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

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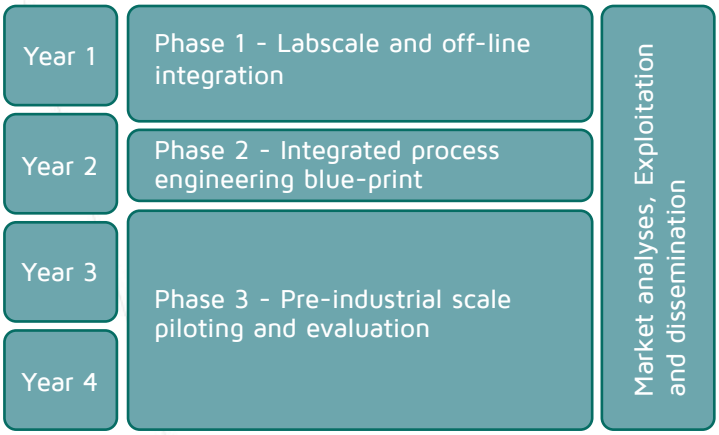
REE4EU project's progress

During the second year, the work has been focused on the development of the process engineering blue print for the pilot build-up.

After a hard, team-work involving the engineering teams IDENER and INOVERTIS, the technology developers SINTEF, UPS and Tecnalia, as well as the industrial partners responsible for the pilots, ELKEM and LCM, the detail engineering documents for the ILE and HTE pilot units were delivered in due time.



In addition to the technical aspects, the REE4EU project is continuously exploring the potential of circular economy implementation to drive new, profitable business with a European focus as well as carrying out a great number of dissemination, communication and exploitation activities. PNO with the key partners of the REE4EU project have accomplished an extensive market study on economically viable RE recovery potential from EoL products complemented with interviews with relevant stakeholders to shed light on the feasibility and current bottlenecks preventing their future use in REE recovery ventures. The REE4EU's Market Analysis Report is available on the project's website.

For any further updates, please follow INNOVATION PLACE page on LinkedIN and Twitter.

HTE Pre-Pilot runs

REE4EU's HTE step has been developed taking into account many years of experience in working close to the aluminium producers and the deep knowledge of the RE electrochemical properties in molten salts owned by both SINTEF and UPS. The information, although scarce, of current REM industrial production in China available from literature, and input from the partner LCM was very helpful as well.

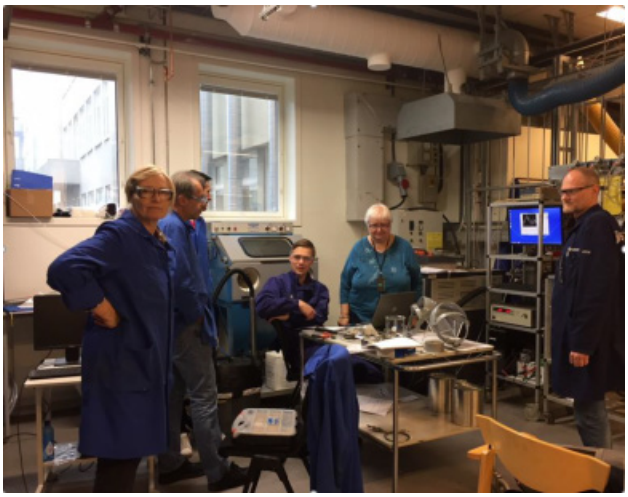
The whole idea behind the REE4EU's concept is the demonstration of the feasibility of obtaining rare earth alloys (REA) by a HTE step using rare earth oxides (REO) - mixtures from secondary sources (wastes). This implies a huge simplification of steps and costs compared to the state-of-the-art (SoA) methods, which separate the different single REO contained in the REO mixture. This is not only labour and cost intensive, but it also implies environmentally unfriendly extraction methods. REE4EU will not only help Europe in securing the supply of one of the most important critical materials, such as rare earth (RE) elements, but will also help European industries be more competitive and, at the same time, environmentally friendly by establishing an effective and greener method of obtaining REA from secondary sources available in Europe.

During the second year of the project, SINTEF has focused on demonstration of the REE4EU's HTE pilot unit at a large laboratory scale with continuous operation of the electrolysis reactor.

The electrolysis cell was, despite of the size differences, similar to that of the pilot installed at Elkem in terms of: semi-closed cell, continuous feeding of the REO-mixture, electrode configuration, and anode-to-cathode current density ratio. At the same time, on-line analysis of the cell off-gas was carried out by FTIR. In this way, information of the optimal and environmentally friendly performance of the HTE cell could be obtained.

Galvanostatic electrolysis was run continuously for 28 hours. It was possible to achieve this by using an automatic feeder of the REO-mixture, which continuously provided the feed material to the electrolysis cell, while SINTEF researchers were following up at all times. UPS researchers also participated in the trials.

SINTEF's engineer Henrik Gudbrandsen preparing the HTE cell



SINTEF and UPS teams participating in the pre-pilot trial at SINTEF's premises

It has been demonstrated that the continuous feeding of PM-derived REO-mixture delivered by VAC, could be used in the HTE and successfully obtains a REA with Fe without any perfluorocarbon gases.

The REA alloy obtained, before and after re-melting to eliminate electrolyte remains

First successful strip cast production of REMA from PM derived REA using THE

LCM has carried out trials in the 1KA electrolysis cell to convert PMS-derived REO supplied by VAC to validate the REE4EU HTE technology. SINTEF participated in the trials and carried out off-gas analysis to assist in process understanding and reducing gas emissions. The ingot produced was converted to a strip cast alloy and supplied to VAC to produce permanent magnet.

NdDyFe alloy produced in 1KA Pilot cell to validate the REE4EU technology

IDENER: Conceptual layout

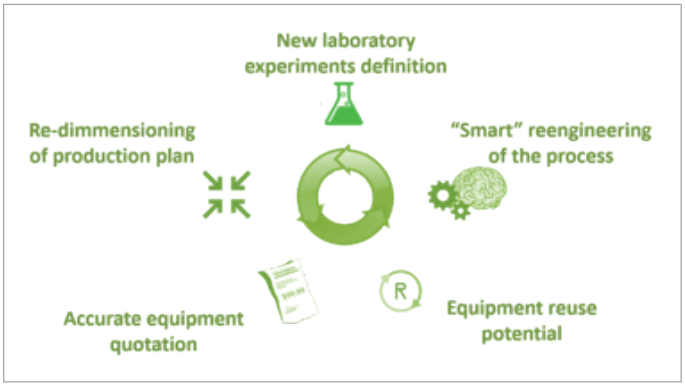
During the second year of the projects, efforts have been focused on initiating a re-engineering process that culminated with a feasible detailed engineering for both process prototypes, keeping the costs within the available budget.

The re-engineering process consisted in several steps that aimed to a more realistic definition of the process:

1) Realisation of new laboratory experiments: To allow further optimisation of different sub-processes, it was required to gain further knowledge on specific aspects of the processes involved.

2) "Smart" re-engineering of the process: to overcome some costly investments, changes on the required equipment was needed. It included adaptation to standard devices and sizes, improved (smarter) ways of performing the same operation and process adaptation to minimise the required equipment.

3) Equipment reuse potential: taking advantage of the vast R&D activity of ELKEM, existing devices were analysed for their potential reuse in the REE4EU prototype.



4) Accurate equipment quotation: to reduce uncertainty and thus being able to better optimise the equipment selection, a strong collaboration with potential providers was established.

5) Re-dimensioning of production plan: last but not least, trying to meet the tight project schedule, the production batches were optimised in order to minimise the sizing of the equipment.

This process ended with a clear set of Detailed Engineering documents that was later used to establish agreements with the providers during the procurement phase. Strong collaboration and tight dialogue with them was accomplished in order to guarantee the project prototype success.

ELKEM: Pilot REE4EU ILE+HTE solution within dedicated facilities for REA production from PMS

Preparations for building up of the main REE4EU pilot are still on-going at Elkem's facilities in Kristiansand, Norway.

The equipment for the ILE step is under assembly, and will be ready for commissioning during the last week in February. The first batch of REO-mixture obtained from PM swarf (PMS) delivered by VAC is expected to have been achieved by the first week of March, with Tecnalia's team present during the first trials.

The equipment for the HTE reactor will be delivered and commissioned in April. Then, the first batch of REA is expected to have been achieved by May, with SINTEF's team present during the trials to perform on-line gas analysis during electrolysis.

Moreover, Elkem team has prepared the PMS material to be fed in the ILE step.

IBC containers to be used for storing process chemicals, intermediate products, wastes in Elkem's warehouse awaiting assembly.

Preparation of the PMS material fromVAC to the ILE step.

REE4EU's Market Analysis Report is now available!

The REE4EU project is continuously exploring the potential of circular economy implementation to drive new, profitable business with a European focus.

As of today, REE4EU's Market Analysis Report (Deliverable 9.4) is freely available to all the project stakeholders. Leveraging on the findings of the European Rare Earths Competency Network (ERECON), this document previews the European market of secondary rare earths present in certain End of Life products which are likely to become the feedstock of future large-scale REE recovery.

For these promising "urban mines", i.e. offshore wind turbines, hard disk drives, electric cycles and vehicles, etc., PNO with key partners of the REE4EU project have carried out an extensive literature review complemented with interviews to shed light on the feasibility and current bottlenecks preventing their future use in REE recovery ventures.

Readers can directly draw useful insights pertinent to future REE recycling such as forecasted material stocks, economic and technical viability of producing secondary REE, legislation associated with the collection at EU level, etc. By comparatively assessing the hurdles and levers underpinning the use of different EoL products as potential REE sources, the Market Analysis report opts to support future investors, industrial stakeholders and policy makers to plan for a future-proof REE supply chain for Europe.

To have access to this very interesting report, please register on the project's website and download the report from the page Public documents.

REE4EU Consortium

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www.sintef.no

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www.tecnalia.com

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For more info about project visit the REE4EU website at: www.ree4eu.eu

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