

Market data & LCA of the ION4RAW process

Mathilde Legay – LGI

Amended version, December 18th

ION  RAW

**Ionometallurgy of primary sources for
an enhanced raw materials recovery**



By-products recovery

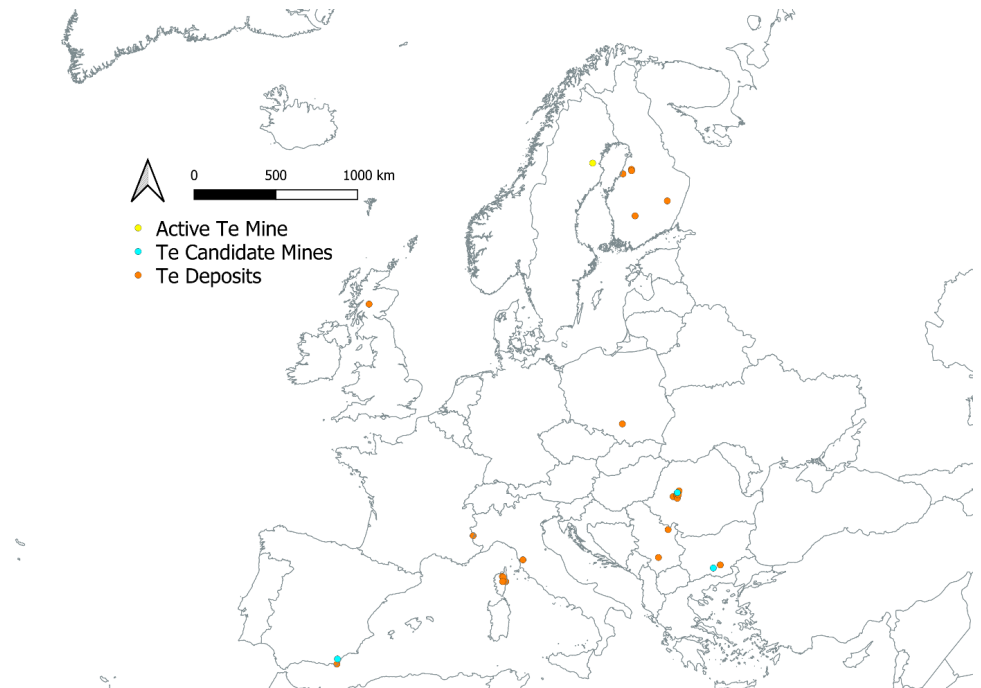
The recovery of by-products through different R&D chemistry processes is of economic and environmental importance



By-products market

Tellurium

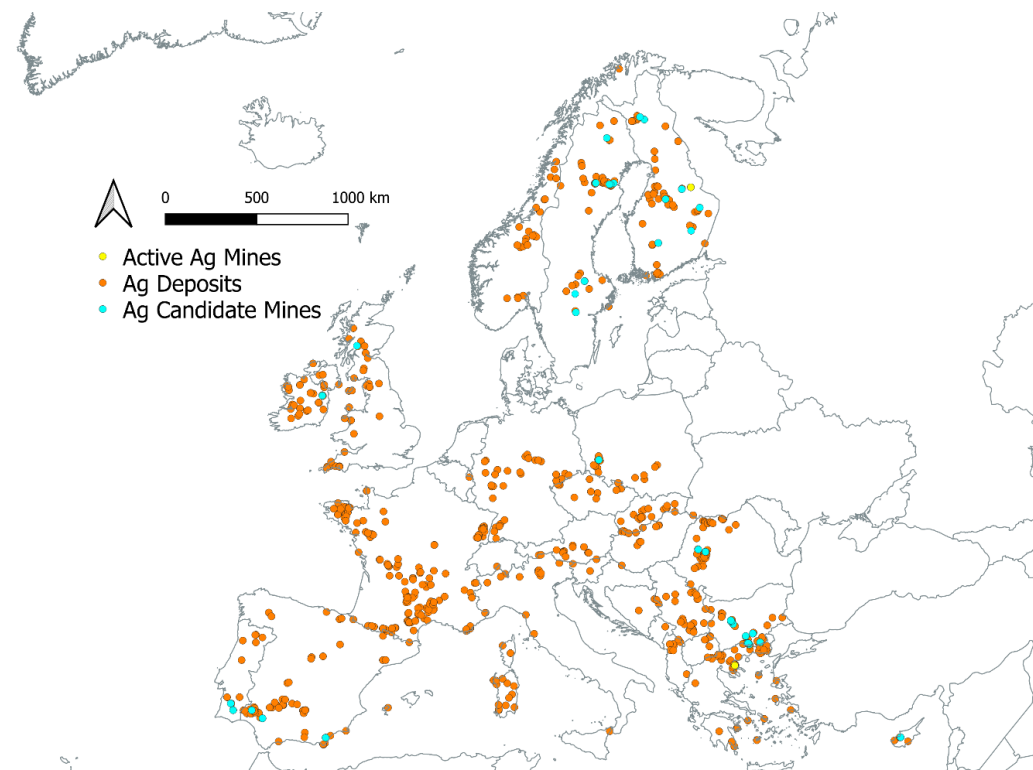
- small market with confidential agreements between producers and consumers.
- China is the main producer of refined tellurium, obtained from copper anode slimes and smelting processes. Other significant producers include Japan, Russia, and Sweden. (USGS, 2022)
- use in thin-film **cadmium telluride solar panels** and **thermoelectric applications**
- The tellurium market was projected to **grow at a rate of 3% annually** from 2018 to 2022, mainly due to its use in Cd-Te thin film solar panels and the investigation of new applications.



By-products market

Silver

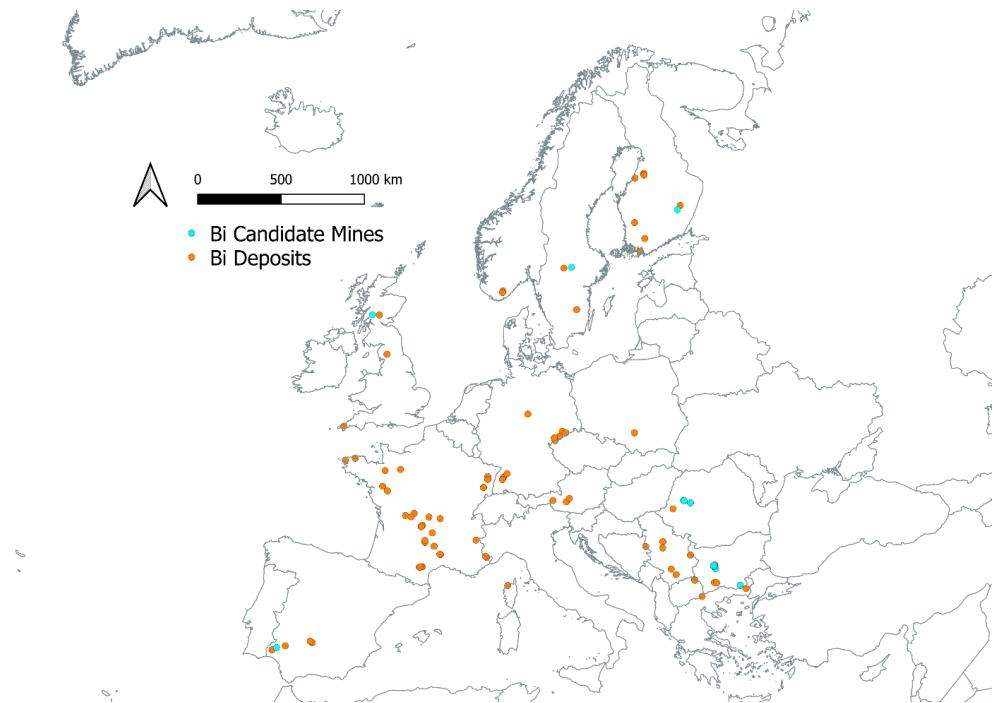
- Only about 30% of the annual supply comes from primary silver mines, while over a third is produced at lead/zinc operations and 20% from copper mines
- The estimated domestic uses for silver were a **physical investment (26%), electrical and electronics (21%), coins and medals (11%), jewelry and silverware (4%), and other (38%)**.
- Demand expected to increase due to the expected growth of electric vehicles (EVs) and continued investment in solar photovoltaic energy



By-products market

Bismuth

- Critical Raw Material
- China leading producer
- Many end-uses, such as coatings, brake lining
- Demand growing by 5% a year until 2030
- Growing demand in semiconductor compounds and alloys



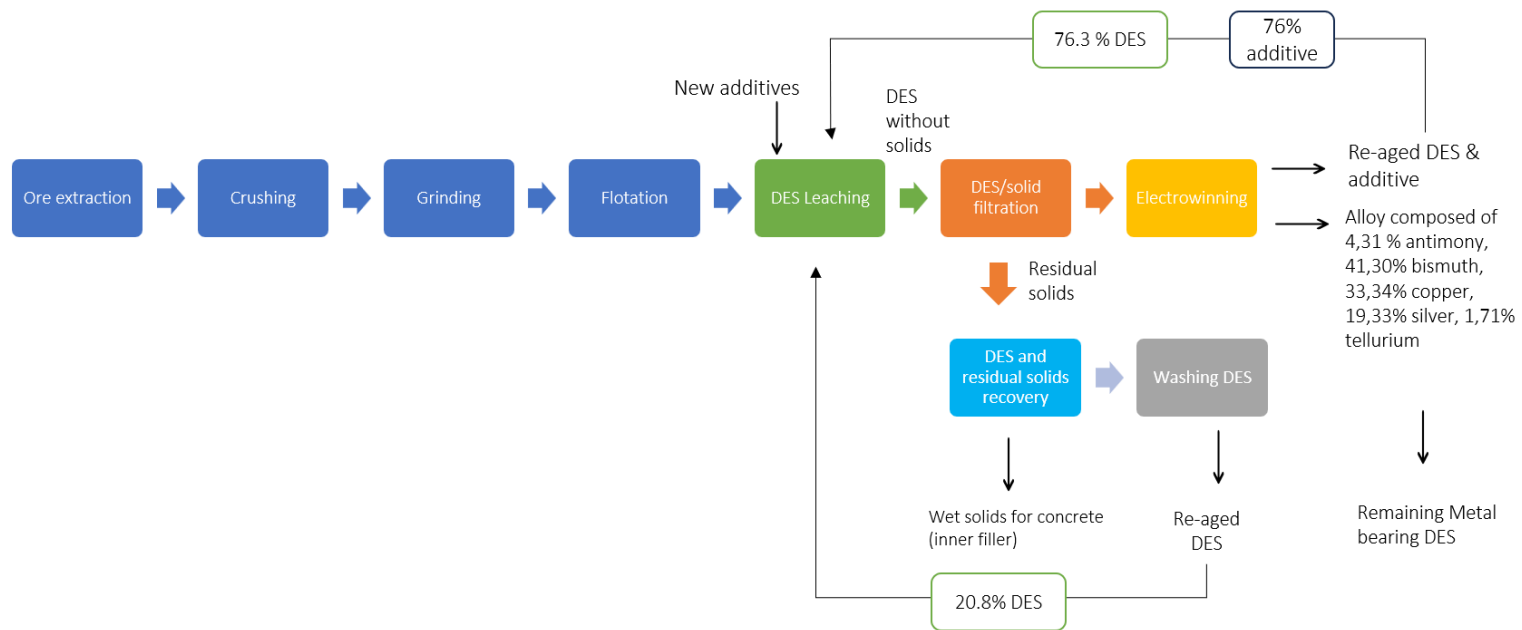
Recent Global Prices for Target Metals (USGS, 2022)

Raw Material	Price 2018 USD/ KG)	in (in 2019 USD/ KG)	Price in (in 2020 USD/KG)	Price in (in 2021 USD/KG)	Price in (in 2022 USD/KG)
Antimony	8,38	6,69	5,87	11,68	13,86
Bismuth	10,14	7,00	5,98	8,23	8,58
Copper*	6,51	5,98	6,16	9,28	8,80
Silver	505,72	522,12	661,65	811,14	675,15
Tellurium	73,67	60,45	56,05	67,26	66

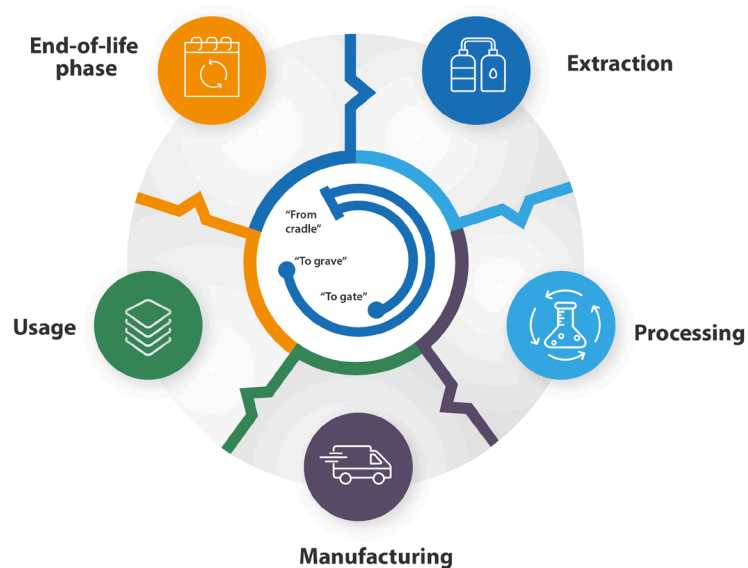
*Price at London Metal Exchange, **Price at Rotterdam Warehouse



ION4RAW Process taken into account in the LCA



LCA methodology



Scope & Goal

- The primary function is to produce 1 kg of metals together after electrowinning: 33 % (w/w) copper, 41 % (w/w) bismuth, 4% (w/w) antimony, 2% (w/w) tellurium, and 19% (w/w) silver.
- Secondary functions consist of recycling the DES at 93% (w/w), the additive at 76% (w/w), and solids without residual DES as inert filler in the construction industry.
- ReCiPe MidPoint method.
- The software OpenLCA 1.10.2 was used with the database Eco-invent v3.6.
- Scope : the project chose to focus on El Porvenir, Cu/Pb concentrate.

Main hypotheses for the laboratory scale LCA

- implementation of the ION4RAW technology close to a copper mine similar than El Porvenir in Europe. The close proximity to the mine eliminates the need for transportation between beneficiation, leaching, and electrowinning.
- The chemicals are assumed to be globally sourced without specific geographical constraints.
- **93% DES recovery**
- **The quantity of additive recovered in the whole process is about 76%**
- The ore extraction, crushing, grinding and flotation of the copper ore are conducted at El Porvenir. These operations are assumed to be taking place in Europe.
- DES Leaching on 1 g of ore is conducted at TECNALIA laboratory (3:1 oxidant :solid ratio) at room temperature.
- Electrowinning is conducted at 50°C for 90 minutes at SINTEF laboratory.
- DES/solid filtration, DES recovery and residual solids valorisation are conducted at LUREDERRA laboratory.
- Physical allocation is applied to both DES/Solid Filtration and DES and residual solids steps.

Results, for 1kg of produced metal

source	Bismuth (Nuss & Eckelman, 2014)	Tellurium (Nuss & Eckelman, 2014)	Antimony (Nuss & Eckelman, 2014)	Silver (Nuss & Eckelman, 2014)	Copper (International Copper Association, 2021)	33 % (w/w) copper, 41 % (w/w) bismuth, 4% (w/w) antimony, 2% (w/w) tellurium, and 19% (w/w) silver ION4RAW process at laboratory scale
Global Warming Potential (kg CO₂ eq/kg)	5,89E+01	2,2 E+01	1,29E+01	1,96 E+02	4,10	6,11E+04
Freshwater Eutrophication (kg Peq/kg)	2,2E-02	8,9E-01	2,4E-01	3,6	2,70E-03*	9,70E+01
Terrestrial Acidification (kg SO₂eq/kg)	3,8E-01	2,5	2,2E-01	8,5	6,10E-02	2,53E+02
freshwater ecotoxicity (FETPinf)	not available	not available	not available	not available	not available	2,23E+04
Ozone Depletion Potential	not available	not available	not available	not available	1,20E-10	7,06E-03

Results interpretation



- Comparison with current technology:
 - not same hypotheses, allocation methods, data timeframe,
 - Indication that the ION4RAW process needs to be further optimised to recover valuable by-products,
 - Need to reduce oxidant to improve freshwater ecotoxicity and freshwater eutrophication
 - Need to compare with LCA on innovative technologies, such as bioleaching

Ecodesign recommendations

- To **decrease the amount of oxidant** in order to reduce both freshwater ecotoxicity and freshwater eutrophication
- To optimise electricity consumption, by scaling up the process, and reducing heating when possible.
- If possible, the **electricity should be decarbonised** at the mine and for the whole ION4RAW process
- To recirculate the metal bearing DES, and add an extra metal refining step, to further **optimise the recovery of by-products**, especially the ones with high economic value
- Ensuring the **purity of secondary materials** is important in order to have products that have a long-lasting life and a good end-of-life.



Industrial symbiosis could be interesting to recover tailings from mines, and metals from anode slimes, slags, and flue dust. It will decrease the environmental burden on all recovered materials.



Thank you. Get in touch for more information!



Follow the progress of the project on the ION4RAW website.



Project coordinator: María Tripiana, IDENER
Contact us: contact@ion4raw.eu



Visit our website: www.ion4raw.eu



Follow us on Twitter!
[@ION4RAW_EU](https://twitter.com/ION4RAW_EU)



Follow us on LinkedIn!
[ION4RAW H2020](https://www.linkedin.com/company/ion4raw-h2020)

WP7 Contact

Mathilde Legay
Mathilde.legay@lgi.earth