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Battery technologies: Advancing e-mobility and stationary solutions

Case study

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The primary aim of this project is to support, through the analysis of climate relevant activities of Horizon Europe, the development and implementation of EU policies. Policy briefs, along with case study and communication materials, are produced to support the development and implementation of EU policies based on the results of the EU Framework Programme for Research and Innovation and other relevant scientific sources.

This document has been prepared for the European Commission's Directorate-General for Climate Action (DG CLIMA) and the European Climate, Infrastructure and Environment Executive Agency (CINEA); however, it reflects the view of the authors (UAB Civitta). The European Commission, or the European Climate, Infrastructure and Environment Executive Agency (CINEA) are not liable for any consequence stemming from the reuse of this publication.

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Introduction

European research and innovation (R&I) in batteries serves as a key enabler for the electrification of the energy and transport industrial sectors, offering the European Union a critical opportunity to reduce its dependency on foreign fuels and enhance its strategic energy autonomy. To support this transition, the Batt4EU Partnership was established under Horizon Europe Cluster 5 (Climate, Energy, and Mobility), with an EU contribution of €925 million for the 2021-2027 period[1]. This partnership acts as a central pillar for improving the European battery ecosystem.

This case study highlights three exemplar Horizon Europe projects delivering technology solutions across different parts of the batteries R&I value chain, from sustainable raw material sourcing to advanced manufacturing and end-of-life recycling:

The **LiCORNE** project aims to establish the first-ever comprehensive lithium supply chain in Europe by recovering lithium from domestic low-grade ores, geothermal brines, and manufacturing waste to reduce strategic dependency on non-EU imports.

The **greenSPEED** project focuses on achieving European leadership in low-carbon cell production by developing "solvent-free" dry electrode manufacturing processes that eliminate volatile organic compounds and can potentially cut production energy demand by half.

Completing the circular value chain, the **RESPECT** project aims to transform the battery recycling landscape by developing a global process flexible enough to treat all kinds of Li-ion batteries in a closed loop.

The implementation of these projects is closely aligned with a robust EU policy framework, most notably the Critical Raw Materials Act (CRMA)[2] adopted in March 2024. This Act sets ambitious 2030 targets, including a requirement for 10% local extraction, 40% domestic processing, and 25% of supply to originate from recycled materials. This complements the EU Battery Regulation[3], which introduces mandatory Carbon Footprint Declarations starting in 2025 and requires industrial and EV batteries to include a Digital Battery Passport by 2027 to ensure full traceability. By integrating these policy mandates with cutting-edge R&I, the EU aims to improve the Life Cycle Assessment (LCA) of every segment in the value chain, fostering a competitive battery industry that meets mandatory climate goals while creating new business models and high-quality jobs.

LiCORNE:

Building a sustainable and autonomous lithium supply chain for Europe

Fact sheet

Duration	**October 2022 until 30 September 2026**
EU contribution	**€ 6 766 313,00**
Type of action	**Research and Innovation Action**
Coordinating organisation	**Fundación Tecnalia Research & Innovation (Spain)**
Consortium size	**14 partners**

Main objective of the project

The primary goal of LiCORNE is to investigate 18 different lithium recovery processes designed to operate at lower temperatures and avoid the use of strong acidic agents, addressing the main drawbacks of current state-of-the-art ore and brine processing. The project seeks to establish a complete and sustainable lithium supply chain within Europe by targeting **three groups of resources: (i) ores and tailings, (ii) continental and geothermal brines, and (iii) off-specification cathode materials.** The aim is to build processing routes that reduce both environmental impact and lithium production costs. Additionally, the project intends to improve social trust and change the perception of mining activities through workshops with local communitiesto discuss concerns around mining and show how lithium extraction can be done in ways that are both practical and acceptable to those living close to future sites.

Project coordinator Dr. Lourdes Yurramendi (Tecnalia) emphasised the project's transformative potential, noting that the ultimate goal is to move past the environmental damage:

"LICORNE is investigating and developing highly sustainable and ground-breaking technologies, eliminating issues encountered in the last century when harmful processes for the environment were used in mining/refining activities".

Connections to relevant EU policy

LiCORNE serves as a technical enabler for major EU policies, most notably the CRMA[4] and its 2030 targets for 10% local extraction and 40% domestic processing of strategic materials. It also aligns with the Circular Economy Action Plan[5] by developing innovative recycling networks that turn waste cathode material back into high-value intermediates.

Impact

The LiCORNE project is expected to have an impact on the Europe's processing and refining capacity to produce battery-grade chemicals such as lithium carbonate, lithium hydroxide, and lithium metal. By reintegrating these recovered materials into the battery supply chain, LiCORNE contributes to the reduction of the European Union's heavy 78% import dependency on lithium from Chile. Furthermore, localising these processes in Europe will simultaneously lower transport costs and associated greenhouse gas emissions.

Status of implementation

As of late 2025, the project has successfully completed its laboratory research phase and moved into the upscaling step to reach Technology Readiness Level 5 (TRL 5).
LiCORNE consortium analysed 18 different technically feasible processing routes and compared them on quality, environmental impact and cost. The final ranking identifiedthe following three routes as candidates for upscaling to TRL5 and aiming at a 90-95% lithium extraction efficiency:

Ores (spodumene) route:

TECHNOLOGIES	Calcination with additives and leaching, direct lithium extraction via adsorption, advanced electrodialysis
FINAL PRODUCT	Lithium carbonate
HIGHLIGHTS	Balanced environmental footprint and cost; 84% final yield

Continental brine route:

TECHNOLOGIES	Liquid-liquid extraction, followed by carbonation
FINAL PRODUCT	Lithium carbonate
HIGHLIGHTS	High product purity; low LCA score; lowest LCC among brine routes

Off-specification cathode route:

TECHNOLOGIES	Chlorination and electrochemical recovery
FINAL PRODUCT	Lithium metal, cobalt and nickel
HIGHLIGHTS	Efficient recovery of multiple critical metals; low environmental impact

Three years of work sit behind the decision to move these flowsheets into the upscaling phase. The team tested, among other innovative technologies, lower-temperature calcination, opto-magnetic sorting, liquid–liquid extraction, electrodialysis and electrochemical recovery on ores, brines and waste cathode material. Every method was put through life cycle inventory to understand its environmental (LCA) and economic (LCC) effects before any route was taken forward. A feasibility study then confirmed that the three selected flowsheets could be taken forward with the equipment available, the required scale and the project's remaining budget envelope.
The pilot will now focus on producing approximately 1 kg of battery-grade lithium chemicals, a necessary step that will show whether these routes can move to industrial and, later, commercial use.

Next steps

Building on the transition from laboratory research to a distributed pilot scale, the consortium is currently conducting a business model analysis to evaluate the commercial viability of its most promising lithium recovery routes. This analysis aims to bridge the gap between TRL5 prototypes and future industrial-scale deployment by establishing a framework where these European-developed technologies can be licensed to resource owners and cathode manufacturers. This strategic evaluation ensures that as the technologies mature beyond the project's scope, they are positioned to support a secure and sustainable European lithium supply chain.

greenSPEED:

Consolidating processes for next-generation European battery manufacturing

Fact sheet

Duration	**1 July 2022 until 31 December 2025**
EU contribution	**€ 5 289 222,25**
Type of action	**Research and Innovation Action**
Coordinating organisation	**Virtual Vehicle Research GmbH (Austria)**
Consortium size	**11 partners**

Main objective of the project

The primary objective of greenSPEED is to develop solvent-free dry electrode coating processes that eliminate toxic volatile organic compounds and massive industrial drying machinery. The project aims to reduce production energy consumption by almost half by combining mixing, coating, and baking into a single process step. Beyond these technical goals, the project intends to strengthen European strategic autonomy by providing domestic suppliers with the critical data needed to compete against global leaders. By creating a collaborative ecosystem where research institutes and large industrial entities exchange specialised knowledge, such as optimised foil roughness and silicon-anode processing, greenSPEED seeks to ensure that the European value chain is technically and economically prepared for large-scale, sustainable industrialisation.

Impact

The greenSPEED project is expected to contribute to achieving European leadership in low-carbon battery cell production by advancing energy-intensive manufacturing stages. A critical anticipated environmental impact is the total elimination of volatile organic compounds through the adoption of dry-electrode manufacturing, which removes the need for toxic solvents like NMP and their associated energy-heavy recovery systems. Through this streamlined approach, the project anticipates reducing the carbon footprint and production costs of battery manufacturing by approximately one-third, potentially improving Europe's competitiveness against global players.

Connections to relevant EU policy

The project's progress is fundamentally linked to the EU Battery Regulation[6], particularly regarding the mandate for life-cycle carbon reductions in battery production. By demonstrating technologies that cut energy demand, greenSPEED provides the technical evidence needed to bridge policy gaps, such as the current lack of incentives for solvent-free or green manufacturing processes.

Alexander Thaler (Virtual Vehicle Research), the project technical coordinator, highlighted the project's role as a vital tool for policy alignment, stating:

"The battery cell we develop is primarily a tool. It's not the final product, a source of critical data that guides our roadmap for further developing this technology".

Status of implementation

At the end of 2025 (near the project end date of 31st December), greenSPEED has successfully progressed from early innovation to validating technologies at TRL 5 and 6. The consortium has demonstrated these advancements through the production of 21700-type wound cells and multi-layer pouch cells, which have undergone cycle-life testing to meet strict automotive requirements. The project has proven that even complex innovation paths, such as the direct application of silicon onto copper foils for anodes, can be successfully processed within a laboratory environment, without the use of expensive and energy-intensive machinery. These results provide the foundational data necessary to judge the next steps for industrialisation.

Key advancements

- Successful validation of greenSPEED technologies at Technology Readiness Levels (TRL) 5–6.
- Production of 21700-type wound cells and multi-layer pouch cells
- Completion of cycle-life testing in accordance with strict automotive performance requirements.

Next steps

As it enters its final stages, the greenSPEED consortium is preparing for a subsequent phase of development that shifts the focus from innovative research toward higher industrial readiness and the fulfilment of rigorous automotive market requirements. This transition must address a significant financial gap between current experimental results and high-volume production. While the project's pilot-scale innovations utilised machinery costing approximately one million euros, progressing to full-scale manufacturing lines requires capital investments of several hundred million euros. This represents a critical bottleneck, as it demands a high level of industry commitment to invest in infrastructure before a specific technology route can be fully commercialised. The ultimate goal is to leverage the data gathered during the project to move from "walking"—validating processing steps at TRL 5 and 6 —to "running a marathon" by securing the massive investment needed for a full-scale project.

RESPECT:

Advancing circularity through flexible and safe battery recycling

Fact sheet

Duration	**1 July 2022 until 30 June 2026**
EU contribution	**€ 8 906 936,00**
Type of action	**Research and Innovation Action**
Coordinating organisation	**Orano Mining (France)**
Consortium size	**16 partners**

Main objective of the project

The RESPECT project aims to transform the European battery landscape by developing a global, flexible, and safe recycling process capable of treating diverse Li-ion battery feedstocks in a closed loop. The primary objective is to establish an efficient and competitive recycling industry that recovers critical materials like nickel, cobalt, lithium, and graphite via both - hydrometallurgical and direct recycling routes, to be directly reintroduced into the manufacturing chain. This RESPECT approach is designed to ensure that the European battery industry remains sustainable and strategically autonomous, by reducing its reliance on virgin raw materials.

Impact

The impact of the RESPECT project is centered on improving the overall efficiency and environmental footprint of the battery life cycle. A significant innovation lies in the pre-treatment process, which enables the early recovery of high-quality graphite and produces a "black mass" that is significantly richer in nickel, cobalt, and lithium, typically containing less than 5% graphite. Since graphite represents in weight approximately 40% of the cell and 20% of the total battery weight, its recovery is essential for meeting large-scale sustainability targets. Furthermore, the project explores direct recycling, a promising alternative that preserves the functional structure of electrode materials, thereby reducing processing steps and minimising environmental impact compared to conventional methods. These advancements not only support a circular economy but also provide the technical data necessary to validate the performance of new cells manufactured with recycled content, with partners of the project comparing these "recycled" cells against those made from virgin materials.

Status of implementation

At the laboratory scale, the project has successfully demonstrated the full dissolution of PVDF (plastic binder) at 100°C and achieved 70% lithium recovery from washing water in a single cycle. Furthermore, 100-500g of recycled NMC cathode active material has been produced using high-quality sulfate salts at this stage. Moving to the pilot scale, key achievements include the production of several kilograms of recycled graphite active materials from both scraps and end-of-life batteries, alongside the production of 1kg of recycled NMC cathode active material using purified leachate - the liquid solution produced during the hydrometallurgical process. Additionally, the project has demonstrated the production of recycled manganese and cobalt sulfate salts from battery leachate with more than 99.6% purity.

Connections to relevant EU policy

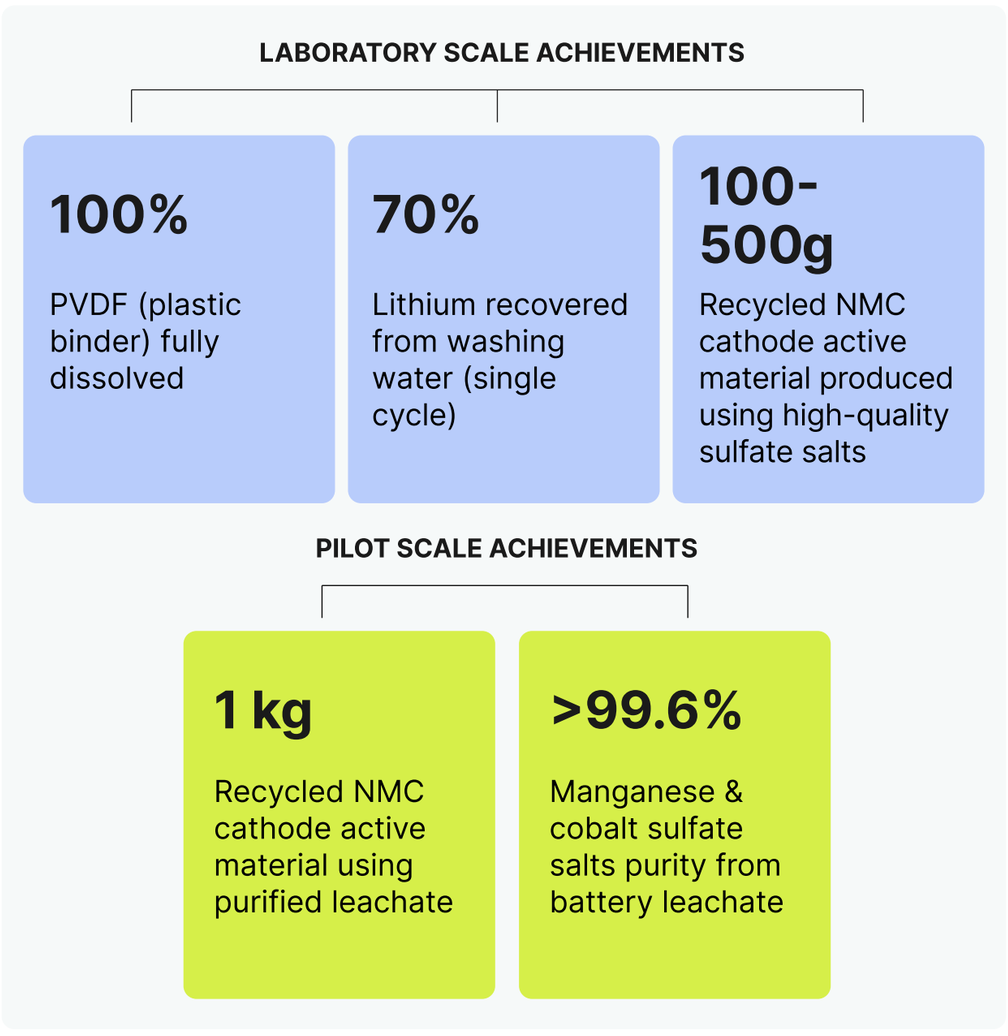
The project's objectives are directly influenced by the EU Battery Regulation[7], which imposes ambitious recovery targets. Although the project has successfully demonstrated the technology at the pilot level, meeting the 2031 mandate of >95% recovery for nickel and cobalt remains a significant technical challenge. This is because current recycling methods, in particular the hydrometallurgy process, have "inherent losses", small amounts of metal that inevitably get trapped in filters or waste liquids, making it difficult to reach a near-perfect 95% efficiency. Furthermore, the regulation requires the recycling of 70% of total Li-battery weight by 2030. This target is difficult to reach unless the regulation is updated to include specific recovery rates for graphite, which makes up a significant portion of the battery's weight.

Next steps

Project coordinator Justo Garcia (Orano) emphasised the project's long-term vision, stating:

"The vision of RESPECT is to contribute to paving the way for increasing global competitiveness, strategic autonomy and circularity of European batteries ecosystem".

Looking toward final outputs and deployment, the results of RESPECT are intended to serve as a benchmark for industrialisation. A key next step in this deployment involves the implementation of the REC2pCAM project, a project supported under the Innovation Fund, by Orano and Neomat PCAM. This follow up deployment project aims to design and operate a hydrometallurgical plant coupled with a PCAM plant to produce cathode materials integrating recycled content. REC2pCAM illustrates the value of a holistic approach, where RESPECT's results in predicting process parameters and impurity removal can directly contribute to the industrialisation of recycled active materials on a single site.



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