MSA-based circular hydrometallurgy for sustainable, cost-effective production of NMC cathode materials

D6.1

Report on identified projects for clustering activities

Authors:

Anna Kritikaki, TUC (WP6 leader)

Lefteris Doitsidis, TUC

Kostas Komnitsas, TUC

Date:

25-03-2024

Deliverable Number	D6.1
Deliverable Name	Report on identified projects for clustering activities
Due Date of Deliverable	31/3/2024
Actual Submission Date	26/3/2024
Dissemination Level	PUBLIC
Public Summary enclosed	N/A
Work Package	WP6 Clustering with other EU projects
No of Pages	34 (incl. cover and annexes)
Keywords	Clustering, EU projects, CICERO
In bibliography, this report should be cited as follows:	A. Kritikaki, L. Doitsidis, K. Komnitsas, "Report on clustering with other EU projects", Deliverable 6.1, CICERO project (MSA-based circular hydrometallurgy for sustainable, cost-effective production of NMC cathode materials), 2024, https://cicero-horizon.eu/

EXECUTIVE SUMMARY

On 16 March 2023 the EC published the Critical Raw Materials Act (CRMA) proposal that states "benchmarks for the strategic raw materials value chain and aims to diversify EU sources. The CICERO project focuses on domestically refining three key battery-related Critical Raw Materials (CRMs): Nickel (Ni), Cobalt (Co), and Manganese (Mn), to fulfil the second CRMA criterion of over 40% domestic processing and refining.

To address the dual issues a) Europe's reliance on third countries (DRC, Indonesia, Chile) b) the fact that these metals are currently produced at a huge cost in terms of environment, health and safety CICERO stands for a sustainable, cost-effective refining model for Ni, Co and Mn, and the downstream conversion into "made-in-Europe" NMC cathodes.

CICERO develops a circular hydrometallurgical Ni, Co & Mn processing/refining scheme that uses methanesulphonic acid (MSA) – a commercial, green, REACH-compliant & affordable acid – rather than H_2SO_4. CICERO recovers, refines and converts Ni, Co and Mn from domestically available secondary raw materials: (a) post-mining raw materials (sulphide & laterite tailings) and (b) Ni/Co/Mn-bearing intermediates incl. MSP, FeNi, Ni-matte and Mn-anode sludge. To achieve this, CICERO develops a suite of novel metallurgical unit processes for advanced MSA leaching and solution purification, the conversion to battery-grade MSA salts, and the synthesis of NMC cathodes in MSA media, with sound reagent regeneration & iron recovery in line with the Twelve Principles of Circular Hydrometallurgy.

WP6 "Clustering with other EU projects" aims to cluster CICERO with projects from past (e.g., H2020/HE projects such as ENICON, EXCEED, Battery 2030) and present related calls (e.g., CL5-2023-D2-01, CL4-2023-RESILIENCE-01-03); to contribute to the objectives of Batteries Europe, the European Raw Materials Alliance and the CRMA; and to reach out to partners in Africa, the Mediterranean Region and the US in view of international cooperation and increased impacts.

This deliverable, as the main outgrowth of the activities of Task 6.1, provides an overview of the identified and monitored related European projects suitable for potential clustering activities with CICERO. All the projects described in this deliverable were contacted by the research team of TUC.

Table of Contents

1. Methodology 6
2. CICERO's potential clustering projects list 6
Appendix 11

1. Methodology

The process towards identifying related projects for clustering activities as conducted by the research team of Technical University of Crete (TUC), was a two-step procedure and carried out, involving:

i. Extensive search in EU databases (i.e. CORDIS) and Internet search for projects with scope and objectives related to CICERO.

ii. Extraction of the essential information and compilation of the related tables.

Initially, extensive search was conducted via cordis (https://cordis.europa.eu). All projects that were part of the same call were selected by default, and then a detailed survey was performed for the projects that belonged in the same thematic area. Based on this search, 24 projects selected for further processing. The list of the projects along with the call in which they were submitted, is presented in Section 2.

2. CICERO's potential clustering projects list

The detailed list of all projects identified suitable for clustering are presented in Table 1.

Table 1: CICERO's clustering projects list[1]

ID	Project's Name	Related Call	Type of Project
1	Sustainable Technologies for Reducing Europe's battery raw Materials dependence (STREAMS)	HORIZON-CL5-2023-D2-01-01: Technologies for sustainable, cost-efficient and low carbon footprint downstream processing & production of battery-grade materials (Batt4EU Partnership)	HORIZON RIA
2	Sustainable processing of Europe's low-grade sulphidic and lateritic nickel/cobalt ores and tailings into battery-grade metals (ENICON)	HORIZON-CL5-2021-D2-01-01: Sustainable processing, refining and recycling of raw materials (Batteries Partnership)	HORIZON RIA
3	Lithium recovery and battery-grade materials production from European resources (LICORNE)	HORIZON-CL5-2021-D2-01-01: Sustainable processing, refining and recycling of raw materials (Batteries Partnership)	HORIZON RIA
4	Recycling of Lithium from Secondary Raw Materials and Further (RELIEF)	HORIZON-CL5-2021-D2-01-01: Sustainable processing, refining and recycling of raw materials (Batteries Partnership)	HORIZON RIA

[1] The links provided in Table 1, are the ones to the official description of each project to the CORDIS site

5	Feasible recovery of critical raw materials through a new circular ecosystem for a Li-Ion battery cross-value chain in Europe (FREE4LIB)	HORIZON-CL5-2021-D2-01-06: Sustainable, safe and efficient recycling processes (Batteries Partnership)	HORIZON RIA
6	Integrated innovative pilot system for critical raw materials recovery from mines wastes in a circular economy context (RAWMINA)	CE-SC5-07-2020 CE: Raw materials innovation for the circular economy: sustainable processing, reuse, recycling and recovery schemes	HORIZON IA
7	Flexible, safe & efficient REcycling of Li-on batterieS for a comPetitive, circular, and sustainable European ManufaCTuring industry (RESPECT)	HORIZON-CL5-2021-D2-01-06: Sustainable, safe and efficient recycling processes (Batteries Partnership)	HORIZON RIA
8	Batteries reuse and direct production of high performances cathodic and anodic materials and other raw materials from batteries recycling using low cost and environmentally friendly technologies (RHINOCEROS)	HORIZON-CL5-2021-D2-01-06: - Sustainable, safe and efficient recycling processes (Batteries Partnership)	HORIZON RIA
9	Recycling of end-of-life battery packs for domestic raw material supply chains and enhanced circular economy (BATRAW)	HORIZON-CL4-2021-RESILIENCE-01-04: Developing climate-neutral and circular raw materials (IA)	HORIZON IA
10	REcycling of low Value components using high purity pre-treatment, dIrecT recycling And green hydrometallurgical approaches for recycling of Lithium Ion and Sodium Ion Batteries (REVITALISE)	HORIZON-CL5-2023-D2-01-02: New processes for upcoming recycling feeds (Batt4EU partnership)	HORIZON RIA
11	Cost-effective processing and refining of lithium into lithium hydroxide from strategic European multi-mineral lithium hard-rock projects (LITHOS)	HORIZON-CL4-2023-RESILIENCE-01-03: Technologies for processing and refining of critical raw materials (IA)	HORIZON IA
12	Sustainable European Rare Earth Elements production value chain from primary Ores (SUPREEMO)	HORIZON-CL4-2023-RESILIENCE-01-03: Technologies for processing and refining of critical raw materials (IA)	HORIZON IA

13	Efficient direct recycling for low-value LFP battery for circular and SustainablE waste management (ReUse)	HORIZON-CL5-2023-D2-01-02: New processes for upcoming recycling feeds (Batt4EU partnership)	HORIZON RIA
14	A circular and chemistry-neutral approach for recycling and recovery of battery waste feeds (RENOVATE)	HORIZON-CL5-2023-D2-01-02: New processes for upcoming recycling feeds (Batt4EU partnership)	HORIZON RIA
15	Cost-effective, sustainable and responsible extraction routes for recovering distinct critical metals and industrial minerals as by-products from key European hard-rock lithium projects (EXCEED)	HORIZON-CL4-2022-RESILIENCE-01-07: Innovative solutions for efficient use and enhanced recovery of mineral and metal by-products from processing of raw materials (IA)	HORIZON IA
16	Demonstration of battery metals recovery from primary and secondary resources through a sustainable processing methodology (METALLICO)	HORIZON-CL4-2022-RESILIENCE-01-07: Innovative solutions for efficient use and enhanced recovery of mineral and metal by-products from processing of raw materials (IA)	HORIZON IA
17	CRM-geothermal: Raw materials from geothermal fluids: occurrence, enrichment, extraction (CRM-geothermal)	HORIZON-CL4-2021-RESILIENCE-01-06: Innovation for responsible EU sourcing of primary raw materials, the foundation of the Green Deal (RIA)	HORIZON RIA
18	Material and digital traceability for the certification of critical materials (MaDiTraCe)	HORIZON-CL4-2022-RESILIENCE-01-05: Technological solutions for tracking raw material flows in complex supply chains (RIA)	HORIZON Research and Innovation Actions
19	Advanced sensing, monitoring and self-HEALING mechanisms to self-repair BATteries (HEALING BAT)	HORIZON-CL5-2022-D2-01-06: Embedding smart functionalities into battery cells (embedding sensing and self-healing functionalities to monitor and self-repair battery cells) (Batteries Partnership)	HORIZON RIA
20	Development of operando techniques and multiscale modelling to face the zero-excess solid-state battery challenge (OPERA)	HORIZON-CL5-2022-D2-01-02: Interface and electron monitoring for the engineering of new and emerging battery technologies (Batteries Partnership)	HORIZON RIA

21	Operando analyses and modelling of interface dynamics and CHARGE transport in lithium-ion batteries (OPINCHARGE)	HORIZON-CL5-2022-D2-01-02: Interface and electron monitoring for the engineering of new and emerging battery technologies (Batteries Partnership)	HORIZON RIA
22	Building more reliable and performant batteries by embedding sensors and self-healing functionalities to detect degradation and repair damage via advanced Battery Management System (PHOENIX)	HORIZON-CL5-2022-D2-01-06: Embedding smart functionalities into battery cells (embedding sensing and self-healing functionalities to monitor and self-repair battery cells) (Batteries Partnership)	HORIZON RIA
23	Coordination of large-scale initiative on future battery technologies (Batteries Partnership) (SALAMANDER)	HORIZON-CL5-2022-D2-01-06: Embedding smart functionalities into battery cells (embedding sensing and self-healing functionalities to monitor and self-repair battery cells) (Batteries Partnership)	HORIZON RIA
24	Zero Emission electric Vehicles enabled by haRmonised circulArity (ZEVRA)	HORIZON-CL5-2023-D5-01: Circular economy approaches for zero emission vehicles (2ZERO Partnership)	HORIZON RIA

For each of the projects presented in Table 1, a table has been created which contains the following information: (i) Project's title, (ii) Acronym, (iii) Webpage, (iv) Related Call, (v) Contact's person name and email, (vi) Starting and Ending date, (vii) The project's description. A sample project's presentation is presented in Table 2. It is worth mentioning that Table 1, was compiled according to the relevance of the project to the objectives and goals of CICERO. The project which are more relevant to CICERO are higher to the list.

Table 2: Sample project's presentation table

PX The projects ID	**The project's title**	**Acronym**	**Project's webpage**
Call: **The EU call under which the project is funded**			
Contact person**: The project's contact persons**		Email: The email address of the contact person	
Start Date: **The starting date of the project**		End date: The ending date of the project	
Project Description: **A short description of the scope and project's objectives.**			

The detailed project list is presented in the Appendix. The full list will be available in a searchable format at CICERO's official site. All the projects presented in Table 1, have been identified as potential partners for clustering activities and they were contacted using an invitation email, which clearly stated the scope and goals of the CICERO project. The related email is presented in Figure 1.

Figure 1: Sample invitation for clustering activities

Dear XXXX,

My name is Anna Kritikaki, and I am contacting you on behalf of **CICERO**'s project consortium (https://cicero-horizon.eu), a project which recently started and deals with MSA-based circular hydrometallurgy for sustainable, cost-effective production of NMC cathode materials.

CICERO aims, to tackle the twin problems of (1) Europe's dependence on a few third countries for refined Ni, Co and Mn salts, and as (2) these metals are currently mined, processed at a massive environmental, health & safety cost in DRC, Indonesia, and China, **CICERO** will develop a sustainable and cost-effective processing and refining model for Ni, Co and Mn, and their downstream conversion into "made-in-Europe" NMC materials for Li-ion batteries. CICERO's unique and innovative approach is that it integrates the Twelve Principles of Circular Hydrometallurgy with the smart use of methanesulphonic acid (MSA).

The **CICERO** consortium, consists of 11 Beneficiaries from 8 European countries (Belgium, Finland, Sweden, Norway, France, Germany, Greece, Italy) plus 2 Associated Partners from Finland. The consortium is well balanced in terms of fully committed companies that operate along the entire battery raw materials chain, including the providers of key chemicals, as well as 6 top-level research institutions.

I'm representing Technical University of Crete (TUC), which is the leader of Work Package 6 "Clustering with other EU projects" that aims to increase **CICERO**'s impact by interacting and joining efforts with other leading initiatives at European level.

If you are interested in getting informed about our activities, participate in upcoming events and potentially participate in joint clustering initiatives, please let us know.

In case that you may have questions, or you need additional clarifications, please don't hesitate to contact us.

Looking forward to hearing from you at your earliest convenience

Best regards,

Dr. Anna Kritikaki

Appendix

P1	Sustainable Technologies for Reducing Europe's battery raw Materials dependance	STREAMS	N/A
Call: HORIZON-CL5-2023-D2-01- Technologies for sustainable, cost-efficient and low carbon footprint downstream processing & production of battery-grade materials (Batt4EU Partnership)			
Contact person: N/A		**Email:** via cordis	
Start Date: 1/1/2024		**End date:** 31/12/2026	
Project Description: In STREAMS, a comprehensive portfolio of at least 12 scalable and flexible technologies and pilot scale solutions for the sustainable production of battery-grade precursors and their respective anode and cathode active materials will be developed, evaluated and successfully demonstrated. These technological processes will be applied to materials from primary and secondary sources including recycled battery mass and photovoltaic waste. This will strengthen Europe's domestic battery materials supply chain and reduce Europe's dependency on imported critical and strategic raw materials supplies. The production technologies will also increase Europe's resilience, competitiveness and strategic autonomy in the global battery manufacturing industry. STREAMS' technological solutions will meet EU requirements for environmentally responsible design, and scale up, and anticipate regulatory compliance by conducting techno-economic, environmental, social impact and integrated risks assessments combined with life cycle sustainability and circularity assessments. The cathode and anode active materials synthesized in STREAMS will be used to manufacture 10 Ah battery cells at pilot scale using sustainable electrode processing. Prototype cells will be tested according to established standards and subjected to advanced post-mortem characterization. STREAM will also identify optimal conditions for future exploitation of the project results.			

P2	**Sustainable processing of Europe's low-grade sulphidic and lateritic nickel/cobalt ores and tailings into battery-grade metals**	**ENICON**	**webpage**
Call: HORIZON-CL5-2021-D2-01-01 - Sustainable processing, refining and recycling of raw materials (Batteries Partnership)			
Contact person: Prof. Koen Binnemans KUL		**Contact person**: https://www.linkedin.com/in/koen-binnemans/	
Start Date: 1/6/2022		**Start Date:** 31/5/2026	

Project Description: Electric vehicles are expected to dramatically increase the demand for nickel (Ni) and cobalt (Co) over the next two decades. Europe is expected to face difficulties in securing a reliable, affordable and sustainable supply chain as the concentration of such minerals in the continent is scarce. The EU-funded ENICON project aims to improve the refining capacity of domestic and imported low-grade Ni/Co. ENICON's metal recovery route using hydrochloric acid dispenses with the old-school hydro-based approach that involves continuously precipitating and redissolving metals. Thus, it reduces the amount of chemicals needed for metal dissolution, which result in the production of potentially harmful waste streams. The cobalt (Co) and nickel (Ni) demand is expected to be about 20 times higher in 2040 than in 2020. Given that Europe plays only a minor role in the global Ni/Co supply chains, which are concentrated in the DRC, Indonesia and China, we face a serious problem in securing a reliable, affordable and sustainable supply of battery-grade Ni/Co, vital for Europe's aims to be climate-neutral by 2050. In view of a "domestic and foreign sourcing" procurement model, ENICON exploits the potential of (low-grade) Ni/Co resources within Europe – i.e. sulphidic Ni/Co ores and derived Ni/Co-bearing pyrite and silicate tailings, and limonitic/saprolitic laterite Ni(/Co) ores – while improving and developing the Ni/Co-refining capacity that can process imported ores, concentrates and intermediates. ENICON comprises both major improvements to existing Ni/Co metallurgical unit operations in Europe as well as the development of a new HCl-based route for both Ni/Co sulphide concentrates and laterites. ENICON's HCl-route dispenses with the old-school hydro-approach of continuously precipitating and redissolving metals that requires lots of chemicals and creates problematic waste streams. The HCl-based route can be extended to the downstream processing of FeNi (Class-II Ni) obtained from laterites; (2) Mixed (Ni/Co) Sulphide/Hydroxide Precipitate (MSP/MHP) from the bioleaching of Co-rich pyrite tailings; and Ni/Co-containing silicate tailings. ENICON targets a "forensic geometallurgy" protocol, making it possible to identify and mitigate the mineralogical and textural reasons for processing losses along existing and new flowsheets. To make the transition to (near) zero-waste processing and to further reduce CO2-footprints, ENICON develops enhanced mineral-matrix valorisation processes. The outputs from ENICON's group of European Ni/Co mining, processing and refining companies will all be benchmarked in terms of positive environmental and techno-economic impacts against current methods.

P3	Lithium recovery and battery-grade materials production from European resources	LICORNE	webpage
Call: HORIZON-CL5-2021-D2-01-01 - Sustainable processing, refining and recycling of raw materials (Batteries Partnership)			
Contact person: Lourdes Yurramendi Sarasola		**Contact person**: lourdes.yurramendi@tecnalia.com	
Start Date: 1/10/2022		**Start Date:** 30/9/2026	

Project Description: Europe imports more than half of the necessary battery materials, such as lithium (Li), nickel (Ni), cobalt (Co) and magnesium (Mg). Domestic production is important. In this context, the EU-funded LiCORNE project will establish the first-ever Li supply chain in Europe. It aims to increase European Li processing and refining capacity for producing battery-grade chemicals from ores, brines, tailings and off specification battery cathode materials. This supply chain encompasses five large primary resource owners having resources of lithium carbonate equivalent (LCE), of which 2.7 million tonnes are located in Europe. The value chain includes a cathode manufacturer able to reuse valuable Li, Co and Ni that will be recycled from waste cathode material. LiCORNE will investigate different ground-breaking technologies in Li processing and recovery. LiCORNE aims to establish the first-ever Li supply chain in Europe. The goal is to increase the European Li processing and refining capacity for producing battery-grade chemicals from ores, brines, tailings and off-specification battery cathode materials. This supply chain encompasses five large primary resource owners (including one of the world leader in Li production) having resources of ~7.8 Mt lithium carbonate equivalent (LCE), of which 2.7 Mt are located in Europe. The European primary resources that are considered in LiCORNE would be enough to supply ~3000 GWh of batteries (i.e., ~10 years to the expected 300 GWh/year production capacity in Europe by 2030). Additionally, the value chain includes a cathode manufacturer who will be able to reuse valuable Li, Co and Ni that will be recycled from waste cathode material, and one producer and distributor of battery-grade Li-chemicals. LiCORNE will investigate 14 different ground-breaking technologies that have been selected for their potential to operate at low CAPEX and OPEX, low carbon footprint, flexibility and industrial scalability. These technologies are led by 8 top R&D centers in Europe to tackle the main bottlenecks in Li processing and recovery. During 2.5 years, R&D partners will investigate those technologies and bring their TRL from 2 to 4. After this phase, and guided by LCA and LCCA, the most promising technologies will be selected for upscaling to TRL5. During this phase a prototype system will be constructed and demonstrated to produce ~1 kg of battery-grade Li-chemicals (i.e., LiOH·H2O, Li2CO3 or Li-metal) from ores, brines, tailings and waste cathode material, with the recycling of Co and Ni from the latter. Results will be communicated and disseminated to a wide range of stakeholders and a first business model for a full and optimized Li supply chain in Europe will be established based on the results of the project and cost of Li produced.

P4	Recycling of Lithium from Secondary Raw Materials and Further	RELIEF	webpage
Call: HORIZON-CL5-2021-D2-01-01 - Sustainable processing, refining and recycling of raw materials (Batteries Partnership)			
Contact person: Gabriel Hidalgo		**Contact person**: Gabriel.hidalgo@abeegroup.com	
Start Date: 1/7/2022		**Start Date:** 30/6/2025	
Project Description: Current recycling technology is focused on recovering Li from battery scrap, while hardly much focus and technological development is going towards other Li sources. Hence the aim is to recover Li from potential secondary sources, in order to reduce unrecovered Li from its waste generation, which is estimated to be approx. 27.33% of the current global Li production. RELiEF proposes an integrated recycling facility for Li from secondary raw material sources with continuous processing to produce battery materials. Li wastes will be reduced by more than 70%, which will instead be recycled into high value battery-grade material. The results of the integrated and continuous process up to battery precursor recovery will be demonstrated at TRL 5 and battery active material closed-loop process will be demonstrated at TRL4 with a 1.5 – 2.5 kg/week output of battery active materials and a new business model will be developed for the materials acquisition and processing, taking into account environmental and social sustainability. The expected results will contribute to decreasing the dependency of the EU on imported battery chemicals and raw materials. RELiEF will greatly strengthen the EU's competitiveness in the battery storage value chain. The RELiEF consortium consists of 12 partners, six of which are SMEs (ABEE, EXT, EURICE, IST, PEG, TC), four are non-profit RTOs (IMNR, INEGI, ZSW, NOVA) and further two are universities (LUT, ULB) and one associated industrial partner (LANX). Thus, it has strong industry involvement, entirely in the form of innovative SMEs covering the technological and also the impact maximization related aspects of the project; a perfect combination of basic research methodologies, chemical process and analysis capabilities, technology development in an industrial environment and strong ties to the recycling and battery industry and policymaking entities inside the EU.			

P5	**Feasible recovery of critical raw materials through a new circular ecosystem for a Li-Ion battery cross-value chain in Europe**	**FREE4LIB**	**webpage**
Call: HORIZON-CL5-2021-D2-01-06 - Sustainable, safe and efficient recycling processes (Batteries Partnership)			
Contact person: Juan Castro		**Contact person**: juacas@cartif.es	
Start Date: 1/9/2022		**Start Date:** 31/8/2026	

Project Description: The transport sector is responsible for around one quarter of Europe's greenhouse gas emissions. Electric vehicles can contribute significantly to the decarbonisation of future road transport. But lithium-ion batteries (LIBs) remain an obstacle: they are not green enough to sufficiently reduce mobility footprints. Recycling is the answer. However, the recovery of lithium is a complicated process that the EU-funded FREE4LIB project aims to simplify. It will develop technologies to achieve six new sustainable and efficient processes to recycle end-of-life LIBs. The project will also deliver three processes aimed at reuse of metals and polymers and electrode synthesis for remanufacturing new LIB battery packs based on the design for recycling. The use of Battery Passports will overcome the current lack of access to open data in the LIB value chain. The negative environmental impacts results from the linear 'take, make, dispose' and dominant economic models of our time, traditionally adopted by decision-making of main stakeholders around mobility are changing thank to EV's irruption, but Lithium-Ion Batteries (LIBs) are not yet green enough to reduce mobility footprint to lowest levels. Thus, recycling has to be developed to achieve higher efficiencies and recovery rates to reintroduce Critical Raw Materials from End-of-Life (EOL) LIBs. Recycling technology is still at the lab-scale due to the complex structure of EOL LIBs. Currently, pyro-metallurgy is the most applied method in the industry. Although this process does not need pre-treatment, its energy-wasting, the equipment investment is large and it will cause serious pollution. In response to these problems, many companies have developed hydrometallurgical processes, that can recover Li and Al with low energy consumption. However, it requires pre-treatment, leaching, purification and other steps, and it could be a long way.

FREE4LIB aims to develop at TRL 5-6 technologies to achieve 6 new sustainable and efficient processes to recycle EOL LIBs (dismantling, pre-treatment and 4 materials recovery processes) delivering innovative recycling solutions to reach highly efficient materials recovery (metal oxides, metals and polymers) improving the supply of secondary resources at EU level. FREE4LIB also will deliver 3 processes aiming at metals and polymers re-using and electrode synthesis for re-manufacturing new LIBs, and it will study options to harness non-reusable elements. It will also deliver a Battery Passport (BP) methodology to improve processes traceability. Besides, 2 Open Platforms will be deployed: BP and Data-driven models for the process's optimisation. Finally, to validate and spread FREE4LIB: new LIBs will be assembled on battery packs and engagement activities with citizens, policymakers and battery stakeholder will be carried out, respectively.

P6	**Integrated innovative pilot system for critical raw materials recovery from mines wastes in a circular economy context**	**RAWMINA**	**webpage**
Call: CE-SC5-07-2020 CE, Raw materials innovation for the circular economy: sustainable processing, reuse, recycling and recovery schemes			
Contact person: Juan Castro		**Contact person**: juacas@cartif.es	
Start Date: 1/9/2022		**Start Date:** 31/8/2026	
Project Description: Used to produce a wide range of goods and applications, an unreliable supply of critical raw materials is a growing concern. Currently, the EU relies on the import of raw materials like Antimony, Cobalt and Germanium. In this context, the EU-funded RAWMINA project will develop an innovative pilot system for the clean and sustainable production of non-energy, non-agricultural raw materials in the EU from mine waste resources. Specifically, it will standardise an innovative energy, water- and cost-effective continuous pilot process for producing raw materials. It will also contribute to reducing production costs and environmental impacts. RAWMINA will develop and demonstrate an innovative pilot system for the clean and sustainable production of non-energy, non-agricultural raw materials (RMs) in the EU from Mine Waste (MW) resources. RAWMINA will implement and standardize an innovative energy, water- and cost-effective continuous pilot process for producing RMs. It will integrate novel bio-leaching and nano-based materials for Sb, Co, Ge and W selective recovery from MW from “unexploited/underexploited metal containing materials”. RAWMINA will improve EU competitiveness and create added value in RMs processing, refining and equipment manufacturing by developing a new circular business model as an alternative to traditional linear mining economy. RAWMINA will integrate different technologies that will be demonstrated (TRL7) with MW of diverse geological compositions from EU and non-EU mines demonstrating flexibility in processing of the innovative pilot system. The project will perform a techno-economic and sustainability assessment throughout the entire life cycle considering health, safety, socio-economic and environmental impacts; maximizing water/energy efficiency and waste/wastewater reduction. IP, exploitation and business plans will be developed ensuring market penetration, technology export and first exploitation plan. RAWMINA will transform MW into a resource, enabling marketable products recovery to be used in batteries, flame retardants, optical fibers and industrial tools. The project will create a CRM Recovery Helix to maximise clustering and will interact with local communities to gain EU citizens trust. It will increase resource efficiency and sustainability of EU industry, contributing to decrease EU CRM import dependency. Apart from sheltering the EU from possible shortages in CRM supply, the project will contribute to reduce production costs and environmental impacts, contributing to the objectives of the European Innovation Partnership on RMs.			

P7	**Flexible, safe & efficient REcycling of Li-on batterieS for a comPetitive, circular, and sustainable European ManufaCTuring industry.**	**RESPECT**	**webpage**
Call: HORIZON-CL5-2021-D2-01-06, Sustainable, safe and efficient recycling processes (Batteries Partnership)			
Contact person: Justo Garcia		**Contact person**: justo.garcia@orano.group	
Start Date: 1/7/2022		**Start Date:** 30/6/2026	
Project Description: In the context of increasing global battery use, developing sustainable, safe and efficient processes is a tangible issue to further enhance circular economy and strategic autonomy of the European Li-ion batteries value chain, in line with the battery partnership's objectives launched under Horizon Europe. RESPECT main objective is to develop a global process encompassing a process-chain flexible enough to treat all kind of batteries in closed loop, considering the variability of Li-ion batteries chemistries (NMC, LFP, NCA, LMO) , applications (EV and ESS) and states (aged, damaged, EoL, production scraps) up to date not covered by any process on the State of the Art. RESPECT addresses two recycling routes: full hydrometallurgy and direct recycling and an improved Life Cycle Assessment of each recycling segment to lower emissions and reduce secondary pollution, safety and health risks. RESPECT will aim to design and validate the recycling processes up to pilot scale to recovering the highest amount of resources, including CRMs and active materials present in the batteries to closing the loop by their reuse in cathode and anode materials for new batteries. Socio-economic, as well as sustainability aspects will be covered throughout the project. To ensure a successful project implementation, knowledge sharing on Li-ion battery green recycling processes will be fostered, based on the engagement with relevant international stakeholders and experts through the advisory board. Based on a solid and interdisciplinary consortium of partners covering the whole value chain, RESPECT seeks high recovery rates (for Li, Mn, Co, Ni or graphite) with low environmental impact and strong energy savings, in accordance with the European Green Deal and the proposed Battery Regulation. With the right conditions, batteries will play a crucial role in climate change mitigation. Lithium-ion (Li ion) batteries – capable of storing wind, solar and electric energy forms – are vital to accelerating the decarbonisation of transport and integrating renewable energies into electricity grids. In this context, the EU-funded RESPECT project will develop a global process encompassing a process-chain flexible enough to treat all kinds of batteries in closed loop. Specifically, it will address two recycling routes: full hydrometallurgy and direct recycling and an improved life cycle assessment of each recycling segment. RESPECT will also ensure knowledge sharing on Li-ion battery green recycling processes through engagement with international stakeholders and experts.			

P8	**Batteries reuse and direct production of high performances cathodic and anodic materials and other raw materials from batteries recycling using low cost and environmentally friendly technologies**	**RHINOCEROS**	**webpage**
Call: HORIZON-CL5-2021-D2-01-06 - Sustainable, safe and efficient recycling processes (Batteries Partnership)			
Contact person: Álvaro Manjón Fernández, TECNALIA		**Contact person**: http://alvaro.manjon@tecnalia.com	
Start Date: 1/9/2022		**Start Date:** 31/8/2026	
Project Description: When the battery of an electric car comes to the end of its life, it is not inactive but has a capacity of at least 75 %. Therefore, it can be repurposed for up to a decade in applications such as stationary energy storage. The EU-funded RHINOCEROS project will seek economical and environmentally friendly routes for reusing, repurposing, reconditioning and recycling end-of-life batteries. Researchers plan to develop a smart system enabling the automated classification of battery materials and the reassembly of working modules in new repurposed batteries. Furthermore, they will investigate ways to cheaply produce high-performance materials for the anode and cathode from the recycled materials. Project achievements will help prevent Europe's technological dependence on other parts of the world. Rhinoceros will develop, improve and demonstrate, in an industrially relevant environment, an economically and environmentally viable route for re-using, re-purposing, re-conditioning and recycling of EoL EV and stationary batteries. Rhinoceros will first develop a smart sorting and dismantling system enabling the automated classification and dismantling of LIBs and the reassembly of still working modules in new repurposed batteries for second life applications such as batteries for energy storage systems. When direct reuse and repurpose of batteries is not possible, a circular recycling route of all the materials present in LIBs (e.g. metals, graphite, fluorinated compounds and polymers, active materials) will be followed to close the materials loop. This route is based on a set of cost efficient, flexible and environmentally friendly routes targeting the pre-treatment, refining and the recovery of materials. Through product qualification by industrial end-users, Rhinoceros will demonstrate the direct production of high performances cathodic and anodic materials and other raw materials at competitive costs from battery recycling. The achievements will bring Europe to an increased independence level from foreigner manufacturers and raw materials suppliers.			

P9	**Recycling of end of life battery packs for domestic raw material supply chains and enhanced circular economy**	BATRAW	**webpage**
Call: HORIZON-CL4-2021-RESILIENCE-01-04 - Developing climate-neutral and circular raw materials (IA)			
Contact person: Technological Centre LEITAT		**Contact person**: https://www.leitat.org/	
Start Date: 1/5/2022		**Start Date:** 30/4/2026	
Project Description: BATRAW main objective is to develop and demonstrate two innovative pilot systems for sustainable recycling and end of life management of EV batteries, domestic batteries, and battery scraps contributing to the generation of secondary streams of strategically important CRMs and battery RMs. The first pilot will deliver innovative technologies and processes for dismantling of battery packs achieving recovery of 95% of battery pack components and separating waste streams including cells and modules by semi-automated processes for recycling. BATRAW's second pilot will scale and demonstrate efficient pre-treatment and continuous hydrometallurgical recycling of battery cells and modules including innovative steps for C-graphite, Al and Cu separation from black mass and Mn extraction, achieving a recovery of the full range of battery RMs (Co, Ni, Mn, Li, C-graphite, Al and Cu) at selectivity of 90-98%. Innovations will be scaled and demonstrated in a pilot systems with recycling capacity of 1 ton lithium-ion battery (LIB) packs dismantled per shift (8 hours) and treat 300 kg BM per day. BATRAW outcomes are of strategic importance within the prospects of the exponentially growing EU battery market and reducing EU import dependency of CRMs. The project will further promote the overall sustainability and circularity of battery products and raw materials by developing new procedures for battery repair and reuse, enabling faster diagnostics and conversion of EV packs into second life batteries, delivering eco-design guidelines for battery manufacturing, demonstrating blockchain platform for raw material tracking and supply chain transparency (Battery Passport) and delivering guidelines for safe transports and handling of battery waste. The project aims to maximize market uptake and impact through ambitious C&D&E plan including circular business models, innovations workshops, dissemination in EU platforms, policy briefs and other strategies to reach markets and stakeholders.			

P10	**REcycling of low Value components using high purity pre-treatment, dIrecT recycling And green hydrometallurgical approaches for recycling of Lithium Ion and Sodium Ion Batteries**	**REVITALISE**	**N/A**
Call: HORIZON-CL5-2023-D2-01-02 - New processes for upcoming recycling feeds (Batt4EU partnership)			
Contact person: Norges Teknisk-Naturvitenskapelige Universitet NTNU		**Email:** Via cordis	
Start Date: 1/11/2023		**End date:** 31/10/2026	

Project Description: REVITALISE delivers a holistic solution for green, low-cost, and low environmental impact recycling of NMC (Hi-Ni), LFP and Na-Ion batteries, representing 85% of battery waste streams up to 2025. REVITALISE develops low-cost and green processes to recover a full range of battery materials, including NMC, LFP, Al, Cu, Li, graphite, fluorides, phosphates and plastics.

Overall recycling rates of 91%+ will be proven at TRL4 for waste processed from post-production scrap and end-of-life battery black mass. REVITALISE will develop innovative pre-treatment technologies based on electrohydraulic fragmentation, ultrasonication and magnetic, and electrostatic separation that will achieve very high levels of material stream purity. This will enable commercially viable recycling of low-value parts. The approach will enable direct recycling of 40% of the cathode and anode active parts, with direct characterisation of the lithiation (or sodiation) being developed that will be used as a basis of a smart-reformation approach for reclaimed active materials. The remaining 60% being suitable for hydrometallurgical recycling based on leaching with green organic acids from food waste, such as vitamin C (ascorbates), vinegar (acetate) and citric acid (citrates) and inorganic acids produced from industrial wastes.

A further innovation is the development of water remediation with Li recovery from all wastewater streams generated, through the implementation of polymeric nanocomposite membrane separation with direct Li recycling for Li in water concentrations down to 0.6mg/L.

The recycled parts will be assessed for (closed-loop) battery and other secondary applications for precursors and semi-products by industrial partners Verkor and Hydro, through reformulation and upcycling of battery materials and validation of remanufactured batteries.

P11	**Cost-effective processing and refining of lithium into lithium hydroxide from strategic European multi-mineral lithium hard-rock projects**	**LITHOS**	**webpage**
Call: HORIZON-CL4-2023-RESILIENCE-01-03 - Technologies for processing and refining of critical raw materials (IA)			
Contact person: Dr. Paivi Kinnunen (VTT)		**Email:** Paivi kinnunen	
Start Date: 1/1/2024		**End date:** 30/6/2027	

Project Description: In 16 March 2023 the EC published the Critical Raw Materials Act (CRMA) setting "benchmarks along the strategic raw materials value chain and for the diversification of EU supplies". By targeting the domestic processing and refining of lithium – arguably "the most strategic CRM"– LITHOS directly contributes to the 1st and 2nd CRMA benchmarks (10% domestic extraction; 40% domestic processing). LITHOS processes and refines the ores from three "Strategic Projects" in terms of domestic battery-grade LiOH·H2O production: two spodumene-bearing pegmatite cases (Keliber's deposits in the Kaustinen region, Finland; Savannah's Barroso Lithium Project, Portugal) and one Rare-Metal Granite (RMG) case (Imerys' Beauvoir mine in France). LITHOS expands and tailors the existing Keliber & M:O flowsheet, which was developed for regular-grade spodumene ores, so that (1) the cut-off grade for spodumene ores is reduced, resulting in larger Li reserves, while (2) allowing the commercialisation of lower-grade pegmatite and RMG deposits. LITHOS triggers innovations along the value chain – mineral processing, concentrate pre-treatment & hydrometallurgical refining – making it possible to deal with different levels and types of impurities in non-spodumene Li minerals (lepidolite & petalite). LITHOS gives specific attention to closed-loop water systems in the mineral processing (KPI: 90% less water consumption). The overall CO2 emissions of the LITHOS flowsheet will be 50% lower than today's benchmark (production of spodumene concentrate in Australia & refining in China). This work is enriched by bespoke thermodynamic modelling and digital twins. Supported by FMG & Euromines, LITHOS intends to replicate the LITHOS "responsible mining and refining" concept to the other 24 identified Li-hard-rock deposits in Europe. LITHOS's meta-objective is to unleash Europe's full Li-hard-rock ore potential (total: 8.8 Mt Li2O) so as to become self-sufficient by 2030–35 in terms of made-in-Europe LiOH·H2O.

P12	Sustainable European Rare Earth Elements production value chain from primary Ores	SUPREEMO	N/A
Call: HORIZON-CL4-2023-RESILIENCE-01-03 - Technologies for processing and refining of critical raw materials (IA)			
Contact person: SINTEF AS		**Email:** N/A	
Start Date: 1/1/2024		**End date:** 31/12/2027	

Project Description: SUPREEMO aims to establish the first pre-commercial Rare Earth Elements (REEs) production value chain (TRL7) using European (EU) primary resources as feedstock, developing sustainable, cost-competitive processing, refining and Rare Earth (RE) Permanent Magnet (PM) production technologies in a responsible way complying with local and international safety regulations. This will contribute in securing REE materials supply for the EU industry and strategic sectors which depends 100 % on Chinese imports. The largest end-user of REEs is the PMs industry, that contain neodymium, praseodymium, and dysprosium as key elements to produce high energy-efficient motors, which are vital for electric mobility and renewable energy technologies. SUPREEMO will exploit the primary resources from two major EU sites: Kvanefjeld REE-deposit Greenland (large scale RE project) with ore reserves of >143 Mtonne and Fen deposit Norway (largest carbonatite deposit in EU) with >200 Mtonne grading 1.2-1.5 % Total Rare Earth Oxides. It will capitalise on technologies demonstrated in previous projects and develop an innovative, environmentally friendly, socially and economically sustainable REEs processing technologies. During phase 1, the partners will optimise the stand alone technologies to elucidate the final integrated process flowsheet with the best processing parameters in phase 2, guided by LCA and LCCA. This will be validated at the piloting activities in phase 3. Finally, the production of 50-100 kg of REO at similar cost to commercial value from Chinese production will be demonstrated at TRL7 by processing ~ 10 tonnes of ores, and the production of Rare Earth Alloy for the manufacturing of 50 kg PMs. Results will be communicated and disseminated to key stakeholders and a concrete first business plan will be set to attract more investors and stimulate a competitive, resilient and sustainable REEs production value chain ready for full-scale deployment in the EU market.

P13	**Efficient direct recycling for low-value LFP battery for circular and SustainablE waste management (ReUse)**	**ReUse**	**N/A**
Call: HORIZON-CL5-2023-D2-01-02 - New processes for upcoming recycling feeds (Batt4EU partnership)			
Contact person: FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV		**Email:** Via cordis	
Start Date: 1/1/2024		**End date:** 31/12/2026	
Project Description: The development of sustainable, safe and efficient processes for battery recycling is crucial to improve the circularity and strategic autonomy of the European Li-ion battery (LiB) value chain, in line with the objectives of the Battery Partnership launched under Horizon Europe. The objective of the ReUse project is to improve the circularity and sustainability of the entire low-value LFP battery waste stream - from production scrap to end-of-life LiB - by developing new recycling processes that maximize the recovery of input elements and components. Specific objectives include the development of automated sorting and disassembly strategies, the improvement of recycling efficiency and direct reuse of battery materials, and the assurance of sustainability through life cycle assessment, life cycle costing and social impact studies. With a focus on maximizing material recovery, energy efficiency and purity, ReUse will develop a robust, flexible and sustainable direct recycling process for waste streams of varying composition and quality. The project aims to increase the global competitiveness of the European battery ecosystem in line with the European Strategic Plan for a clean and sustainable transition towards climate neutrality. Building on the BATTERY 2030+ Roadmap and the European Partnership on Batteries, ReUse aims to contribute to the policy needs of the European Green Deal and efficient recycling technologies. The project will address the urgent need to address the shortcomings related to the technological, economic and environmental sustainability of recycling EoL LiBs, especially LFP batteries, which make up 46% of the global LiB market by 2030.			

P14	A circular and chemistry-neutral approach for recycling and recovery of battery waste feeds	RENOVATE	N/A
Call: HORIZON-CL5-2023-D2-01-02 - New processes for upcoming recycling feeds (Batt4EU partnership)			
Contact person: CONSORZIO INTERUNIVERSITARIO NAZIONALE PER LA SCIENZA E TECNOLOGIA DEI MATERIALI		**Email:** Via cordis	
Start Date: 1/1/2024		**End date:** 31/12/2026	

Project Description: The increasingly rapidly growing electric vehicles (EV) market results in higher growth rates in all the LIBs volume categories, from cradle to grave. This trend makes ever more urgent the boosting of battery recycling for several reasons, the most important ones being: i) the preservation of the environment, and ii) the development of a circular economy reducing the demand for virgin materials and the Europe's dependence from third countries. All these crucial aspects need to be handled through the development of new recycling and re-use concepts, fostering demonstrable effects in terms of efficiency and sustainability. RENOVATE aims at developing and demonstrating new circular economy solutions for the European battery value-chain, targeting the re-use of 100% of in-specification cell fractions (e.g. metallic foil, graphite, electrolyte, fluorinated compounds and cathode active materials) within the battery value chain, fostering a closed-loop circular approach that can reduce battery material waste going to landfill, increase the availability of battery precursors in the European battery eco-system, and demonstrate new added-value business cases for recyclers and battery materials users. All recycled materials will be recovered over all potential streams (pre-customer scraps and End-of-Life products). The ultimate goal is to support the green and digital transformation of the European battery industry to increase its competitiveness and promote its just growth path. Holistic, flexible, and closed-loop processes for the recycling of EoL batteries based on both low and high energy density chemistries will be designed and validated to allow real and easily implementable "net zero carbon" process. A specific aim will also be smart re-integration of the side streams (e.g. waste chemicals/solvents) in the recycling processes and/or in in other industrial activities to minimize the residues coming from batteries production.

P15	**Cost-effective, sustainable and responsible extraction routes for recovering distinct critical metals and industrial minerals as by-products from key European hard-rock lithium projects**	**EXCEED**	**webpage**
Call: HORIZON-CL4-2022-RESILIENCE-01-07 - Innovative solutions for efficient use and enhanced recovery of mineral and metal by-products from processing of raw materials (IA)			
Contact person: Matti Okkonen, VTT		**Email:** https://www.linkedin.com/in/matti-okkonen-1a81a360/	
Start Date: 1/1/2023		**End date:** 31/12/2026	

Project Description: The EU is almost entirely dependent on importing rare earths and lithium (Li) for batteries needed to decarbonise the energy and mobility sectors. This is surprising considering Europe has 27 Li hard-rock (pegmatite and rare-metal granite) deposits. One explanation is the reluctance among Europeans to conduct primary (Li) mining in Europe, despite their enthusiasm about electric vehicles. The EU-funded EXCEED project will develop a new mining paradigm for zero-waste, multimetal/mineral mining. This will be combined with sustainable mineral processing to provide additional critical raw materials and industrial minerals from four lithium mines in Finland, France, Portugal and the United Kingdom. EXCEED's long-term impact includes the replication of its solutions to the other 23 European pegmatite and rare metal granite deposits.

Europe is 100% reliant on imports of Li for the Li-ion batteries that are central to decarbonising the energy and mobility sectors. Some fraction of our needs can come from recycling the batteries already in use, but realistically, primary supply will still have to cover 90% of the Li requirement. Paradoxically, Europe hosts 27 Li hard-rock (pegmatite & Rare-Metal Granite) deposits, representing vast lithium resources (8.8–21.7 Mt Li2O). However, the identified potential remains largely untouched, which is partly due to a reluctant attitude towards primary (Li) mining in Europe. Europeans are very enthusiastic about EVs, but rather less so about the necessary mining & refining of Li-bearing ores to realise them. By upscaling and integrating results from earlier projects, EXCEED's 15 partners develop a new mining paradigm, i.e. zero-waste, multi-metal/mineral mining. This will be combined with sustainable mineral processing to provide us with additional critical raw materials (CRMs: rare earths, Nb, Ta, W, Be) and industrial minerals (quartz, feldspar and micas), coming from 4 lithium mines (as case studies) in Finland (Keliber), Portugal (Savannah), France (Imerys) and the UK (Imerys). The project adopts a mineral-centric, integrated methodology based on an innovative predictive and forensic geometallurgy, supported by enhanced in-line characterisation tools and the development of digital twins. EXCEED develops, upscales and demonstrates cost-effective, sustainable and responsible extraction routes for recovering CRMs and industrial minerals (the latter for use as low-carbon ceramics and cements), as by-products from the 4 Li-bearing hard-rock ores. EXCEED's long-term impact includes the replication of the EXCEED solutions to the other 23 European pegmatite and Rare-Metal Granite deposits, thus boosting domestic CRM production (up to 21.7 Mt Li2O & 1.5 Mt of other CRMs), in a way that gains public support by respecting the environment and creating local jobs.

P16	**Demonstration of battery metals recovery from primary and secondary resources through a sustainable processing methodology**	**METALLICO**	**webpage**
Call: HORIZON-CL4-2022-RESILIENCE-01-07 - Innovative solutions for efficient use and enhanced recovery of mineral and metal by-products from processing of raw materials (IA)			
Contact person: Ana Lara Quijano, IDENER		**Contact person**: https://metallico-project.eu/About+us/Partners.htmlA	
Start Date: 1/1/2023		**Start Date:** 30/6/2026	
Project Description: The European Union has underexploited potential to produce critical raw materials (CRM) and special metals, as stated in the Study on the EU's list of Critical Raw Materials (2020). Concretely, the battery sector is considered as a key strategic sector for the EU due to the increased use of batteries in different important sectors such as electric mobility. Thus, METALLICO proposal presents a new opportunity for the European Union. It is composed by an strategic consortium along the value chain, including mining and industrial sites with primary and secondary sources of critical and battery metals (Li, Co, Cu, Mn, Ni); experienced partners to pilot novel processes for producing battery-grade materials based on previous projects and activities; industrial and SME end-users in the battery, cement, paint, and ceramic sectors; and partners to demonstrate the social-license-to-operate (including the support of government bodies), sustainability and commercial chances that the solution represents. Worldwide, these battery metals are predominantly in Chile, Australia, South Africa, China, and The Democratic Republic of Congo, representing a high risk for the EU in terms of supply shortage. For example, in the case of Li, the EU import reliance is 87% for lithium concentrates and 100% for refined compounds as there is no domestic refining. METALLICO includes 4 cases studies in the EU to recover: battery-grade Li2CO3 from a primary spodumene/lepidolite/petalite deposit; Co concentrates and battery-grade CoSO4 from a mine secondary resource (CLC); and Cu, Co, Mn, and Ni concentrates from metallurgical slag from a Pb refining company (KHGM) and secondary mine tailings (THARSIS). Upscaling of sustainable and innovative upstream and downstream processes will demonstrate the techno-economic recovery and production of these critical and important metals for the EU.			

P17	CRM-geothermal: Raw materials from geothermal fluids: occurrence, enrichment, extraction	CRM-geothermal	webpage
Call: HORIZON-CL4-2021-RESILIENCE-01-06 - Innovation for responsible EU sourcing of primary raw materials, the foundation of the Green Deal (RIA)			
Contact person: Katrin Kieling, Simona Regenspurg		**Contact person**: coordinator@crmgeothermal.eu	
Start Date: 1/5/2022		**Start Date:** 30/4/2026	
Project Description: Geothermal fluids often carry high amounts of critical raw materials (CRMs). Studies have shown that even a single well has the capacity to provide Europe with a sufficient amount of elements to cover the needs of key industry sectors. Combined extraction of heat and minerals maximises returns on investment, minimises environmental impact, requires no additional land use, has near-zero carbon footprint and eliminates dependence on external supplies. To assess the overall supply potential, the EU-funded CRM-geothermal project will enlarge an existing geothermal fluid atlas by collecting new data and sampling wells to determine their CRM content. The potential of different geological settings for combined extraction in Europe and East Africa will be evaluated. Geothermal fluids often carry high amounts of elements that the EU considers as 'critical' raw materials (CRM). Preliminary calculations show that even a single well has the potential to produce single-digit percentages of the EU needs. Combined extraction of heat and minerals maximises returns on investment, minimises environmental impact, requires no additional land use, leaves no mining legacies, has near-zero carbon footprint, and enables domestic supplies of CRM. To assess overall supply potential, CRM-geothermal will enlarge an existing geothermal fluid atlas by collecting new data and sampling wells for their CRM content in Europe and East Africa. The potential of different geological settings for combined extraction will be evaluated. Extraction/separation techniques exist but need to be adapted to the harsh conditions of such systems (high temperature, pressure and salinities). Combinations of materials and flow-schemes will be assessed at lab-scale to optimise systems for different geothermal settings and CRM. A modular, mobile plant will be developed and deployed at existing geothermal sites to conduct pilot studies, investigating upscaling and system integration. The technological developments will be accompanied by assessments of environmental and social impacts to ensure good governance. An UNFC/UNRMS compliant reporting template will be developed to create trust among investors, regulators and the public. The project will advance key reference points for stakeholder engagement, in order to obtain and maintain a 'social license to operate'. Combined extraction creates new business opportunities for both SMEs and larger companies, and its economics under likely future market developments will be investigated with a view to proposing suitable business models. CRM-geothermal will open up a potentially huge untapped resource and deploy solutions to help Europe fulfil the strategic objectives of the EU Green Deal and the Agenda for Sustainable Development.			

P18	Material and digital traceability for the certification of critical materials	MaDiTraCe	webpage
Call: HORIZON-CL4-2022-RESILIENCE-01-05 - Technological solutions for tracking raw material flows in complex supply chains (RIA)			
Contact person: Daniel Monfort Climent, BRGM		**Contact person**: d.monfortcliment@brgm.fr	
Start Date: 1/1/2023		**Start Date:** 31/12/2025	
Project Description: MaDiTraCe's main goal is to enlarge and integrate the portfolio of technological solutions reinforcing the reliability of critical raw material (CRM) tracking and the transparency of complex supply chains. The project aims to develop and test independent digital and geo-based approaches for CRM traceability and to integrate them with a generic certification scheme for CRMs throughout mineral supply chains from the mine to the manufactured and recycled products. The project intends to increase the TRL of experimental or largely untested methods in both domains, digital and material sciences. A special attention will be payed to the complexity of mineral supply chains with points of material aggregation and of transformation (processing, refining…) including circular economy (recycling). This methodology will enable downstream industrials to prove the reliability of their sustainability claims, complying with regulation in force (notably EU Battery regulation, German Supply Chain Act) and anticipating implementation of regulation to come (EU Directive on Corporate Sustainability Due Diligence). MaDiTraCe's fundament is a strong stakeholder process (WP1) with upstream and downstream industrials from mining to manufacturing industry and large networks involved via the consortia (EIT-RM) and clusters (ISMC) participating in the project. Continuous interaction with this industrial and policy-oriented stakeholder community on the traceability technology (WP2 and WP3) and the certification schemes (WP4) developed in the project will ensure to stay in line with industrial needs and expectations with respect to regulatory compliance. It will also facilitate implementation and exploitation (WP5) of the project outcomes.			

P19	Advanced sensing, monitoring and self-HEALING mechanisms to self-repair BATteries	HEALING BAT	webpage
Call: HORIZON-CL5-2022-D2-01-06 - Embedding smart functionalities into battery cells (embedding sensing and self-healing functionalities to monitor and self-repair battery cells) (Batteries Partnership)			
Contact person: TECHNISCHE UNIVERSITAT DORTMUND		**Email:** https://www.healingbat.eu/#contactourteam	
Start Date: 1/6/2023		**End date:** 31/5/2027	
Project Description: HEALING BAT is an EU project that brings together 10 European research centres, leading universities and innovative companies from 6 different countries to investigate the EU batteries of the future, which will be smart and more sustainable. Within 4 years, the Horizon Europe project will develop and implement self-healing materials and healing strategies in key battery components, used in the conventional lithium-sulfur (Li-S) battery, and extrapolate the designs and concepts to develop a new class of self-restoring Li-S batteries. HEALING BAT will also create a toolbox consisting of self-healing materials, battery sensors and bespoke battery management systems (BMS), with the aim of maximising the performance of the developed Li-S battery in terms of quality, reliability and lifetime, as well as avoiding or timely healing occurring damages that could lead to battery degradation. For this purpose, the EU project has been granted more than €5.7 million from the European Commission and the respective UK and Swiss funding agencies, under the umbrella of the Horizon Europe programme for research and innovation. HEALING BAT also takes part in BATTERY2030+, a large-scale European research initiative that brings together several Horizon Europe EU projects to invent the sustainable batteries of the future, that will demand fewer resources and improve the competitiveness of EU battery cell industries.			

P20	**Development of operando techniques and multiscale modelling to face the zero-excess solid-state battery challenge**	**OPERA**	**webpage**
Call: HORIZON-CL5-2022-D2-01-02 - Interface and electron monitoring for the engineering of new and emerging battery technologies (Batteries Partnership)			
Contact person: UNIVERSIDAD AUTONOMA DE MADRID		**Email:** Via Cordis	
Start Date: 1/6/2023		**End date:** 31/5/2027	

Project Description: Green, high-performing and safe batteries based on abundant materials are a key element in the transition to a carbon-neutral future. However, to accelerate their development, a deep understanding of the complex electro-chemo-mechanical processes within the battery is required, which is only accessible through advanced experimental and computational methods. Zero-excess solid-state batteries, where the anode is formed in situ, have emerged as a promising new generation of environmentally friendly batteries with high energy density, improved safety and higher cost-efficiency, but only after solutions for non-uniform anode formation were found. In OPERA, seven leading research institutions, two synchrotron radiation facilities, a small-medium sized enterprise and a large technological company, all from complementary research fields such as batteries, surface and material science, and multiscale modelling, propose a unique strategy to face the current challenges of this technology. OPERA relies on the development of novel operando experimental techniques at the ESRF, ALBA and DESY synchrotrons and at the lab-scale, providing complementary information on multiaxial stress fields, chemical composition, nucleation and growth kinetics, structural defect formation and degradation of well-defined model cells with a resolution down to the atomic scale. The new insights and collected multiparameter data will be incorporated into a novel multiscale modelling approach supported by machine learning algorithms. This will ultimately lead to a conceptual understanding of the in-situ anode formation and, based on this, innovative improvement approaches to enable this type of energy storage technology, which will be an important step towards increasing the global competitiveness, resilience and independence of the EU.

P21	Operando analyses and modelling of interface dynamics and CHARGE transport in lithium-ion batteries	OPINCHARGE	webpage
Call: HORIZON-CL5-2022-D2-01-02 - Interface and electron monitoring for the engineering of new and emerging battery technologies (Batteries Partnership)			
Contact person: Luxembourg Institute of Science and Technology (LIST)		**Email:** webpage	
Start Date: 1/6/2023		**End date:** 31/5/2027	
Project Description: Battery innovation has played a major role in the development of new energy production & transport technologies, becoming true enablers of a clean, affordable and secure energy economy. However, innovation is currently being hindered by the lack of understanding of the processes happening at atomic levels in the batteries' interfaces and interphases. Thus, the OPINCHARGE consortium aims to develop a set of effective operando nanoanalytical techniques and methodologies to understand the interfacial processes in batteries in unprecedented level of detail. For this, 10 organizations from 7 different countries will work together, combining their expertise and infrastructure, to find new ways of addressing this challenge. This will be fostered through 3 main pillars of technique innovation: chemical-based, isotope-based, and physics-based. Consequently, main techniques to be addressed operando will be: X-ray scattering, enhanced Raman, STEM-EELS & EDX, FIB-SIMS, Neutron imaging, OEMS and NMR. Parallelly, the consortium will integrate AI/Machine Learning support, in order to improve data acquisition and analysis, making the data crunching processes more efficient and meaningful. Likewise, data treatment and sharing are cornerstones of the project, as Open Science practices and scientific collaboration with the community are recognized by the consortium as key aspects of the BIG-MAP objectives of the Batteries partnership and 2030+ programmes. With a 36 month duration, the project is divided in 7 work packages distributed among the partners according to their expertise, with LIST as leader of the consortium. Dissemination, exploitation and communication activities will allow to maximize the impact of the results and the outreach of these, by actively promoting the diffusion of the information derived from the activities of the project.			

P22	**Building more reliable and performant batteries by embedding sensors and self-healing functionalities to detect degradation and repair damage via advanced Battery Management System**	**PHOENIX**	**webpage**
Call: HORIZON-CL5-2022-D2-01-06 - Embedding smart functionalities into battery cells (embedding sensing and self-healing functionalities to monitor and self-repair battery cells) (Batteries Partnership)			
Contact person: Joris de Hoog Vrije, Universiteit Brussel (VUB)		**Email:** jdehoog@vub.be	
Start Date: 1/6/2023		**End date:** 31/5/2027	
Project Description: PHOENIX aims to develop battery cells with integrated sensors (mechanical, enhanced impedance spectroscopy, temperature, gas, reference electrode) and self-healing (SH) functionalities (magnetically activated polymers, thermally activated polymers, metallic organic frameworks coated separator, core-shell NMC composites). Tailor made triggering devices to activate SH mechanisms will be developed, prototyped and demonstrated in Generation 3b and 4a Li Ion batteries. A Battery Management System (BMS), capable of detecting defective operations and of triggering SH functionalities will be developed with in-line communication. The degradation detection and quality, reliability and life (QRL) will be tested through dedicated profiles (fast charging, extreme temperatures, calendar life). The novel batteries' manufacturing will be studied from a recycling and mass production point of view. PHOENIX's objectives: (1) Develop sensors to detect healable degradation mechanisms, (2) Develop materials with SH functionalities triggered by external stimulus to eliminate/avoid failure mechanisms in battery cell components, (3) Develop triggering devices to activate SH mechanisms, (4) Demonstrate proof of concept for coupling sensors and SH agents via BMS, (5) Detect critical degradation processes during cell ageing and estimate the QRL over the life span, (6) Assess the environmental sustainability and demonstrate the competitive advantage over alternative approaches such as replacement, recycling or second use, (7) Adopt an adaptable approach towards battery cells mass production processes which do not hinder the subsequent recycling process and enables an economic evaluation of the developed cells. PHOENIX will collaborate with the BATTERY 2030+ initiative and will contribute to Europe's competitive and sustainable battery manufacturing industry. PHOENIX consortium is a partnership of 4 RTOs, 1 university, 4 SMEs expert in materials, sensors, modelling, BMS, recycling and battery manufacturing.			

P23	**Smart sensors and self-healing functionalities embedded for battery longevity with manufacturability and economical recyclability**	**SALAMANDER**	**webpage**

Call: HORIZON-CL5-2022-D2-01-06 - Embedding smart functionalities into battery cells (embedding sensing and self-healing functionalities to monitor and self-repair battery cells) (Batteries Partnership)

Contact person: Dr. Samson Y. Lai

Dr. Carlos Escudero

Email: samson.lai@ife.no, carlos.escudero@ife.no

Start Date: 1/6/2023

End date: 31/5/2027

Project Description: The core concept of the SALAMANDER project is to develop and integrate embedded sensors and self-healing functionality in Li-ion batteries (LIB) to enhance their quality, reliability, and lifetime. This is achieved by demonstrating "smart" aspects in the battery which analyze indicators of its own degradation and independently respond with external stimuli to trigger on-demand self-healing. To achieve this goal, the project proposes 3 types of sensors with 2 types of self-healing mechanisms to counteract the most threatening and damaging reactions that occur in a typical LIB. On the anode, a resistance sensor array will be printed onto its surface to sense the degree of electrode fracture in the silicon/carbon composite anode. The anode will be embedded with a self-healing polymer network which upon thermal activation helps re-bind the silicon nanoparticles. For the cathode, an electrochemical sensor array is printed onto the separator to sense the dissolution of Mn from the $LiNiMnCoO_2$ (NMC) cathode. To prevent Mn ions from critically degrading the cell, the cathode will be embedded with heat-activated scavenging species which remove these ions. Lastly, an internal temperature sensor helps control the degree of thermal activation. In each degradation scenario, the sensors communicate with the battery management system (BMS), which uses a physics-based model to trigger controlled heating to activate self-healing. Additionally, a life cycle assessment will be conducted to validate the recyclability of the SALAMANDER battery and quantify how the environmental impact of manufacturing is offset by longer-lasting batteries. Thus, although the project's technology is anticipated to be disruptive at the cell and BMS levels, its design would remain compatible with existing manufacturing and recycling processes. These outcomes thereby help meet the goal of BATTERY 2030+ for a competitive, sustainable European battery value chain and a more circular economy.

P24	Zero Emission electric Vehicles enabled by haRmonised circulArity	ZEvRA	N/A
Call: HORIZON-CL5-2023-D5-01- Circular economy approaches for zero emission vehicles (2ZERO Partnership)			
Contact person: Fraunhofer gesellschaft zur forderung der angewandten forschung ev		**Email:** Via cordis	
Start Date: 1/1/2024		**End date:** 31/12/2026	

Project Description: ZEvRA's main objective is to improve the circularity of light-duty EVs throughout their entire value chain, from materials supply and manufacturing to end-of-life (EoL) processes, which aligns with the European Union's goal of achieving zero CO2e emissions by 2035, particularly in the EV value chain. To do so, ZEvRA will develop a Design for Circularity (DfC) methodology and a holistic circularity assessment aimed at improving the production of electric vehicles (EVs) based on the 9Rs. This methodology will be validated by developing zero emission solutions for the most important automotive materials, covering > 84% material mix: steel, three versions of aluminium (wrought, casting, and foam), thermoplastics composites (long and continuous fibre-reinforced), unfiled/short fibre plastics, glass, tyres and Rare Earth Elements (REE). These solutions will be supported by a set of digital tools to support the manufacturing of the use cases, the assessment of circularity, traceability, and the virtual integration of components into a full replicable vehicle. To maximise the outreach of our methodology and zero emission solutions, ZEvRA will develop a dedicated training & upskilling programme for the automotive workforce and academia, together with activities aimed at increasing awareness & acceptability of the proposed zero emission solutions. Lastly, circular business models targeting EoL and logistics aimed at improving the economic feasibility of circularity in EVs are advanced. ZEvRA’s innovations aim to improve zero emission approaches in the life cycle and value chain of at least 59% of European EVs by 2035 through the 5 OEMs and Tier 1’s that are part of the consortium, which includes industry and academia covering the entire automotive value chain.