EUROBAT
ASSOCIATION OF EUROPEAN AUTOMOTIVE AND INDUSTRIAL BATTERIES MANUFACTURERS

+ 32 2 761 1653
eurobat@eurobat.org
www.eurobat.org
@eurobat_org
www.linkedin.com/eurobat-association

EUROBAT Article for the Innovation News Network: "The major challenges to address with battery R&D"

EUROBAT is the **association of Automotive and Industrial Battery Manufacturers and their subcontractors** in Europe, the Middle East, and Africa. Representing the European battery industry, EUROBAT covers **all mainstream battery chemistries** available on the market: **lithium, lead, nickel, and sodium.**

Battery Innovation is an ongoing process, in the 19th century basically **driven by continuous efforts to develop a robust longer-lasting source of electricity that could provide reliable energy and power output**. This effort resulted in lead-based battery products, a technology that has been a cornerstone for centuries and is still successfully used in today's applications.

Battery Innovation in the 20th century was **driven by various emerging applications at that time**, such as portable electronics, telecommunication, automotive vehicles, railway rolling stock, aviation, ships and submarines, satellites and the need for Uninterruptible Power Supplies (UPS). **Each application demanding more specific battery characteristics**, which resulted in significant diversification of battery products. Lithium-ion batteries came in the late 20th century, thanks to their higher energy density and relatively low weight, bringing solutions on the market to compliment the widely used affordable and proven safe and sustainable lead-based technologies.

Today's drivers for battery innovation have become even more wider and complex – it is not limited to optimising the specific battery characteristics of the applications they serve -, but also to maximise the contribution of the industry and its products to meeting Europe's objectives regarding environmental concerns, energy independency, security of supply of raw materials and to further electrify transportation and other sectors. **In this new context, EUROBAT initiated a "*White Paper Batteries Innovation Roadmap 2030*" in June 2020, which was later updated in June 2022 in order to re-assess market and technology evolutions on all four mainstream and future promising technologies in relation to the applications they serve.**

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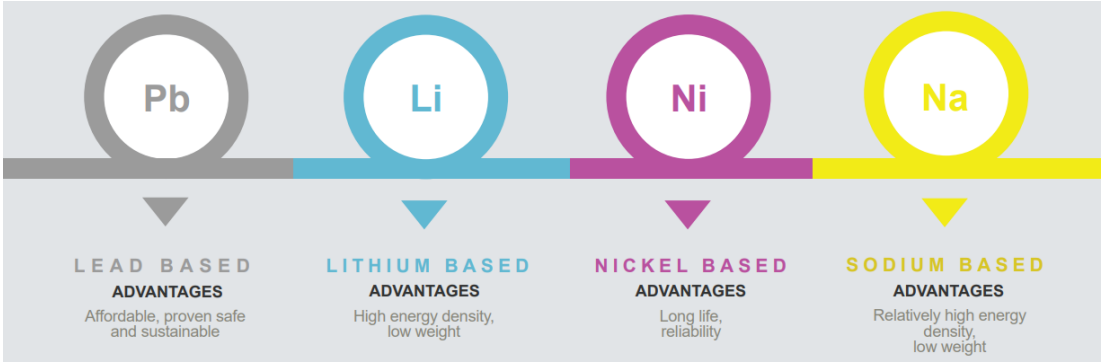
The roadmap highlights the state-of-the-art and innovation potential of each of the various mainstream chemistries:



Lead-based battery R&D

Still in the lift and useful to compete with upcoming new storage technologies. There are application specific innovation potentials e.g. to improve dynamic charge-acceptance for automotive at uncompromised high temperature durability or by improving the energy and power densities with improved cycle-life for specific industrial applications in the field of stationary and off-road transportation. Lead-based batteries show a high development potential by implementation of new innovative materials (like synthetic expanders, nano-based carbon materials, new alloy compositions) and improved battery design.

Thin Plate Pure Lead (TPPL), Bipolar and Carbon Enhanced Lead Acid batteries are promising candidates for increased service life, PSOC operation and improved power density. The outstanding feature in this process is that these improvements have been tailored to the particular applications.

In addition to fundamental research to enhance the electrolyte, materials, and components used, the introduction of smart battery operation modes also holds potential, positioning this battery chemistry in a leading role in specific automotive and industrial applications by 2030.

Lithium-based battery R&D

Currently, the most promising technology, the major requirement for higher energy densities to achieve increased driving range is directly linked to e-mobility. This results in a development roadmap for 2030 that mainly considers the lithium-based technologies based on modified Nickel Cobalt Manganese Oxide (NMC) materials, with increased nickel and reduced cobalt content in combination with high capacitive anode materials with carbon/silicon composites. Solid state technology is also targeted to increase the energy density and improve the safety aspect.

Due to the variety of possible combinations of cathode and anode materials, the resulting Li-ion batteries show specific and individual performance characteristics suitable for different kinds of applications. The development of Li-ion technologies suitable for industrial and automotive

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applications is still a challenge in terms of alternative material research, activating extraction processes, ethically sound mining, recycling and safety. In addition to NMC based lithium-ion technology, LFP (Lithium Iron Phosphate) is the favored choice for stationary applications, particularly due to long cycle life. Ongoing R&D is steering towards “intrinsically safe” Lithium Manganese Iron Phosphate (LMFP) with higher energy density. Both LFP and LMFP are devoid of critical raw materials like nickel and cobalt.

Nickel-based battery R&D

Thanks to decades of safe use under the most extreme climate, cycling and/or fast charging operating conditions, nickel-based batteries (Nickel cadmium and Nickel metallhydrid (NiMH)) is still used in special and niche applications, with different designs. There are still improvement potentials by using innovative materials.

The technology can be further developed for existing applications and as a replacement solution with its key performance properties in extreme conditions. Nickel-based batteries are among the electrochemical storage systems that should be considered to remain in the market for targeted industrial applications over the next decade.

Sodium-based battery R&D

In contrast to other battery types, high-temperature nickel based batteries (operation Temperature > 300°C) consist of liquid-electrodes and a solid electrolyte. Commercially available representatives are sodium nickel chloride (NaNiCl), and the sodium-sulfur battery (NaS), which are used in stationary larger back-up power and load-leveling applications.

Both technologies have still improvement potentials regarding to energy efficiency (thermal losses due to heating necessary to maintain the cell temperature), internal resistance (which is positive for NaNiCl). Other factors to work on are the high demand for nickel and the complex modular construction.

Nowadays, the major focus is the promising drop-in technology of room temperature Sodium-Ion battery (SIB). The working principle is comparable to the Li-Ion batteries. Major advantage is the use of non-critical materials and the potential of lower costs.

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The current EUROBAT Innovation Roadmap 2.0 takes also into account the innovation potentials of most promising technologies, such as lead bipolar, sodium-ion room temperature, post-lithium-ion all solid state Gen. 4b and Gen. 4c, as well as Lithium Sulfur and Lithium-Air Gen 5**, and why it is important to continue their developments.**

Considering the projected timeline for innovations to enter the markets, to upscaling European production capacities and taking into account the promising recent market predictions (demand side), we can conclude that li-ion and lead-based batteries will remain the dominant battery technologies in 2030. The Avicenne report September 2023 commissioned by EUROBAT predicts a global battery market of 4150 GWh, of which 3360 GWh lithium-based and 774 GWh lead-based technologies.

The EUROBAT Batteries Innovation Roadmap is a living document. **We anticipate a 3rd edition to be released during the EUROBAT Annual Event in Brussels on 4-5 June, 2024.** In this document we will be able to evaluate the impact of the different EU policy initiatives and new legislation in place since we published the roadmap 2.0. **EUROBAT supports the European Commission's European Battery Alliance (EBA)** and aims to remain at the forefront of technology developments across various sectors. This includes scaling up competitive and sustainable domestic production capacities for all technologies, from raw materials to battery pack production.

In today's situation, we can already confirm that **our technology leadership**, which we will describe in the next update, will involve **new areas of innovation, such as manufacturing processes and recycling, with a strong focus on developing a circular economy and incorporating sustainability aspects,** whether or not with governmental and/or private-led R&D funds.

Other transversal aspects and major challenges that need to be addressed with R&D are **data management, digitalisation and standardisation needs** (implementation of the battery mandate M/579 and improve the use of the Battery Passport in future) in order to better direct waste streams, to meet higher collection rates (all elements) and to maximise the use of recycled primary and secondary materials in new batteries (all technologies).

The recently introduced **Net-Zero Industry Act,** as part of the Green Deal Industrial Plan, and the **reform of the Electricity Market Design** will further **attract R&D on battery integration in many applications,** as well as **investments to scale up manufacturing of clean technologies** (including battery manufacturing). ***In short, the future of the European battery manufacturing industry presents challenges that we must overcome to succeed.***