E R A·M I N 2

RESEARCH & INNOVATION PROGRAMME ON RAW MATERIALS
TO FOSTER CIRCULAR ECONOMY

EU co-funded
ERA-MIN Joint Call 2017

First year Project reports
Publishable summaries

Contents

INTRODUCTION

The EU Co-funded ERA-MIN Joint Call 2017 was successfully launched with a 2-step submission procedure with a provisional call budget of € 15 million (including European Union contribution) and the participation of 17 countries/regions: Argentina, Belgium/Flanders, Brazil, Chile, Finland, France, Germany, Ireland, Italy, Poland, Portugal, Romania, Slovenia, Spain, Spain/Castille and Léon, Sweden, South Africa, and Turkey. In order to secure a sustainable and responsible supply of raw materials to the economy and industry, the EU Co-funded ERA-MIN Joint Call 2017 addressed three segments of the non-energy, non-agricultural raw materials:

- ✓ Metallic,
- ✓ Construction, and
- ✓ Industrial minerals.

The ERA-MIN Joint Call 2017 in figures:

- ✓ 94 pre-proposals submitted;
- ✓ 493 applicants involved (of which 133 enterprises)
- ✓ 5 main call topics on "Raw materials for the sustainable development and the circular economy";
- ✓ 35 full-proposals submitted;
- ✓ 16 transnational R&I projects funded;
- ✓ 88 beneficiaries (of which 34 enterprises);
- ✓ 12.3 million € of public (national, regional and EU) funds;
- ✓ 16 million € of total project costs.

The publishable abstracts of the 16 funded projects were compiled in a brochure and can be consulted in ERA-MIN's website (https://www.era-min.eu/results).

The following 16 projects were selected for funding (in alphabetical order of the acronyms):

1. AMTEG - Advanced Magnetic full TEnsor Gradiometer instrument
2. BIOMIMIC - Innovative biotechnological methods for effective mining of secondary material
3. BASH-TREAT - Optimization of bottom ash treatment for an improved recovery of valuable fractions
4. Deasphor - Design of a product for SUBSTITUTION of phosphate rocks
5. FLOW - Lightweight alkali activated composite foams based on secondary raw materials
6. Gold_Insight - Tracing Gold-Copper-Zinc with advanced microanalysis
7. INSTanT – Innovative sensor technology for optimized material recovery from bottom ash treatment
8. LIGHTS - Lightweight Integrated Ground and Airborne Hyperspectral Topological Solution
9. Li+WATER - Membrane electrolysis for resource-efficient lithium and water recovery from brines
10. MaXycle - A novel circular economy for sustainable RE-based magnets
11. MetRecycle - Recycling of metals using functionalized magnetic nanoparticles (FMNP)

12. MINTECO - Integrated eco-technology for a selective recovery of base and precious metals in Cu and Pb mining by-products
13. MONAMIX - New concepts for efficient extraction of mixed rare earths oxides from monazite concentrates and their potential use as dopant in high temperature coatings and sintered materials
14. RecEOL - Recycling of End-of-Life Products (PCB, ASR, LCD)
15. REWO-SORT - Reduction of Energy and Water consumption of mining Operations by fusion of sorting technologies LIBS and ME-XRT
16. SUPERMET - Recovery of Precious Metals from Spent Catalysts by Supercritical CO2 Extraction Assisted by Polymers

The 16 projects selected for funding had starting dates in April/May 2018 and 13 of them had 36 months duration while two of them had 24 months duration (Gold_Insight and Li+WATER) and one had 29 months duration (BIOMIMIC).

The average size of the consortia is 4.5 partners, and three of the 16 consortia were formed with only two partners; project BIOMIMIC is the project with the largest number of partners, without counting with the coordinator there are 10 partners (Figure 1).

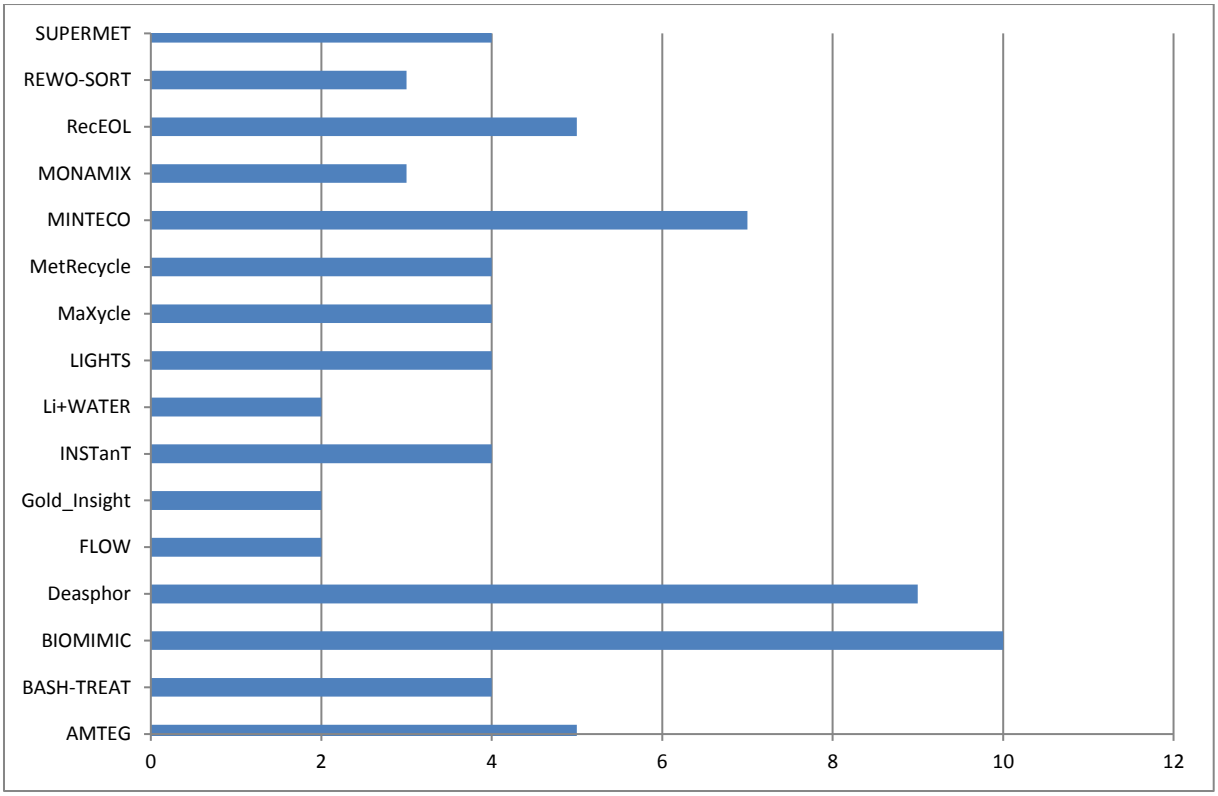


Figure 1 – Distribution of partners per consortium, not counting with the coordinator institution.

In terms of topics, the EU co-funded Joint Call 2017 had 5 main topics and 17 subtopics. A summary of the subtopics addressed by the funded projects is in the table below:

Main Topics and subtopics	**AMTEG**	**BIOMIMIC**	**BASH-TREAT**	**Deasphor**	**FLOW**	**Gold_Insight**	**INSTanT**	**LIGHTS**	**Li+WATER**	**MaXycle**	**MetRecycle**	**MINTECO**	**MONAMIX**	**RecEOL**	**REWO-SORT**	**SUPERMET**
1. Supply of raw materials from exploration and mining	●					●		●							●	
1.1 Exploration	●					●		●								
1.2 Mining operations															●	
1.3 Mine closure and reclamation																
2. Design													●			
2.1 Product design for increased raw material efficiency										●			●			
2.2 Product design for reuse or extended durability of products										●						
2.3 Product design to promote recycling										●						
2.4 Product design for critical materials substitution				●									●			
3. Processing, Production and Remanufacturing			●	●	●				●	●	●	●				
3.1 Increase resource efficiency in resource intensive production processes		●	●						●			●				
3.2 Increase resource efficiency through recycling of residues or remanufacturing		●	●	●	●						●	●				
3.3 Increase resource efficiency using information and communication technologies										●						
4. Recycling of End-of-Life products		●					●							●		●
4.1 End-of-life products collection and logistics										●						
4.2 End-of-life products pre-processing: pre-treatment, dismantling, sorting, characterisation							●			●						
4.3 Recovery of raw materials from End-of-life products		●					●			●	●			●		●
4.4 Increase recycling of End-of-Life products through information and							●			●						

communication technologies																
Main Topics and subtopics	**AMTEG**	**BIOMIMIC**	**BASH-TREAT**	**Deasphor**	**FLOW**	**Gold_Insight**	**INSTanT**	**LIGHTS**	**Li+WATER**	**MaXycle**	**MetRecycle**	**MINTECO**	**MONAMIX**	**RecEOL**	**REWO-SORT**	**SUPERMET**
5. Cross-Cutting Topics																
5.1 New business models		●								●				●		
5.2 Improvement of methods or data for environmental impact assessment		●	●							●						
5.3 Social acceptance and trust/public perception of raw materials		●														

In terms of the topics& subtopics addressed by the funded projects:

- ✓ all 5 main topics are covered;
- ✓ 7 out of 16 projects cover only one subtopic (AMTEG; FLOW; GOLD_INSIGHT; Li+WATER; LIGHTS; REWO-SORT; SUPERMET), whilst 9 of them are multidisciplinary/cross-cutting projects, with 2, 3, 6 or 11 subtopics covered; this is in line with ERA-MIN 2's objective of covering the entire raw materials value chain, from sustainable exploration, exploitation, processing, substitution of critical raw materials and resource efficient production to short-term economic feasible and low environmental impact recycling;
- ✓ subtopic *3.2 Increase resource efficiency through recycling of residues or remanufacturing* stands out with 7 funded projects, when compared to the other subtopics (Figure 2).

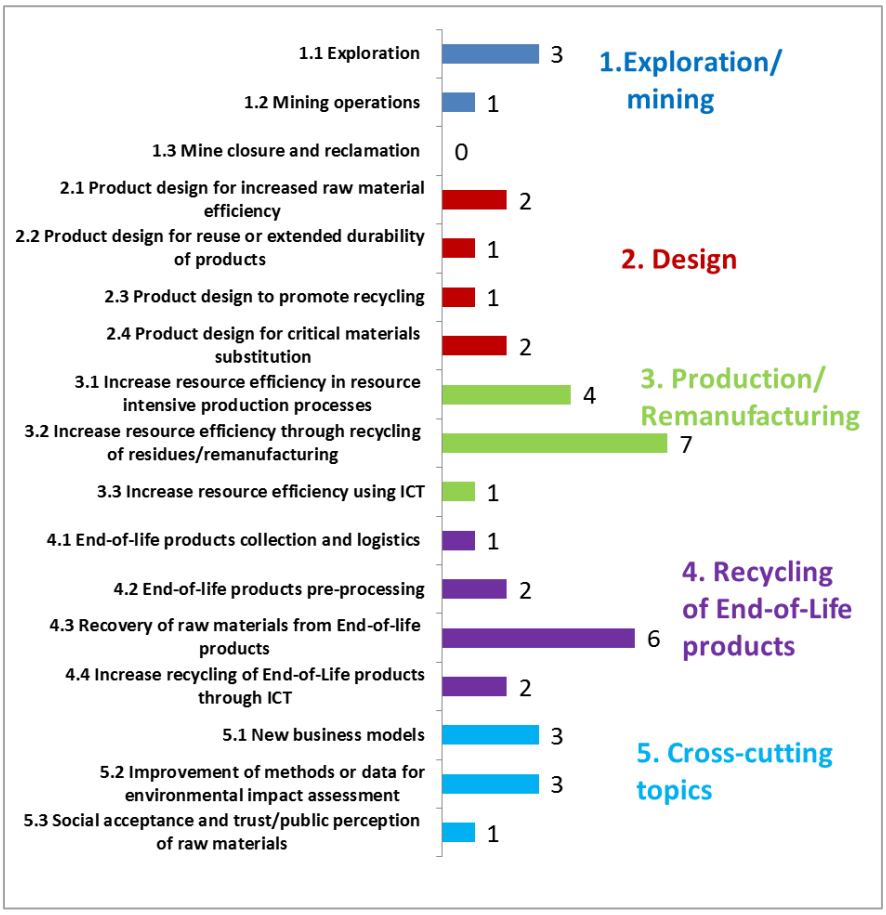


Figure 2 – Subtopics addressed by the 16 funded projects (Source: D3.5. List of projects selected for funding)

In terms of project budget, the average requested budget per project is €765,095, and the project with the highest requested budget is Deasphor with €1,405,498 (ten partners coordinated by Portugal).

France, Germany and Slovenia coordinate altogether the majority of the selected projects (9 out of 16) but the largest number of funded partners are from Germany, Sweden followed by France. To be noted that a Hungarian company participating with own funds is a partner in one of the projects (BIOMIMIC).

The average size of the consortia is 4.5 partners, and three of the 16 consortia were formed with only two partners; project BIOMIMIC is the project with the largest number of partners, without counting with the coordinator there are 10 partners (Figure 3).

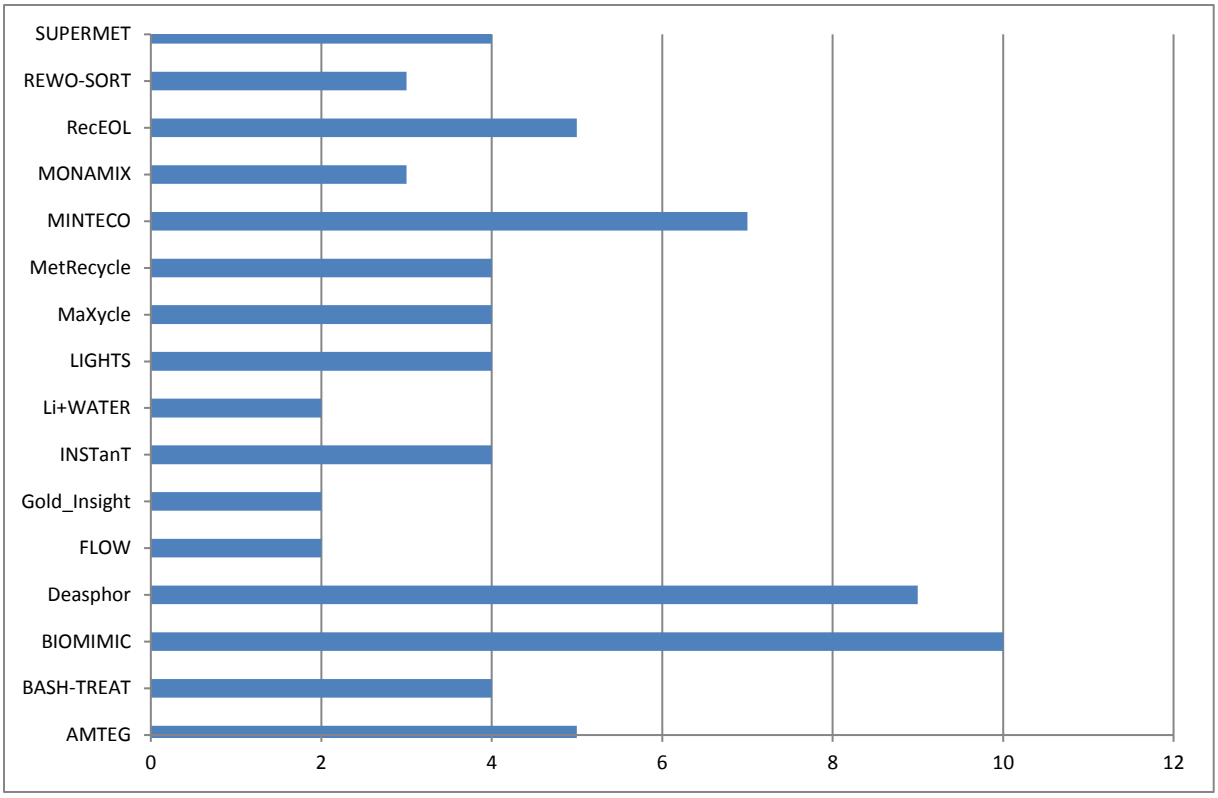


Figure 3 – Distribution of partners per consortium, not counting with the coordinator institution.

This report contains the public information of the *Deliverable 4.3– First Report on the mid-term assessments of co-funded projects* which is confidential and has assessed the consortium composition, the participating countries; the total requested funding and real project funding, existing and new collaborations, how the consortium was formed, number of young researchers, number of publications, participation in meetings/events, researchers exchange, innovation activities, outreach, open access and gender balance.

PROJECT'S RESULTS

The main objective of ERA-NET calls is to attract new transnational research collaborations. Regarding this, in EU Co-funded ERA-MIN Joint Call 2017:

- ✓ 31.25% of the consortia never had collaborated before,
- ✓ 50% were formed by a mixture of existing and new collaborators; and only
- ✓ 18.75% were composed solely by partners that have collaborated before.

Concerning the ones that found new partners for this call, two projects used the partner search tool on ERA-MIN website, seven found them in networking events including workshops, seminars, scientific conferences (e.g. 2017 InnoMine Chile workshop) and four through web search, social or professional networks.

For the ones that have collaborated before the EU Co-funded Joint Call 2017, seven of the projects submitted previous grants for transnational research projects, namely to: H2020 Twinning, EARTO, ERA-MIN 2014 and 2015 calls, EU-H2020-SC5, Bilateral project Slovenia – Argentina (2013 -2014), COST action MP1202 (10/12/2012 to 09/12/2016), H2020-H-CCAT project, EIT Raw Materials, DT-NMBP-19-2019.

The data on the 16 projects is available in a Catalogue of Projects, a table and a list of abstracts at the ERA-MIN 2 website:

- https://www.era-min.eu/sites/default/files/docs/2018_09_20_eramin2_brochura_web_0.pdf;
- https://www.era-min.eu/sites/default/files/docs/era-min_funded_projects_2017_table.pdf;
- https://www.era-min.eu/sites/default/files/publications/era-min_funded_projects_2017_projects_abstracts.pdf;

ERA-LEARN platform, that hosts a database of Public-Public Partnerships, their calls and funded projects, also has information on the 16 funded projects provided by the ERA-MIN 2 coordinator:

https://www.era-learn.eu/network-information/networks/era-min-2/era-min-joint-call-2017

The promotion activities of projects and their results were done through different means:

1. Dissemination on social and professional networks and blogs
2. Press releases:

3. Other dissemination means:

4. Projects websites: 14 of the 16 funded projects have already designed their projects websites and uploaded information on them. The development of such websites strengthens the promotion and offers paths for new collaborations.

The evaluation of the outreach to companies or stakeholders on the developments/results obtained in these projects is an objective. 10 of the 16 projects mentioned that they have approached or have been approached by companies or stakeholders.

As gaining public and policymaking trust in industrial activities is increasingly important in securing the raw materials supply in Europe from primary and secondary sources, funded projects were also asked to report whether policymakers where invited to project related events/networking. Even though most of them answered that perhaps in the second year of the project this would be more appropriate to report, there are still some incentives:

- ✓ the International Conference Nano4Circularity was organized by IOS and Chamber of Commerce and Industry of Styrian (ŠGZ) which is leading SRIP – Network for the Transition to Circular economy;
- ✓ State Secretary of Romanian Minstry for Research and Innovation, with the occasion of EmergeMAT conference and project meeting, 15 Nov. 2018, Hotel CARO, Bucharest;
- ✓ Dissemination work was performed through Pollutec technical fair in France (Nov-2018)

313 researchers were reported to be working on the 16 funded projects (corresponding to 88 beneficiaries), with an average of 16 persons per project; 31% of them are young researchers.
14 Projects also reported the creation of 5 permanent and 48 temporary jobs.

Regardless of the short project duration so far, a notable scientific output has been reported by the projects. Figure 4 shows the total scientific achievements of the projects: i) 4 peer reviewed publications, ii) 2 books or book chapters, iii) 26 conferences/proceedings/presentations and iv) 28 other outputs (poster presented in conferences, info-days, master thesis etc.).

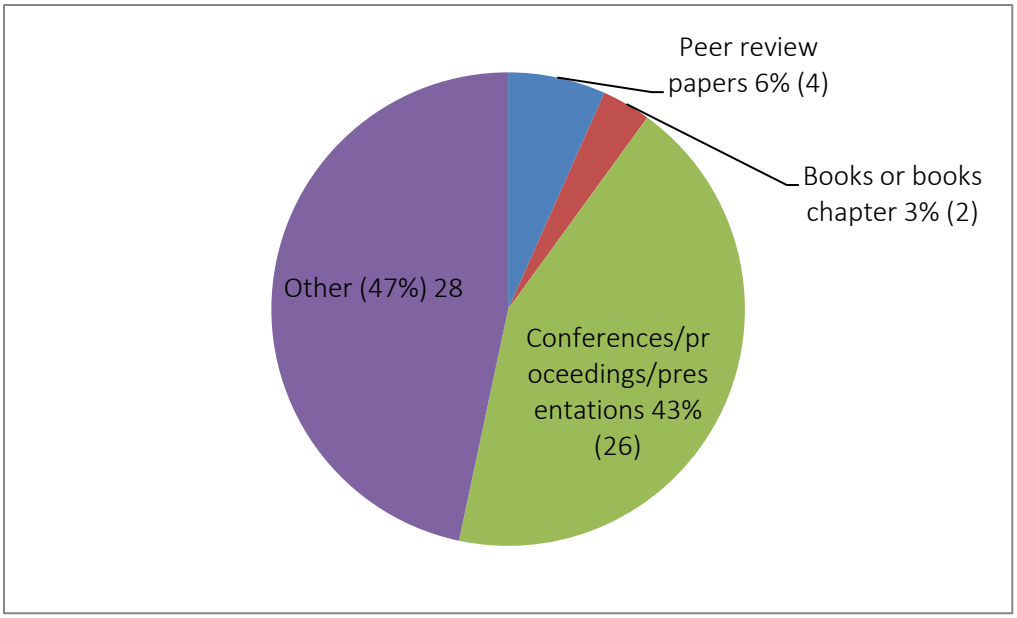


Figure 4 – Type of publications of projects.

Knowledge transfer and dissemination of results within ERA-MIN calls follow the approaches and principles of open science: 19 out of the 32 results reported publications in open access.

MID-TERM SCIENTIFIC EVALUATION

ERA-MIN 2 has organised the Mid-Term Seminar on 18th November 2019, in Brussels, during the Raw Materials Week. This closed meeting took place after the public 1h30 min session "ERA-MIN" within the *Horizon 2020 Technology Success Stories event*, organised by EASME. In this session, 8 R&I projects funded by ERA-MIN Joint Call 2017 highlighted how activities in the area of raw materials will benefit from project developments, or in broader terms how industry and society benefit from EU research funding. The selected 8 projects (AMTEG, REWO-SORT, MONAMIX, BASH-TREAT, MaXycle, BIOMIMIC, SUPERMET and MetRecycle) reflected the high diversity in terms of geographical coverage, thematic areas addressed and objectives/expected impacts.

At the Mid-term Seminar, the project coordinator, or a representative, of each funded project presented the status of the project and its results to the Call Steering Committee (CSC), the coordinators of the other funded projects and to invited stakeholders. This event was an excellent opportunity for synergies and networking between the projects and exchange of information with the funding agencies.

In terms of topics addressed, it was noted that:

i) projects LIGHTS, Li+Water and RECEOL are all covering battery related topics;
ii) BIOMIMIC and FLOW focus on fly ash whereas BASH-TREAT and INSTANT focus on bottom ash;
iii) Synergies were found between METRECYCLE and MAXYCLE.
iv) Both projects MetRecycle and FLOW are contribuing for the Strategic Research and Innovation Partnership – Networks for the transition into circular economy (SRIP – Circular economy) in Slovenia.

CONCLUSIONS

This report refers to the monitoring of the first year of the EU co-funded projects, as expected no major problems were found, showing that the projects are generally progressing well during their first

year. The few stated difficulties, delays and changes led to some adjustments, either in the work plan or in the consortia.

It was shown that 50% of project consortia were built on previous connections to which new partners have associated. There is good balance in terms of gender since 47% of researchers are female.

So far, projects appear to be going on the right way after the first year implementation period and seem to be well set up for success, considering that:

- new collaborations were established and consortia have applied to other 50 new national/transnational calls;
- over 40 project meetings reported, indicating a close collaboration between consortia partners;
- they already have a good record of publications;
- they have developed several new methods, processes and products;
- three patents, one licence were approved/submitted for approval;
- the majority has a dissemination plan where mainly social and professional networks and blogs will be used, and in most of the cases, a dedicated website;
- the large number of communications already presented in scientific conferences (events used not only for networking but also for engaging with stakeholders and industry).

The mid-term Seminar on November 2019 in which all the 16 project coordinators presented the results concluded sucessfully the mid-term scientific assessment.

The results of the first year confirm the high potential of this kind of transnational projects to enhance collaboration and reduce fragmentation of European Research Area networks in European Union.

PUBLISHABLE SUMMARIES

As the publishable summaries of the sixteen reports show, the projects are highly diverse in terms of geographical coverage, subtopics involved (focus) and objectives/foreseen results.

Project no./acronym	**ERA-MIN-2017_72/AMTEG**
Title	Advanced Magnetic full TEnsor Gradiometer instrum0
Duration	01.05.2018-30.04.2021
Coordinator	Supracon AG *(Germany)*
Partner 1	Nordika Geophysics *(Sweden)*
Partner 2	Leibniz Institute of Photonic Technology *(Germany)*
Partner 3	Ingenieur-Gesellschaft für Interfaces mbH *(Germany)*
Partner 4	Geognosia S.L. *(Spain)*
Partner 5	Nordic Iron Ore AB *(Sweden)*
Project website	Not yet

The entire project showed expected progress in the first year. The sensor milestone had been reached faster than expected and within the second project reporting period a lot of developments have to be performed to reach the entire goal of establishing a new technology that is able to detect targets with low contrast between target and environment.

Project no./acronym	**ERA-MIN-2017_157/BASH-TREAT**
Title	Optimization of bottom ash treatment for an improved recovery of valuable fractions
Duration	01.05.2018-30.04.2021
Coordinator	Hamburg University of Technology *(Germany)*
Partner 1	Politecnico di Torino *(Italy)*
Partner 2	Heidemann Recycling GmbH *(Germany)*
Partner 3	Bundesanstalt für Materialforschung und -prüfung *(Germany)*
Partner 4	Sysav *(Sweden)*
Project website	site under construction

BASH - TREAT

The management of 250 Mio. Mg Municipal Solid Waste is one of the main challenges and focus of the European Union. What it has been seen in the last decade is a progressive decrease in landfilling towards higher recycling quotas (47 % for recycling, against 24 % landfilling). When and only if, recycling is no longer suitable, the energy still embedded in waste can be recovered by means of thermal treatments.

However, metals such as copper, aluminium, silver and even gold concentrated in the combustion residues, and minerals, can be recovered and inserted in circular material loops. Roughly 20 Mio. Mg bottom ash are nowadays produced, from which 7 % ferrous and 1.5 % non-ferrous metals in average are recovered. Still, a part of these metals is unexploited and lost just by ash disposal. In fact, remarkable differences exists among the EU countries not only in metal recovery performances, but also in the reuse of the mineral fraction, for which there is a lack of a unified regulation.

In average, five different technologies are used in bottom ash treatment plants for metal recovery, which consists in screening in different fractions and the removal of the fines. Ferromagnetic and eddy current separators beneficiates of the previous screening stage, while manual sorting is applied mostly for the coarser fractions, while wind sifters are used for the removal of unburned light material.

These treatments however are not evenly applied in EU. In fact, at least 20 countries incinerate more than 10 % of their MSW. Nevertheless, bottom ash treatment is reported only in twelve countries. Changing the perspective, the reported treatment capacity is around 8.4 Mio. Mg bottom ash, which means that only for 40 % of the produced bottom ash there is a reported treatment. This means that more than 700000 Mg metals are virtually lost.

After having assessed the previous baseline for metal recovery potential, the project will apply standardised treatments in different representative European scenarios (Sweden, Germany, Italy). This will be beneficiary to underline existing differences in bottom ash quality and to investigate the application of further technologies to improve the actual state-of-the-art.

Project no./acronym	**ERA-MIN-2017_86/BIOMIMIC**
Title	Innovative biotechnological methods for effective mining of secondary material
Duration	01.05.2018-30.04.2020
Coordinator	Research Institutes of Sweden *(Sweden)*
Partner 1	Fraunhofer Institute for Systems and Innovation Research *(Germany)*
Partner 2	Flocazur AB *(Sweden)*
Partner 3	Nordic BioEngineering AB *(Sweden)*
Partner 4	Purac AB *(Sweden)*
Partner 5	Aughinish Alumina Ltd *(Ireland)*
Partner 6	Luleu University of Technology *(Sweden)*
Partner 7	Fortum Waste Solutions *(Sweden)*
Partner 8	G.E.O.S. Ingenieurgesellschft mbH *(Germany)*
Partner 9	University of Limerick *(Ireland)*
Partner 10	Geonardo Environmental Technologies *(Hungary)*
Project website	https://biomimic-project.eu/

The European Commission has identified several metals as critical for a high-tech and green development but have a fluctuating availability caused by politically and economically driven factors. Ironically, metals of a high economic value are being landfilled or end up in hazardous waste, posing threat to the environment and health. The ERA-MIN 2 funded European project BIOMIMIC addresses metal recovery from bauxite residue leachate originated from alumina production plants, acid mine drainage and fly ashes from municipal solid waste incineration.

Global production of alumina has more than tripled in the last 30 years and reached 132 Mt in 2017. In BIOMIMIC WP2 it was estimated together with industrial partners that an average of 0.75 m3 of leachate is generated per ton alumina. Following this logic, about 149 million m3 of leachate were generated globally in 2017. BIOMIMIC is currently developing remediation technologies for this process water using biosorption. The technology can also be used for recovering metals. The estimated global annual current value of metals is in the range €40 – 160 million. The leachate contains considerable amounts of aluminium, molybdenum, nickel, vanadium and gallium. The latter two are currently classified as critical raw materials by the European Union (European Commission 2017a). The amounts of the critical raw materials gallium and vanadium contained in the yearly generated bauxite residue leachate could cover 38% and 0.34% of European demand, respectively. However, gallium is recovered as a byproduct during alumina production in for example China and Germany the supply potential of gallium is currently much higher than the actual demand and modelled scenarios suggest the situation to stay that way until around 2030 (Løvik et al. 2016; Rongguo et al. 2016). Therefore, vanadium is the more interesting metal to recover from the bauxite residue leachate. Within the BIOMIMIC project, a biosorption process for the recovery of vanadium from bauxite residue leachate is being developed. The selected biosorbents were effective in removing three selected metals, aluminium, vanadium and gallium from bauxite residue leachate solution at an elevated pH of 11. In the case of aluminium removal, both the seaweed hydrochar (R: 34%) and the schwertmannite (29%) offer significant potential as biosorbents. Given the relatively harsh pH of the leachate solution used in the adsorption process (pH 11.3), these recovery levels are highly significant. In the case of vanadium removal, schertmannite shows strong potential (R:59%).
Schwertmannite also shows equally high potential for the removal of gallium (R:42%) under these conditions. Preliminary assessment suggests that if the new technology is applied in the whole of

Europe, about 17 t/yr of vanadium could be recovered, which would cover 0.15% of European demand.

Another industrial process stream of interest for BIOMIMIC sulfate reduction technology development, is acid mine drainage. The area around Freiberg in Germany was a traditional mining area. Mining operations for silver, zinc and lead were carried out starting in the Middle Ages and lasting until 1968. Then, mines were shut down and shafts were flooded. Ever since, drainage waters from these mines flow into local rivers carrying with them considerable amounts of metals (from an environmental perspective). The BIOMIMIC biological sulfate reduction technology was successful in effective removal of copper 93%, cadmium 99%, zinc 99% and aluminum 77% that were precipitated as sulfides inside the bioreactor down to levels of 10, 3, 56 and 60 µg/L, respectively from this stream. Even if the metal concentrations, e. g. zinc (85t/yr) and copper 0.8t/yr) are too low for an economic recovery and are negligible compared to European demand, they are major in terms of reduction of metal load introduced into receiving water bodies. The results indicate that technology is in principle suitable for the treatment of the mine water for environmental reasons prior to discharge into the river Freiberger Mulde. Environmental aspects of BIOMIMIC processes will be assessed in more detail in Work Package 5.3.

Finally, the third important stream for BIOMIMIC technology development is municipal solid waste incineration ashes. Municipal solid waste generation has been very slowly decreasing in the European Union in recent years. From a maximum of 261 Mt in 2007, values went down to 249 Mt in 2017. At the same time, the share of waste being incinerated is strongly increasing. While 39 Mt or 15% of municipal solid waste was incinerated in the EU in 2000, the amount almost doubled to 68 Mt or 27% in 2017 (eurostat 2019). Amongst other measures, this development is enforced through a landfill target of no more than 10% of municipal waste in 2030 in the European Union. This trend is therefore expected to continue in the coming years (European Commission 2017c). Incineration of municipal solid waste leads to the production of different types of ashes and residues, which contain a considerable amount of metals. While bottom ash already undergoes state-of-the-art material recycling processes for the recovery of ferrous and non-ferrous metals, fly ash is only deposited or used for backfilling. Only in Switzerland, the FLUWA/FLUREC process has been developed and is currently being established for the recovery of zinc, cadmium, lead and copper from municipal solid waste incineration fly ash in 17 plants (AWEL 2013; BIOMIMIC assessment). According to our assessment, in 2017, approximately 1,400 kt of fly ash were produced. The largest amounts were generated in Germany (320 kt), France (250 kt), the United Kingdom (220 kt) and Italy (120 kt). The largest impact on security of supply is possible for antimony, lead, magnesium and cobalt for which the amount of metals in municipal solid waste incineration fly ash could cover between 2.5 and 1.0% of EU demand. Antimony, magnesium and cobalt also belong into the group of critical raw materials as assessed by the European Union (European Commission 2017a).

Within the BIOMIMIC project, three bioreduction processes for the treatment of fly ash from municipal solid waste incineration are being developed (G.E.O.S. and RISE and Nordic Bionegineering) also biosorption will be evaluated in a later stage. The first step consists of leaching the ash, which is done in Sweden at Fortum Waste Solutions for both processes in the same way. Afterwards, each process has its own metal recovery step with different yields and specificities. Yields used for calculations are preliminary estimations made at an early stage of the project. They should therefore be revised towards the end of process development. The process recovers about 90% of cadmium, cobalt, copper, nickel, lead and zinc contained in the leachate. For the critical raw material cobalt, this converts to approximately 11 t of metal that could be recovered per year from fly ash, thereby potentially providing 0.6% of European demand. For aluminum, the possible contribution of the BIOMIMIC process reaches 0.4% of European demand. Currently, yields for lead, cadmium, copper and zinc achieved through the FLUWA process seem to be higher than the ones in the leaching process of BIOMIMIC. If these metals are targeted by BIOMIMIC, the leaching step should be further improved

for the developed process. The metal recovery step of BIOMIMIC, however, already shows good yields for these metals covered also by the FLUREC process. BIOMIMIC results also show the possibility for selective precipitation of Cu, Zn in a leachate metal mixture. The technoeconomical and environmental concerns will be addressed in the future but the ambition of BIOMIMIC is to target environmental as well as environmental concerns while developing a competitive process that can catalyze recovery of metals from these sources.

To summarize, BIOMIMIC addresses key problem areas of complex waste processing, including dilute and complex metal mixture, chemical usage and water management. The primary objective of BIOMIMIC is to create and validate new biotechnological metallurgical methods that have the potential to concentrate metals selectively in dilute solutions while reducing the environmental footprint of the waste and wastewater. With the success so far and with the planned activities the project have a potential to contribute to the ERAMIN goals of recycling of raw materials from complex products, overcome metallurgical and especially extractive metallurgy challenges, responsible and sustainable development, through increasing the raw materials supply while reducing impacts on the environment, creating new business models, improving methods or data for environmental impact assessment and social acceptance and trust/public perception of raw materials.

Project no./acronym	**ERA-MIN-2017_40/DEASPHOR**
Title	Design of a product for SUBSTITUTION of phosphate rocks
Duration	01.05.2018-30.04.2021
Coordinator	Faculty of Sciences of Porto University *(Portugal)*
Partner 1	Universidade Federal de Sergipe *(Brazil)*
Partner 2	Università degli Studi di Brescia *(Italy)*
Partner 3	Central Mining Institute (Glowny Instytut Gornictwa) *(Poland)*
Partner 4	University Politehnica of Bucharest *(Romania)*
Partner 5	Swerea MEFOS *(Sweden)*
Partner 6	Ege University *(Turkey)*
Partner 7	UMR GeoRessources *(France)*
Partner 8	Campoaves - Aves do Campo, SA *(Portugal)*
Partner 9	P.U.P.H „PROGEO" Sp. z o.o. *(Poland)*
Project website	

Laying hens manure was sampled in Turkey whereas poultry litter samples were collected in Portugal, Romania and Poland, and their proximate analysis made. Samples of combustion ash of layens hens manure from GÜRES Central (Turkey) and CAMPOAVES (Portugal) were also collected.

The ash from GÜRES was analysed via XRF, micro-XRF, XRD and SEM/EDS and the results show higher concentration of P in the fly ash and concentration of P as rims around calcite grains in bottom ash. Further investigations will concern the nature of the phases in particular identification of the main bonds characterizing the phases using Raman spectroscopy. Powders will be analysed both by XRD, and quantitative chemical analyses (both bulk analyses, and in situ micro-XRF and LA-ICP-MS analyses of trace elements in the different phases). These steps are necessary before any attempt of P extraction.

Preliminary trials laboratory scale combustion tests were made and data acquisition already started.

Project no./acronym	**ERA-MIN-2017_94/FLOW**
Title	Lightweight alkali activated composite foams based on secondary raw materials
Duration	01.05.2018-30.04.2021
Coordinator	Slovenian National Building and Civil Engineering Institute *(Slovenia)*
Partner 1	University of Oulu *(Finland)*
Partner 2	University of Modena and Reggio Emilia *(Italy)*
Project website	http://flow.zag.si/en

New possibilities for recycling of inorganic wastes or industrial residues have been investigated within the FLOW project. Namely, the main objective of FLOW project is to develop new lightweight alkali activated foams based on raw materials.

Two types of slags, the electric arc furnace slag (A) and the ladle furnace slag (R) were selected as precursors within FLOW project in Slovenia, and they have been tested as potential precursors for alkali activation. For this purpose chemical and mineral compositions were performed on both slags usig X-ray fluorescence (XRF) and X-ray diffraction (XRD) analysis. The influence of particle size, ageing and curing on mechanical strength of the specimens has been stuied. Also foaming and stabilization agents have been selected and suitable ratio of precursors and activators have been studied.

In Finland, partners have started working on alkali-activation process optimization of the following precursors: desulphurization slag, ground-granulated blast-furnace slag (GGBFS), ladle slag, metakaolin and mineral wools. In the first phase, the particle size distribution was planned based on their chemical reactions and pre-treatments. Finally, mechanical strengths and microscopic analysis of the designed mixtures were investigated at different curing conditions (curing in the oven with temperature and curing at the lab condition). Moreover, the physical and chemical performance of the developed materials exposed to the harsh conditions (freeze/thaw, carbonation, high temperature) was studied.

All precursor samples were also tested by Italian partners to assess their evironmental impact with water leaching test, according to EN-12457 (European Regulation) to detect eventual release of toxic cations. They have performed also reactivity potential of precursors for alkali activation process.
Results have been so far communicated to the industrial partners, presented at two conferences, contributed to two master theses and published in three SCI papers.

Project no./acronym	**ERA-MIN-2017_179/Gold_Insight**
Title	Tracing Gold-Copper-Zinc with advanced microanalysis
Duration	01.04.2018-30.03.2020
Coordinator	Trinity College Dublin *(Ireland)*
Partner 1	Luleå University of Technology *(Sweden)*
Partner 2	Swedish Museum of Natural History *(Sweden)*
Project website	https://www.tcd.ie/Geology/resources/links/GoldInsight

The proposed research under the Gold_Insight project contributes to the Challenge of securing Primary Resources by developing innovative techniques for exploration. These innovative new techniques arose from a novel combination of state-of-the-art micro-chemical analysis: trace element mapping and will be further advanced using in situ Pb and S isotope analysis as well as trace-element informed geochronology. The tools have been trained on known orogenic gold (Au) and Au associated with copper (Cu) – zinc (Zn) volcanogenic massive sulphide (VMS) exploration targets for which full 3D geological and structural models will be developed in time and integrated with absolute geochronology. The targets are in active emerging orogenic gold districts in Sweden and Ireland where low environmental-impact extraction is feasible. A three-partner consortium from two EU countries with some of the most exciting developments in exploration for Au and with outstanding field resources, analytical facilities, and world-leading expertise. The outputs of this project will significantly de-risk exploration in these and other minerals districts and develop an innovation platform for higher participation of EU institutions in the global exploration market. Orogenic gold deposits also often host other precious or base metals, including significant quantities of tellurium and its discovery will help secure the supply of this energy-critical-element (ECE).

Trinity College Dublin, Ireland

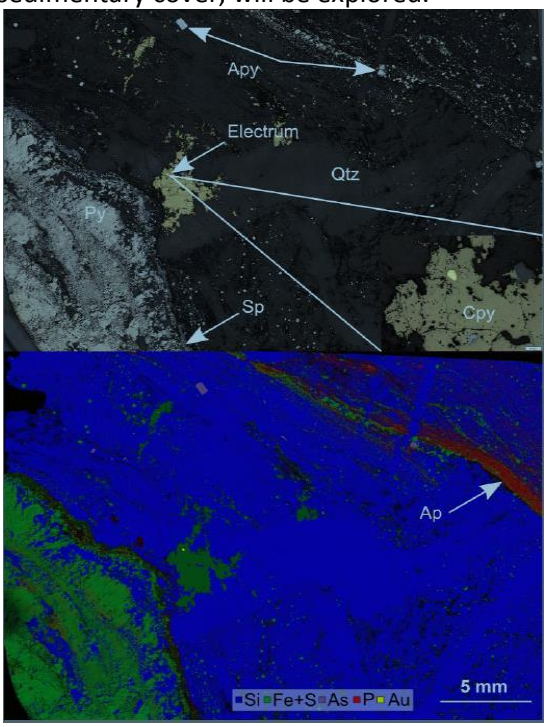
Petrographic investigation of the quartz vein hosted Kilmacoo gold occurrence spatially associated with the copper rich Avoca massive sulphide ore body evidenced a close association between gold and sulphides. Visible electrum grains (Figure 1) are frequently observed within chalcopyrite, and more rarely as minute inclusions in both arsenopyrite and pyrite. Mineralogical investigations (McClenaghan et al., 2019; Riegler et al., 2019) also revealed complex sulphide paragenetic succession from framboidal pyrite to colloform and idiomorphic cements with overall a low arsenopyrite content. The presence of hydrothermal phosphates (apatite and monazite) subsequently altered in aluminum phosphate sulphate minerals, as well as a broad diversity of phyllosilicates were also documented. These observations as well as the cross-cutting relationships tends to indicate a brittle deformation event involving possible remobilization of some of the copper mineralization from the main VMS ore body. At the present time the source of gold is still under investigation to determine the possible contribution from both local and distal sources.

Figure 1. A) Thin section reflected light image of a gold bearing quartz sulphide vein sample from the Kilmacoo occurrence. B) coincident scanning electron microscope energy dispersive X-ray spectrometry (SEM-EDS) element map. Abbreviations: Ap (apatite), Apy (arsenopyrite), Cpy (chalcopyrite), Py (pyrite) Qtz (quartz), Sp (sphalerite),

Luleå University of Technology, Sweden

Characterization of the Barsele Gold deposit located near Storuman in Northern Sweden reveals that mineralization is hosted in approximately N-S to NW-SE trending D3 oriented quartz-carbonate veins and microfractures associated with a granodiorite intrusion. Petrographic, SEM and LA-ICPMS investigations show that gold is primarily free milling hosted in quartz veins associated with sulfide minerals and in some cases scheelite, with a minor proportion occurring as invisible gold associated with sulphide minerals. LA-ICPMS mapping is ongoing to investigate trace element associations with

mineralization, and sulfide evolution during the gold event as well as overprinting and remobilization of metals from a nearby gold-bearing VMS (Norra). Dating of the host intrusion at Barsele through the Gold_Insight Project returned an age of 1.872 Ga ±11 Ma (Thomas et al., 2019). Based on this new date for the host rocks to mineralization, the Storuman area appears to be a westward extension of the Skellefte District; illustrating a potential for VMS mineralization in a so far underexplored zone west of the main known VMS occurrences. Gold mineralization appears to be orogenic in nature with the granodiorite host providing a favourable structural host for veining rather than a source for most of the gold. Further work is planned to investigate
the source of gold, with attempts to directly apply dating techniques (Re-Os on arsenopyrite) to the mineralization ongoing in association with University College, Dublin as part of this project. The possibility of an event Triassic in age, perhaps linked to postulated Mesozoic unroofing of Paleozoic sedimentary cover, will be explored.



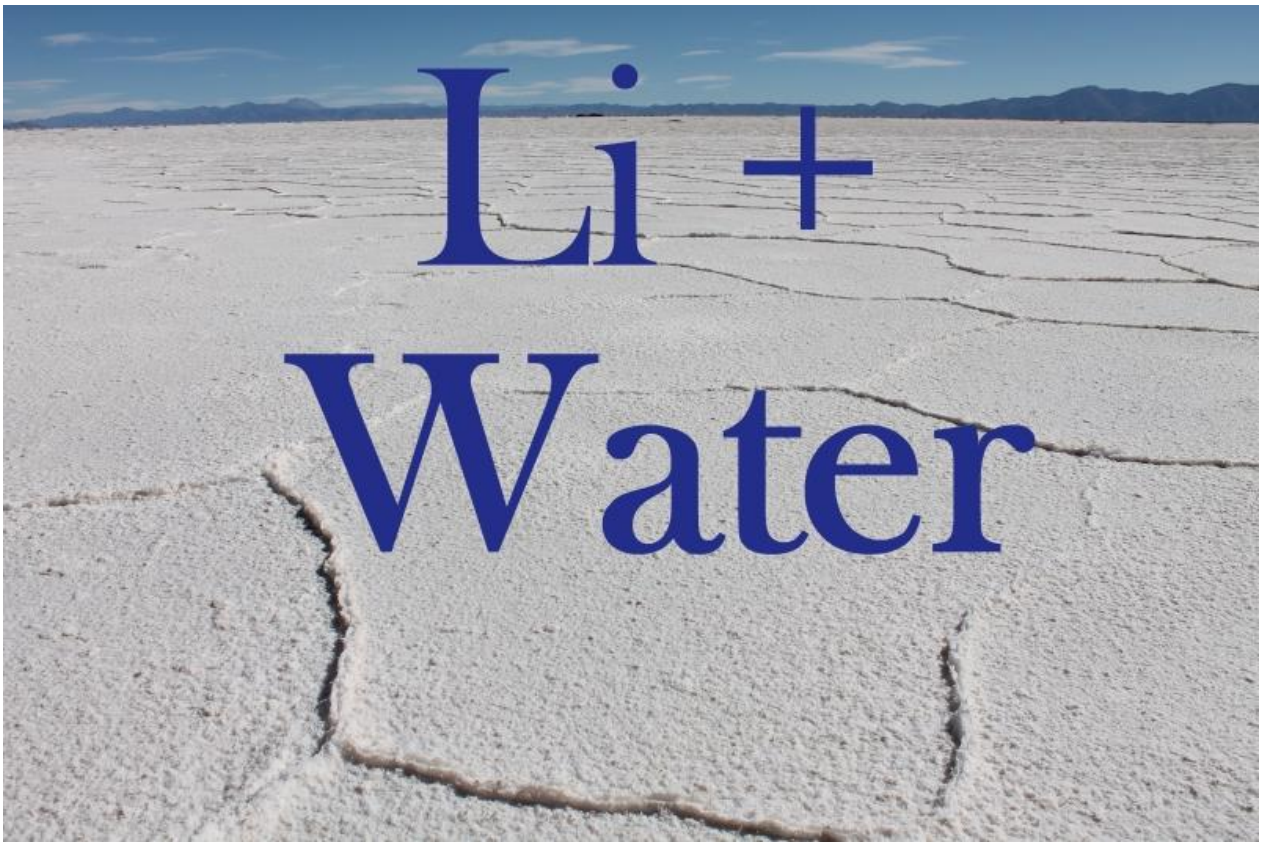
Project no./acronym	**ERA-MIN-2017_105/INSTanT**
Title	INNOVATIVE SENSOR TECHNOLOGY FOR OPTIMIZED MATERIAL RECOVERY FROM BOTTOM ASH TREATMENT
Duration	01.02.2018-31.01.2021
Coordinator	Vlaamse Instelling voor Technologisch Onderzoek *(Belgium)*
Partner 1	RWTH Aachen University *(Germany)*
Partner 2	SUEZ Treatment and Recycling NV *(Belgium)*
Partner 3	Tomra Sorting GmbH *(Germany)*
Project website	site under construction

Within the European Union, more than 400 Waste-to-Energy plants are currently in use to convert 88 million tonnes of waste (municipal, commercial and industrial) to generate energy and decrease the volume of these waste streams. This thermal process produces approximately **18 Mt of bottom ash** which could be considered as the **'final sink' for many End-of-Life products**. Important quantities of metals (ferrous and non ferrous) and minerals (both industrial minerals and minerals for construction) are present in these bottom ashes offering **a great opportunity for recycling and turning this complex waste into new raw materials**.

The objective of the INSTAnT project is to **close the material cycle of resources/materials present in bottom ashes** by using **smart recycling technologies** to 1) optimise process conditions in bottom ash treatment plants to **maximize metal recovery**; 2) separate out a valorizable **pure glass fraction**, and 3) detect and remove impurities that hamper the **high-grade recycling of the mineral fraction**.
INSTAnT will develop innovative **sensor-based characterization technology** allowing for fast, non-destructive, reliable material characterization to create data-driven decision tools for bottom ash treatment **plant optimization** and **enhanced resource recovery** (metals and minerals). This technology is based on machine learning and will turn big data into useful information by using artificial intelligence.

Furthermore, INSTAnT will adopt a novel **sensor-based sorting technology** to separate glass from the mineral fraction of bottom ash. This will not only generate a new valorizable glass fraction, but also increase the quality of the mineral fraction to be used as high-grade construction material.
Within INSTAnT, five partners **(SUEZ, TOMRA, XRE, RWTH and VITO)** are joining forces and bring together expertise in **waste recycling**, **sensor-based technology** and **big data** to maximize material recycling and reducing waste disposal whilst generating **new business opportunities**.
Currently the Consortium has been busy preparing representative samples and adapting the characterization and sorting technologies to the bottom ash stream and the challenges defined in the project. Samples were gathered from different bottom ash treatment plants and the treatment process of the Suez plant was accurately mapped. Pure material fractions were prepared from the different BA samples that will serve as training fractions for advanced machine learning models such as deep learning. Different sensor technologies for the separation of glass from the mineral fraction were tested and their efficiency was compared. With this progress, the consortium is now ready to develop the characterization technology for bottom ashes and apply it to study and optimize physical separation processes of bottom ash treatment plants. In addition, the sensor separation of glass will be optimized in the coming period.

Project no./acronym	**ERA-MIN-2017_83/Li+WATER**
Title	Membrane electrolysis for resource-efficient lithium and water recovery from brines
Duration	01.04.2018-31.03.2021
Coordinator	Universidad Nacional de Jujuy *(Argentina)*
Partner 1	Universiteit Gent *(Belgium)*
Partner 2	IVL Swedish Environmental Research Institute *(Sweden)*
Project website	



The Li+WATER project seeks to develop an integrated membrane electrolysis concept to recover lithium and other industrial minerals from both continental brines, as well as other less concentrated aqueous sources. Our technology is based on a 3 stage process, each based on a water electrolyser with a side crystallizer. The chambers of the electrolysers are separated by anion or cation exchange membranes (AEM or CEM). At the anode, water will be oxidized to oxygen, and/or chloride to chlorine gas. In the cathode, water will be reduced to hydrogen, and the pH will increase. The applied potential and the need to maintain electroneutrality will make cations and anions selectively move to the cathodic or anionic compartments. In Stage I, native brine is introduced into the cathodic compartment of a 2-chamber electrolyser (AEM). As the pH increases, $Mg(OH)_2$ and $Ca(OH)_2$ precipitate. We have recently produced very important advances in this first stage. We were able to fully deplete from Mg^{2+} and Ca^{2+} cations three samples of different compositions of native South American. Our results, which have been presented in a provisional patent application and are already published showed that the method is reproducible and repeatable, and the operational costs can be even lower than the current technology. In parallel, we are studying the influence of the different brine components in the crystallization of the hydroxides. So far, borates seem to have the most important effect.
In Stage II, brine that was pre-treated in stage I is fed into the middle compartment of a 3-compartment electrolyzer (anode – AEM – middle compartment – CEM – cathode). Cations migrate to the cathodic compartment. While the complexity is maintained in terms of the cation composition, these are now paired with the same anions, OH^-, making borates and sulphates no longer an issue. CO_2 is bubbled

into a side-crystallizer and pH is kept close to 8.3, so as to precipitate most of Na^+ as pure $NaHCO_3$. For this stage all experiments have been performed with native brine that has previously been depleted from divalent cations following Stage I. We are currently performing an in-depths analysis of fluxes across the cationic membrane. Because K^+, Na^+, and Li^+ have different ionic radii, there is a preferential migration across the membrane in the order $K^+ > Na^+ > Li^+$. In parallel to the electrochemical approach, we are also studying alternative methods to decrease the total salinity of the brine, since our preliminary economic assessments indicate that this second stage is the most costly of all three stages. It is yet too early to take decisions regarding the most efficient, economical and environmentally friendly methodology for decreasing the total salinity, and therefore, different methods are currently under exploration.

In the third and last Stage of the proposed methodology, a brine that has already been depleted from divalent cations and is heavily reduced in Na^+ concentration (after Stages I and II) is fed into the middle compartment of a 3-compartment electrolyser, identical to that of stage II. Cations migrate again to the cathode, where CO_2 is bubbled again into the side-crystallizer and at pH above 11 pure Li_2CO_3 is precipitated. While we optimize Stage II, we are currently working on this Stage with artificial brines. In this case, we are also performing an in-depths analysis of fluxes across the membrane. The preferential migration already seen in Stage II has also been observed here. Experiments with artificial brines have resulted in the precipitation of Li_2CO_3 (lithium carbonate) samples of at least 94 % purity, as determined by atomic spectroscopy and X-ray diffraction.

Project no./acronym	**ERA-MIN-2017_34/LIGHTS**
Title	Lightweight Integrated Ground and Airborne Hyperspectral Topological Solution
Duration	01.05.2018-30.04.2021
Coordinator	Université de Lorraine *(France)*
Partner 1	Faculty of Sciences, University of Porto *(Portugal)*
Partner 2	Laboratoire de Géologie de Lyon - Université Lyon 1 *(France)*
Partner 3	Helmholtz-Zentrum Potsdam - Deutsches GeoForschungsZentrum *(Germany)*
Partner 4	Beak Consultants GmbH *(Germany)*
Project website	http://lights.univ-lorraine.fr/

Lights

The general objectives of the project are:

1. To develop a software for easy and fast detection of lithium-host minerals combining droneborne remote sensing data and field observations
2. To understand how pegmatitic Li-deposits are formed. This is critical to establish how remote sensing and field observations can be used to unveil lithium deposits.

During the first year of the project, the drone and tripod procedures for acquiring data have been settled. They will be applied at the very beginning of year two. Work on the application of LIBS to quantification of Li on the field shows that several calibration curves will be necessary depending on Limineral type and Li-concentrations. The variety of possible Li-bearing minerals and the strong matrixeffects explain the difficulty encountered up to now in such direct quantification. The interface for data capture on the field, including spectral data, has been implemented in the advangeo® software. The project is globally in-line with its schedule and going forward to a proof of concept of hyperspectral investigation or Li-ores at the target scale.

The work for year two will focus on:

- on-site tests of the drone and tripods with related data acquisition;
- finalizing the calibration curves for Li quantification;
- understanding the mineral changes from fresh pegmatite to its parts affected by meteoritic alteration;
- performing a sequence of data acquisition using the advangeo® interface in real conditions with all data types.

Project no./acronym	**ERA-MIN-2017_142/MAXycle**
Title	Circular economy, magnet recycling, NdFeB magnets, end-of-life magnets, Eco-labelling
Duration	01.05.2018-30.04.2021
Coordinator	Jozef Stefan Institute *(Slovenia)*
Partner 1	Magneti Ljubljana, d.d. *(Slovenia)*
Partner 2	OBE Ohnmacht & Baumgärtner GmbH & Co. KG *(Germany)*
Partner 3	Pforzheim University of Applied Sciences *(Germany)*
Partner 4	IVL Swedish Environmental Research Institute *(Sweden)*
Project website	http://www.maxycle.eu/

In the first year of the project, we developed a system for eco-labeling of the newly produced permanent magnets based on rare earth. We are introducing the use of a very effective HPMS process to re-establish the processing of extracted materials directly from the Nd-Fe-B alloy. Besides, we are focusing on improving the removal methods of coatings before the HPMS process starts.

The ways to eliminate the eventual residuals of the coatings layers, which can inhibit the process and influence the magnetic properties have been studied.

We also developed a method for the ecological recycling of magnets at the end of use and patented it.

Project no./acronym	**ERA-MIN-2017_90/MetRecycle**
Title	Recycling of metals using functionalized magnetic nanoparticles (FMNP)
Duration	01.05.2018-30.04.2021
Coordinator	Institute for Environmental Protection and Sensors (IOS) Ltd *(Slovenia)*
Partner 1	Sveriges Lantbruksuniversitet *(Sweden)*
Partner 2	Instituto de Nanosistemas *(Argentina)*
Partner 3	SiKEMIA *(France)*
Project website	http://www.vibegraphics.net/recycle/

Target waste electrical and electronic equipment (WEEE) for recycling of rare earth elements (REE) have been defined and selected. Based on the obtained literature data, the commercially viable recycling efforts should be likely to concentrate on recovering REEs from products with high concentrations of valuable REEs, that allow for considerable economies of scale. Priority WEEEs sectors were identified in which recycling have a significant impact on the most critical elements; these are i) Permanent magnets and ii) NiMH batteries. The main REEs mostly contained in these two sectors, and present a market potential, are mainly Nd, Pr, Dy, and Sm, while La, Ce, and Eu in a lesser extent. The methods of collecting and sorting of WEEEs and the necessary infrastructure were reviewed. Test solutions, simulating the composition of products of acid leaching for the two materials (NdFeB and SmCo magnets) were produced and evaluated for development of recycling strategy. In the first year period various advanced adsorbent nanomaterials (ANMs), such as surface functionalized superparamagnetic iron oxide NPs and surface functionalized silica (SiO2) NPs were prepared.

Prepared materials were extensively characterized in order to obtain information on morphology, composition and surface characteristics. Coupling agents (bifunctional molecules) which are able to, on one side, graft on the NPs surface and, on the other side, immobilize REE have been identified. The novel adsorbent nanomaterials (ANMs) prepared were tested. So far synthesized amino functionalized magnetic NPs were used for removal of Tb3+ from standard aqueous solutions. The adsorbent/adsorbate system was analysed by determining equilibrium mass of adsorbent, appropriate equation of adsorption kinetics (kinetic analysis), the most appropriate adsorption isotherm (analysis of the effect of the adsorbate concentration), the nature of adsorption (thermodynamic analysis). The results are published in scientific paper „Terbium Ion Adsorption from Aqueous Solution by Using Magnetic γ-Fe2O3-NH4OH@SiO2 Nanoparticles Functionalized with Amino Groups" (Materials, April 2019). Approaches to bulk separation of REE were investigated for production of concentrates for futher ANMs based separation. Due to awareness of possible adverse effects of NPs on human health and in the environment, toxicological and ecotoxicological tests of the developed ANMs were carried out.

In the first year period, the project and results were promoted as widely and as effectively as possible to all relevant stakeholders, scientific publicationd and media. Project meeting was held to promote mutual cooperation and results implementation. The project webpage was prepared and continuously updated, as well as project logo was contructed.

Project no./acronym	**ERA-MIN-2017_119/MINTECO**
Title	Integrated eco-technology for a selective recovery of base and precious

	metals in Cu and Pb mining by-products
Duration	01.04.2018-30.03.2021
Coordinator	BRGM *(France)*
Partner 1	National R&D Institute for Nonferrous and Rare Metals *(Romania)*
Partner 2	National Institute for Research and Development in Optoelectronics INOE 2000 *(Romania)*
Partner 3	Eskisehir Osmangazi University *(Turkey)*
Partner 4	Romaltyn Mining SRL *(Romania)*
Partner 5	Mineral and Energy Economy Research Institute of The Polish Academy of Sciences *(Poland)*
Partner 6	Team Group Metals Sp. z o.o. *(Poland)*
Partner 7	AJELIS *(France)*
Project website	site under construction

Metal-bearing mining wastes are produced during the recovery and processing of nonferrous metals from ores. Mining waste can be considered as a valuable secondary resource containing base and rare metals. Nevertheless, one should take into consideration the presence of hazardous elements for environment with threats to air, soil and water. Most of these solid-state mining wastes have been disposed in tailing reservoirs, without active management. The project aims establishing a global management methodology to treat historical mining sites from case studies.

Lab scale experiments (TRL< 4), on well-known representative samples, will first allow establishing optimized protocols to concentrate the metals in smaller fractions by innovative mineral processing and to recover the metals by hydrometallurgical techniques. The main steps (pre-concentration/ leaching/ highgrade metal recovery) will be studied in details by research institutes to optimize first relevant process sequences. Then, a global coherent flowsheet will be proposed and the developed technologies will be further validated by the industrial partners (SMEs) at TR>4. Final economic and environmental assessment will be performed. The consortium gathers 8 partners from 4 countries (France, Romania, Poland and Turkey) is composed of university, 3 research institutes, 1 public institution and 3 SMEs with complementary expertise.

MINTECO project started to work on case studies on flotation mining residues 1) associated to the historical exploitation of multi-metals sulphidic ore and still containing some Au (Romania); and 2) associated to zinclead oxide ore exploitation, still containing large quantities of Pb-Zn (%) and some Ag. Representative samples were obtained and delivered from the Romanian site, grab sampling was performed in Turkey. A review of possible Polish sites to be investigated was also performed.
The results of the evaluation of mineral processing techniques to concentrate metals in Romanian mining residues (Au, Pb, Zn, Cu) and Turkish residues (Pb, Zn, Ag) show at this stage little progress due to the metal distribution in the finest particles. Dedicated mineralogy work is underway to help orientate further work. Direct hydrometallurgy on Turkish residues shows high recovery of Pb and Zn in various conditions, which is very encouraging. Further work will be on Ag recovery and best choice of reagents and conditions to optimize economic and environmental issues. Leaching work with thiosulfates and ionic liquids need further improvements. In parallel, synthesis of adapted fibrous ion exchange minerals were performed taking into account the chemical mechanism of extraction of precious metals. Partners should test them on their leaching solution. Flowsheets of various hydrometallurgical steps and options will be soon integrated to deliver first environmental and economic assessment of the technologies and help further choices.

Project no./acronym	**ERA-MIN-2017_87/MONAMIX**
Title	New concepts for efficient extraction of mixed rare earths oxides from

	monazite concentrates and their potential use as dopant in high temperature coatings and sintered materials
Duration	01.05.2018-30.04.2021
Coordinator	National R&D Institute for Nonferrous and Rare Metals *(Romania)*
Partner 1	ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development *(Italy)*
Partner 2	SC MGM Star Construct SRL *(Romania)*
Partner 3	Institut de Chimie de la Matière Condensée de Bordeaux *(France)*
Project website	www.imnr.ro/monamix

Monazite is one of the most valuable natural resources of rare earth elements used as dopants with high added value applications in many areas, including catalysis, glassmaking, metallurgy, optoelectronics, batteries and coatings for extreme environments.

Extraction of individual lanthanides from mining concentrates requires very complex and reagents consuming sequential processes due to their very similar electronic configuration and physical-chemical properties. The complexity of the separation process is therefore reflected in the high price of the individual lanthanides.

The MONAMIX project aims to demonstrate the potential use of mixed REOs, instead of individual ones, obtained directly from monazite concentrates with naturally occurring composition, as dopant in the design of high temperature oxide coatings and sintered zirconia-based oxide materials. This may result in a high impact in reducing the actually reagents consumption and costs by eliminating their individual extraction and separation as well as reducing the environmental impact in extraction.

Two types of new products using naturally mixed REOs – Zirconia ceramics are under development:
- Thermal barrier coatings working at temperatures up to 1400–1500 0C, fulfilling the industry demand to increase the lifetime of Ni/Cr alloys and reduce the critical raw materials content in substrate alloys;
- Sintered natural mixed-REOs doped zirconia ceramics for solid oxide fuel cells with controlled ionic conductivity at temperatures close to 4000C with low REO catalysts content.

Also fundamental researches are driven for development of a new class of high entropy oxides with new properties.

Project no./acronym	**ERA-MIN-2017_99/RecEOL**
Title	Recycling of End-of-Life Products (PCB, ASR, LCD)
Duration	01.05.2018-30.04.2021
Coordinator	University College Cork / Environmental Research Institute *(Ireland)*
Partner 1	Composite Recycling Ltd *(Ireland)*
Partner 2	Coolrec BV *(Belgium)*
Partner 3	Technische Universität Bergakademie Freiberg *(Germany)*
Partner 4	Alumisel *(Spain)*
Partner 5	Muldenhütten Recycling und Umwelttechnik GmbH *(Germany)*
Project website	https://receol.ucc.ie

Led by University College Cord, the RecEOL project started 30th April 2018. The project involves six international partners from idustry and academia from Ireland, Belgium, Germany and Spain. The aim of the project is to validate a patented process for recycling of end-of-life products (PCB, ASR & LCD).

In year 1, all deliverables in relation to project management have been produced. In WP2, analytical experiments have taken place in advance of the execution of the pilot plant trials involving samples of waste ASR, PCBs and comouter parts. Quantitative assessment of the metal components in these waste streams is essential to determining their siutability for the RecEOL process and value. In WP3, a pilot plant trial plan has been developed, some experimentation in relation to indium removal have taken place and all other experiments will be executed in full in year 2. Two publications are in preparation as a result of this work. In WP4, the timeline for task 4.1 has benn changed to month 13-24 of the project. Several analytical experiments have been conducted on Cu, Al, Fe, Si. Ag, Pb etc to optimise their recovery in the recycling process. Task 4.3 which was due to start in month 8 will now start in month 13.

Some delays have been encountered in setting-up the experimental unit in University College Cork which have affected progrtess in this work packages but these issues have now been solved. The outcomes of the project will not be affected by these delays.

Project no./acronym	**ERA-MIN-2017_89/REWO-SORT**
Title	Reduction of Energy and Water consumption of mining Operations by fusion of sorting technologies LIBS and ME-XRT
Duration	01.05.2018-30.04.2021
Coordinator	Fraunhofer Gesellschaft *(Germany)*
Partner 1	University of Chile *(Chile)*
Partner 2	Luleå University of Technology *(Sweden)*
Partner 3	SECOPTA analytics GmbH *(Germany)*
Project website	https://www.iis.fraunhofer.de/en/ff/zfp/projects1/rewosort.html

REWO-SORT

Within the first year of the project the consortium formed and setup the steering committee in order to take decisions and govern the project itself. The first task of the project – gather representative samples from industrial copper mines – was carried out by incorporating Rafaela mine site in Chile and thereby ensuring industrial participation, sampling, testing and evaluation based on industrial needs and daily challenges.

To ensure high variety of the samples, different kinds within the same class (oxides, sulfides) were taken as reference samples for validation purpose. Feasibility measurements with LIBS and MEXRT were performed to mirror the technical state of art and create ground truth data for upcoming work on neural networks and sensor fusion. While sensor data fusion for the combination of both measurement techniques is one of the main objectives of the ongoing work and currently under development, preliminary results were promising.

The consortium agreed on publishing periodically updates of the work on conferences and aims to achieve scientific impact on journal papers.

Project no./acronym	**ERA-MIN-2017_36/SUPERMET**
Title	Recovery of Precious Metals from Spent Catalysts by Supercritical CO2 Extraction Assisted by Polymers
Duration	01.05.2018-30.04.2021
Coordinator	Ecole Nationale Supérieure de Chimie de Montpellier *(France)*
Partner 1	NATIONAL INSTITUTE OF RESEARCH AND DEVELOPMENT FOR OPTOELECTRONICS *(Romania)*
Partner 2	Association : Innovation Fluides Supercritiques *(France)*
Partner 3	Heraeus Deutschland GmbH & Co. KG *(Germany)*
Partner 4	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. *(Germany)*
Project website	https://supermetproject.eu/

SUPERMET PROJECT

SUPERMET project proposes to explore an eco-friendly disruptive technology for the recycling of precious metals, especially palladium (Pd) and platinum (Pt), from spent catalysts, e.g. from petrochemistry catalysts, by extraction in supercritical CO2 (scCO2) thanks to complexing polymers bringing the insoluble precious metals into the scCO2 medium. Precious metals are used extensively in applications for catalysis not only in the petrochemistry, but also in the field of automotive emission catalysis and in the synthesis of fine chemicals. The scarcity of these metals poses a risk for the European countries which do not have this primary resource. The pyrometallurgical and hydrometallurgical state of the art techniques developed for the recovery of these metals are energy-intensive, destructive, and generate large volumes of toxic effluents.

With our proposed innovative recycling process, the catalytic support and the precious metal remain intact and can be reused as well as the used CO2 and polymer, so that there are no toxic effluents. Due to adjustable solvent properties of scCO2, the dissolved polymer-metal complex can be removed from the CO2 simply by depressurization. So, this new process is eco-efficient and solves a core problem of the state of the art processes.

During the first-year of the project, metal-complexing polymers were synthesized by ICGM. Afterwards, they were characterized and evaluated for their use in the extraction process. Besides screening experiments of extraction by ICGM and Fraunhofer ICT, Fraunhofer ICT has started to plan its equipment for the following extraction experiments at larger scale. Virgin and spent industrial and automobile emission catalysts were characterized extensively by Heraeus and ICIA and supplied by Heraeus to the partners. ICIA has developed and set up the analytical methods which are necessary to analyze the precious metals in this project.