: 130.5 kWh/kg Nd → 91.35 tCO₂eq/tNd³</td>
<td>EU average renewable → 29% (in 2015)</td>
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<td><strong>Total material consumption</strong>*</td>
<td>Critical materials used from primary sources</td>
<td>Closed loop recycling 100% savings</td>
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<td>Currently RE recycling rate 1%, mostly from pre-consumer materials</td>
<td>90% recovery from in-process waste</td>
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<td>20% recovery from EoL products</td>
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<td><strong>Economic added value</strong></td>
<td>Non existing in Europe</td>
<td>Minimum recovery 0.2 kton/yr → 5.4 mEUR/yr</td>
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<td>10% of the value of Europe's exports contain RE → ca. 174 billion € in 2016 (external exports)</td>
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<td><strong>Environmental</strong></td>
<td>Many steps using high toxic solvents</td>
<td>Less steps, reduction of toxic solvents</td>
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*Core SPIRE indicator
¹ Bayan Obo; 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.

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

**RE Recycling in Europe for the development of GREEN TECHNOLOGIES**
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