ERA·MIN 2

RESEARCH & INNOVATION PROGRAMME ON RAW MATERIALS
TO FOSTER CIRCULAR ECONOMY

EU co-funded
ERA-MIN Joint Call 2017

Second year project progress reports
Publishable summaries

September 2020

ERA-MIN 2 comprises a progressive, pan-European network of 21 public research funding organisations from 18 countries/regions (Argentina, Belgium-Flanders, Brazil, Chile, Finland, France, Germany, Ireland, Italy, Poland, Portugal, Romania, Slovenia, South Africa, Spain, Spain-Castilla y Léon, Sweden and Turkey).

Built on the experience of the EU project ERA-MIN (2011-2015), **ERA-MIN 2** aims to enhance and strengthen the coordination of research and innovation programmes in the field of non-energy, non-agricultural raw materials (construction, industrial and metallic minerals) to support the European Innovation Partnership on Raw Materials, the EU Raw Materials Initiative and further develop the raw materials sector, in Europe and globally, through funding of transnational research and innovation (R&I) activities.

ERA-MIN 2 will support demand driven research on primary and secondary resources, and substitution of critical raw materials under a circular economy approach, to give the opportunity to the R&I community to apply to world-wide coordinated funding, gaining access to leading knowledge and new markets, while reducing fragmentation of R&I funding across Europe and globally. This will be achieved through one EU co-funded call for R&I proposals in 2017 and two additional calls, in 2018 and in 2019, designed and developed specifically for the non-energy, non-agricultural raw materials sector.

Publishable summary: The report compiles the second year progress reports of 13 of the 16 projects co-funded by the European Commission under the ERA-MIN Joint Call 2017.

Contents

1. Introduction

Raw materials are particularly essential for the development of innovative environmentally friendly technologies and for the manufacture of the new and innovative products used in our modern society, such as batteries for electric cars, photovoltaic systems and devices for wind turbines. Without raw materials, there wouldn't be any roads, houses, computers, smartphones, vehicles or airplanes. Economic sectors such as construction, chemicals, automotive, aerospace, machinery and renewable energy correspond to more than 30 million jobs in the EU depend on the sustainable supply of raw materials. Considering this, ERA-MIN 2 was established as a progressive, pan-European network of research funding organisations that aims to support the European Innovation Partnership on Raw Materials (EIP RM) and further develop the raw materials sector in Europe through funding of transnational research and innovation (R&I) activities. This will be achieved through calls: one co-funded call in 2017, as well as two additional calls in 2018 and in 2019, designed and developed specifically for the non-energy, non-agricultural raw materials sector.

The current public report assesses the second year progress reports of the projects funded under 2017 call. This assessment is considered relevant for the following reasons:

- ✓ Promotion of ERA-MIN 2 results contributes to sharing existing knowledge and experience and developing new frameworks for engagement with social scientists working in the area of public awareness, acceptance and trust;
- ✓ The results will help in defining new priorities and strategies for future calls;
- ✓ A maximal transparency of public money spending is provided.

At ERA-MIN 2 level, the data on the 16 projects were made available through a catalogue of projects with a list of project summaries, a list of projects, and the summaries of first year progress reports at the ERA-MIN 2 website:

- ✓ ERA-MIN Joint Call 2017 - Catalogue of projects[1]
- ✓ 2017 – ERA-MIN Joint Call on Raw Materials for Sustainable Development and the Circular Economy[2]
- ✓ ERA-MIN Joint Call 2017: Publishable Summaries - First Year Project Reports[3]

2. Results

The results presented below are based on the answers to survey and annual reports provided by the project coordinators of 13 out of 16 funded projects.

Two projects BIOMIMIC and Gold_Insight did not provide the second year progress report since they will both end in October 2020, so they will deliver their results of the second year in the final reports after this date.

The Argentinian project coordinator of project Li+Water will provide the mid-term report before the end of 2020.

This report refers to the monitoring of the second year of the R&I transnational projects, an year with COVID-19 pandemia, which affected the implementation of the projects in the middle of this year

[1] https://www.era-min.eu/sites/default/files/docs/2018_09_20_eramin2_brochura_web_0.pdf
[2] https://www.era-min.eu/sites/default/files/docs/era-min_funded_projects_2017_table.pdf
[3] https://www.era-min.eu/sites/default/files/docs/era-min_call_2017_first_year_of_funded_projects_summaries.pdf

2020. Most of the projects were affected by this pandemia, which resulted in extensions requests, but also most of them declare will be on track after this granted extensions.

Still, projects have a good success, considering that:

- besides national and international collaborations also with other initiatives, cooperation with 2 projects funded under ERA-MIN Joint Call 2018 was reported. Moreover, consortia have applied to other 63 calls of which 17 were funded;
- they have developed several new methods, processes and products;
- 4 patents submitted for approval, 1 granted and another in preparation were reported in second year whereas in first year 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; 11 projects (BIOMIMIC, DEASPHOR, Gold_Insight, MaXycle, REWO-SORT, RecEOL, MONAMIX, SUPERMET, LIGHTS, FLOW and MetRecycle) 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.
- they already have a good record of different type of publications (93 in second year and 60 in first year); a total of 18 peer-review papers were reported, 4 books or book-chapters, 6 publications co-authored by R&D and industrial partners, 43 conference proceedings/presentations and a total of 22 other dissemination activities. An important aspect of these results is that a percentage of 41% of them follow the approaches and principles of open science.
- In terms of human resources, 248 researchers were reported to be working on the 13 funded projects with an average of 19 persons per project; 25% are young researchers.
- In terms of gender dimension, 37% of persons involved in projects are women. Projects also reported creation of 9 permanent and 34 temporary jobs.

3. PUBLISHABLE SUMMARIES

As the publishable summaries of the 13 reports show, the projects are highly diverse in terms of geographical coverage, subtopics involved (focus) and objectives/foreseen results.

AMTEG

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 overall progress of the project has developed not completely according to the plan due to SARS-CoV19. Firstly, the close cooperation is still limited, some devices got stuck in transportation since March 2020 in South Africa (expected arrival mid of September), and instrument testing in Sweden and Spain are critical. The progress detail: The specifications of the entire system (WP1) had been discussed and the specifications document has been finished as planned. It is an open document and therefore will be successively further adapted. The next generation of sensor finished and tested (WP2), sensor electronics (WP3), development of data acquisition with GPS and advanced IMU (WP4), optimised flight control (WP6), advanced processing of sensor data (WP7) and demonstrator instrument assessment (WP8) ongoing. In WP2 the milestone of 1st generation sensor had successfully been achieved. The dynamic range and other specs were achieved. Adaptions for fabrication ended in a 2nd generation. Gradiometers can be used w/o internal SQIF amplifier. In WP3 the 2nd version of amplifier with fast reset option developed. Slew rate of more than 3 MΦ0/s were achieved with gradiometers and sampling rate of 1 MSa/s. Need to improve inductive coupling of gradiometers to enhance performance further. Stable operation demonstrated in cryo-probe configuration. Assembly in cryostat is ongoing for testing in real environment to investigate the fast solution with stable parameters. In WP4 the selection of DAS and IMU components had been finalised for the 1st generation subsystems. The development of graphical user interface (GUI) is ongoing. Flight control work had been performed by partner IGI and first results had been presented on the 1st progress meeting in May 2019. The purchased µIMU was intensively tested in interaction with an existing DAS. It turned out that the data obtained with this IMU is of higher quality than with the previously preferred fibre gyroscope IMU. In addition, the first generation of electronics with the IMU was tested in a new bird, which amounts to a considerable reduction of the motion noise or shifts the motion noise into the non-critical frequency range. A specific housing was developed and manufactured for this bird. However, important insights into the behaviour of the electronics have been gained from the laboratory setup and will be incorporated into the production of the current DAS. At present, there is the prospect that the test with sensors and electronics announced for 2020 will take place to the extent planned. WP5 Integration is ongoing. However due to travel limitations, flight testing in Spain and Sweden in Summer 2020 are questionable. We are still in close discussion with partners in Spain for organizing the field tests. In WP7 different approaches and denoising algorithms had been developed and successfully tested on existing data sets. In the frame of MVI tools a first version of cuboid and tetrahedral voxels had been implemented in the tool box. In WP8 the operation principles, parameters and ideas on test site selection had been intensely discussed with all partners. The targets as well as their specifications estimated form the view point of the new instrument under development had been discussed with all partners.

BASH-TREAT

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

After assessing the potential for metal circularity in Europe trough the advanced treatment of bottom ash, two industrial tests have been performed for the maximisation of the recovery of metals from both coarse and fine fractions.
The advanced metal recovery should be however implemented in a vaster view of material recovery, including the correct management of the bottom ash mineral fraction. This mineral stream counts for more than the 90 % w/w of total bottom ash, and currently there are several limitations for its recovery.
However, in this large mineral output there is still the chance to recycle other materials than metals. Expecially glass and ceramic, imporant source of silicates, show to be included in well-defined grain sizes, whose treatment aimed for their recovery would minimize the mass flow to be landfilled (12 – 20 %). The recovery of these fractions seems feasible, since their composition is marginally effected from the incineration process.
Differently, the other melting products existing in bottom ash require further treatments for being included in material circularity schemes. Other minerals and iron oxides present after incineration in fact show a non-negligible content of heavy metals, both in a glassy and stable form, as well as present in form of inclusions on chloride and sulphate salts. The solubility in water of these salts appears to be the main obstacle for the utilisation of this fraction as substitute building material or for utilisation in open environments. Therefore a promising novel dry process for the minimisation of water soluble compounds based on the superficial abrasion of the mineral particles has been estabilished.
The strong minimisation of soluble compounds {-26% for chloride and -44 % for sulphate salts) is strongly correlated to a drastic minimisation of the most relevant heavy metals in bottom ash {like Crtot, Cu, Mo).
For the fine fraction, the investigations follow a different approach. After maximising the removal of metals, furhter recovery requires a wet treatment to enhance the physical differences between metallic compounds and mineral fractions. The use of gravity separation table to concentrate fine metal particles is a promising technology which makes possible the treatment of fine solids, increasing the overall metal recovery.

BIOMIMIC

Project no./acronym	**ERA-MIN-2017_86/BIOMIMIC**
Title	Innovative biotechnological methods for effective mining of secondary material
Duration	01.05.2018-31.10.2020
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/

DEASPHOR

Project no./acronym	**ERA-MIN-2017_40/DEASPHOR**
Title	Design of a product for SUBSTITUTION of phosphate rocks
Duration	01.05.2018-31.03.2021
Coordinator	Faculty of Sciences of Porto University *(Portugal)*
Partner 1	Universidade Federal de Sergipe *(Brazil)* – *left the project*
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	https://www.fc.up.pt/deasphor/

Project DEASPHOR aims to increase the potential of aviary manure ash as secondary source of P in substitution of phosphate rocks. For that purpose beneficiation methods and combustion conditions are tested. The first stage of the project was finished and a diversity of poultry manure and incineration ash was assessed regarding geochemistry and petrography.The laying hens manure ash from fluidized bed combustion (FB ashes) consists mainly of CaO, followed by P2O5, MgO, SiO2, Al2O3 and Fe2O3, alkalis in the form of K2O and Na2O, and traces of Mn, Zn and zinc. The main phases are free calcium oxide (CaO), Ca-silicate (Ca3(SiO4)O), Ca-phosphate (Ca10(PO4)6O) or Ca-phosphate-silicate (Ca15(PO4)2(SiO4)6).The basic design of a laboratory scale bubbling fluidized bed combustion system was completed, manufactured and installed with similar features a full scale system. However, the analysis of the combustion process test results show that independent combustion of chicken manure in a fluidized bed furnace is not possible due to the diverse nature of the raw material, the main product of the process is a fine-grained fraction, but sand-sized mineral fractions remain in the bed. At 850°C, the bed particles partially agglomerate and led to fluidization disorders and problems. At this temperature SO2 and NOx concentrations are below the standard values, while CO, is above acceptable values. At 750°C agglomeration does not occur, but at 650°C the resulting gases contain a large amount of organic compounds.A complete structural, morphological and chemical characterization of the different FB ashes was made, hydrochar and biochar produced from laying hens litter to assess total phosphorus, and the determination of bioavailable phosphorus in samples was performed by Olsen Method. Soluble phosphorus may be recovered from the phosphorus in ash, and P-concentrated in the biochar/hydrochar can be used as a soil additive or as a concentrated phosphorus source.Several laboratory procedures were developed based on metallurgical approaches, alkaline and acid attack, which covered almost all the possibilities for the chemical recovery of P. Preliminary studies show efficient the P-extraction from FB ashes by metallurgical approaches, ash digestion and solvent extraction processes intending to produce high-quality H3PO4 demonstrated an extraction of 77 wt.% of P into the organic phase, independently of the type of alcohol used as extractant. The use of ash residue after beneficiation and chemical extraction of phosphate compounds is an important step of P-recovery from ash manure. The preliminary beneficiation of the residues was made and, and each fraction characterized together with the residues obtained after leaching.

FLOW

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 the 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 secondary raw materials. Two types of slags, the electric arc furnace steel slag (A) and the ladle furnace basic slag (R) were selected as precursors within FLOW project in Slovenia. Firstly, the basic chemical and mineralogical analysis of the precursors and their behaviour in alkali-activation process were studied. Afterwards, the foaming process was introduced with the addition of different amounts and types of foaming and stabilizing agents. Due to very brittle nature of such alkali-activated, highly porous materials, also different types of fibres were added to the final mixtures, which significantly affected/improved the mechanical strength properties. Finally, the microstructural analysis of porous alkali-activation foams was performed by means of SEM, microCT as well as by thermal conductivity measurements of the materials. In Finland, partners have been working on fibre-reinforced cementitious composites from steel slags and mineral wool. They also developed the hot-pressing technique to fabricate fiber reinforced alkali-activated cementitious composites. The developed composite mixtures can attain almost final strength after 2–3 h of pressing at 100–120 °C. In addition, the fiber reinforced composite exhibited high mechanical performance to that of conventional oven-cured AAMs. Therefore, this technique can shorten the moulding time in production, while still attaining high mechanical performance. Understanding of the behaviour of cementitious material and its composites in service life is an important factor that will suggest a proper use of the material. Among different mixtures from steel slags, they selected an ettringite-based binder from ladle slag to investigate its response under physical and combined physical chemical attacks. Additionally, some applications in service for the use of this cementitious binder and its fiber-reinforced composite were suggested. The aging condition was set based on the conditions in northern Europe, and the mechanical performance of the material in such conditions was investigated. The Italian partners checked the chemical resistance of the Alkali Activated Materials – AAMs adopting tests in different media either as prescribed by current regulation (leaching test in water according to EN 12457-4) as well as optimised in their labs by adapting current tests to AAMs. In this last case they have specifically adapted the leaching test in acetic acid, simulating the leaching action of meteoric water and acid rain. They also contributed to the investigation of the durability of AAMs with testing for chemical reactivity the final solid products in HCl. Such test was adopted from the ceramic materials regulation and modified to produce useful results in terms of structural geopolymeric network degradation. Results have been so far communicated to the industrial partners, presented at several conferences, contributed to two PhD thesis, published in 7 SCI papers, and additionally promoted by project movie clip available on YouTube:

- https://www.youtube.com/watch?v=5URKVe9RI2g&fbclid=IwAR1O7msYa5Aplrj5dwSOT1r-
- RfkLW_xofb1oaOLNQavw2n82DFYcPv8Zl1E.
- More information is available at public web page and FB page:
- http://flow.zag.si/

- https://www.facebook.com/Eramin2FLOW/?view_public_for=109848827237708

Gold_Insight

Project no./acronym	**ERA-MIN-2017_179/ Gold_Insight**
Title	Tracing Gold-Copper-Zinc with advanced microanalysis
Duration	01.04.2018-30.10.2020
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

INSTanT

Project no./acronym	**ERA-MIN-2017_105/INSTanT**
Title	INNOVATIVE SENSOR TECHNOLOGY FOR OPTIMIZED MATERIAL RECOVERY FROM BOTTOM ASH TREATMENT
Duration	01.05.2018-30.04.2021
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)*
Partner 4	TESCAN XRE NV (*Belgium*)
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 impuritities 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.
During this reporting period, initial classification models were developed resulting in up to 90% classification test accuracy. However, the detector resolution (1.6 mm) proved to be too low to reveal the small difference in fractions between experimental settings (only 1-2 wt.-%). A new detector with 100 µm resolution was installed, and the classification models are currently being improved accordingly.
Different sensor technologies for the separation of glass from the mineral fraction were tested and their efficiency was compared. In line with market demand, emphasis was placed on obtained a pure (glass-free) mineral fraction.
In the coming period, a second sampling campaign will deliver the data for validation testing and development of a process model.

Li+WATER

Project no./acronym	**ERA-MIN-2017_83/Li+WATER**
Title	Membrane electrolysis for resource-efficient lithium and water recovery from brines
Duration	01.04.2018-31.03.2022
Coordinator	Universidad Nacional de Jujuy *(Argentina)*
Partner 1	Universiteit Gent *(Belgium)*
Partner 2	IVL Swedish Environmental Research Institute *(Sweden)*
Project website	

LIGHTS

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 is moving on toward the delivery of an integrated methodology to more efficiently probe the Li-potential of pegmatites. Drone conception and flights have been successfully performed. Data corrections from drones appeared more demanding than expected but are on their way to being successfully performed. Field validation proves that direct quantification of Li is possible and is now focussing on accompanying elements to improve mineral identification from elemental information. The artificial intelligence frame is now set and waiting to be fed by data to show its full potential.

MaXycle

Project no./acronym	**ERA-MIN-2017_142/MAXycle**
Title	Circular economy, magnet recycling, NdFeB magnets, end-of-life magnets, Eco-labelling
Duration	01.05.2018-31.07.2021
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/

Classifications and coating thickness measurements were performed on different EOL magnets using SEM/EDX analysis and light microscopy. There is a great variety in the type of coatings, depending on the manufacturer. REM/EDX determined the chemical compositions of the magnets. All data were pre-classified, and a suitable database system was selected. Experiments to remove coatings and residues were carried out by various methods.
Hydrogen-based Processing of Magnet Scrap (HPMS) was used for feedstock preparation. Experiments were carried out on various magnets, and the HPMS process was modified to achieve optimized material for different densifying methods.
After sintering, cross-sections of the magnets were examined with a scanning electron microscope and element analysis by EDX. The magnetic measurements were performed by using Permeagraph and Vibrating Sample Magnetometer. The sintered magnets showed values that are close to those of the EOL magnet.
A joint exploitation and communication plan was developed for each project, first elements of the communication strategy with experts, stakeholders, and the general public were implemented.
Additional comments to this reporting:
As already mentioned several times in the report's text, the consortium asked the national authorities for a prolongation of three months. This request was due to the lockdown caused by the Corona -19 crisis. The permissions were given.

METRECYCLE

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://metrecycle.eu/

Acidic leaching of permanent NdFeB magnets was performed using aqua regia. Obtained solution was neutralized using sodium bicarbonate, filtrated and analysed alongside the dried filter cake. EDS analysis confirmed the content of three REE elements, Nd, Ce and Pr and will be used for further development of the recycling strategy. In the second year's period time, the work on the synthesis and characterization of the various advanced adsorbent nanomaterials (ANMs) and ligands continued. Adsorption characteristics of the four important classes of mesoporous adsorbents produced in WP2 were evaluated. Some of the results are published in scientific paper "Synthesis and characterization of novel γ-Fe_2O_3-NH_4OH@SiO_2(APTMS) nanoparticles for dysprosium adsorption" (Journal of hazardous materials, 2019), in the review article "Adsorption of rare earth metals from wastewater by nanomaterials : a review" (Journal of hazardous materials, 2020) and in the chapters "Silica and titania nanoadsorbents for application in molecular recognition technology" (book: Biocompatible hybrid oxide nanoparticles for human health, 2019) and "Molecular recognition approach to REE extraction, separation and recycling" (book: Rare Metal Technology 2020, 2020). The scale-up synthesis was successfully carried out for mesoporous magnetic core-shell ANM – Fe_2O_3@SiO_2. In vivo and in vitro toxicological test were taken to assess the impact of ANMs on the environment and human health. The global inventory for future LCA analysis was built and the LCCA for first scaled-up ANMs calculated. Three project meetings were organized to promote mutual cooperation and results exchange. The project webpage was continuously updated and enhanced with the dropbox hyperlink for eased data exchange amongst the project partners.

MINTECO

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 allow to precise base metal speciation in Romanian samples but Au appeared to be too disseminate to do so. 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 still need further improvements; namely the low Au content is problematic. In parallel, synthesis of adapted fibrous ion exchange minerals were performed taking into account the chemical mechanism of extraction of precious metals. ESOGU and INOE are testing them on their leaching solution. Flowsheets of various hydrometallurgical steps and options have been discussed with MEERI to deliver first environmental and economic assessment of the technologies and help further choices.

MONAMIX

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. Three research organizations (IMNR Romania, ENEA Italy and CNRS-ICMCB France) and an SME (MGM Star Construct srl Romania) work together to show the validity of this innovative approach.
Thermal barrier coatings based on zirconia ceramics doped with mixed rare earth oxides fulfilling the industry demand to increase the lifetime of Ni/Cr alloys and reduce the critical raw materials content

in substrate alloys have been obtained on pilot EB-PVD equipment. Thermal shock tests done show good adhesion at working temperatures up to 1250 0C.
Sintered natural mixed-REOs doped zirconia ceramics for solid oxide fuel cells with enhanced ionic conductivity at temperatures close to 3000C show the high potential for improving the performances of solid electrolytes for batteries and sensors applications.

RecEOL

Project no./acronym	**ERA-MIN-2017_99/RecEOL**
Title	Recycling of End-of-Life Products (PCB, ASR, LCD)
Duration	30.04.2018-29.04.2021
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

In year 1, all deliverables in relation to project management have been produced. Update of the project website (http://receol.ucc.ie) took place in year 2 and included the addition of project promotional material (posters and video). RecEol Coodinator/PI participated in the ERAMIN2 mid-term Seminar in Brussels in November 2019. In WP2 to date, Alumisel (with the Lurederra Technological Centre, Spain) and Coolrec have examined ASR, PCBs, batteries and other shredder fractions to determine the pre-treatment requirements for pilot plant trials. Further analyses will take place on the pilot plant in UCC. Some comprehensive work on the recycling of indium from Indium Tin Oxide (ITO) had been conducted by TU Freiberg and has been shown to be a potential technology. In WP3, UCC and CRL completed a plan for the experimental trials, and a high-level
Integrated Risk Assessment which has been approved. This should enable UCC to initiate experiments on the RecEOL pilot plant. Two scientific papers were submitted, with one rejected (to be resubmitted) and one currently under review. Experimental work associated with WP4 due to the challenges encountered in WP3 which are outlined in detail in this report. UCC-led tasks will progress in the next reporting period. TU Freiberg have continued to progress on ITO experiments as part of WP4 and Coolrec has started putting together data on some of the mechanical treatment techniques.
Delays have been encountered in setting-up the experimental unit in University College Cork which have affected progress across a number of work packages. It is expected that all issues have now been resolved. The Covid-19 pandemic has also caused delays with many partner institutions currently closed. It is expected that all experiments will progress on easing of the Covid-19 restrictions.

REWO-SORT

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

The project has successfully completed the second year. Major milestones have been reached e.g. the completion of work package 2 "Evaluation of the state of the art". First milestones from WP3 ("Sensor data fusion using deep neural networks") are also completed and tasks from WP3, WP4 ("Evaluation of the impact") and WP5 ("Integration of geological features") are in progress. After the dropout of a partners personnel, the work on WP3 has been redistributed within the consortium. Financing of the additional workload is realized as own contribution.

In WP2, both LIBS and MEXRT measurements were performed on copper ore samples (sulphides and oxides) from Chile. Subsequently, that data was analyzed and evaluated using the current analysis methods and compared to the reference analysis by wet chemistry. As expected, accuracy in determination of the copper content is better using LIBS, but it only analyzes a small spot on the surface. However, MEXRT measures the entire volume of the sample, with reduced accuracy. Sensor data fusion performed in WP3 is targeted to increase the accuracy by combination of both techniques. The data structures and procedures for data handling and preparation of training data have been assembled successfully. In WP4, task 4.1 ("Data analysis from tests") and 4.2 ("Maximum separation efficiency estimation") started with results from WP2 and preliminary results from WP3 respectively. WP5 also uses preliminary data from WP3, and task 5.2 ("Extract geological features from sensor fusion data") is still in progress.

Within the consortium, there is good international cooperation. A video conference is held every two weeks to keep all partners up to date. During the project meeting in November 2019 in Santiago de Chile, the European partners had the possibility to get in contact with both academia and industry (small mines, system integrator, technology development and basic research) in Chile. The partners invited to the meeting in Chile would like to thank the involved companies and especially the University of Chile for organizing and enabling this opportunity.

SUPERMET

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 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, virgin and spent industrial and automobile emission catalysts were characterized extensively by Heraeus, ICGM and ICIA and supplied by Heraeus to the partners. Metal-complexing polymers were synthesized by ICGM. Afterwards, they were characterized and evaluated for their use in the extraction process. Screening experiments of extraction by ICGM and Fraunhofer ICT have been started. ICIA has developed and set up the analytical methods which are necessary to analyze the precious metals in this project.

In the second year of the project, the life-cycle assessment of the conventional process has been delivered by IFS (with Inovertis as subcontractor). The preparation and characterization of pre-treated supported catalysts has been performed by Heraeus and samples have been delivered to ICGM, ICT and ICIA. Some polymers have been produced by ICGM and delivered to ICT. Screening extraction experiments have been continued by ICGM and ICT. Parameter optimization has been started by ICT. Heraeus has started to explore methods to isolate the metal from the polymer/metal mixture after extraction. IFS has launched the LCA of the SUPERMET process. IFS has presented a technological survey on supercritical fluids industries. The results of the project have been presented in 7 scientific congresses and 1 international workshop: https://supermetproject.eu/category/scientific-congress/. 6 articles are planned, among which 3 drafts of articles are in progress (1 is almost accepted for publication in https://www.journals.elsevier.com/journal-of-co2-utilization).