



HEI4S3-RM
Building Ecosystem Integration
Labs at HEI to foster
Smart Specialization
and Innovation
on Sustainable
Raw Materials

Communication to the Society and Awareness of the circular economy approach in the raw material sector

Sustainability Innovation Projects based on circular economy in a copper smelter (Module II)

ATLANTIC COPPER

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22nd of November 2022



fcx.com

Atlantic Copper Smelter and Refinery



ELECTRIFYING THE FUTURE

- Atlantic Copper
- Innovation
- REDSCOPE
- WhISPER
- Conclusions

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Atlantic Copper

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- Spanish Company belonging to the leading US natural resource company, Freeport-McMoRan
- Production of high-grade refined copper from ore mined in various parts of the World
- World-class competitive copper smelter & refinery in the port of Huelva, south-west Spain, which processes 1 MM tons of ore to produce 300,000 tons of refined copper annually
- Atlantic Copper is the largest copper producer in Spain and the third in Europe
- The direct, indirect and induced employment generated by the Company is estimated at nearly 3,000 jobs
- In 2020, Atlantic Copper reported a turnover of €1,776 million and is ranked the first Andalusian Company in terms of exports

Atlantic Copper: a reference



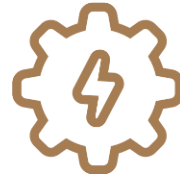
#1

In copper production in Spain and 3rd smelter in Europe



#1

In sulphuric acid production in Spain



#1

Smelter in energy efficiency in the world. Lowest energy consumption by dmt of concentrate smelted



#1

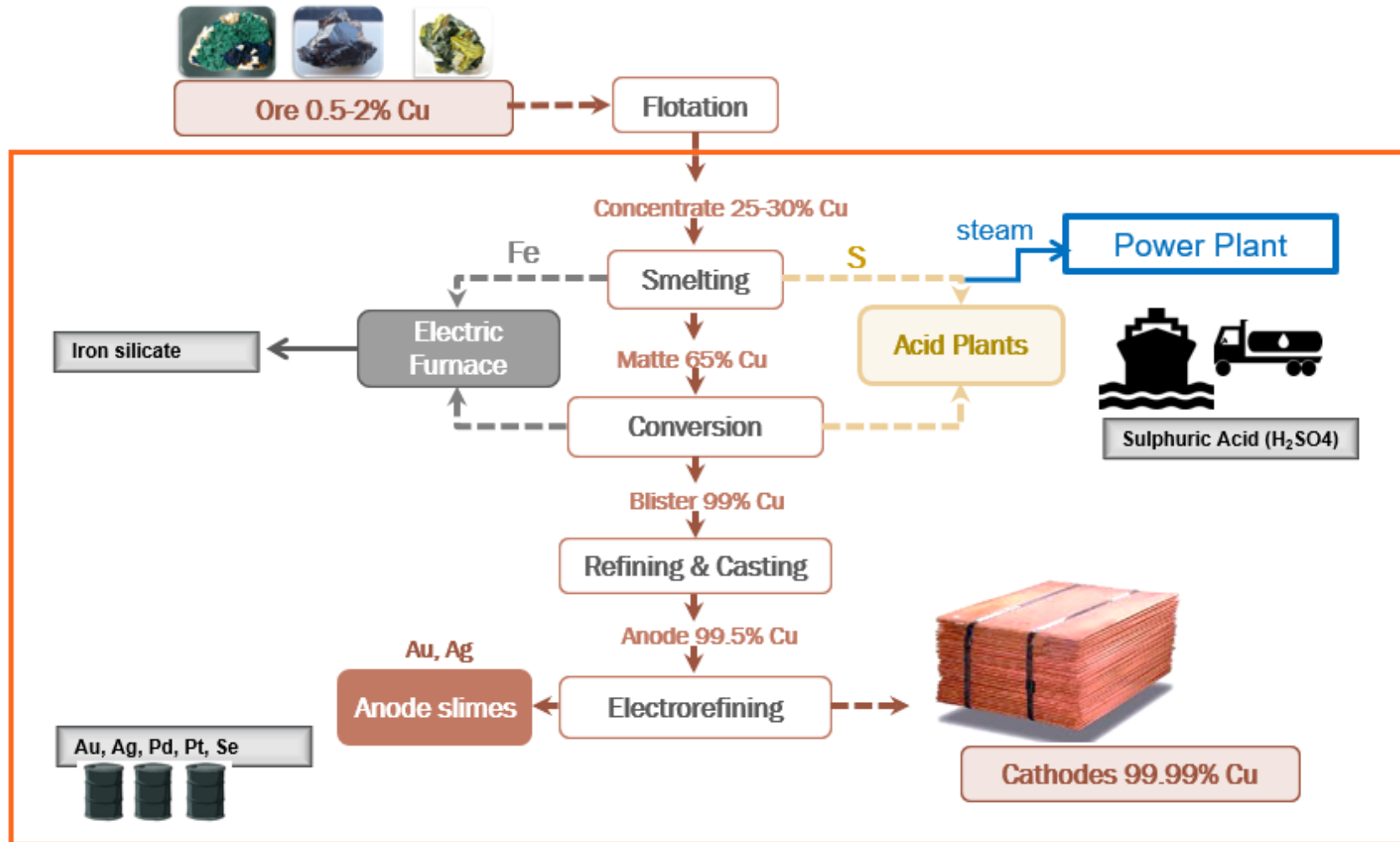
In exports in Andalusia



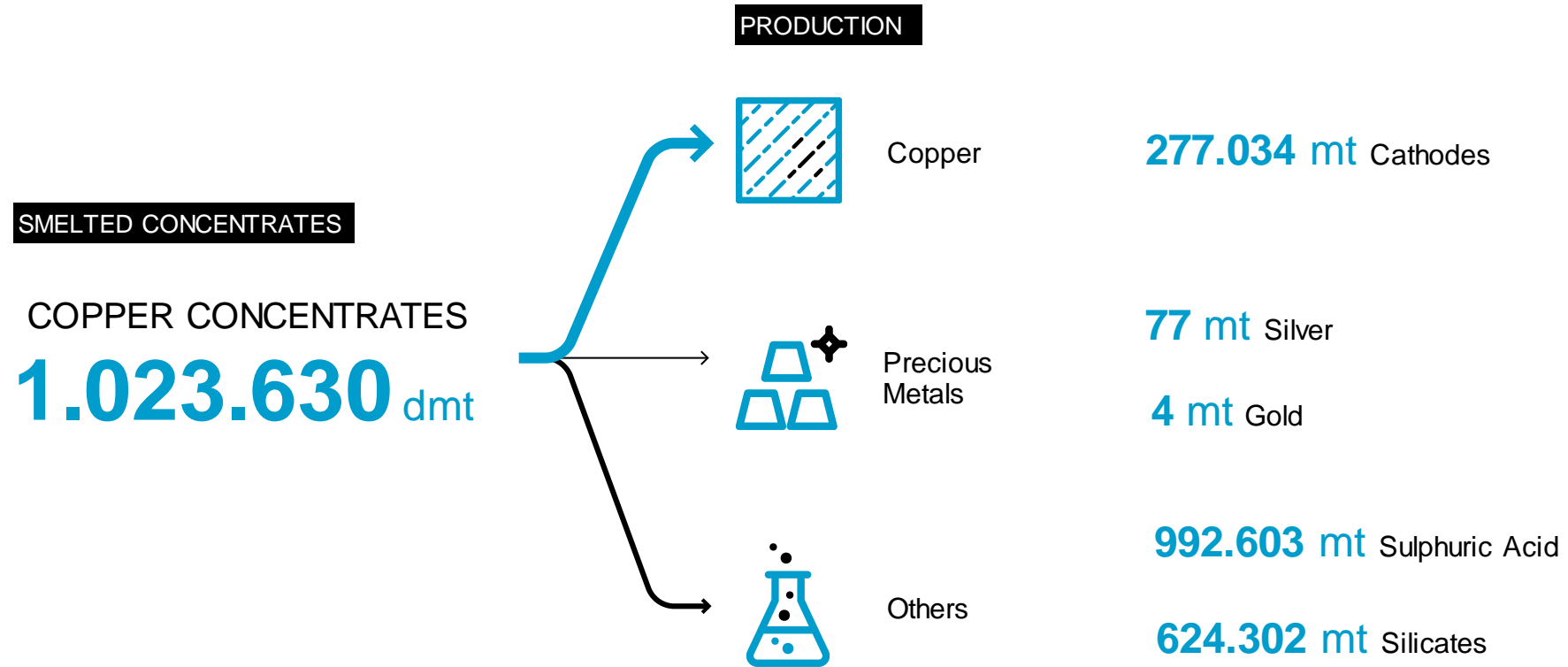
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In female leadership (50% of women in Management Committee)

The Process



Production in 2021

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Source: Atlantic Copper, December 2021.



AC Sustainability Track Record

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- Atlantic Copper is ranked as the world's lowest unit energy consuming copper smelter
- During the last 10 years:
 - 20% drop in unit energy consumption
 - 34% reduction in CO₂ GHG emissions
 - 34% reduction in SO₂ emissions
 - 59% reduction in particles emissions
 - 100 million euros of investment in energy efficiency and environmental protection
- Renewable energy sources account for 30% of Atlantic Copper's current electrical energy mix

- First European copper smelter to be awarded The Copper Mark for responsible production practices



- Atlantic Copper validates the rating in **ESG (Environment - Social and Governance) performance** by Vigeo Eiris Moody's.



Innovation to drive the Green Transition



Atlantic Copper: a reference

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How we got this achievements in sustainability indicators?



A TOOL for CHANGE


*R&D: Applying
resources to generate
Knowledge*

R&D&i




*Innovation: Using
Knowledge to
generate value*

Staying One Step Ahead



***R&D: Applying
resources to
generate
Knowledge***



***Innovation: Using
Knowledge to
generate value***

- R&D plus Innovation play a crucial role in supporting Atlantic Copper's recent excellent production and results track record, focusing primarily on:
 - Technical knowledge management and industrial technological surveillance
 - Ensuring optimal and efficient plant performance
 - Identifying and developing technological improvement opportunities
 - Engaging grants and external funding
- Current R&D plus Innovation initiatives cover important operational areas such as:
 - Sustainable operations: emission and effluent control, hazardous waste management
 - Operational efficiencies: energy management, metal recoveries, operational cost savings, production capacity
 - New business opportunities: management of impurities in copper concentrates (Bi/Sb removal plant), copper scrap treatment, by-product recoveries (Ni, Se, Te), waste stream valuation (Zn, In)

Knowledge Generation



- Atlantic Copper maintains close R&D relations with many leading universities:

Spain:

- ▶ Technical University of Madrid (Madrid School of Mines, Gómez Pardo Foundation)
- ▶ University of Barcelona
- ▶ University of Seville
- ▶ University of Huelva

Germany:

- ▶ RWTH Aachen University
- ▶ University of Freiberg

Austria:

- ▶ Montanuniversität Leoben

Finland:

- ▶ Aalto University

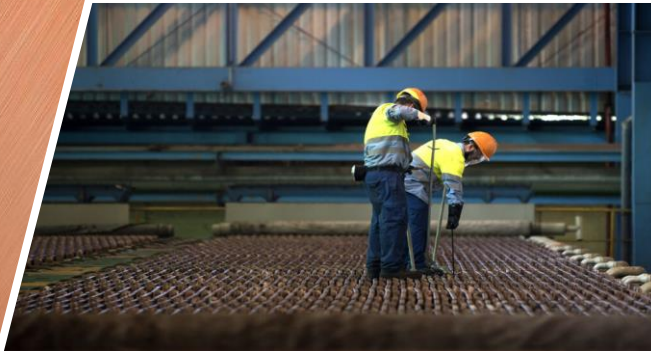
- Annual R&D budget is approximately 1.5 million euros
- Examples of R&D projects channeled through the Huelva University metallurgical studies program:
 - Flash smelting thermodynamic fundamentals
 - Copper tank house electrolyte performance study
 - Waste streams valuation
 - Tank house wireless voltage sensors
 - New SO₂ sorbent materials

Sponsored on-site Industrial PhDs

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- University of Huelva postgraduate completing his doctorate in collaboration with the Queensland University on the PS Converter impurities modelling



- University of Huelva postgraduate, in this case in conjunction with both the Missouri University and Aquisgran (Aachen) university, is writing his thesis on electrolyte chemical balances



- Seville University postgraduate completing his thesis on Sb and Bi waste stream valuation

Taking Industry to the Academia

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- Atlantic Copper sponsored on-site Industrial PhDs



- Sponsored Metallurgical Student training and research programs in three different universities in Spain



- Vocational training and internships

Student Studies Programs



- Since 2014 Atlantic Copper sponsors a specialized metallurgical studies course at the school of mines in the Technical University of Madrid
 - 40 students per year attend the course which includes lectures, field trips, year-end prizes, etc.
 - Close relations with other universities and research institutions
 - EIT Raw Materials support
- Atlantic Copper also sponsors a metallurgical program at the Huelva University
 - Stimulating copper metallurgical research with special emphasis on efficient sustainable production processes and circular economy
 - Promoting knowledge transfer between the Academia and Industry and visa versa
 - More than 800 thousand euros spent over the last five years in research projects, PhD thesis, academic publications, metallurgical course, year-end prizes, etc
- The Atlantic Copper Foundation sponsors a student program in the Andalucía International University
 - Metallurgical courses and seminars, grants for Master courses, research prizes and industrial internships

Vocational Training

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- Through regional Polytechnic Colleges, Atlantic Copper runs four Dual Vocational training courses:
 - Industrial Chemistry
 - Occupational Health & Safety
 - Transport & Logistics
 - Course covering Mechanical, electronic & instrumentation
- Annual internship program typically takes on some 50 students each summer
- University student activities with support from the EIT Raw Materials
 - In 2019, Atlantic Copper hosted the first “Company Challenge” where 20 Alumni from a range of EIT RawMaterials activities travelled to Huelva for an intensive two days of problem solving
 - Last summer, Atlantic Copper participated in the RACE 2020 (EIT Raw Material’s Global and Digital Raw & Circular Economy Expedition)
- This summer Atlantic Copper will host a summer camp under the Master Programme on Sustainable Materials (Suma – Imagine III)

AC Sustainability Track Record

Examples of Resource Efficiency projects in industry

Innovation to drive the Green Transition

RED SCOPE

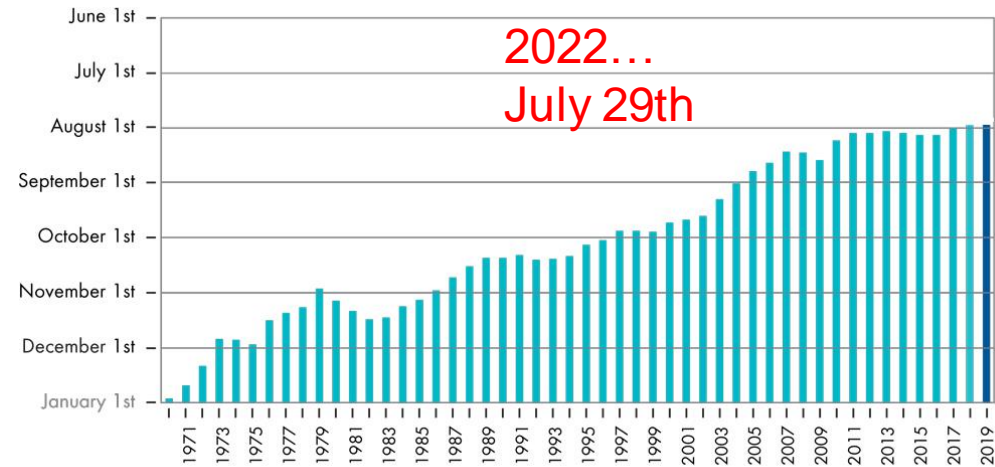
Some facts that have made us think...

By the year 2030

60% of world population will live in cities
41 megapolises with more than 10 million inhabitants



Earth Overshoot Day⁽¹⁾ is coming earlier



Source: Global Footprint Network National Footprint Accounts 2019

Mineral resources could be depleted



The water crisis

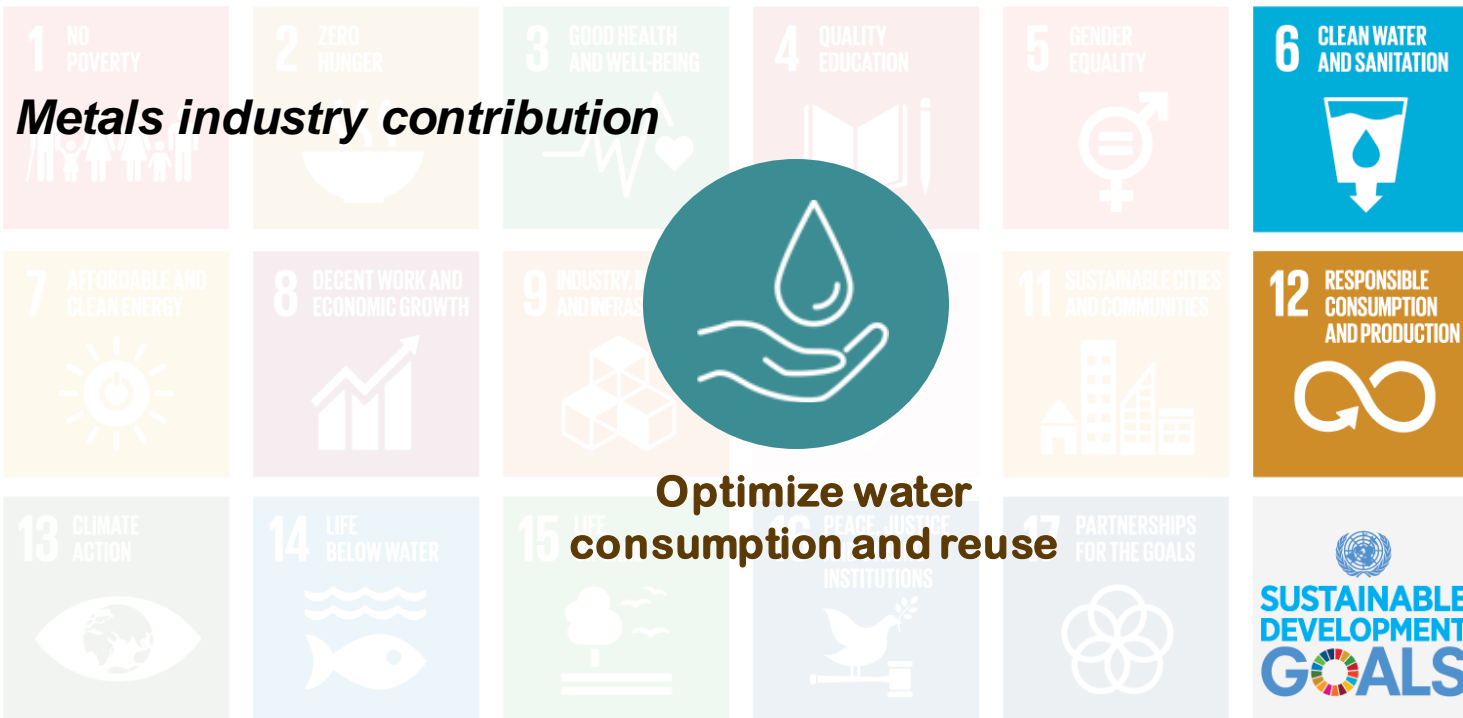
More than a **billion people** currently live in water-scarce regions, and as many as **3.5 billion** could experience water scarcity by **2025** ⁽¹⁾

Water demand will be **40%** higher than supply in **2030** ⁽²⁾

Sources (1) WRI and (2) Suez

⁽¹⁾ Earth Overshoot Day marks the date when humanity has used more from nature than our planet can renew in that entire year.

An ambitious agenda for 2030

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An example of an EIT RM funded project

- Recovery of Effluent Discharge for Sustainable Copper Processing in Europe



- Pilot plant, funded by EIT Raw Materials, successfully completed in 2018-2019 demonstrating the feasibility of a new innovative process to maximize wastewater recovery in a copper smelter

Consortium



Planning 2017-2019

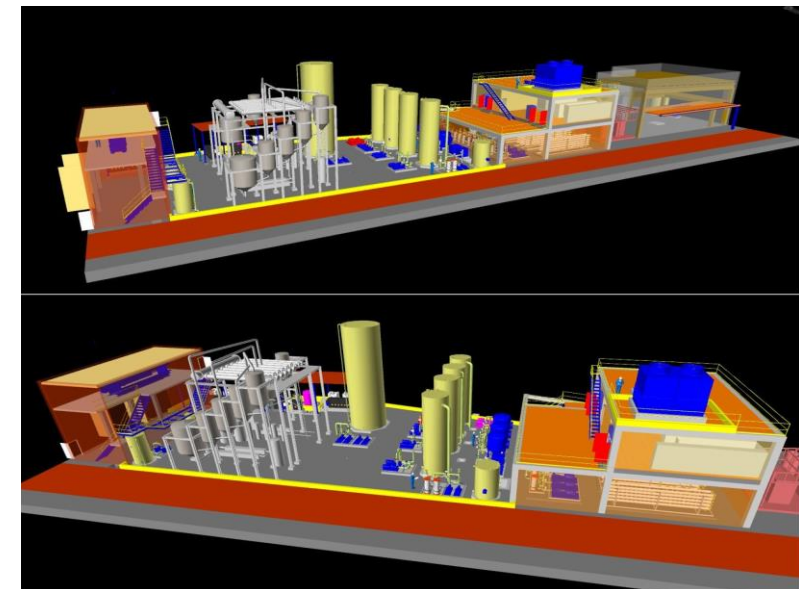
Video redscope

[\(1600\) Project RED SCOPE - YouTube](#)



An example of an EIT RM funded project

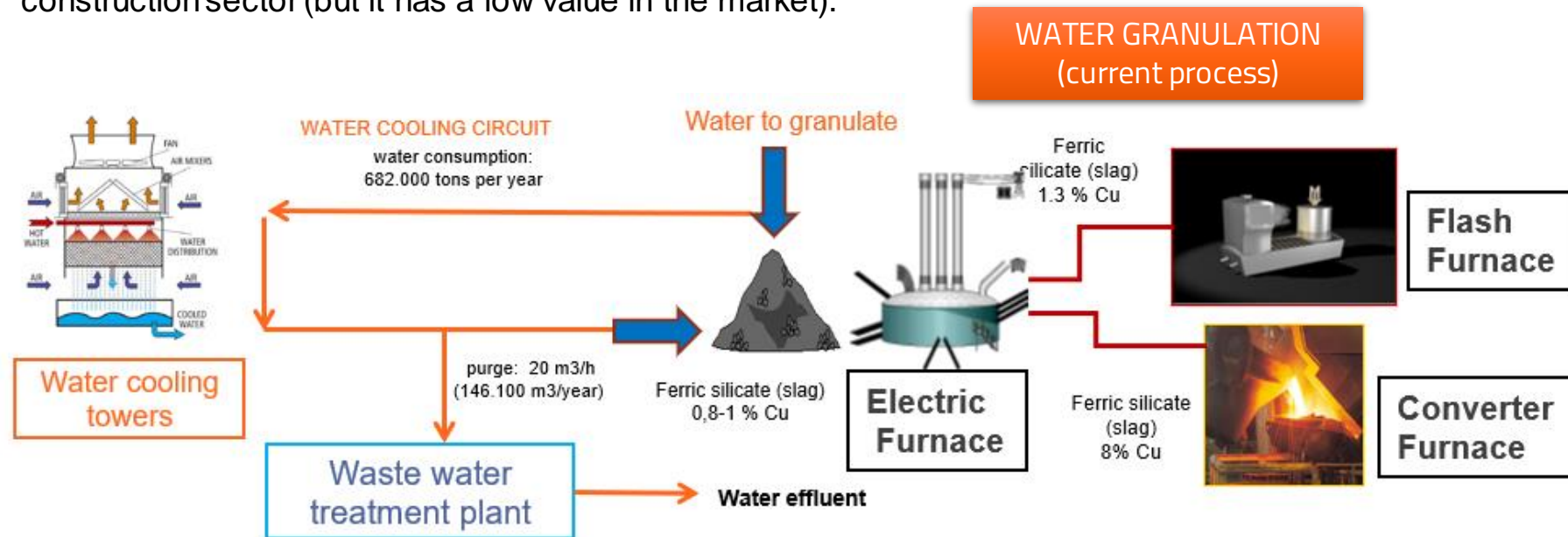
- Full plant installation is now in progress, 24-month construction period
- Capital investment of 12.6 million euros
- The new plant will achieve a 25% saving in current freshwater usage





Background WhISPER project

- ✓ The European copper sector generates approximately 5 million tons of iron silicates during copper production by the pyrometallurgical route, containing valuable metals and other compounds.
- ✓ Traditionally, copper slags were considered as undesirable “waste” materials that had to be discarded at an additional cost.
- ✓ This material is considered a product by Atlantic Copper and it can be used for several applications in the construction sector (but it has a low value in the market).



- ✓ There are significant environmental, operational and economic **challenges** like **Water consumption and wastewater generation, Energy loss , Limited Valorisation** (the water-granulated slag has a **low market value**). Technical standards are highly restrictive, and the inclusion of a new material into existing standards is not easy to implement.

Background WhISPER project



There were some innovative technologies to produce the copper slag in a more sustainable and environmentally friendly way



HATCH



One of those technologies was **air-granulation process** provide by HATCH, and it was based on an air-granulation system in which the molten slag is dispersed by a jet of air and produce granulate iron silicate.

This process could constitute a solution to the challenges related to the current slag treatment method but there was a **High Uncertain**: There are no similar plants in the copper industry. It was not validated.

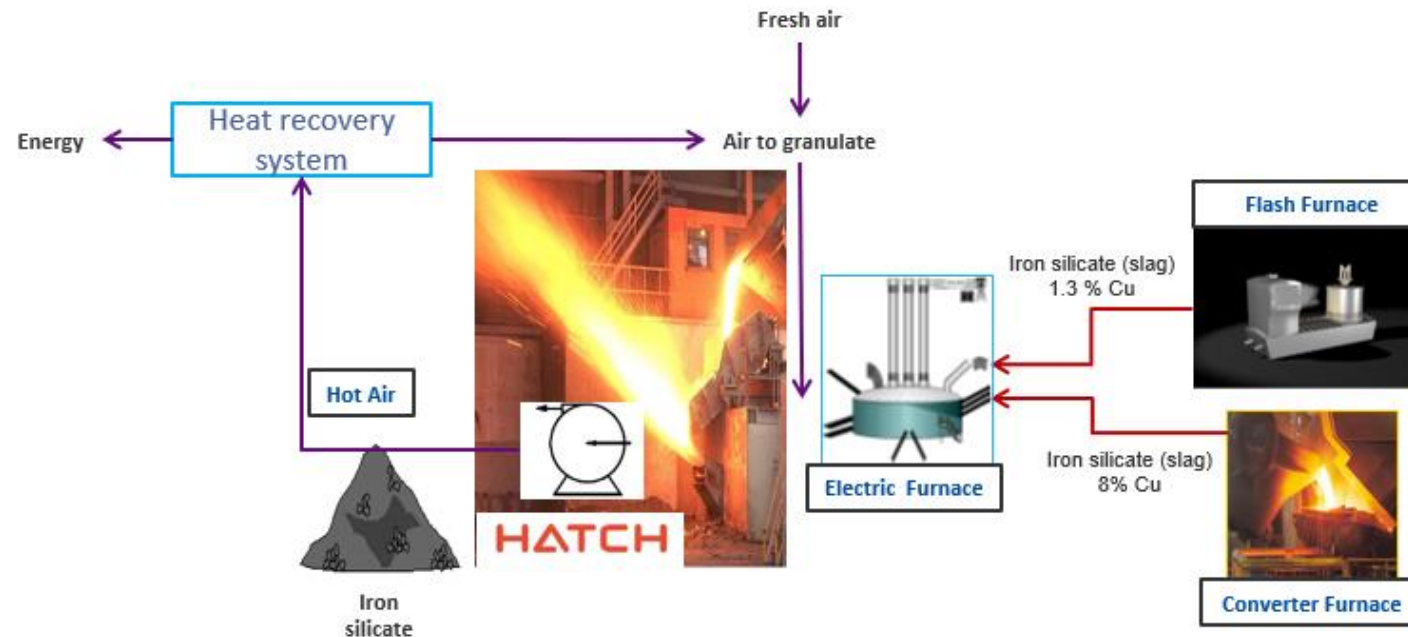


Waterless Iron Silicate Production with Energy Recovery



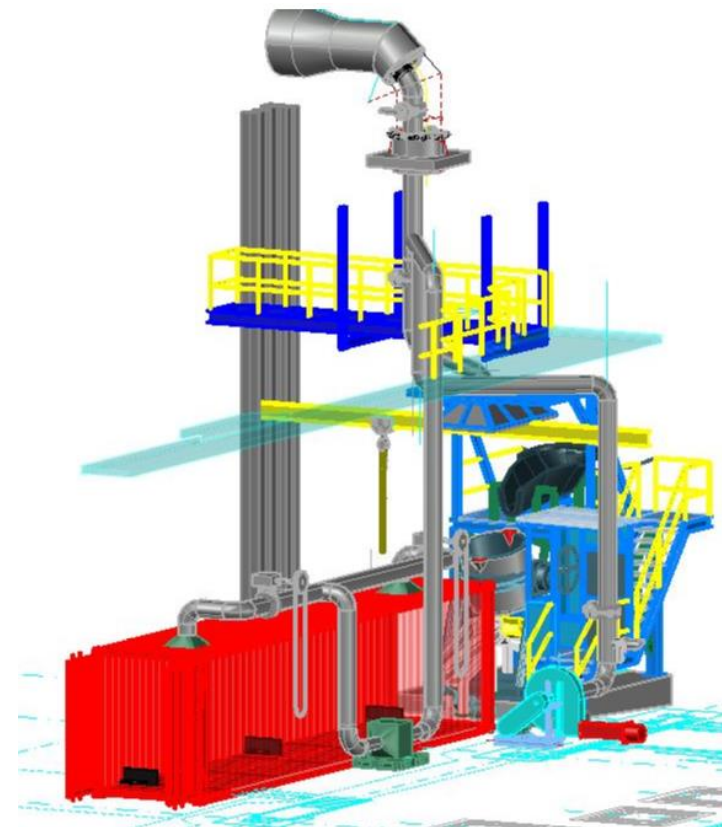
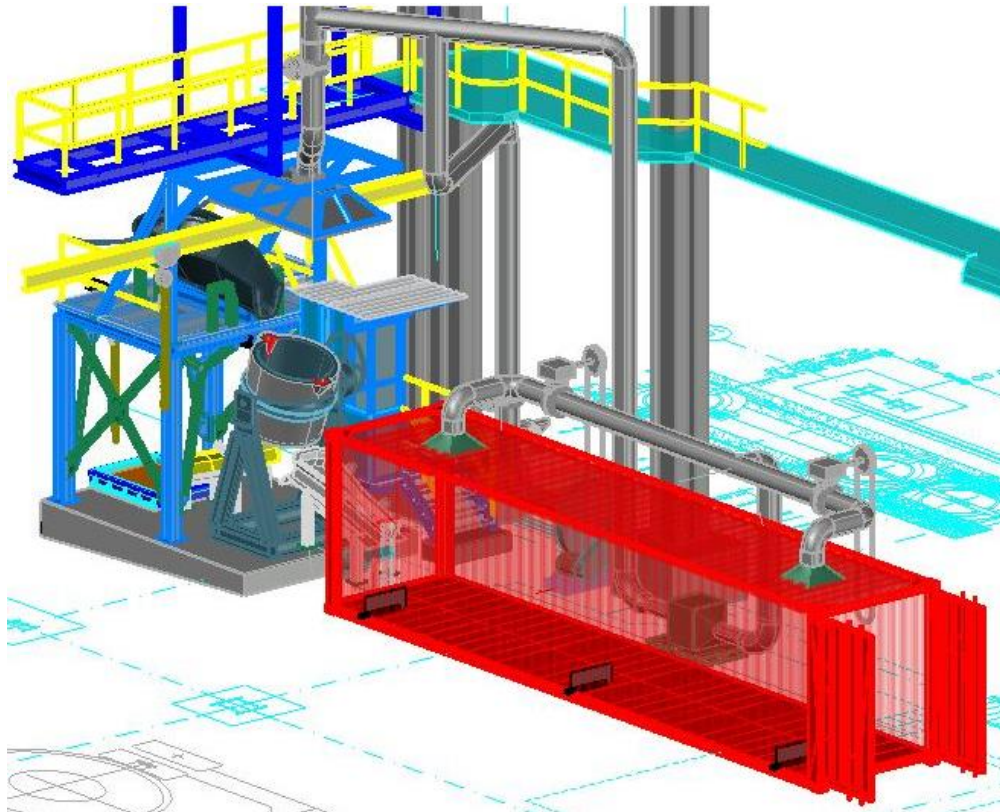
A R&D project, funded by EIT Raw Materials, aimed at **validating an innovative and sustainable air-based pyro-metallurgical system to produce iron silicate through a pilot test campaign executed.**

The new system will drastically reduce water consumption, recover significant amounts of energy and improve the quality of the iron silicate, adding value to the final product



Benefits:

- Significant reduction in water consumption.
- Recovery and use of energy contained in molten slag.
- Validation of new uses of iron silicate, with a greater added value.
- Safety: Avoid explosions risks due to molten material in contact with water.



- ❑ The pilot plant was installed at the Atlantic Copper facilities (Sept 2020)

Pilot plant

Tilting ladle


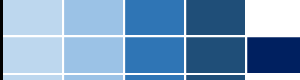
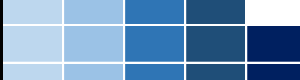





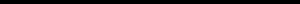


Atomization chamber

[whisper_largo_ing – YouTube](https://www.youtube.com/watch?v=whisper_largo_ing)

Conclusions from test camping

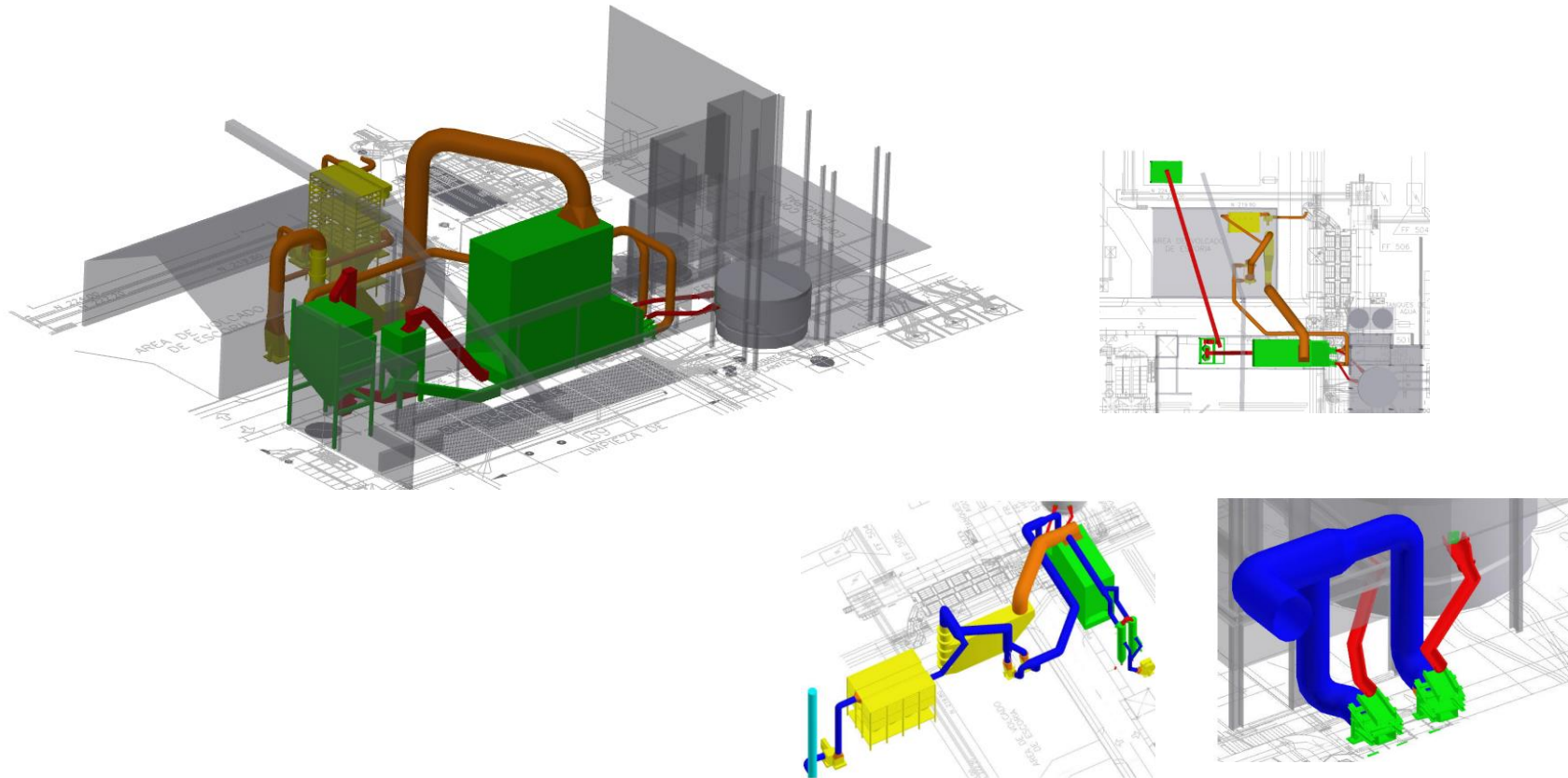
- **Dry granulation is possible** with similar particle size distribution and composition.
- To be taken into account: a) operational parameters to be optimized at industrial scale, b) important decrease of amorphous phase, c) Part of sulfur is lost, so possibly it goes to off gas extraction. Further studies suggested.
- Energy and/or heat recovery is theoretical feasible. 34 GWh/year vs 10-11 GWh/year of consumption.
- New use validated: aggregate for concrete.
- New use validated: binder in cementitious material.
- Other new uses under study
- Finely milled water granulated slag better performance as binder. Milling studies will be done with RSF, wet and dry granulated slag.

		Level of success	Level of criticality
Prototype construction	The prototype was built as designed Full scale is feasible		Wanted Critical
Prototype operations	Technically, it worked as expected		Critical
	Iron silicate granulation		Critical
	Hot air recirculation		Wanted
	Safety		Critical
	Waterless		Critical
Material obtained: The granulated silicate meets the the market demands	Heat recovery		Wanted
	Current uses: Abrasive		Critical
	Current uses: Cement		Critical
	New uses: Asphalt mixture		Added value
	New uses: Aggregate for concrete		Added value
	New uses: Add. immobilization polluted soil/water		Added value
	New uses: Thermoelectric cement		Added value
	New uses: Binder - Replacement fraction of cement		Added value
	New uses: Binder - Hybrid (cement + alkali salts)		Added value
	New uses: Binder - Strong alkali-activation (full cement replacement)		Added value
	New uses: Ammonium removal wastewater		Added value

NEXT STEPS

Industrial scale: preliminary lay out (June 2022)

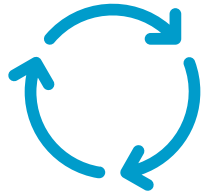
New feasibility study is ongoing to upscale the technology at Industrial scale



❑ First estimation of a full plant installation would require up to 25 million euros Capex

The Circular Economy, in our DNA

Copper is a 100% recyclable metal

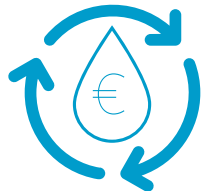


We 'circularize' all the natural resources used in the process. Our smelter currently has the capacity to treat about 35,000 tons of recycled copper per year (12%) and we are launching



We recover the heat from the process to convert it into electrical Energy that we self-consume (17% in 2021)

Projects: WhISPER and ceramic filters



We recirculate and minimize the water that we consume to reduce the water footprint (50% of the annual water consumption)

Projects: Red_Scope and WhISPER

To conclude



□ In Atlantic Copper we are very committed towards respect for the **environment, green transition and sustainability.**

□ **Innovation** based to face efficiency resource and **circular economy** is without doubt a **key factor.**



□ True sustainability in the industry **requires considerable efforts:** hardworking **people** involved in the projects and **investments in R&D** in order to generate knowledge that applied in the process directly impacts into the sustainability of the Copper Smelter&Refinery

Innovation to drive the Green Transition



Thanks





ELECTRIFYING THE FUTURE

¡THANKS!

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