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The international quarterly for the battery technology industry

Advanced Automotive Battery Conference

Event preview in association with

Cambridge EnerTech

Welcome to the 15th International Advanced Automotive Battery Conference!

On behalf of myself and my colleagues, it is my great pleasure to welcome you to Mainz and the 15th International Advanced Automotive Battery Conference Europe! As the General Manager of Cambridge EnerTech, it is my privilege to extend this heartfelt greeting to each and every one of you.

This year's conference promises to be an exceptional gathering of industry leaders, innovators, researchers, and enthusiasts in the field of advanced battery technologies for automotive applications. With the EV landscape evolving at an unprecedented pace, our event serves as a pivotal platform for the exchange of knowledge, ideas, and insights that will shape the future of electric vehicles.

Throughout the duration of the conference, you will have the opportunity to engage in thought-provoking discussions, attend informative sessions, and network with fellow professionals who share your passion for advancing battery science and technology. From cutting-edge research presentations to practical applications and market trends, the program is designed to inspire, educate, and empower all participants.

The AABC Conference series was founded more than 20 years ago to review the status of automotive battery technology and provide informed glimpses into the future. The program will uncover the underlying technical and business issues that will impact the pace and path of vehicle electrification worldwide.

As we embark on this journey together, I encourage you to make the most of your time at the conference. Whether you are a seasoned industry veteran or a newcomer to the field, your contributions and perspectives are invaluable to our shared mission of driving progress and innovation in automotive electrification.

On behalf of the organising committee, I extend my sincere gratitude to our sponsors, exhibitors, speakers, and attendees for their support and dedication. Together, we will make the 15th International Advanced Automotive Battery Conference Europe a catalyst for advancing technology in the global battery ecosystem.

Thank you for your participation, and I look forward to meeting you all in person at the conference!

Warm regards,

Craig Wohlers
General Manager
Cambridge EnerTech

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Graphite and anodes - a new gold for battery revolution

Shruti Kashyap, Product Director, Benchmark Mineral Intelligence

Shruti has two decades of experience analysing and researching commodities ranging from iron ore, coal, nitrogen and anode raw materials. She is responsible for Benchmark's forecasts on anode raw materials – graphite and battery chemicals (PPA, HPMSM and Fluorspar).

Graphite, like many other essential minerals, has seen a surge in demand due to the rising need for batteries. There are two main types of graphite: Synthetic and Flake, each produced via different methods. Synthetic graphite is made from coke, including needle and petroleum coke, whereas flake graphite concentrate is obtained through mining. The supply of coke and the swift establishment of mines are critical for the industry's success.

China dominates this market, accounting for approximately 70% of flake graphite production and controlling 92% of both natural and synthetic anode production. China's ongoing export controls and restrictions have created uncertainties in the stable supply of graphite, increasing the urgency to diversify sources away from China. The global graphite industry is on the brink of expanding production outside of China.

Africa is at the forefront, projected to nearly double its share of global flake graphite production to around 30% by 2030. Countries like Canada and Australia are also investing in vertically integrated graphite and anode projects. Although synthetic active anode material projects are emerging outside of China, the country is expected to retain a significant dominance, with over 90% of the market share in synthetic active anode material production by 2030.

However, developing graphite supply chains outside of China presents significant challenges, particularly in the current low-price market. Graphite from non-Chinese sources tends to be costlier, as China's production benefits from lower energy and labor costs. Consequently, the price incentives required to develop projects outside China are substantially higher than current levels, especially for flake graphite.

Some ex-China anode projects are progressing, but obstacles are causing cancellations and delays. In Europe, for instance, anode projects are struggling highlighting the need for stronger policy support to boost market demand and provide investment incentives for new initiatives. Meanwhile, U.S. cell manufacturers are exposed to tariffs on anode and flake graphite imports from China. Flake graphite is currently subject to a 25% tariff from China, expected to rise to 45% by January 1, 2026. Additionally, a U.S. International Trade Commission investigation into potential anti-dumping and countervailing duties on Chinese graphite materials could result in tariffs as high as 920%.

China has previously retaliated against U.S. trade protectionism, having first imposed export restrictions on graphite in late 2023. The situation intensified in December 2024 when China announced an immediate ban on graphite exports to the U.S. for military applications and instituted stricter reviews for U.S. end-users, citing national security concerns.

As the demand for graphite and anodes is poised for significant growth—especially with the expansion of electric vehicle (EV) and energy storage system (ESS) markets—the ongoing tensions between China and the U.S. are generating uncertainties that could delay projects. While trade protectionism is prompting global policy initiatives, a coordinated and strategic approach will be essential for the industry's success moving forward.

Battery recycling methods & markets

Steve Sloop, PhD, President, OnTo Technology LLC

By 2030 the battery manufacturing industry is on course to reach $120 billion worldwide. However, with so many uncertainties, the recycling market has projections of $14 to $40 billion. Recycling must be economically sustainable, with future $10/kg cathodes, can it achieve such a goal?

A supportive recycling industry will be expected to:

1. operate with end-of-life batteries as an asset
2. produce cost-competitive elements, electrodes, or electrode precursor materials
3. safely address large-scale throughputs
4. accommodate low cobalt or no cobalt cathode formulations.

This tutorial will comprehensively address technologies of pyrometallurgy, hydrometallurgy, hybrid approaches, and direct recycling. The instructor will introduce these and discuss them in light of cost goals and market realities.

Lithium-ion battery (LIB) manufacturing has relied upon performance to realize market growth for application such as electric vehicles (EV). The foundational features for LIB include portability, energy delivery, and cost. Not until recently has the recycling been considered part of the foundation of mass adoption of EVs – that it could be a feature of the technology. For the conference, OnTo Technology founder and president will present a tutorial on recycling technologies and a podium presentation on recycling of LIBs.

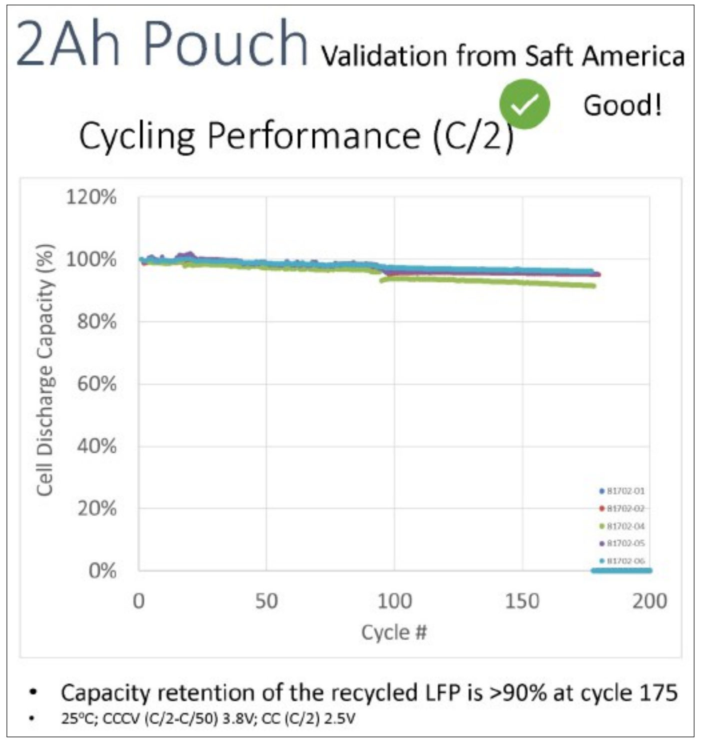


Figure 1. Recycled LFP from cathode healing™ used in new cells manufactured by a third party show industrial viability in reusing LIB materials in original manufacturing.

The recycling technologies tutorial will cover the basics of pyrometallurgy, hydrometallurgy, and transportation logistics for end-of-life (EOL) LIBs. The technical presentation will share recent innovations in recycling with cathode healing™, a direct recycling technology pioneered by Dr. Sloop.

The cathode healing™ technological development will highlight 3rd party manufacturing validation for using direct recycled EOL LIB materials for making new batteries. This is a breakthrough for the industry that demonstrates a high level of technical development with secondary manufacturing. That is, using recycled material in manufacturing new products.

Highlights of the demonstration include using recycled nickel manganese cobalt oxide (NMC) and lithium iron phosphate (LFP) chemistries from EOL LIBs obtained from industrial sources to make new active materials for manufacturing new LIBs. This shows OnTo's deliberate philosophy for technology development from concept through operational demonstration. The figure below shows the third-party results for using recycled LFP in making new batteries.

Recent price references for recycled LFP in China show the value to be near $4/kg. The technologies used to produce the reclaimed LFP can be operated well below the Chinese price point. The patent portfolio includes coverage in China, which provides for a foundational component to defend and utilize direct recycled material in modern manufacturing of LFP and NMC batteries.

Breakthrough silicon anode technology: ready for market, built for scale

Ionel Stefan, Chief Technology Officer, Amprius Technologies

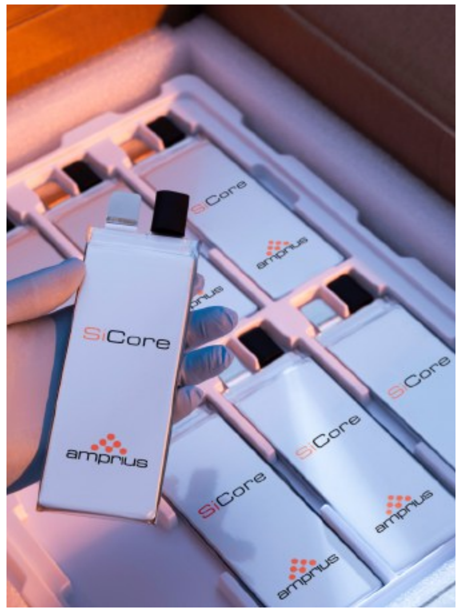
Ionel Stefan is Amprius' Chief Technology Officer. He joined Amprius in its very early days in 2009 as a senior scientist, initially to lead electrochemistry for silicon nanowire anode-based lithium-ion batteries. Dr. Stefan now leads Amprius' development of silicon nanowire electrochemistry, cell technology and product development. At Amprius, he has served as Principal Investigator on multiple projects, including NASA, Army, DOE and USABC-funded research and development efforts.

As electric mobility pushes the boundaries of performance, efficiency, and endurance, the limitations of traditional lithium-ion batteries have become increasingly evident. Amprius Technologies has developed a breakthrough solution with its proprietary silicon anode lithium-ion cells, delivering unmatched energy density, power output, fast-charging capability, and good cycle life.

This presentation will explore how Amprius' advanced battery technology is uniquely enabling next-generation electrification in both aviation and electric vehicles (EVs), while scaling to meet growing global demand.

With commercially available batteries with specific energy exceeding 450Wh/kg and volumetric energy reaching 1,000Wh/L, Amprius cells are currently among the highest-performing lithium-ion batteries available today. These performance levels—validated by customer adoption and third-party testing—provide a critical advantage in applications where weight, volume, and power are limiting factors.

Amprius' silicon anode technology is already powering some of the most demanding electric aviation platforms. In aviation, the energy-to-weight ratio is the defining metric for mission success. Our cells are helping unmanned aerial vehicles (UAVs), high-altitude pseudo-satellites (HAPS), and electric vertical take-off and landing (eVTOL) aircraft extend flight times, carry higher payloads, and improve operational efficiency. A notable example includes the recent 67-day record-breaking flight of AALTO's Zephyr HAPS aircraft—powered by Amprius batteries—demonstrating sustained operation in the stratosphere through night and day cycles.



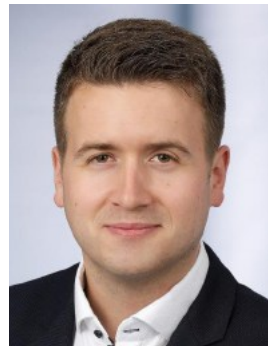
While aviation and aerospace are our primary markets, the advantages of silicon anode cells are equally compelling in ground mobility. The EV sector is increasingly constrained by the tradeoff between range, charge time, and battery size. Amprius' battery solutions offer OEMs a pathway to improve energy density by up to 100% over conventional graphite cells, enabling longer driving range, reduced battery pack weight, or smaller pack sizes.

This informative session will present an overview of our latest product roadmap, including the commercial availability of both our high-energy SiCore platform and the ultrahigh-performance SiMaxx platform. We'll also discuss the evolution of our contract manufacturing strategy, which has enabled Amprius to move from pilot-scale to gigawatt-hour production—an essential step in meeting the needs of our customers.

Whether in the air or on the road, Amprius is accelerating the transition to cleaner, more capable electric mobility. Our technology is ready for market and built for scale—setting a new benchmark for what lithium-ion batteries can deliver.

Conductive additives: tailored solutions enabling high-performance cathodes

Simon Lorger, PhD, New Business Development Manager, Cabot Corporation



Cabot's conductive additives, including conductive carbons, carbon nanotubes, and carbon nanostructure dispersions, are critical components lithium-ion batteries making up a small fraction of the battery composition but playing a crucial role in functionality and performance. The ability to tailor dispersions using novel and commercial conductive additives shows clear benefits in imparting electronic conductivity at the lowest loadings enabling high performance for various cell chemistries.

Conductive additives are small, but critical components of lithium-ion battery (LIB) electrodes, connecting active materials within a conductive matrix to allow an efficient charge transfer process. Though they are only about 1% of the total battery composition, conductive additives play a crucial role in the functionality and efficiency of lithium-ion batteries. Conductive additives are integrated into both the cathode and anode to help enhance electrical conductivity and improve battery performance, such as higher energy density and longer cycle life.

Cabot Corporation is a leading global specialty chemicals and performance materials company serving key industries for over 140 years. Cabot has established its position as a global leader in conductive additives for battery materials and plays an important role by providing tailored solutions that enable the next generation of high-performance batteries.

Cabot has a unique, comprehensive conductive additives product portfolio and vertical integration capabilities in conductive dispersions (slurries), backed by a deep understanding of battery material requirements. Cabot's conductive additives offer engineered performance for a variety of lithium-ion battery chemistries such as NMC, LFP, and LMFP.

Tailored solutions are a unique advantage of Cabot. The conductive dispersions, which can consist of a single additive or a blend of additives, offer manufacturers maximum flexibility. Cabot's dispersions are compatible with existing manufacturing processes and can be tailored to meet specific performance, cost, and processing needs. For example, blended CNT and conductive carbon dispersions enable battery manufacturers to increase the content of active materials and achieve improvement on electrode resistance when using Cabot's high surface area LITX® conductive carbons. This enables faster-charging, high-energy density batteries, promoting wider electric vehicle (EV) adoption crucial for reducing CO_2 and other emissions in the automotive industry.

In addition to enhancing battery performance, Cabot is driving solutions that address sustainability and lower costs. Lower additive loading reduces material consumption and the overall carbon footprint of battery production. This commitment is backed by a global network of manufacturing facilities and battery-focused research & development centers across Europe, Asia, and North America. Cabot's conductive additives are already utilized by 9 of the top 10 battery cell manufacturers and are used in collaboration with leading automotive original equipment manufacturers (OEMs), demonstrating their reliability and effectiveness, further validating product performance in real-world applications.

Cabot's tailored conductive additive solutions are enabling the next generation of high-performance cathodes not only by meeting performance demands, but also by shaping new possibilities and enabling a more sustainable future. Cabot delivers performance, innovation, and global reach, which empowers manufacturers to produce more powerful, reliable batteries, advancing the transition to an electrified world.

Cathode active material calcination refractory saggars for a competitive, resilient and circular European supply chain

Inigo Anza PhD, Global Technology Director, Technology & Product Development, Morgan Advanced Materials - Molten Metal Systems

A fundamental concern for CAM manufacturers is how to achieve and retain operational excellence in their calcination tunnel kilns. Morgan Advanced Materials pioneers the first ever western-made, long lasting, recyclable, lightweight and energy efficient saggars for CAM manufacturing. Made with proprietary recipes, these saggars will bring reduced cost of ownership, decreased inventories, zero waste and supply chain resilience.

Production of polycrystalline co-precipitated NMC811 cathode active material (CAM) requires on average 10,000 refractory saggars. These carry the cathode precursor across a tunnel kiln for its calcination for around 30 calcination cycles, before they are damaged and disposed of. Europe's saggars demand for 2026 is forecast to reach 250,000 saggars and to explode up to 5million in 2030, or 30,000 tonnes of saggars.

Saggars operational expenses, today

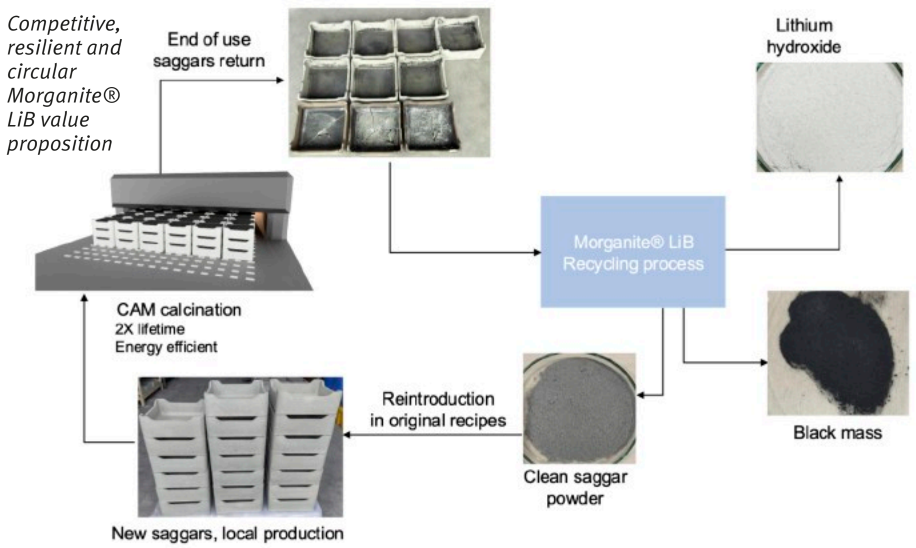
A typical 10,000 tonnes CAM 5GWh annual production tunnel kiln, has approximate annual operational expenses of 7-8M€ for oxygen gas consumption, 2M€ of electricity consumption and 1M€ saggars consumption (or 250k€ per GWh). Besides that, there are significant challenges to cope with – long supply chains extending to the Far East where saggars are produced, and end-of-use saggars being a hazardous waste that needs to be dealt with.

Saggars expenses, tomorrow

Novel premium cathode powder developments like single crystal NMC, higher nickel contents up to NMC955, and alternative manufacturing methods like the dry cathode synthesis method (which skips the precursor hydrometallurgical step) require 50-100°C higher operating temperatures, 5-10hours longer calcination times and purer and more aggressive chemicals inputs. These are likely to have a saggar lifetime reduction of 3X (down to 10 calcination cycles) and quite often a 3X capacity reduction (from 6-7kg to 2-3kg) of CAM powder per cycle and saggar. Saggars annual operational expenses may therefore increase to over 1M€ per GWh or 5M€ per 10,000 tonnes tunnel kiln.

The opportunity

This presentation will review the mechanism by which saggars get damaged, degrade and eventually fail, and what mitigation actions CAM manufacturers are taking to reduce saggars operational expenses on their premium CAM developments. It will finally present the value proposition of Morgan's saggars solution – Morganite LiB® – which shows 2X longer lifetime across the whole CAM powders quality spectrum, saggar recyclability, a localised de-risked supply chain and superior energy savings.



Competitive, resilient and circular Morganite® LiB value proposition

Li metal anode innovation at scale

Marina Yakovleva, Director, R&D and New Business Development, Rio Tinto

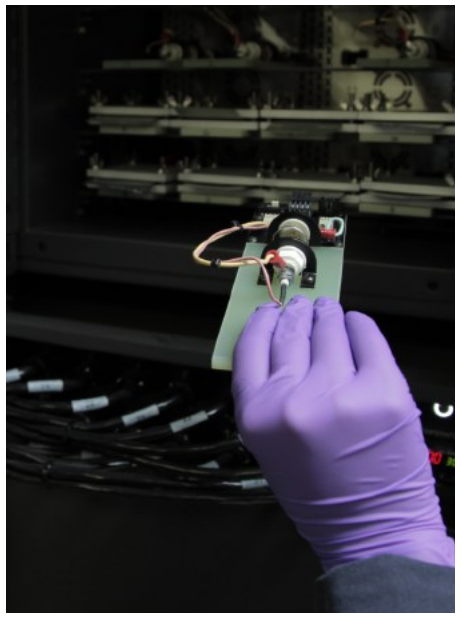
Lithium-metal anodes offer exceptional energy density but face challenges such as manufacturability, dendrite growth and instability. This work explores scalable innovations to overcome these barriers, enabling safer, high-performance batteries for broad commercialisation.

At Rio Tinto, we are leveraging cutting-edge approaches and strategic industry partnerships to pioneer technologies that enhance battery safety, performance, manufacturing efficiency and sustainability.

Our LIOVIX® product is a unique printable lithium formulation that improves the performance of lithium-ion, lithium metal and Li/S batteries. This breakthrough innovation helps reduce manufacturing costs and enables the next generation of battery technology, while enhancing safety and sustainability.

Since LIOVIX® delivers lithium in a stable, protected form, it reduces the need for extremely stringent environmental conditions for handling and manufacturing. LIOVIX® also gives battery makers greater control and precision in how much lithium they use (thereby significantly reducing waste), while boosting process efficiency and throughput, and opening pathways to transition from conflict minerals towards more accessible battery materials.

With LIOVIX®, Rio Tinto is finding better ways to meet the demands of today and raise the bar for tomorrow's battery technology.



Powering the future: niobium-based Li-ion batteries for heavy-duty electrification

Dr Alex Groombridge, Chief Technology Officer, Echion Technologies

Alex is responsible for the technology vision, the industrialisation of Echion products and strategic development and direction of the business. He is excited by disruptive innovation and the challenge presented by the decarbonisation of transport and tackling climate change. He is a keen implementer of rapid change and brings that energy and mindset to his role at Echion.

Industries with ambitions to decarbonise operations that rely upon heavy-duty vehicles, such as mining, transportation and construction, are not being served by the batteries on the market today. Common electric vehicle (EV) battery technologies do not provide the safety, charge rate and temperature dependence to make decarbonising these industries a realistic goal.

These performance restrictions are driven by fundamental limitations in the anode active materials used in most EV batteries today (graphite, silicon, lithium-titanium-oxide). To address these, we need new active anode materials that increase available energy density, and boost Li-ion diffusion while avoiding issues of lithium (Li) dendrites. If new battery technologies are to be adopted at scale, they must be able to deliver both high performance and low total cost of ownership, whilst avoiding the supply chain risk that is associated with many rare earth minerals.

At Echion Technologies, our niobium-based anode active material, XNO®, is able to meet the unique performance characteristics required by industries reliant on heavy-duty vehicles. It provides best-in-class Li-ion diffusion, no Li dendrites, and is highly stable. This enables battery cells that can fast-charge in six minutes, last for more than 10,000 cycles, and operate a high power while at extreme temperatures (-40°C).

In order to ensure a robust supply chain, in late 2024, we opened our first production facility in Brazil together with the world's biggest supplier of niobium, CBMM. This facility can produce 2,000 tons of XNO® per year, roughly equivalent to 1GWh of Li-ion cells, ensuring we can meet demand for XNO® at scale.

Most recently, our technology has been proven in a common mining vehicle, a Toyota Land Cruiser 79 Series, retrofitted with XNO® for both full electric and hybrid operation. The Land Cruiser demonstrates the high performance of a battery pack powered by XNO® and we believe it could complete around 90% of a typical underground mine shift for a light utility vehicle on battery power alone. Furthermore, it will provide the opportunity to explore the effectiveness of regenerative braking and demonstrate how this can be utilised in future large electric mining vehicles.

Developed in partnership with Switch Technologies, this project has provided vital in-market end use data that I will be inviting you to explore with me at my presentation at AABC Europe 2025 on Tuesday 24 June.

I will be sharing with audience members the latest developments of niobium as an anode material and outlining how we will go further in the coming months through our roadmap for technical advancement. I hope to see you there.

Immersion-cooled battery technology and high-speed BMS

Nicolas Jaeckel, PhD, Team Leader, LION Smart GmbH

Nicolas Jäckel finished his PhD with the focus on structure and properties of supercapacitor and lithium-ion battery electrodes. He worked as the battery expert for Knorr-Bremse in the eCubator, an incubator focussing on the electrification of commercial vehicles. Now he is focussing on high-voltage batteries for various applications.

The future of electromobility depends heavily on innovative solutions in battery technology. LION Smart, a company of LION E-Mobility AG based in Garching near Munich, has positioned itself as one of the leading providers of intelligent battery solutions. With years of industry experience and a strong focus on performance, safety, and efficiency, the company is setting new standards - especially in the field of immersion-cooled battery systems.

Technological excellence through immersion cooling and high-speed BMS

Immersion-cooled battery technology improves thermal management by fully submerging battery cells in a dielectric fluid, enhancing the battery's dynamic behaviour, efficiency, and lifespan.

Combined with high-speed BMS that include EIS, real-time analytics, and precise state estimation, this innovation optimises battery performance and ensures safety even under very high charging and discharging rates. As a result, LION Smart offers a unique solution tailored to the requirements of the next generation of vehicles.

Ideal for high-performance applications

Thanks to its outstanding thermal stability and ability to handle extremely fast charge and discharge cycles, this battery technology is particularly suited for applications with high power demands. Whether in high-performance sports cars or in electric trucks that must deliver consistent power under demanding conditions – the immersion-cooled solution from LION Smart excels in reliability, efficiency, and maximum safety. The capability of fast charging while maintaining thermal stability makes this technology the ideal choice for vehicle classes where power, availability, and endurance are critical.

Why LION Smart is the right partner for immersion-cooled batteries

LION Smart has already successfully completed proof-of-concept projects with an OEM customer for PHEVs, demonstrating best-in-class cooling performance and optimal thermal management. The BMS solution with single-cell monitoring, including EIS, leverages advanced algorithms for precise determination of SoH, SoC, and other state parameters (SoX). In addition, the system enables early detection of risks such as thermal runaway or lithium plating – crucial factors for ensuring safety and reliability. This solution is now ready for nomination and industrialisation, offering OEMs a mature and future-proof technology platform.

Innovation meets practical experience

LION Smart impresses not only through technological innovations but also through its deep understanding of customer needs and industrial implementation expertise. With state-of-the-art testing and development centres in Germany and a dedicated team of experts in battery systems and software development, the company is ideally equipped to deliver tailored solutions quickly and efficiently to the market.

Conclusion

In a world increasingly shifting towards electromobility, the importance of reliable and high-performance battery systems cannot be overstated. With its immersion-cooled battery technology and state-of-the-art Single-Cell BMS, LION Smart provides an innovative response to the growing demands for safety, efficiency, and fast charging capabilities. OEMs looking for an experienced and forward-thinking partner should strongly consider LION Smart—for the battery of the next generation.

Analysis of process water from recycling of Li-ion batteries

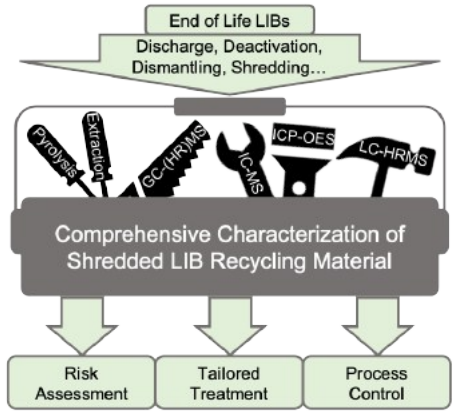
Sascha Nowak, PhD, Head of Analytics & Environmental, Electrochemical Energy Technology, University of Münster

Water-using recycling processes—such as wet crushing and electrohydraulic fragmentation—generate large amounts of contaminated process water, resulting in increased costs for the disposal of hazardous waste and safety guidelines. To improve wastewater management, safety, and sustainability of water-assisted recycling processes, comprehensive knowledge of the battery components in the water are required. Analytical techniques can play an important role during these processes, including wet shredding processes, wastewater management, and analytical techniques.

The widespread use of lithium-ion batteries (LIBs) in a multitude of industrial and private applications has led to the need for recycling and reutilisation of their constituent components. Water-using recycling processes – such as wet crushing and electrohydraulic fragmentation – generate large amounts of contaminated process water, including cathode active material, graphite, binders, and electrolyte components, resulting in increased costs for the disposal of hazardous waste and safety guidelines.

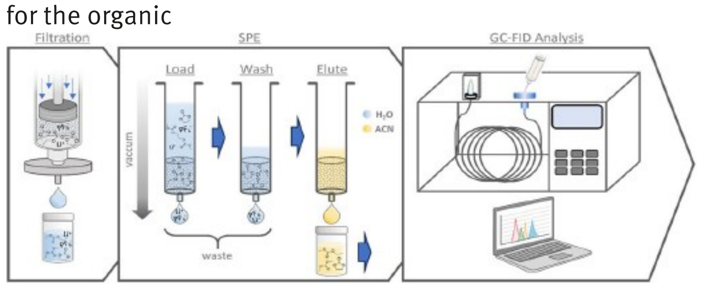
To improve wastewater management, safety, and sustainability of these water-assisted recycling processes, comprehensive knowledge of the battery components in the water are required. Analytical techniques support and validate these processes, including wet shredding processes, wastewater management, and quality control.

Therefore, comprehensive application of a wide range of analytical methods enables a better understanding of elemental composition and present organic species. Despite material complexity and lack of information on material history, an understanding of the present recycling material can be obtained.



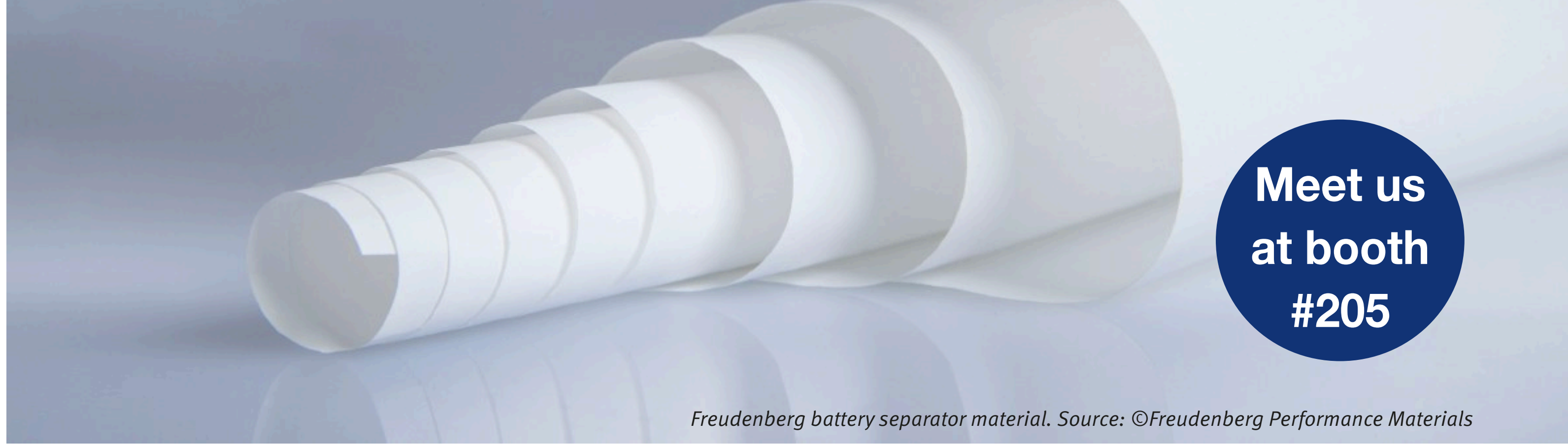
Source: Peschel et al. Chemistry - A European Journal, Nr. 28 (22): e202200485. doi: 10.1002/chem.202200485.

Beside the information about the remaining compounds like metals or other elemental impurities, which are accessible by already established methods, especially for the organic compounds and conducting salt residues inside the wastewater, quantitative information is needed for regulation, management and processing. However, water can interfere with the GC column and lead to degradation and the large volume expansion demands smaller injection volume, which makes the task challenging. Normally, volatile organic electrolyte solvents and their decomposition products are quantified using different gas chromatography-detectors like flame ionisation or mass spectrometry. Nevertheless, in this case, a different approach is needed. Therefore, a quantitative extraction of the analyses from the wastewater is mandatory. Solid-phase extraction (SPE) is a common approach to solve these issues, but was so far not applied to lithium ion battery recycling wastewater. A novel method was established to quantify the amounts of organic solvents in the wastewater.



Source: Buchmann et al. Advanced Energy and Sustainability Research, 2400311. doi: 10.1002/aesr.202400311.

Freudenberg innovative battery separator solutions for stationary energy storage systems and further applications



Freudenberg battery separator material. Source: ©Freudenberg Performance Materials

Freudenberg Performance Materials (Freudenberg) is the leading manufacturer of innovative technical textiles for nonwoven battery separators..

The Freudenberg range of battery separators increase the cycle-life, performance and safety of batteries for stationary energy storage systems, as well as batteries used in transportation, communications and computer systems. This includes nickel-cadmium, nickel-metal hydride, nickel-zinc, nickel-hydrogen, metal-air and lead-acid batteries plus many more.

A wide range of solutions due to broad technology platform

One highlight is the latest unique surface finishing technology that provides excellent electrolyte absorption as well as increasing the speed. The company combines this new finishing and a variety of other finishes with its versatile nonwoven technologies to develop further custom-made separators that meet the needs of energy storage system manufacturers and other battery manufacturers in the aviation, rail vehicle construction or computer systems sectors.

Freudenberg has the broadest range of nonwoven technologies in the industry, including wetlaid, drylaid and spunbond processes. These offer unique capabilities to tailor material homogeneity and uniformity, electrolyte absorption, wicking rate, air permeability, thickness and tensile strength.

With production sites on several continents, Freudenberg can manufacture locally and offer major battery manufacturers optimal service.

Role of Freudenberg separators

Freudenberg high-performance nonwoven separators play an important functional role in batteries. Besides their primary function of separating the electrode and cathode, Freudenberg separators form an electrolyte reservoir in the battery, and contribute to enhancing battery functionality, self-discharge, and durability. What is more, they help to prevent short circuits by avoiding dendrite growth.

About Freudenberg Performance Materials

The company supplies textiles for a broad range of markets and applications such as apparel, automotive, building interiors, building materials, healthcare, energy, filter media, shoe and leather goods as well as specialties. In 2023, the company generated sales of more than €1.4 billion, had 32 production sites in 14 countries around the world and had more than 5.000 employees. Freudenberg Performance Materials attaches great importance to social and ecological responsibility as the basis for its business success.

In 2023, the Freudenberg Group employed more than 52,000 people in around 60 countries worldwide and generated sales of some €11,9billion. For more information, please visit www.freudenberg.com.

Advanced cell diagnostics: Coventry University's contribution to European projects on monitoring tools for prototype energy storage systems

Tazdin Amietszajew, PhD, Associate Professor in Battery Diagnostics, Coventry University

Innovative battery diagnostics, key to high performance and safe systems, are emerging across Europe. Our projects include prototype cells with distributed thermal arrays, fibre-optics and reference electrodes for battery optimisation and self-healing. These adaptive methodologies suit various systems and industrial applications. Integrating new monitoring solutions into cells and BMS provides unprecedented insights into battery state for characterisation, prototyping, and optimisation.

Diagnostics go hand in hand with new batteries prototyping, crucial for achieving high performance without jeopardising safety. Coventry University sits at the forefront of exploring advanced diagnostic tools for prototype cells, leveraging cell prototyping lines to incorporate distributed thermal arrays, fibre-optics, reference electrodes, and other technologies aimed at battery optimisation and healing. These adaptive methodologies are designed to suit various systems and industrial applications, providing unprecedented insights into battery state for characterisation, rapid prototyping, and optimisation for deployment.

The integration of new monitoring solutions into prototype cells and BMS offers detailed insights into previously only estimated battery's conditions, due to the challenging nature of sensitive yet chemically harsh in-cell conditions. With the influx of new materials and chemistries, meeting safety, performance requirements, and accurate prognostics remains a significant challenge. This is where prototype diagnostics come into play, utilising the synergy between electrochemistry, electronics, and AI data analysis.

Coventry University's projects focus on monitoring prototype battery systems performance. These tools are adaptable for many types of cell. The novel technologies being developed span from flexible printed circuit boards for thermal, magnetic, and gas sensing, through fibre optics for temperature, mechanical strain, and lithium ions movement monitoring, to photodiodes for detecting electrode and electrolyte colour changes, which serve as indicators of SoC and SoH.

Notably, a recently finished project, SeNSE, has successfully assembled cells with embedded thermo-electrochemical sensing arrays, subsequently culminating in the development of a full battery module equipped with a BMS capable of adaptive system control based on in-cell sensor data. Our current projects take this a step further, e.g. HealingBat utilising the embedded sensors to trigger a self-healing mechanism.

Embedding these advanced diagnostic tools into prototype cells presents its own set of challenges. However, access to prototyping lines across Europe, such as AIT in Austria or FFB in Germany, and Coventry University's own facilities, has proven extremely beneficial. These resources, mixed with our cross-disciplinary expertise enables the successful integration of sensors and diagnostic tools into prototype batteries, facilitating comprehensive testing and optimisation, shortening the system evaluation time or increasing the insights into its performance.

The demands placed on battery performance are increasing all the time, and the use of embedded adaptive diagnostics is going to play a crucial part in meeting those. We are getting approached more and more by industry players asking for the cutting edge cell diagnostics solutions. We also see this trend reflected by the scientific community, such as in the Batt4EU 'Strategic Research and Innovation Agenda', where battery sensing is seen as one of the enablers towards development of safe energy storage technologies.

Unlocking battery insights: advancing aging diagnostics with digital twins

Serena Carelli, PhD, Battery Modelling, Electra Vehicles Inc.

Understanding battery aging is key to improving safety, performance, and longevity. Electra's EnPower Cell Design Studio and Cell Digital Twin transform laboratory data into actionable insights. In this session, we showcase how integrated degradation modelling and automated diagnostics identify aging modes and mitigation strategies. With real-world use cases, we will also demonstrate how these tools deliver predictive insights to optimise design and ensure future-ready energy solutions.

As electrification expands, understanding battery aging is critical to ensuring safety, performance, and longevity. The EnPower Design Suite combines physics-based modelling, AI analytics, and Digital Twin architecture to provide predictive insights across the battery development lifecycle.

The platform supports the full battery development cycle, from design exploration and virtual prototyping to degradation analysis and system-level optimisation. Central to its innovation is integrated degradation modelling paired with automated diagnostic workflows, enabling early detection of failure modes and formulation of effective mitigation strategies.

Battery aging is driven by a complex interplay of electrochemical, thermal, and mechanical degradation mechanisms. Models such as Pseudo-2D (P2D), Single Particle Models (SPM), and (soon) Equivalent Circuit Models (ECM) capture key aging pathways, including:

- Loss of Lithium Inventory (LLI) from SEI growth or lithium plating
- Loss of Active Material (LAM) due to structural degradation
- Resistance growth from passivation or electrolyte breakdown
- Capacity fade under thermal and cycling stress

The Cell Design Studio facilitates early-stage simulation of battery performance by enabling virtual comparisons across materials, chemistries, and geometric configurations. Users can assess critical metrics such as state-of-health, remaining useful life, and risk scores across experimental datasets.

The Cell Digital Twin builds on this by ingesting lab data to calibrate aging models in real time. It tracks key indicators like resistance, capacity fade, and thermal behaviour while dynamically updating internal parameters to generate an evolving health profile. Machine learning components automate model retraining, flag outliers, and forecast system behaviour under operational stress.

The Battery Digital Twin scales these capabilities to module and pack levels, enabling system validation, load scenario testing, and thermal optimisation – all without extensive hardware iteration.These tools support diagnostic-driven mitigation strategies, such as optimising material choices, refining charge protocols, and developing adaptive control algorithms that adjust to real-time battery health. This approach shortens the design-test-refine cycle, reduces reliance on physical prototypes, and accelerates development.

By linking simulation, testing, and AI diagnostics in a feedback loop, EnPower supports a closed-loop R&D workflow. Simulations inform prototyping, experimental data improves model accuracy, and predictive insights guide ongoing design refinements. This cycle reduces development time, cuts costs, and enhances decision-making.

With EnPower Design Suite, battery developers gain a powerful toolkit for diagnosing aging, simulating performance, and delivering future-ready energy solutions with confidence.

Coming to America: lessons learned from new factory investments

David Verner, Director of Energy Strategy, Gresham Smith

David Verner has more than three decades of experience working with national and international clients on major investments in diverse markets including energy storage, advanced manufacturing, and automotive facilities. Most recently, he is providing executive leadership and oversight for multiple battery giga-factories ranging from a 2GWh facility in a renovated existing building up to a 47GWh, 4,300,000ft² greenfield plant representing more than $4.5 billion in investment. David has spoken and written extensively about plant design, lean design and construction, site selection and other topics.

Establishing a manufacturing operation in the United States differs significantly from other countries. To help navigate these differences, four key areas deserve focused attention.

1. Understanding the regulatory environment

In the U.S., laws and regulations are decentralised across three levels of government: federal, state, and local. While federal laws apply nationwide, most project-related issues—such as permitting, taxation, and environmental regulations—are managed at the state or local level. Because each state operates under its own regulatory framework, it's essential to factor these differences into your site selection process.

2. Site selection – location strategy vs. technical evaluation

Selecting the right site is one of the most impactful project decisions—but companies often rush from identifying a preferred location into incentive negotiations without properly evaluating the technical suitability of the land. This can result in cost overruns, delays, or even project abandonment.

It's helpful to view site selection as two separate efforts:

- **Location Strategy** narrows options based on high-level factors such as labor markets, logistics, tax incentives, and infrastructure.
- **Technical Evaluation** follows, focusing on factors like environmental impacts, geotechnical conditions, grading requirements, and regulatory constraints.

3. Assembling the right project team

Ultimately, the success of your project comes down to the people executing it. Owners should not underestimate the need for experienced, dedicated support. Design and construction projects require skill sets that are different from day-to-day operations. Hiring a full-time owner's representative—or freeing up internal resources of their existing responsibilities—is critical.

4. The role of contractual relationships

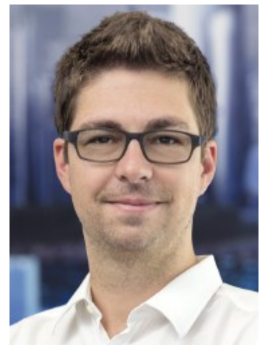
The structure of your contracts will influence team behaviour. Aim for methods that promote collaboration—such as design-bid-build with early contractor involvement or integrated project delivery. Creating a cooperative culture from the outset is essential, especially when teams span multiple countries and disciplines.

Avoid separating construction and process budgets, which often leads to misaligned priorities. Joint planning and clear decision-making protocols—especially around escalation paths—support better coordination and quicker, informed decisions during project execution.

Laying the groundwork for long-term success

Doing business in the U.S. requires understanding a different set of rules. Focus on regulatory nuances, conduct robust technical evaluations, invest in the right team, and choose collaborative contract structures. These decisions will shape your project's success well beyond the groundbreaking.

Secure twinning for the upcoming EV battery regulations with digital battery passport solution



Wenzel Prochazka, PhD, Senior Product Manager, Electrification Systems, NXP Semiconductors Austria

In order to securely "twin" a real battery with its cloud-based virtual needs to use tags or unique markings in transporting goods and parts implement unique IDs in cells and modules, secure storage on a and communication methods that respect CRA and GDPR together with EU battery regulation.

The European Union (EU) passed the new battery regulation, which is based on the digital product passport "DPP" legislation and is inherently linked to the GDPR and CRA. In this year, the implementation deadlines continue to require an increasing scope towards full implementation and challenges for some of the importers have become obvious. In its full implementation stage, which will be reached in July of 2027, the EU battery passport will require secure twinning to meet the new privacy and cyber security requirements.

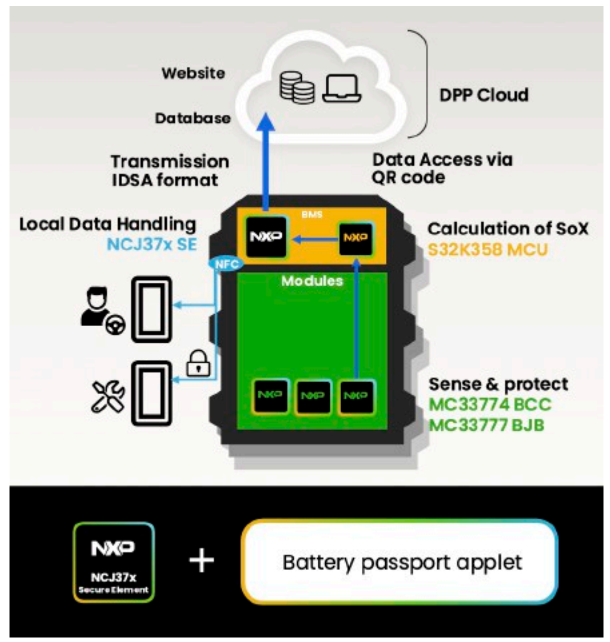
What is secure twinning? It means that the physical battery has a secure endpoint, and the cloud system can trust the receive data to not be tampered with or altered. Also, it means that in case any kind of tampering or tuning is recognised in the data, there is a way for the OEM to trace back to the battery and be sure that the battery under question is the one that has been targeted. Measures can be applied by the OEMs to bring the battery back into conformity.

Having the secure endpoint in the battery itself instead of the telematics unit of the car will provide flexibility and effort reduction in case the battery needs to be exchanged or reutilised in the second life application. In this way, the battery is securely twinned over its full lifetime until recycling with the cloud representation of the battery passport.

NXP is offering a solution for the battery passport based on its secure element NCJ37x for automotive and SE52 for BESS and other industrial use cases. These both feature a specific applet dealing with all the data that needs to be stored for the battery passport and the access management for people with legitimate interest (link www.battery-pass.eu). Since the NCJ37x is also an NFC device, the battery passport data can be locally provided even in case of a low voltage system disconnect or failure of the battery.

Additionally, all the memory write protection and persistence of the data even after a reflash of the BMS software (as required by the legislation) can be handled by the secure element without needing to change the microprocessor of the BMS system. This will save all OEMs from needing to redevelop the BMS system in between the delegated act publication (end of 2025) and the full implementation timeline (middle of 2027).

Overall, the proposed solution is flexible and fast responding to the implementation of battery passports not only in the EU but also in other parts of the world looking into the future. It is a software defined solution and can be adapted to evolving requirements.



Battery cost reduction: strategies and market dynamics

Dr Wolfgang Bernhart Senior Partner, Automotive Competence Center, Roland Berger Strategy Consultants GmbH, and Dennis Roman Gallus, Roland Berger GmbH

Outlook on achieving manufacturing targets with on-demand supply balance for Li, Ni, Co, Mn, and graphite; alternative feedstock and processing routes; comparing costs and CO2 emission; strategies to secure critical raw materials adopted by major players; framework for holistic evaluation of manufacturing strategies.

To comply with the EU's stringent emission regulations, expanding the market share of battery electric vehicles (BEVs) is crucial, particularly beyond the 'early adopters'. This broader market requires affordable, high-volume vehicles and faces several challenges:

Cost disparity of BEV vs. ICE: stems from higher component costs, particularly for batteries and electronics. This disparity compresses margins and forces compromises on customer features, diminishing the appeal of available models.

Limited entry-level options: By early 2025, only three BEVs in the EU will be priced below € 20,000. High battery costs severely impact especially entry-level vehicles.

Competitive pressure from China: Chinese brands are offering BEVs at significantly lower prices than their European counterparts, intensifying competition and pressuring local manufacturers. To boost BEV sales profitably, OEMs must focus on reducing battery costs through material cost optimization and enhanced R&D and process efficiency.

Material cost optimisation

Optimising material expenses is vital for reducing battery costs. Chinese leading battery producers have achieved >20% lower costs (see Fig 1) compared to EU OEMs through:

Economies of scale: Gigafactories enable large-scale production, spreading fixed costs over more units and reducing per-battery expenses.

Supply chain integration: Vertical integration grants greater control over raw material sourcing and processing. Fully integrated Chinese OEMs like BYD can achieve marginal costs for LFP cells as low as $ 33/kWh.

Technology innovation: Integrated cell-to-pack designs and larger cells (e.g., BYD Blade, CATL Shenxing) lower material costs while enabling low-cost chemistries like LFP beyond the entry segment, by enhancing energy density and fast charging capabilities on system level.

Enhanced R&D and process efficiency

Streamlining production processes and reducing development time are crucial for cost savings. Key strategies:

'Battery first' approach: Designing vehicles around the battery rather than customised options reduces development time and costs.

PDP and testing optimisation: Streamlining product development process and testing can lower costs. Faster adoption of new technologies can yield additional cost advantages.

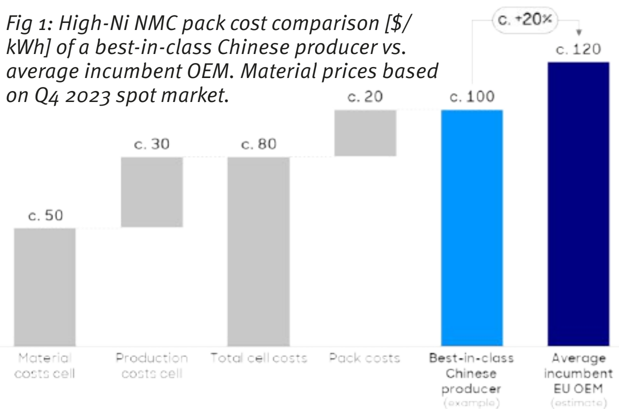
Production process optimisation: Innovations such as alternative CAM production routes and dry coating in cell production can further lower costs. Improving overall equipment effectiveness and minimising material losses contribute to overall gains.

Localisation of production: Locating factories closer to raw materials and automotive assembly plants reduces logistics costs and enhances supply chain resilience.

Industry impact and outlook

Battery costs have decreased dramatically, plummeting nearly 90% from $1,420/kWh in 2008 to $140/kWh in 2023, with further reductions expected. In 2024, average battery pack prices fell by 20% to $115/kWh, edging closer to cost parity with ICEs. Aggressive battery cost reduction efforts are essential for Western OEMs to compete globally and drive profitable electric vehicle adoption.

Fig 1: High-Ni NMC pack cost comparison [$/kWh] of a best-in-class Chinese producer vs. average incumbent OEM. Material prices based on Q4 2023 spot market.



Beyond trial-and-error: generative engineering & digital twins for scalable battery innovation

Dr. Katharina Gerber, Engagement Manager for Battery Industry, Siemens DISW

In today's battery market, innovators require a strategy beyond hands-on trial-and-error. This session introduces the Siemens Xcelerator portfolio—a unified suite of advanced software tools that integrates generative engineering, digital twins, and AI-driven analytics to help battery developers lower prototyping costs, speed scale-up, and enhance design outcomes. Through integrated simulation, data management, and streamlined workflows, manufacturers can build the foundation for smart factories—expediting time-to-market while ensuring consistent quality from initial materials research to full-scale production.

As global demand for advanced batteries grows across electric vehicles, aerospace, and energy storage, traditional trial-and-error development can't keep pace. A digital-first, generative engineering approach— powered by digital twins—is transforming how batteries are designed, validated, and scaled.

This integrated, model-based methodology combines high-fidelity, physics-based simulations with AI-driven design exploration. Engineers can virtually screen chemistries, electrode architectures, and electrolyte formulations, dramatically accelerating early-stage innovation while reducing dependency on physical prototyping.

Advanced simulation tools model electrochemical behavior, thermal dynamics, and mechanical stress at both cell and pack levels. These insights enable virtual prototyping under extreme conditions such as fast charging or thermal runaway, helping teams optimize for safety, durability, and performance from the start.

Digital continuity across the battery lifecycle supports informed decision-making from materials discovery to full system integration. Early-stage insights carry through to battery sizing, packaging, and deployment— ensuring design choices align with specific application needs across EVs, aircraft, and grid-scale systems.

Reduced-order models derived from detailed simulations enable real-time execution, supporting software- and hardware-in-the-loop testing for battery management systems. This seamless integration of virtual and physical validation significantly shortens development timelines and boosts agility.

By embedding intelligence at every step, generative engineering and digital twins unlock scalable, predictive battery development. The result: safer, more efficient, and cost-effective batteries.

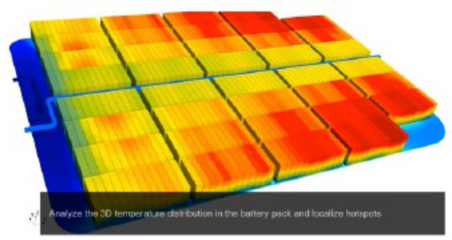


Fig. 1: Thermal Mapping of Battery Pack. 3D temperature distribution map visualizes heat gradients within a battery pack during operation. The model highlights suboptimal thermal zones—critical insights that guide targeted improvements in cell arrangement, cooling strategies, and overall thermal design.

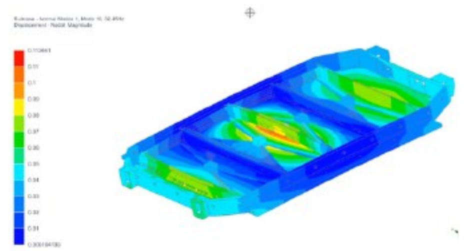


Fig. 2: Structural Integrity of EV Battery Pack. 3D visualization of stress and deformation patterns across the battery pack structure during vehicle operations helps to ensure the mechanical robustness of the battery enclosure and internal components under real-world conditions.

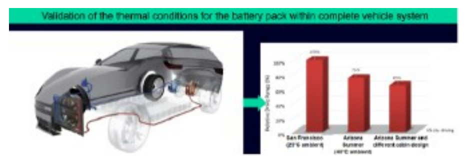
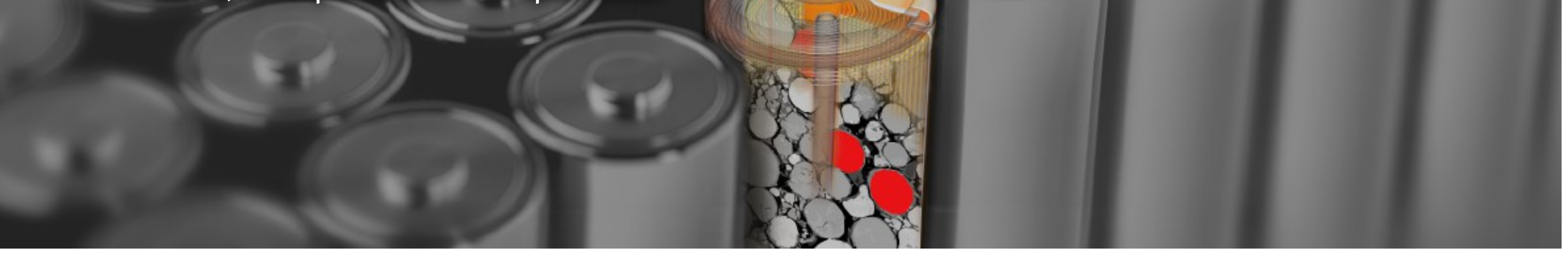


Fig. 3. System-Level Performance Prediction: simulated predicted performance of an EV battery pack under various driving conditions improves range estimation accuracy.

Analytical solutions for impurity control in battery manufacturing

Zhao Liu, Senior Manager Market Development,Clean Energy, Thermo Fisher Scientific

Effective impurity control in battery manufacturing is essential for ensuring optimal performance, safety, and longevity of batteries. This presentation will explore analytical solutions designed to identify, quantify, and mitigate impurities throughout the battery manufacturing process, from the quality control of incoming raw materials to inline process quality control. By employing advanced characterisation techniques, we share a comprehensive approach to analyse contaminants including metal ions, organic residues, and particulate impurities.



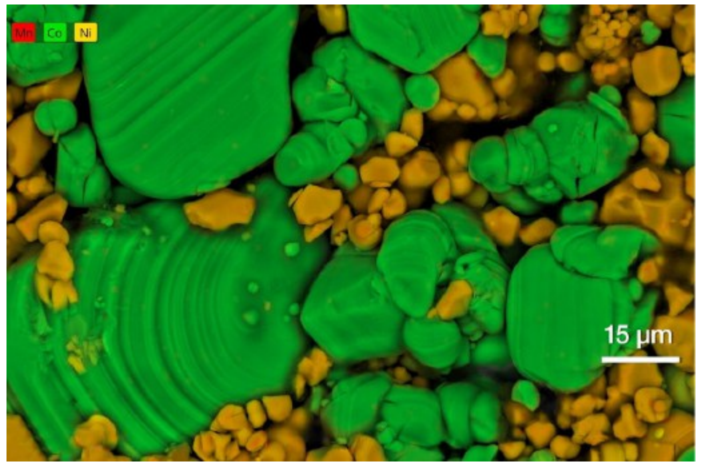
The growing demand for high-performance energy storage systems has intensified research into advanced batteries, particularly lithium-based batteries. As these systems become more complex, with increasingly engineered materials and architectures, understanding their physical, chemical, and electrochemical behaviour across multiple length scales is essential. From the nanoscale features of solid electrolyte interface layer to the macro scale integrity of full cells, every level contributes to performance, safety, and degradation mechanisms.

Multi-scale imaging characterisation techniques have emerged as indispensable solutions for probing the intricate structures and dynamic processes within batteries. Electron microscope technique, including scanning electron microscopy (SEM), focused ion beam scanning electron microscopy (FIB-SEM), and transmission electron microscopy, offering insights at different spatial resolutions and dimensions at multiple length scale, where they enable comprehensive analysis of battery materials, interfaces, and failure modes. In addition, imaging analysis software like Avizo provides more in-depth quantitative analysis on the battery structure-performance correlations.

In particular, the combination of multimodal and multi-scale imaging allows researchers to bridge the gap between atomistic mechanisms and macroscopic device behavior. This approach facilitates a deeper understanding of phenomena such as lithium plating, dendrite growth, particle cracking, solid–electrolyte interphase (SEI) formation, and mechanical degradation under cycling. Moreover, these techniques support both ex situ and in situ/operando investigations, enabling the observation of materials in realistic electrochemical environments.

SEM: Apreo ChemiSEM

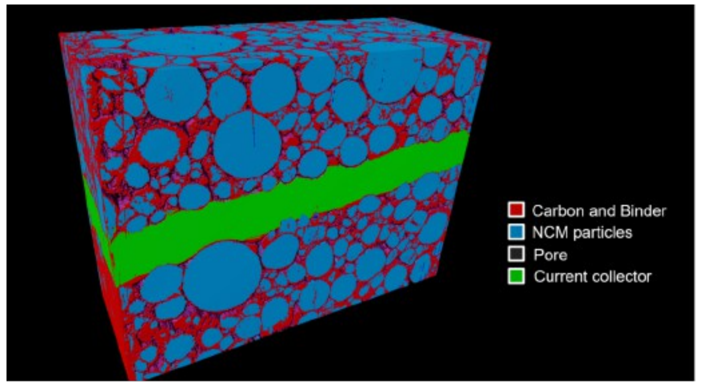
The new Thermo Scientific Apreo ChemiSEM System is designed to enhance battery research by streamlining the imaging process, making it easy for both seasoned professionals and beginners to use. Addressing the integration challenges of adding EBSD to existing workflows, the Apreo ChemiSEM provides exceptional sensitivity, speed, and precision for complex material analysis. With its advanced SEM imaging capabilities, integrated EBSD, and Energy Dispersive Spectroscopy (EDS) in one unified platform, it delivers high-resolution imaging and accurate chemical composition analysis. This eliminates the need for separate equipment and complicated software, saving time and simplifying system alignment and analysis.



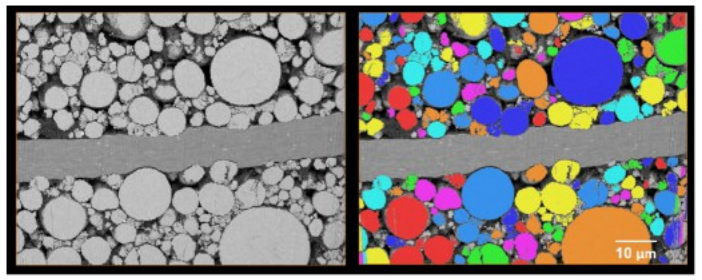
ChemiSEM image of a battery anode's surface showing cobalt's (in green) an nickel's (in yellow) distribution (15 keV)

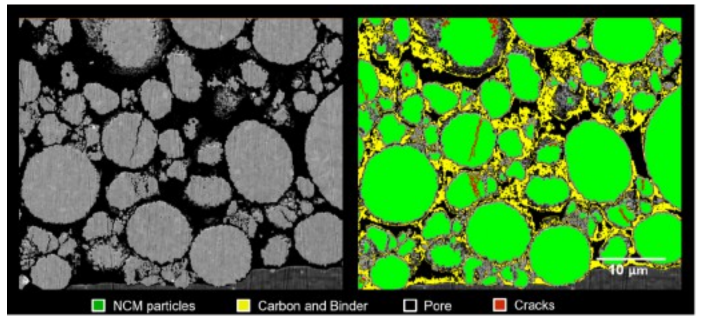
FIB-SEM: Helios 5 Hydra DualBeam

The Thermo Scientific™ Helios 5 Hydra DualBeam (plasma focused ion beam scanning electron microscope, PFIB-SEM) is a versatile multi-application tool that has four different ion species (argon, nitrogen, oxygen, and xenon), allowing you to choose the ions that provide the best results for battery samples.



Segmentation of NCM particles, pore, binder, and current collector using Helios 5 Hydra DualBeam and Avizo Software

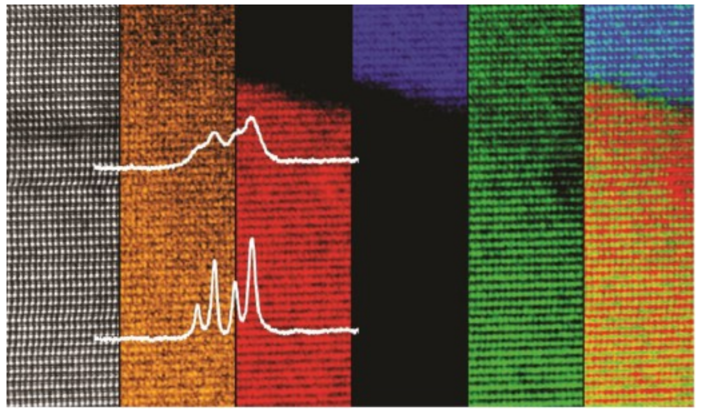




Individual particles segmentation. Resolution 50 x 63.5 x 100 nm using Helios 5 Hydra DualBeam and Avizo Software
Segmentation of NCM particles, pore, binder and cracks using Helios 5 Hydra DualBeam and Avizo Software

TEM: Iliad Scanning Transmission Electron Microscope

The new, fully integrated, and advanced Thermo Scientific™ Iliad (S)TEM features the new Iliad EELS Spectrometer and Energy Filter with the dedicated Zebra camera as well as the NanoPulser, the new electrostatic beam blanker to enable best experience of analysing chemical and structure information of battery sample up to atomic resolution



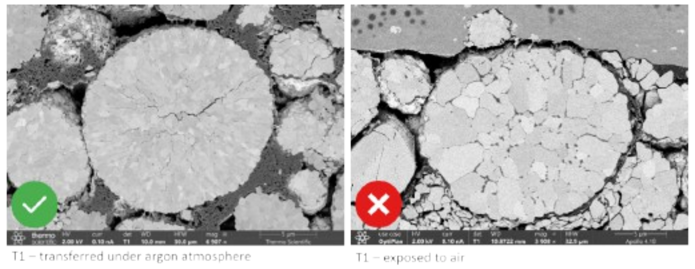
Advanced optics integration for superior EELS performance. Atomically resolved EELS elemental map of LaMnO3/LaFeO3 interface.

Inert gas sample transfer workflow

For air- and moisture-sensitive materials, this challenge is even more pronounced as the sample integrity must be preserved to characterise the material in its native state. In the context of battery research, reactive elements such as lithium can experience degradation when exposed to the environment during analysis.

Consequently, microscopy solutions with complicated sample transfer processes can increase the time it takes to image materials and make preservation more difficult. Using an inert gas sample transfer workflow that employs a sample transfer solution such as Thermo Scientific™ CleanConnect™ not only helps preserve sample integrity but also enables uncomplicated sample handling with easy integration into SEM solutions.

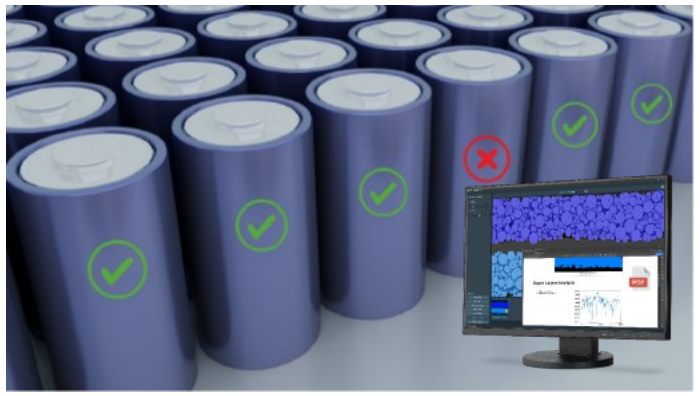
Inert gas sample workflows can be employed with Thermo Fisher Scientific's SEM portfolio to perform microanalysis or microanalysis with polishing. In workflows where ion-milling and polishing is required, Thermo Fisher Scientific's Red Dot award-winning CleanMill Broad Ion Beam (BIB) system can quickly prepare the sample for imaging thanks to its high-energy ion source.



AI-powered battery characterisation and quality control: Avizo Software

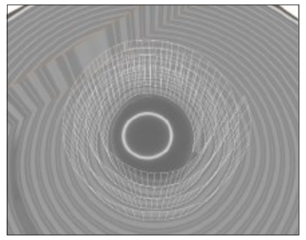
As battery fabrication increases, suppliers now produce both more materials and new materials. Quality control is thus very important to keep productivity high and batteries safe. Since battery chemistry is multi-scale, electron microscopes are commonly employed to check for cathode secondary particle cracking, calendaring, layer thickness, and sample homogeneity.

Though some work can be done by eye, reproducible and trustworthy image analysis is now routinely employed to speed up work and keep the analysis unbiased. Thermo Scientific™ Avizo™ Trueput Software automates SEM images analysis. Engineers at Thermo Fisher Scientific custom design a workflow for your needs, and Avizo Trueput runs the analysis in a few clicks. Reports from this software are easy to read and trigger counter-actions.

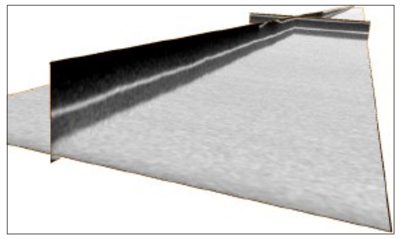


Battery cathode, active material connectivity analysis with Thermo Scientific PFIB DualBeam combined with Avizo Software

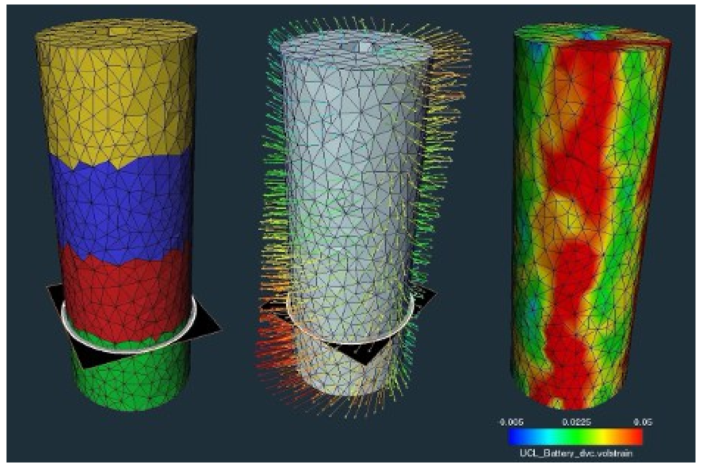
For more advanced work, or work extending into 3D, Thermo Scientific™ Avizo™ Software offers unique flexibility for working with image data. For example, if you wish to match imaging and spectroscopy data from 3D FIB-SEM tomography, Avizo Software gives users the power to co-register, co-visualize, and segment these volumes. Since this software is flexible, it also works well with TEM tomography for nanostructure analysis such as the studies of lithiation, solid-electrolyte interphase, and cathode particle delithiation. CT data pose no limitations, and analysis such as detecting delimitation, measuring deformation due to cycling or virtually unrolling the battery to inspect for defects can become routine workflows.



Cross-sections from helical CT of a cylindrical cell. Wireframe surface traces the anode and is used as a template for virtual unrolling.



Virtually unrolled volume. Using Avizo Software, this method permits viewing and measuring the layers of the cylindrical cell as a flat sheet.



Digital volume correlation (DVC) of the cylindrical cell before and after cycling using CT instrument and Avizo Software. Left image shows subregions to permit large volume study. Middle image shows the displacements as vectors. Right image overlays the volumetric strain from DVC onto the mesh generated from the CT data. Strain was heterogenous and greatest at the bottom of the cell near the anode tab.

In conclusion, as battery technologies continue to evolve, the role of multiscale and correlative imaging will become even more important. Ongoing advances in imaging resolution, image and data analytics, and in situ/operando capabilities are expected to further enhance our ability to probe dynamic processes within batteries. Ultimately, these developments will accelerate the discovery and optimization of materials and architectures that meet the increasing demands of energy storage applications in a sustainable and scalable manner.

Sodium-ion vs. lithium-ion: advancing low-voltage batteries for sustainable automotive applications

Brahim Soltani ,Team Manager, Battery & Safety, Sébastien Sallard, Senior Engineer, Battery & Safety, Alexander Fandakov , Team manager, Battery & E Traction, IAV France

The automotive industry is reducing emissions amid global warming concerns, with the EU planning a 2035 ban on internal combustion engines. While electric vehicles are key, complementary solutions like improving low-voltage batteries in mild hybrids are needed. Sodium-ion batteries (SIBs) emerge as a promising alternative to lithium-ion batteries, offering better cold performance, sustainability, and reduced reliance on critical materials.

The development of mild hybrid electric vehicles (mHEVs) with 48V batteries has recently gained interest among OEMs, with a significant increase in their market share. Among the various mHEV powertrain architectures, the P2 layout can be regarded as state-of-the-art, as it represents a very good trade-off between cost, complexity, and efficiency in CO_2 reduction.

The most common technology for storing energy in the 48V system in mHEVs is the LIB, among which LFP is now becoming the chemistry of choice. Compared to other chemistries, LFP batteries are cheaper, more durable, and safer. However, drawbacks include the accurate quantification of their state-of-charge, dependence on lithium price volatility, and reduced performance at low temperatures.

In recent years, commercial sodium-ion batteries (SIBs) have attracted growing interest. SIBs have lower energy densities compared to LIBs but are well-suited for power applications, offering robustness, long lifespans, and stable performance at low temperatures. Additionally, SIBs can be nearly free of scarce and costly elements such as lithium, cobalt, nickel, and graphite, boosting this technology's sustainability.

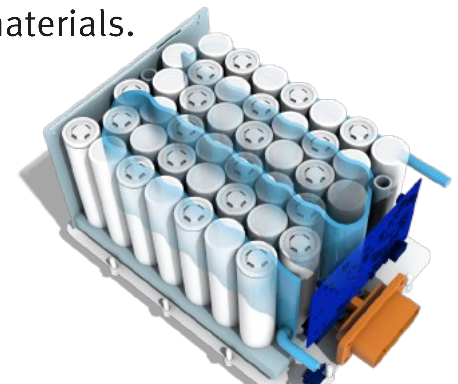


Figure 1: 48V SIB concept

To demonstrate the capabilities of SIB in low-voltage applications IAV with HiNa developed two 12V SIB L3 and L5 prototypes, as a proof of concept. We now introduce a P2 48V sodium-ion mHEV battery concept in a comparative study against state-of-the-art LFP batteries, considering both power and energy cell types:

- In addition to the inherent safety of the used SIB cell, the 48V module features venting channels and interface. A liquid side cooling system was also integrated to improve thermal management efficiency
- The comparative study indicates that at standard temperatures (≥20°C), the maximum current peak of the SIB module is equivalent to that of an LFP-based module. However, as temperature decreases, LFP modules exhibit a sharp drop in maximum discharge current, while the SIB shows more stable performance.
- The supply chain for SIBs is significantly less critical than for LIBs, as the materials used in SIB cells (no cobalt, lithium) are available and abundant.
- While SIBs are currently more expensive than LFP, this is expected to change as the technology matures and scales, potentially shifting the cost-benefit balance in favour of SIBs in the near future.
- A Life Cycle Assessment study concluded that the overall environmental impact of SIBs is approximately 70% lower than that of LFPs, both currently and projected into 2030.

From chemistry to commercialisation: developing battery cell specifications for electric vehicles

Maithri Venkat, Manager—Battery Cell Lifetime and Parameterisation, Lucid Motors, Inc.

Behind every high-performing electric vehicle lies a foundation of carefully crafted battery cell specifications. These technical guardrails transform raw materials and chemistry into consistent, scalable, and safe energy solutions. More than just numerical targets, they reflect deep engineering insight, customer understanding, and manufacturing discipline—bridging innovation and execution from lab to road.

As electric vehicles reshape the future of mobility, the battery cell sits at the crossroads of chemistry, engineering, and user experience. While new materials and formats often grab attention, the journey from laboratory concept to road-ready product depends on the careful definition of technical requirements. These requirements capture both the possibilities of electrochemistry and the demands of real-world automotive conditions. They translate cell behaviour into actionable inputs for thermal systems, powertrains, and battery management software—framing expectations for performance, safety, and longevity.

Clear, well-structured targets enable faster development, align supplier capabilities, and provide the foundation for scalable, high-quality production. A well-defined cell specification enables fast, confident iteration during early development and acts as a contract for mass production. It is the silent architect behind the scenes of every EV launch, ensuring that cell behaviour is not only technically sound, but aligned with customer expectations and regulatory constraints.

To move beyond lab-perfect performance and deliver real-world reliability, battery cell specifications must be grounded in how vehicles are truly used – not just how they are tested. This means integrating insights from fleet data, user behaviour, climate exposure, and long-term degradation patterns.

Rather than defining a single ideal target, robust specifications account for statistical variation—across production lots, operating temperatures, and aging profiles. Metrics such as energy retention, impedance growth, and safety thresholds are framed not just by averages, but by the tails of the distribution, ensuring that every cell within the pack contributes to a consistent customer experience over time. In this way, specifications become a practical expression of performance under uncertainty, built to withstand the variability of both manufacturing and the road.

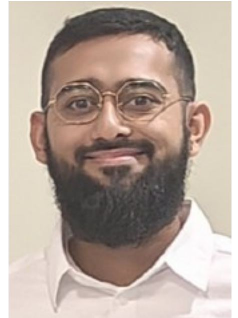
Once the targets are set, the responsibility shifts from definition to execution. This phase demands disciplined collaboration between OEM and supplier teams. The OEM defines the specification envelope in context of the full vehicle, while the supplier must demonstrate process capability and statistical control.

Quality teams on both sides play a central role in bridging lab assumptions with production outcomes. Incoming cell audits, SPC reviews, and deep dives on cell anomalies ensure that the delivered product reflects the intent of the specification. Software and controls teams tune diagnostic thresholds and derating logic around observed distributions.

In practice, a cell specification is less a finish line and more a framework for continuous learning. It evolves as pilot lines mature, as new form factors emerge, and as new field data highlights emerging risks.

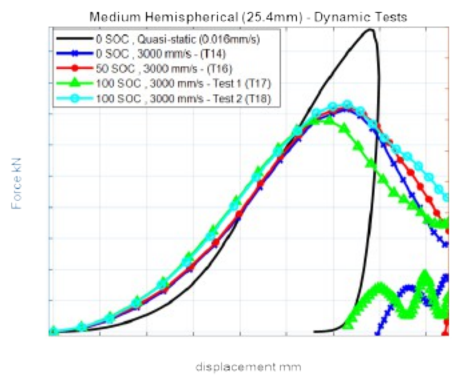
Mechanical testing and modelling of lithium-ion cells for EV safety

Huzefa Patanwala, Graduate Research Assistant, Electric Vehicle Safety Lab, Temple University



This study investigates the mechanical response of pouch and prismatic LIB cells under quasi-static and dynamic loading conditions to enhance EV battery safety. A full suite of quasi-static tests was conducted at 0% SoC, while dynamic testing was performed on a limited set of load cases to mimic real-world crash scenarios. Additional dynamic impact testing was conducted for pouch cells at 100% SoC and varying impact speeds. A finite element analysis (FEA) model was developed to predict cell behaviour. The findings provide key insights into how form factor, impact speed, and SOC influence battery behaviour and failure mechanisms.

The widespread adoption of electric vehicles (EVs) marks a significant shift in transportation, with lithium-ion batteries serving as their primary energy source. However, these batteries pose safety risks, particularly in high-speed crashes, due to their potential for thermal runaway following mechanical abuse. Reports of EV fires and battery failures highlight the need for a deeper understanding of how lithium-ion cells respond to impact and deformation. Ensuring battery safety and crashworthiness requires both experimental characterisation and the development of finite element models to assess abuse and failure under real-world conditions.



This study examines both pouch and prismatic cells to provide a comprehensive assessment of their mechanical response under varied quasi-static and dynamic loading conditions. Since we have included two form factors in our study, their mechanical response is analysed individually and compared to identify variations and trends in behaviour. Additionally, as prismatic cells from different manufacturers can vary significantly in design, this study includes two distinct prismatic cells to provide further insight into how design differences influence mechanical response.

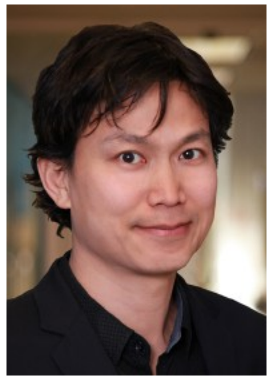
A full suite of quasi-static tests was performed at 0% SOC, covering localised loading scenarios (flat punch, hemispherical punch, rod indentation) and global loading scenarios (three-point bending, axial compression). To investigate high-speed mechanical abuse, dynamic

impact testing was conducted, allowing for comparisons between quasi-static and high-speed response. Additional dynamic testing, only for pouch cells, included SOC variations (0–100%) and multiple impact speeds, allowing the evaluation of mechanical response, temperature rise, and internal short-circuit behaviour across various SOCs.

To complement the experimental work, a finite element model (FEA) was developed in LS-DYNA to predict cell behaviour under both quasi-static and dynamic loading conditions. By integrating experimental testing with finite element modelling, this study provides key insights into how cell type, impact speed, and SOC affect lithium-ion battery response.

Enevate breakthrough unlocks ultra high energy density cylindrical cell

Benjamin Park, PhD, Founder & CTO, Enevate Corp.



In the evolving landscape of energy storage, silicon-cell technology is of innovation and potential. This talk will explore work done at showing benefits of Enevate's unique silicon cells, highlighting their exceptional performance, and commercial viability. As the demand for sustainable energy solutions intensifies, Enevate's cells are leading drive for next-generation energy storage solutions.

As the market for cylindrical cells continues to grow and find new applications across multiple sectors, Enevate has achieved a significant milestone with the successful build of an ultra-high energy density 21700 cell. Enevate, a pioneering battery innovation company enabling extreme fast charge and high energy density battery technologies for electric vehicles (EVs) and other markets, announces that it has applied its innovative battery solution to cylindrical cells for the mobility market and other high energy applications.

Enevate has successfully engineered 21700 cylindrical cells with its partners, which achieve an impressive electrical charge capacity greater than 6.5Ah, and an ultra high energy density greater than 300Wh/kg, utilising Enevate cutting-edge battery technology. This achievement significantly surpasses current industry energy cells, which typically average 5Ah. The substantial increase in capacity directly translates to longer driving range for electric vehicles, addressing a key concern for consumers and accelerating EV adoption. As development progresses, Enevate is targeting a 4C charge rate for future iterations of the 21700 cell, while maintaining the exceptional greater than 6.5Ah capacity. This will not only enhance range but also dramatically reduce charging times, bringing the convenience of EV charging closer to that of traditional refueling.

"EVs utilising cylindrical cells are an important and large market segment in the automotive market. Enevate's advanced battery technology is ideally suited to serve this market," said Dr. Benjamin Park, Enevate Founder and Chief Technology Officer. "EV drivers are increasingly demanding vehicles with longer battery runtimes to alleviate range anxiety. Our new 21700 cell directly addresses this need, offering a compelling solution for both auto makers and consumers."

Furthermore, the newly developed 21700 cell has demonstrated remarkable cycle life, exceeding 1,000 cycles in rigorous full depth of discharge cycle testing. This longevity ensures a prolonged lifespan for both the battery and the vehicle, reducing replacement costs and contributing to the overall sustainability of electric vehicles.

"The successful first-time build of the 21700 cell underscores the advanced capabilities of Enevate's technology and the exceptional talent of our team," said Enevate CEO Bob Kruse. "This is the first of many cylindrical cell milestones on our roadmap. We are looking ahead to building larger cylindrical cell formats further demonstrating the technology's potential."

This breakthrough positions Enevate at the forefront of battery innovation, driving the industry towards higher performance, and more energy dense, battery solutions. The enhanced energy density, faster charging capabilities, and extended cycle life of Enevate's 21700 cell are set to revolutionise the EV market, paving the way for broader adoption and a cleaner future.

Québec: Europe's raw battery material partner in North America

Nikolaus Hottenroth, Attaché Économie et Innovation, Délégation générale du Québec à Munich

Since the end of 2019, Nikolaus has held the position of Attaché Économie et Innovation at the Quebec representative office in Munich, where he supports Quebec companies expanding into German speaking markets . He is especially interested in the battery supply chain and automotive, energy, aluminium and construction sectors.

Québec is a stable, reliable jurisdiction where mineral development strategies break new ground in a quickly evolving global context.

Québec has more than 20 producing mines, 49 mining projects, and well over 300,000 active mineral titles. Investments in the mining sector in Québec were \$5.7 billion, and the value of all mineral shipments was \$12.8 billion in 2023. In 2024, Québec amended its Mining Act, which now demonstrates a clearer path for reaching social acceptability and maximising geological potential.

Québec has the most diversified mineral substances of all Canadian provinces. Seventeen different minerals are mined, or projected to be mined: gold, iron, zinc, copper, titanium, niobium, lithium, feldspar, graphite, mica, salt, nickel, platinum group elements, rare earths, and phosphate are among the top of the list. Silver, cobalt, tantalum, magnesium and other minor metals are also extracted from certain producers. The variety of minerals is in part due to Québec's vast area, 1.7 million square kilometres, as well as a diversity of geological environments, and its 150 years of mining know-how.

In 2020, Québec became the first jurisdiction in Canada to publish a forward-looking critical and strategic mineral plan with four main orientations simply summarised as explore, develop, recycle, and communicate. Our vision was to become a leading jurisdiction for the development of strong ESG projects, notably thanks to its production of low-cost green renewable hydroelectricity.

Québec also structured programs to enhance the circularity of products by increasing the recycling of consumed raw materials and the traceability of raw battery materials.

The results of our plan are significant: the number of critical and strategic mining projects has increased by 61% between 2019 and 2024; mining investments have also increased for critical and strategic materials by 91%, from about \$3 billion in 2019 to \$5.8 billion in 2024, according to our preliminary data.

To attract investors, Québec has developed one of the most generous tax credits for mineral exploration in Canada, reducing the cost of capital for the entire cycle from exploration to development. As such, exploration expenditures also increased dramatically for critical and strategic materials, going from \$142 million in 2019 to \$477 million in 2024, thus increasing by 235%, according to our preliminary data.

The success of the critical and strategic mineral plan was also made possible thanks to the visionary and coherent government policies, such as a complete integration with Québec's battery strategy, the 2030 Plan for a Green Economy, the Northern Action Plan, and Québec's Green Hydrogen and Bioenergy Strategy.

Through innovative and collaborative initiatives, Québec has become one of the first commercial producers of lithium in eastern North America, the first scandium producer in North America, the only niobium producer in North America, and the top graphite producer in North America. Québec also hosts the newest lithium producer in Canada, and innovations to develop gallium from waste byproducts in Québec's aluminium industry are also underway.

Indeed, Québec is positioning itself as a stable, reliable partner of raw materials for like-minded jurisdictions throughout the world.

Sustainable nickel and cobalt for the energy transition

Anne Oxley, Founder & CTO, Brazilian Nickel

Brazilian Nickel's Piauí project will produce nickel and cobalt in product (MHP) to feed EV cathode production using a lower cost, intensive, simple and flexible heap leaching process. This process carbon but BRN has several work programs looking at innovative the carbon footprint or even eliminate the CO2 emissions with a a net carbon zero or even carbon negative producer Anne will speak recent updates to the project and will be chairing sessions on Raw Materials.

As most of us are aware, securing supplies of minerals that are essential to the energy transition has become a top priority for industry and governments in today's highly unpredictable trade environment. When these critical materials are concentrated in the hands of just a few players, the risk of production disruptions and wider economic damage becomes significant.

The world urgently needs alternative supply chains for responsibly sourced and produced raw materials, and that's what we are ready to deliver at Brazilian Nickel.

Brazilian Nickel's flagship project, the Piauí Nickel Project, is a shovel-ready nickel laterite heap leaching project in northeast Brazil with average production of 26ktpa nickel and 1ktpa cobalt. The company expects to start delivering materials that are essential to the clean energy transition and EV battery value chain within 3-4 years.

Brazilian Nickel has seen growing recognition that securing sustainable future supply of Nickel is crucial for Western EV battery manufacturers and their supply chains. Recently, BRN agreed preliminary offtake agreements with European battery materials processors Pure Battery Technologies and Electro Mobility Materials Europe SAS to support EV production in Europe.

The Piauí Nickel Project will extract nickel and cobalt using heap leaching, which has lower capital and operating costs and lower GHG emissions than other laterite processing methods including high pressure acid leaching (HPAL) and only produces solid residues. The process has been extensively demonstrated and proven on the site. As a final step before full-scale commercialisation BRN constructed a small-scale operation that first produced nickel contained in MHP in 2022.

BRN is also working on innovative ways to further reduce its CO_2 emissions even further.

MHP Production at the PNP 1000 iperation

Brazilian Nickel's main focus is to get the Piauí Project operating as soon as possible, but it is evaluating other projects where heap leaching can help deliver a successful operation.

Sourcing materials responsibly is crucial for EV makers, given that their clients tend to be more aware of environmental and social issues than most. Brazilian Nickel's carbon-free power generated by its on-site sulphuric acid plant, which is integral to the heap leaching process, helps keep emissions low. Community engagement is integral to BRN's mission of producing sustainable nickel: more than 75% of our current workforce in Piauí is hired locally with 35% of BRN being female, meaning that the Piauí site has a positive social impact in an underdeveloped region. The Piauí site received the Nickel Mark award, the first in Brazil to do so, a further verification of BRN's commitment to responsible and sustainable production.

Brazilian Nickel is positioned to become a significant player in the global market for EV battery raw materials. With resource-rich sites in Brazil, proven technology, and world class team, the company is ready to bring the Piauí Nickel Project into full production.

The role of the supply chain in delivering cost-competitiveness in batteries

Sam Adham, Head of Battery Value Chain, CRU

Battery manufacturers and automakers are prioritising cost reduction as the main survival mechanism in a market with intense price competition. We will examine how the best do it: supply chain strategies go hand-in-hand with manufacturing know-how to deliver cost-competitiveness and the value of new strategic partnerships born out of battery- and auto-makers' involvement in raw materials as well as the competition for the best feedstock and where the bargaining power lies in the supply chain.

Amid the geopolitical turmoil and pullbacks of investments throughout the battery supply chain, there is still something to look forward to: batteries are now super-cheap and still getting cheaper.

Average production costs have fallen steeply, driven by plummeting material prices and incremental improvements in manufacturing efficiency. LFP battery cell costs are now approaching $45/kWh. Combined with intense price competition, this is enough to drive profound growth in demand for electric vehicles and battery energy storage systems.

How is this possible?

Cost-effectiveness primarily relies on specialist knowledge that can only be obtained over many years. Asian companies are the undisputed leaders in the battery sector. Nearly every aspect of cell production in China is so well-optimised that, in many cases, further improvements are becoming exponentially difficult to achieve.

Despite intense price competition, Chinese companies have a genuine underlying cost advantage, enabled through manufacturing excellence, supply chain efficiencies, and technical innovation.

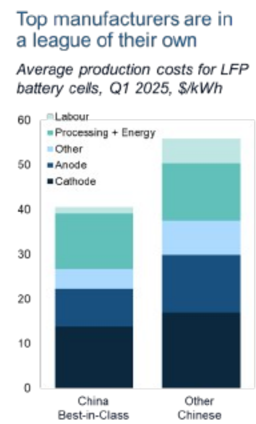
The power of these advantages is demonstrated by the top two manufacturers in China – BYD and CATL – whose dominance has shaped the industry into a near-oligopoly. Their cost-competitiveness gives them an edge over other manufacturers at a time when price competition is hitting profit margins in China's battery industry.

Costs have further room to fall beyond this. Although only incremental improvements are now being made, all cost parameters have yet to reach their maximum potential.

What is holding back cheaper batteries in the rest of the world?

It will take time for super-cheap batteries to truly proliferate globally. The cost of production outside of China is, generally speaking, inherently higher due to different labour and energy costs. Tariffs and trade barriers are rising on batteries, components, and input materials. New manufacturers lack the know-how to build batteries at scale. And automotive manufacturers are struggling with profitability in EVs such that they are not yet able to pass on the savings to consumers.

However, it is possible, through several realistic pathways, to reach a level of cost-effectiveness such that the end uses such as electric vehicles and energy storage systems are reasonably affordable.



Three key areas will make or break western production facilities: automation, energy prices, and factory yields. History tells us the latter is extremely difficult to master, and it is why new companies are struggling to ramp up.

Given this, it has always been our view that the European and North American battery industry will continue to consist of the Asian incumbents who, although being held back by investment risks, will soon proliferate their cost advantages to unlock more profound demand growth in those markets.

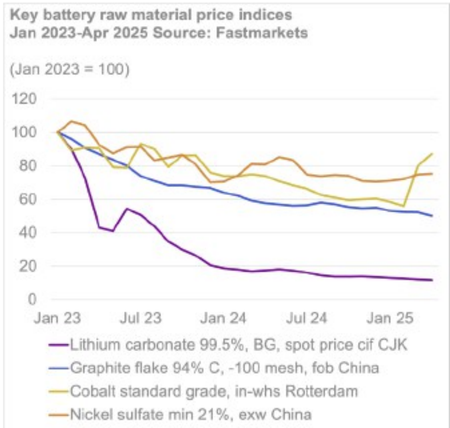
The state of the battery metals market

William Adams, Head of Base Metals and BRM principle analyst, Fastmarkets

William has been involved in the metals markets since 1986, he runs the research for Fastmarkets battery metals and oversees base and precious metals research. Fastmarkets as a Price Reporting Agency (PRA) provides price discovery on the battery raw materials and Fastmarkets Research aims to provide a clear and focused understanding of the metals markets. Prior to working for Fastmarkets, William worked with Rudolf Wolff & Co Ltd, which was one of the founding members of the London Metal Exchange, where he gained broad insight into all aspects of the metals markets, working in their London, New York and Tokyo offices.

Most of the battery raw materials are in a situation where there is significant oversupply and as a result prices have fallen to multi-year lows. The one exception is cobalt. Cobalt prices had been at multi-year lows, dropping below \$10 per pound in late-March, from around \$11/lb in December, but since the DRC introduced an export ban, prices have surged to \$16/lb. The higher prices may be temporary though as the export ban was for four-months only and despite the ban, production is likely to have continued as cobalt is produced as a co-product of copper.

The oversupply in all the battery raw materials has come about mainly as a result of China's keenness to build more production capacity, to win market share, and to lower raw material prices to make cheaper batteries for EVs and energy storage systems (ESS). They have built lithium capacity at home by developing lepidolite mines, as well as expanding brine and hard rock projects, graphite by building more synthetic graphite capacity in China, cobalt by building more capacity in the DRC and nickel and cobalt by investing heavily in Indonesia.

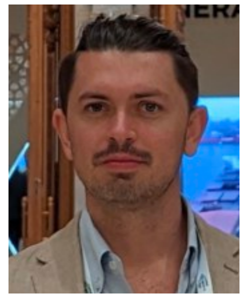


Low prices have also come about as demand, while not weak, has not be as strong as earlier projected. This is especially so for NCM lithium-ion batteries and that is due to a sudden slowdown in EV sales in Europe in 2024, following the removal of subsidies in some key markets, and due to the cost of living crisis, the affordability of EVs compared with ICE vehicles and some negativity in the press about EV ownership, including charging infrastructure. In the US, EV uptake has tended to be slower than in Europe, with charging infrastructure one issue and the preference for big trucks, that need big batteries and are therefore are expensive, being another.

As a result, demand for NCM batteries was not as strong as it could have been and not as strong as the mid-stream lithium-ion battery supply chain had planned for. So, inventories have built up along the supply chain. That said, while EV growth was not as strong as expected, it was still healthy, seeing 25% growth in 2024, globally. ESS demand was, however, stronger than expected and benefitted from the lower cost of batteries. But, ESS batteries tend to be built with LFP cathodes, rather than NCM cathodes, which again weighed on demand for nickel and cobalt.

Overall, the price weakness in the battery raw materials is much more to do with oversupply rather than weak demand and we are now in a situation where we are waiting for demand to grow to a level where it absorbs supply again. But, in this low price environment we expect more production cutbacks, which would help rebalance the market and provide some support to prices. We expect to see this unfold later in 2025.

Anode active material supply-chain developments and diversification



Joe Williams, Head of Technical Marketing, Syrah Global DMCC

Update on Natural Graphite Anode materials market developments, trade flows, and efforts toward diversification. We include some lessons from bringing up the first ex-China integrated production facility based in USA, and some messages to consumers and policy makers across EU.

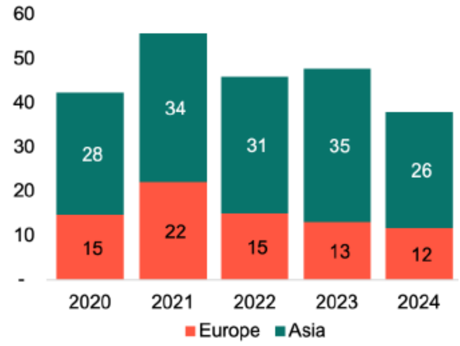
China holds a dominant position in the global graphite market, in extraction, processing, and finishing material into active anode material (AAM). Among all critical minerals, graphite has highest degree of geographic concentration, with China responsible for 80% of global mining output and nearly 100% of intermediate processing capacity.

As global geopolitical fragmentation continues, trade friction and disruption will continue. Regions must diversify the supply of critical materials infrastructure to ensure the sustainable growth of key industries such as electric vehicle manufacturing and energy storage.

Geographical concentration of mining and refining for critical minerals

The primary export markets for Chinese graphite materials include the US, Japan, South Korea, and increasingly Indonesia. Trade data from China Customs (2024) indicates growing volumes into Southeast Asia, reflecting broader investment in materials processing and battery manufacturing capacity across the region.

Indonesia is expanding its downstream capacity in battery materials, with companies such as BTR New Energy, CATL, and LGES investing in facilities for AAM production, battery cell manufacturing, and component assembly. This development is driving increased demand for imported graphite, primarily sourced from China.



China exports of natural flake graphite to Europe and Asia (kt). Source: China Customs Data

China exports of natural graphite flake

In both Europe and Asia, majority of demand remains from stable primary industries such as steel and foundry. Intermediate processing capacity for AAM is severely underdeveloped.

China exports of natural graphite AAM

China's exports of natural graphite AAM show growing demand across Europe and Asia between 2020 and 2024, with Hungary, Japan, and South Korea consistently among the largest importers. Notably, Germany and Poland show sharp increases over this period.

Graphite remains a key material for European cell production. Countries such as Germany, Hungary, and Poland continue to expand battery gigafactory operations. The European Battery Alliance (EBA) lists graphite as one of its strategic raw materials due to its role in lithium-ion anodes. Europe continues to depend heavily on China for graphite and AAM supply, as shown by rising import volumes into major hubs. Diversifying key supply chain inputs is critical for continuity planning, enhancing supply security and supporting the long-term viability of Europe's growing energy, autonomy and automotive sectors.

Syrah Resources' operational capabilities

Syrah Resources is a vertically integrated natural graphite and Li-ion battery AAM producer with operations in Mozambique and the US. Syrah's Balama asset holds the world's largest, and an exceptionally high-grade, graphite resource, the Vidalia facility in Louisiana produces high-purity AAM for lithium-ion batteries. Vidalia delivers high-purity, high-density AAM, meeting key customer specifications. As the only operational commercial-scale AAM facility in North America, Vidalia is undergoing qualification with tier 1 customers, with plans to expand production to 45ktpa to strengthen global battery supply chains.

The Vidalia AAM facility is currently operational. Should you wish to discuss AAM supply.

Building successful & sustainable battery raw material supply chains

Barry Jackson, CEO, Ascentia Resources

This presentation identifies how building sustainable raw-material supply chains can create competitive advantages for automotive and battery companies. It explores strategies for building resilient sustainable supply chains through ethical sourcing and the right partnerships. Attendees will discover market insights and how to develop sourcing strategies that capitalise on opportunities to achieve long-term successful sustainability in the battery ecosystem, reduce costs and risks, navigate market complexities, and improve competitiveness

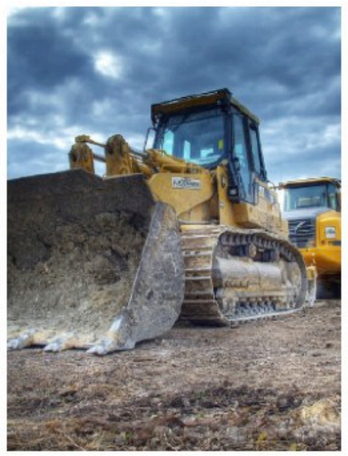
With 25 years of global experience in the metals and mining industry - spanning leadership roles at Anglo American, Outokumpu - Barry brings unmatched insight into the raw materials and supply chains that power the energy transition.

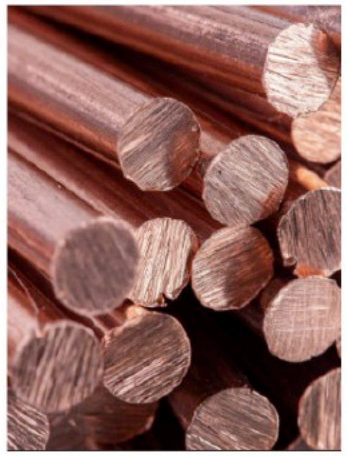
In his presentation, Building Successful & Sustainable Battery Raw Material Supply Chains, Barry will explore how ethical sourcing, strategic off-takes and robust supply strategies can unlock real competitive advantages for automotive and battery manufacturers. As the battery ecosystem grows in complexity and global significance, sustainability is no longer just a license to operate - it's a source of resilience and differentiation.

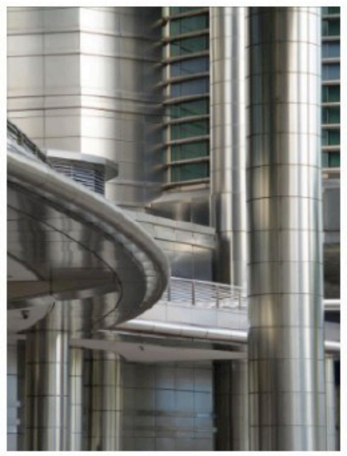
Barry will share cutting-edge market insights, practical frameworks and proven approaches to help attendees develop sourcing strategies that are not only sustainable but also commercially successful. Learn how to capitalise on emerging opportunities, navigate supply chain risks, reduce long-term costs and strengthen your market position.

Whether you're a procurement professional, sustainability leader, or strategy executive, this session will equip you with actionable tools to future-proof your supply chain and drive success in the rapidly evolving battery industry.

Be part of the conversation shaping the future of mobility and energy. Join Barry at AABC and gain a competitive edge through sustainable supply chain innovation.







Niobium anode battery technology for fast-charging and long-life applications

David Steven Jacoby, Managing Director, Energy Consulting, Boston Strategies International

Niobium anode battery technology offers a breakthrough in fast-charging and long-cycle-life energy storage, enabling significant lifecycle cost advantages across multiple transport and industrial applications. This presentation will showcase a detailed comparative analysis of niobium anode batteries versus conventional LFP batteries, demonstrating how transit buses, AGVs, forklifts, mining trucks, and e-ferries can achieve reduced fleet sizes, lower battery weight, lower battery volume, and improved operational efficiency.

The global electrification movement is accelerating, but energy storage systems must evolve to meet the rising demands of industrial fleets, transport operators, and power-intensive sectors. At this year's AABC, David Steven Jacoby, Managing Director of Boston Strategies International and a supply chain expert, will present groundbreaking insights on niobium anode battery technology, a high-power alternative that delivers both technical and economic performance at scale.

Niobium anode batteries offer rapid charge capabilities, extended cycle life, and reduced system volume and weight, solving multiple constraints that have limited the adoption of battery-electric fleets in industrial applications. David's presentation, rooted in detailed lifecycle cost analysis and real-world application data, will compare niobium chemistries with lithium iron phosphate (LFP) across six key use cases: transit buses, AGVs, forklifts, e-ferries, mining trucks, and port/airport tractors.

The results are compelling. Niobium-powered transit buses can reduce fleet size by 18%, eliminate battery replacements, and deliver a 36% total cost advantage. AGVs achieve up to a 77% reduction in battery volume and 38% lifecycle cost savings while E-Ferries, Mining Trucks, Forklifts and Port Tractors have up to 28% life cycle cost benefits. These improvements are not theoretical, they are based on actual product performance and validated commercial benchmarks.

David brings a distinctive perspective to this conversation. As a professor of operations and supply chain management at New York University and the University of Pennsylvania, Senior Fellow at Boston University's Institute for Global Sustainability, and author of eight books on energy and supply chains, David is known for connecting deep technical insight with actionable strategy. His career spans over 30 countries, advising on electrification, decarbonisation, and sustainable technology implementation.

At AABC, he will frame niobium technology not just as a battery innovation, but as a supply chain enabler, reducing energy intensity, improving operational efficiency, and reshaping fleet economics. His firm, Boston Strategies International, works closely with energy producers, equipment manufacturers, and operators to implement advanced technologies that reduce both cost and carbon footprint.

For decision-makers exploring the next leap in electrification, David's session offers a timely and actionable roadmap. Whether you are optimising fleet performance, reducing lifecycle costs, or planning for zero-emissions targets, this session will reveal why niobium might be a promising solution in today's battery landscape.

How software-defined batteries are redefining the charging experience

Ian Campbell, PhD, CEO & Co-Founder, Breathe Battery Technologies

Electric vehicles are becoming increasingly software-defined, from assistance systems to enhanced connectivity to battery technology. representing 30% to 57% of the total vehicle cost, it's natural that exploring the potential for software to optimise battery performance. of the software-defined battery, this session will explore the battery software and technology innovations powering the EVs of the future.

As electric vehicles continue to evolve, the boundaries between hardware and software are becoming increasingly blurred. From vehicle dynamics to user experience, software is playing a central role in shaping the future of mobility. Nowhere is this more evident than in the battery — the most valuable, performance-critical component of an EV. At AABC Europe 2025 (26th June, 09:35 am), Dr Ian Campbell, CEO and co-founder at Breathe Battery Technologies, will speak on this shift in his session titled “How Software-Defined Batteries are Redefining the Charging Experience.”

Batteries now account for 30% to 57% of the total vehicle cost, placing enormous pressure on OEMs to deliver performance, reliability, and longevity without inflating development timelines or budgets. While newer entrants are demonstrating the ability to launch vehicles within significantly shorter timelines, traditional models of development - often stretching over four to five years - are becoming increasingly unsustainable. This growing gap is pushing the industry to adopt smarter, software-driven approaches that can accelerate innovation and better meet evolving customer expectations. Ian’s talk will explore how the industry is moving away from manual calibration and static look-up tables, towards intelligent software layers capable of responding dynamically to the internal states of the battery.

Supporting this shift is the growing adoption of comprehensive software tools designed to improve every stage of battery system development. These solutions allow engineers to make better-informed design decisions earlier in the development process, providing greater visibility into trade-offs between performance, durability, and safety, allowing for more precise and efficient battery systems. They reduce reliance on extensive physical testing and enable more dynamic control strategies that respond to real-world conditions. With an ever-increasing software toolchain, OEMs are better positioned to optimise battery performance, reduce costs, and deliver higher-performing EVs to market faster.

As the session will reveal, the rise of software-defined batteries is not just a technological evolution — it’s a transformation in the very approach to battery system design and control. For attendees looking to stay ahead of the curve in EV battery innovation, Ian’s presentation promises both practical insights and a look at where the industry is heading next.

Sepion Technologies announces advanced thin-film separator coatings for Li-ion and Li-metal

Brian Sisk, PhD, CTO, Sepion Technologies

Lithium-metal battery research has for decades demonstrated energy density advantages, but those benefits have not overcome challenges with respect to charging, safety, degradation, cost, and system integration. In this presentation, we present a systems-focused, requirements-based approach that links systems engineering, relevant cycles, cost, and materials science to help optimize lithium-metal batteries for EVs.

US-based Sepion Technologies has announced new specialty coatings designed to improve existing Li-ion batteries now and help usher Li-metal batteries into the automotive market. Sepion’s products work differently than conventional ceramic coatings, yet perform the same essential safety functions while providing additional benefits. Sepion’s coatings improve energy density, shed weight, reduce moisture, and help block harmful metals from reaching the anode. Best of all, Sepion’s products are cost-competitive with standard ceramic coatings and are coated directly on a conventional polyolefin separator, making them a drop-in replacement in standard Li-ion Gigafactory manufacturing.

Sepion’s technology is based on advanced polymers that are extremely resilient to high temperatures (no measurable glass transition, decomposition near 400°C) and create a highly regular network of small pores (0.8–4.0nm). The temperature stability allows separators coated with Sepion technology to better maintain their shape at high temperature, which improves safety. The pore network helps ensure that Li passes through almost unimpeded, while harmful transition metals – Ni, Mn, Fe, Cu, Co, and others – are slowed or stopped.

For Li-ion, Sepion’s technology unlocks low-cost cathode materials such as LMFP and next-generation lithium-manganese-rich (LMR) materials, including high-voltage lithium manganese oxide (HV-LMO). Additionally, by improving energy density and reducing weight, up to 8kg can be saved per vehicle simply by using Sepion technology. Mass and volume savings are highly prized by automakers, so Sepion’s coatings provide significant value – in many cases, value that exceeds the price of the component, making them almost cost negative!

“Ceramic separators played a crucial role in the development of mass-market EVs by solving critical safety challenges without compromising power or cost,” reports Brian Sisk, CTO of Sepion Technologies. “We aim to disrupt incumbent technology through “smart” separators that enable high-performance and low-cost chemistries, while solving for the mass, moisture, and energy density challenges caused by those ceramic coatings.”

For Li-metal, Sepion’s technology helps improve power, life, and stability by optimizing the lithium/electrolyte interface. That stable lithium interface allows Sepion to charge Li-metal batteries in as little as 12 minutes! Combined with a non-flammable electrolyte for Li-metal, Sepion’s technology package for Li-metal allows cost, performance, and safety to be met for next-generation battery chemistries. “Sepion’s advanced Li-metal technology allows us to offer an unprecedented combination of low cost, high power, excellent safety, and strong cycle life – a rare combination for lithium metal batteries,” states Peter Frischmann, CEO of Sepion technologies. “We feel this technology is a missing piece of the puzzle that will help unlock Li-metal commercialisation.”

Sepion Technologies has begun commercialisation of its first product, market introduction is expected in late 2025 or early 2026.

Caption: Sepion’s coated separators (left) are applied using conventional thin-film coating techniques to a conventional separator (right), resulting in a separator that is lighter, thinner, and dryer than competing technologies, while also helping to block harmful metals.

Advancing quality control in battery electrode production through data-driven sensor technologies

Muhammad Momotazul Islam, Process Development and Process Monitoring, Fraunhofer IKTS

Quality control in electrode manufacturing is essential for producing high-performance batteries used in electric vehicles, renewable energy storage, and consumer electronics. This research explores advanced sensor technologies for monitoring wet film thickness and homogeneity. The study also develops sensors for inline defect detection, using AI-based neural networks for classification. The goal is to optimise coating parameters, enhance defect detection, and integrate adaptive control systems.

As global demand for high-performance batteries rises across automotive, stationary storage, and consumer electronics markets, ensuring consistent electrode quality has become a top priority for manufacturers. The 'Process Development and Process Control' research group at Fraunhofer IKTS in Germany is addressing this challenge with a cutting-edge approach to real-time monitoring, data analytics, and process optimisation for electrode coating in roll-to-roll (R2R) systems.

At the core of this development is a sensor-integrated quality control system designed to monitor wet film thickness, homogeneity, and edge profile geometry with high precision. Using advanced confocal sensor technology, the system delivers feedback on key parameters. The sensor integrated in the production system represents a holistic version by means of heterogenous data. These data are then processed and analysed to identify cause-and-effect relationships, providing operators with a deeper understanding of process stability and enabling tighter control of key parameters.

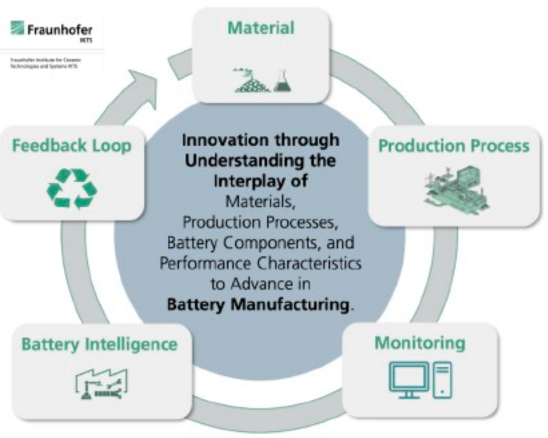


Figure: Process interactions and performance pathways in battery manufacturing in IKTS.

This real-time insight supports the implementation of quantitative quality gates, allowing for early detection of deviations and immediate corrective action – resulting in reduced material waste and more consistent product output.

To directly address coating defects inline, the team at Fraunhofer IKTS has developed a novel laser speckle photometry (LSP) method. This inline sensor captures high-resolution surface data and applies AI-driven neural networks for the rapid detection and classification of coating anomalies such as voids, streaks, and edge elevations. Results are benchmarked against reference measurements and electrochemical performance to ensure that real-time corrections translate to improved cell behaviour.

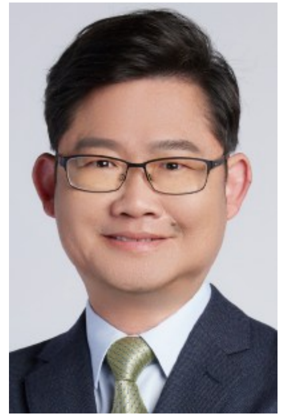
This comprehensive manufacturing approach is being applied across a range of material systems, including NMC622, graphite, and LFP, with a focus on adaptability to meet evolving production demands. The framework combines hardware, advanced data processing, and data-driven decision to create a modular, future-proof quality assurance platform.

These developments will be showcased by emphasising how intelligent control integration into battery production can unlock greater manufacturing efficiency, product consistency, and performance. Demonstrations and case studies will highlight how the system enables tighter tolerances, smarter defect handling, and greater process transparency across the entire battery manufacturing chain.

Smart manufacturing system for LMFP

Jack Lee, Vice President, HCM Co., Ltd.

As a critical cathode material for lithium-ion batteries, LMFP is gaining significant industry attention for its potential to enhance battery performance and sustainability. HCM is leading the charge in LMFP development with its strong in-house equipment R&D capabilities, enabling both material innovation and large-scale production. This presentation will explore the advancements in key manufacturing equipment, the application of CFD simulation technology, and the integration of digital intelligent manufacturing systems.



HCM, based in Taiwan, has over a decade of experience in R&D and production of lithium manganese iron phosphate (LMFP) cathode materials, with strong background in powder equipment. As LMFP gains traction in EV and energy storage markets for its safety, long cycle life, and cost advantages, challenges like high production costs and strict quality control persist.

To meet these demands, HCM combines advanced equipment, automation, and energy management to reduce labor, improve yield, and enable scalable, high-quality LMFP production. Beyond manufacturing, HCM also provides turnkey solutions, delivering total equipment and process integration tailored to customer needs.

Accelerating innovation with CFD simulation

In LMFP production, spray drying and calcination are key to achieving high-performance cathode materials. The spray dryer transforms slurry into fine, uniform powder, directly affecting cathode electrochemical performance. Using Computational Fluid Dynamics (CFD) simulation, we optimised nozzle design to achieve finer, more consistent particles, reducing development time and costs.

For calcination, temperature uniformity is essential for complete material reaction and product quality. Through CFD simulation and furnace redesign, we developed a multi-layer kiln system that ensures stable heat distribution and thermal efficiency. This design not only enhances reaction uniformity and product consistency but also reduces equipment footprint by 75%, enabling more compact, scalable production setups.

Automation and smart manufacturing

A Manufacturing Execution System (MES) is essential to smart production. HCM uses Siemens Opcenter, which not only offers process optimisation tools but also supports custom development and easy integration with existing battery manufacturing systems. Its PAC functionality enables seamless communication with equipment and inspection systems, allowing full automation and reducing on-site labor by over 50%.

At our smart manufacturing centre, real-time production data is visualised for supervisors to monitor KPIs, track LMFP production stages, and perform data analysis. It can assist production personnel in rapid response and decision-making, and achieve comprehensive production for consistent, high-quality LMFP materials.

Scalable solutions and global expansion

To support turnkey customers, our smart manufacturing centre offers plant simulation that creates realistic previews of LMFP production lines. This enables early optimisation, lowers deployment risks, and, combined with modular design, allows rapid replication and scaling to meet growing battery industry demands.

In 2025, HCM will launch a 2200-ton-per-year modular line at our factory, equipped with next-generation technology and a smart manufacturing system. This site will validate our total solution approach, supporting global customers and accelerating expansion in the fast-growing battery materials market.

Virtual design and performance analysis of lithium-ion batteries with physics-based simulations

Falco Schneider, PhD, Scientist, Flow and Material Simulation, Fraunhofer ITWM

Physics-based simulations allow to make predictions about the thermo-electrochemical behaviour of lithium-ion batteries and provide a tool for cause-and-effect analysis for experimental observations. In this talk we are going to discuss how such models can be used to perform digital performance analysis of lithium-ion batteries. Due to their physical nature, the models allow to conduct studies under exactly controlled conditions and potentially extend existing experimental data sets.

Characterizing and designing lithium-ion batteries through physical prototypes and experimental measurements poses significant challenges to the battery industry, due to the substantial financial and timely investment. In order to alleviate this issue, physics-based simulations can be utilized to reduce the number of experiments to perform and accelerate development.

Once parametrized, these types of models allow to make predictions beyond the parametrization experiments. Furthermore, they provide detailed insights into the internal physical transport processes and help to identify potential bottlenecks and aging risks under exactly controllable operating conditions.

The battery and electrochemistry simulation tool BEST

Fraunhofer ITWM is a research institute with a strong focus on applied mathematics and develops software solutions for simulating a large variety of physical processes for industry application. With our Battery and Electrochemistry Simulation Tool BEST, we offer a dedicated thermo-electrochemical simulation software for lithium-ion batteries. It provides two main modelling approaches: BESTmicro and BESTmeso.

The former is a detailed model spatially resolving the electrode microstructure over the full electrode thickness and revealing effects and local heterogeneities resulting from the complex microstructure morphology, see Fig. 1. The latter offers a homogenised modelling approach not explicitly resolving the microstructure but capturing its effective transport properties, resulting in a trade-off of an increased computational efficiency at the cost of a slightly reduced level of detail. This gain in efficiency allows to extend the simulation studies from representative volume elements of the electrodes to full cell layouts and investigate effects taking place on the cell scale.

In their core, both models capture the charge and ion transport in a Li-ion battery to characterise its electrochemical behaviour. From that, a variety of derived quantities like the anode plating potential or heat generation can be computed. Additional model extensions like temperature evolution, voltage hysteresis or electrochemical double layer for simulating electrochemical impedance spectroscopy (EIS) are available as well.

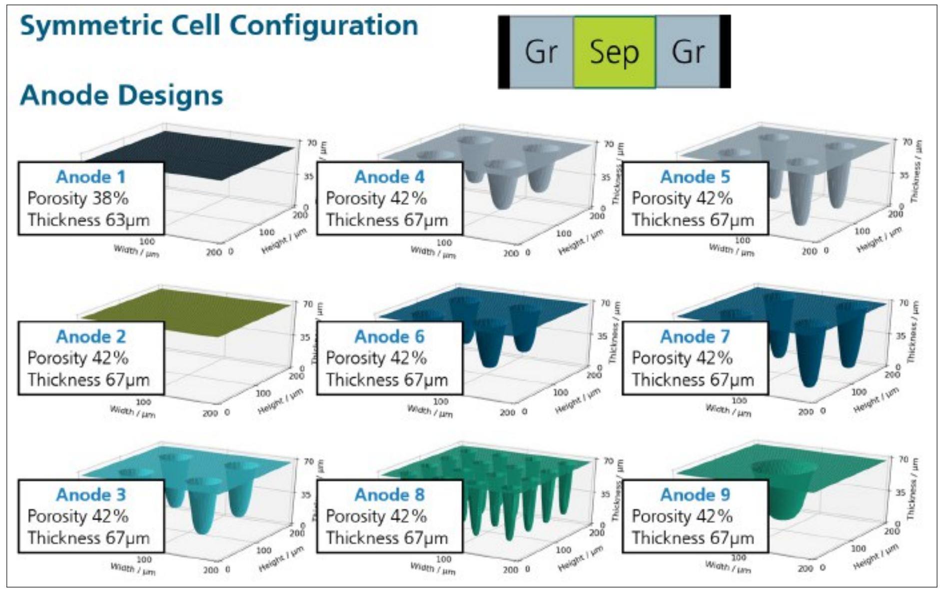


Fig. 1: The simulation software BEST allows for detailed insights of the electrochemical transport process on the electrode microscale and facilitates digital design and experiments for Li-ion batteries.
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Fig. 2. Example of a digital design study performed with BEST. The virtual EIS experiment of differently perforated graphite electrodes reveals a clear trend for minimizing the electrodes ionic resistance and improving its fast-charging capability by introducing densely distributed, narrow electrolyte channels on the separator facing side with design number 8.
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Leveraging physics-based simulations to improve lithium-ion batteries

The simulation software BEST is developed and used in a variety of research projects to facilitate the development of novel Li-ion batteries and address questions from industry partners.

One example is the optimisation of electrode perforation patterns for minimising ionic resistance of electrodes and maximising fast charging capabilities, see Fig.2. Another example concerns the prediction of battery performance under realistic driving conditions which has been achieved by coupling BEST with our in-house vehicle simulation software Virtual Measurement Campaign VMC®.

An ongoing investigation is currently concerned with studying the effects of partially wetted cell stacks on the resulting cell impedance to draw conclusions how to monitor electrolyte wetting by EIS. In all these scenarios, the physics-based simulation approach allows to gain an understanding of cause-and-effect relationships by studying the predicted physical fields. Beyond these electrochemical investigations, we are utilising our software portfolio to generate a better understanding of individual production processes, like for example electrolyte wetting and foam encapsulation of cells inside modules.