EUROBAT

ASSOCIATION OF EUROPEAN AUTOMOTIVE
AND INDUSTRIAL BATTERY MANUFACTURERS

2035
Battery Innovation Roadmap
WHITE PAPER

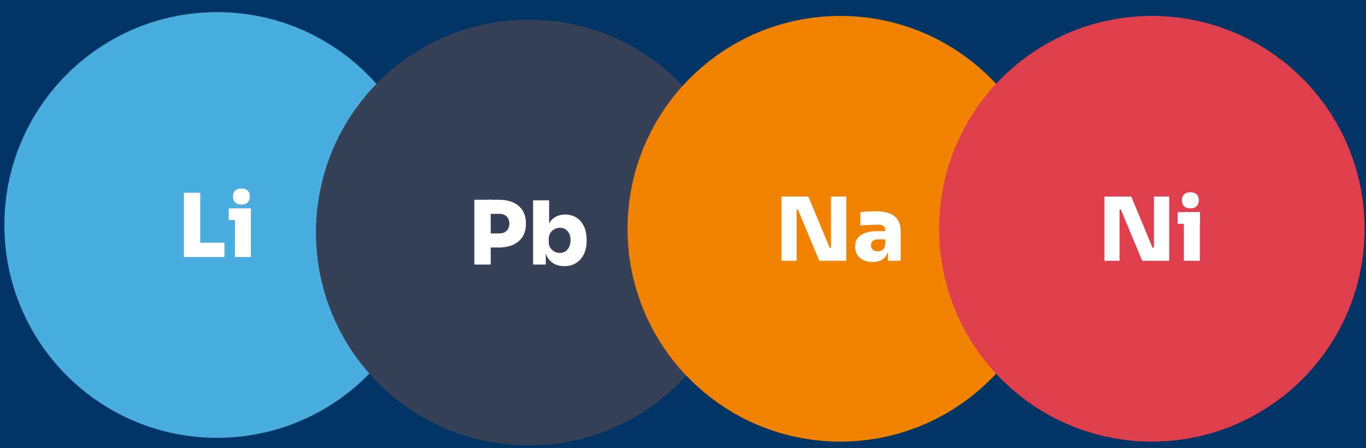
Version V 4.0 | June 2026

Building upon the foundations laid out in the Innovation

Building upon the EUROBAT Innovation Roadmap V3.0 (June 2024), this updated edition re-assesses the battery landscape and market outlook towards 2035, **reflecting evolving technologies, accelerating electrification, and Europe's changing policy framework.**

This Roadmap provides an updated perspective on:

- **Battery technologies** – state-of-play and innovation potential of lithium-, lead-, sodium-, and nickel-based batteries
- **Emerging solutions** – R&D needs and opportunities for promising high-TRL battery technologies
- **Electrification trends** – accelerating deployment of battery-powered applications and new market demands driving innovation
- **Digitalisation** – the growing role of data, smart battery management, and the introduction of the Battery Passport
- **Policy and regulation** – implications of recent EU policy initiatives and implementation of the Battery Regulation (EU) 2023/1542
- **Market outlook** – evolving market perspectives and future positioning of battery technologies towards 2035



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WHAT IS EUROBAT

EUROBAT is the association representing the European battery industry, bringing together manufacturers of automotive, industrial, and energy storage batteries as well as companies across the battery value chain – system integrators and supply industry.

In a nutshell, EUROBAT acts as the voice of the battery sector in Europe, supporting innovation, sustainability, competitiveness, and effective regulation. It engages with EU institutions and stakeholders on topics such as battery technologies, electrification, energy storage, recycling, circularity, and implementation of European battery policy and legislation.

REPRESENTS ALL BATTERY TECHNOLOGIES

EUROBAT covers the main battery technologies used across automotive, industrial, and energy storage applications. These include:

LITHIUM BASED BATTERIES

Used widely in electric vehicles, consumer electronics, industrial equipment, and stationary energy storage.

LEAD BASED BATTERIES

A mature and highly recyclable technology used in automotive starter batteries (12V SLI), backup power, industrial traction, and stationary applications.

SODIUM BASED BATTERIES

Including emerging **sodium-ion Room Temperature** and established high-temperature sodium systems, increasingly considered for stationary storage and selected mobility applications.

NICKEL BASED BATTERIES

Primarily **Nickel-Metal Hydride (NiMH)** and **Nickel-Cadmium (NiCd)** in particular, used in industrial, rail, aviation, backup, and specialised applications requiring robustness and long service life.

Beyond these mainstream chemistries, EUROBAT also monitors and supports discussion around **emerging and next-generation battery technologies,** particularly those approaching higher technology readiness levels (high-TRL), where they may contribute to Europe's future energy storage and electrification needs.

COVERING 5 APPLICATION AREAS

AUTOMOTIVE MOBILITY

Batteries contribute to the decarbonisation of the European transport sector - reducing CO2 emissions via start/stop batteries and innovative solutions in xEVs.

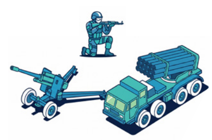
STATIONARY ENERGY

Batteries are indispensable for storing renewable stationary energy coming from solar and wind farms in on grid and off grid solutions. They also contribute to a more stable and reliable grid.

MOTIVE POWER APPLICATIONS

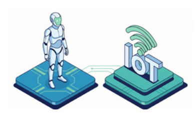
Material handling & off-road vehicles

Batteries are a perfect fit for powering industrial vehicles, while also reducing noise and emissions. The concepts of smart charging of road vehicles to support the energy system is also relevant for off-road (rail, marine and air transportation) because their wide deployment and large energy capacities.



DEFENCE

Batteries are crucial for the defence industry because they provide reliable, mobile, and resilient energy essential for powering mission-critical systems, communications, mobility, and autonomous operations in demanding and often infrastructure-limited environments.



ROBOTICS & IOT

Batteries are crucial for robotics and IoT applications because they enable autonomous, portable, and reliable operation of connected and intelligent devices, ensuring flexibility, mobility, and continuous functionality across diverse environments.

1. EXECUTIVE SUMMARY

The EUROBAT Battery Innovation Roadmap 2035 provides an updated strategic framework to navigate the rapidly evolving landscape of mainstream and emerging battery technologies. Building on the foundations of Roadmap version 3.0 (June 2024), this new edition reflects the most recent technological advances, market developments, and regulatory drivers shaping battery research, development, and deployment in Europe, with time horizon 2035

Key features of this new roadmap affecting R&D on batteries, include:

- An updated assessement of the innovation potential of the mainstream battery technologies lithium, lead, sodium and Nickel based
- Reviewed analysis of the most promising high-TRL technologies
- Impact of further innovative electrification of end-user battery-powered applications in diverse sectors, including new areas such as in the Defence industry, robotics and IoT
- The growing importance of digitalization, Battery Passport, and data governance across the battery value chain
- New challenges related to implementing legislation from the Battery Regulation around circularity and critical raw materials aspects
- New challenges strengthening Europe's independence in material supply, energy, and manufacturing

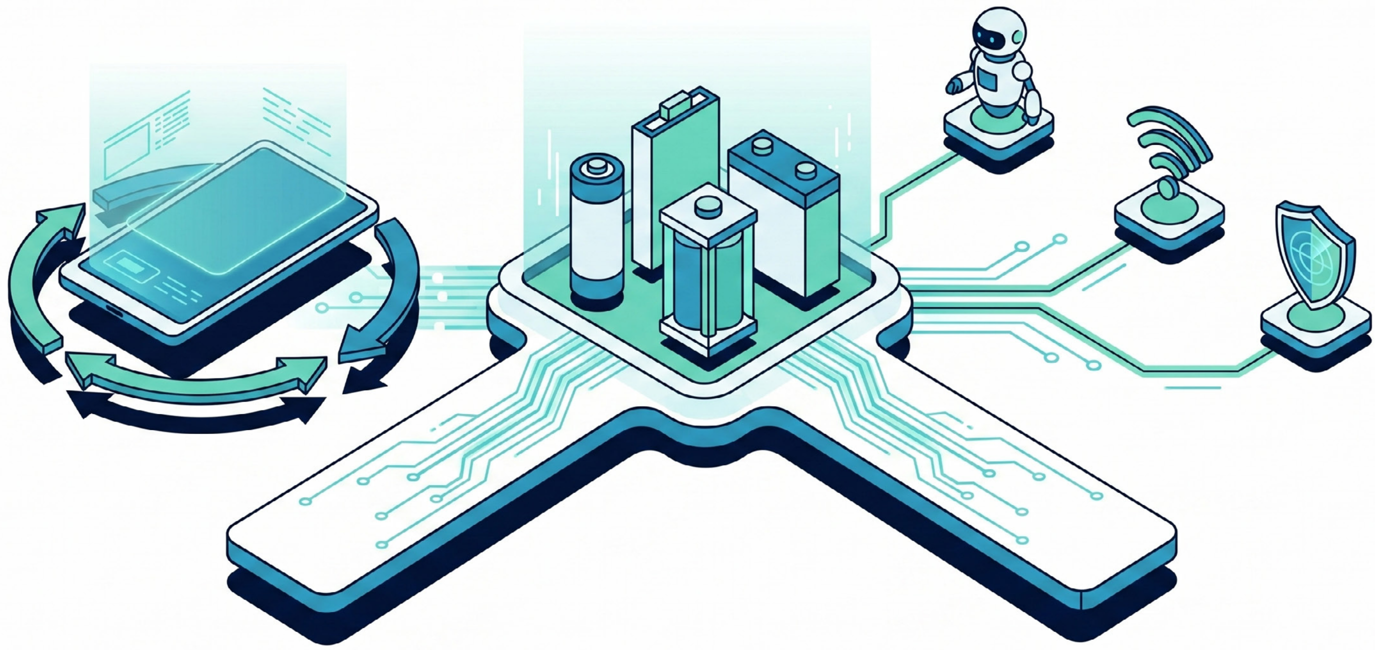
KEY POINTS ADDRESSED IN THE ROADMAP

- **To electrify all sectors, continuous innovation across every battery technology domain remains essential** — no single chemistry can meet the full range of application demands. Key priorities vary by use case and include power and energy density, longevity, cost, safety, and sustainability.
- **The ongoing implementation of the EU Battery Regulation (2023/1542) has introduced new R&D challenges across all chemistries** — lead, lithium, nickel, and sodium-based — each requiring tailored approaches to meet its sustainability and circularity requirements, As the four mainstream battery technologies — lead-based, lithium-based, nickel-based, and sodium-based — differ in maturity with respect to these sustainability requirements, tailored R&D strategies are required for each technology to progress along the circular-economy pathway.
- **Digitalisation, and in particular the deployment of the Battery Passport, represents another major innovation driver.** The roadmap identifies R&D challenges associated with data management, traceability, and lifecycle monitoring, including the potential use of blockchain or similar technologies. These tools are expected to support regulatory compliance, improve transparency, enhance recycling and material recovery, and offer additional benefits for production optimisation and system integration.

Innovation and accelerating electrification have long driven R&D in mainstream battery technologies. Increasingly, EU policy is shaping the agenda too — notably the EU Battery Regulation (2023/1542), new legislation on material supply independence and energy resilience, and the ongoing digitalisation of all sectors. Together, these are steering innovation towards more circular, sustainable, safe, and efficient battery solutions, in line with the EU's broader environmental objectives. Updated battery market figures and revised growth projections reflect all of the above factors.

A **central message of the roadmap is that no single battery chemistry can meet the full spectrum of requirements across all applications.** Continued electrification therefore depends on sustained innovation across multiple technology domains. Different end-user applications impose distinct performance priorities — such as power density, energy density, durability, cost efficiency, safety, and environmental footprint — which must be addressed through targeted R&D efforts.

Overall, the European battery manufacturing industry — across all mainstream technologies — want to demonstrate a strong commitment to supporting the EU's carbon-neutrality and sustainability ambitions. This commitment is reflected in increased investments in innovation, scaling-up of manufacturing capacity, and continuous improvement of battery performance, safety, and circularity. The EUROBAT Battery Innovation Roadmap 2035 provides a coherent and forward-looking reference to guide these efforts and to strengthen Europe's competitiveness in the global battery ecosystem.



2. INTRODUCTION: SCOPE & PURPOSE

This report presents a pathway for the further development of battery technologies to 2035, outlining how research and innovation (R&I) can support the EU's transition towards:

- **Climate neutrality**
- **Strategic independence and resilient supply chains**
- **Environmental sustainability beyond carbon**
- **Efficient and flexible system integration across sectors and markets**
- **Reduced overall system costs** (e.g. electricity grids, heating and cooling, mobility)

Achieving these goals requires EUROBAT members to validate technologies under real operating conditions and to support regulatory evolution enabling scalable deployment, including on affordability and environmental performance. Batteries also have a role to play in crisis resilience — for instance during climate extremes or geopolitical shocks.

Cross-cutting enablers — including digitalisation, AI-assisted supervision, digital twins, cybersecurity, circularity, and early-stage societal engagement — are essential to this agenda, as is the active involvement of aggregators and system providers in the R&D phase.

Finally, while emerging technologies and scalable solutions depend on startups and public and private investment, greater attention must also be given to strengthening and scaling up existing battery manufacturing capacities in Europe.

Why this update?

The 4th edition of the EUROBAT Battery Innovation Roadmap provides policymakers with factual information on the innovation potential of mainstream and emerging battery technologies. While deeper R&D remains essential to deliver clean-tech batteries sustainably, the Green Industrial Deal makes it more urgent than ever to translate R&D outcomes rapidly into new and greener gigafactories — scaling up production not only for EVs and energy storage, but across a wide range of applications.

This edition integrates the latest technological developments and updated EU policy objectives, with particular focus on the EU Battery Regulation's sustainability requirements and Europe's drive to strengthen strategic independence, expand domestic production capacity, and build more resilient supply chains across all mainstream technologies. The Roadmap is designed as a living document, subject to biennial review to reflect ongoing technological and policy developments.

The Roadmap is structured in two parts:

- **Main document** — Aimed at policymakers, it outlines the state of play and innovation potential of mainstream and emerging battery technologies, and highlights their contribution to climate neutrality and the EU's critical raw materials agenda.
- **Technical Annex** — Aimed at the R&D community, it provides deeper technical insights into research priorities and directions to 2035 and beyond.

What is New in the Roadmap

Since the previous edition (June 2024), the policy landscape has shifted significantly, bringing new priorities and drivers for battery innovation. EU industrial policy has moved up the agenda, with EUROBAT strengthening its engagement on key initiatives including the Industrial Accelerator Act, the Net-Zero Industry Act, Innovation Fund mechanisms, trade competitiveness, and supply chain resilience. The "Union Made" initiative and the broader "Made in Europe" ambition are now explicit reference points for the European battery industry.

On the technology side, sodium-ion (Na-ion) batteries have reached commercial readiness and are entering specific applications, marking a notable milestone since the last edition. New and emerging application areas have also been identified — most prominently in defence, robotics, and the Internet of Things — further broadening the electrification horizon beyond traditional markets.

This edition also reflects an updated assessment of EU policy goals and their implications for R&D priorities across all battery technologies, incorporating developments related to the EU Battery Regulation, the Critical Raw Materials Act, and Europe's drive to strengthen domestic manufacturing capacity and supply chain resilience. Together, these shifts define a more complex, multi-goal innovation agenda — one that requires sustained collaboration across the entire battery value chain.

3. OVERAL CONTEXT
BATTERY MARKETS & OUTLOOK

3.1 Overall Context shaping the Road to 2035

The convergence of **accelerating EC policy support, progressive Battery Regulation implementation,** and **a shifting global competitive landscape** is reshaping Europe's battery markets — driving demand across automotive, grid, and broader applications, while raising the bar on sustainability, traceability, and supply chain resilience. It is against this backdrop that EUROBAT has updated its market estimates, presenting in this Roadmap its best outlook for battery technology evolution through to 2035.

EC Initiatives Driving Electrification and Battery Demand

- **Fit for 55 Package** — accelerating electrification across transport and energy; most now adopted into EU law
- **RePowerEU (June 2022)** — targeting energy independence from fossil fuels, with battery storage explicitly identified as a key enabler via Innovation Fund financing
- **Green Deal Industrial Plan (March 2023)** — three instruments with direct battery impact: the NZIA to scale clean tech manufacturing; the CRMA to secure raw material supply chains; and a new *Electricity Market Design* unlocking BTM and FTM storage opportunities
- **Clean Industrial Deal (February 2025)** — reinforcing industrial competitiveness alongside decarbonisation, complementing the NZIA with broader policy support
- **Industrial Accelerator Act (forthcoming)** — a "Made in Europe" agenda to stimulate demand, accelerate factory deployment, and secure supply chains; set to shape Framework Programme 10 and the European Competitiveness Fund

The Battery Regulation, progressively in force since 2023, shifts Europe toward a differentiated model of sustainable, traceable, and circular battery manufacturing. Collectively, these measures are impacting the battery technology mix, in particular with Sodium-Ion RT entering specific market segments with substantial quantities by 2035.

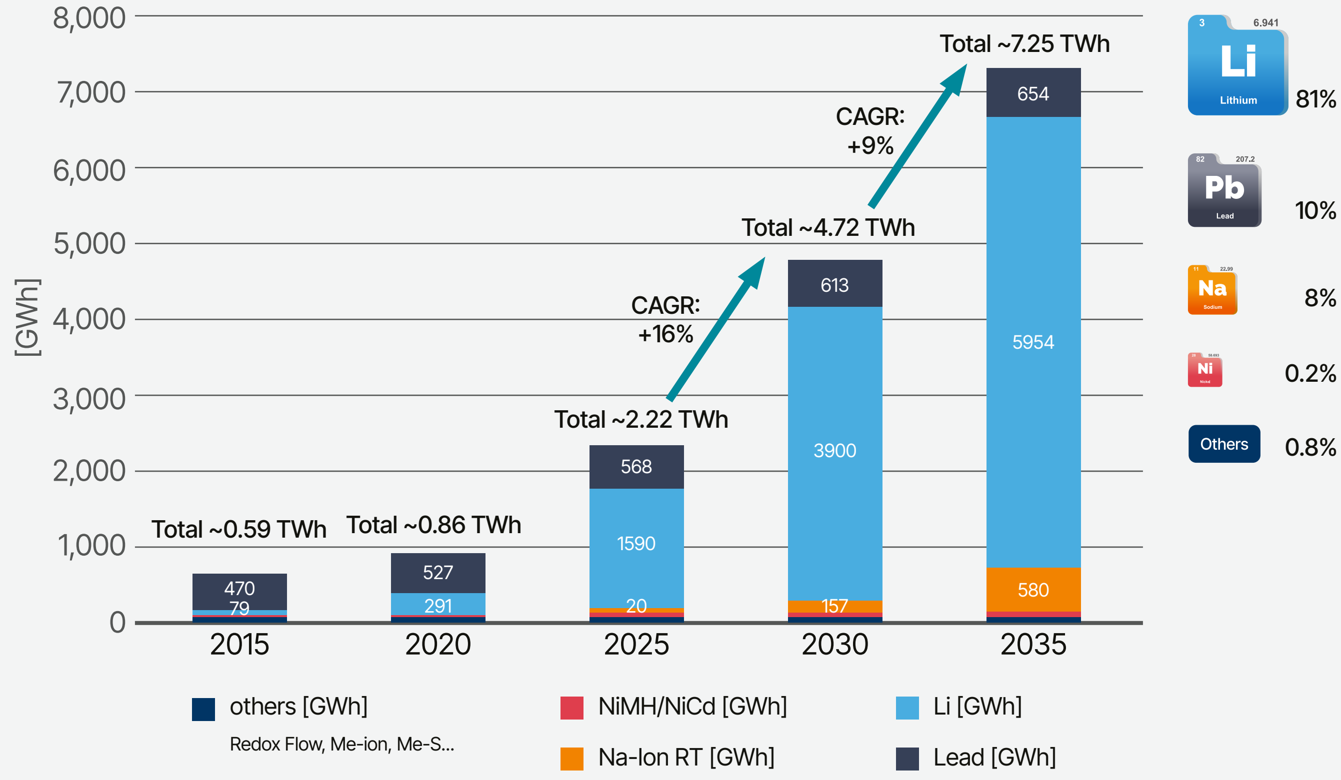
As we operate on a **global level playing field, the Geopolitical Context is navigating the domestic industry in** a more complex and competitive global environment than just two to three years ago, with increases security of supply and enhancing strategic autonomy.

3.2 Battery Markets & Outlook

Considering all the elements highlighted above, this roadmap considers both global and European contexts to assess the battery market and its evolution across battery technologies.

Drawing on trusted sources and reflecting the latest market realities, EUROBAT has reviewed and updated its best estimates. These estimates are derived from consolidated analyses of multiple recognised industry and market intelligence sources, including Mordor Intelligence, PwC Consulting, IHS, Roland Berger, Bloomberg, McKinsey, Battery Insights, BNEF, SPE, IEA, and Fraunhofer. Figures relating to lead-based batteries throughout the roadmap are primarily sourced from

Global Battery Market Evolution across Battery Technologies with Horizon 2035



EUROBAT best estimates derived from consolidated analyses of multiple recognized industry and market intelligence sources, including BNEF, McKinsey Battery Insights, IEA, SolarPower Europe, EASE (non-exhaustive list). The lead battery figures throughout the report are derived from KPMG Study Sept 2025, commissioned by ILA/CBI

the KPMG study report commissioned by ILC/CBI (September 2025).

The graph including EUROBAT best estimates of the global battery market evolutions across battery technologies with horizon 2035 is presented hereafter.

3.3 Concluding key take-a-ways

By 2035 we expect the Total market size (all battery technologies) to reach 7.25 TWh, of which:

Lithium-based (81% of global market)

→ Continues its double digit CAGR to reach 5.96 TWh, although slower BEV roll-out than expected and BESS market uptake (BTM & FTM) to compensate

Lead-based (>10% of global market)

→ Stable market with 6% CAGH to reach 654 GWh, with 12V SLI & Aux main application besides motive power and UPS/TLC applications

Sodium-ion RT (8% of global market)

→ Expected to reach 580 GWh, competing with Pb- & Li-based batteries in specific applications (ex. BESS, L-type vehicle propulsion, SLI application)

Nickel-based and other technologies (1% of global market)

→ Nickel-based (0.2% of global market) remaining crucial in specific niche markets across different applications worldwide

→ Other technologies (0.8% of global market), covering Redox Flow, Metal-Ion, Metal-Air and Metal-S, these technologies, while representing only a fraction, to remain in the market as potential alternatives - to further investigate

Most promising high-TRL future Technologies, also in BEV and BESS applications – entering the markets in substantial quantities:

- Sodium-Ion RT & LFP (with LMFP)
- Both technologies currently dominate production facilities in Asia
- Increasing opportunities for domestic players in North America and Europe
- Need to build local value chains to serve these technologies

The Diversity of Battery Technologies will Remain Through 2035

Diversifying battery technologies is essential to building more resilient supply chains.

While lithium-ion remains the preferred technology for battery energy storage (BES) and utility-scale applications, potential global lithium shortages combined with growing EV demand may give rise to material availability constraints. At the same time, the electromobility transition is progressing below expectations, though it is expected to accelerate in order to meet the European Commission's zero-emission targets by 2050.

Lead-based batteries represent a distinctly European technology, with gigafactories already established across the continent to meet additional demand. These technologies continue to deliver steady improvements in performance and reliability, particularly in UPS/telecom, motive logistics, and automotive 12V SLI/auxiliary markets.

In this context, sustained investment and continuous innovation across both mainstream and emerging battery technologies are critical to diversifying and strengthening supply chains.

4. DRIVERS FOR BATTERY INNOVATION

Battery innovation has historically been driven by market needs and end-user applications, which explains the broad spectrum of battery products, sizes, technologies, and chemistries available today. European industry has long excelled in serving both mass and niche markets — leading standardisation efforts and delivering innovative products across a wide range of applications — maintaining Europe's strong position in the global battery industry.

Today, R&D is increasingly shaped by EU policy objectives, aimed at:

- Further electrifying mobility, energy, and other sectors (Chapter 4.1)
- Advancing sustainability and the circular economy (Chapter 4.2)
- Leveraging opportunities from digitalization and the introduction of the Digital Product Passport (Chapter 4.3)
- Strengthening Europe's resilience and strategic independence (Chapter 4.4)

Innovation across the entire battery value chain is therefore necessary; at the level of the raw and active materials (e.g. low cobalt, high nickel cathodes, silicon or sodium-ion anodes, coating technologies...), at the level of the cells and modules design and production (solid state, digital twins), or at system level to optimize the integration of the battery In the application (e.g. aviation, FTM and BTM BESS).

4.1 Further electrifying mobility, energy, and other sectors

Sectors such as transportation, industrial automation, buildings, renewable energy integration, and ICT will all contribute to rising energy demand in the coming years. A competitive and sustainable European battery industry is indispensable to making electrification a success across these sectors. This requires a regulatory framework that treats all battery technologies equally, building on existing EU manufacturing expertise, fostering clean-tech innovation in line with carbon-neutrality goals, and advancing circularity and supply chain resilience.

Market demand and policy support are converging to accelerate battery R&D. While Battery Electric Vehicles and stationary energy storage represent the largest growth markets, significant momentum is building across many other sectors. Part II of the Technical Annex details the critical applications identified across five R&D areas in support of EU objectives:

R&D Area 1 – Automotive Mobility Applications

This area in the roadmap will cover the largest and most strategically significant segments of the European battery Market:

- 12V Auxiliary Batteries & 12V Start-Lighting-Ignition Batteries (SLI batteries)
- Traction Batteries for Battery Electric Vehicles (xEV batteries)

R&D Area 2 – Motive Power off-road Applications

This area will covers a very wide range of vehicles and will present the key features of the following markets:

- Batteries in all kinds of material handling and logistics machinery
- Batteries in all kinds of off-road Industrial Vehicles
- Batteries in railway, Marine and Aviation applications

R&D Area 3– Stationary Energy Storage Applications

Covering more specifically the following key markets

- Uninterrupted Power Supply (UPS) & Telecommunication Power Supply (TLC)
- Residential/Commercial Storage (BTM) & Utility Grid-scale Storage (FTM)
- Off-grid applications (developing countries, weak grids or small islands)

R&D Area 4 – Batteries in Defence Applications

Batteries are critical enabler of modern defence capabilities, powering applications from drones and unmanned systems to electrified military platforms. As Europe strengthens its strategic autonomy, demand for reliable, high-performance battery technologies is growing considerably. This roadmap examines the innovation challenges and strategic opportunities shaping the future of batteries in defence.

R&D Area 5 – Batteries for Robotics and Internet of Thinks (IoT)

R&D Area 5 covers batteries for robotics and the Internet of Things (IoT) — two fast-growing sectors placing distinct and demanding requirements on battery technology. Robotics applications require high power density, reliability, and long cycle life to support autonomous and industrial systems, while IoT devices prioritise miniaturisation, ultra-low self-discharge, and extended operational lifetimes. Together, these emerging applications represent a significant and rapidly expanding market for innovative battery solutions.

Each application chapter outlines the integration aspects, key performance indicators (KPIs), and innovation priorities for the relevant battery technologies. The selection of KPIs — such as energy and power density, recharge time, energy throughput, cycle life, and recycling rates — is determined by the specific requirements of each application.

4.2 Advancing sustainability and the circular economy

The ongoing implementation of the EU Battery Regulation (2023/1542) has become one of the most significant drivers of battery R&D in Europe. By addressing the full lifecycle environmental impact of batteries — from sustainable raw material sourcing and carbon footprint reduction through to recycling and end-of-life recovery — the Regulation is setting a new bar for what it means to bring a battery to market in Europe.

Not all mainstream technologies — lead, lithium, nickel, and sodium-based — are at the same level of maturity with respect to these sustainability requirements. Tailored R&D is therefore essential across each technology domain, covering three key areas: design (reducing hazardous substances, improving energy throughput, and enabling safe repair and second-life use); production (cutting carbon footprint through renewable energy, reducing water consumption, and increasing recycled content); and information provision (carbon footprint declarations, recyclability data, supply chain due diligence, and minimum performance requirements).

Circularity has rapidly evolved from a downstream waste-management concern into a core innovation frontier. Recycling now has the potential to address raw material security, reduce import dependence, lower carbon emissions, and improve resource efficiency — making it strategically central to Europe's battery ambitions. This is driving innovation in black-mass processing, hydrometallurgy, direct recycling, automated disassembly, and second-life battery applications. Under extended producer responsibility (EPR), battery manufacturers are increasingly taking an active role in end-of-life R&D, developing and managing tools to optimise raw material traceability, recycled content, and waste management across the value chain.

The Battery Regulation also introduces the Battery Passport, embedding traceability and lifecycle accountability directly into market access requirements. Alongside ESG and supply chain due diligence obligations, these measures are driving a more transparent and accountable battery value chain — supported by harmonised European standards developed under the CEN/CENELEC mandate M/579.

Sustained and targeted innovation across all mainstream and emerging technologies remains essential to meet the EU's Green Deal decarbonisation goals, advance strategic autonomy over primary and secondary battery materials, and deliver a truly sustainable circular economy for batteries.

4.3. Leveraging opportunities from digitalization and the introduction of the Digital Product Passport

Digitalisation is profoundly reshaping the battery industry, transforming every stage of the value chain — from R&D and manufacturing through to operation, maintenance, and end-of-life management. The integration of digital technologies such as AI, machine learning, digital twins, and advanced data analytics is accelerating battery development cycles, optimising production processes, and enabling more predictive and efficient battery management in the field.

At the heart of this digital transition is the EU Battery Passport, a flagship requirement of the EU Battery Regulation (2023/1542). The Battery Passport will establish a standardised digital record for every battery placed on the EU market, capturing key data on materials sourcing, carbon footprint, performance, and recyclability throughout the battery's lifecycle. By making this information transparent and accessible across the value chain — from manufacturers and system integrators to recyclers and regulators — the Battery Passport is set to become a powerful enabler of circularity, facilitating second-life assessments, improving sorting and recycling efficiency, and reducing the overall environmental footprint of batteries.

Beyond compliance, digitalisation offers significant competitive opportunities for European industry. Digital twins, for instance, allow manufacturers to simulate and optimise battery performance and production processes before physical implementation, reducing costs and time to market. AI-assisted supervision and cybersecurity frameworks are also becoming increasingly important as battery systems grow in complexity and connectivity, particularly in grid-scale storage and mobility applications.

Societal and regulatory dimensions are equally important. Early-stage engagement with consumers, policymakers, and civil society will be essential to build trust in digital tools and ensure that the data ecosystems underpinning the Battery Passport are robust, secure, and fit for purpose. Aggregators and system providers also have a critical role to play, and their active involvement in the R&D phase will be key to developing scalable and interoperable digital solutions.

Embracing digitalisation and the Battery Passport is therefore not merely a regulatory obligation — it is a strategic opportunity for European battery manufacturers to lead on transparency, sustainability, and innovation in a rapidly evolving global market.

4.4. Strengthening Europe's resilience and strategic independence

The policy and strategic landscape shaping Europe's battery industry has shifted markedly over the past two to three years — from an agenda dominated by EV demand and climate transition to one balancing industrial competitiveness, strategic autonomy, and sustainability in equal measure.

Europe has moved from an optimistic gigafactory expansion phase to a more demanding execution reality. The challenge is no longer announcing capacity, but operating it competitively against high energy costs, capital intensity, and strong Asian and US competition. Batteries are now treated as a strategic industry alongside semiconductors and energy infrastructure, with the focus broadened from cell assembly to the full value chain — materials, processing, recycling, manufacturing, software, and battery passports.

Materials security is reshaping chemistry innovation, with European R&D diversifying towards LFP, sodium-ion, solid-state, and cobalt-free chemistries to reduce geopolitical exposure and import dependence. Localising critical material processing and recycling within Europe has become an explicit industrial policy priority.

The EU Battery Regulation, the Critical Raw Materials Act, the Net-Zero Industry Act, and the PBG BREF are collectively reinforcing this direction — creating incentives for traceable, circular, and domestically produced batteries while driving manufacturing innovation across the value chain.

Sustained investment in European industrial policy and R&D across all battery technologies remains essential to building a resilient and competitive European battery ecosystem — and strengthening strategic independence is ultimately a powerful and defining driver of R&D&I across all technologies and throughout the entire value chain.

5. R&D AREAS AND POTENTIALS PER BATTERY TECHNOLOGY

Demand for batteries has grown steadily in recent decades, accompanied by significant advances in battery performance **driven by increasing electrification across a wide range of applications.** As global efforts intensify to achieve climate neutrality, the continued electrification of the most carbon-intensive sectors—particularly transport and energy—is placing even greater demands on mainstream battery technologies and accelerating the need for further innovation.

At the same time, **maintaining industrial competitiveness and strengthening Europe's position across niche, mass-market, and emerging battery applications** have become strategic priorities. In response, Europe introduced the new Battery Regulation, placing environmental sustainability at the core of battery production while supporting the broader ambitions of the green energy transition. Beyond promoting sustainable manufacturing practices, the regulation also addresses critical challenges such as **securing reliable access to battery raw materials** and fostering a resilient European battery value chain.

Alongside the **mainstream lithium-, lead-, sodium-, and nickel-based technologies** currently available on the market (Chapter 5.1), the EUROBAT TF Innovation industry experts identified a **selection of the most promising high-TRL emerging battery technologies.** These technologies were assessed and selected based on their innovation potential and technology readiness level, highlighting developments that may play a significant role in the future battery landscape (Chapter 5.2).

5.1. Mainstream Battery Technology families available in the market

5.1.1. Lithium-based batteries

Li-ion technologies have a high energy density and low weight. The technologies considered in this Roadmap consist of a combination of specific anode and cathode materials.

Recycling is undertaken through pyrometallurgy or hydrometallurgy, and more recently, by direct recycling and some newly installed capacities are currently under development. End-of-life cells and modules, as well as production scraps, are not crushed but treated directly. Valuable metals are recovered for conversion into active cathode materials for the production of new batteries. Lithium represents a small fraction of what is recovered and is not currently reused in the battery value chain.

Production processes, recycling processes and transportation have been identified as challenges to recycling. Recycling targets for lithium batteries will be maintained at the current level of 50%, but active material recycling is expected to increase from 65% to 85% by 2035. The recovery of nickel, cobalt and lithium will also be fully commercially viable in future.

Lithium-ion (Li-ion) is considered the leading lithium technology for automotive and Energy Storage applications where there is a cyclic demand and will remain so in 2035. For industrial, the Lithium-ion market progression is slower as lead acid batteries are predominate and proven for these applications Lithium is currently deployed in mass-produced standard cell types in different applications – a strategy driven by cost and safety reasons. 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 2035 that mainly considers the lithium-based technologies based on modified expensive nickel cobalt manganese oxide (NMC) materials, from NMC 111 to NMC 811, with increased nickel and reduced cobalt content in combination with high capacitive anode materials with carbon/silicon composites

Lithium Iron Phosphate (LFP) and Sodium-ion will be also part of the market share, from entry level to middle and lower upperclass Electric Vehicles. The high cost of the NMC materials led to a shift to LFP based batteries and pushed also the development of higher energy density for LFP cells.

Development of Solid state technology is being targeted to increase the energy density and improve the safety aspect. As a first step towards this and since there are strong difficulties to overcome for an all solid state battery, initial approaches contain a small amount of liquid electrolyte (ex 10%) commercially presented as semi-solid-state batteries. The main challenge of the Solid state technology remains in the loss of the high energy density from cell to pack level. The reason for this are the required high mechanical pressures to guarantee the battery packs function and life cycle stability. The Li-ion technologies considered in this Roadmap consist of a combination of different available anode and cathode materials, which are described in the Technical Annex.

For more detailed information on the state-of-the-art status and the improvement potential of lithium-based batteries, please consult the →Technical Annex.

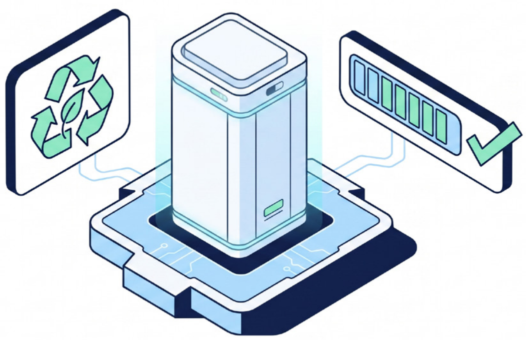
5.1.2. Lead-based batteries – Reliable, Sustainable and Circular

Lead-based batteries have been in use for over a century due to their affordability, safety, and sustainability. Occupational lead exposure is well-managed, with the industry implementing strict measures to protect workers during manufacturing.

Recent advances in lead battery technologies should be recognized as part of Europe's path to achieving the Green Deal's zero-carbon targets. Lead batteries remain critical in applications where cost efficiency, reliability, and established infrastructure are priorities. They are expected to maintain a steady presence across multiple industries worldwide, supporting OEMs as they diversify their offerings.

The EU has a mature collection and recycling system that ensures 99% of end-of-life lead batteries are recovered. Recycled lead and plastics reduce the need for primary materials, minimizing the environmental footprint. Secondary lead usage will further increase, and ongoing R&D will improve impurity levels and efficiency. By 2030, recycling targets aim for 90% overall efficiency and 99% recovery of active materials, ensuring a fully circular value chain.

Lead batteries combine proven performance, economic value, and environmental responsibility, making them a sustainable choice for Europe's energy and transport sectors.



5.1.3. Sodium-based batteries

High-Temperature Sodium-Based Batteries: Current Status

High-temperature sodium-based batteries, including **Sodium-Sulfur (NaS)** and **Sodium-Nickel-Chloride (NaNiCl, or ZEBRA) technologies,** represent mature yet specialized solutions for large-scale energy storage. ZEBRA stands for **Zero Emission Battery Research Activity** and refers to a type of **sodium–nickel–chloride (NaNiCl) high-temperature battery.** It was developed in the 1980s by **Ames Research Center and later industrialized by ABB.**

Sodium-Sulfur (NaS) batteries have achieved global installed capacities of approximately **4.9 GWh,** with significant deployments in Japan. Between 1990 and 2020, **TEPCO (Tokyo Electric Power Company)** conducted both pilot trials and operational installations totaling around 1.5 GWh, primarily for **grid support, frequency regulation, and peak-shaving applications.** NaS batteries operate at high temperatures of **300–350 °C,** requiring dedicated thermal management, but this design delivers **high energy density, long cycle life, and reliable performance,** making the technology commercially proven and attractive for utility-scale stationary storage.

In comparison, **Sodium-Nickel-Chloride (NaNiCl, ZEBRA) batteries** have a smaller installed base, approximately **130 MWh** globally, and are mostly deployed in **niche industrial and specialized grid applications.** While NaNiCl cells offer a high safety margin and competitive performance, broader commercial scale-up has been slower due to higher manufacturing complexity, cost considerations, and competition from Li-ion systems. Nevertheless, both high-temperature sodium chemistries continue to demonstrate **robust performance in applications requiring durability, thermal resilience, and long operational life,** and they remain relevant alternatives for stationary energy storage where large-scale, high-temperature solutions are advantageous.

For more detailed information on sodium-based batteries, please consult the →**Technical Annex**.

Room-Temperature Sodium-Based Batteries: Current Status

Sodium-ion batteries have a similar working principle to Li-ion batteries. As sodium resources are cheap and equally distributed worldwide (2.75% of the earth's crust is sodium, compared to 0.0065% for lithium), and considering the technological similarities with existing Li-ion batteries, the industrialization process of sodium-ion batteries will be accelerated.

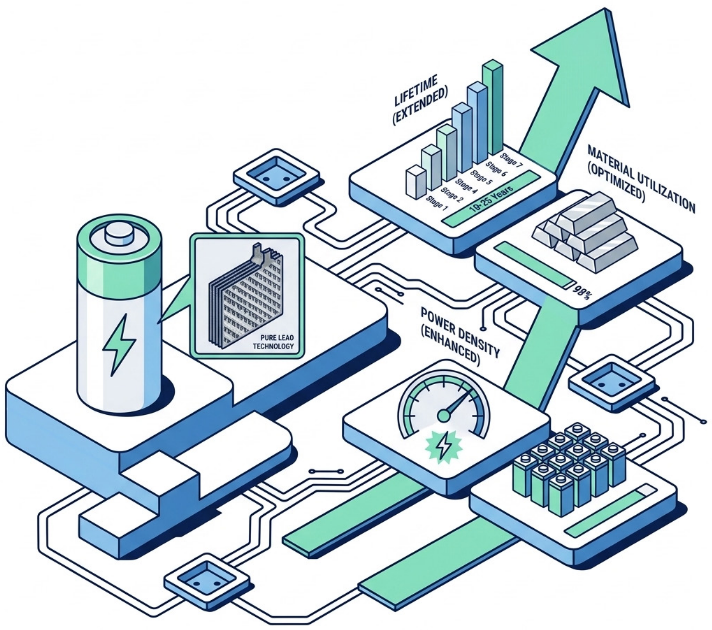
Based on potential application scenarios, higher energy density, longer cycle life and better low temperature performance are the most critical indicators. In total, the cost and safety advantages of sodium batteries will gradually gain in prominence. Therefore, it is likely that sodium-ion batteries will be used in two- and three-wheeled vehicles, in 12V starter applications, in A0 and A00 passenger vehicles, and in certain industrial applications (e.g. stationary) – to effectively supplement Li-ion batteries.

RT sodium battery cells are already in mass production in Asia. Estimated 157 GWh of installed capacity in 2030 is visible. The technologies are based on Prussian blue/white analogues (especially for first generation cathodes), layered oxide and polyanion cathode technology. The temperature ranges from -40 to +60 degrees with almost stable charge at a cycle life up to 10,000.

This outclasses NMC and LFP. The lower voltage, higher weight are disadvantages, which are currently in further development. GEN2 (LO) ramping up in 2026 is already providing an energy density of 175 Wh/kg and is closing the gap to LFP.

Asia has already a wide variety of sodium based stationary battery storages available the expansion into the world market is expected mid of this year, at the latest next year, as manufacturing capacities are rising fast and steep. Applications for automotive purposes are announced and can be prior for small cars at lower cost, which are usually used by families for secondary purposes in suburban surroundings.

The economies of scale will push the cost for sodium battery cells under the LFP costs.



28 58.693
Ni
Nickel

5.1.4. Nickel-based batteries

All Nickel-based batteries offer a long lifespan thanks to their ability to operate in a wide range of temperatures. There are two major types:

- **Nickel-Cadmium batteries (Ni-Cd),** renowned for their very long life and unmatched sturdiness, as well as their progressive aging which can be monitored, hence allowing preventive maintenance.
- **Nickel-metal hydride batteries (Ni-MH):** offering a higher energy density, generally well suited for high-current-drain applications. The Ni-MH technology however requires a BMS for its proper operation, hence introducing an element of vulnerability.

Industrial Ni-Cd technology is today the technology of choice for several highly demanding industrial applications. Due to their superior resistance to mechanical and electrical stress as well as to extreme temperatures and frequent temperature changes, Ni-Cd batteries are the best solution in challenging conditions for mission critical applications such as off-shore oil and gas production, the supply of back-up power in nuclear power plants, as well as for telecommunication base stations and transportation infrastructure when located in harsh climate conditions.

Ni-Cd batteries are widely used as back-up power where human life is at stake and unflinching reliability must be ensured. This is the case in the railway rolling stock (with over 50% market share) as well as in civilian and military aircraft (with over 70% market share) in which they supply emergency power in case of failure of the main energy supply. Other critical applications include backup power systems in energy generation and distribution facilities, large data centers, hospitals, lighting and ventilation in road tunnels, coastal lighthouse systems, as well as many installations in harsh climate or remote locations.

Industrial Ni-Cd batteries constitute a highly specialized market which grows along with a country's infrastructure. The market is currently growing modestly in the EU (1 to 2% pa), but at a faster rate in Asia and in the Americas, which makes the EU industrial Ni-Cd manufacturing base a significant exporter.

For industrial applications, nickel-based batteries will most likely remain relevant even in a decade or more. Manufacturers are further improving the already superior characteristics of these batteries, such as low maintenance requirements and tolerance to extreme temperatures.

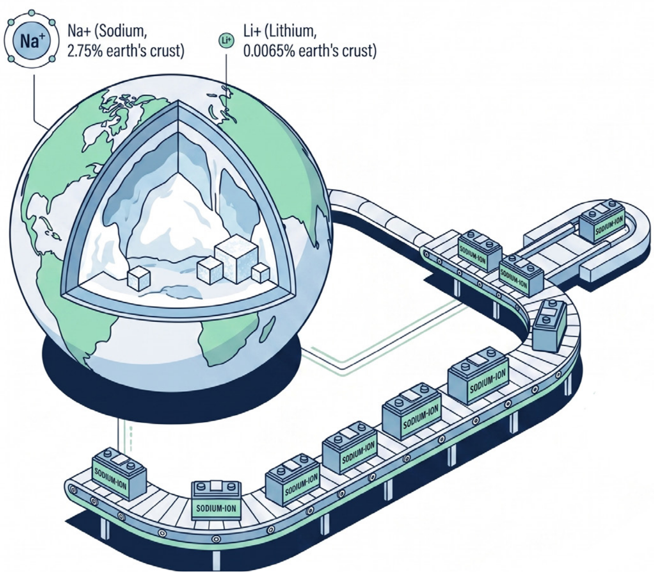
Used industrial Ni-Cd batteries are extremely well collected in the EU. Fully permitted specialized recyclers extract the embedded metals (nickel, cadmium, and steel) with very high efficiency.

In the course of the previous decade, the recycling efficiency of Ni-Cd batteries in the European Union had to be improved to reach the 75% level mandated by directive 2006/66/EC, and industry is currently working to reach the 80% recycling efficiency goal set by the new European Battery regulation 2023/1542, a level which will be mandatory by 2025.

Furthermore, an additional requirement has been introduced in this new European Battery regulation to especially recover 90% by 2027 (and 95% by 2031) of the embedded nickel.

To meet the demanding electrification requirements of standby applications operating under extreme conditions, nickel-based battery technologies are the preferred choice.

For more detailed information on Nickel-based batteries please consult the →Technical Annex.



5.2. Most Promising high-TRL Emerging Battery Technologies

The promising future technologies identified in this chapter have been selected based on **two key criteria:** sustainability aspects and Technology Readiness Level (TRL).

Sustainability aspects. Particular emphasis is placed on technologies that reduce the carbon footprint and provide more sustainable alternatives to both primary and secondary raw materials, especially those classified as Critical Raw Materials (CRMs). By decreasing reliance on such materials, these technologies contribute to greater sustainability, strengthened supply-chain resilience, and enhanced security of raw material availability.

Technology Readiness Level (TRL). Given the urgency of reducing CO_2 emissions and accelerating the energy transition, the maturity of a technology is a critical consideration. Technologies with higher TRL levels are prioritised, as they are closer to commercial deployment and therefore capable of delivering a more immediate impact in supporting decarbonisation objectives.

Driven by the ambition to enhance battery performance across real-life applications, and guided by the imperatives of durability, safety, sustainability, and affordability, industry experts have identified a portfolio of promising technologies for inclusion in this roadmap. Sustainability remains a central driver, with the objective of developing batteries that minimise environmental impact while adhering to high social and ecological standards throughout their lifecycle. This includes ensuring long service life, operational safety, and the potential for repair, reuse, and repurposing.

Based on these considerations, the essential electrochemical energy storage systems identified as the most promising future technologies are presented hereunder. More detailed information on these emerging battery technologies and their readiness for (mass) markets is available in the →Technical Annex.

5.2.1. Advanced Lead-based Battery Technologies

Key areas for innovation are improvement of lifetime, higher material utilization, high power density and increase energy density. In general, positive alloys have to be improved. For e.g. pure lead technology is one option to improve performance in all aspects as mentioned above.

Bi-polar lead technologies would give in addition a significant improvement in terms of power and energy density increase. Other areas of innovation are additives to the positive and or negative active material. They can potentially delivery improved lifetime and better mass utilization.

Recycling lead acid batteries has already achieved an excellent level (>85%). The lead material is fully recycled without downsizing. Partly sulfuric acid and housing material without flames retardant additive is recycled in addition. A new part of innovation is the potential recycling of housing material with flames retardant additives.

A new driver for innovation is the battery passport requirement. The new battery regulation requires industrial batteries > 2kWh a digital twin (a virtual representation to reflect a physical object accurately). It spans the object's lifecycle, is updated from real-time data and uses simulation, machine learning and reasoning to help make decisions. Li batteries need battery management system (BMS) by definition, so including information functionalities on SOC, SOH and other parameters is easier as lead batteries do not have a BMS. One of the innovation focus areas is to develop a BMS for industrial lead-based batteries to establish a digital twin.

For SLI batteries we will see a merger of the classic SLI function (starting, lightning and ignition) and auxiliary batteries. Those batteries require prediction algorithms to determine the power capability for functional safety. Means the reliability of battery performance must be improved via design and manufacturing processes. Software must be improved to project the power capabilities of the battery precisely for functional safety applications.

More information on Advanced lead-based battery technologies is available in the → **Technical Annex**.

5.2.2. Next generation Sodium-ion RT Battery Technologies

Sodium-ion batteries have a similar working principle to Li-ion batteries. As sodium resources are cheap and equally distributed worldwide (2.75% of the earth's crust is sodium, compared to 0.0065% for lithium), and considering the technological similarities with existing Li-ion batteries, the industrialization process of sodium-ion batteries will be accelerated.

Based on potential application scenarios, higher energy density, longer cycle life and better low temperature performance are the most critical indicators. In total, the cost and safety advantages of sodium batteries will gradually gain in prominence. Therefore, it is likely that next generation sodium-ion batteries will be used in two- and three-wheeled vehicles, in 12V starter applications, in A0 and A00 passenger vehicles, and in certain industrial applications (e.g., stationary) – to effectively supplement Li-ion batteries.

More information on sodium-ion room temperature battery technologies is available in the →**Technical Annex**.

5.2.3. Post Li-ion Battery Technologies

Inexpensive and environmentally friendly metals, such as sodium and polyvalent light metals, should one day replace the current Li-ion battery technologies. A major challenge, however, is the development of durable and stable electrodes with high energy density and, at the same time, fast charging and discharging rates.

As there are many Li-ion variations, the Technical Annex includes a tabulation of the categorization of Li-ion technologies, indicating the timeline of **the readiness level for mass-market introduction for the proposed technologies.** More information on the classification of Li-generation technologies with characteristics and estimated timeframe to enter the market is available in the →Technical Annex.

5.2.3.1. Lithium All-solid-State Battery Technologies (Li-ASSB – Gen 4b & 4c)

Solid-state batteries use an electrolyte made of solid material instead of the usual liquid electrolyte. This technology could bring economic and sustainable benefits. The main advantages of future solid-state batteries are:

- Significant increase in the energy density of cells
- Significant decrease in fire risk due to the less pronounced flammability of the electrolyte
- Significant reduction in the use of cobalt

Readiness for the mass market of Gen 4b is expected after 2025, while the mass-market readiness level of Gen 4c is expected from 2030. In between, we can expect:

More information on lithium all-solid-state battery technologies is available in the →Technical Annex.

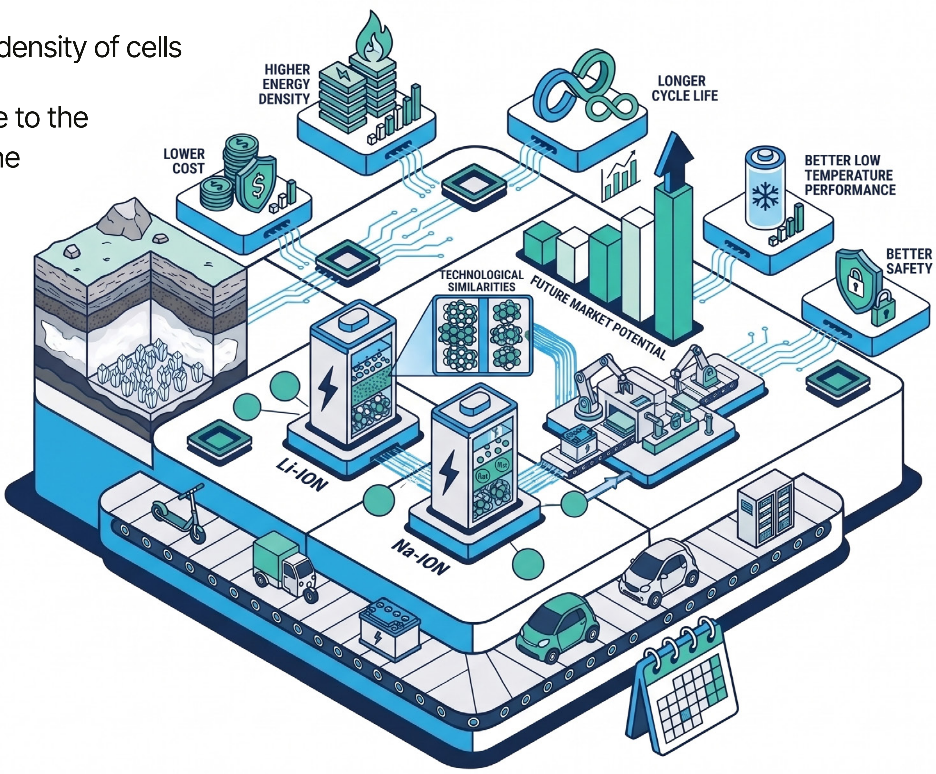
5.2.3.2. Lithium-Sulfur Battery Technologies (Li-SB)

The low cost and high abundance of sulfur (i.e. the active cathode material) make LiSB more appealing than Li-ion batteries given the fact that the latter use critical materials, such as cobalt and nickel, in the manufacturing of the cathodes.

The high energy and low cost make LiSB a promising energy storage technology in practical applications, such as portable devices, electric vehicles and grid storage when coupled with the harvesting of renewable solar or wind energies. LiSB are promising because of the high energy density, low cost and natural abundance of sulfur. More information on LiSB technologies is available in the →Technical Annex. Readiness for the mass market is expected after 2030.

5.2.3.3. Lithium-Air Battery Technologies (Gen 5)

Lithium-air batteries possess great potential for efficient energy storage applications to resolve future energy and environmental issues. The extremely high theoretical energy density is attractive, but there are still various technical



limitations to overcome. The performance of lithium-air batteries is governed mainly by electrochemical reactions that occur on the surface of the cathode. Widespread interest in various carbons and their applicability as cathode materials in lithium-air batteries arises as a result of their highly specific surface area and porosity, their light weight and their low production cost.

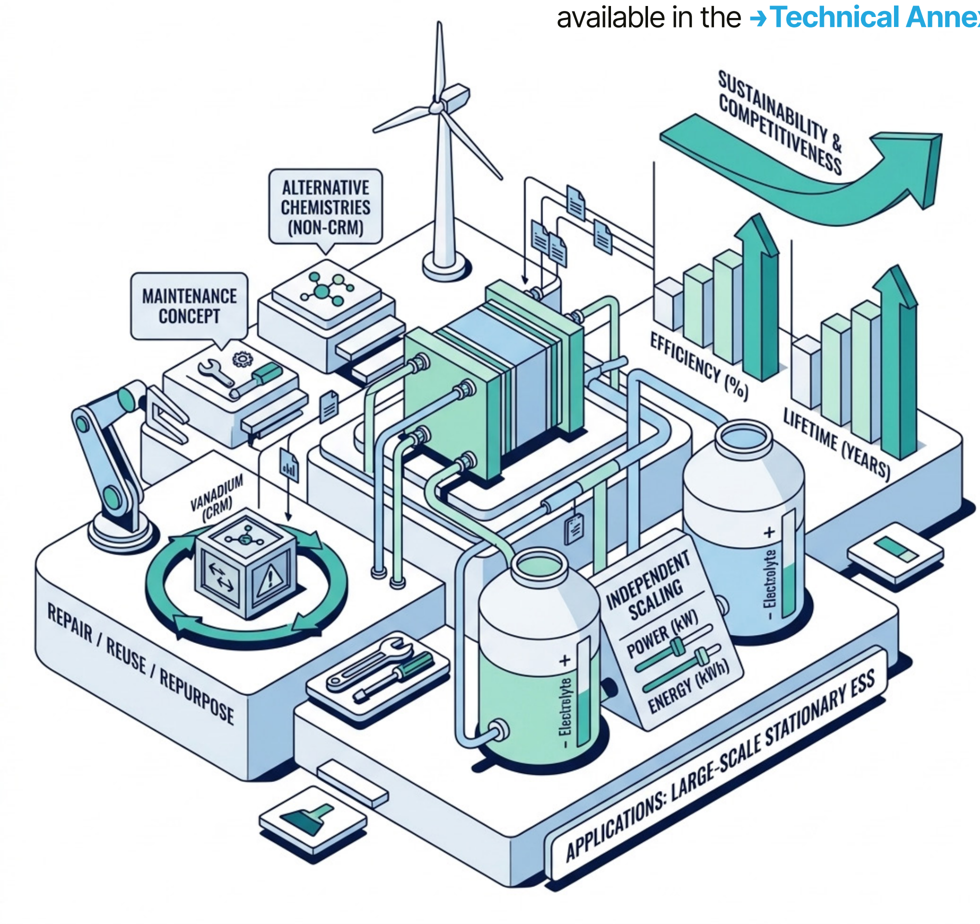
More information on lithium-air battery technologies is available in the →Technical Annex. Readiness for the mass market is expected after 2030.

5.2.4. Redox Flow Battery Systems

Redox flow battery system is another electrochemical system for large stationary applications like ESS batteries. Vanadium bases system are mature and in small scale production with good results in ESS application.

The battery systems can demonstrate excellent efficiency and good lifetime results. The independent sizing of energy and power of the system is a strong advantage. Energy density is defined by the size of the external tanks for the liquids. A drawback of the Vanadium Redox Flow technology is that vanadium has been categorized as a critical raw material. Despite the reliance on vanadium as a critical raw material, ongoing efforts focused on alternative chemistries, improved system design, and material circularity are expected to further enhance the sustainability, scalability, and competitiveness of redox flow battery technologies for long-duration energy storage applications.

More information on Redox flow technologies is available in the →Technical Annex.



6. CONCLUDING REMARKS AND RECOMMENDATIONS

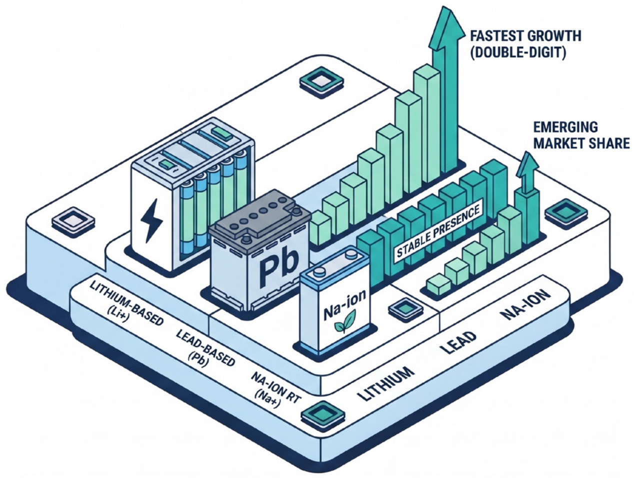
Key Findings

The battery technologies identified as most promising in the Roadmap span a range of technology readiness levels (TRLs). Sodium-ion room temperature (RT) batteries stand out as a breakthrough, representing the earliest realistic entry point for new technology at meaningful market scale. The ramp-up of Sodium Polyanionic cell production for EV and stationary applications — with an operational temperature range of -40°C to +60°C — is already underway in Asia, and sodium-ion RT technology is beginning to enter niche European markets such as marine applications.

The dominant picture through 2035 is one of continuity alongside emerging competition. Taking into account projected innovation timelines, production upscaling, and market projections from multiple credible sources, lithium-ion and lead-based batteries will remain the leading technologies in European and global markets. Sodium-ion RT, however, is expected to capture a small but meaningful share in specific segments, maturing rapidly through continued R&D investment.

Technology outlook by chemistry:

- **Lithium-based** — by far the fastest-growing segment, with consistent double-digit annual growth
- **Lead-based** — stable outlook, even accounting for the potential EU automotive ICE phase-out in 2035
- **Sodium-ion RT** — a credible and sustainable alternative, gaining competitiveness in targeted markets



Continued R&D remains essential across all mainstream chemistries. Incremental improvements in performance and sustainability are needed to meet — and ideally exceed — the requirements of EU Battery Regulation 2023/1542. While the Regulation's specific requirements vary by technology, its overall direction is clear: batteries must become lower-carbon, responsibly sourced, longer-lasting, and fully circular, with full lifecycle transparency.

Established technologies also retain significant innovation potential through 2035:

- **Lithium-ion** — the breadth of Li-ion chemistries offers a wide array of KPIs available for targeted improvement
- **Lead-based** — branching into digital territory for the first time, with Battery Management Systems (BMS), dedicated software, and digital twin development creating new pathways for optimisation and integration

Looking ahead to 2035, lithium- and lead-based batteries will remain the dominant technologies in both European and global markets. Alongside

these established chemistries, sodium-ion room temperature (Na-Ion RT) batteries are expected to steadily capture a small but meaningful share in specific market segments, increasingly competing with lithium- and lead-based solutions. In summary:

- **Lithium-based:** by far the fastest-growing segment, with consistent double-digit annual growth
- **Lead-based:** set to remain stable, even in view of the potential EU automotive ICE phase-out in 2035
- **Sodium-ion RT:** an emerging sustainable alternative, maturing rapidly and becoming increasingly competitive in targeted applications through continued R&D investment

Hereunder a technology outlook table, capturing the market evolution across the mainstream battery technologies, up to horizon 2035 and beyond:

Summary Table: Market evolution across battery technologies up to horizon 2035 and beyond

	3 6.941 Li Lithium NCM, LFP , LMO,NCA, LCO (C; LTO; Si/C); SemiSolid State	82 207.2 Pb Lead EFB – VRLA - AGM, Pb-C, Thin Plate Pure Lead, BiPolar	11 22.99 Na Sodium NaS, NaNiCl (HT), Na-Ion (RT) Gen I (PBA)	28 58.693 Ni Nickel NiCd & NiMH
> 2026	Performance and sustainability improvements Semi Solid State	Performance and sustainability improvements Embedded BMS & software	Na-Ion (RT) Gen II (Layered Oxides; Na-Ion (RT) Gen III (Polyanionic)	Continuation of electro-chemistry & cell construction improvements
> 2030	Li-Sulfur, All Solid State	Performance and sustainability improvements	Semi Solid State	Performance and sustainability improvements
> 2035	Li-Air, All Solid State	Performance and sustainability improvements	All Solid State	Performance and sustainability improvements

*Sustainability requirements: in accordance to the Regulation EU 2023/1542

Strategic Recommendations

The European battery industry, represented by EUROBAT, stresses the importance of developing all battery technologies to maximise their contribution to Europe's decarbonisation objectives and strategic autonomy. This Roadmap affirms that the various battery technologies — each with distinct characteristics and development potential — are complementary and collectively essential to advancing the EU's Green Deal agenda. Given the diversity of performance requirements across a wide range of applications, no single technology fits all needs

→ Make Europe resilient by broadening technological development across all battery chemistries

Policy should focus on objectives rather than prescribing technologies, giving industry the freedom to determine the best path to meet those objectives. Selecting one technology over another today is inherently a bet based on current knowledge alone.

- Future EU public R&D funding should be distributed more evenly across technologies, targeting applications with the best available solutions. Fostering innovation across all battery chemistries — lithium, lead, sodium, and nickel — will strengthen EU industrial resilience and advance Europe's strategic autonomy in battery materials.

- Alongside continued R&D on mainstream technologies, further investment is needed in high-TRL promising technologies, particularly sodium room temperature batteries (Na-ion RT), which represent the most promising near-term option in terms of cost, raw material availability, and performance.

- R&D aimed at improving recyclability, increasing recycled content, and reducing reliance on critical substances will support the objectives of the EU Critical Raw Materials Act (CRMA), introduced in March 2023 in response to growing pressures on Europe's raw material supply chains.

→ Strengthening Europe's Competitiveness, Sovereignty and Global Standing

Europe must ensure a level playing field for all battery technologies, recognising their complementary nature and essential role in transforming the EU into a prosperous, resource-efficient, and competitive society — one that achieves net-zero emissions by 2050 while maintaining strategic sovereignty over its critical industrial value chains. Delivering on this ambition requires a legislative framework that actively promotes a robust, sustainable, and internationally competitive European battery supply chain.

- The Net-Zero Industrial Act (NZIA), introduced in March 2023, should be actively pursued to provide a supportive industrial framework — through faster permitting, clear market signals, procurement rules, skills development, and strategic project support — that makes Europe a more attractive and competitive destination for battery manufacturing investment, reducing dependence on non-European supply chains.

- The diversity of Europe's battery technology portfolio is essential for meeting varied and evolving application needs, while mitigating risks from fluctuations in raw and active material costs. Over-reliance on a single technology poses a strategic risk to Europe's global competitiveness and sovereignty, with potential consequences for citizens' purchasing power and the erosion of industrial expertise across key EU markets.

- Building on existing European manufacturing capacities and know-how will accelerate the transition by bringing academic innovation more rapidly into new products, and new products into scaled production lines — serving both niche and mass markets to meet future demand. In this context, the Battery Booster Facility, adopted by the Commission in December 2025 as part of a broader European automotive and industrial policy package, is considered essential for boosting European battery production by combining financing, supply chain support, and industrial policy tools to help domestic manufacturers reach commercial scale.

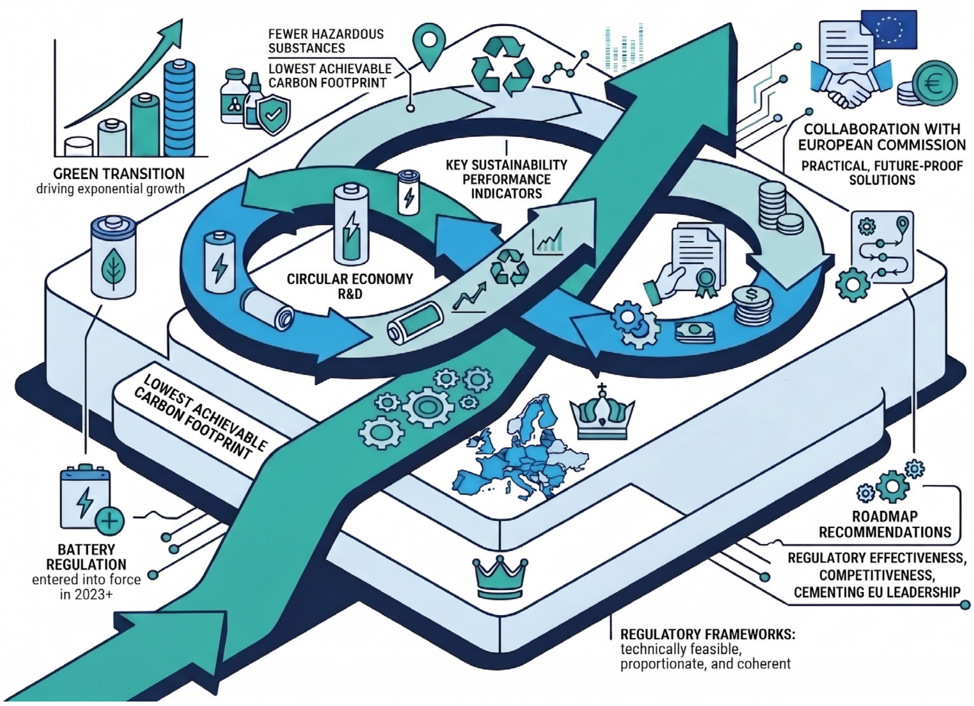
→ Advancing Europe's Transition to a Sustainable, circular and Sovereign Economy

→ Since the Battery Regulation entered into force in 2023, additional environmental challenges must be addressed to fully realise the circular economy ambition. Mainstream battery technologies are not all at the same level of maturity in this respect, and each will require tailored R&D efforts to advance across the circular economy's key sustainability performance indicators.

→ The four pillars of the Green Deal Industrial Plan — (1) simplifying permitting, (2) enhancing skills, (3) facilitating open and fair trade, and (4) providing grants and loans — should be applied across the entire battery manufacturing value chain to maximise the industry's contribution to the green transition and to reinforce Europe's industrial sovereignty.

→ With the green transition driving exponential growth in battery demand, Europe should actively facilitate the expansion of local production capacity, prioritising batteries manufactured with fewer hazardous substances and the lowest achievable carbon footprint — strengthening both sustainability outcomes and supply chain independence.

→ EUROBAT remains fully committed to the EU's sustainability, circular economy, and strategic autonomy objectives. Achieving these goals, however, requires regulatory frameworks that are technically feasible, proportionate, and coherent across legislative instruments. Implementing the recommendations set out in this Roadmap would improve regulatory effectiveness, safeguard industrial competitiveness, reinforce Europe's sovereignty over critical battery value chains, and cement the EU's leadership in sustainable battery manufacturing. EUROBAT stands ready to work with the European Commission and co-legislators to develop practical, future-proof solutions for the European battery ecosystem.



TECHNICAL ANNEX

The Technical Annex to the Roadmap 4.0 provides the reader with detailed background information on the mainstream and future battery technologies and their potential for improvement for each application addressed in the roadmap.

While part 1 of the annex focuses entirely on the details of battery technology features, part 2 covers the technical details on a diverse range of end-user battery-powered applications in the areas of automotive mobility, motive power, and stationary applications, with the aim to provide stakeholders with comprehensive insights into the latest developments and opportunities in the battery manufacturing industry.

LISTS OF ABBREVIATIONS AND OF SOURCE REFERENCES

→ List of abbreviations

A0 and A00 – very small vehicle size segments used mainly in Europe to classify passenger cars, with A00 being even smaller than A0

AGM – Absorbent Glass Mat

CAGR – Compound Annual Growth Rate

DOD – Depth of Discharge

EFB – Enhanced Flooded Battery

EPR – Extended Producer Responsibility

ICE – Intern Combustion Engine

IoT – Internet of Thinks

NMC – Lithium Nickel Manganese Cobalt Oxide

NMFP – Lithium Nickel Manganese Iron Phosphate

SoC – State of Charge

SoH – State of Health

LCO – Lithium Cobalt Oxide

LFP – Lithium Iron Phosphate

VRLA – Valve Regulated Lead-Acid

→ List of Source References

BEPA and the Batt4EU Partnership

CETP – Clean Energy Transition Partnership

EGVIA2ZERO – European Green Vehicles Initiative Association representing the private side of the 2ZERO Partnership

ERTRAC – European Road Transport Research Advisory Council

ETIPSNET – European Technology and Innovation Platform on Smart Networks for Energy Transition

ESE – Energy Storage Europe

FBE – Flow Batteries Europe

ILA/CBI KPMG Study – Sept 2025

LDES Council (Long-duration Energy Storage)

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Date of publication: June 2026

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