MARKET INTELLIGENCE REPORT

COBRA

KEY TECHNICAL, POLICY AND MARKET DEVELOPMENTS INFLUENCING THE ELECTRIC VEHICLE BATTERY LANDSCAPE

CURATED BY
MAARTEN BUYSSE
OLA OLUGBAYILA
PHILIPP ZENG
MARCOS IERIDES &
AMY MCCREADY

bax

COBRA'S FINAL RESULTS & REFLECTIONS

JULY 2024

INTRODUCTION

This edition of our market intelligence report highlights the final results of the COBRA project, a collaborative EU initiative aimed at developing next-generation cobalt-free batteries for electric vehicles. Over four years of intensive research and development, the COBRA consortium has achieved significant advancements in Li-ion battery technology, eliminating cobalt and enhancing all key components of the battery system.

The project has successfully produced a prototype featuring an LNMO cathode and a composite anode of silicon and graphite, paired with an innovative battery management system. This system integrates advanced safety and efficiency features, including wireless communication and sophisticated sensors. The COBRA project promises significant benefits for the European battery industry by enhancing performance, safety, and sustainability by reducing dependency on cobalt.

We delve into the key components developed by the project partners, showcasing advancements in cell chemistry, battery management systems, and manufacturing processes. These innovations ensure the new technology can be seamlessly integrated into production lines and scaled up for widespread market adoption. Additionally, the report includes insights from COBRA project coordinator, Jordi Jacas of IREC, offering final reflections on the project's journey and celebrating its impressive achievements.

DEVELOPED BY

Bax
cobra@baxcompany.com
Phone: +34 93 476 04 44
www.baxcompany.com

Philipp Zeng
Intern
P.zeng@baxcompany.com

Olamilekan Olugbayila
Innovation Consultant
o.olugbayila@baxcompany.com

Marcos Ierides
Senior Innovation Consultant
m.ierides@baxcompany.com

Maarten Buysse
Innovation Consultant
m.buysse@baxcompany.com

Amy McCready
Communications Consultant
a.mccready@baxcompany.com

IN COLLABORATION WITH

Jordi Jacas
Project Coordinator, COBRA
Senior Researcher, IREC

OVERVIEW

Below we present an overview of the key battery components developed by the COBRA project partners.

If you would like to reach out to one of the partners for more information, please send an email to cobra@baxcompany.com.

1) ANODE

Low-cost, recycled silicon powder

Recycled and treated silicon (Si) obtained from several waste streams. Optimised for purity, particle size, and morphology achieved through various techniques for purification and particle size/morphology adaptation.

Silicon-graphite anode composites

Silicon-graphite anode composites formulated for high-energy cells. High-performance Si for use in battery anodes, optimised for the ratio of graphite/silicon, the binder composition, porosity, mass loading, and thickness.

2) CATHODE

Cobalt-free, li-rich cathode composite powders

High-quality powder with small particle size, large specific surface area, and high chemical and phase purity. Produced by Cerpotech, using spray pyrolysis.

Performance optimisation via chemical doping

Cathode composition ($Li_{1.1}Ni_{0.35}Mn_{0.55}O_2$) optimised using dopant concentration. The best discharge capacity, cycle life and low voltage fading obtained for the Al-doped ($Li_{1.1}Ni_{0.35}Mn_{0.54}Al_{0.01}O_2$) sample.

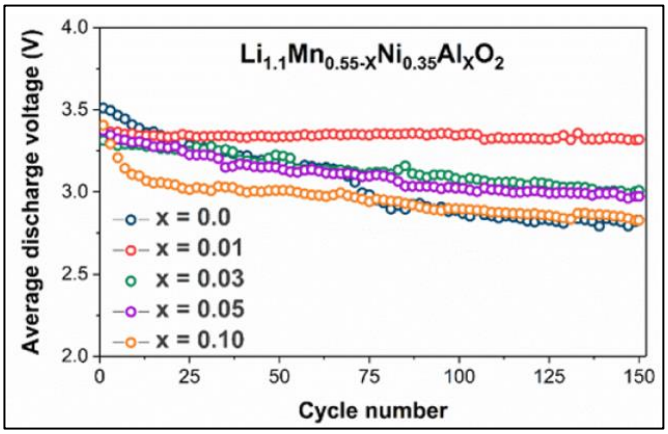


Figure 1: Cycling results of Cobalt-free cathode compositions

3) ELECTROLYTE

Ionic liquid-based electrolyte

Optimised electrolyte formulations and production to ensure high safety, energy density and battery lifetime.

SOLVIONIC

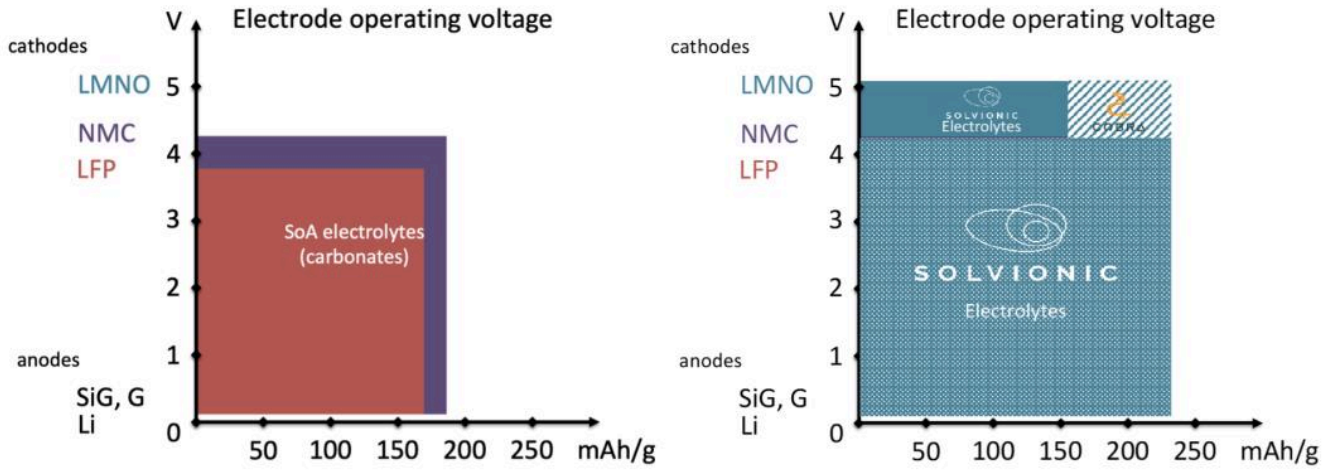


Figure 2: Improvement of cell properties by Solvionic's electrolyte

4) BATTERY CELL

Optimised full cell formation process

Fast formation protocol carried out with a micro cycling process. The cell formation process brings significantly time reduction from the conventional 216 hours to 95 hours, whilst ensuring safe and high-quality cell activation.

Fraunhofer ISIT

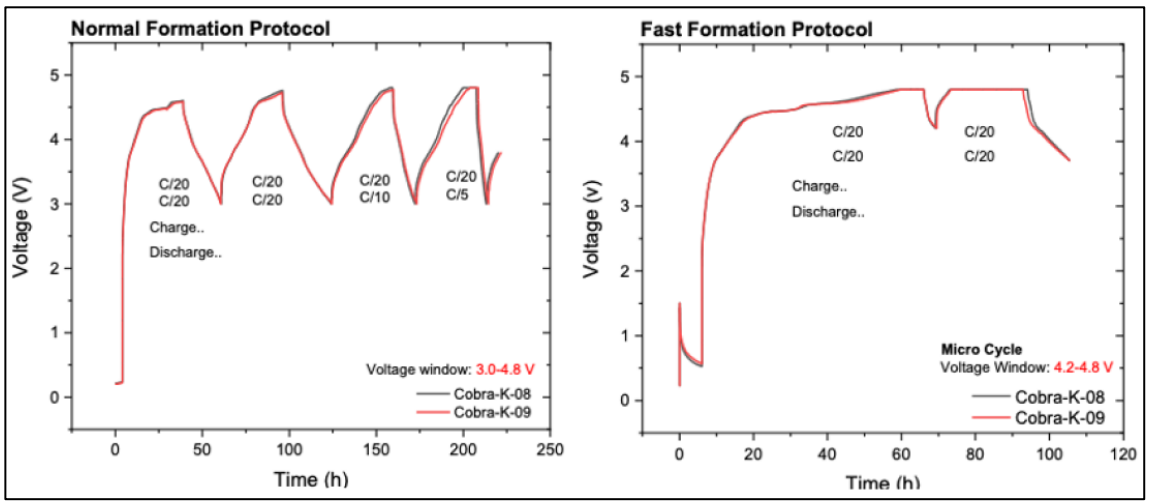


Figure 3: Battery Cell: Formation protocols

5) BATTERY PACK

Battery test protocols

Battery testing protocols developed by project partners (IDIADA) includes procedures defined for validation of BMS functions, communications, and operation of battery packs (including fire resistance).

Structural and vibration simulations assessment

Finite Element Analysis to validate the stability of the battery pack under mechanical shock conditions, according to the R100 regulation and extract natural vibration frequencies.

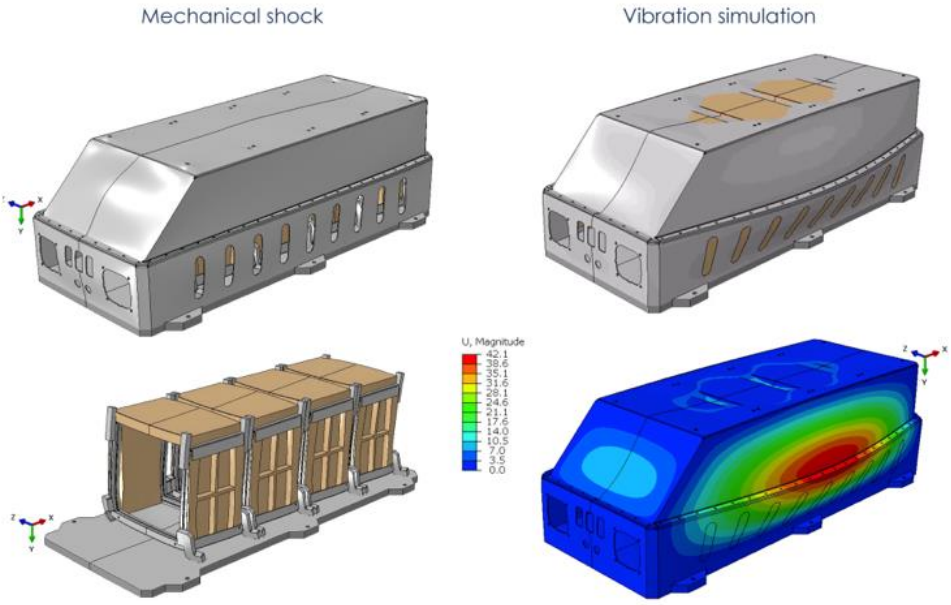


Figure 4: Mechanical and Vibration Simulation Results

Sustainable battery housing

Battery housing made from lightweight and low-cost green materials ensures the protection of the battery from the environment and safeguards the environment in the event of an accident. The housing also integrates fire and EMC protection to ensure safe operation.

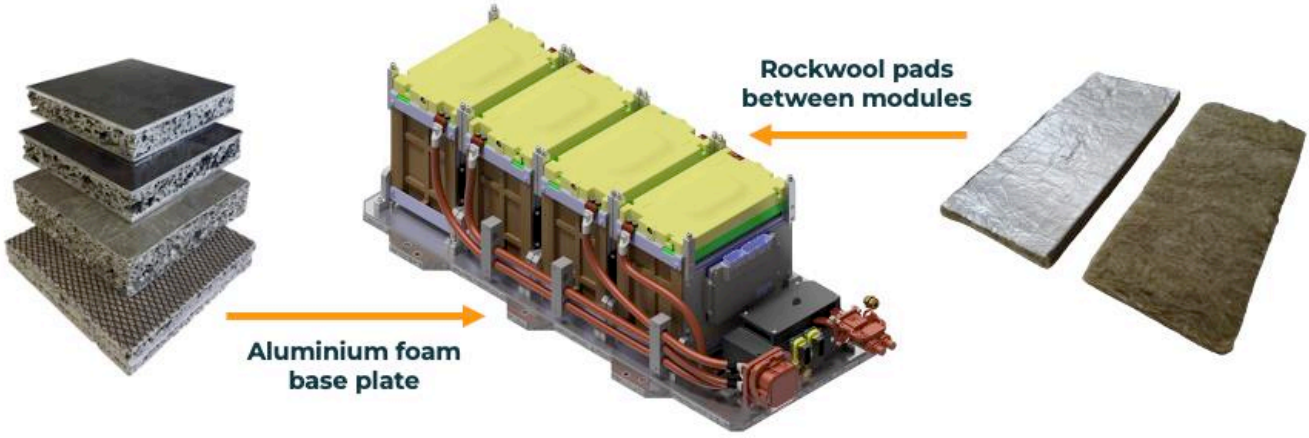


Figure 5: COBRA pack prototype with innovative lightweight materials

Thermal management system

Modular and adaptable cooling and heating system, designed for easy and cheap industrialisation. Its operation is validated through CFD and thermal simulation to ensure adequate working conditions.

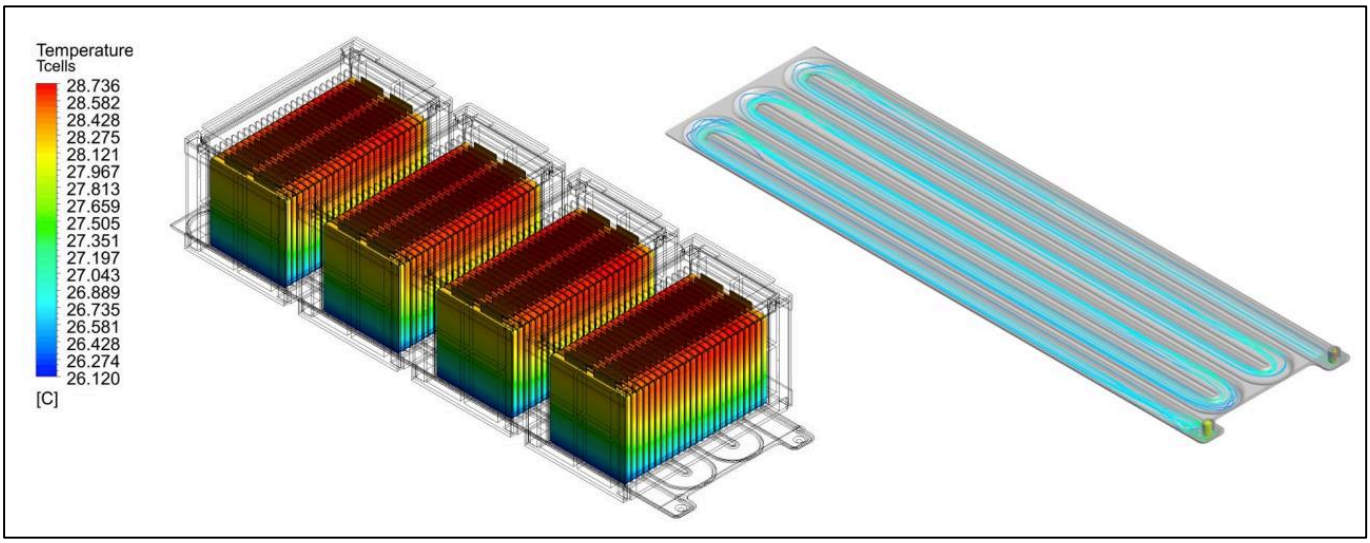


Figure 6: Thermal management system design and thermal simulation test results

6) BATTERY MANAGEMENT SYSTEMS (BMS) AND SENSORS

EIS performed at cell level

Measurement know-how and equipment for EIS (Electrochemical Impedance Spectroscopy) performed at cell level.

Charge Management Controller (CMC)

Advanced battery pack charge management algorithm, using battery core temperature information provided by the Thermal State Observer, degradation information, as well as internal cell states to determine the optimal trade-off between charging speed and battery degradation.

Thermal State Observer (TSO) for battery modules

Improved thermal state estimation algorithms, enabling estimations of the core temperature instead of that of the surface only, allowing to increase safe operating conditions.

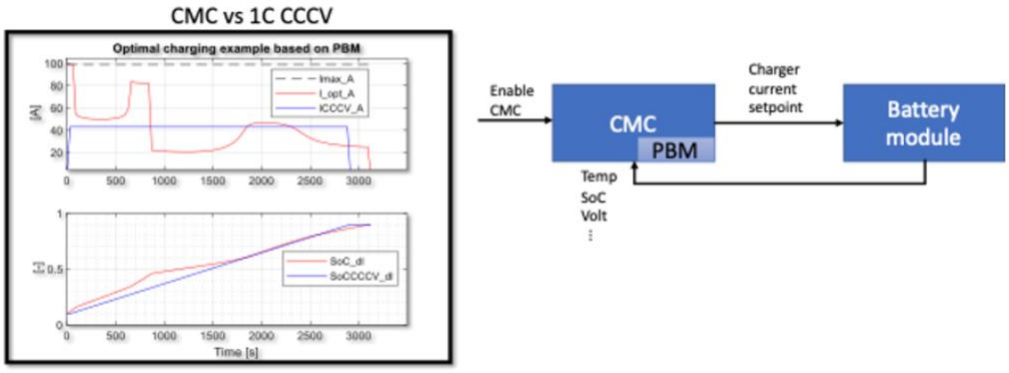


Figure 7: Charge Management Controller (CMC) Performance and concept (TNO)

Thermal Runaway detection algorithm based on smart sensors

Thermal runaway probability and subsequent warning signal, using strain information provided by strain gauge sensors.

State-of-Charge (SoC) estimation algorithm

SoC estimation, based on cell-level EIS sensors, is embedded in AVL's BMS software. This results in less time-consuming parameterisation of battery models, a decreased need for additional ageing estimation, and an expanded operational window due to fewer estimation errors in both low and high SoC regions.

iMCU (Intelligent Module Controller Unit)

Open decentralised BMS scalable from single module operation up to hundreds of modules. The BMS is designed to incorporate smart sensing capabilities and execute advanced models and algorithms to compute internal battery states with high accuracy.

Wireless Optical Communication System

An IR-based Wireless Optical Communication System for New Generation Battery Pack.

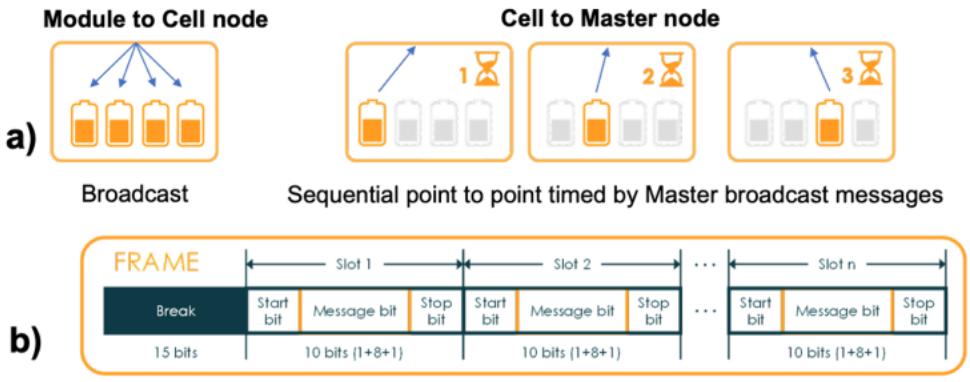


Figure 8: Wireless Optical communication system: a) Broadcast request and sequential response – b) Example of communication frame (CEA)

Smart sensors

Network of strain gauge sensors to increase accuracy of state estimation and failure prevention.

Figure 9: Smart Sensors: Cycling & Thermal Test Protocols

7) PROCESS ASSESSMENT

Quality & reliability assessment of cell design and manufacturing

Fraunhofer ISIT

Methodology to assess the impact of cell design on quality and reliability over the full lifetime of the battery.

Materials social life cycle and recyclability assessment

eurecat Centre Tecnològic de Catalunya

Methodology to assess social impacts, based on UNEP/SETAC guidelines precepts for Social Assessment,

Methodology to assess the impact of the cell design on recyclability over the full lifetime.

FINAL REFLECTIONS ON COBRA PROJECT AND FUTURE OUTLOOK

CONVERSATION WITH **JORDI JACAS**
(COBRA PROJECT COORDINATOR & SENIOR RESEARCHER at IREC)

What are the COBRA project's most significant achievements?

The COBRA project covered the whole value chain of battery development, from the research and development of new battery components, manufacturing of sustainable modules and packs, and smart sensing to environmental, economic, and social aspects, including strategies for recycling and second-life batteries. The project has reached many achievements. Still, if I have to mention the most significant ones, I would highlight: 1) the development of cobalt-free cathode technology based on lithium-rich oxides via aluminium doping, 2) the improved sustainability of the anode electrode using recycled silicon, 3) the implementation of various sensors (thermal, impedance, gas, and strain gauge) at the cell or module level, together with optic-based communications at the BMS level, and 4) the fabrication of an eco-friendly battery pack using green and recycled materials with validated properties for the EV industry. These developments are relevant to generation 3b technology but can also be applied to other next-generation storage systems and applications beyond the EV industry.

Are there any specific milestones that you believe were pivotal to the project's success?

The fabrication of the final high-energy pouch cells, which were 25 Ah, was a significant achievement that contributed to the project's success. The second major success was implementing advanced sensing at the cell or module level; the results and outcomes will contribute to developing safer batteries.

How important were the collaborations and partnerships within the consortium for the project's success?

They were very important. I'd like to answer this question as the WP1 leader and not as the coordinator. Together with SU, Cerpotech, and IMEC, new cathode formulations based on lithium-rich cobalt-free oxides were fine-tuned using aluminium doping, leading to a significant improvement in cycling stability, a major drawback to address for the future implementation of generation 3b batteries, which aim to be close to 2000 cycles. This collaboration within the consortium resulted in several papers and, more importantly, expertise on the physicochemical and structural factors governing the electrochemical performance of these challenging materials.

What lessons were learned from these collaborations, and how can they be applied to future Horizon Europe projects and the battery industry at large?

Personally, it was enriching to participate in the discussions of prototype pouch cell fabrication that were conducted during the project. However, it was also extremely challenging as many requirements were needed, starting from significant amounts of "good" materials to the optimisation of the cell specifications, which are many and go beyond the day-to-day work at the laboratory level. As a lesson learnt, the answer is easy: we need more pilot plants. This is key to launching future battery technologies at scale.

What were some major or unexpected challenges faced during the project, and how did you overcome them?

Our most significant challenge was integrating the new battery components into a pouch cell. Aspects such as material upscaling with demonstrated reproducibility and the processability of the electrodes for large-scale (high-energy) battery cell manufacturing were ambitious in the COBRA project. First, we had to establish extra control steps for the material batches to ensure reproducibility. Secondly, we evaluated different post-treatment processes at a large scale within the consortium, which were not considered initially. Upscaling new battery chemistry into working cells at a large scale takes much time, well beyond four years. Remember that state-of-the-art technology based on cobalt-rich materials and graphite has taken over 20 years to reach its maturity level.

What advice would you give to future coordinators and partners to make the most of a collaborative project (both for themselves and for Europe)?

COBRA has been a large consortium of 19 partners with many developments covering the whole value chain. It was important to set clear targets for each development in addition to the overall project scope and, as much as possible, minimise the dependency of developments on each other. So, good organisation and communication are very important. In a similar way, this communication needs to be fluent and efficient with the Project Officer, as it was in COBRA.

What do you see as the next steps towards commercialisation/exploitation for the innovations developed within COBRA?

A notable development conducted in COBRA was a new pack constructed from green and recycled materials. Wood and recycled aluminium were used for the fabrication. The pack is lighter and compliant with the high safety standards of EVs. This job was conducted by Carissma, and currently, several OEMs from the automotive industry have contacted them for further development. I would say that this is a good example of COBRA's impact on the European battery ecosystem.

What do you see as the main long-term impact(s) of the project's results on the future of EU battery industry and sustainability practices?

Producing high-quality materials is becoming more challenging due to sustainability constraints. This is fine; we like challenges as battery researchers or engineers for a better environment. This is our job. Cobalt-free materials are promising for many reasons but challenging at the same time. There are several candidates, and all have pros and cons. However, while we are investigating their properties and enhancing performances, we also need to consider large resources, which means more material suppliers. So, in COBRA, we have helped to implement recycled materials, such as silicon for the anode and aluminium for the pack, and to produce promising cathode materials in Europe, which could help to minimise our dependency on Asian suppliers These are very important topics for the future battery ecosystem, and I am sure COBRA will impact them in the long term.

IREC is the Catalonia Institute for Energy Research, (Institut de Recerca en Energia de Catalunya). Created in 2008, it aims to contribute to the sustainable development of society and to increase the competitiveness of industry in the energy sector. The centre develops research of excellence in the medium and long term, innovation and the development of new technological products and the dissemination of important knowledge and findings to the general public.

TECHNICAL DEVELOPMENTS

COBRA PROJECT CONCLUDES, DELIVERING COBALT-FREE LITHIUM-ION BATTERY SYSTEM

The EU-funded COBRA project has concluded after four years, achieving its goal of developing a cobalt-free lithium-ion battery system for electric vehicles. The project produced an innovative battery management system and a prototype using an LNMO cathode and a composite anode of silicon and graphite. This system integrates advanced safety and efficiency features, including wireless communication and sophisticated sensors. The COBRA project promises significant benefits for the European battery industry by enhancing sustainability and reducing dependency on cobalt.

READ MORE

TOHOKU UNIVERSITY DEVELOPS PAPER-BASED MAGNESIUM-AIR BATTERY

Researchers at Tohoku University, inspired by plant respiration, have developed a high-performance paper-based magnesium-air (Mg-air) battery. This eco-friendly battery is activated by water and is suitable for use in GPS and pulse oximeter sensors. Achieving an open circuit voltage of 1.8 volts, a current density of 100 mA/cm² at 1.0 volt, and a maximum output of 103 milliwatts/cm², the battery uses non-toxic materials, making it a promising alternative for environmentally friendly power generation.

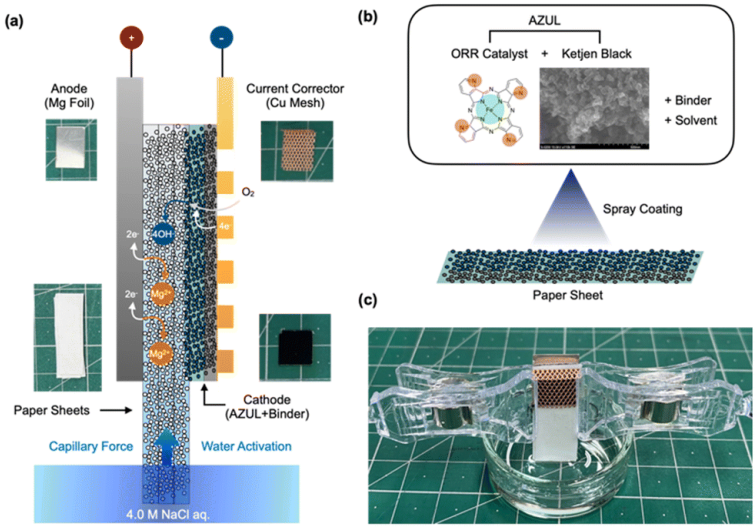


Figure 10: Schematics of the water-activated paper-based battery cell (a) and cathode fabrication (b), and photograph of the water activation setup for battery performance evaluation (c)

READ MORE

BREAKTHROUGH IN GEL ELECTROLYTE-BASED BATTERIES

Professor Soojin Park and his team at POSTECH have developed a stable, commercially viable gel electrolyte-based battery, overcoming significant safety and production challenges. Published in the journal Small, their research highlights the use of a bifunctional cross-linkable additive and electron beam technology to enhance battery performance and durability. The new batteries show a 2.5-fold reduction in gas generation and maintain high capacity even after extensive cycles, marking a significant step forward for electric vehicles and other applications.

READ MORE

MARKET DEVELOPMENTS

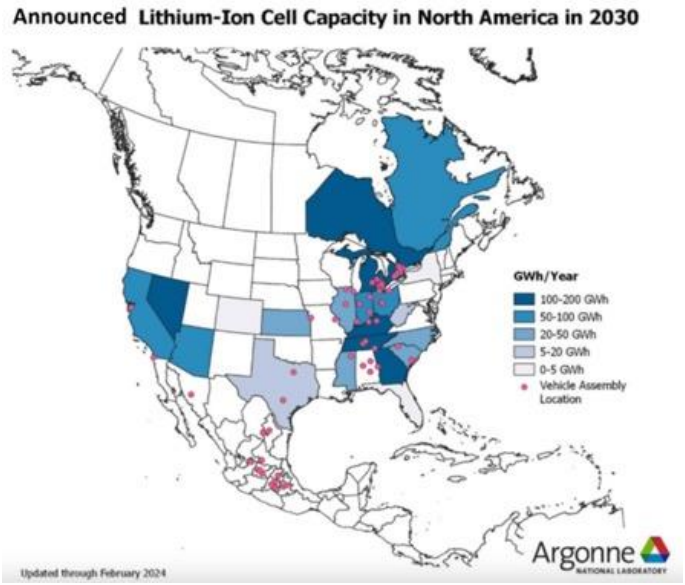
GOTION AND INOBAT CONFIRM GIGAFACTORY IN SLOVAKIA

The Slovak government has signed an Investment Agreement with Gotion InoBat Batteries (GIB), a joint venture between Chinese battery company Gotion High-tech and Slovak company InoBat. The gigafactory, located in the Šurany eco park, will have a planned capacity of up to 60 GWh, with the first phase of 20 GWh set to begin operations in 2026. This phase will cover over 100 hectares and employ more than 1,000 workers. Construction starts at the end of 2024. The project aims to be a zero-carbon battery factory, contributing to Slovakia's role in the green energy sector.

READ MORE

BATTERY CELL PRODUCTION IN NORTH AMERICA TO EXCEED 1,200 GWH PER YEAR BY 2030

North American battery cell production capacity is projected to surpass 1,200 GWh annually by 2030, enough to power 12-15 million new electric vehicles each year. In the U.S., most battery manufacturing will occur near vehicle assembly plants, primarily in the Midwest and Southeast, to minimise shipping time and transportation costs. This growth, forecasted by Argonne National Laboratory, highlights the strategic importance of localising battery production to support the expanding EV market.



READ MORE

UL SOLUTIONS ACQUIRES GERMANY-BASED BATTERY TESTING COMPANY BATTERIEINGENIEURE

UL Solutions Inc. has acquired BatterieIngenieure GmbH, a German company renowned for its specialised battery performance testing. This acquisition bolsters UL Solutions' global battery testing infrastructure, adding a state-of-the-art laboratory in Aachen, Germany. BatterieIngenieure excels in testing, simulation, and failure analysis of cells, small modules, and battery systems for electric vehicles and other applications, with notable expertise in battery life expectancy estimation. The company is expanding its Aachen facility to enhance testing capacity and has strong ties with European automotive manufacturers. This acquisition complements UL Solutions' existing labs in China, South Korea, and the U.S.

READ MORE

POLICY DEVELOPMENTS

GLOBAL BATTERY ALLIANCE LAUNCHES SECOND WAVE OF BATTERY PASSPORT PILOTS

The Global Battery Alliance (GBA) has initiated the second wave of its Battery Passport pilots, involving 11 consortia led by major global battery manufacturers such as CATL, LG Energy Solution, and Samsung SDI. This effort aims to establish a sustainable and transparent battery value chain by 2030. The pilots will feature a product-level ESG score and involve various track-and-trace solution providers. The initiative builds on the first Battery Passport proof of concept launched in January 2023 and seeks to mainstream sustainability in the rapidly growing battery industry.

READ MORE

SERBIA TO APPROVE RIO TINTO LITHIUM MINE

Serbian President Aleksandar Vucic is set to approve Rio Tinto's development of Europe's largest lithium mine, two years after the project was halted due to environmental concerns. Vucic cited new guarantees from Rio Tinto and the EU addressing these concerns. The Jadar mine could significantly contribute to the EV value chain in Serbia, potentially producing 58,000 tons of lithium annually by 2028, enough for 17% of Europe’s EV production. The project, initially revoked in 2022 following protests, could meet 90% of Europe’s current lithium needs.

READ MORE

The COBRA project has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement 875568.

BECOME A SPONSOR

Support us in powering our Market Intelligence Reports!

We'd love to continue delivering valuable market intelligence reports on the battery industry. With the COBRA project now ending, new sponsorship opportunities are now available.

By becoming a sponsor, you'll gain exposure to COBRA's community of 2,000+ battery enthusiasts as well as 10,000+ users on evmarketreports.com, representing 3,000+ companies and governments.

If you're working in the battery field and share our enthusiasm for advancing battery technology, please contact **cobra@baxcompany.com** for more information.

bax