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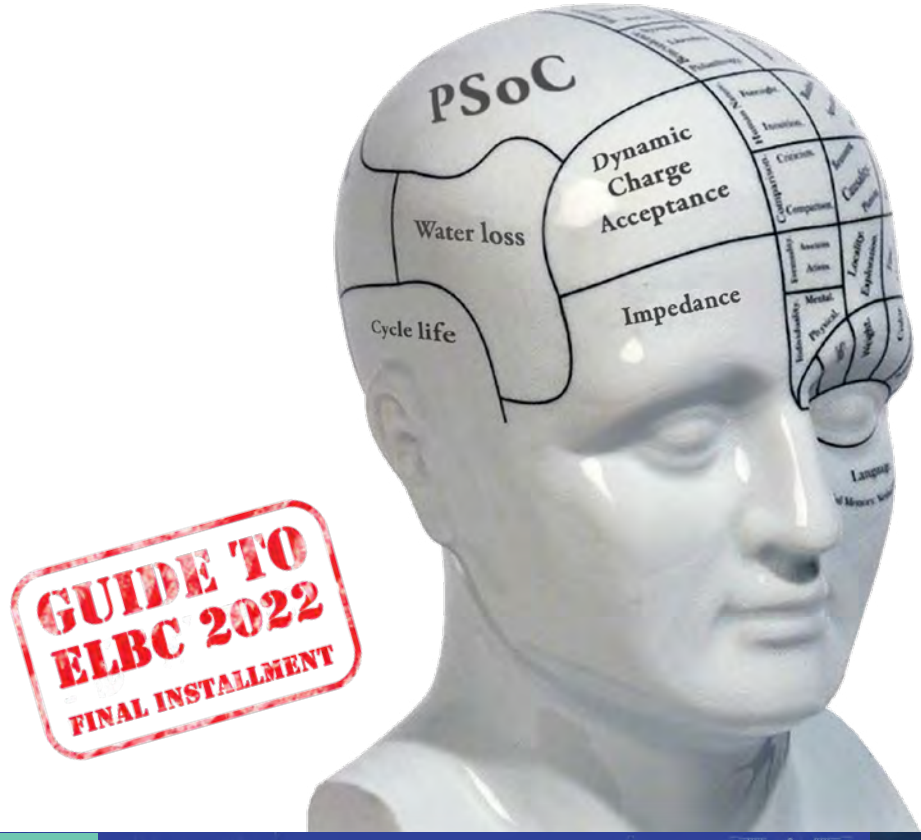
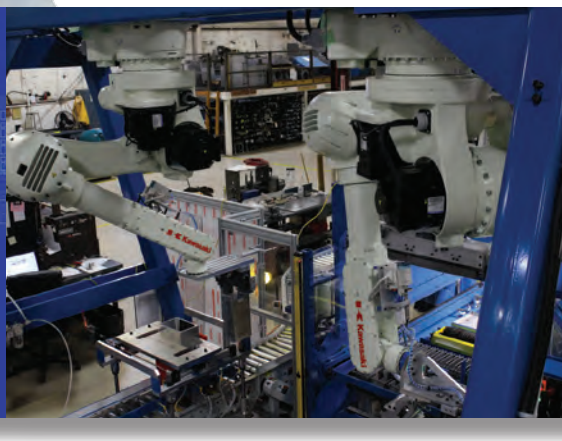
September 5-9, 2022 **ELBC 2022, Lyon, France**



GUIDE TO ELBC 2022
FINAL INSTALLMENT



Daramic's Kevin Whear
Life at the cutting edge of better separator design

What's on ... and where!
Our insider's guide to the high (and low) life of Lyon

Full abstract details
Including a comprehensive booth planner guide

ABC's Ed Shaffer
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Lead re-imagined

Return to the fray as ELBC looks for better battery formulations

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Mike Halls • editor@batteriesinternational.com

Always winter but never Christmas

A rising tide lifts all boats. In recent years that's been the fundamental proposition justifying a promised boom for the lead battery business.

Demand will be such for energy storage, people say, that no one chemistry will be able to satisfy all our needs — all battery technologies will rise on this tide of demand.

The basis for this thinking at least is logical. But only in part.

Yes, climate change is real. The world needs to decarbonize rapidly. As fossil fuels are replaced with renewable sources of power such as wind or solar, the need to bridge intermittency, when the wind doesn't blow or the sun shine, will be ever greater.

Energy storage will become the new pillar supporting modern society. Batteries will be an essential for transportation, the home, the electrical grid. Everything.

But this is where the thinking starts to break down. What if demand for energy storage is not as strong as some people are predicting? What if the electromobility revolution stalls and EV uptake is limited?

Most estimates for our energy needs are looking achievable. Analysts' forecasts continue to show double digit growth for lithium batteries and single growth for lead ones.

The huge electrical grid markets of the future will be valued in the billions of dollars but what percentage of them, at the moment, have lead batteries? Less than 2%. Lithium batteries easily make up the balance. And in the US, which leads the world in the adoption of renewables, battery sales for ESS is firmly being placed with lithium buyers.

This is the moment — and ELBC is the venue for us to discuss this — when we need to hear the truth of the matter.

For the last five years the standard lead policy line is that we'll be absolutely vital in the future. But for those of us still caught in mid-winter of sales of not spectacular growth, the promise of Christmas seems a long way off. ■

Mike Halls,
Editor

A TRULY IMPORTANT MEETING — WITH MUCH TO DISCUSS

This ELBC meeting is different from those of the last few years — and possibly the most important of the previous decade. The energy storage landscape — from automobiles to the electricity grids of the future — is changing rapidly.

The last event, because of the Covid pandemic, had to be held as a virtual conference and was not the forum to discuss in depth these issues. The logic behind the ELBC meetings was always meant to be a confluence of displaying the intellectual rigor of advances in lead battery technology and the markets that we operate in, as much as the social business and networking that the industry needs to strive forward.

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BIENVENUE À LYON!

It has been a long time. It is with great anticipation that we look forward to re-connecting with our friends and colleagues at ELBC 2022.

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Welcome to Lugdunum!

This year's delegates will find a thriving, fascinating city with some fascinating — if dark — secrets and a great dining scene. This is France after all. Julia Berg reports

Lyon has been a major French city from the earliest times. The Romans founded Lugdunum in 43BC where it became a major hub in the ever-expanding network of Roman roads. It is also the country's third largest city.

On to that darker side of the city, Lyon is a place which, from time to time, has been drenched with blood.

In one of the goriest battles of its age in AD197 the armies of emperor Septimius Severus fought with those of the usurper Clodius Albinus for the city. In those days, the outcome of battles were usually decided within a few hours, but this battle that lasted two full days, resulted in thousands of deaths.

Worse was to follow as the victorious Severus had Albinus' body stripped and beheaded. He then rode his horse over the headless corpse in front of his victorious troops. As a last gesture of spite he had Albinus's body and those of his wife and sons thrown into the River Rhône before executing all of Albinus' political supporters.

The following centuries were relatively quiet for Lyon which from the 11th century onwards went on to become a centre of clerical power.

The Renaissance ushered in a period of economic prosperity and intellectual brilliance. In 1464, the establishment, of commercial fairs and the arrival of Italian merchant bankers in the city enabled Lyon to truly flourish. By the 17th century this was the silk-manufacturing capital of Europe. Printing was introduced as early as 1473, and Lyon soon became one of the most active printing centres in Europe.

Does history really repeat itself? Sadly, in Lyon, it seems so. The city was again drenched with blood during the French Revolution when there were up to 2,000 public executions following a siege by Republican forces. Having decided that guillotining was taking too long, one enterprising general tied

Nostradamus's glimpse into the future

Nostradamus, the 16th century seer and astrologer, when he wasn't predicting the rise of Napoleon, Adolf Hitler, the French Revolution, 9/11 and the like, had a few predictions about Lyon.

In 1642, he predicted that two conspirators would be decapitated on the Place des Terreaux during a visit by Cardinal Richelieu, Louis XIII's right-hand man. This came true.

He is also said to have predicted that Pope John-Paul II would die in Lyon. So, when the pope visited in 1986, the local authorities, were unwilling to dismiss the prophecy, and took extra security precautions.

An embassy for extra-terrestrials

Forget Area 51! Extra-terrestrials visited Lyon (apparently) in the ninth century. The earliest written encounter of being abducted by aliens occurred in the ninth century.

Recently the Raelian sect — which firmly believes in extra-terrestrial life — gathered on the Place Bellecour, the huge square at the heart of Lyon, to propose Earth's first ever alien embassy should be built. Unfortunately planning permission wasnt forthcoming!

Food, glorious food

Lyon is legendary for its cuisine. Even in a country that invented the concept of the Michelin star, the city is unique in its diligence in creating some of the world's best meals.

Tired and hungry batterymen and women seeking high-charged pick-me-ups can find 20 Michelin starred restaurants in the city or close by.

Don't take our word for the excellence of their culinary skills head to *www.guide.michelin.com* and type in Lyon!

While in this city, maybe try one of Lyon's specialities. This is pâté

(aka Lyon these days)

265 people into the middle of a square and fired three cannons of grape shot into them. The local shopkeepers were aghast and complained about the blood in the gutters. (Bad for trade!)

The Republicans then tore down the houses of the rich and, with the perfect symbolism that only history can provide, were ordered by Napoleon to be rebuilt when became emperor in 1804.

During World War II, Lyon was a centre for the occupying Nazi forces, including Klaus Barbie, the infamous 'Butcher of Lyon'. However, the city was also a stronghold of the French Resistance, the many secret passages known as *traboules*, permitted people to escape the Gestapo raids.

Today, visitors can try to discover the *traboules* for themselves or they can take a guided tour. Some local historians swear that they have counted as many as 400 *traboules* although only 40 are now open to the public. There's also an excellent museum to the Resistance.

In the 1960s, a stronger French economy, spilled over into Lyon and the city has since then become an epitome of a broader France — prosperous, thriving yet with a beating heart and a vibrant cultural core that dates back centuries.

en croûte, a combination of charcuterie pressed and encased inside a firm pastry crust. This was no culinary gimmick but was designed to preserve the meat and the crust was rarely, if ever, eaten. So proud is Lyon of the dish that there is an annual "world pâté en croûte championship".

It's impossible to talk of food in France without mentioning wine and Lyon is sandwiched between Burgundy to the north and the Rhône valley to the south. Wine tours and tastings are easily bookable.

No longer is every red liquid in this city dark blood red. Thankfully. Enjoy stunning Lyon!

Unusual Lyon

• **The first manned balloon** was invented in Lyon created by the Montgolfier brothers who were industrialists from central France. Étienne, drew up a small paper balloon — based only on hot air — which he launched in 1783 fuelled by scrunched-up paper and olive oil. The two then built a bigger one and the following year the first manned flight happened.

• **The Lyon crocodile.** In 1745, so legend goes, a crocodile escaped from a ship near Marseille and then swam up the Rhône and settled under a bridge in Lyon. There it upturned boats and fed on the passengers. Two prisoners on Death Row offered to capture the reptile in exchange for freedom. They did eventually catch it, and the crocodile is now stuffed and on exhibit at the Museum of Civilian Hospices.

• **Lyon is the birthplace of cinema.** Americans claim that Thomas Edison was the father of the cinema. This may technically be correct: Edison built his kinetoscope, or peep-hole viewer, in 1891, but it allowed only one person at a time to watch moving pictures. The Lumière Brothers created the cinematograph in 1895, and their moving pictures were projected and could be watched by everyone in the room.

• **Frédéric Auguste Bartholdi, creator of the Statue of Liberty** also built Lyon's best-loved fountain in the Place des Terreaux.

• **Lyon has its own Eiffel Tower.** At a distance, you'd think this was a replica of the Eiffel Tower. Of course as you get closer, you'll notice this is a mini version (80 meters as opposed to the Eiffel Tower's 324).

GETTING AROUND LYON

Metros trams buses

Lyon has five efficient metro lines, five tram lines and 138 bus lines. The average ticket price is €1.80. Get 10 in a bundle for a little more than 16€. A weekly pass costs €15.

Rental bikes — MyVélo'v

Lyon was the first city in France to have its own shared cycle scheme. The metropolis area has 5,000 bikes from 300 pick-up/drop-off points. The price of a one-trip ticket is €1.80 while a one-day ticket is €4. The first 30 minutes of each trip is free. After that, the cost escalates. For €5, you can make unlimited journeys for 72 hours.

Taxis

Lyon has an extensive taxi network and one can travel almost anywhere for under €20. The journey from the airport to the city centre costs around €50. Take advantage of an online Uber-style service with English-speaking drivers. *www.welcomepickups.com/lyon/lyon-taxi/*

And don't forget the funiculars

One of the top 10 things to do in Lyon is to take the funicular and see the city from above. From Old Lyon, you can ride two 19th-century funiculars up the hill to either Fourvière Basilica or the Roman amphitheatres. Just a hundred years ago, Lyon had five of these lines.

Global leadership for a sustainable future

The enormous demand for energy storage in the coming years throws up environmental challenges for all battery chemistries says Andy Bush, managing director of the International Lead Association and conference organizer of ELBC.

The EU Batteries Regulation is not without its flaws, and we encourage the legislators to listen to industry to make this a win-win for the environment and the battery sector.

It has been a long time coming, but ELBC is back — and we are looking forward to meeting colleagues from the global lead and lead battery industries again, for the first time in four years.

Our theme — lead batteries for the future — could not be more relevant as we continue to see a surge in demand for battery energy storage across many different products and applications.

This enormous increase in demand cannot be met by a single technology that requires unprecedented amounts of critical raw materials that are sourced from areas of the world that are impacted by geopolitical and environmental, social and governance issues.

The extraction and processing of crucial resources such as lithium is concentrated in a small number of countries. About one-tenth of all nickel comes from Russia.

These issues do not only impact availability but drive-up prices.

Establishing recycling targets and mandating a minimum recycled content for lithium-ion batteries will not on its own fix this problem and countries must better recognise that a mix in battery technologies will be necessary.

We believe that low cost, safe and sustainable advanced lead batteries manufactured from a strategically autonomous and locally-sourced recycled raw material must ultimately be part of the solution and will drive strong future growth in energy storage applications.

ELBC's packed program will explore this topic, among others, through a mix of important technical updates as well as topical input on markets and business assessments from influential manufacturers and analysts.

The challenge, and the opportunity, is the same as ever. We must continue to innovate and demonstrate how our high-quality, reliable and cost-effective solutions will support greater electrification and decarbonisation. And we must continue to burnish our credentials as a responsible global industry.

ELBC will help demonstrate to customers, stakeholders and policy-makers alike just how critical advanced lead batteries are to providing solutions and helping deliver reliable, safe and low cost energy storage.

Communicating these benefits clearly to a global audience requires an organisation that is firmly set on supporting a sustainable future for lead. And that is ILA's leadership role.

None of the battery innovation and market growth we aspire to will be possible if the regulatory landscape in Europe or the United States creates excessive barriers for battery manufacturers or their suppliers, or worse.

The EU Batteries Regulation due to be adopted next year will establish a new European regulatory landscape for batteries that will last for decades. This text, that for the first time covers the full lifecycle of batteries — from sourcing of raw materials to recycling

Lyon comes full circle: home to André-Marie Ampère and now host to ELBC

— is ambitious and designed to promote the adoption of truly sustainable energy storage solutions.

However, it is not without its flaws, and we encourage the legislators to listen to industry to make this a win-win for the environment and the battery sector.

We will continue to play an important role advocating for proportionate regulation based upon risk rather than hazard but companies in the battery value chain must continue to play their role by adopting the most effective measures to protect people and the environment.

Whilst most responsible operators embrace this challenge, we are still reminded that informal and dangerous battery recycling practices still prevail in some regions. These practices must be phased out which is why we were delighted this year to join the Protecting Every Child's Potential partnership, a public-private partnership that is mobilising action to abolish dangerous practices that result in harmful lead exposure.

Alongside the formal technical program, ELBC is the event where many important conversations and discussions take place, through our networking events, between manufacturers, suppliers, analysts and many more besides — all of us working together to support a sustainable future for our industry.

I am delighted that once again ELBC is back and in person — and I hope you enjoy a productive and inspiring conference. ■

Accelerating the speed of battery evolution

Alistair Davidson, director of the Consortium for Battery Innovation and co-organizer of this year's ELBC, highlights the role that CBI is playing within battery development.

The Consortium for Battery Innovation is now in its fourth year and our membership, research programs and project work continue to grow apace.

Our membership base now stands at 110 members or partners, and we are delighted that this is our first ELBC as co-organizers with ILA.

We will be showcasing our extensive work program at ELBC, as well as introducing new elements to the schedule including the electric vehicle workshop, highlighting the essential role of auxiliary lead batteries in the e-mobility transformation.

We are also presenting a new concept, the battery academy, a workshop designed to give attendees an immersive understanding of the fundamentals of lead battery technology.

All this sits alongside our extensive work schedule, which a current technical program targeting goals set in our new technical roadmap, government-funded research, and a suite of work avenues focused on energy storage applications.

There are many global market opportunities in battery energy storage which we think the lead battery industry is best-placed to exploit — from renewables for energy storage to grid stabilization.

Our analysis has indicated that there is a huge potential market for lead batteries in energy storage — conservatively a potential multi-billion dollar market. We will be exploring these opportunities in more depth in our forthcoming work program.

The CBI team is involved in a range of new government-funded projects, soon to be announced, from supporting sustainable battery microgrids in Africa with trailblazing technology, supported by the EU and other funding streams, to projects in the United States working alongside the US military, and Argonne National Laboratory.

Our Battery Match service, launched last year, puts specifiers looking to develop energy storage solutions in touch with battery manufacturers and advises them on the best options for their project.

CBI's core research and performance activities are driven through our second technical roadmap, which sets goals for research and performance to ensure advanced lead batteries continue to improve.

Underpinning our technical work we continue to explore all of the potential market growth opportunities as demand for battery energy storage continues to grow.

As a global organisation maintain a high profile and keeping members and other stakeholders informed about our work is vital and we have expanded our own communications and marketing activity to include much wider engagement on social media channels.

There is a huge potential market for lead batteries in energy storage — conservatively a potential multi-billion dollar market. We will be exploring these opportunities in more depth in our forthcoming work program

Above all ELBC is an important event for our members – and potential new members – to discuss all of the latest research developments and market opportunities. I look forward to seeing you. ■

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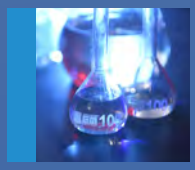

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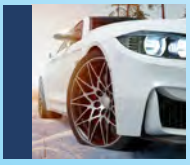

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WGBI to launch 'global expansion' at ELBC

Julie McClure, the president of Women in the Global Battery Industry (WGBI), will launch the group's global expansion recruitment drive at ELBC.

McClure, chairman of MAC Engineering, will also provide an update on the group's activities and plans for the future during her ELBC address on September 7.

The update will come as WGBI approaches the end of its first full year of programming — a milestone that is being marked by launching the group's international expansion at Lyon.

WGBI was created under the auspices of BCI to establish an organization of professionals and members of the academic community, to promote and develop the growth of women in the battery industry.

WGBI director Pam O'Brien says membership in the first eight months grew to almost 200, mostly in North America. "Now we are working on expanding our outreach globally."

The group has already been working hard to promote its work and encourage the next generation of professional women to join the battery industry.

As a chemistry-neutral professional body, WGBI aims to extend its membership recruitment reach beyond BCI and the lead battery industry.

The group welcomes individuals from companies whose portfolios include lead and lithium in addition to other battery technologies, supplier companies, and professionals working in all areas of the business including HR, marketing, engineering, legal, research and development.

WGBI's members and other women professionals attending ELBC will take part in a meeting and reception during the conference on September 7. Participants will be briefed on WGBI's membership benefits, which include a quarterly webinar series, monthly informal discussion groups, a private LinkedIn group, mentor program, and in-person events, as well as having the opportunity to network with industry colleagues.

The ELBC reception is being sponsored by Hollingsworth & Vose.

Nick Starita, H&V president, energy solutions and new ventures, said the company was "proud to support the WGBI mission to promote and develop the growth of women professionals in the battery industry, both at events like ELBC and through membership and leadership in the organization".

H&V quality manager Helen Keeling said: "Being a member of the WGBI is great for networking with fellow professionals and helps us grow within the industry. The WGBI is a great support and helps promote women professionals in the battery industry.

"Being part of the group gives us the opportunity to share knowledge and contribute to a developing industry."

At the BCI annual convention in Florida in May, WGBI sponsored two university students from Florida State University, as part of the group's mission to provide leaders of the future exposure to opportunities available in the battery industry.

At next year's BCI convention in Louisville, Kentucky, WGBI will launch a poster contest for university students involved in research in the battery industry in conjunction with the convention's technical summit.

"We have not formalized the program yet, but there will be WGBI recognition for women participants," O'Brien says. ■

'Being part of the group gives us the opportunity to share knowledge and contribute to a developing industry' — Helen Keeling

Pam O'Brien (right) with Gina Radke, the owner and CEO of aerospace manufacturing company, Galley Support Innovations, who was a keynote speaker at BCI's annual convention in Florida last May.

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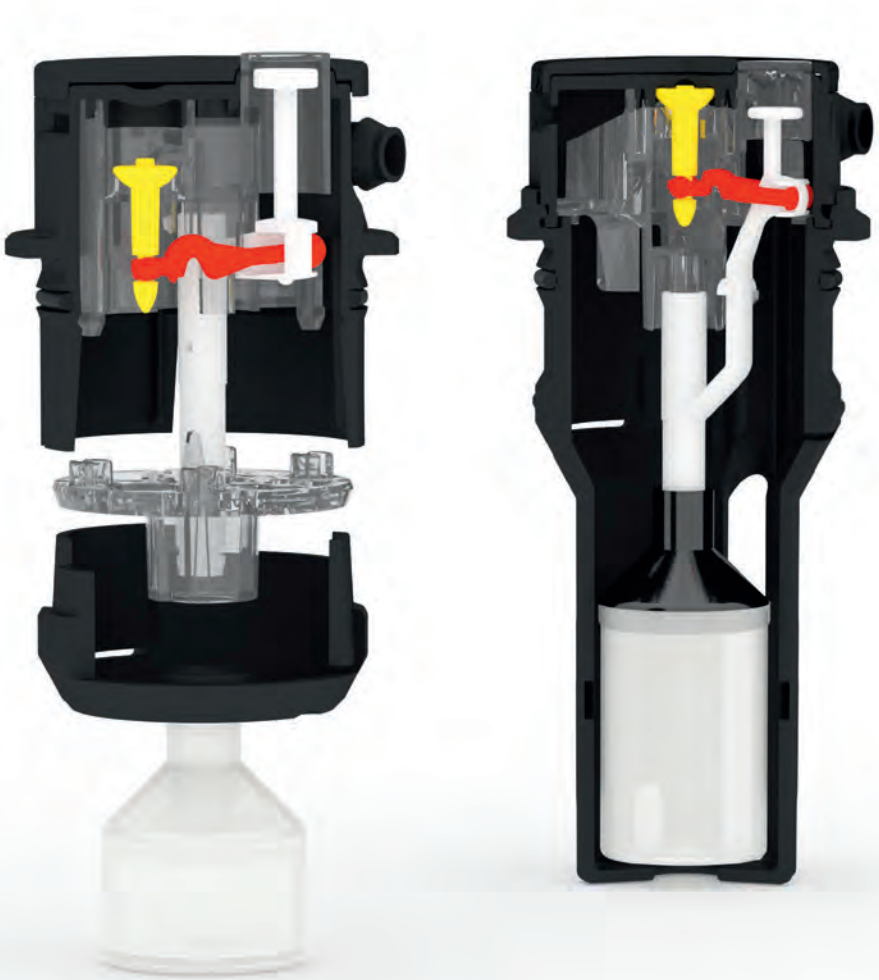

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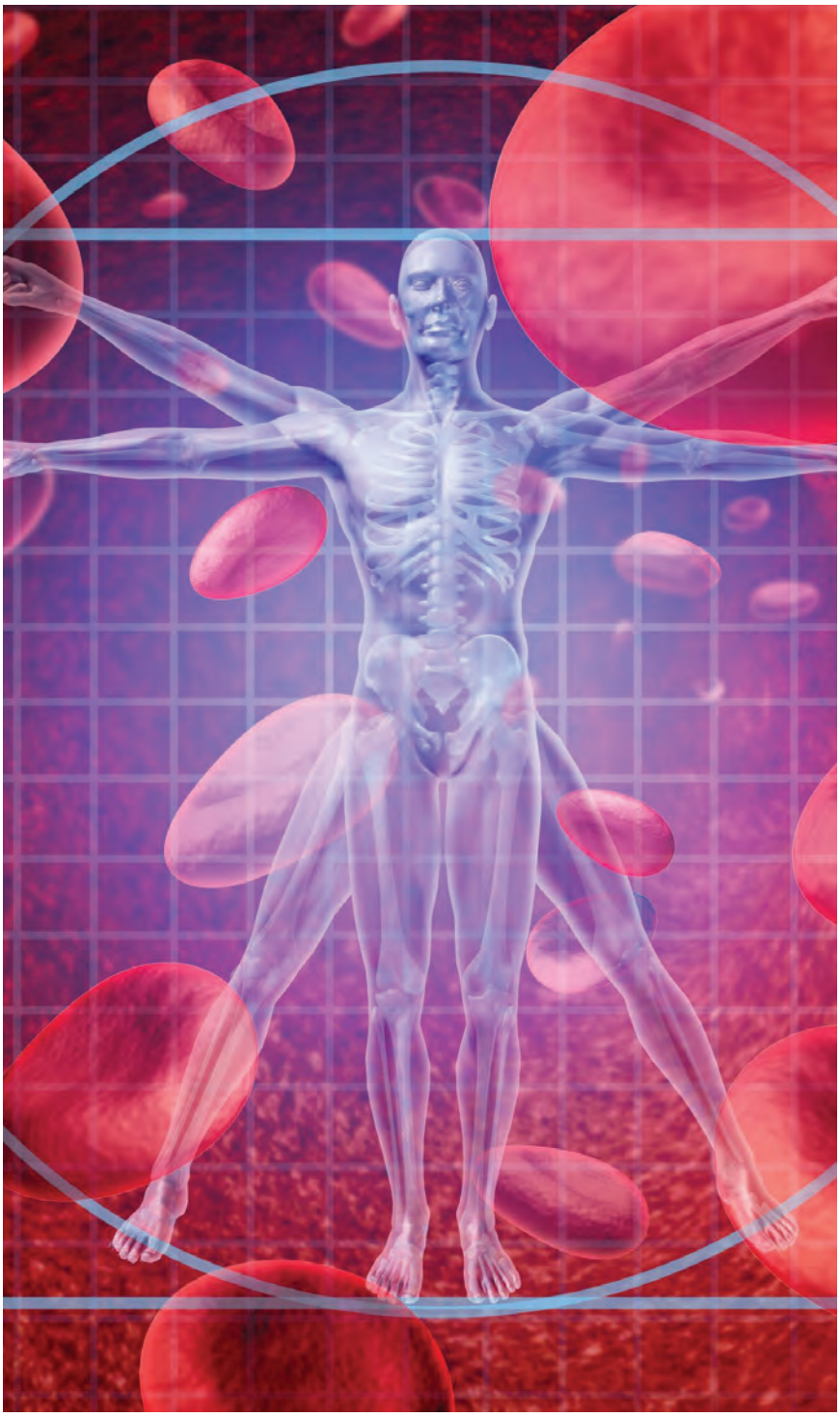
Four industry associations continue to strengthen their program of maintaining high standards of employee health and safety.

Industry bodies recommit themselves to lowering blood lead levels by 2025



This spring, the four associations representing the North American and European lead battery value chains significantly strengthened the industry's 25-year-old program to prioritize worker health protections with regard to lead exposure.

Battery Council International, the International Lead Association, the association of European automotive and industrial battery manufacturers (EUROBAT), and the Association of Battery Recyclers recommitted to the industry's continuous improvement goal that no worker should have a blood lead level above 20 micrograms per decilitre by the end of 2025, and committed to continuous improvement of worker blood lead levels.

Roger Miksad, BCI executive vice president, tells *Batteries International*: "The health and safety of employees is a priority of our members. BCI's voluntary blood lead program was established in 1996 — the first of its kind in the world — and for more than 25 years, the lead battery industry has been a global leader in developing best practices for worker health.

"Since 2011, the US and European trade associations have coordinated a consensus voluntary program, and we are proud that the members of all four associations have made significant investments and commitments to worker health, and have demonstrated continuous improvement.

"The latest program update reflects our members' ongoing commitment to the health and safety of their employees."

According to industry representatives, the revised program sets ambitious goals and targets intended to drive continuous improvement in the global lead industry community, including both lead producers and battery manufacturers.

The program update was developed by a global committee of association staff and member volunteers who worked collaboratively over the year to develop this set of recommendations to help guide the members' continuous improvement efforts and programs.

Andy Bush, ILA managing director, noted that "ILA's voluntary blood lead program is unique in being both global and representing primary lead producers as well as refiners and recyclers. This latest update to our long running program reconfirms the industry's determination to continuously improve worker health and safety practices worldwide."

The associations have also committed internal resources, and have ongoing programs, to help their members implement plans to achieve these targets as early as possible. The associations have also long been open about sharing best practices with non-members around the globe to drive global EHS performance.

These best practice sharing efforts have been strengthened in the new program.

In addition to the BLL targets, the associations have also adopted recommended guidelines for employee exposure monitoring and management. These recommendations cover employee biological monitoring and training protocols — including testing and tracking the blood lead levels of every lead-exposed staff member to ensure compliance with the voluntary program — which provide a template from which companies of all sizes can build robust worker health policies and programs.

Mark DeLaquil, ABR general counsel, told *Batteries International:* "The battery recycling community is committed to safe, responsible recycling to make our communities stronger and our future more sustainable. Voluntarily updating the employee blood lead level reduction program demonstrates that commitment.

"We collectively believe it is not enough to simply meet minimum regulatory requirements for lead exposure. We're aiming higher. Through industry collaboration, we're redefining those standards and raising the bar to advance worker health and safety programs for the greater good."

Rene Schroeder, EUROBAT executive director commented: "Battery manufacturers, including manufacturers of lead batteries, work with hazardous substances, and take responsibility for the protection of their workers. We appreciate the success of the joint cooperation with the other associations.

"A regular review of the investments and measures that industries take, such as workshops, know-how exchange and the like allows us to maintain this trajectory of reduced blood lead levels."

Steve Binks, who oversees the ILA's program, said: "Our blood lead reduction program has consistently delivered impressive results over many years.

"We recognize the new target will be a significant challenge for some companies, however we remain committed to supporting all our members in the continuous improvement in the management of their employee lead exposures." ■

"Since 2011, the US and European trade associations have coordinated a consensus voluntary program, and we are proud that the members of all four associations have made significant investments and commitments to worker health, and have demonstrated continuous improvement"
— Roger Miksad, BCI

The four associations have worked collaboratively over the past year to develop a global consensus for the 2022 re-commitment. The 2022 policy was adopted this year at the annual meeting of each association's respective board of directors (Battery Council International, May 1; 2022; EUROBAT April 28, 2022; Association of Battery Recyclers, May 12, 2022; and International Lead Association, June 28, 2022).

"We collectively believe it is not enough to simply meet minimum regulatory requirements for lead exposure. We're aiming higher. Through industry collaboration, we're redefining those standards and raising the bar to advance worker health and safety programs for the greater good" — Mark DeLaquil, ABR

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The importance of long duration energy storage cannot be belittled in the world's drive to decarbonization and the shift in our energy mix to renewables. Ed Shaffer, CEO and founder of Advanced Battery Concepts, explains the latest thinking and methodology behind what needs to be done.

Creating an energy storage system that is fit for purpose

Governments across the world are investing heavily to promote a carbon-free grid where power is derived from renewable energy sources like wind and solar. The intermittent nature of renewable power sources requires energy storage to ensure security and availability of electricity to customers.

Last year, the COP26 Long Duration Energy Storage Council estimated that nearly 140,000GWh of energy storage needs to be deployed by 2040 to achieve a global carbon-free electric grid. Starting today that would require 7,700GWh of battery deployment annually.

Current large-format, rechargeable battery production is approximately 700 GWh a year across all chemistries and geographies. In other words, long-duration energy storage markets represent an order of magnitude increase in battery production opportunity.

To meet this huge opportunity, any energy storage solution (ESS) must meet a myriad of requirements to ensure responsible adoption.

First and foremost, energy storage must be economically responsible. Today, electricity is delivered to consumers from $0.10/kWh in the US to €0.22/kWh ($0.24kWh) in Europe. To ensure adoption, energy storage systems cannot burden average consumers with exorbitant costs.

In the US, multiple studies, including the US department of energy (DOE), are targeting storage costs of $0.05/kWh.

Unfortunately, today's large-format solution chemistries do not meet this objective. In 2020, the Pacific Northwest National Laboratory published a cost analysis comparing today's lead batteries (PbA), to lithium-ion; nickel-manganese-cobalt cathode (NMC) and iron phosphate cathodes (LFP), Figure 1.

Numerous marketing studies stated that lithium prices would continue to decline but that has not been the case due to key material supply-demand imbalance. In fact, rather than lowering prices numerous lithium battery users and suppliers announced price increases above 20% this year.

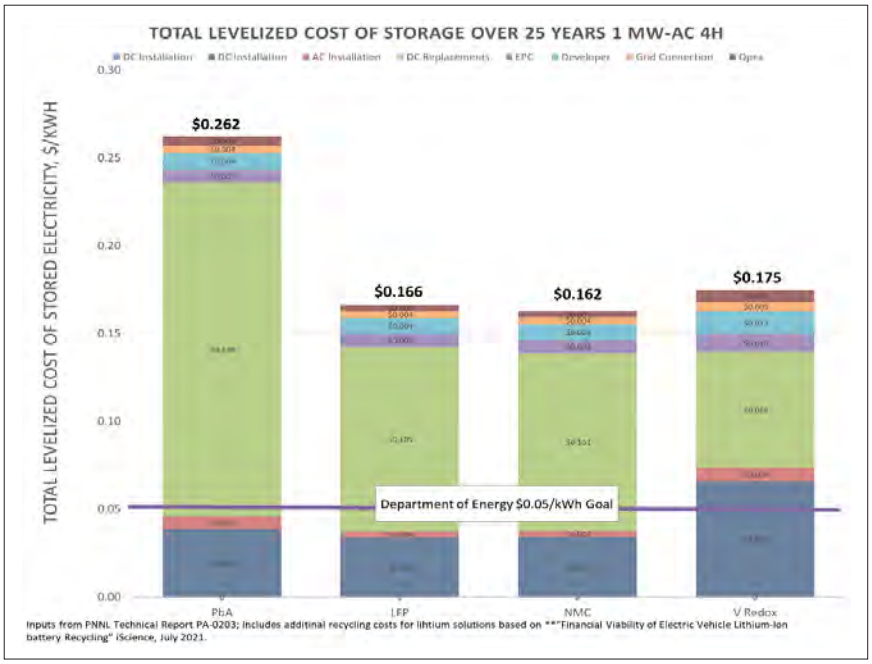

Figure 1: The analysis, shows the costs of lithium to be two to three times above the target and today's lead batteries being four to five times the target.

Contrary to lithium metal, lead metal pricing has been stable. And with more EVs the lead metal price could decrease due to fewer car starting batteries being needed.

Second, energy storage solutions must be socially responsible. To start with, energy storage must be safe to not jeopardize human life or property. Unfortunately, many high energy density batteries, such as lithium-ion, use carbonate solvent electrolytes with flash ignition temperatures as low as 145°C.

As we have seen too often in the news, this allows lithium batteries to ignite under thermal runaway scenarios far too easily. To improve safety for large energy storage installations, extensive fire mitigation systems must be added; but this results in higher costs. Ironically, one of the world's largest lithium ESS in Moss Landing, California was delayed twice because the fire mitigation system instigated "thermal events".

Social responsibility also requires battery raw materials be readily and globally available. The DOE has a new mantra that energy storage needs to be available to everyone, everywhere. This is an appropriate goal, but constrained material supply makes this challenging to achieve.

In a recent report by the International Energy Agency (IEA) it directly stated that: "The geographical concentration of production of key lithium battery materials is unlikely to change in the near term."

The surge in electric vehicles increases this strategic lithium supply-demand gap even further. EV batteries need high-energy density lithium to ensure range, but long duration energy storage systems don't. Using lithium solutions for energy storage systems only exacerbates the supply gap heightening national security worries unnecessarily, Figure 2.

Third, energy storage solutions must be environmentally responsible. The entire objective of a carbon-free electric grid is to reduce our carbon footprint. The first question to ask is did we help

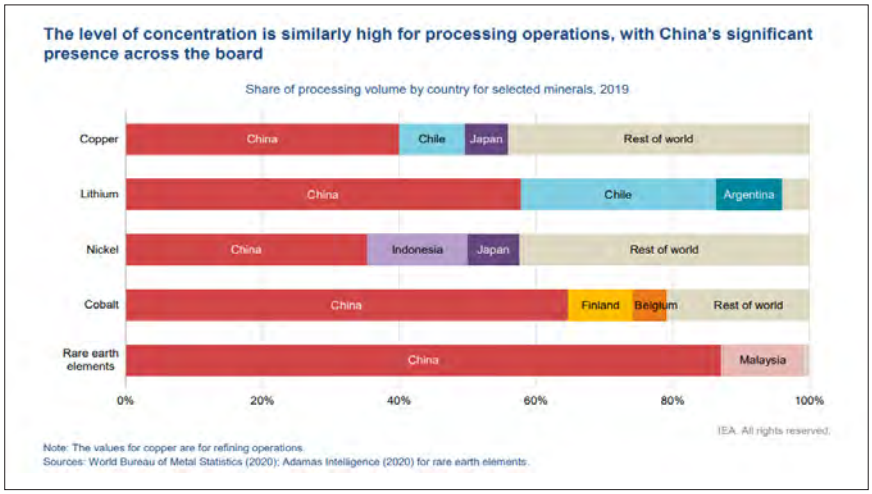

Figure 2: Today, the supply of key refined materials for lithium batteries is dominated by China. Conventional wisdom recognizes that the constraint of strategic materials causes national security concerns as evident by oil and natural gas supply worries.

the environment more with the solution than hurt the environment producing it?

A good example where this question must be asked is the latest emphasis on green hydrogen. Hydrogen production can be extremely energy intensive and with a negative return on energy investment. That is, it can take more energy to produce hydrogen than the amount of energy you get from it which means more carbon emissions were created than saved.

Careful analysis, from cradle to grave, must be paid to ensure the energy return on investment (EROI) or better greenhouse gas return on investment (GHG-ROI) is positive and as high as possible.

The best way to promote environmental stewardship and improve GHG-ROI is responsible recycling of key battery materials. Mining and refining are extremely energy intensive and too often destructive to our eco-systems reducing GHG-ROI. For example, over 2.2 million litres of water are evaporated to produce one tonne of lithium carbonate equivalent to 20 Tesla battery packs.

The amount of water required to make millions of EV lithium batteries annually is staggering let alone lithium needed for long duration energy storage. At this time no economically viable process for recycling lithium exists today. That is, the price of secondary lithium from recycled batteries is higher than the price of primary mining and refining of lithium materials.

As a result, we will continue to build more mines and evaporate more water until equilibrium between secondary and primary costs are balanced.

Lead chemistry-based energy storage solutions offer many advantages to meet our global long duration energy storage needs but improvements are needed. The main area for improvement is the cost of lead batteries which according to the PNNL report is too high.

Cost for energy storage is typically represented by the levelized cost of stored electricity (LCOSE) which is the sum of all costs (initial capital, battery replacements and operating expenses) over the life of the project reduced by the energy through-put of the battery and its recharge efficiency.

Energy through-put is often conflated with cycle life; however, this is incorrect as the number of cycles depends on many variables which effects energy throughput: depth of discharge, rate of discharge, temperature, etc. So, for lead batteries to reduce cost they must have higher energy throughput, lower manufacturing costs and improved recharge efficiency.

Battery Council International (BCI), International Lead Association (ILA) and the Consortium of Battery Innovation (CBI) are working with multiple research groups and government agencies to achieve these improvements. Many BCI members are working with the US Department of Energy's Argonne lab on basic research and manufacturing programs to understand core lead chemistry principals.

The CBI is offering financial matching support to a variety of groups globally to improve ESS performance. Other groups, such as Advanced Battery Concepts and Gridtential are making tremendous strides in showing how advanced bipolar battery architecture can have significant impact on lead battery performance and cost.

Where lead-chemistry excels is its social responsibility. Lead batteries use aqueous electrolytes such that the only flammable part of the battery is its plastic case. Most energy storage cases are made from ABS plastic with a flash ignition temperature of 348°C.

Given the fact that lead metal melts at 327°C it is nearly impossible for a lead battery to auto ignite under thermal runaway scenarios. Also, lead is the largest secondary battery industry today with over 430GWh sold per year. Lead is globally available from multiple non-conflict sources as well as supporting materials used in lead batteries such as plastic, separators and electrolytes.

Lead has an amazing recycle rate of over 98%. This is driven by economics: primary and secondary lead costs are similar. No other storage chemistry compares. However, lead recycling relies on pyro-metallurgical processes which if not properly managed can cause lead exposures to surrounding communities.

Another major area where lead can lead the way is improved recycling, recovery and reuse processes to minimize the environmental impact. Many companies today are exploring novel hydro-metallurgical processes to advance the environmental responsibility of the lead industry.

Looking forward, the LDES market is vital to carbon reduction from our electric grid. No other chemistry is better positioned to facilitate a carbon-free grid than lead batteries. Lead technology has the best global supply position which is easily available to all countries avoiding national security concerns. Its recycling infrastructure of spent batteries is unparalleled. And the research in progress today will improve energy throughput and reduce production costs.

Simply put, lead technology is the best positioned solution for long duration energy storage because it is the most economically, socially, and environmentally responsible choice. ■

Ed Shaffer, CEO and founder of Advanced Battery Concepts has spent the last 14 years focused on developing technology to accelerate adoption of much needed alternative energy systems. In an extensive career he has held a variety of roles including new business development, global R&D manager and scientist. He received his PhD in Materials Science from MIT.

The next generation of electrical storage projects are more than likely to be hybrid variations between existing and developing technologies. Abertax and its researchers have been looking at one new avenue of research.

A new product for future carbon neutral homes

A group of researchers at the University of Malta and Abertax Technologies have teamed up to develop a micro combined heat and power (CHP) source of energy using back-up power to ensure the integrity of the project.

The concept was to develop an IOT product for generating and storing energy to provide the energy required in a household at any time — even in the absence of the grid.

This variation cannot be practically stored in a domestic battery energy storage due to price, safety and space. To run the system without the grid, battery energy storage is a must.

There are already a number of households that have a grid connected PV systems that rely on the grid to ensure that the PV can generate the maximum power at all times to harvest all the maximum possible energy. The grid here is assumed and used as an "infinite storage system" with the grid operators having to adjust their energy supply to cope with the variations caused.

This situation has a limit especially when decentralized sources of energy start to approach a high percentage of the total grid energy demand.

The research team has designed a system to control this by a scalable and non-invasive system that will utilise any existing grid connected generators. This can be done by the addition of a smart micro CHP with an integrated energy storage setup.

The proposed system will use existing grid connected components and will be able to operate with and without the grid. The operation of the system will become more critical to manage and control without the grid as the "infinite storage" is not present in the system any more.

When designing such a system it is very important to consider three main criteria:

1. The yearly energy consumed by the consumer
2. The seasonal energy demands required
3. The maximum instantaneous power demand

Various case studies were carried out by the research team over a number of years on houses installed with grid connected PV systems. Such properties have large seasonal variations — they generate much more energy than they need in the spring and summer while less during autumn and winter.

This variation cannot be practically stored in a domestic battery energy storage due to price, safety and space. To run the system without the grid, battery energy storage is a must.

The question is what is the capacity of the storage required?

To satisfy design criteria 2, it clear that even in southern European countries where the weather is warmer, a CHP or some other form of heating is required. The authors propose the use of a CHP and heat pumps as this will drive the efficiency of the combined setup over 100%.

The presence of a self-excited CHP makes it possible to satisfy the heat demand and partly assist in meeting design criteria 3 — to supply part of the load during peak power demands which tend to occur during evenings in winter.

The proposed setup has three sources of energy apart from the grid and to cope with the minimum peak power (in the absence of the grid), it is important that the loads during the day are managed efficiently.

While the PV source is limited by the instantaneous maximum power being generated during daylight, both the CHP and the energy storage can usually cope with a relatively high peak power at any time of the day. So peak evening loads should be limited to the peak power possible from the battery storage and the CHP.

This means that rather than a high energy capacity, the battery storage and its inverter should be able to handle a high discharge current.

The energy into the battery can be replenished at any other time when the load demand is not high. In fact, the maximum energy demand in a day ever registered in the above cases was of 24kWh during a cold winter day.

With this concept in mind the team developed a micro-CHP that was fitted in the space of a kitchen appliance. The CHP runs from LPG, generates 2.5KW of electrical energy, 5.8kW of heat, and has a 3kWh battery backup integrated in the same unit. The unit communicates via Wi-Fi and can be controlled from a mobile application. ■

Abertax will be exhibiting at stand 42

This means that rather than a high energy capacity, the battery storage and its inverter should be able to handle a high discharge current.

The project *'A Smart Micro Combined Heat and Power System'* is financed by the Malta Council for Science and Technology, for and on behalf the Foundation for Science and Technology through the Fusion R&I Technology and Development Programme.

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Staying one step ahead of the battery manufacturers

Batteries International spoke to **Kevin Whear,** better known as Daramic's vice-president of technology and the key figure in extending the company's range of product lines in recent years.

Another year, another separator launch.

That's rather been the impression the battery industry has been getting for the past decade about separator manufacturer Daramic.

In the last few years the firm has produced a range of novel yet effective separator solutions as the lead battery industry tries to catch up with the technical (and commercial) realities of lithium batteries.

Some of the areas that Kevin and his research team have looked at in boosting the performance of polyethylene (PE) separators include adjusting the separator profile, improving the separator formula and determining how additives, notably carbon, can boost performance.

Kevin, tall, bearded, quietly spoken but hugely articulate is well known at the industry conferences and meetings. He has been at the cutting edge of Daramic's international performance since the early 2000s.

After graduating in 1986 he worked for Texaco as a process engineer before joining WR Grace, the huge American chemical business, in its Polyfibron division.

Here he was steadily promoted over the next few years and when venture capitalists bought part of Grace's business in August 1994, he moved to the new company that was named Daramic, after Grace's business product of the same name.

From the start of his time at Grace and also at Daramic he came under the wing of Werner Boenhnstedt who was not expert about separator manufacturing — Kevin already knew much of this as well as quality control — but had an international reputation for his knowledge on alloys, materials chemistry and the workings of his batteries.

"Werner helped my career develop. He was paternal, a sincere and good mentor," says Kevin. "He offered one major challenge for me, when we went to our regular meetings in Germany all talk would only be in German and I'd listen to an hour's discussion to be given a two-minute summary in English.

"My German is now rather good as I studied it in my spare time so I could understand and contribute!"

For most of the 1990s it would be fair to say that Daramic was ahead of the game in producing PE separators for the rising tide of flooded battery and maintenance free batteries that were becoming more commonplace.

After the shift from Grace the new company knew that it needed to expand, move into new markets while also driving down costs.

The company's first new manufacturing facility was organized in Thailand in 2000 and years later more sites were added in China. Since then, Daramic has continued to add extra lines to these plants and most recently Daramic has started new operations in India.

One of the big production advances in 1990s was the move away from cast grids to expanded metal and punch plate grids. The problem for battery makers was that the number of electrical shorts created by punctures rose substantially.

"There were failure rates from as much as 1% to even as high as 5%," says Kevin. "So, we developed a more resistant separator which we called Daramic HP that reduced puncture rates by 75%."

Whear says that the biggest changes in the lead battery industry occurred around 2010. Lithium was clearly making the leap from phones, cameras and tablets to area that lead dominated — most particularly at that time, an emphasis on electric vehicles.

Kevin and his research team have looked at three particular areas in boosting the performance of polyethylene separators: adjusting the separator profile, improving the separator formula; and how additives, notably carbon, can boost performance

Lead was under threat and the challenge was real even though many in the battery community denied that lithium was a danger (or they did for a while but changed their mind when they saw the cost per kWh for lithium cells plummet).

"Lithium had a huge technical capability, leaving aside cost and safety considerations. Lead was the converse," Kevin says. "Battery manufacturers were rattled — instead of the regular squabbling between themselves they started to collaborate more, trying to bump lead's capabilities up closer to that of lithium.

"The whole industry looked at improvements on issues such as dynamic charge acceptance, charging and discharging while the battery was in a partial state of charge, limiting dendrite formation, and extending cycle life.

"And, of course, all these changes threw different strains on the battery the most obvious being increased water loss — a major factor in early battery failure."

Kevin talks about having an epiphany around this time. "During this period my understanding of what we did changed," he says. "It sounds almost contradictory, but I had to think more like a battery guy than a separator guy."

"To take onboard the worries of the battery manufacturer and the way they are thinking of developing their product lines."

"In the 1970s WR Grace invented the separator world with PE separators and the challenge 50 years later was to reinvent battery separators to meet the new market challenges! And, though we accounted for just 3% of the cost of the battery, could we affect a huge leverage in performance?"

With HD plus, the separator halts the antimony deposition and the new formulation provides lower internal resistance, improving charge acceptance and increasing capacity

Perhaps the first leap forward was the development of DuraLife between 2012 and 2014 which helped solve grid corrosion for high performance batteries. This, for the first time, used cross-negative ribbing.

This was an update on a previous product called HPV. Avoiding water loss is an important factor in keeping batteries healthy. The industry standard for this, at that time, came from car-maker Volkswagen which used four-9s lead — the highest purity of lead available — to achieve a battery that didn't lose water.

"Our new DuraLife separator performed so well that some car manufacturers found they could use lower quality lead instead, making the cost of the battery cheaper," says Kevin.

The next leap forward came in 2016 with Hi-Charge a separator adapted for batteries that had to operate in a partial state of charge.

Typically, for example, a forklift truck battery would be operated for eight hours, then charged/overcharged for the next eight before returning it to the fleet the next day. This way ensured a long cycle life.

Clearly if the forklift could be opportunity charged this would save time and batteries. Part of the feature, serrated ribs on the separator, continued to offer Kevin and his research team opportunities to explore and improve.

A variant of HiCharge was configured for India the following year and was sold as e-Rickshaw. Since then it has been Daramic's fastest growing product line.

"We wondered whether the g-forces on a car as it stopped, accelerated and turned could be used with a configuration of the serrated ribs to help decrease acid stratification."

"Stratification is a common issue affecting battery life, especially for batteries under heavy cycling duty. Acid stratification is caused by

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Exmet plate test

	Positive +	Negative -
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Number of Plates per Chamber:	126000	138600
Kg of Lead per Pallet:	179	176
Kg of Lead per Chamber:	5355	5267
Kg of Mass per Pallet:	347	416
Kg Mass per Chamber:	10395	12474
Total weight per Pallet:	575	641
Total weight per Chamber:	17250	19240,8
Cycle time for “horizontal plates”:	14+8 hours*	14+8 hours*
Cycte time for “vercical plates”:	14+8 hours*	14+8 hours*

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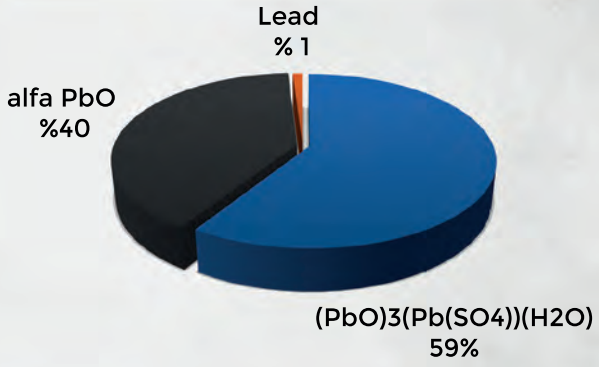
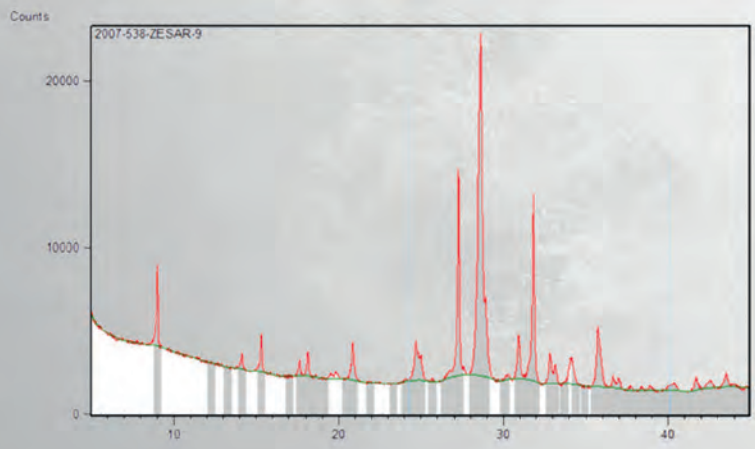
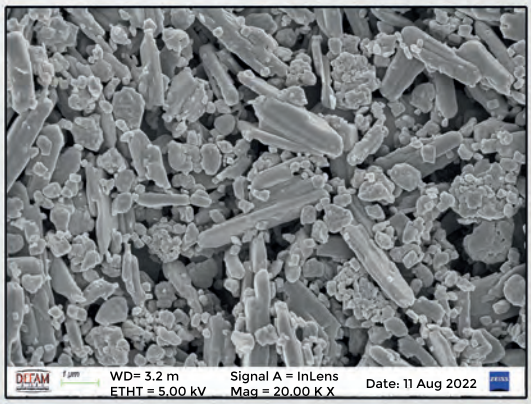


XRD pattern and SEM image



Position [’2Theta] (Copper (CU))



*Cycle time may vary depending on paste formulation.

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Kevin with some of his family — he has 10 children, 16 grandchildren and three more on the way

dwelling at a low state of charge (< 80%), insufficient recharge or if the electrolyte cannot be remixed by various methods."

This unequal distribution of the acid between the positive and negative plates causes problems, the increased concentration of sulfuric acid at the lower portions of the battery active material plates promotes the formation of a surface layer of passive lead sulfate. Conversely, the lower concentration of acid present at the upper portion of the cell induces accelerated corrosion to the grid structure and reduces plate activation.

Stratification produces inflated open circuit voltage measurements, reduced CCA performance and unequal charge across the plates, each of which can lead to reduced battery performance.

Kevin saw this as yet another way of making the separator integral to the performance of the battery. Daramic then designed a rocker table which would mimic the stresses the battery would be subjected to when in motion.

Cleverly, he saw this as something that could best be understood by mapping electrolyte flows using a computational fluid dynamics, modelled on a computer. The result of this was he was able to fine-tune separator profiles from hundreds of possibilities into a finished one.

In 2017 this research was commercialized in a variety of products, RipTide M (where the M stands for mixing) to enhance EFB durability by reducing acid stratification in a partial state of charge environment, which is more typical in start-stop applications. There was also RipTide C (compression) where extra rigidity to the separator casing was added to improve the stratification. There was also Daramic EFS which specifically designed to support start-stop vehicle batteries by reducing the battery's internal resistance and improving voltage drop and CCA.

With the rest of the industry Kevin is now looking at how the use of carbon can improve battery health and life.

The latest product known as HD Plus is an advancement of an early product, simply called Daramic HD.

One of the problems associated with lead batteries is the self-discharge of the negative plate as a result of the deposition of antimony on to the sponge lead electrode, a process known as antimony poisoning. This results in gassing and water loss and eventually a shorter battery life. Antimony, however, is a useful additive for lead batteries in that it can increase conductivity of the grid enabling deeper and better cycling.

So, with HD Plus, the separator halts the antimony deposition and the new formulation provides lower internal resistance, improving charge acceptance and increasing capacity.

HD Plus increases capacity by 9%-13% versus standard separators, resulting in increased back-up time for users.

With 34 years of experience under his belt, Kevin is preparing a shift away from the Daramic side of Polypore to work on strategic marketing for other aspects of the firm specifically its lithium separator businesses Celgard and Hipore. Polypore is in turn owned by Japanese conglomerate Asahi Kasei.

"I'm looking forward to the job change, though I'll still be doing this for a while," Kevin says. "I've lived a life of travel to date — I've platinum cards on two airlines — I want to relax and spend time with my family [he has 10 children, 16 grandchildren and three more on the way] and my Christian ministry in helping some of the deprived and broken people that live in our communities." ■

Our new DuraLife separator performed so well that some car manufacturers found they could use lower quality lead instead, making the cost of the battery cheaper

ELBC throughout the years — sharing, networking, learning

The ELBC's peripatetic travels around Europe have provided the industry with magnificent locations as well as great events — think of palaces in Istanbul, castles in Malta and 19th century fairground museums in Paris. But mostly it has been at the heart of bringing an industry together and, as a consequence, resolving some of the toughest scientific and technical questions challenging the lead battery world.

The European Lead Battery Conference has had a remarkable and colourful history — but its importance to the development of lead batteries since the first event in Paris in 1988 cannot be underestimated.

It is equally remarkable not just for the way it has created intellectual debate when little had existed before but just how affectionately both the pioneers and seasoned attendees speak of the event.

Clearly, they also associate the ELBC with forming long and important friendships and they have enjoyed the social side, which has sometimes been quite extraordinary; but they are also quick to praise the technical advancements that have often resulted from the meetings of minds at the event.

And these have helped shape the entire global lead battery community.

Secrecy and paranoia

The ELBC also led the way in terms of helping open a forum where the lead battery industry could talk to each other. The sharing of information and ideas in such an open way has not always been encouraged by the battery sector — for a long time many companies positively protected their ideas and baulked at the idea of speaking freely on technical issues.

The ELBC was a pioneering and controversial idea when it first set out to bring senior battery executives together. Before the first ELBC in 1988, it was rare for technical personnel and sometimes senior management in the battery industry to attend conferences.

Adversaries from other companies rarely met. Publications were discouraged and even prohibited in some companies.

That said, there were some small battery workshops and symposia that proved exceptions to this attitude, such as those held at meetings of the International Power Sources Symposium (UK), the Electrochemical Society (USA) and The Faraday Society. But these were involved in pure research, very academic and rarely attended by engineers, chemists or metallurgists from industry.

This mentality was understandable in a sense.

At that time, the industry was dominated by a small number of big battery companies including Exide, Varta, JCI, Chloride, GM, Delco, Tungstone, and the Swedish, French and Spanish Tudors.

But in reality, the first four of these, with their worldwide subsidiaries, effectively controlled the global lead battery industry. The manufacturers were protective of their work and any research that could give them a competitive advantage.

Their cautious confidentiality was understandable since they all developed, produced and tested new materials — such as alloys, additives, separators — and new manufacturing processes extensively before using them in their products. They were seeking improved, more reliable, performance and durability.

Even as the industry started to change and more third-party suppliers emerged, the battery industry retained a suspicion of sharing information and giving away trade secrets.

Only a few years before the first ELBC meeting, independent supplies of separators, additives and alloys became available but most had specifications defined by the battery companies and a restriction on who they could supply.

Consequently, companies were suspicious of conferences and the exchange of technical information.

ELBC locations 1988-2020	
1988	Paris
1990	Brussels
1992	Geneva
1994	Munich
1996	Sitges/Barcelona
1998	Prague
2000	Dublin
2002	Rome
2004	Berlin
2006	Athens
2008	Warsaw
2010	Istanbul
2012	Paris
2014	Edinburgh
2016	Valletta
2018	Vienna
2020	Virtual
2022	Lyon

Before the first ELBC in 1988, it was rare for technical personnel and sometimes senior management in the battery industry to attend conferences. Adversaries from other companies rarely met. Publications were discouraged and even prohibited in some companies.

A game changer in Asia

The idea of what would eventually become the ELBC was conceived against this backdrop of secrecy by Michael Mayer, who working for the Lead Development Association (LDA) — now the ILA — was maintaining regular communication with the main battery companies through providing information and assistance where possible.

In the late 1970s and early 1980s, he started organizing half-day informal seminars at the LDA's offices in Berkeley Square, London, to which he invited representatives from European battery companies. Around 40 to 50 people would attend and discuss a wide range of topics such as dry charging, wrought grids and alloys.

"Held every few months they were affable and useful without confidentiality being breached or being contentious," said one attendee.

But it took another catalyst for the concept of the ELBC to truly emerge.

In August 1986, the first Asian Battery Conference (1ABC) took place in Hong Kong. In May the year before, Jerry McAuliffe, director of the Zinc and Lead Asian Service, and John Manders at ZALAS (Zinc and Lead Asia Service) invited David Rand a CSIRO head, to discuss about setting up the event. Some 180 delegates attended this first meeing.

The ABC acted as a catalyst for the European event's formation, with positive feedback and a good response to the seminars prompting the LDA and key industry figures to turn Mayer's planning into the solid reality of the European Lead Battery Conference.

Rand had some years earlier already met Mayer, who was promoting lead batteries at a BCI conference in Munich. He invited Rand to speak at one of the LDA events in London. They also both attended 2ABC in Singapore in August 1987.

"It was there that Michael invited me to help him and Ken Peters form the first European Lead Battery Conference (1ELBC)," says Rand. "This was held in France in September 1988. Some 220 delegates attended."

The three conspirators became lifelong friends and in discussing topics and themes for discussion at ELBCs enjoyed many escapades together, especially when it involved an atmosphere of warm British ales and steam trains.

On the back of the 1ELBC success, an early organizing committee of sorts started meeting to review offers for papers and consider programmes for future meetings.

The ABC acted as a catalyst for the European event's formation, with positive feedback and a good response to the seminars prompting the LDA and key industry figures to turn Mayer's planning into the solid reality of the European Lead Battery Conference.

"It was obvious from the number of offers of papers received that there was great interest in discussing common problems and experiences and, moreover, confidentiality could be maintained," Rand says. "Some meetings later, a more formal selection committee was formed to put the programme together."

In those days, the proceedings from such events were published in the *Journal of Power Sources* and also distributed in book form by Pasminco Metals. This biennial practice, which continued up to 11ABC in 2005, stopped in 2007 after the journal publisher decided that the papers were not attracting sufficient citations, especially when compared with other battery chemistries.

Keeping focus despite growth

Since those early and very heady days, the event has grown in terms of its importance as well as its sophistication and number of delegates. Nevertheless, its technical focus and format in many ways has remained little changed.

Demand for papers reached the point that the decision had to be made where necessary to run two sessions in parallel to enable more content and more speakers to participate, while allowing delegates to choose the topics in which they were most interested.

"There was no theme as such but similar topics were grouped in the five half-day sessions and holding these in parallel, or having several halls at the same time, was contentious," Peters said much later.

"The compromise, which was very successful, was to have two sessions dedicated to the suppliers and equipment manufacturers in parallel with two sessions which mostly covered more basic research and technical work. Both were uniformly well attended."

The initial concerns of the battery manufacturers with respect to confidentiality were eventually allayed as they understood the advantages of such an event — and started to see its increasing popularity globally.

The event pioneered the way for similar conferences of frank dialogue about mainstream issues were launched later, perhaps the most notable being the creation of LABAT in Bulgaria and the start of other conferences in India and China.

Must-attend events

But the increasing attendance and willingness to present some details of their work demonstrated their popularity and opportunity for discussing common problems without revealing confidential details. ABC became an instant must-attend event, ELBC followed in its footsteps.

"Programmes tended to follow industry changes and trends. Delegates welcomed the opportunity to hear about other people's problems and successes and, hopefully, came away with helpful ideas for their work," Peters said much later. "In this respect the concept of ABC and ELBC and the following successful series was new and created a template for industry conferences worldwide."

But these conferences were more than just a template for others. They became a hugely useful forum for the entire industry.

Neil Hawkes, lead analyst at CRU, the commodity analysis firm, has attended ELBC for over a quarter of a century — he went to the first one in 1996. He says he likes the consistency the event has maintained in terms of its structure and the real value for him is securing face-to-face time with a high number of senior executives in a short space of time.

"The conference hasn't really changed in terms of its ethos and structure," he says. "The format usually has people like me on the first morning presenting on the market more generally — the big themes of the moment — and then it goes to much more technical content after that.

"But it has grown into a huge event using that formula and has become more formal by necessity as a result.

In the early days, it was a more relaxed atmosphere with fewer people, now I sometimes feel like I am speed dating with the meetings there!

"But the real value has always been meeting the lead producers that go there. I find it a very friendly conference from that perspective. It is very sociable compared with comparable conferences I attend."

Geoffrey May, director of FOCUS Consulting, who has only missed a couple of events since the start, says the conference's commitment to staying true to its roots has stood it in good stead.

Now, with its steady growth over the years both in numbers and stature, May believes ELBC is an unmissable event. "In an era where conferences are produced rather like stage shows and marketed to the audience to attract delegates and exhibitors, ELBC is organized on more traditional lines with a call for papers and only the keynote speakers are invited by the organizing committee," he says.

"The call for papers brings in a large number of offers of papers and the Technical Programme Committee has to sift through the offers. New research is given a high priority and the quality of the work, the reputation of the authors and the relevance to current issues is important in selecting the papers."

A European tour

Since the first ELBC in Paris, the event has visited many European cities, developed an exhibition — and a quite special gala dinner — that has gone from strength to strength. The credit for much of the work in this area goes to Maura McDermott, the conference organizer through thick and thin.

"The numbers of delegates grew and there was great competition and interest in the choice of venue, which was handled by Maura and her team," one attendee said. "Then a highly successful exhibition was organized by Allan Cooper and demand for exhibition space has grown ever since."

McDermott has been fully involved since the second ELBC in Brussels in 1990. She undertakes all the administration on the event: coordinating speakers, exhibitors — and making that tough decision each year as to where to host the event. McDermott says that her greatest challenge every year is finding a suitable venue to host the event.

While it is too small for some of the bespoke exhibition centres around Europe, designed to host thousands of delegates, it is too large for many hotels.

"And we like to have a certain layout, with everything on one level," she says.

She estimates that whereas the first event in Paris attracted around 200 attendees, Brussels increased this to around 220. To put this number in context, the 16ELBC in Vienna in September 2018 set a new record with more than 900 delegates in attendance.

An important development for the ELBC was the addition of an exhibition, which has also enjoyed strong growth. She says that from around 19 booths in its first year the event has now reached more than 100 exhibitors.

"In the early days it was very academic in its focus; while much of the content still is, one of the big changes has been the exhibition we now do and that has meant a lot more networking and face-to-face time for people," she says.

As more exhibitors and suppliers attended, many started hosting their own dinners and entertainment external to the event itself. With the increasing attendance, the supply companies sought local castles, palaces or well known local hostelries to entertain their customers.

"It is a case of just going to see what is available in different cities in Europe. We would get lost in a venue that is too spacious," says McDermott. "And, of course when we do find a venue, getting the right dates can be difficult. We book two to three years in advance, but even then it can be difficult to get the dates we want."

The conference did originally experiment with putting on activities for the spouses and partners of delegates — city tours and other social activities. But these were scrapped after it became apparent these individuals preferred to organize themselves.

"We did a few in the early days but there was not much take up and it became apparent that a lot of the ladies who were attending already knew each other and preferred to organize themselves," she says.

The pandemic in 2020 wreaked havoc on the plans to go to Malta that September and all the more so in that the north of Italy was the hardest hit in the early part of the year.

The ILA clung on for as long as it could, hoping that the country lockdowns and bans on travel would ease. By May it was clear that even if (and it was a big if) the situation improved it would be too late to organize the event.

The virtual conference

Rather than call it a no-show, Andy Bush, head of the ILA took the brave decision to hold a virtual conference. "We started from scratch," he later recalled. "A completely blank sheet of paper and worked out what we figured would work and then went out to find people who could do this."

Even the organizers were surprised at the success that materialized. Ambitious plans to hold a session in a studio in Germany as well as in England seemed to work out perfectly. For a while it even looked that this seemed to be the template for the future.

One of the surprising features of this virtual conference was that it went off without any great difficulties. In terms of the presentations only two had minor technical connection flaws. Moreover, the electronic nature of the questioning at the end of the session proved highly positive on occasion. Additionally, some of the virtual chat rooms were still being used a couple of weeks afterward.

"Although the ILA reacted well to the challenge of the pandemic and kept the technical momentum behind the conference series running, the problem with it being virtual is that networking was almost impossible to do," said one delegate to this year's conference. "Some of the exhibitors tried their hardest to engage with people — some didn't though and it showed — but even so, there's a huge difference between sitting at home on a zoom call and sitting with a coffee or a beer in a conference bar or reception hall.

"I'm glad the new combination of the organization of ELBC and CBI is going to be face-to-face. It'll be good to be all back together again." ■

Since those early and very heady days, the event has grown in terms of its sophistication and number of delegates. Nevertheless, its technical focus and format in many ways has remained little changed.

Here are some of the idiosyncratic discussions of the *Batteries International* newsroom in the run-up to ELBC 2022.

A pick of the best

We live in a subjective world. One man's meat is another man's poison. Or, if you know that it comes from the French, it was originally *poisson* meaning fish. So we know that many of the choices we make here will be ridiculed by some (ignorant journalists) angered by others (we didn't mention you) and then praised for our perspicuity (yes, we did mention you).

In the run-up to preparing this show guide we regularly talked about who was giving what presentation and what would we do — a networking break as an escape for a coffee or a beer? Or a sneak peek at the back of the hall, or at the front, listening with notepads bristling.

Wednesday

Leaving aside the fact that the first day's session in the morning is virtually obligatory and the organizers nearly always put their heavy hitters there, we'd highlight **Neil Hawke's** paper as particularly interesting. It ends with a deep dive into the future and an interesting take, from an expert, of how the lead battery market will evolve in a world running mostly on EVs.

We would also highlight **Julie McClure's** paper on women in the global battery industry not because we think it'll contain much that we haven't already heard at BCI but the fact is that the establishment of a women's group is a pivotal moment in an industry traditionally dominated by men. This needs our attention and support.

On Wednesday afternoon our team will be split between the supplier's forum in session 4 in one long parallel session. Almost everything from CAM's **Francesco Marfisi** on an induction melting oven for grid manufacture to **Nicolas Clement's** new AGM separator look good.

John Wirtz II's take on new manufacturing techniques for TPPL should be interesting because we also have EnerSys' **Raju Kurian** talking (unfortunately around the same time in the other parallel session about what we believe is a technology that has still yet to reach its full potential).

Thursday

Thursday morning starts strongly. **Stefan Stübing** is apparently not going to be full of CEO platitudes but direct and saying what parts of this industry should be doing. **Nick Starita** and **Ray Kubis** always give good presentations — we recommend taking extensive photos of their slide decks, they are truly informative — though we guess we have already heard the substance of their thoughts at BCI in May.

Thursday afternoon sessions seem to us to be dominated by the 'everything interesting in session 6 versus the super-scientific in session 8'. Unfortunately, **Stuart McKenzie** from Arc Active had not released his paper at the time of going to press, but Arc Active is one of the most exciting lead battery developers in the last five years.

Don Karner, who follows Stuart, is not just a great speaker but his firm EAI is at the cutting edge of research with Argonne National Laboratory in the US on the Lead Battery Science Research Program. This is already providing a huge success and a boost for the industry's prospects in the future with the US government now committed to spending serious money on R&D. Roll on the time when we see the same thing happening in Europe.

We expect the talk by Entek's **Richard Pekala** later in the afternoon on the role of silica in separators to be informative but that may be due to a lack of technical knowledge on some of our parts!

We'd definitely recommend the panel discussion on future ESS systems at the end of the day. Since the next major market direction for lead battery technology is probably going to be in ESS, the four panellists have a lot to say.

Matthew Raiford's CBI perspective should be interesting in that this is a market the consortium is looking to develop. **Bernhard Riegel** from Hoppecke is also perhaps one of the best experts in Europe on the subject.

And then there are two heavy hitters on the panel in terms of battery development — **Ed Shaffer,** a highly articulate and thoughtful developer of bipolar batteries and **Stuart McKenzie,** as mentioned before; both of whom are at the cutting edge of larger technology trends.

Friday

The first two sessions that really interested us clashed on Friday's timetable. The first comes from **Dani Strickland,** a professor at Loughborough University in the UK, who will discuss how to redesign lead batteries to become 'battolysers' — capable of producing green hydrogen. A tonne of money across Europe is going into hydrogen; it would be nice to see lead batteries be part of that action.

Unfortunately, Dani's talk clashes with **Eckhard Karden,** a very clear speaker who will be presenting a paper on high temperature testing for automotive 12V batteries, which may seem esoteric but looks at a fundamental issue for lead batteries. We're torn both ways on these two.

We could have said much more about some of the papers and the speakers — there are some very distinguished, specialist people on display — but we confined ourselves to just this snapshot. Give me an extra page it'd have been double. ■

SESSION 1: Markets and Trends • Wednesday 9.00am-12.00pm

Delegates should be all scrubbed, smartly suited up and hopefully already anticipating the first lead battery conference in Europe for four years.

The first morning, the whole conference will be seated together — parallel sessions will then follow in the afternoon through to Friday lunchtime when the conference closes at 1pm.

Today, on the first day — please note two things:

- The expo opens at 10.30 and will close at 5pm on Wednesday and Thursday and shuts at Friday lunchtime.
- The International Lead Medal will be awarded around 11.30 before everyone goes to lunch.

Let battle be enjoined, let the conference begin!

Short opening address

Andy Bush, International Lead Association

Lead Batteries — key to the need of unlocking energy storage solutions

Chris Pruitt, president/CEO, **East Penn Manufacturing.**

Energy storage has become even more critical to our world as we move toward solutions that enable decarbonization and greenhouse gas reduction. Electric vehicles and renewable energy are some of the key topics in the conversation of ways to unlock an accelerated path to our progress. However, challenges remain in understanding all the implications (good and bad) that surround many initiatives.

Regardless, the lead industry must play a leading role in this important evolution and have a strong voice at the table. Lead batteries will be the key to creating successful results and are ready to meet the challenges of economics, safety and a circular economy.

This presentation will highlight areas where the lead industry can and will be successful in responsibly powering the next generation of needed solutions.

The rechargeable battery market worldwide

Christophe Pillot, director, **Avicenne Energy**

The main goal of this presentation is to review the worldwide rechargeable battery market today and trends to 2030. A focus will be on the potential for lead batteries in the following applications:

- Automotive
- Industrial and back-up
- Motive
- E-bikes
- Utility and renewables

Competition in these applications from lithium-ion and other technologies will be assessed.

Evolution rather than revolution — time for battery metal lead to show resilience as ICE age draws to an end

Speaker: Neil Hawkes, commodity analyst**, CRU**

The LME lead price recovery from the depths of the first virus wave in early 2020 has been impressive, if somewhat erratic in nature, reflecting the uneven pandemic exit path around the world.

Alongside the broader macro recovery in economic activity lifting all LME metal prices, key 'micro' lead industry drivers have also played a part. Lead supplies have struggled to keep up with a strong rebound in lead demand, hit by production shortfalls in North America and Europe, with all eyes on Asian supplies, notably China, to come to the rescue.

The resilience of the lead-based battery sector, under threat from the rise of lithium-based batteries; is the key factor that will determine the lead price path in the years ahead. CRU believes that lead is set to play a role in a 'greener', more sustainable world. The only uncertainty is how big or small that role will ultimately prove to be.

Women in the global battery industry

Julie McClure, chairman, **MAC Engineering**

To introduce the Women of the Global Battery Industry (WGBI) to the ELBC community, I will discuss the goals of the newly formed organization. I will also give a quick introduction of the steering committee and key committee chairs.

An overview of the past events, current events, and future events will give prospective members an idea of the direction of the organization.

Topic: Positive energy: CBI's roadmap charts path to new generation of batteries

Alistair Davidson, director, **Consortium for Battery Innovation**

Significant opportunities exist for lead battery technology in current and future markets. However, in order to meet ever increasing end-user requirements, the lead battery must continue to adapt and improve through advanced research and innovation. This presentation will discuss the work of the Consortium for Battery Innovation – the only global lead battery research consortium.

Key research themes and areas will be presented, highlighting the latest consortium findings and how these are contributing to significant performance enhancements. These will be discussed in relation to the new CBI Technical Roadmap.

Utility and renewable energy storage applications offer huge opportunities for all battery technologies – and new projects related to lead batteries used in energy storage applications will be introduced and discussed.

The impact of government policies on lead battery and lead metal use in China

Jianbin Meng, director of economics and environment, **International Lead and Zinc Study Group (ILZSG)**

The paper will discuss the main economic, industrial and regulatory policies that have implications on the use of lead and lead acid batteries.

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SESSIONS 2 & 3: Key innovations in the industry • How lead is powering industry

SESSION 2 • 1.30pm-2.30pm

Lead battery science research program overview at Argonne National Laboratory

Tim Fister, material scientist, **Argonne National Laboratory**

Grid energy storage is rapidly emerging as a significant market for electrochemical energy storage. Unfortunately, the current generation of lead battery technology is not generally viewed as competitive in this market.

The North American lead battery industry has organized to address this need by establishing the Lead Battery Science Research Program (LBSRP). Over 90% of the North American lead battery industry participates in the multi-year LBSRP. Managed by Electric Applications Incorporated, the LBSRP is conducted in cooperation with CBI at the Argonne National Laboratory under a Cooperative Research and Development Agreement.

This presentation provides an overview of the investigations conducted by the LBSRP during its first three-year program of work. Additionally, an overview of research work planned during the current three-year program is presented.

CBI technical program: improving energy storage system and automotive batteries

Begüm Bozkaya, technical manager, **Consortium for Battery Innovation**

The CBI has developed a technical program to advance the lead battery technology to deliver reliable, safe, cost-efficient, and sustainable batteries. The technical program mainly focuses on 12 V automotive and energy storage systems to enhance the dynamic charge acceptance and lifetime of batteries under partial state-of-charge operations.

This presentation is concentrated on the main findings obtained from the current research projects. Additionally, new technical projects that are selected from the CBI´s Request for Proposals 2022 will be overviewed.

CBI targets — A guideline for product development in automotive and ESS applications

Spartacus Pedrosa, director, **ITEMM**

The CBI Technical Roadmap is an important asset, pushing lead battery technology to keep playing a major role in a high-tech battery starved world.

On the renewable energy segment, battery energy storage systems will become mainstream support for power generation. This brings a huge opportunity to the lead battery industry, if a higher cyclability is reached. As a 100% recyclable product, environmental, social, and governance (ESG) agendas should emphasize the use of advanced lead battery technology, like lead carbon batteries, in this market.

For both segments, this study will show how Moura Batteries is using CBI KPI's to drive its innovation, pushing all technical team efforts to enable the use of lead batteries in these market focused challenges.

SESSION 3 • 3.00pm-4.15pm

Maintenance free thin plate developments for motive power applications

Raju Kurian, EnerSys

Modern maintenance free material handling systems used in motive power Class 1,2,3 and AGV's demand batteries to perform continuously in multiple shifts operation involving shorter frequent plug-ins in between operational periods.

TPPL (Thin Plate Pure Lead) technology has been developed in 2V cells and 12V blocs and applied to such applications, as its high electrode surface area and low internal resistance allow rapid charging of the battery pack with high in-rush current, enabling to achieve full or near full SoC with short duration charging compared to their traditional flooded counterpart.

In addition, advances in active materials, charging, design and advanced materials allow the batteries to efficiently operate in Partial State of Charge with periodic extended charging steps to ensure the battery returns to full SoC.

Pro-active protection of your assets: battery fleet management

Michael Gellert, project manager, motive power, **Exide Technologies**

The cloud based fleet management software, Motion+ Fleet, works via smart connected chargers on both lead acid and lithium-ion batteries, on one site or at multiple sites worldwide, providing operators and warehouse managers with the battery's and charger's vital parameters.

Once the batteries and chargers are IoT-connected they may call service to themselves or place spare part or replacement orders to keep the intralogistics flow running. The presentation will include the optimization of the total cost of ownership based on installations on reference customers' sites.

Panel discussion • 4.15pm-5.00pm

Threats and opportunities for industrial lead batteries

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LABAYEN LABORDE GROUP

SESSION 4: Suppliers Forum • Wednesday 1.30pm-4.15pm

CAM Innovation FASTMELT: the first induction melting oven for grid production

Francesco Marfisi, marketing manager, **CAM**

After several years of research and development efforts, CAM presents the first, on demand system that generates liquid lead by means of magnetic induction for producing battery grids.

This melting oven transforms only the lead needed for direct production, eliminating the need for standby ovens as per the current state of the art, while also reducing the footprint of today's systems by four-fold.

FASTMELT is the new system by CAM which will replace the current gas burning or electrical ovens for the production of lead grids.

PowerFill – A novel AGM separator improving acid filling and battery performance

Nicolas Clement, chief scientist, **Holllingsworth & Vose Company**

AGM separators are being relied upon increasingly more in automotive and industrial applications.

One challenge many customers encounter during AGM battery assembly is the slow and uneven filling of acid electrolyte. Slow filling reduces the battery assembly speed while uneven acid distribution in the AGM separator and plates potentially cause dry spots and black spots on the plates during battery formation. Uneven acid distribution can degrade battery performance.

A key factor affecting the acid filling speed is the gas pocket trapped toward the centre of the plates and AGM separator. The gaseous species in the pocket is air and possibly CO_2 generated by the reaction of the acid with carbonate species in the plates. The gaseous species have the tendency to hinder the flow of the acid into the centre area, unless removed from the battery.

H&V has developed PowerFill AGM to solve these challenges by enhancing the surface of the separator to create open channels. With the open channels on the PowerFill AGM separator, the gaseous species in the pocket can escape more easily from the battery during the acid filling process, thereby allowing acid to flow quickly and evenly into the centre of the plates/AGM.

The patented technology can be applied to various types of AGM, and the resultant separators still retain the same strength and compression retention behaviour of the base AGM.

A new innovative red lead — combining the advantage of tetrabasic seeding with red lead

Ian Klein, consultant, **PENOX GmbH**

The new patented product "RL+" is a functionalized red lead combining a tetrabasic lead sulphate (4BS) seeding with the known advantages of the red lead. PENOX has been offering TBLS+® since 2004, and the material supports effective tetrabasic curing with a low addition rate, thanks to the small particle size (d50 = 0.5 to 0.7 µm) of PENOX seeds compared to the powder 4BS additives. RL+ allows a similar effective tetrabasic seeding since the surface of the red lead is precoated with very small 4BS seeds.

Consequently, the requirements for mixing 4BS seeds in the industrial paste mixing process are reduced, and a more homogenous distribution of the seeding crystals is obtained faster and in a more reliable way.

RL+ offers the following advantages:

- homogenous 4BS structure of the cured positive active mass (PAM)
- defined porosity of the PAM
- energy-efficient formation, which results in a stable formed PAM
- high mass utilization.
- high cycle life performance.

Innovations in thin pure lead and lead-tin grid and plate production technology

John Wirtz II, president, **Wirtz Manufacturing**

AGM-VRLA Thin Plate Pure Lead (TPPL) lead-acid cells and batteries are an ideal solution for many applications requiring high performance, and long service-life.

This presentation reviews the recent advances in continuous grid casting and plate pasting process technology; illustrates the importance of select-

Nicolas Clement,
Holllingsworth & Vose Company

Ian Klein,
PENOX GmbH

John Wirtz II,
Wirtz Manufacturing

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SESSION 4: Suppliers Forum • Wednesday 1.30pm-4.15pm

ing the appropriate manufacturing process to both produce and handle grids manufactured from 'soft', 'thin', pure-lead and lead-tin alloys; and 'advanced' plate-pasting process(s) capable of producing pasted plates with consistent characteristics; in particular, pasted plate thickness, active material weight, paste-to-grid adhesion and over-paste distribution; for the consistent high-speed production of optimum quality positive and negative pasted plates for use in 'high performance', prismatic, AGM-VRLA TPPL lead-acid cells/batteries.

High performance PE separator for deep-cycle battery applications

Sachin Kumar, R&D Manager, **Microporous**

Microporous has developed a new high-performance PE/Rubber hybrid battery separator for deep-cycle battery application. Our new high-performance separator, we have used proprietary components that greatly reduce the internal electrical resistance of the separator, we have demonstrated the ability of our separator to greatly enhance the charge acceptance and capacity retention of the battery while keeping long cycle life.

This also has components that imparts improved antimony suppression during the cycling of the batteries.

In our presentation, we will discuss our separator performance results from 6V golf cart battery testing as well as battery test results from other battery types.

Our new separator can also be made in either leaf or roll form which provides flexibility to battery manufacturers during production.

Sachin Kumar,
Microporous

Economic manufacturing process for VRLA batteries in gel technology - Gel Circulation System

KD Merz VP technology, **Abertax Technologies**

Gel cells and batteries are types of Valve Regulated Lead Acid (VRLA) batteries, which do not need any water refilling during the whole service life. A new manufacturing process has been developed to perform the formation and filling of such cells and batteries with an innovative circulation technique which requires much less investment in terms of the manufacturing equipment. The electrolyte is coagulated *in situ* with silica which forms a gel inside the cells.

This new process is less labour intensive and saves time. It results in an improved quality and performance of the batteries, as confirmed by electrical tests of cells that have been filled by this process.

Furthermore, the process is more environmentally friendly since there is no acid wastage. During the filling process with this new and innovative system, the battery plates are never exposed to air, and are covered by acid and/or gel at all times — promoting higher quality batteries.

Example systems in operation and a brief overview of the principle of this circulation process will be presented. Also, a comparison of the economic and quality advantages of the Abertax approach will be discussed versus other manufacturing processes.

Based on the achieved results and the advantages it has over the standard and conventionally used Gel-Filling techniques already in the industry, this system is already being preferred by established Gel-Battery manufacturers over other traditional and established practices.

KD Merz,
Abertax Technologies

Fumed metal Fumed metal oxides as pore forming agents in LAB electrodes

Michael Glagla, technical market manager, **Evonik Industries**

To extend the advantages and thus expand competitiveness, LABs must meet the increased requirements and therefore continuously improve. Evonik offers the possibility to improve existing systems by adding customized additives to LAB electrodes.

The focus of this presentation is on structural modifications of the positive and negative active mass (PAM and NAM) to increase overall porosity and to adjust the pore size distribution within the electrodes.

Functionalization of the active masses with fumed metal oxides results in improved electrode plates with an increased porosity. The associated improvements in the electrolyte accessibility have a direct influence on the active mass utilization and thus on the forming efficiency and final battery capacity.

In addition to creating a more advantageous pore size distribution, the use of fumed metal oxides as a coating on electrode materials such as leady oxide and red lead results in pastes with stable high density but lower viscosity and longer storage stability. Such paste characteristics are beneficial when it comes to maximum throughput in both continuous and batch production lines.

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SESSION 4: Suppliers Forum • Wednesday 1.30pm-4.15pm

Optimization of battery fleet operations through AMC monitoring

Malcolm Tabone, Abertax Technologies

Battery Monitoring Systems give a detailed picture of the state of the battery. The Abertax BMS and e2BMS monitoring systems can identify battery abuse in terms of temperature limits, watering intervals, depth of discharge, voltage imbalances and, by means of algorithms, use the sensor data to estimate remaining battery life under the current conditions.

Abertax has developed the AMC, the Abertax Master Control system. The AMC is a hardware device combined with powerful software modules that allow multiple configurations, resulting in a flexible system guaranteed to meet any practical scenario.

It regularly monitors all devices from one on-site location. Consolidated reports of the condition of all batteries used in the company are also possible. With this extended overview, improvements can be made to create budgets, plan service calls and schedule maintenance operations to ensure your batteries operate under optimum conditions and reward you with maximum return on investment.

Innovative multiple quality test machine in the production line

Michael Wipperfürth, VP sales, **CMWTEC**

Michael Wipperfürth, CMWTEC

This paper presents the capabilities of our universal Quality Test Software (QTS) in combining different test profiles to create a new approach to a high current discharge machine in terms of its programming flexibility and ability to accurately distinguish between acceptable and unacceptable batteries.

Additional internal resistance tests in combination with the high current test provide further insight into the quality of the battery.

It will show how complementary evaluation criteria such as DCR, ACR and the CCV discharge curve vs. time can be implemented and combined by program selection.

The presentation concludes that the new generation of our End-Of Line Test machine (EOL) with Quality Software (QTS) allows a simplified programming of customized test and evaluation profiles to improve the reliability of results.

Meeting EFB challenges — reducing water loss while increasing DCA

Michael Jacobs, global business leader, **W. L. Gore & Associates**

W. L. Gore associates introduces a new technology, GORE Catalytic Device, which helps reduce water loss while increasing DCA and improves high temperature durability in EFBs using Gore's ePTFE technology.

Meeting the increased demand for high performance batteries while adhering to stricter regulations to reduce gas emissions is one of the biggest challenges the automotive industry faces.

Unlock Higher Levels of Battery Production Quality With Mate Gauge Inline Measurement Solutions

Steve Mate, CEO, **Mate Gauge**

Lead battery manufacturing is a game of microns. Any slight deviations in layer thickness along your rolling and pasting lines can significantly affect the quality of your product downstream.

Unlike typical production monitoring solutions, Mate Gauge enables the unique opportunity for battery manufacturers to optimize their processes through real-time, data-driven decision making.

Our inline laser thickness gauges provide insights and tools to help tighten production tolerance spread and shift the nominal thickness standard.

Mate Gauge combines hardware and software to deliver a complete and comprehensive thickness gauging solution designed to improve quality, enhance efficiency, and reduce material overages in the battery manufacturing industry.

CX SMART; the new solution tailored by Engitec Technologies for regional ULAB recyclers

Engitec's Stefano Buono, Dario Gadda, Daniele Silla, Engitec, Italy.

Alongside recyclers with international presence, utilizing Engitec plants exceeding 200,000tpy of batteries, there is a remarkable number of regional recyclers with limited availability of tonnage. For such local recyclers, Engitec Technologies has tailored the new CX SMART capable of processing up to 12,000 ULAB and incorporating the well-known Engitec technique.

The authors (above) will explore the technical features of the newly launched CX SMART.

Steve Mate, Mate Gauge

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WIRTZ

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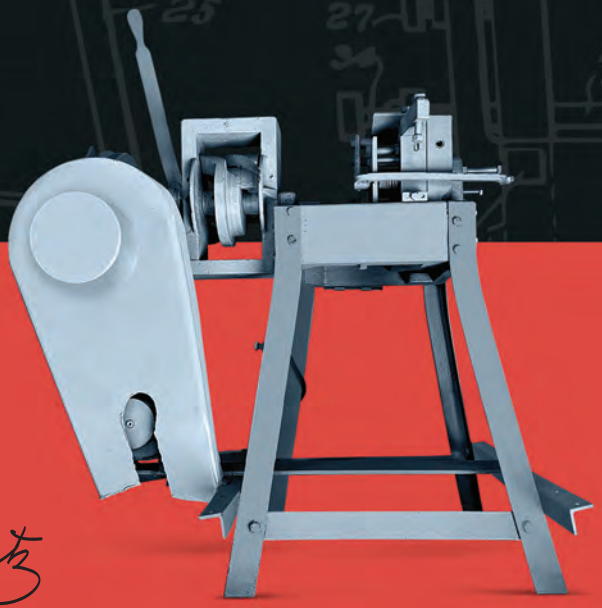

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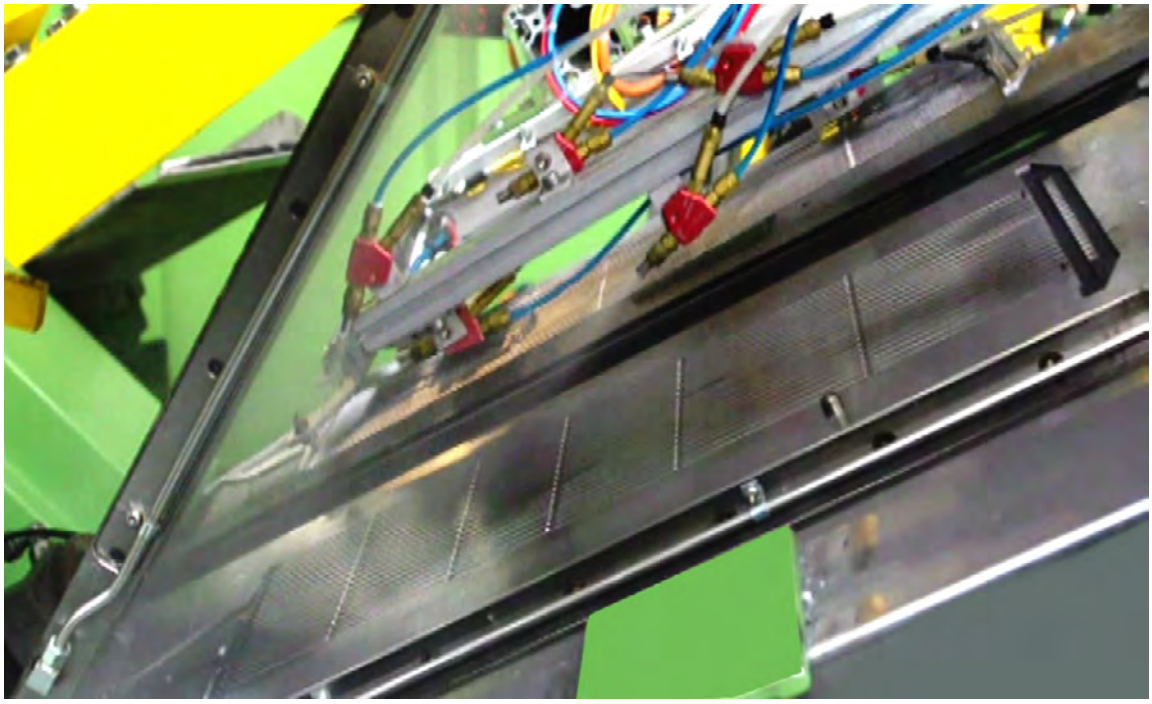

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SESSION 5: Market and Trends • Thursday 9.00am-12.00pm

Seize market opportunities, manage change and secure progress

Stefan Stübing, president/CEO, **Exide Group**

There are business opportunities beyond today's traditional applications and energy storage offers great opportunities that complement our traditional markets — in automotive there's the EV auxiliary batteries, in the industrial sector – on/off grid energy storage systems

We need to manage the technological change. What does it take to stay successful with lead acid batteries in competition with lithium-ion?

Secure progress needs to be made in the European regulatory environment. So what is needed to stay competitive and support the Green Deal in light of the EU Battery Regulation, REACH Revision and the End of Life Directive?

Industrial lead battery global market trends & forecast

Nick Starita, president, **Energy Solutions Division, Hollingsworth & Vose**

The global industrial lead battery market continues to evolve based on the changing needs of its diversified customer base and government regulations. In order to understand these global market dynamics, data and insights were gathered from industry experts to analyze both the stationary and motive power segments. We will review the industrial battery market trends and lead battery forecast for each region and application to draw conclusions about the future business outlook for our industry.

Transportation battery forecast to 2027… dynamic developments continue

Ray Kubis, chair, **Gridtential Energy/ Silicon Joule Technology**

The paper will cover forecasted volume and mix of batteries in energy content and value across the electrification of light vehicles, and also from eBikes to eBuses, and the evolving commercial truck fleets. This will include the assumptions on the technology mix and opportunities for battery makers and examples across the diverse transport options worldwide for people and goods.

Continuing role for lead batteries in China's e-bike market

Huw Roberts, director, **CHR Metals**

This paper will review recent developments in the Chinese e-bike market and consider the potential for innovative lead batteries to be the power source of choice as two and three-wheel e-mobility is pursued in South Asia.

In April 2019 China introduced new standards for e-bikes. Among other changes, the weight of an e-bike including batteries was limited to 55kg. It was widely assumed that this would end the use of lead batteries in the key market sector, to be replaced by lithium batteries. Three years on, lead batteries continue to power most electric two and three-wheelers on China's roads.

In addition to regulating e-bikes, China also introduced specifications for e-mopeds and e-motorbikes which are not subject to a limit on weight. These two classes of electric two-wheelers continue largely to be powered by lead batteries, these being cheaper than lithium batteries. Even in the smaller e-bike sector, lead batteries are still being used.

CBI technical roadmap: driving innovation across the industry

Matthew Raiford, senior technical manager, **CBI**

The Consortium for Battery Innovation has developed a new roadmap to support and motivate further research and innovation in lead batteries. Development of the roadmap is directly driven by the needs of the market and clear performance goals will be discussed for lead batteries in: micro-hybrid, low voltage EV/auxiliary, energy storage systems, telecom, UPS, and motive power.

Discussion of these key performance indicators will focus on goals for the near and far term, including what possible research pathways could lead to batteries that meet future market needs.

Nick Starita, Hollingsworth & Vose

Ray Kubis, Gridtential Energy/ Silicon Joule Technology

Matthew Raiford, CBI

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SESSION 6 & 8 (Parallel): Thursday 1.00pm-2.30pm

SESSION 6

Opportunities for lead batteries in energy storage systems

Lead battery ESS for sustainable energy projects

Carl Telford, research and innovation manager, **CBI**

CBI is pursuing global public-funding mechanisms for BESS — including opportunities in Europe. CBI proposes that — in a suitable location—project partners deploy modular off-grid energy solutions in communities that currently have no access to reliable sources of energy (energy islands).

Lead battery technologies can enable electrical energy storage, but also provide the enabling components for a novel hydrogen energy solution. This presentation will cover our project development and proposed solutions.

ArcActive carbon — fibre electrodes for automotive and ESS lead batteries

Stuart McKenzie, CEO, **ArcActive**

No synopsis available at time of going to press.

EV fast charger lead battery back-up: challenges and opportunities

Don Karner, president, **Electric Applications Incorporated**

A rush to develop a comprehensive charging infrastructure is underway. With a focus on vehicle fast charging at powers of 350kW to 600kW, battery energy storage is required to minimize the grid power demand. Lead batteries provide an excellent solution for this application. However, the design and certification requirements for this application are both new and still evolving.

This presentation provides an overview of the operational and safety challenges for lead batteries in EV fast charge demand reduction duty. Typical duty cycles and performance requirements will be discussed along with safety certification and test requirements for the North American market.

Advantages of advanced bipolar lead batteries for long duration energy storage

Ed Shaffer, CEO/founder, **Advanced Battery Concepts**

Long duration energy storage (LDES) stabilizes the electricity network as renewable power sources are added. Nearly 140TWh of long-duration storage, or 7,700 GWh per year, is required by 2040 to meet established global initiatives for a carbon-free electric grid. This production objective is 18 times larger than the current lead-battery industry representing a huge opportunity for growing our industry.

To compete in this market, the lead battery must advance. In this paper we show how bipolar architecture enables lead chemistry to not only compete in this market but excel. Specifically, we show how bipolar designs achieve the three key performance requirements to participate — economic responsibility, social responsibility, and environmental responsibility. We will compare advanced bipolar lead to other LDES systems including traditional lead, lithium, and other novel approaches.

For a complete analysis by Ed Shaffer of the challenges facing the lead battery market, see page 16 in this show guide.

SESSION 8

Towards robust PSoC operations

Oxygen reduction promoting Ostwald ripening of lead sulphate at negative electrode surface

Eberhard Meissner, independent consultant

When battery degradation or failure related to negative electrodes is analyzed, researchers report often about sulfation at the negative active mass (NAM) surface: notably a high concentration of lead sulphate and an accumulation of large crystals. The authors explain these findings by "preferred NAM discharge in a thin layer" close to electrode surface, combined with lack of recharge but without providing experimental evidence for their hypotheses or considering other mechanisms.

Within the theory of porous electrodes, thickness of the electrode outer portion taking part in a certain reaction is characterized by the "depth of current penetration". This approach is well established with batteries and fuel cells, to optimize electrode thickness for a specific electrochemical reaction (including material properties) at targeted operation conditions (discharge rate, temperature, and other parameters).

Only marginal further benefits arise from thicker electrode design

Oxygen reduction at the NAM physical surface, taking place at relatively low specific rates (mA/Ah) also during electrical rest and discharge periods, is expected to enhance Ostwald ripening of $PbSO_4$ crystals in the surface region. Large $PbSO_4$ crystals formed this way are known to be difficult to be recharged again. This mechanism appears to explain surface sulfation reported from NAM electrodes more plausibly than assuming locally preferred NAM discharge at the electrode surface.

Effect of crystal control technology and temperature on operating lead batteries

Boris Monahov, chief scientific officer, **WaveTech Group**

The Crystal Control Technology of WaveTech uses a specifically modulated electric signal which is sent to the battery through the terminals. The signal provides extra energy to the charge carriers which in turn changes the ionic kinetics and the structure of the electric double layer formed on the surface of the positive and negative plates. Dissolution, nucleation, and growth of crystals in the interface electrode/electrolyte is optimized. More uniform crystals are formed, and the concentration polarization is reduced.

Recent studies have shown that CCT enhances the crystal dissolution and precipitation reactions in lead-

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NEW DEVELOPMENTS FOR FINISHING LINES:

FAST AND PRECISE AGM FILLING, EVEN FOR SMALLEST BATTERIES

HIGH RATE DISCHARGE (HRD) – IMPEDANCE (ACR/DCR) COMBI MACHINE FOR MORE MEANINGFUL MEASUREMENTS

CMWTEC technologie GmbH is a small family operated business in the Midwest of Germany producing highest quality machines for the Finishing Line in the battery production.

For more than 43 years CMWTEC has been a forerunner with regards to developments for the battery industry.

While having the roots in the lead acid sector we are also the most competent and innovative partner to the Lithium battery industry to help our customers making batteries more effective, more reliable and more economical.

In this article we would like to draw your attention to a few new developments.

The demand of AGM batteries is constantly increasing.
The speed of production lines must become faster and faster to keep up with the market requirements. But the quality must get better and better at the same time.

Besides speed and volumetric accuracy the biggest challenge is to fill an AGM battery in such a way that the packs inside will be soaked all the way through without any dry spots in the center.

This is commonly done by evacuating the inside of the battery to a level of about 20% of the atmospheric pressure so that the acid will basically be sucked into the battery. The patented VACBOX acid filler of CMWTEC creates a Vacuum not only inside the battery. The pressure inside and outside will be the same. This ensures that the box will not deform during the filling

process as it does under different pressures inside and outside.

High filling speed can lead to damages on the separator top areas inside the packs.

Since the filling speed and the vacuum level can be controlled independently when using the VACBOX System the filling process can be adapted to customer's individual battery specialties much more targeted.

Picture: Martin Grosskreutz,
Sales Engineer

CMWTEC technologie GmbH
THE BATTERY FINISHING LINE EXPERT

The demand for highest quality and fast production becomes more and more important.

CMWTEC combines proven technology with innovative developments for tailor made concepts to help the battery producers achieve the ambitious requirements of the automotive industry.

We have recently updated the flow concept of the acid in such a way that highest output rates at lowest volume tolerance can be realized, thus boosting quality and speed at the same time.

Filling small batteries with subsequent small filling holes fast and precisely is a particular challenge.

Using the patented VACBOX System in conjunction with especially designed pre-filling chambers CMWTEC has optimized the filling process so that also in this application there will never be any dry spot inside the battery pack.

Ask us at our booth number 105 of the ELBC exhibition for details on how our machine concept can fill up to 8 AGM batteries per minute.

The End of Line Test machine (EOL) according to the HRD principle is already well established in the market. Also combination machines implementing multiple units such as HRD, HVT (High Voltage Testing), Terminal brushing or greasing all the way up to marking of box and / or terminals have become more and more sought after.

In our new development we combined the HRD with an impedance measurement in one unit.

This enables the user to choose for example a testing order like ACR/DCR – HRD – ACR/DCR.

The possibility to compare the impedance results before and after the High Rate Discharge test will reveal new information about the quality of a battery.

While the typical impedance measurement is carried out at one single frequency (i.e. 1 kHz) the results from tests with multiple frequencies carried out by our SerEIS (Serial Electrochemical Impedance Spectroscopy) device also help to collect a magnitude of helpful data to determine the quality of a battery.

Hear more about the possibilities and advantages of this new and unique concept at our booth 105 at ELBC but also in the conference paper of our VP Sales Michael Wipperfürth, with the title "Innovative multiple quality test machine in the production line".

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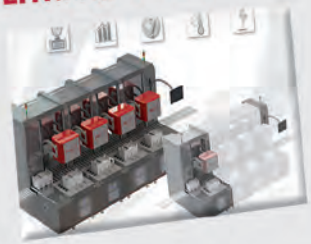
- **END OF LINE TEST LITHIUM BATTERY**



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SESSION 6 & 8 (Parallel): Thursday 1.00pm-2.30pm

acid batteries so that formation is accelerated (by up to 15%) and becomes more efficient. The capacity of these formed by CCT batteries can increase up to 30%.

Another effect is the increased stability of the porous microstructures of both positive and negative active materials (PAM and NAM) where the capacity is born. As a result, batteries operating with CCT can have up to twice longer service life. The way the NAM and PAM microstructures change on cycling under the action of CCT are different.

Two more beneficial effects of CCT have been observed by testing commercial VRLA batteries:

- The rate of hydrogen evolution and the flow rate of gas leaving the cells of brand new commercial batteries on overcharge is slowed down by CCT.
- Under the influence of CCT, the charge acceptance of VRLA cycling batteries increases. The effect depends on battery size, as well as on temperature.

The influence of the external surface area of tailored carbons on EIS

Sophia Baucknecht, graduate research scientist, **TU Berlin**

The dynamic charge acceptance of lead-acid batteries has become one of the most important criteria for micro-hybrid vehicles. Novel additive combinations, involving carbons in the negative active mass, have resulted in a two to threefold increased DCA.

However, the properties of carbon that improves DCA require further investigation. It was found that the increase of the external surface area of the carbon increased the DCA of lead-acid cells.

Therefore, in this work, similar carbon additives with a distinct difference in the external SA were used as additives for the NAM to ensure that differences in DCA are remarkable. The main focus of this work is the electrochemical impedance spectroscopy which is used as a characterization technique to identify different processes within the cells due to different external SAs of carbon additives.

Assessment of carbon black-organic expander interactions on capacity, dynamic charge acceptance, cold cranking and partial state of charge life in lead batteries

Tim McNally, R&D manager, **Borregaard USA**

Numerous investigations have demonstrated charge acceptance and life of lead batteries in PSOC operation can be improved by the addition of high levels of specialty carbon additives to the NAM.

In this work, we investigated the interaction of lignosulfonate expanders Vanisperse A and Vanisperse DCA with eight commercially available carbons.

We conclude the effective dose of lignosulfonate is contingent on the carbon's specific surface area and that a minimum threshold effective dose of lignosulfonate is necessary to preserve or improve key battery performance.

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SESSION 7 & 9 (Parallel): Thursday 3.00pm-4.15pm

SESSION 7
Lead carbon electrodes for automotive and ESS batteries

Investigations on the effect of carbon surface functional groups on electrochemical behaviour of lead-carbon electrodes

Jochen Settelein, Fraunhofer Institute for Silicate Research ISC

The influence of surface functional groups of carbon additives on the electrochemical performance of negative electrodes for lead-acid batteries is presented. Two groups of additives were synthesized to determine the influence of basic and acidic surface groups. Additionally, the effect of specific external surface area is included to compare the effect of structural versus chemical properties of carbon.

The presentation will include the characterization of 14 carbon additives, including determination of the amount and type of surface functional groups as well as carbon's porous texture.

Additionally, more advanced analysis methods such as cyclic voltammetry and the adsorption of water and of lignosulfonate will be presented and discussed and relationships between carbon properties drawn.

Finally, an outlook regarding the effect of the modified carbon additives on the electrical performance negative lead electrodes is provided.

Lead-carbon interactions: improving charge acceptance while reducing water loss

Francisco Trinidad, independent consultant

The presentation will explore different strategies to increase charge acceptance (by increasing the electrochemical active surface area of lead-carbon electrodes) while reducing water loss (by selectively modifying the surface properties to increase hydrogen over-potential).

Carbon nanomaterial compounds as negative active material enhancers

Miguel Garcia, research scientist, **Exide Group**

This work studies the effect of advanced conductive carbon nanomaterials on the performance of negative active masses of lead acid batteries. The objective of this study is to increase the dynamic charge acceptance and cycle life of the batteries at partial state of charge (PSoC) by reducing sulfation and improved conductivity of the NAM.

Preliminary results are showing promising benefits versus control batteries (containing other carbon compounds in its composition) with no detrimental effects regarding the high conductivity of the additives. In a future stage of the project, an optimization in the additive dosage will be carried out to find out the best benefit/price ratio to improve the characteristics of the batteries without compromising their economic viability.

SESSION 9
Innovations in battery and power management

The role of silica in separator technology

Richard Pekala, chief technology officer, **ENTEK International**

Silica is a major component of separators used in Pb-acid batteries. This paper reviews how silica is manufactured and then discusses the influence of key characteristics such as particle size, oil absorption, surface area, and fibre diameter on separator processing and properties. This will examine the chemistry-structure-property relationships of three different separators, which are polyethylene, synthetic pulp and absorptive glass mat, as they relate to battery performance.

Finally, we will demonstrate the importance of controlling particle size on separator homogeneity and how under certain conditions, silica can be dissolved into the acid electrolyte of a Pb-acid battery.

VRLA battery state of health estimation using a stress factor-based machine-learning algorithm

Marcel Franke, graduate research scientist, **TU Berlin**

In this study, a state of health algorithm based on machine learning is developed. The different stress factors that affect lead acid battery degradation are identified. Based on a real-world application, a generic ageing test cycle is created and tests are performed.

The measurements are analysed and a dataset containing the different stress factors is created for a specific period. The capacity of the battery is determined periodically during the test to obtain the current state of health of the battery. Each set of stress factors can be allocated to a specific state of health.

This data is used to train a neural network. The neural network can be used to predict the state of health of the battery for the given application.

A DC hybrid micro CHP with battery backup using lead-acid batteries

Joseph Cilia, professor, **University of Malta**

Combined heat and power engines (CHP) systems combined with other renewables and heat pumps, present an interesting compromise to solve the reliability issue of renewable energy availability. The waste heat produced is utilised and the consumer can also be independent from the grid. The authors present a micro-CHP that has a DC output with an integrated bank of smart VRLA-batteries, allowing it to act as an effective backup energy storage for domestic use, while allowing independent starting and islanded operation.

The authors will show the results of their CHP in conjunction with PV panels and a two-way smart-inverter, capable of supplying, and sourcing power to and from the grid.

PANEL: Ensuring lead batteries play a role in future ESS systems

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SESSION 10 & 12 (Parallel): Friday 9.00am-11.00am

SESSION 10
Automotive Product and Test Development

High-temperature endurance test for automotive 12V batteries

Eckhard Karden, Technical expert, Battery & Energy Storage Technology, **Ford Research & Innovation Center**

Durability at high temperature is very important for automotive batteries, and several test methods have been established in standards and specifications to assess, in particular, robustness against corrosion and water loss.

For micro-hybrid vehicles, it has been shown that these tests are not necessarily representative of field conditions, and would prohibit several technologies (e.g., negative mass additives) that would enhance dynamic charge acceptance and rechargeability.

Within the framework of CENELEC TC 21X, the European battery standardization group, a new test procedure has been developed that should better represent field life in modern vehicles. The paper will present extensive validation data and suggest levels of durability criteria.

Development of new additive for positive active material and application to enhanced flooded batteries for micro-HEVs

Akihiro Nishimura, The Furukawa Battery Co

Micro HEVs with stop start and regen brake system are increasingly being used in developing countries, because micro-HEVs are a more reasonable cost than HEVs and EVs.

Usually micro-HEVs are adopting EFB. However, there is an increasing demand for EFB with high capacity and further longer life by car manufacturers.

Generally, there is a trade-off between the capacity and the cycle life, so increasing the cycle life tends to reduce the capacity. Furukawa Battery has developed a new EFB which is improved both capacity and cycle life by improving the positive active material by using a new additive.

The developed EFB has been adopted by car manufacturers. In this paper, the results of the improvement study of the positive active material and the test results of the EFB using new additive are presented.

CLARIOS AGM xEV batteries. The new product line to meet future power net requirements for vehicle applications

Olaf Sielemann, director of engineering EMEA, **Clarios**

Future vehicle applications, like mild-hybrids, PHEV and BEV, will have new requirements for the low voltage power net architecture. For instance, the engine cranking function will be less important or disappear from the 14V power net. As a result the classical starting battery function will be less important or even obsolete. Energy throughput and power pulse capability, also at low temperatures, becomes key to serve new targeted features..

The battery AGM xEV battery series is designed to meet those new OEM requirements and applications. During the presentation key applications changes, the new requirements and the corresponding battery designs will be highlighted.

Progress in development of test procedures for European Standards of EN 50342 family — new version of Micro Hybrid Test (MHT)

Torsten Hildebrandt, chair TC 21X WG3, **CENELEC**

The family of European EN 50342 standards are the basis for qualification and validation of lead batteries in modern vehicle applications. In particular, the documents EN 50342-1 (basic battery definitions and tests) and EN 50342-6 (additional requirements for start-stop applications) are widely accepted and the basis for international documents like IEC 60095-1 and IEC 60095-6.

Based on intense validation testing and scientific discussion a new version 2 of the Micro-Hybrid Test procedure (MHT) has been developed. The majority of this new test is unchanged from the previous version, with the main differences being increase of test temperature to 40°C, shortened rest times and improved total number of cycles to reflect real-life battery duty in regard of charge throughput and operating conditions.

The new version of the test and the results of the validation runs will be presented and an outlook concerning implementation into the next revision of EN 50342-6 will be given. In addition, an overview about the latest changes to the family of EN 50342 documents will be presented.

SESSION 12
Innovative Components for Lead Battery Systems

Lead acid battolysers, the pathway to low cost green hydrogen?

Dani Strickland, professor, **Loughborough University**

This talk discusses the possibility of redesigning the lead acid battery into a lead acid battolyser. A battolyser is a battery/electrolyser combined and is

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based on aqueous flow battery technology. The future zero-carbon electricity grid requires long-term storage both from batteries and green hydrogen. Electrolysers are expensive and use scarce materials such as Iridium.

The battolyser concept was developed at Delft University in 2017 and has focussed on converting Nickel-Iron batteries to battolysers. The work at Loughborough University is focused on re-designing the lead acid battery into a battolyser. There are advantages in using lead acid, including a developed recycling chain.

This talk discusses two aspects of the research; the business case for using battolysers especially in conjunction with wind power and includes up to date test results from the research program looking at performance and degradation under both electrolysis and battery functionality. The talk concludes with the challenges that still need to be solved.

Cyclic ageing of titanium-supported lead dioxide electrodes for bipolar battery applications

Angel Kirchev, R&D engineer at the Laboratory for Electrochemical Storage, **CEA Liten**

Titanium foil coated with doped tin dioxide is very attractive option for positive current collector interface of bipolar lead batteries due its outstanding corrosion resistance and excellent mechanical performance.

Despite these advantages, lead dioxide electrodes prepared by pasting and formation exhibit rather poor capacity retention during cycling with moderate depth of discharge. The phosphoric acid and two of its derivatives, one inorganic (calcium hydrogen phosphate) and one organic (poly-vinylphosphonic acid), have been studied as additives for improvement of the capacity retention of such positive electrodes.

The experiments have been carried out on small-scale working electrodes with construction resembling the end-plate electrode of a bipolar battery. The electrochemical cells employed oversized conventional negative plate and externally compressed AGM separators. The results showed that the jar-formation process in the sulfuric acid electrolyte containing phosphoric acid successfully overcomes the capacity retention problem at all studied cases.

It leads also to considerable improvement of the lead dioxide utilization. The cycling ageing of the electrodes combined with periodic impedance spectroscopy measurements, indicated progressive capacity loss corresponding to the typical processes of degradation of the lead dioxide structure and rather small changes in the electrode resistance, thus proving the corrosion resistance of the current collectors.

A novel performance additive to reduce electrolyte stratification in lead batteries: Gravity-Guard

Marco Robotti, Technical manager EMEA, **Hammond Group**

Electrolyte stratification in lead batteries is a known cause of reduced battery life and performance. Heavy-duty cycling or low state-of-charge applications are often associated with insufficient recharge or poor acid mixing conditions resulting in electrolyte stratification.

To reduce electrolyte stratification, Hammond Group Inc. has developed a novel lead silicate performance additive, Gravity-Guard. As an additive to the negative, positive, or both active masses, Gravity-Guard creates a network of micro silica gel structures which improve the retention and distribution of H+ ions within the active material.

By slowing the release of H+ ions to the bulk solution, Gravity-Guard minimizes acid stratification, thereby reducing lead sulphation and helping to maintain battery life and performance in applications including stationary AGM, motive power, golf car, and automotive EFB.

A L4 Taguchi DOE plan was selected to evaluate Gravity-Guard with particle size and loading as main variables. Testing was carried out on laboratory scale 2V cells, typically good as performance indicators, and full scale 12V batteries, at HGI's research laboratory in collaboration with industry partners. Results showed significant positive effects in reduced acid stratification and improved battery cold-cranking and cycling performance.

Contributions towards a higher energy efficiency in formation of lead-acid batteries

Rainer Bussar, Battery additives manager, **PENOX**

The formation of plates and cells or batteries is a crucial production step. The latter is associated with increased costs due to continuous and recently increasing electricity prices. Many technical improvements have been made in the past years, for instance, the so-called "closed-loop" formation introduced by Inbatec, allowing for a faster and more effective battery formation.

PENOX focuses on bringing additional value to the battery industry by analysing the impact of different structural and chemical characteristics of leady oxides on formation efficiency.

The idea of PENOX follows the concept of tuning the performance of leady oxide by surface treatment and other functionalization. Such enhanced generation of leady oxides offer the following characteristics:

- specific particle size supporting a stable porosity of the active mass beneficial for enhanced mass utilization
- adjusted content of beta-PbO to support a strong backbone of the formed positive active mass for high cycle life
- improved tetrabasic structure by surface functionalisation of the oxide with tetrabasic seeding crystals in PAM and NAM, and iv) improved conductivity by functionalisation of the leady oxides.

"Red Lead Plus" (RL+), introduced in 2021 by PENOX, is one example of such innovative, functionalized oxide. Other functionalized leady oxides, such as Barton oxide and other Pb(II)-oxides coated with tetrabasic seeds to be also used in NAM, and a leady oxide doped with pyrogenic oxides are under research.

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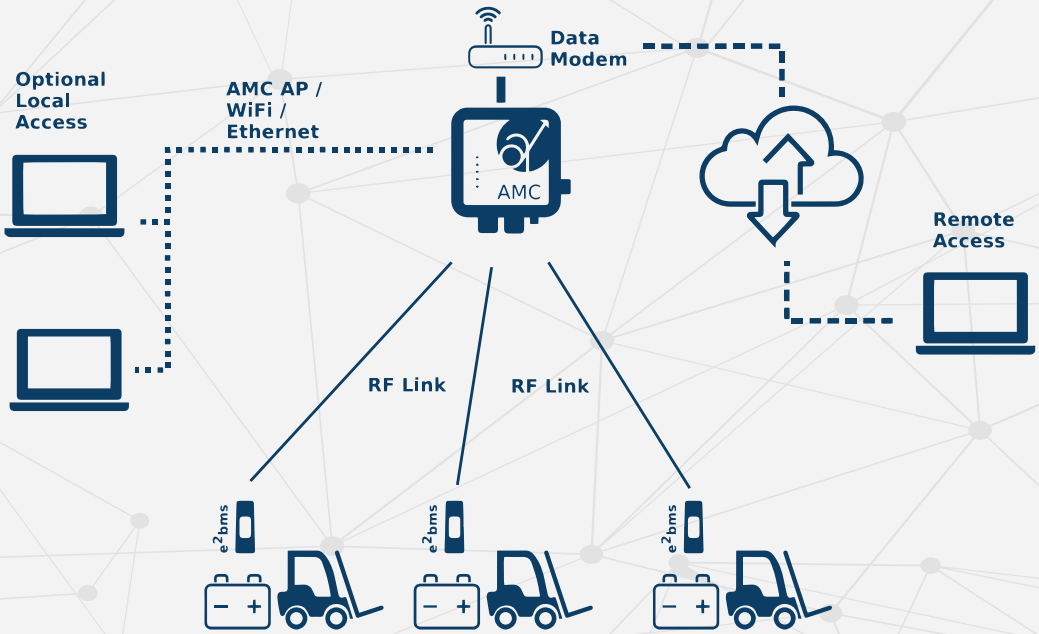

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SESSION 11 & 13 (Parallel): Friday 11.00am-12.15pm

SESSION 11
Pushing the boundaries of Science – What's next for lead batteries?

New applications of MOLECULAR REBAR for automotive, auxiliary, and beyond

Paul Everill, chief technology officer, **Black Diamond Structures**

In this, our largest annual technical update, we will share three new customer testimonials which exemplify the benefits that MOLECULAR REBAR can provoke in lead-acid battery designs.

First, we will review how our engineers deployed our materials to help a South African battery manufacturer develop a new battery with market-leading dynamic charge acceptance, improved crankability, but no change to existing water loss parameters.

Second, we will continue the story of our custom-built, Addenda-manufactured expander, designed from the ground up to maximally showcase MOLECULAR REBAR capabilities, by reviewing its performance in the strenuous new key life test (nKLT) / high temperature endurance test.

Third, we will discuss MOLECULAR REBAR in traction/forklift applications where our materials' ability to excel in deep discharge scenarios and recover charge more efficiently has resulted in new, more durable batteries being commercialized in Europe.

We also plan to share new thoughts regarding MOLECULAR REBAR mechanism of action which further differentiates itself from its competitors.

Paul Everill,
Black Diamond Structures

Minicell design to accelerate lead battery research

Subhas Chalasani, East Penn Manufacturing

East Penn Manufacturing has been proactively supporting CRADAs (Cooperative Research and Development Agreement) in collaboration with Argonne National Laboratories (ANL), where lead battery chemistry has been researched using state-of-the-art facilities. East Penn has been supplying lead electrodes and specially designed minicells to support the CRADA activities at ANL.

In this presentation, the results of various electrochemical tests performed at East Penn, on single electrodes, as well as on 2V minicells will be presented. These results will be compared with that of 12V batteries, to see how they can predict the battery behaviour. The electrochemical tests include cyclic voltammogram and electrochemical impedance techniques. Both the advantages and the short comings of the single electrode and minicell tests, including HRPSoC cycling, will be highlighted. The failure mode analysis of the batteries will also be discussed.

Subhas Chalasani,
East Penn Manufacturing

In-operando neutron diffraction studies of the charge/discharge processes inside the positive electrodes of commercial batteries

Miguel Rodríguez-Gómez, PhD student, **Instituto de Nanociencia y Materiales de Aragón, CSIC-U. Zaragoza**

We have carried-out in-operando neutron diffraction analyses of the charge/discharge processes inside the positive active mass (PAM) of industrial lead batteries, where the main problems of charge/discharge efficiency limitations are originated, focusing on the spatial distribution of the different crystallographic phases as a function of the kinetics of the transformations.

The experiments were carried out in the VULCAN instrument at the Spallation Neutron Source of the Oak Ridge National Laboratory (Tennessee, USA), where volume gauge experiments were performed comparing fresh and cycled cells. VULCAN is a time-of-flight diffractometer which provides fast volumetric mapping and the possibility to study kinetic behaviours.

Both static and dynamic mapping experiments were performed during charge-discharge cycles. More than 8500 diffractograms were obtained and subsequently analysed by using GSAS software.

The main object of analysis are the composition maps, but information on lattice parameters, crystallinity, stoichiometry, hydration, grain size, preferred orientation, etc. has also been obtained and studied. All these parameters have been mapped as a function of charge state, time, voxel location, etc. We have observed stratification processes and local inhomogeneities, as well as differences in the behaviour of fresh and cycled cells.

These experiments are part of a project to determine how, where and when the formation and charge/discharge electrochemical processes occur in the positive electrode. In this way we will be able to design new strategies to improve the energy efficiency and the PSoC cycle life of batteries for the forthcoming energy storage systems.

Please note all speakers and times were accurate at the time of going to press in end-August

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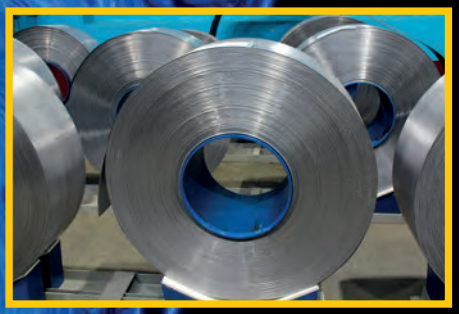

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SESSION 11 & 13 (Parallel): Friday 11.00am-12.15pm

SESSION 13
Automotive Batteries for Functional Safety

Internal short circuits in automotive lead batteries for safety applications, Part 1: robustness of batteries

Dirk Weber, EMEA flooded systems design lead, **Clarios**

In laboratory experiments in cooperation with Bosch, Clarios was able to intentionally create short circuits in lead batteries, determine their ohmic resistance and to perform further laboratory tests with artificial short circuits, which can be switched on and off externally.

With this setup, we were able to track battery performance during and after removal of a simulated short circuit in a battery cell. Finally, the battery voltage did not drop suddenly, but in a time frame of several days to weeks.

This large window is based on the robustness of the lead battery system and allows defective parts to be replaced before the performance loss becomes critical for vehicle safety applications. Additionally, the battery was able to substantially recover after the artificial short-circuit was removed.

In this first part of the presentation, experimental data will be provided, complemented by the battery power prediction approach presented by Bosch in the second part of the presentation.

Internal short circuits in automotive lead batteries for safety applications, Part 2: predicting battery failure

Christel Sarfert, engineer, **Robert Bosch**

One of the most important changes and challenges is the application of lead batteries in the safety context and in varying Powernet topologies. New functions for battery state detection have to be developed. These functions have to ensure the capability of the lead battery to deliver the necessary power for safe-stop manoeuvres at any time or rather to diagnose in time if this power cannot be supplied anymore.

Christel Sarfert,
Robert Bosch

In addition, the functions have to fulfil the ISO 26262 standard for vehicle safety applications. Bosch has developed the necessary methodology. Based on worst case battery behaviour introduced in challenging laboratory experiments performed in cooperation between Clarios and Bosch, this presentation will show how the performance of those functions can be achieved. Using experimental data generated in different types of short-circuit laboratory experiments as already described by Clarios, we will show that we are able to predict critical conditions in a timely manner.

Verification of state-of-function algorithms for functional safety of lead batteries

Jonathan Wirth, research scientist, **RWTH Aachen University**

With increasing automated functions in vehicles, the functional safety of the low-voltage power supply including the lead battery as the main energy storage is getting increased attention. Advanced driver assistance systems, for example, rely on a secured availability of power for a certain period of time as the driver needs a certain lead-time to take over full control.

This presentation will discuss the need for a short-term diagnosis for the state-of-function with restricted use of historical data to prove its reliability. Instead, it should rely on stimuli for tracking of the battery state. These stimuli include frequent AC small-signal current ripples and occasional discharges for parameter determination.

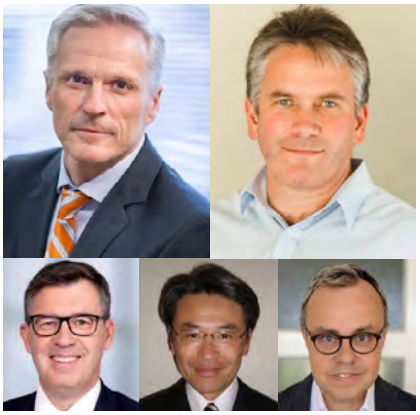
Jonathan Wirth,
RWTH Aachen University

A verification approach will be presented using laboratory measurements on a large selection of battery types and state-of-health conditions. The methodology and measurements are agreed and organised by a working group supported by the Consortium for Battery Innovation and includes a database for the measured data to which the members are contributing.

The presentation will conclude with first results of the measurements and the verification process to support the suitability of the approach.

Panel discussion • 12.15pm-1.00pm

The future of lead batteries for automotive applications



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A decade of turmoil but also of progress

To the outsider the lead battery business seems to be a tranquil landscape where nothing seems to change very rapidly. But to those in the know, the history of the battery is more a series of torrid episodes resembling scenes from *Peyton Place* than *Little House on the Prairie*! It's also a strange industry. Competitive to its core but gracious in helping competitors when circumstances change.

2012

• **Johnson Power Solutions** opens its first US battery recycling centre in Florence, South Carolina.

• **Emerson** completes acquisition of **Chloride Group,** the end of one of the most famous brands in lead battery history but one that had lost its way a quarter of a century before.

• **Exide Technologies'** recycling plant in Frisco, Texas is closed, followed by Vernon, California the year after. The issue of lead contamination of the surrounding areas continued to be a problem for Exide until it was sold this year. It also closes its plant in New Zealand.

Exide Technologies' recycling plant in Vernon, California closed in 2013

2013

• **Exide Technologies** files for bankruptcy protection a second time. As with first Chapter 11, it will take two years before it is able to trade again.

• After 22 years of struggling, bipolar start-up **Atraverda** goes into receivership.

• Charlesbank Capital Partners makes initial investment in **Trojan Battery.** The firm had been in the Godber family since its foundation in 1925.

• **Ador Digatron** joint venture goes ahead between German headquartered Digatron and Ador, a well respected Indian firm and a further move by Digatron to expand its presence in Asia.

• **Hammond** releases K2 range of expanders, offering a step change in lead acid battery performance, particularly in terms of cyclability in partial state of charge and offering performance benefits that can be adjusted to varying temperature ranges and demands. Initially most suited for stop-start and micro-hybrid applications.

• **Atomized Products Group** sets up new $4.3 million operation in Chesapeake in US state of Virginia.

• South Africa's **Metair** buys 100% of Turkey's **Mutlu Holding** and a 75% stake in **Mutlu Akü,** the lead battery maker. It was already lining up taking a stake in German battery manufacturer Moll (2015), which gives it a part stake in Chaowei, a Chinese battery firm.

• At the end of the year Seven Mile Capital Partners buys **Microporous** from **Polypore/Daramic** for $120 million. A new management team is set up early in 2014.

2014

• **Aqua Metals** demonstrates a novel way of recycling lead acid batteries without the use of smelting. Commercialization of the technology stalls thereafter. After the initial public offering peak of $21 a share, the price now trades under $1.

2015

• **Zesar** invests in new factory in Manisa, near Turkey's port city of Izmir. Later expanded to another factory. Plans are to double the firm's manufacturing area to 10,000m².

2015: Zesar invests in new factory in Manisa, near Turkey's port city of Izmir

• **GS Yuasa** acquires Turkish battery firm, boosts stake in Malaysia, expands further in Indonesia.

• **C&D Technologies'** CEO plans revamp aimed to restore lead battery reputation the firm had in the 1990s and 2000s.

• **ALABC** restructuring approved by its members and ILA.

• Bipolar batteries make a spectacular return to the limelight with two firms, in particular **Advanced Battery Concepts** and **Gridtential,** providing viable alternatives to regular lead batteries.

ABC develops GreenSeal technology, a full suite of patented technologies and simplified production processes, to enable the construction of reduced lead content, high performance, lower cost lead batteries in existing formats for today's and newly enabled future markets. Commercial adoption follows.

Gridtential introduces its Silicon Joule technology. This is a substrate that replaces the grid in a battery, resulting in a large reduction in the amount of lead required and better performance. Like ABC's bipolar batteries most of the regular production of the battery can be built on existing plate-making lines, modified assembly lines and existing formation/finishing lines.

• **Asahi Kasei** acquires Polypore International, the parent company to Daramic and affiliates.

• Death of **DeLight Breidegam,** charismatic founder of East Penn Manufacturing and creator of the largest family owned battery business in the US.

East Penn's DeLight Breidegam: a remarkable life at the heart of the battery industry

2016

Sally Breidegam Miksiewicz

INNOVATION AWARD

Presented by
Battery Council International

• **BCI** launches innovation award. **Hammond** wins award for further development of its K2 range of expanders and opening up its E=MC² laboratory to serve the battery industry.

• Tactical tax reasons are involved in the creation of **Johnson Controls** International based in Ireland and formed through a merger of Johnson Controls and Tyco International.

• End of a legend. **Ann Noll,** one of the great institutions of Battery Council International, retires after 37 years with the council. Greatly missed by North American battery firms as well as worldwide.

• Four lead association bodies **BCI, ILA, EUROBAT** and **ABR** agree to kickstart a global pro-lead battery campaign. This is the first attempt at full coordination between the organizations.

• **Cellusuede** moves into new base and 125,000sq ft factory at Rockford in US state of Illinois.

• **Ecoult,** the East Penn subsidiary, installs UltraBattery in smart grid test bed in Dublin.

• Founder of ALABC **Michael Mayer** dies.

• A watershed moment for lead battery research when **Argonne National Laboratory, RSR Technologies** and **East Penn Manufacturing** agree to work together under a standard US government cooperative research and development agreement.

RSR and East Penn to use Argonne's state-of-the-art analytic technologies to accelerate lead battery research. These same technologies have already been used by lithium battery researchers in previous years.

Tests undertaken will investigate the fundamental transport processes in lead batteries, using a variety of characterization techniques available at Argonne.

Scientists at Argonne who will be assigned to the project have extensive experience in synchrotron X-ray techniques, in particular for characterizing materials under controlled electrochemical conditions.

2017

• **ENTEK International,** battery separator designer and producer, signs an agreement with Separindo, the Indonesia-based polyethylene battery separator producer and Japanese glass company NSG Group, to make and sell PE separators across Asia. Breaks ground on new plant for this in 2019.

• **BCI leads the way** with pushing for lower blood lead levels for workers in battery plant.

• **Death of Detchko Pavlov,** Bulgarian academician and probably the greatest expert on the lead battery that has ever lived. Over his lifetime his research contributed to much of our present understanding of how lead batteries work. He is particularly remembered for the generosity of spirit in sharing this knowledge around the world.

Detchko Pavlov: generosity of spirit

• **Doe Run** expands lead mining on back of higher lead prices.

• **Monbat** buys Italian recycling firm Piombifera Italiana.

• **Penox** opens new product development centre in Germany.

• Chinese e-bike lead battery maker **Danneng Power International** expands output with $870m sales.

• **BM Rosendahl** opens development centre.

• **EC** fines lead cartel Recyclex, Campine, Ecobat Technologies for fixing lead prices.

• **Exide Industries** opens $100m plant in Bengal.

• **Belectric,** a UK lead acid/lithium battery firm, is bought by German utility Innogy SE (previously RWE).

• **Black Diamond Structures** opens battery testing for nanomaterials technology facility in Texas.

2017: Daramic greenfield plant in Gujarat, India finished and operational

• **Exide Technologies** waives the right to use Exide brand name in perpetuity to Indian battery giant Exide Industries. This follows a 20-year dispute over the issue.

• **Daramic** greenfield plant in Gujarat, India finished and operational.

• **NorthStar** wins BCI award for its remote monitoring technology. This allows battery users to review the battery's health and status at any time from anywhere. The embedded battery sensor communicates with both site technicians and power systems to ensure correct installation and settings. The device was launched for the telecom sector, but will be expanded to new segments.

2018

• **Batek Makina** opens 43,000 sq ft plant in Dilovasi in Turkey.

• **Furukuwa Battery** partners Vietnam's **Pinaco** in UltraBattery manufacturing deal. Furukuwa already had operations in China, India, Indonesia and Thailand.

• **C&D Technologies,** a portfolio company of KPS Capital Partners, acquires **Trojan Battery Company.**

• **Proposal for new body to replace ALABC** mooted at Vienna ELBC. **The Consortium for Battery Innovation** emerged the following year.

• **SY Innovations** formed, designed to support SY Group and explore new markets, products and sales/marketing techniques.

• **Gridtential** wins BCI award for its bipolar battery solution but automation problems on the production line dog adoption despite backing from well-known battery manufacturers.

• Chinese battery firm **Leoch** makes undisclosed investment in UK firm DBS Energy.

• **Hollingsworth & Vose** invested in capacity expansion in raw material and global separator production to support the AGM market.

• **Duracell** unveils new lead battery, citing cost benefits against lithium.

• Solar power company **Mobisol** partners African lead battery firms for storage component to its offering.

• Canada's **Discover Energy** buys Korean lead manufacturing business **iQ Power Asia.**

• India's **Exide Industries** moves into lithium with **Leclanché** in joint venture.

• Innovative New Zealand lead battery pioneer **ArcActive** partners **East Penn.**

• **Amara Raja, Gravita** sign recycling deal. **JCI,** which has worked with Amara Raja for 20 years, formalized an agreement between the two this year.

• **Narada** inaugurates first of five grid-scale lead carbon ESS in Germany.

• **EnerSys** buys Canada's Alpha Technologies for $750m in push into energy storage markets.

• Korean lead battery maker **AtlasBX** gets go-ahead to build lead battery plant in US.

• **Trojan Battery** sold to **C&D Technologies** as last remaining link with Godber family cut.

2018: Batek Makina opens 43,000 sq ft plant in Dilovasi in Turkey

2019

• **RSR Technologies** wins BCI award with possibly the most important advance in lead research this side of the century.

RSR, working with East Penn Manufacturing and the US Argonne National Laboratory, used Argonne's Advanced Photon Source synchrotron to look at, in real time, the crystallization of lead plates at the atomic level during the charging and discharging process.

The results of the research enable the firm to develop its alloy, known as Supersoft-Hycycle, which enhances lead battery performance.

Tim Ellis, president of RSR Technologies, said: "With this we can compete and win against lithium in many applications with higher performance.

"The work at Argonne has helped us understand the physical processes taking place in real time inside batteries to develop higher performance advanced lead batteries. Our Supersoft-Hycycle lead really improves cycle life as validated by

Wirtz expands its product lines once more, enters nickel-zinc market

many of our customers, especially in higher temperature and extreme operating conditions."

The alloy is already being used by South African battery firm Auto-X, the maker of the Willard brand of batteries.

• **Microporous** forms joint partnership with Chinese firm **Zisun,** the largest fully integrated producer of glass micro-fibres and media in Asia, allowing Microporous to add AGM separators to its product range.

• Specialist battery machine maker **Wirtz Manufacturing** invests in nickel-zinc battery maker **ZAF Energy Systems.**

• **Johnson Controls Power Solutions** — the former battery division of JCI bought by Brookfield Business Partners for $13 billion — launched itself with the name Clarios.

• Lead batteries in India lose subsidies under new **FAME-II** regulations.

• **East Penn** takes stake in lithium battery maker **Navitas.**
• **Exide Industries** moves into e-rickshaw battery manufacturing.

• **Water Gremlin** moves back to full production after agency shut-down.

• **Upside Group** switches on 25MWh lead carbon system in Germany.

2020

• **Hammond Group** completes the first step to employee ownership.

• **Covid-19** claims first lead battery insolvency victim, **Moll,** but outlook for the firm brightens later.

• **Exide Technologies** (and four subsidiaries) files for Chapter 11 bankruptcy protection to facilitate the sale of its North American assets. In July Exide sells its North American assets to Atlas Holdings.

• German formation firm using acid recirculation technology **Inbatec** and **Kustan** become equal and independent subsidiary of new firm RedDotPlastics.

• **ArcActive** wins BCI innovation award with technology to replace negative battery electrode with non-woven carbon fabric that achieves high DCA with minimal loss. Later in the year ArcActive is very close to full commercialization of the product.

• **Neutron diffraction** is used for the first time to improve lead battery performance, says **Consortium for Battery Innovation.** The project, launched in Spain under the CBI's technical programme, uses hi-tech neutron diffraction techniques to explore what happens as lead batteries charge and discharge. Exide Technologies and the Institute of Materials Science of Aragon work with the CBI on the project.

• **Exide Technologies** officially separates from its North American business and in October becomes a new European, Asia-Pacific firm under new ownership but retaining Stefan Stubing as president, CEO and director. The European business, now free from the US parent, is free to focus on its automotive and industrial energy storage technologies. It has two R&D facilities as well as 11 production plants across Europe.

• **Don Gribble, inspirati**onal founder of *Batteries International*, passes away in November.

• **California DTSC** issues writ to former Exide Technologies — now called Stryten Energy — to recover Vernon clean-up costs. Saga continues.

• **End of the year round-up.** Lithium ion battery prices drop to lowest ever. Meanwhile, the numbers of lithium battery recalls explode for safety reasons. Chronologically, first for LG Chem home systems (December), Polestar 2 models recalled (November), GM recalls 68,667 Chevrolet Bolts (November), BMW recalls 40,000 cars in various ranges (October), Hyundai recalls 77,000 Kona Electric models (October), Ford recalls 20,000 Kuga plug in hybrids (August).

2021

• **Batek Makina,** the Turkish battery equipment manufacturer, takes over Italian formation firm Bertola and its subsidiary Moran.

• **India's second largest lead battery maker Amara Raja** announces plans in February to begin working on lithium battery cells.

• **Hammond, East Penn, Consortium for Battery Innovation** launch joint research program in March. CBI meanwhile announced it had launched a new European research project using neutron diffraction.

• **China moves to ban lead batteries in low-speed electric vehicles.**

• **Chris Pruitt, East Penn CEO** takes over as new BCI president.

• **Kathryn Bullock,** one of the greats in the electrochemical history of the lead battery, passes away in May.

• **Hammond Group wins BCI innovation award** for development of using lead silicate as a way to counter the destructive effects of acid stratification in lead batteries. This is subsequently called GravityGuard.

• **Oxis,** the lithium sulfur battery developer, is acquired by Johnson Matthey.

2021: China moves to ban lead batteries in low-speed electric vehicles

• **Victory for Battery Council International** in May as lead batteries removed from California's DTSC danger list. This is a huge vindication of the value of BCI's tireless campaigning on the subject.

• **Lead/lithium hybrid trial starts in Poland in July.** GS Yuasa, next month, wins another installation of lead/lithium hybrid capitalizing on the energy strength of lithium batteries with the price advantages and stability of lead ones.

• **Clarios** pulls $1.7 billion capital raising via an IPO at last minute citing market volatility.

• **Ecobat buys German lithium battery recycler Promesa** in July in clear sign of future plans. It follows this up in October with acquisition of Emrol.

• **ENTEK** closes acquisition of NSG separator division in September can offer AGM, P/E and lithium separators.

• **Women in The Global Battery Industry group** launched at BCI meeting held in San Diego, California.

• **Sunlight Systems,** the Greek battery manufacturing firm, announces in September it will spend €50 million ($59.2 million) to create the world's largest motive lead battery unit.

• **Long Duration Energy Storage Council** formed in November by 24 tech companies.

• **Monbat** announces plans to open a bipolar lead battery facility by 2024. In following June agreement reached with ABC when Monbat managers secure near 21% stake in the group.

• **Stryten buys** vehicle power division of Galvion a military equipment maker. In December it buys Tulip Richardson Manufacturing which makes injection moulding products and in January acquires Storion Energy, a vanadium flow battery technology firm.

2022

• **Disturbing signs of imminent lithium battery shortages** according to reports circulating well before the Russian invasion of Ukraine and the ensuing chaos.

• **Shake up of maritime transportation** rules becomes likely after cargo vessel *Felicity Ace* sinks off Azores with talk of possible cause being lithium fire in EVs being transported.

• **Shareholder reveals** in February ahead of Metair's results announcement that the South Africa holding group is to sell off its batteries business.

• **Surprises at Ecobat** as Marcus Randolph is appointed in March as its president and CEO taking over from incumbent Jimmy Herring.

• **Clarios** acquires Spanish recycler Metalúrgica de Medina.

• **India's Exide Industries** announces plan in March to invest $800m in lithium manufacturing.

• **Bipolar batteries** to the fore as Gridtential signs development agreement with Camel Energy. Meanwhile Advanced Battery Concepts pushes ahead with sales contracts for its GreenSeal batteries.

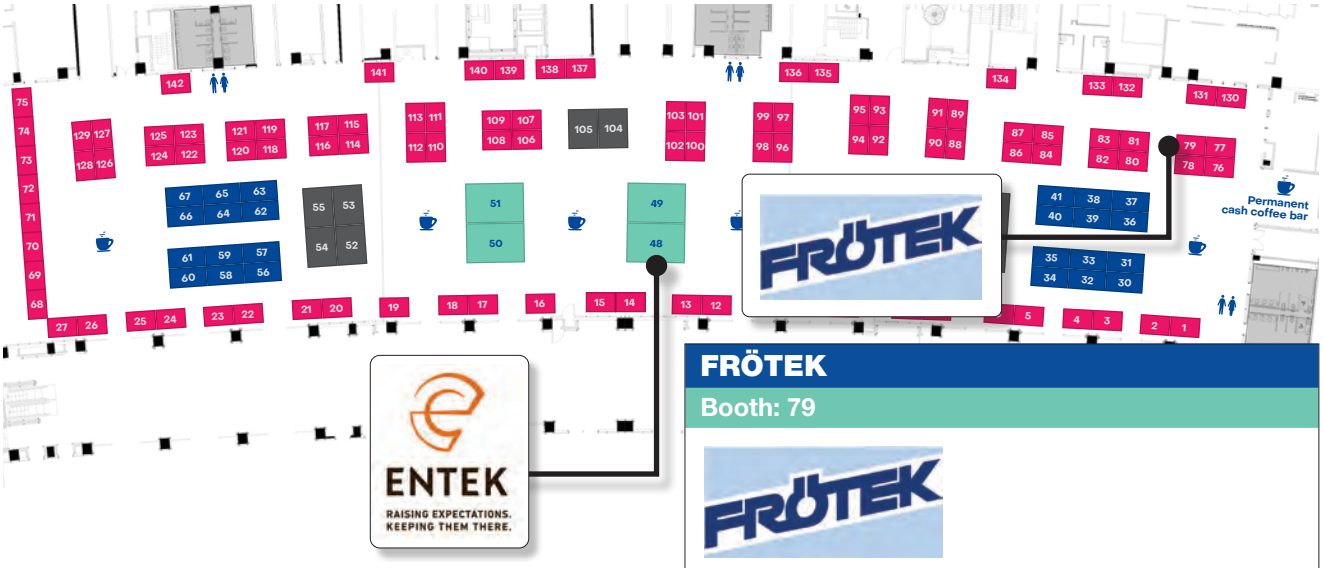
• **Ahlstrom-Munksjö** launches AGM line in June in Italy. European battery production is still a very mainstream market.

• **EU warns** in June 'hazard' classification could endanger battery investments

• **Campine** acquires Recyclex in €3.5m agreement in July after court process in May. ■

2022: *Felicity Ace* sinks off Azores with talk of possible cause being lithium fire in EVs being transported

ELBC CONFERENCE AND EXHIBITION LAYOUT



ENTEK

Booth: 48

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FRÖTEK

Booth: 79

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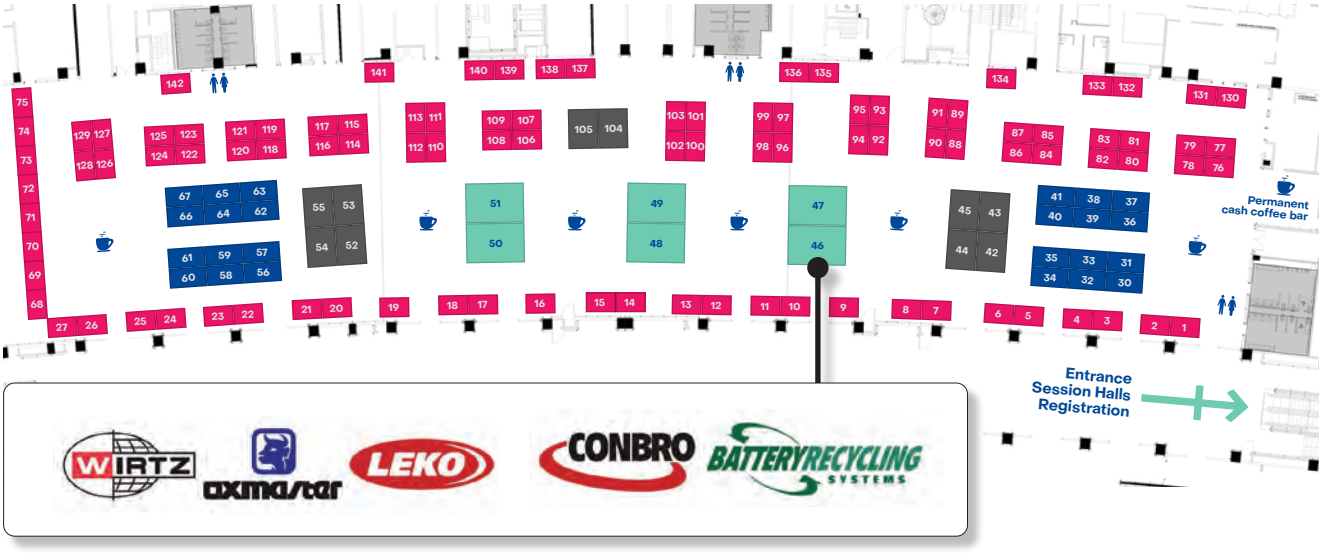

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Booth: 46

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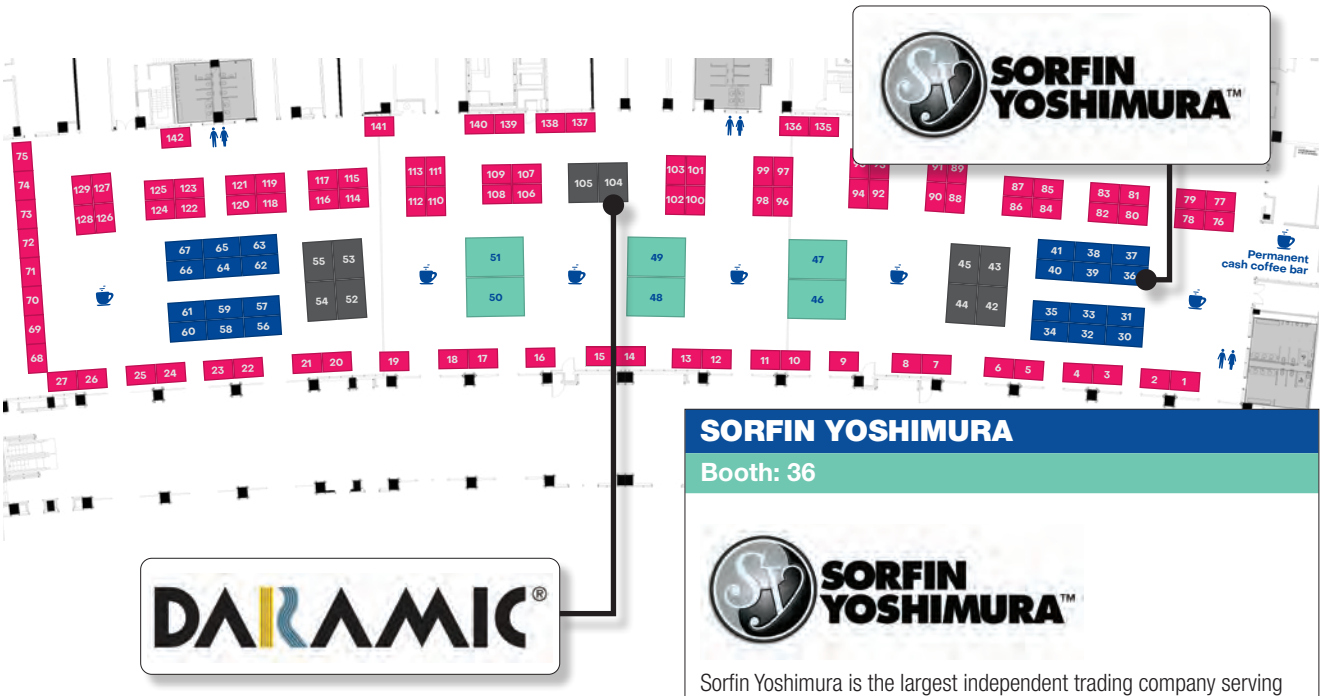

DARAMIC

Booth: 104

Daramic is the world's largest manufacturer and supplier of battery separators for automotive, industrial and specialty lead-acid applications. As the inventor of polyethylene separator, Daramic has led the way in developing innovative technology for the global lead-acid battery industry nearly 90 years

- **Innovation:** Our scientists and engineers continue to break new ground in the development of advanced separator technology. Our 3 global innovation centers in Owensboro, US; Sélestat, France and Bangalore, India are dedicated to innovation to meet ever-changing industry needs
- **Local Supply From A Global Perspective:** 10 Manufacturing facilities and 7 Sales offices located in 8 different countries provide local service from a global perspective
- **Reliability:** State-of-the-art processes and manufacturing equipment deliver consistent, reliable product quality
- **Full Automotive Solutions:** Leverage the innovation synergy from its sister companies, the world's largest li-ion battery separator makers, that position us to provide full solutions for automotive battery applications from basic SLI to Start-Stop to Hybrid and Electric Vehicles

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SORFIN YOSHIMURA

Booth: 36

Sorfin Yoshimura is the largest independent trading company serving the worldwide lead acid battery industry.

Sorfin Yoshimura has offices in the USA, Japan, China, France, and Brasil in addition to agency cooperation in several other countries around the world.

We are a global company sourcing the best machinery, materials, and technical services for your battery factories specific needs.

Sorfin Yoshimura offers our customers the benefit of our decades of lead acid battery industry experience. We serve hundreds of customers throughout the world each year and customize our services for each and every factory.

We are constantly combing the world for the latest innovations in both materials and machinery; seeking to add vendors to our already vast network. When you choose Sorfin Yoshimura, you will quickly identify the unique combination of commercial savvy and engineering know-how that has enabled us to become the company that we are today.

We look forward for you to contact Sorfin Yoshimura.
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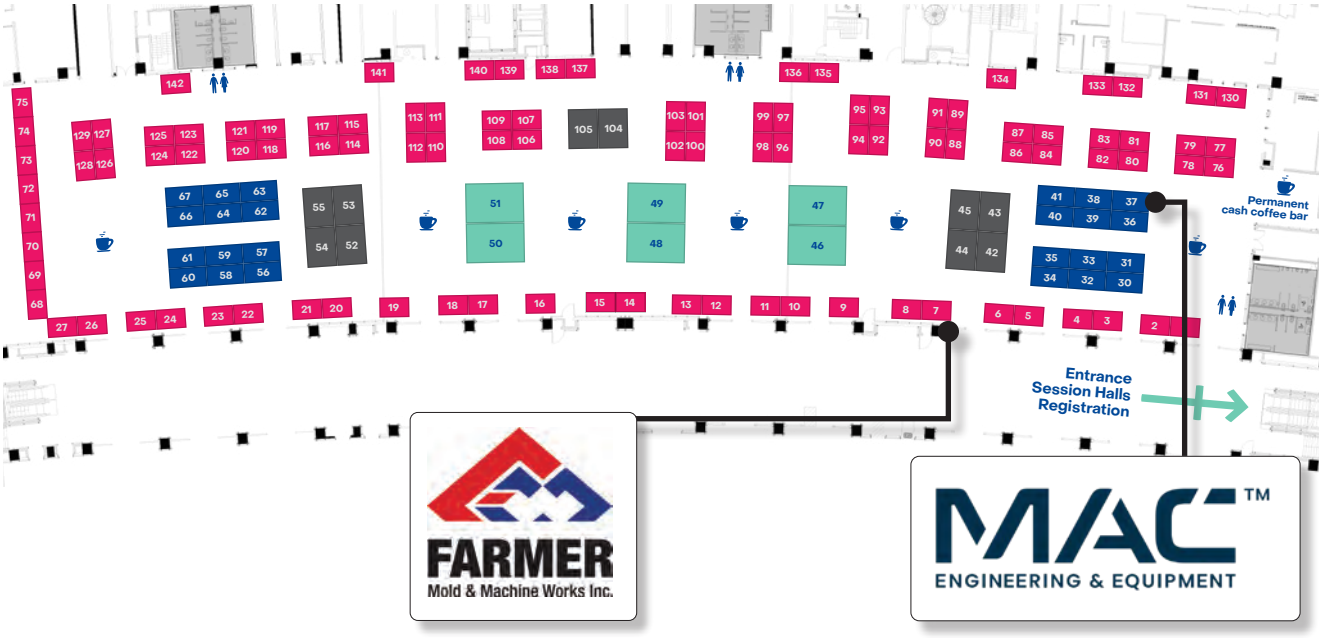

FARMER MOLD & MACHINE WORKS

Booth: 7

Family owned and operated since 1938, Farmer Mold & Machine Works specializes in the design and manufacturing of any type of machinery, including battery assembly equipment, parts casting equipment, and plant automation and process engineering.

Further, if you need something that's not already in our current product line, Farmer can work with you to create custom machinery for your specific applications — whether a new technology or refining an existing process.

Our portfolio of machinery not only sets the standard within the industry but is ever-growing. Plus, Farmer provides sales and support for acid dilution systems, plate curing ovens, and semi- and fully automated material handling equipment to several industries worldwide.

Our highly interactive and innovative approach to automated machine, tool and die, and mold design follows precise safety standards and utilizes the best materials to produce top-of-the-line machines and equipment that are built to last in 24/7 environments.

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MAC ENGINEERING

Booth: 37

MAC Engineering has supplied the lead acid battery industry with high quality downstream battery making equipment since 1965.

We offer complete systems for feeding, pasting, flash drying and stacking any continuous or gravity cast plate making technology.

From motorcycle and automotive batteries, to industrial and traction, we have equipment to handle any size of battery production.

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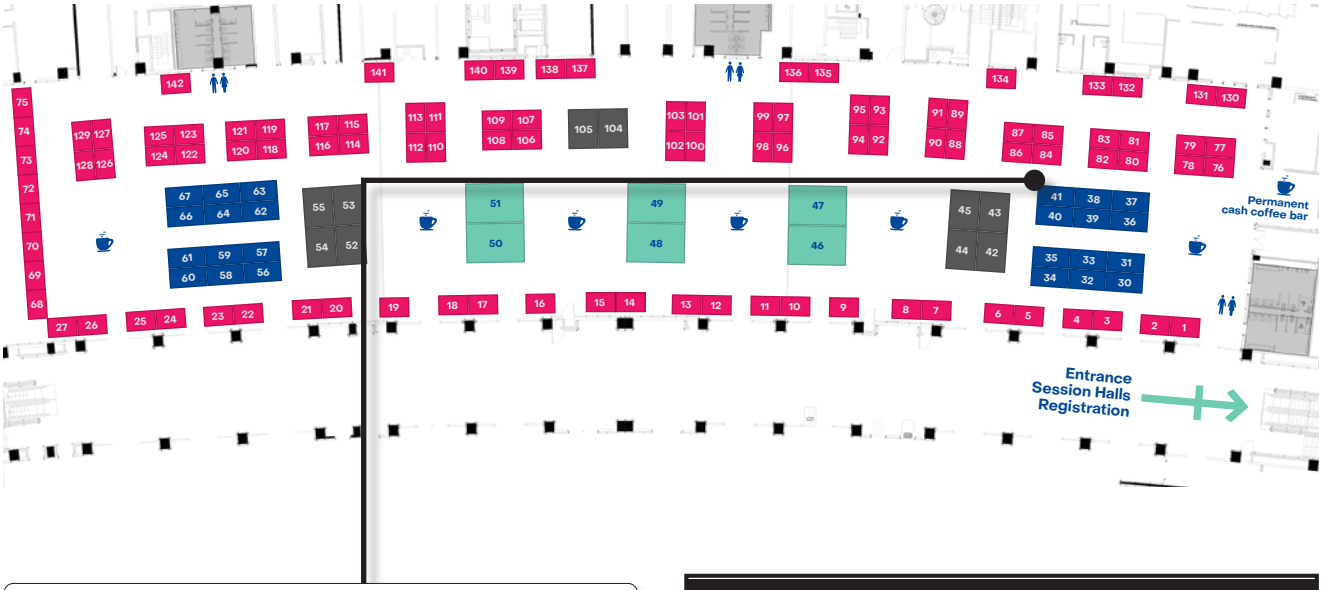

HAMMOND
THE CHANGE CATALYST®

HAMMOND

Booth: 41

HAMMOND
THE CHANGE CATALYST®

Founded in 1930, Hammond Group, Inc. (HGI) is a battery additives/oxides and specialty chemical company that is advancing hybrid automotive and renewable energy markets through proprietary battery chemistry. HGI supports these emerging markets with two US manufacturing operations in Hammond, IN and another in Pottstown, PA. HGI also has International operations in Gateshead, England; and another in Kuala Lumpur, Malaysia.

Be sure to stop by our booth and talk with our specialists about how HGI can help your company overcome technical challenges. We offer technical assistance programs which allow our customers to utilize our experts to augment their research efforts, reduce capital expenditure and fixed costs, and rapidly develop new products.

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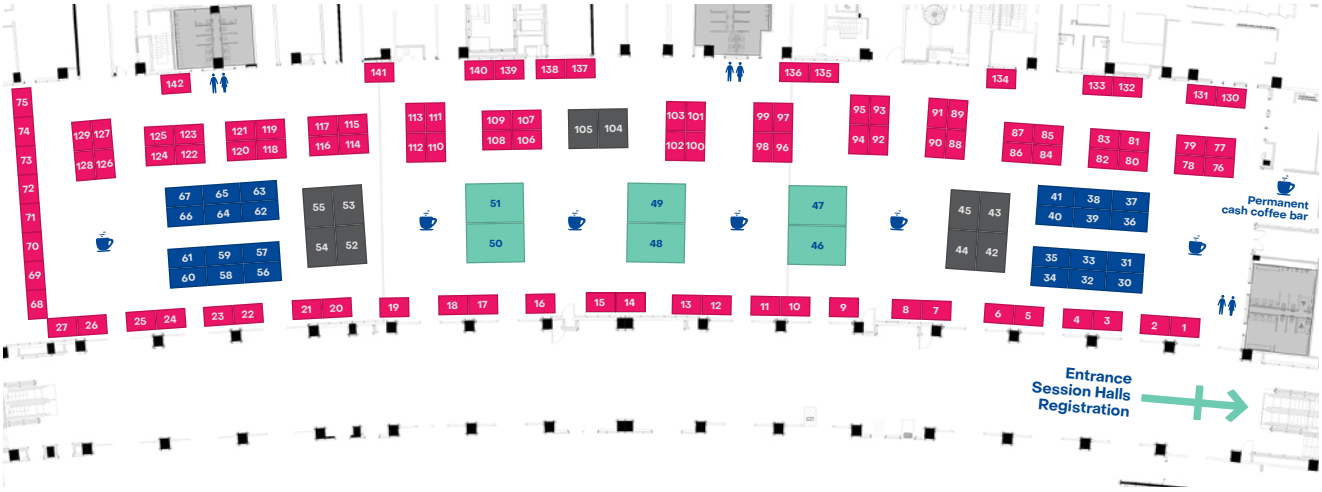

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