RESEARCH ACTIVITIES IN RESIDUE VALORIZATION

- Aluminium
- Alumina
- Bauxite
- Iron
- Scandium
Activities for Residue Valorization

The ENEXAL BR Treatment Process

• 2012: Electric Arc Furnace and Melt Fiberizing unit installed in AoG Pilot Plant

• During a two-year long experimental campaigns treated more than **30 t of BR**

• **More than 5 t of Pig Iron** produced and tested in secondary steel production

• **High Quality mineral wool product** produced from the slag (zero waste process)
Activities for Residue Valorization

ENEXAL AoG Pilot Plant
Activities for Residue Valorization

Conclusions from ENEXAL

☑ The revenues of pig iron and mineral wool could match and exceed the operational cost of the unit

☒ Pig iron revenues alone would only cover up to 35% of operational costs

☒ The mineral wool market is limited in size (60,000 - 100,000 t) and could not absorb the mineral wool that would be produced from a full BR processing (>300,000 t of slag)

NEXT STEPS

➢ Produce more products to achieve a viable process
BAUXITE RESIDUE, GREECE

ALUMINIUM OF GREECE

Industrial by-product of primary aluminium industry
More than 700,000 t produced annually in Greece and stored near the plant
0.14% TREO including Sc (Potential global Sc resource)

The amount of REE present in the Bauxite Residue produced annually in Greece, amounts to nearly the 10% of the annual European demand
Activities for Residue Valorization

Mud2Metal: Holistic Valorization of BR

- 100% utilization of the BR stream
- Economically Viable
- Near Zero-Waste
- Industrial Symbiosis
Activities for Residue Valorization

H2020 2016-2020
Coordinator AoG
Sc is an “exotic” REE produced in minor quantities—not traded as a commodity

Sc can ‘substitute’ Y in many material applications achieving superior results:

- In SOFC Sc-stabilized Zirconia has lowered operational temperatures leading to commercialization of the technology
- Sc drastically improves Aluminium alloy properties increasing strength, corrosion resistance, allowing welding and others

The Al-Sc-Mg alloy powder is used in additive layer manufacturing (3D printing) by AIRBUS
Activities for Residue Valorization

Pilot plant unit to operate in AoG in mid 2019

SCALE:
Production of Sc compounds & Sc-Al alloys from European metallurgical by-products

Sc from waste
Sc concentrates
Sc Metal
Sc$_2$O$_3$
Activities for Residue Valorization

Upscaling ULCOWIN technology for CO₂–Free Steel production

SPIRE, 2017-2022, Coordinator ArceloMittal
Activities for Residue Valorization

- Iron metal electrolytically produced from iron oxide without direct involvement of carbon or fossil fuels.
- Powered by RES - cell with expert system to operate non-continuous according to RES real time availability
- Ambient temperature operation
- Soda as electrolyte
- Study for use low grade/alternative iron ores like Bauxite residue and Bauxite ore

SPIRE, 2017-2022, Coordinator ArcelorMittal
Activities for Residue Valorization

ENSUREAL: Integrated cross-sectorial approach for environmentally sustainable and resource-efficient alumina production

Revisit the ‘Pedersen’ process for extracting Al and Fe from lower grade bauxites and BR

Pilot Scale tests at AoG

SPIRE 2017-2021, Coordinator SINTEF
Activities for Residue Valorization

Bauxite/BR

Coke

Lime

Pig iron

Leachable slag

Residue

Soil enhancement

Alumina

Rare earths

Soil enhancement
Activities for Residue Valorization

removal
removing waste from alumina production

H2020 2018-2022, Coordinator AoG
RemovAL overcomes the barriers of economic viability by pooling together and integrating proposed stand-alone solutions, while adhering to the following principles:

- **treat waste with waste**
- **recover valuable critical metals**
- **develop marketable products**
- **customise the solution to the industrial ecosystem of each alumina plant**

**near zero-waste processing, near break-even flowsheets**

RemovAL builds on the results of **9 recent research projects**
Activities for Residue Valorization

6 innovative pilot plants across Europe

Combined they will form a network of technological nodes, enabling optimum processing flow sheets for valorising the produced bauxite residue

The validation will be done for 3 European alumina producers (representing 44% of the European alumina production) and one legacy site owner

RemovAL is a consortium of 27 partners from 12 European countries
Activities for Residue Valorization

1. **de-alkanization**
   Demonstrate at pilot scale the de-alkalization technology to remove alkali content from bauxite residue at levels below 0.5% wt, making it suitable for various applications.
   - At least 40 t of bauxite residue will be processed by AAL at a mobile pilot plant in IRELAND.

2. **green soil stabilizer**
   Demonstrate the use of processed bauxite residue as green soil stabilizer for civil works applications, though the stabilization of bauxite residue with other industrial by products.
   - At least 800 t of bauxite residue will be processed and used by ACCIONA as a raw material for the construction of a road in Spain.

3. **lightweight aggregates & high performance binders**
   Demonstrate at pilot scale the production of lightweight aggregates and high performance binders, through different thermal treatments of bauxite residue.
   - At least 10 t of bauxite residue will be processed in the RIO TINTO Pilot plant in France.
Activities for Residue Valorization

1. Microwave furnace
   Demonstrate at a prototype microwave furnace the production of metallic iron from processing bauxite residue with other industrial by-products in Spain and Greece.
   At least 250 kg of bauxite residue will be processed in CENIMAT’s mobile prototype plant in both Spain and Greece.

2. Hydrometallurgy
   Demonstrate the production of REE concentrate, alumina/soda solution and rutile concentrate from the hydrometallurgical processing of engineered slagssmelter produced in RemaAL Pilot plant in Greece and the Bayer liquor from the alumina and the ferro-silicon alloy from Electric Arc Furnace (EAF) co-processing of bauxite residue with other industrial by-products like Spent Pot Linings (SPL) from aluminum primary production.
   At least 150 kg of bauxite residue will be processed in a REMAAL pilot plant in Germany.

3. Ferro-silicon alloy
   Demonstrate at pilot scale the production of ferro-silicon alloy from Electric Arc Furnace (EAF) co-processing of bauxite residue with other industrial by-products like Spent Pot Linings (SPL) from aluminum primary production.
   At least 50 kg of bauxite residue will be processed in the AES pilot plant in Greece and in the EUKEM pilot plant in Norway.

METALLURGY OF GREECE

ALUMINIUM BUSINESS UNIT
Activities for Residue Valorization

Bauxite Residue
A future valuable mineral resource

The research leading to these results has received funding from the European Union Seventh Framework Programme and H2020.