LC-BAT-5 CLUSTER

3beLiEVe COBRA HYDRA SeNSE

Dear Reader,

Welcome to the first edition of the LC-BAT-5 cluster newsletter. This is a collaborative action undertaken by the research and innovation projects **3beLiEVe, COBRA, HYDRA, and SeNSE**. We are focusing on advancing next-generation Lithium-ion battery technology for automotive applications and have received funding under the EU's Horizon 2020 research & innovation programme LC-BAT-5-2019 – *hence our name*. We have joined forces to take advantage of synergies in communication, dissemination and technical matters. **Together we aim to deliver the Lithium-ion batteries made in Europe that will power our cars in 2025 and beyond.**

The central role that batteries will play in the future of mobility and smart electrical grids is widely accepted, even though a lot of work still lies ahead of all of us to research, invest in, and build that future. Policymakers are well aware of this, and battery research in Europe today is at the very heart of the industrial policy and research agenda, with the European Battery Alliance and long-term research initiative Battery 2030+ playing the role of European ambassadors and pillars of this revolution.

Whilst labs all over the world are announcing new advances in cell chemistry almost daily, an increasing number of investors and market players are intensively working to build factories capable of producing batteries at scale, the so-called gigafactories; Germany, Sweden, and other EU countries are already seizing the opportunity and planning, building or expanding production facilities. Yet, the know-how for producing high-performing battery cells is not enough. The next generation of Li-ion batteries made in Europe needs to be conceived as sustainable products from day one – from materials sourcing, production, use and reuse, to recycling. This means reducing at minimum the use of so-called critical raw materials (cobalt and natural graphite), which are scarce in Europe and are extracted elsewhere, often using ethically- and environmentally-questionable practices, extending the useful life of the battery as much as possible by facilitating its reuse in a second life application, and enabling its final disassembly for recycling. Squaring all these requirements is no trivial task, and that's where research like that conducted by the LC-BAT-5 cluster comes into play.

As you can see, the battery space is currently an exciting domain to be active in. I hope you will find this newsletter interesting and informative. Make sure to visit the projects' websites, as well as their Twitter and LinkedIn channels to stay up-to-date.

Enjoy the read!

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3beLiEVe

3beLiEVe aims to strengthen the position of the European battery and automotive industry in the future electric vehicle market by delivering the next generation of battery cells, designed and made in Europe, for the electrified vehicles market of 2025 and beyond. The project activities are focused around three thematic areas: **cell chemistry, sensors, and manufacturing.**

At the heart of the developments lies the cell chemistry. The objective is for the cell to achieve an energy density of 750Wh/L and to withstand 2000 deep cycles, including fast charging at 3C, in addition to a host of detailed automotive requirements. An **LNMO cathode and a silicon-graphite anode** will be used, which ensures that the cell is intrinsically free of critical raw materials such as cobalt and natural graphite.

The cell will be augmented with a set of internal and external sensors to enable smart, adaptive operating strategies and advanced diagnostics in order to extend the useful life of the battery in first and second life applications and improve safety. Challenges include the adaptation of internal sensors to withstand the chemical environment in which they will be immersed; sealing of the cell after sensor integration; and merging and evaluating the data from the different sensors to support meaningful operating strategies.

Finally, we consider how the solutions developed in 3beLiEVe can be upscaled for industrial manufacturing. This begins with a quality control step: we aim to subject the final coated electrode foils to inspection by an optical camera. The obtained images are analysed using machine learning, and any coating defects are detected and automatically classified. This should allow a comparison of cell performance with electrode coating quality. Next, we aim to model the needed production steps in a virtual environment, to determine what a manufacturing setup for this technology would look like on the gigawatt-hour scale. To develop a solution that is in line with a circular economy, the cell, module, and pack design also seeks to facilitate reuse in a second life application. For this, we have selected a use case where the 3beLiEVe battery is used as a stationary battery energy storage system in conjunction with a photovoltaic array in the context of an island electrical grid. Finally, special attention is also paid to appropriate materials selection and easy disassembly to facilitate the final recycling step. Factoring in revenues from second life and recycling, we aim to demonstrate a lifecycle cost of 90 €/kWh at scale.

The project will deliver **two 12kWh-demonstrator battery packs at TRL6 and MRL8.** These aim at demonstrating the 3beLiEVe technology performance for applications in light duty (i.e. passenger cars, freight vehicles) and commercial vehicles (i.e. city buses and trucks) in fully electric/ plug-in hybrid (BEV/PHEV) configurations. The project consortium consists of 21 partners from 10 different European countries representing two automotive OEMs, nine industrial companies, four SMEs, five research centres and one university.

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COBRA

The COBRA (CObalt Free Batteries for FutuRe Automotive Applications) project is a collaborative research and innovation project on next-generation batteries with the main purpose of creating a novel cobalt-free lithium-ion battery technology that helps to solve the major challenges encountered by electric vehicles (EV). The project covers the holistic optimisation of all materials and components in order to deliver a pouch cell with a high energy density of at least 750 Wh/l (entailing a 20% improvement compared to baseline) and at least 2.5C fast charging capability to fulfil the peak current demands during acceleration and deceleration. The main advancements of COBRA will comprise: (1) the development of novel battery components that will increase the overall electrochemical performance of the battery cells while reducing cost and use of critical materials through the proposed development and combination of **novel LNMO cathode, a novel composite anode based on nanometer silicon and graphite and a novel polymer-based ionic liquid electrolyte**. (2) The leverage of the use of smart sensors to optimise the system control integrating smart sensors in the cells, including hazardous gas and failures premature detection, pressure, and electrical impedance spectroscopy. The development of smart monitoring and management systems will ensure exceptional battery performance and extended lifetime. Besides, the Battery Management System (BMS) will include improved battery state estimation algorithms, battery pack charge management and degradation modelling derived from the network of smart sensors in cells. Finally, COBRA focuses on (3) the manufacturing of a cost-effective and environmentally sustainable battery-pack built from recycled materials, aspiring for an eco-design for easy disassembly together with the development of environmentally friendly recycling processes for cell chemistry at a lab level.

Overall, the delivered technology will consist of **four 30kWh battery packs at 400V**, proved at TRL6 (BP) and validated on an automotive EV testbed. COBRA will use the pre-design of 2 generations of small pouch cells to explore potential new materials that will be incorporated in the final big pouch cell (GEN X). This will then be compared to the existing commercialised technologies included in a GEN 0 pouch cell to guarantee the improvement.

The COBRA project consortium consists of 19 organisations from 8 European countries representing 3 universities, 7 RTOs, 4 SMEs and 5 enterprises covering the entire value chain and strongly engaging the EU battery industry. Additionally, the involvement of several leading organisations for battery manufacturing ensures the easy adaptation to production lines and scale up to contribute to a higher market adoption while helping to strengthen Europe's position in the field.

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HYDRA

HYDRA takes a multi-headed approach to develop the next generation of safe, low-cost, and high-performance Li-ion batteries. Using advanced hybrid electrode technology, **HYDRA will create generation 3b Li-ion battery cells with optimized energy-power characteristics.** These hybrid electrodes will be produced using sustainable aqueous processing methods and implemented according to the principles of eco-design. HYDRA cells will be manufactured on the pilot scale and demonstrated at TRL6.

To reach this target, HYDRA mobilizes a strong commitment from the European battery industry. Partners include suppliers across the battery value chain, and a direct liaison to the market in sectors such as automotive and maritime transport. Industry commitment in the project ensures a fast uptake of results.

Model-based design workflows combined with advanced characterization methods will help HYDRA researchers better understand the mechanisms that have so far limited the lifetime of high-energy Li-ion batteries and predict the effects of material and cell design modifications. The project will develop multi-scale multi-physics models to describe the performance and lifetime of battery cells. This will lead to the development of a lifetime prediction tool that will help industry adopt HYDRA cells in their systems.

Ecological and economic sustainability are central to the HYDRA concept. **HYDRA cells use abundant electrode materials like iron, manganese, and silicon, and eliminates the use of the CRMs cobalt and natural graphite, with a net CRM reduction of >85%.** The new materials will be produced in an environmentally friendly, energy-efficient manner, and using water in place of organic solvents. All aspects from raw materials via battery cell production and end-use/market to recycling and 2nd life usage will be evaluated.

Through the development of sustainable and high-performance Li-ion cells, HYDRA will contribute to the future of electric mobility and help support the Green Transition.

SINTEF · FAAM RESEARCH CENTER · POLITECNICO DI TORINO · solvionic · Elkem · DLR · Corvus Energy · UCLouvain · JM · ICSI · cea

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SeNSE

The SeNSE project aims at enabling next-generation lithium-ion batteries with a **silicon-graphite composite anode and a nickel-rich NMC cathode** to reach 750 Wh/L. Cycling stability is the key challenge for the adoption of this cell chemistry. The objective is to reach 2000 deep cycles by (i) reducing the surface reactivity of the active materials by a combination of novel film-forming electrolyte additives and active materials coatings, (ii) compensating irreversible lithium losses through an on-demand reservoir of excess lithium in the cathode, and (iii) identifying and controlling critical cycling parameters with data provided from in-cell sensors. Adaptive fast charging protocols will be integrated into the battery management system based on dynamic in-cell sensor data and by implementing thermal management concepts on materials and electrode level.

To improve the sustainability of the battery and to lower production costs, the content of the critical raw materials cobalt and natural graphite will be reduced. Enabled by protective coatings, aqueous slurry processing will be developed for the cathode. The feasibility and scalability of the SeNSE battery technology with respect to the call targets will be demonstrated through 25 Ah pouch cell prototypes and a 1 kWh module. Scalability to the gigawatt-scale and cost-effectiveness of the proposed solutions, including aspects of recycling and second-life use, will be continuously monitored.

The SeNSE consortium consists of six industrial partners (Enwires, FPT Motorenforschung, Huntsman Advanced Materials (Switzerland), Lithops, Northvolt, Solvionic) and five academic partners (Austrian Institute of Technology, Coventry University, Empa, Jülich Research Centre (Helmholtz Institute Muenster), University of Muenster (MEET)) from seven European countries and is led by Empa, the Swiss materials science research institute of the ETH domain.

LITHOPS BATTERIES

Empa Materials Science and Technology

WWU MÜNSTER

JÜLICH Forschungszentrum | HELMHOLTZ-INSTITUT MÜNSTER

enwires more energy in your battery

Coventry University

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

HUNTSMAN Enriching lives through innovation

solvionic

FPT POWERTRAIN TECHNOLOGIES

northvolt

The table below provides an overview of the LC-BAT-5 Cluster projects and their main characteristics, for a better understanding of the similarities and differences between them.

PROJECT COMPARISON TABLE

	3beLiEVe	COBRA	HYDRA	SeNSE
PROJECT DURATION	01/2020 - 06/2023 (42 MONTHS)	01/2020 - 06/2023 (42 MONTHS)	05/2020 - 08/2024 (52 MONTHS)	02/2020 - 01/2024 (48 MONTHS)
CONSORTIUM	21 ORGANISATIONS 10 COUNTRIES	19 ORGANISATIONS 8 COUNTRIES	12 ORGANISATIONS 7 COUNTRIES	11 ORGANISATIONS 7 COUNTRIES
CELL CHEMISTRY	LNMO / GRAPHITE-SILICON	LITHIUM-RICH LNMO / GRAPHITE-SILICON	LNMO, LFP / GRAPHITE-SILICON	NI-RICH NMC / GRAPHITE-SILICON
DEMONSTRATORS	30AH POUCH CELLS 2 X ~12KWH	50AH POUCH CELLS 4 X ~30KWH	12AH POUCH CELLS MARITIME INTEGRATION	25AH POUCH CELLS 1 KWH MODULE
SENSORS	1 INTERNAL 2 EXTERNAL	1 INTERNAL 2 EXTERNAL	1 EXTERNAL	INTERNAL
MANUFACTURING INNOVATIONS	AUTOMATED ELECTRODE INSPECTION PRODUCTION PROCESS MODELING	IMPROVED ELECTROLYTE FILLING BETTER CELL FORMATION	AQUEOUS CATHODE PROCESSING ROLL-TO-ROLL PILOT SCALE PRODUCTION	THIN CURRENT COLLECTORS AQUEOUS SLURRY PROCESSING
CIRCULAR ECONOMY	2ND LIFE RECYCLING	2ND LIFE RECYCLING	2ND LIFE RECYCLING	2ND LIFE RECYCLING
PROJECT WEBSITE	3BELIEVE.EU	PROJECTCOBRA.EU	H2020HYDRA.EU	SENSE-BATTERY.EU
GA#	875033	875568	875527	875548

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