European Commission

EU Raw Materials Week

An insight into successful raw materials projects

EU Horizon Technology
Success Stories
Vol. 2

Foreword

Raw materials are at the heart of our economy. They are key inputs for delivering a more resilient, green, and digital recovery, and crucial and for the competitiveness of the European industry. In this framework, Research and Innovation remains a key element of the EU policy on raw materials.

As stated by **Thierry Breton**, Commissioner for the Internal market, during the EU Raw Materials Week 2022: ***"If we want to talk about green transition and technological sovereignty, we need to talk about security of raw materials supply - within and outside of Europe. Let's cooperate to reach this ambitious but critical goal!"***

HaDEA, the European Health and Digital Executive Agency, is proud to contribute to this goal by overseeing and supporting the implementation of Horizon 2020 and Horizon Europe projects in the field of raw materials.

In the previous programming period (2014-2020), the European Commission invested around €600 million in raw materials projects. Over €470 million are being committed under Horizon Europe for the period 2021-2024 for raw materials research and innovation. This covers primary and secondary raw materials, raw materials supply chain and policy support. The first 30 Horizon Europe raw materials projects, worth €260 million funding, have been signed in 2022.

The 'EU Horizon Technology Success Stories' that HaDEA co-organised in the framework of the EU Raw Materials Week was a great opportunity to present a selection of nine projects, funded under Horizon 2020, that are bringing tangible advancement in the area of raw materials.

Several of these projects deal with critical raw materials that are key for ICT and robotic technologies, such as magnesium or silicon (among others). Others focus on critical raw materials that are crucial for permanent magnets (used in electrical motors or wind turbines) and lithium-ion battery technologies: rare earth elements (REEs), lithium or cobalt.

It is my hope that the presentation of these projects' results will inform stakeholders on the paramount importance of new technologies in making the supply of these raw materials as sustainable and efficient as possible – whilst inspiring scientists, companies, academia, and public bodies.

Marina Zanchi
Director of the Health and Digital Executive Agency (HaDEA)

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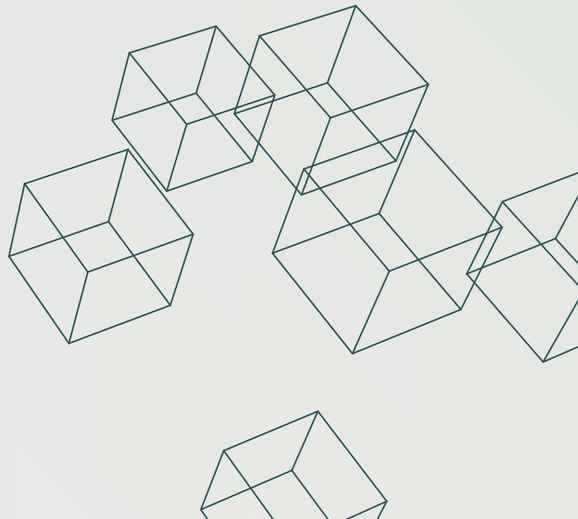
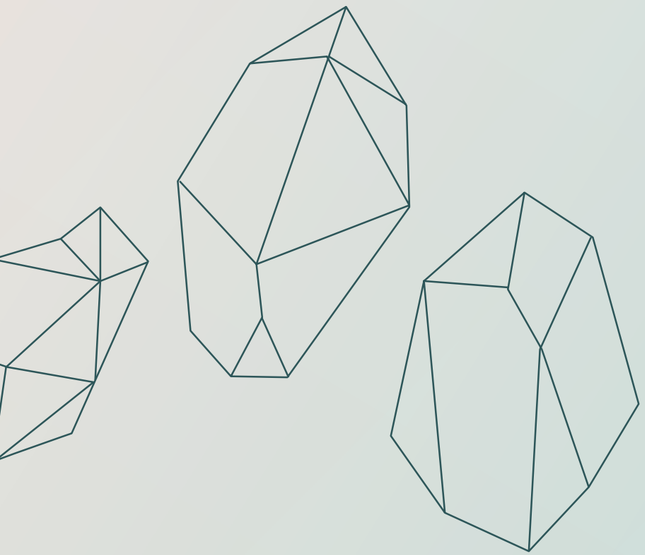


1. Critical raw materials for ICT and robotics



As underlined by the JRC's foresight study on critical raw materials[1], "44 raw materials are relevant to robotics, of which the EU produces only 2%". "Almost the entire periodic system of elements can be found in digital technologies, with a particular high share in consumption of elements like copper, gallium, germanium, gold, indium, platinum group metals (PGMs), rare earth elements (REEs) and tantalum", for which "Europe is largely dependent on other countries".

It is essential for the EU to support new technologies that tackle the sustainable and efficient supply of these raw materials. The following Horizon 2020 projects managed by HaDEA have achieved significant success:

Fine-grained structures in ores often contain valuable metals and minerals. However, dealing with fine particles is extremely challenging for conventional mineral processing technologies. **FineFuture** seeks to develop new technologies to valorise fine particles from mining waste into valuable materials. The project has successfully demonstrated the application of these new technologies, e.g. with magnesium ores. Magnesium is a crucial raw material that is essential for the development of ultralight and high-performance metal alloys. These alloys are particularly useful for small electronic (ICT) applications and robotics.

Even abandoned mines and untapped deposits, which were considered non-viable for extraction, could contain substantial amounts of valuable raw minerals. **ROBOMINERS** proposes an innovative approach to use a robot miner for mineral deposits that are small or difficult to access. It could be used to access ultra-depth deposits with enrichments of the critical raw material vanadium, used in high performance alloys and innovative materials, e.g. for robotics..

Sea4Value designs and implements technologies for recovering minerals and metals from seawater desalination brines. The aim is to make desalination plants the third source of valuable raw materials in the European Union, such as magnesium and scandium.

Silicon is used in several high-tech industries, among which robotics and ICT. **SisAlPilot** demonstrates an innovative silicon production process with low environmental impact, using secondary aluminium and silicon raw materials.

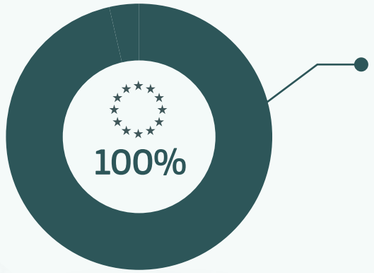
[1] European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020 – https://europa.eu/!9H7X99

FineFuture

Innovative technologies and concepts for fine particle flotation: unlocking future fine-grained deposits and Critical Raw Materials resources for the EU

Research and Innovation Action (RIA)

1 June 2019 – 30 November 2022



EU contribution
€6 195 022

Total budget
€6 195 022

cordis.europa.eu/project/id/821265

finefuture-h2020.eu

Keywords

Fine Particle Flotation
Advancing the understanding of the principles.

Flotation technologies
Knowledge-driven development of these innovative technologies.

Ore valorisation
Successful valorisation of selected classes of ores (e.g. magnesite and copper ores, manganese ores).

Results

Above all, FineFuture has improved the understanding of flotation reagents' effect into mineral surfaces, by means of density functional theory molecular dynamics (DFT-MD) simulations. It has also developed testing and characterisation of new flotation frothers.

With the introduction of new tools, such as four-dimensional particle tracking velocimetry, FineFuture could measure bubble-particle collisions in turbulent flows for the first time. This enabled the development of an improved model to predict bubble-particle collision rates in flotation slurries. New flotation reactors were developed, integrating microbubble generators and sonification. In addition, FineFuture implemented the first environmental life cycle assessment (LCA) on flotation technologies.

Finally, FineFuture successfully valorised mining tailings, in particular, iron and manganese ores, achieving flotation flowsheets for the latter.

Follow-up

The results of the project have the potential to positively impact the minerals processing industry, as the involved industrial partners are interested in using FineFuture's innovative technologies.

Although not all case studies achieved the expected results, they have proven that there is a huge potential for a more efficient recovery of very fine particles.

The consortium is looking for collaboration to further enhance the innovative approaches, in particular in ultra-fine particle flotation technology, and to increase their potential impact.

The project improved the recovery rate of minerals from the flotation cells. Nevertheless, not all principles, such as the bubble generation, are fully understood yet. Further research is needed to better exploit the recovery potential.

Benefit for EU

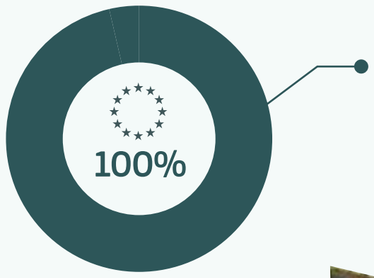
Unlocking the potential of very fine-grained minerals through FineFuture technologies can reduce the EU's dependency on critical raw materials.

ROBOMINERS

Resilient Bio-inspired Modular Robotic Miners

Research and Innovation Action (RIA)

1 June 2019 – 30 November 2023



EU contribution
€ 7 445 900

Total budget
€ 7 445 900

cordis.europa.eu/project/id/820971

robominers.eu

Photo of ROBOMINERS RM3 outdoor testing ©ROBOMINERS

Keywords

Mining technology
Developing novel ideas from other sectors - robotics - and applying them to the mining ecosystem.

Robotics
Construction of a fully functional modular robot miner prototype following a bio-inspired design.

Selective mining
The robot is used for mineral deposits that are small or difficult to access in a flooded underground environment.

Results

ROBOMINERS developed new mineralogical and geophysical sensors for ore detection and in-stream analysis allowing selective mining; for example, in narrow veins or in small but high-grade deposits.

The project created new production tools for small-scale mining enabling low-impact mining with minimal waste.

ROBOMINERS delivered a new robot miner design, touch-based sensors for robot navigation and mapping, as well as self-awareness AI for autonomous robots, allowing them to work underground in unstructured/unknown harsh environments.

Follow-up

This is a research project with a low technology readiness level (TRL 5). Hence, further research is needed to increase the TRL, and eventually bring it closer to the market.

Benefit for EU

The development of ROBOMINERS technologies would open up the possibility to exploit any remaining mining resources, irrespective of the size and geometry of the deposit.

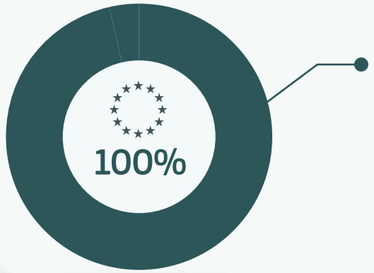
Mines would become virtually invisible, since robots will work at big depths, excavating galleries with a size that fits precisely the mineralised areas of an orebody, minimising the excavation of waste rock, and sending to the surface a high-grade, pre-processed ore. This novel approach addresses many of the environmental concerns that are associated with conventional mining. The project's high-tech vision might also have a transformational effect on the industry, making mining research more attractive to young scientists.

Sea4Value

Development of radical innovations to recover minerals and metals from seawater desalination brines

Research and Innovation Action (RIA)

1 June 2020 - 31 May 2024



EU contribution
€6 995 736

Total budget
€6 995 736

cordis.europa.eu/project/id/869703

sea4value.eu

Keywords

Brine mining
The project focuses on the use of seawater brines as source of critical raw materials.

Novel concentration and selective recovery technologies
Sea4Value draws on a combination of advanced technologies and seeks to design technically and economically viable process for multi-element recovery.

Sustainability
Sea4Value aims to develop environmentally and economically sustainable new technologies.

Results

Sea4Value has published a brine catalogue: the project partners compiled a database containing the composition (major and trace elements) of brine and seawater samples worldwide.

Multi-mineral and modular process: this process will be the first industrially viable brine mining method.

From March 2023 until May 2024, the process will be validated at TRL 5 using a mobile lab installed in two different oceanic settings: Mediterranean (Denia, Spain) and Atlantic (Fonsalia, Canary Islands, Spain).

Follow-up

Stakeholders could use single or multiple Sea4Value technologies depending on brine composition, to be applied not only in seawater brines but also to other high saline streams. The main stakeholders interested in the project are processing industries; desalination plants designers, operators and constructors; raw materials end-users; research community, etc. There is a lot of interest from abroad (Middle East, Oceania) as these regions are much more dependent on desalination and might benefit greatly from Sea4Value's technologies.

Benefit for EU

Sea4Value aims to set the base for converting seawater desalination brines as the third source of critical raw materials and to reduce the dependency on non-EU countries. Using seawater brines as source of raw materials offers several advantages compared to conventional mines: it constitutes a multi-mineral source, it requires low energy for its extraction, and it is widely available, as nearly 20 000 sea water desalination plants are already installed worldwide.

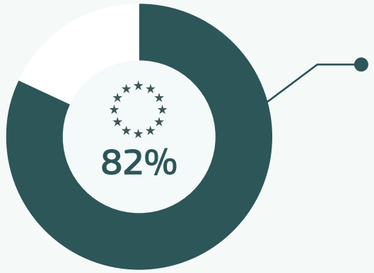
The project contributes to the security of water and material supply, whilst reducing the dependency on raw material imports. Furthermore, due to climate change, water scarcity will increase the demand for desalination plants in southern Europe. The Sea4Value technology could potentially improve desalination efficiency and reduce brine discharge.

SisAl Pilot

Innovative pilot for silicon production with low environmental impact using secondary aluminium and silicon raw materials

Innovation Action (IA)

1 May 2020 – 30 April 2024



EU contribution
€ 11 942 623

Total budget
€ 14 518 629

cordis.europa.eu/project/id/869268

www.sisal-pilot.eu

Keywords

Silicon production
Achieving a CO_2 reduction in the production process of silicon.

Waste valorisation
Utilising aluminum side streams for silicon production.

Industrial symbiosis
Aluminium industry becoming both a supplier and customer for the silicon industry.

Results

SisAl Pilot has demonstrated, with a production in tonne-scale, that silicon can effectively be produced aluminothermically. This is the first large scale demonstration of an alternative production to the conventional carbothermal submerged arc furnace (SAF) based silicon process. This new technology is designed to reduce the CO_2 emissions in the production of silicon.

Follow-up

Spanish partners have expressed interest in commercialising the high-purity silicon production using the SisAl Pilot process.

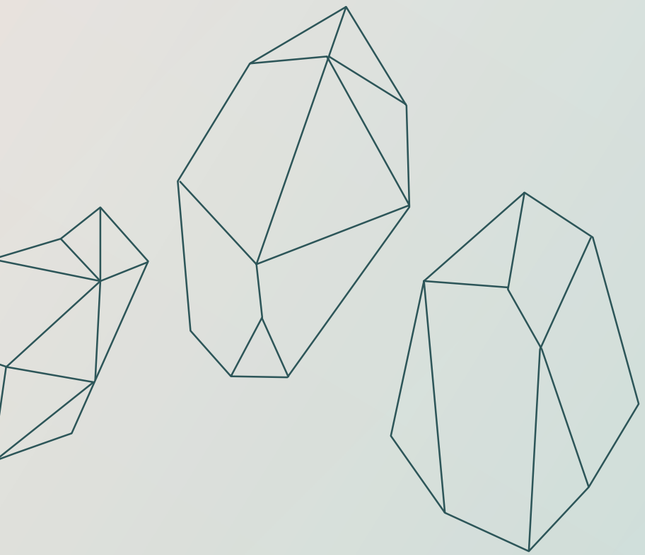
SisAl Pilot is in dialogue with some stakeholders about a continuation of the project, exploring other funding possibilities.

Benefit for EU

SisAl Pilot has the potential to make EU's silicon production more resource efficient, lower in CO_2 emissions and in energy consumption. This technology promises to make the EU self-sufficient in silicon, a critical raw material.

In addition, by demonstrating the advantage of industrial symbiosis between different industrial sectors, the SisAl technology can pave the way for circular production routes.

2. Critical raw materials for batteries and permanent magnets



The JRC's foresight study also underlined "major concerns (...) about the supply of rare earths for the production of permanent magnets – key components for the wind turbine generator" but also for traction motors or digital technologies. Another significant bottleneck for the green and digital transition is linked to lithium-ion batteries, in terms of raw materials supply, and of battery production.

Discover five Horizon 2020 projects that seek to address these challenges:

GOLDENEYE implements a unique combination of remote sensing and positioning technologies, exploiting Earth observation and Earth global navigation satellite systems (GNSS) data. The platform will allow satellites, drones and in-situ sensors to collect high-resolution data of mine sites. This data can be processed and converted into actionable intelligence for safety, environmental monitoring and overall productivity, allowing more efficient exploration, extraction and closure.

SUSMAGPRO develops a recycling supply chain for permanent magnets in Europe, demonstrating the effective reuse of neodymium magnets in different industrial sectors.

SecREEts seeks to establish a stable and secure supply of rare earth elements based on a sustainable extraction from European apatite sources used in fertiliser production.

SEArcularMine develops innovative, sustainable and cost-effective technologies to secure European access to magnesium (Mg), lithium (Li) and other trace elements (Rb, Sr, Cs, Ga, Ge, Co), from waste brines in Mediterranean basin saltworks. The project aims to achieve very low energy consumption, whilst also using novel technology to generate electricity from salinity gradients of seawater.

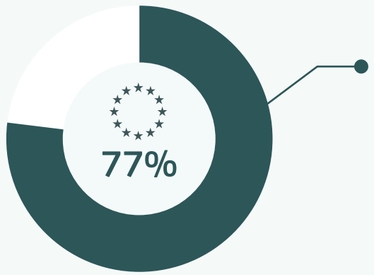
CROCODILE develops a system based on advanced hydrometallurgical and electrochemical technologies to recover cobalt and produce cobalt metal - used in lithium-ion batteries - from a wide variety of secondary and primary European resources.

GOLDENEYE

Earth observation and Earth GNSS data acquisition and processing platform for safe, sustainable and cost-efficient mining operations

Innovation Action (IA)

1 May 2020 – 31 October 2023

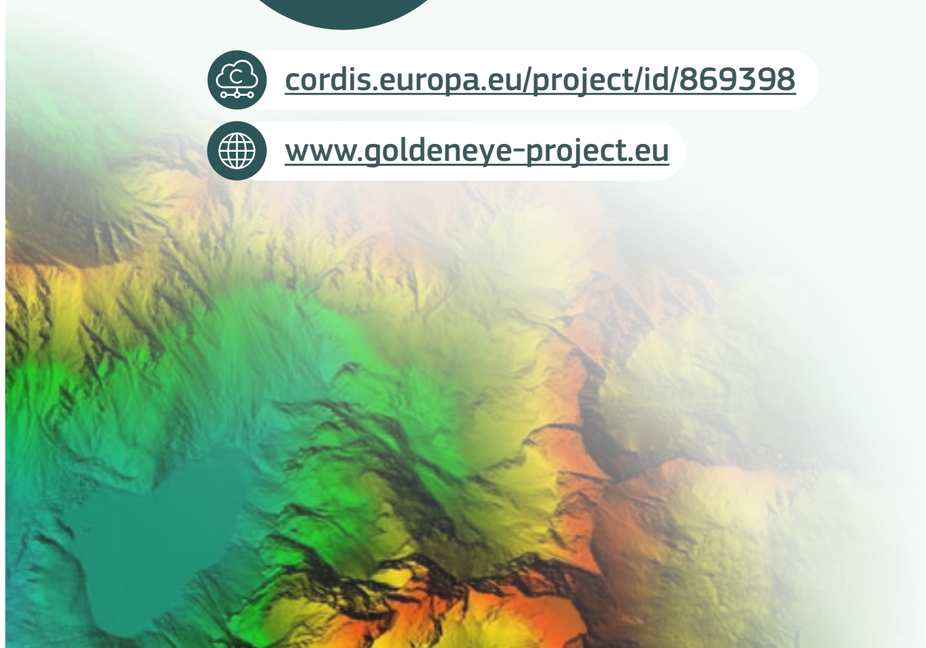


EU contribution
€ 8 360 390

Total budget
€ 10 829 238

cordis.europa.eu/project/id/869398

www.goldeneye-project.eu



Keywords

Exploration
2D and 3D mineralogical mapping of prospective mining areas with novel sensors and data fusion from drones, satellite imagery, and proximal data using artificial intelligence knowledge packs.

Safety of operations and operational efficiency
An underground GPS positioning system for monitoring employee locations, inspection of underground tunnels.

Environmental monitoring
Acid mine drainage and slope stability analysis in existing mining and post-closure areas, based on satellite and drone imagery using artificial intelligence knowledge packs.

Results

Exploration: drone imaging, on-site mineral detection tools (XRF, AHS and Raman) and satellite data has reduced the time needed for exploration targeting to one-fourth.

Extraction: the improved drilling and blasting 3D designs with exact positioning increased the effectiveness of the blasting works, saving money and blasting mixture. Furthermore, monitoring the stability of the old benches, and waste dumps reduces the risks of falling debris.

Underground applications: GPS underground sensing using drone flight was successfully tested for location tracking of people 400 meters below ground level. The results have raised a lot of industrial interest due to the affordability of the system.

Environmental and post-closure: monitoring the stability of tailing dumps, degree of acid mine drainage and potential for secondary extraction of rare earth elements from tailing ponds in post-closure sites.

Follow-up

After successful demonstration of the GOLDEN AI platform, there are solid plans for post-project collaboration to commercialise it and to improve the services. Partner OPT was engaged by Airbus DS in the commercial proof-of-concept contract, where the GOLDEN AI platform is being used in pre-commercial validation. The project is expected to be completed in 2023 with the demonstration of the newly developed service to the target groups of stakeholders, wide groups of Copernicus users in particular. GOLDENEYE will exploit the synergies with ongoing projects in the Group for Earth Observation (GEO) community.

Benefit for EU

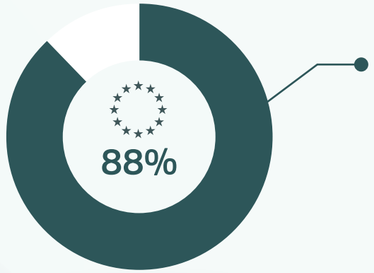
The improved GOLDENEYE environmental monitoring helps to prevent mining-related accidents. In the future, the tools developed in the project might improve the valorisation of tailings areas, helping to mitigate damage from mines. Furthermore, the project is investigating the opportunities of revitalising the mining activities in some areas to support the European raw material supply chain.

SUSMAGPRO

Sustainable Recovery, Reprocessing and Reuse of Rare-Earth Magnets in a Circular Economy

Innovation Action (IA)

1 June 2019 – 30 November 2023



EU contribution
€ 12 977 445

Total budget
€ 14 741 592

cordis.europa.eu/project/id/821114

www.susmagpro.eu

Keywords

Recovery
Recovery of end-of-life (EoL) rare earth magnets from waste electrical and electronic equipment (WEEE).

Recycling
The magnets are recycled using the IP-protected hydrogen-based processing of magnet scrap (HPMS) short cycle processing route.

Reuse
Demonstration of the effective reuse of recycled rare earth materials within several industries.

Results

SUSMAGPRO has created an automated, mobile sensing line to separate neodymium iron boron (NdFeB) magnets from WEEE (HDD, game controllers) through a new sensor array which integrates magnetic scanner and optical sensors at 9 kg NdFeB/hour.

NdFeB powder was extracted from permanent magnets. The first successful magnets were produced with recycled rare earths materials, with no performance differences between new and recycled magnets.

A database with 120 entries was set up with information on end-of-life magnets from different scrap sources, related to composition, form, physical and electronic characteristics.

Follow-up

Patenting of key innovations is under consideration. Two spin-offs have already been created, one by the University of Birmingham (HyProMag Ltd) and one by Pforzheim University (HyProMag GmbH), to recycle NdFeB magnets using the HPMS short-loop technology.

Other projects such as the Horizon Europe project REEsilience, which started in July 2022, are building on SUSMAGPRO innovations, concentrating on the resilience and higher autonomy of European supply chains.

Knowledge from the project is used to contribute to standardisation documents and policy recommendations.

Benefit for EU

SUSMAGPRO increases the availability of critical raw materials for the production of permanent magnets in Europe and initiates the adoption of recycled rare earth elements into a range of magnetic products.

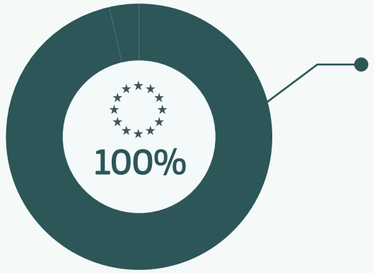
SUSMAGPRO provides an eco-friendly, sustainable source of rare earth elements and permanent magnets in Europe, contributing to a stable supply and reducing dependence on imports for various industries.

SEArcularMINE

Circular processing of seawater brines from saltworks for recovery of valuable raw materials

Research and Innovation Action (RIA)

1 June 2020 – 31 May 2024



EU contribution
€ 5 834 016

Total budget
€ 5 834 016

cordis.europa.eu/project/id/869467

www.searcularmine.eu

Keywords

Circular economy
Aims to reduce the use of primary resources, by recovering energy and critical raw materials from waste brines in saltworks.

Technology
New approaches specifically designed to target elements separation from complex inorganic matrix.

Sustainability
Economic and environmental sustainability regarded as a first driver of innovation.

Results

The project aims to construct the first pilot-plant devoted to the valorisation of the residual solution after sodium chloride extraction in saltworks. The pilot plant will test the viability of ResourSEAs' patented approach.

SEArcularMINE:

- develops three innovative technologies to target the extraction of magnesium (Mg), lithium (Li) and other trace-elements – rubidium (Rb), strontium (Sr), caesium (Cs), gallium (Ga), germanium (Ge), cobalt (Co);
- establishes multiple auxiliary processes to provide full circularity during the production process;
- produces energy from salinity gradient power;
- generates modelling tools for simulation, sizing and evaluation of the processes to ensure optimal use of resources for given framework conditions; and
- characterises and maps the locations of bittern in Europe and the Mediterranean basin.

Follow-up

Magnesium hydroxide will be transformed in metallic magnesium in a follow-up project.

Battery materials should be upgraded to meet market requirements.

Stakeholders from the salt-making industries have been invited to participate in a specific event for market uptake.

Benefit for EU

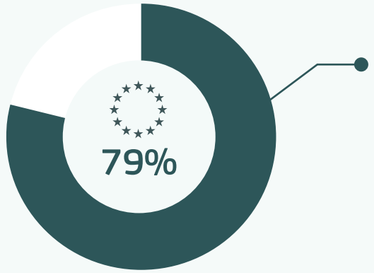
The SEArcularMINE approach is an opportunity for Europe to acquire independence for certain elements - such as Mg, Li, Co, Rb, Cs - that are traditionally extracted from ore mines rarely located within the EU.

CROCODILE

First of a kind commercial compact system for the efficient recovery of cobalt designed with novel integrated leading technologies

Innovation Action (IA)

1 June 2018 – 30 November 2022



EU contribution
€ 11 625 289

Total budget
€ 14 623 772

cordis.europa.eu/project/id/776473

h2020-crocodile.eu

Keywords

Waste Management
Treatment of a wide variety of secondary (batteries, catalysts, scrap) and primary (limonitic laterites) European resources containing cobalt.

Cobalt
Recovery of cobalt critical material and production of cobalt metal.

Novel metallurgy
Showcase innovative metallurgical systems based on advanced pyro-, hydro-, bio-, iono-, and electrometallurgy technologies.

Results

The main result is the demonstration of a first mobile value pilot plant processing black mass from spent batteries into cobalt metal. The process is based on advanced hydrometallurgical and electrochemical technologies.

Follow-up

The CROCODILE consortium plans to use the developed technologies themselves to optimise their existing recycling processes. In addition, the process to produce cobalt metal from black mass may be commercialised. The project partners have already received some requests for this.

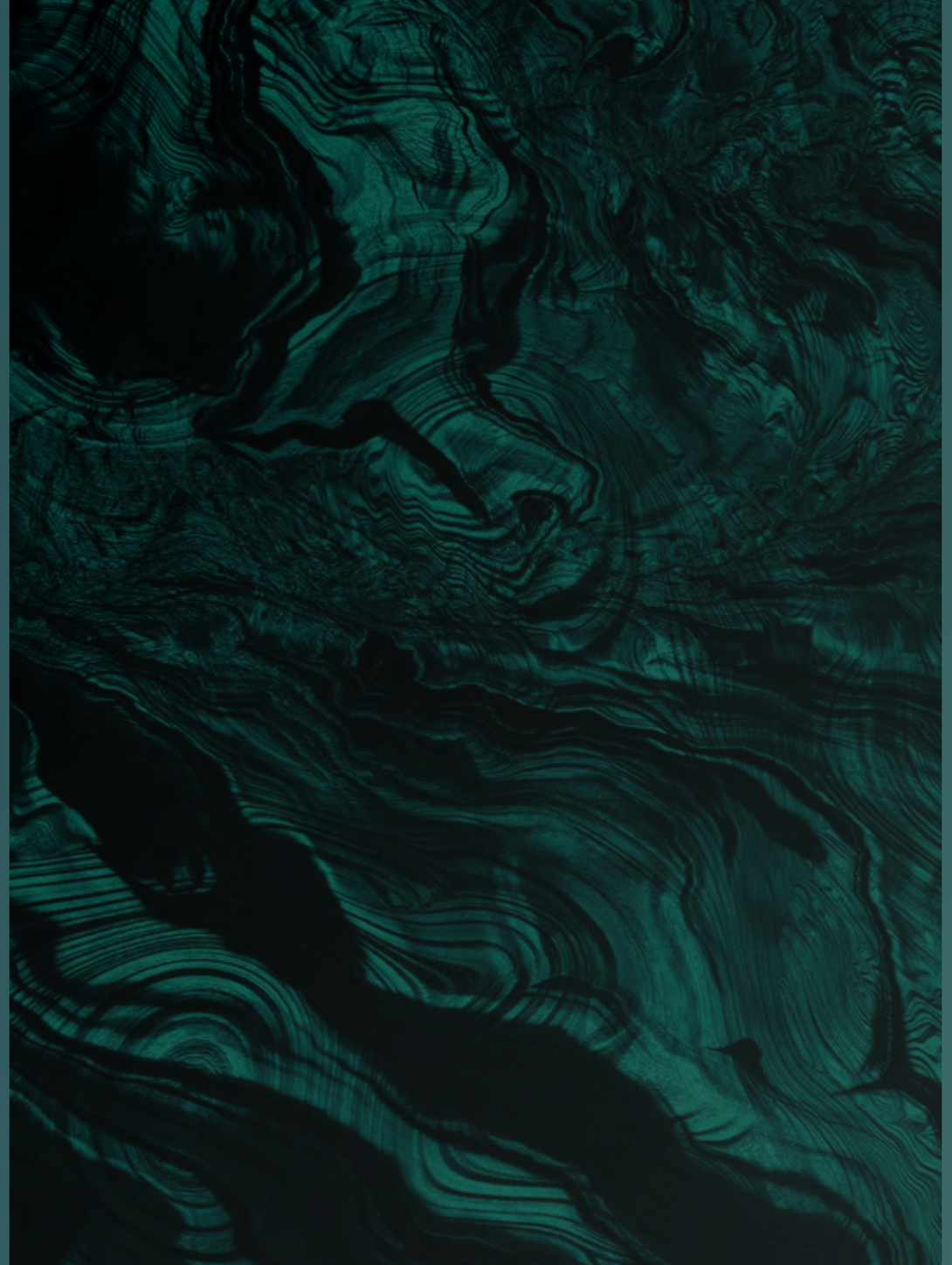
Stakeholders can either license the innovative technologies or order turn-key processing plants. Also, a pay-per-use model for the CROCODILE mobile plant is planned.

There is considerable interest from recycling and collection companies seeking to retrieve lithium-ion batteries from electric vehicles for the purpose of recycling. This involves pre-treatment of end-of-life batteries to obtain and process black mass into valuable metals such as cobalt.

Benefit for EU

CROCODILE:

- provides technologies to recover metals that are scarce and critical for Europe from end-of-life Li-ion batteries;
- makes the economy less dependent on critical metal imports from outside the EU;
- protects the environment by recycling of waste; and
- builds up material processing know-how in Europe.



3. Conclusion

The projects presented in this document and at the ‘EU Horizon Technology Success Stories’ event are only highlights from the rich landscape of innovative Horizon projects in the field of raw materials. Under Horizon 2020 (2014-2020), the European Commission invested around €600 million in 82 raw materials projects, mostly for technological research and innovation.

With over €470 million funding earmarked to raw materials topics under Horizon Europe for the period 2021-2024, the R&I community will continue tackling the challenges along the raw materials value chain. The first Horizon Europe raw materials projects started in 2022 and picked up the relay. Many more are to follow, leading to scientific and technological developments.

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