Application for a Raw Materials Commitment

**Recovery of Critical Metals from the Bauxite Residues (red mud) of the primary alumina refining industry**

**Acronym:**
Mud2Metal

**Links to the Strategic Implementation Plan:**
- **I. Technology Pillar**
  - I.B Priority Area: Technologies for primary and secondary raw materials’ production
    - Action area n° I.4: Processing and refining of raw materials
      - 1) Innovative and flexible processing
      - 2) Metallurgical systems

**Objectives of the commitment:**

The Bauxite Residues (red mud) are a red slurry consisting of the un-dissolved portion of the bauxite ore, produced on a dry-basis at an almost 1:1 mass ratio with alumina, amassing to a total of 100 to 120 million tones per year globally. BR consists for the most part of Fe and Al oxides, while in lesser or trace amount oxides of Si, Ca, Na, Ti, V and REE (such as Sc, Ce and others). Till this day BR are not exploited but rather stored in artificial ponds and landfills. Therefore stockpiled and annually produced BR can be considered an important low grade resource for extracting critical metals like REEs, metals with high economic importance for Europe like Ti, V as well as base metals like Al and Fe. The goal of the Mud2Metal consortium will be to develop innovative and sustainable technologies for the recovery of the important metallic values found in the BR.

**Description of the activities:**

The Mud2Metal consortium will seek to develop both the fundamental knowledge and the applied technology for recovery of metals from the BR. Fundamental knowledge production into the interactions of the metal oxides in the BR and their potential separation methods will be pursued through industrially sponsored PhD programs with collaborating university departments. Applied technologies will be developed through focused RTD projects aiming at:

- Removing the iron content (44% to 48%wt) of the BR through microwave roasting for partially reducing the hematite oxides into magnetite oxides, and followed by a dry or wet magnetic separation step. Such a technology will not only achieve the recovery of iron oxides from the BR but will also reduce significantly the volume of the BR, enriching practically the content of all other
metal oxides and facilitating their easier recovery. The use of microwaves as a heating source has already been proven effective in this system and will allow to greatly minimize the energy and the capital cost of a BR roasting procedure, which conventionally takes place in large metallurgical reactors (i.e. rotary kilns).

- Achieving the hydrometallurgical separation of REE oxides from the BR through the use of mineral acids or through the use of Ionic Liquids (ILs). Ionic liquids (ILs) are novel “custom-tailored” solvents for the sustainable extraction and separation of metal ions. Their ability to solubilise a variety of non-ferrous metal oxides and hydroxides at low temperatures makes ILs attractive and “green” alternatives to the traditional aqueous electrolytes used in hydrometallurgical processes which are associated with large volumes of effluent production and require intense processing conditions (elevated temperatures and pressures). The use of ILs as REE leaching agents for REE ore concentrates is already being tested under the FP7 EURARE project.

- Achieving the hydrometallurgical separation of other valuable metal oxides from BR with mineral acids or ILs. Namely the extraction of the oxides of Al (app. 20%wt), Ti (app. 5-6%wt) and V (app 0.5%wt) will be researched as all of these are of high economic value.

Based on the currently available knowledge the overall Technology Readiness Level (TRL) of the intended research is estimated between 4-6.

**Description of the expected impacts:**

The Mud2Metal consortium will seek to develop a cascade of innovative processes which will allow the exploitation of the BR by-product in a manner which will maximize the overall resource efficiency of the initial bauxite ore and minimize the environmental footprint of the Bayer process. Namely:

- Separate recovery of economically important BR metal oxides amassing to more than 70% of its total weight on a dry basis.
- Significant reduction of the final by-product volume from the primary alumina refining industry to be handled, alleviating financial and environmental burdens for the industry and the society.
- Production of critical raw materials (REE) from a low grade ore, through innovative technologies
- Almost complete exploitation of the initial bauxite ore mined and used in the primary alumina refining industry.
- Maintaining and enhancing knowledge and technological excellence of the metallurgical RTD in Europe.
- Creation of new jobs and training of young engineers in technological excellence.

**Expected innovation outcomes:**

New processes
New technologies

**Name of the coordinating organisation:**

ALUMINIUM S.A

**Country:**
Greece

**Entity profile:**
Private sector - large company

**Role within the commitment:**

The Alouminion of Greece (AoG) will be the coordinator and center of the Mud2Metal consortium, since AoG produces each year approximately 700,000 tonnes of BR (currently filter-pressed and stored in landfills). AoG will provide know-how, expertise and raw material to facilitate all RTD activities while all technologies developed in the consortium will be pilot tested in the AoG plant.

**Other partners:**
Name of partner: National Technical University Athens
Country: Greece
Entity profile: Academia
Role within the commitment: NTUA has great expertise in the development and techno-economic evaluation of innovative processing technologies for the treatment of ores and industrial minerals, the development of novel technologies for the production of high added value materials from industrial minerals and from mining and metallurgical wastes. Moreover NTUA has great experience with research in BR treatment, having developed several innovative processing technologies for production of pig iron, mineral wool products, geopolymeric insulation materials and others. NTUA will be a technology developer.

Name of partner: MEAB CHEMIETECHNIK GMBH
Country: Germany
Entity profile: Private sector - SME
Role within the commitment: MEAB is a competent partner in the development and optimization of solid-liquid and liquid-liquid extraction processes, as well as designing the industrial scale up of such processes. MEAB has a strong background (including several patents) in solvent extraction, a technology which will be of great importance for recovering selectively minor elements of BR like REE, Sc, Ga from leach solutions.

Name of partner: RHEINISCH -WESTFALISCHE TECHNISCHE HOCHSCHULE AACHEN
Country: Germany
Entity profile: Academia
Role within the commitment: The IME Process Metallurgy and Metal Recycling of Technical University Aachen (RWTH Aachen) is a Europe’s leading institute for process metallurgy and metal recycling, with extensive expertise in metallurgical waste treatment. In the consortium RWTH will be a technology developer.

Name of partner: KATHOLIEKE UNIVERSITEIT LEUVEN
Country: Belgium
Entity profile: 
The University of Leuven (KUL) is the only European partner in the US NSF supported I/U Cooperative Research Center for Materials Resource Recovery and Recycling CR3. This activity is part of the larger KUL SIM² Network, which is considered as a flagship consortium for KUL. One of the research lines of SIM² is the recycling of REE from end-of-life products and secondary waste streams (i.e. red mud). In the consortium KUL will be a technology developer.

**Existing EU contribution:**
Yes

**Source:**
FP 7

**Period to implement the commitment:**
Wednesday, 1 January, 2014 to Thursday, 31 December, 2020