+ CBI BATTERY INNOVATION ROADMAP

Sustaining Europe's battery powerhouse

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+ Introduction

The Consortium for Battery Innovation's Roadmap sets out performance targets for the next wave of advanced lead batteries, ensuring that European-based industries stay ahead and retain their leadership in research, development, and advanced manufacturing capabilities.

The EU lead battery value chain makes some of the most advanced batteries in Europe – recycling them in a fully closed loop system. These are batteries used across a wide range of strategically significant applications and essential services, from defence to renewable energy storage, and from telecoms to vehicles.

Batteries are one of the key enablers for sustainable development, green mobility, clean energy, and climate neutrality. Demand for batteries will grow rapidly in the coming years, notably for electric vehicles, light means of transport using batteries for traction, and energy storage, making the market for batteries an increasingly strategic one at the global level.

Towards 2030, deployed lithium-ion battery energy capacity will grow significantly and is likely to play a major role in the global battery market. In addition, lead batteries will also continue to play a significant role in market segments such as Uninterruptible Power Supply (UPS), telecoms, data centres, and safety critical energy storage applications such as backup for nuclear power stations and safety batteries in most EVs – and they will remain the preferred 12 V choice for many automotive applications – particularly starting, lighting, and ignition (SLI), start-stop, and auxiliary/safety batteries in most vehicles. Lead-based batteries will also remain critical for many defence and aerospace applications. The lead-based battery segment will represent a more than €50 billion industry by 2030, in which European companies remain successful global players in a value chain employing more than 180,000 people across the EU.

To remain relevant in a rapidly changing world, innovations in advanced lead battery deployment and improvements will continue to be a priority. And Europe's industrial capacity must not be suppressed by ill-advised regulatory and policy-driven mandates.

Therefore, alongside the technical performance improvements and innovations set out in the Roadmap, we ask policymakers to support a successful European lead-battery industry by:

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Ensuring a level policy playing field for all battery technologies

There is currently much focus on incentives for the development of lithium-ion capability with insufficient support for mature but successful technologies such as those based on lead and nickel. This imbalance is illustrated by the example of the Industrial Accelerator Act that requires a battery management system (BMS) - which is not present in, nor required for, lead-based technologies - to be in place as one of the "Made in Europe" requirements.

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Supporting innovation in all battery technologies

Current EU policies such as the "Battery Booster Facility" and funding instruments exclude mature battery technologies from innovation funds. This is an oversight as mature batteries also have significant opportunities for performance improvement across the full range of current applications. And they can be used to develop – and be deployed in – novel technologies, including for example the "battolyzer" in LoCEL-H2, and in applications needed to deliver the energy transition.

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Ensure EU legislation does not try to pick a winner

For example, initial draft proposals for the implementing act of Battery Regulation Article 10 (minimum performance and durability standards) would have had an unintended consequence of excluding many lead-based industrial batteries from the EU market. Policymakers must recognise that some Battery Regulation minimum standards may need to be chemistry-specific as "one-size-fits-all" requirements may result in regrettable substitution.

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Removing single market barriers that inhibit circularity

Rules for cross-border shipment of waste batteries to facilitate recycling are still not harmonised across Member States. This unnecessary bureaucracy creates significant delays in recovering battery raw materials.

The EU and Member States must value and nurture industrial powerbases such as the lead battery value chain to ensure they are secure, supporting them as they innovate and develop next-generation products and services that generate growth, promote resilience, enable electrification, and meet the demands of European citizens.

+ Background

The Consortium for Battery Innovation (CBI) serves as a research organisation for the sustainable, domestic lead battery manufacturing industry in the EU and Europe. With more than 50 EU entities in membership and more than 120 members and partners worldwide, CBI is a multi-technological global battery research organisation focused on developing and aligning battery technologies to specific applications.

CBI and the International Lead Association (ILA), have developed EU specific and global data on the impact of the lead battery market on key economic indicators and also the technical contributions of lead batteries in the EU. Additionally, CBI has developed a Roadmap, outlining how EU member company manufacturers can continue to develop the domestic lead battery industry to meet current and future needs.

Our European membership base

ILA and CBI have a strong European footprint and are present in 17 EU Member States and the United Kingdom. The membership includes:

Lead battery producers:
AT, BG, CZ, DE, FR, EL, IT, LU, PL, PT, ES, UK

Lead battery recyclers:
BE, CZ, DE, EL, ES, FR, IT, PT, SE, SI, UK

Other lead manufacturers: BE, BG, DE, IT, PL, SE, UK

Lead ammunition producers' trade association: BE

Producers of radiation shielding to defence, nuclear and other sectors: DE, FR, IE, NL, UK

Research institutes: DE

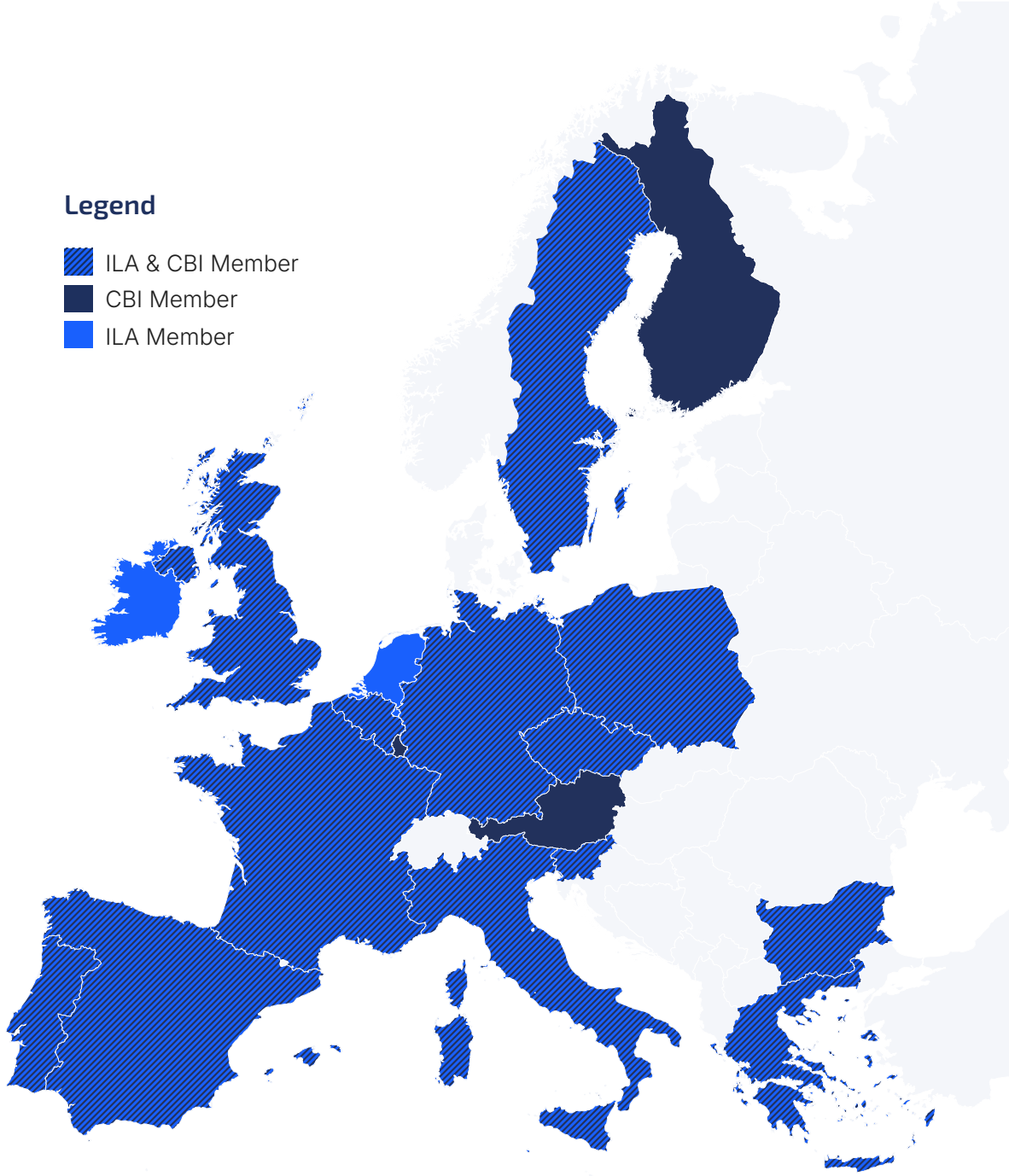

Figure 1. The EU Member States and ILA/CBI members participating in the lead battery and lead production industries.

+ A significant contribution to the EU's economy:

Developed in Europe,
Made in Europe,
Recycled in Europe.

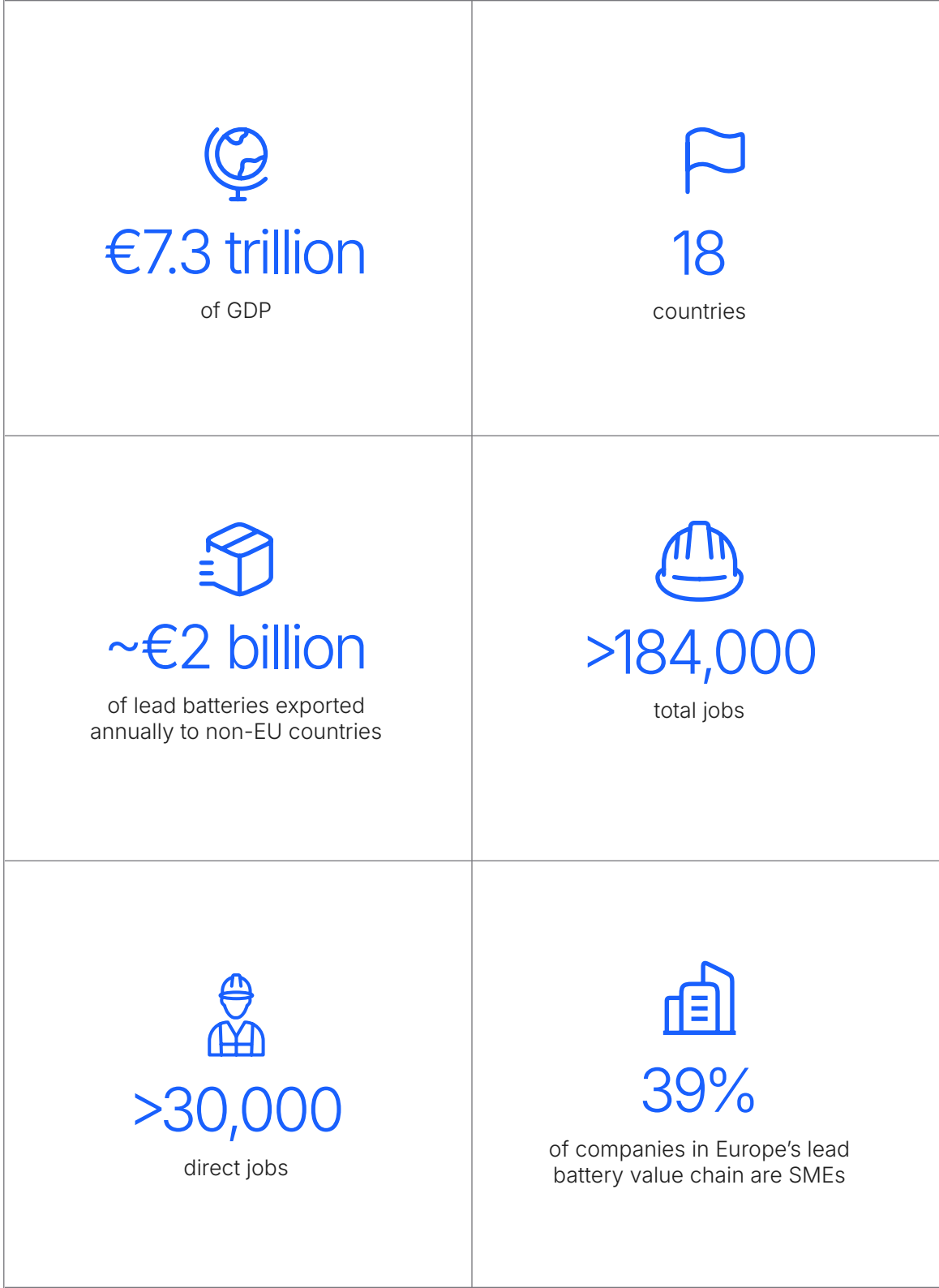

Figure 2. Summary of the economic impact of the lead battery manufacturing and supply chain on the EU's and UK's economy. Source: Economic Contribution of the European Lead Battery Industry, EBP US, Inc, January 2022

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The lead battery industry contributes significantly to the EU and European economy, providing over 30,000 high paying direct jobs and supporting over 180,000 jobs. The lead battery market and its supply chain is vital to the European economy, providing crucial power and energy resources, contributing over €7.3 trillion to the region's GDP.

Every EU Member State relies on lead batteries to provide energy for over 150 applications[1]. The EU has a significant lead battery industry, meaning that the majority of the batteries Europe needs are produced domestically, by European manufacturers operating in a highly regulated environment that protects human health and the environment.

Furthermore, at the end of their useful life 99% of lead batteries available for collection are recycled within the EU to produce battery-grade raw materials that can be used to produce new batteries. On average a new battery manufactured in the EU contains >80% recycled materials.

[1] Battery Council International, 2023.

Lead batteries provide energy storage for several key societal needs:

1.

Required in nearly all conventional and micro-hybrid vehicles, and also acts as the auxiliary/ safety battery in most electric vehicles.

2.

Backup for all EU nuclear power plants, ensuring safe operation and mitigating catastrophic failure for approximately 25% of the power generation plants in the EU.

3.

Provide standby power for over 5 million substations, utility pole reclosers, telecommunications, and cable broadband.

4.

The most popular option for forklift batteries, providing the traction power for EU warehouses.

5.

Vital to dozens of military and defence applications, from submarines to aviation.

6.

Data centre infrastructure taxes the EU grid, lead batteries provide backup and demand reduction.

The battery market has expanded and changed dramatically over the past five years with the continued evolution of policies, supply chains, manufacturing, and end-user requirements.

This Roadmap has historically focused only on the research areas, performance indicators, and market drivers for lead batteries, but has now expanded to become a multi-technology resource. Figure 3 shows the global battery market for lead batteries, with steady growth in many applications and explosive growth in critical safety battery markets. The Roadmap also looks at the entire battery market for each of the major applications discussed, automotive (start-stop / micro-hybrid and auxiliary), energy storage systems (ESS), uninterruptible power supplies (UPS), telecom, military, and low speed electric vehicle (motive power, e-bike, and e-rickshaw).

Evolution of lead battery market demand

(2019–2030, GWh)

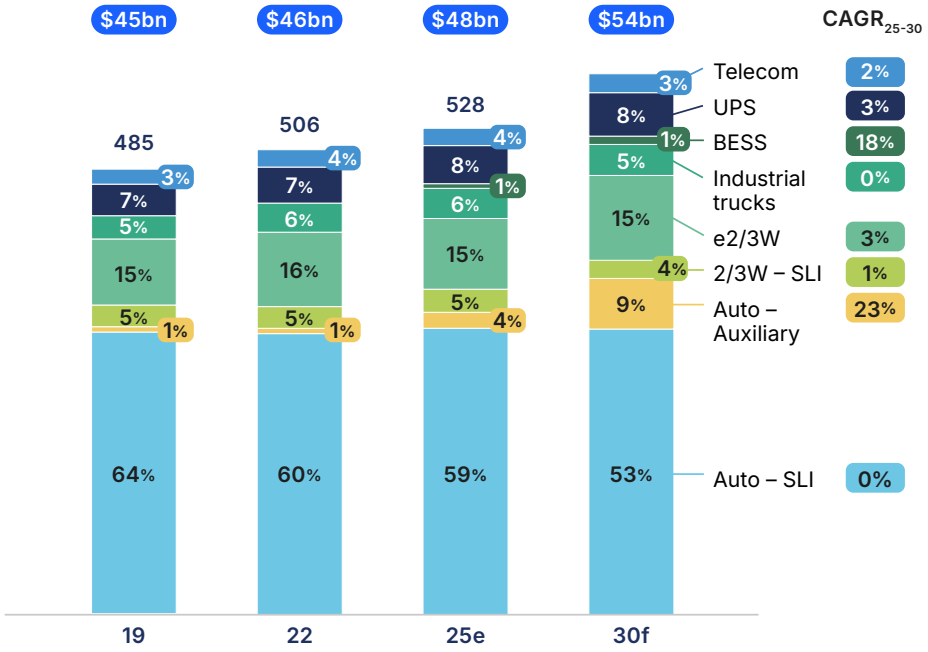


Figure 3. The global lead battery industry accounting for the major markets. Auto-auxiliary is new market, specifically for critical safety batteries in EVs and auxiliary batteries in ICE and hybrid vehicles. Source: KPMG 2025

The strong growth of the lithium-ion battery industry, predominantly based on the ongoing strong industrialisation push from China, has put the global battery industry (including the Chinese market) under pressure. Figure 4 shows the growth of the entire global battery industry. Over-capacity lithium-ion cell production has driven the price to historic lows, with cells well below $100/kWh.

At the same time regional tax incentives are lifting battery manufacturing in the US and Europe, financially bolstering current manufacturing. In large markets such as the US, tariffs are stimulating onshoring as well, disrupting legacy supply chains and establishing instability in applications such as UPS for data centres and ESS.

The worldwide battery market in value by chemistry

(2010-2030, GWh)

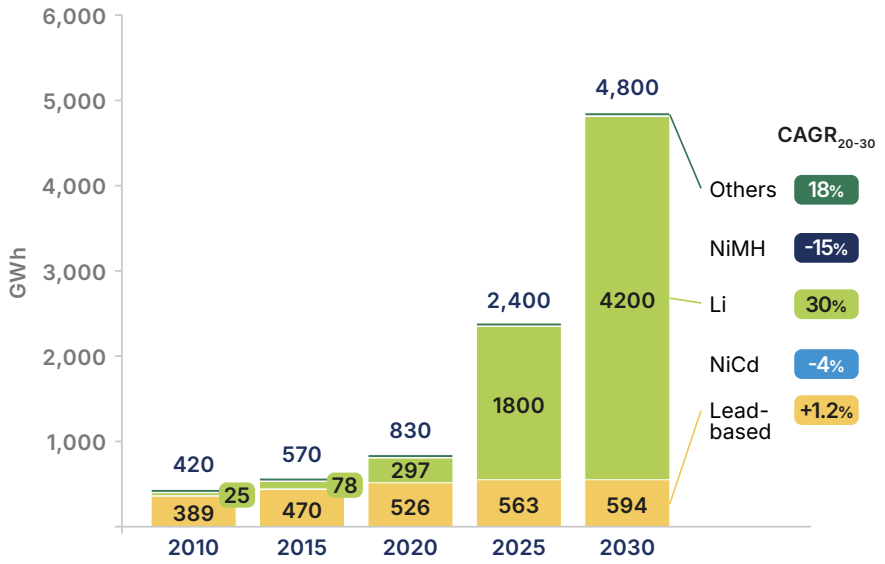


Figure 4. The global battery industry market by GWh. The 'others' category consists of flow, Zn-based, and sodium-based. Pack level: pack including cells, cell assembly, BMS, connectors - power electronics (DC-DC converters, inverters, etc.) not included. Source: Avicenne 2025.

The Roadmap uses publicly available information on macro-market trends and supportive market analyses from premier organisations in battery volume and demand forecasting, specific technical feedback from institutions such as the EU Commission's Joint Research Centre, and gathered information and expertise from battery manufacturers and end-users around the world.

In-depth information on lithium-ion, lead, zinc, nickel, and flow battery technologies are covered, including key performance indicators, necessary research areas, and what constitutes state of the art. Across the six applications, competitive technologies are described, below in Table 1 is an overview of the technologies covered in each application.

Application	Battery Chemistry
Automotive (Micro-hybrid and Auxiliary)	Lead, Sodium and Lithium Batteries
ESS	Sodium, Zinc, Flow and Lead Batteries
UPS	Lithium, Zinc, Nickel and Lead Batteries
Telecom	Lead Batteries
Motive Power	Lithium and Lead Batteries
Low Speed Electric Vehicle (e-bike, e-rickshaw)	Lithium and Lead Batteries

Table 1. The battery chemistries discussed by application.

CBI uses its Roadmap not only as a resource for our members, but the outlined market directions, research areas, and key performance indicators directly influence the research our membership chooses to fund and pursue. In the past three years, 16 research projects have started with eight ongoing.

+ CBI and its members have consistently delivered on goals and targets set in previous roadmaps. This has involved higher service and cycle life, faster recharge times and charge acceptance and more energy throughput.

1.

In safety critical applications, lead batteries are the preferred option. EU producers have employed new state of the art devices prolonging operational life of these batteries even further. CBI has worked with nuclear governance authorities to make them aware of the continued performance improvements seen in lead batteries.

2.

Low voltage (12 V) automotive lead batteries have continued to improve. In micro-hybrid applications, quality and performance have increased, and the advanced products of 2021 are now commonplace with EU producers leading the market.

3.

For vehicle auxiliary applications, EU automakers and battery producers have developed new understanding of the interplay of the main lithium-ion traction battery, the critical safety battery, and sensors, leading to better systems solutions and longer service life in lead auxiliary and critical safety batteries.

4.

Lead batteries for ESS have changed significantly; CBI has developed innovative battery management protocols and systems engineering available to EU member company manufacturers now.

5.

AI data centres, financial institutions, telecommunication networks, and substations in the EU use advanced absorbent glass mat (AGM) and gel lead batteries. These batteries offer world class service life. Since the previous Roadmap, CBI's members have benefitted from reports outlining new duty cycles, new devices developed in the industry to prolong life, resulting in added years to service life.

6.

Motive power lead batteries have adapted quickly to the continuous use profiles needed in many e-commerce warehousing. Advanced lead batteries with lower maintenance and faster opportunity charging are now available, a new development since the 2021 Roadmap.

CBI has seen the use of lead batteries in Behind-the-Meter (BTM) and in UPS increase due to these improvements. Furthermore, lead batteries made in the EU remain the state of the art in automotive SLI, micro-hybrid, start-stop, auxiliary, and critical safety use cases.

5X **Better Recharge Capability**
0.4 → 2.0 A/Ah

3X **Increase in Cycle Life**
1500 → 4500 Cycles
10 → 15 Years

+40% **Increase in Energy Density**

Key lead Battery Energy Storage System (BESS) R&D to unlock their full potential:

+

Decreased Levelised Cost of Storage

Increases in cycle life at higher utilisation has reduced LCOS, providing better discharge throughput. Furthermore, member companies have worked with CBI to create more cost-effective PCS and balance of plant.

+

Standardisation

Create a standard for the different lead BESS systems, to improve their compatibility, decrease overall costs and increase adoption.

+

Advanced Monitoring

Enhance lead-based BESS with advanced monitoring capabilities to boost battery cycle life and performance, on a par with lithium battery standards - compensating for the historical lack of needed monitoring.

Figure 5. Summary of the performance improvements for lead battery products over the past five years and key R&D opportunities. Source: Battery Energy Storage Systems (BESS) 2035 Market Outlook and Opportunities, KPMG, 2025

Low Voltage Automotive: Micro-hybrid and Auxiliary

1.

EU battery manufacturers are global leaders in low voltage automotive batteries. Over 50 million high quality, sustainable lead batteries are made domestically every year in the EU.

+ Low Voltage Automotive: Micro-Hybrid and Auxiliary

12 V lead battery products have been the low voltage option of choice for over a hundred years in the automobile industry. Classically, lead batteries have provided starting, lighting and ignition (SLI) capability in conventional internal combustion vehicles. In the past two decades, starter batteries specifically designed for start/stop and micro-hybrid vehicles have made possible these cost effective, highly deployed carbon reduction technologies. Over the past decade, lead batteries are now additionally used as the critical safety battery in most EVs, providing instantaneous power demand in the event that the main traction battery is compromised. The critical safety battery market is growing quickly with 23% Compound Annual Growth Rate (CAGR) through 2035 expected, making EU manufacturers market leaders in this application. The 12 V automotive lead battery industry is extensive in the EU, with manufacturing present in 11 Member States, as shown in Figure 6.

EU Member States produce over 100 GWh, amounting to over 50 million automotive units for the SLI, micro-hybrid and auxiliary market. The EU automotive lead battery industry is a prime example of how domestic engineering excellence, artful collaboration, and stable supply chains can play a crucial role in the EV market.

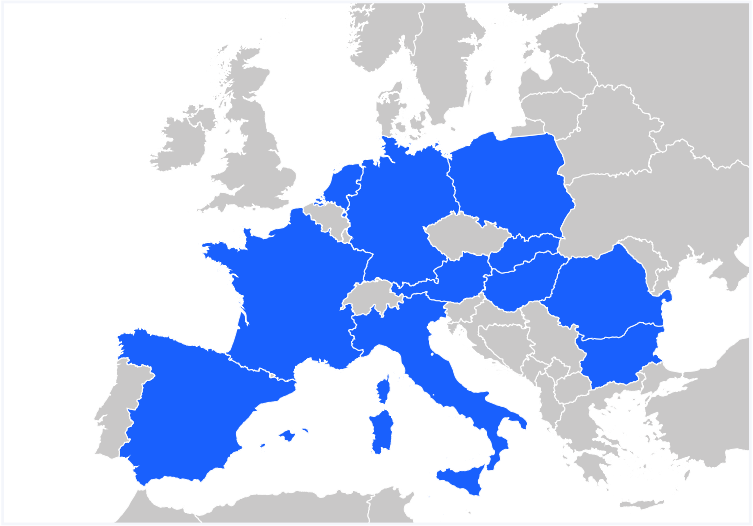


Figure 6. The 11 EU Member States with 12 V automotive lead battery manufacturing.

CBI and its predecessor Advanced Lead Acid Battery Consortium (ALABC) has supported the growth of the EU automotive battery industry for over 35 years and has closely tracked the technical needs of the industry as automobiles grew from needing SLI batteries into micro-hybrid and now to needing auxiliary batteries. For micro-hybrids, lead batteries have adapted to meet the mature market – increasing charge acceptance and high temperature durability while maintaining other performance characteristics and staying cost competitive and fully recyclable.

The critical safety battery is a major growth market and will be a significant revenue stream for EU producers for decades to come. CBI has worked closely with EU automobile and lead battery manufacturers to identify performance improvements and related research areas to ensure domestically manufactured lead batteries remain the best option as critical safety backup for electric vehicles. As shown in Table 2, there are clear goals for lead batteries in micro-hybrid and auxiliary applications.

Application	2025 CBI Roadmap Targets	2035 CBI Roadmap Targets	CBI Research Areas
Micro-hybrid/ Start-Stop	▪ High charge acceptance ▪ Excellent temperature performance ▪ Good deep cycle behaviour	▪ Maintain performance ▪ Increase quality without compromising cost	▪ Continue to improve manufacturing to lower costs
Critical Safety Backup	▪ 5-year life ▪ Cost effective ▪ Charge recovery capable	▪ 7-year life ▪ Improve charge recovery ▪ Maintain competitive costs	▪ Additive studies to improve charge acceptance ▪ Optimise designs toward the changing needs of EVs

Table 2.

The CBI performance categories and research areas for start-stop, micro-hybrid and auxiliary lead batteries.

Improvements for lead batteries in auxiliary applications are focused on optimising designs and charging strategies via collaboration with automotive producers in the EU, creating products better aligned to the needs of the EU EV industry.

Primary performance metrics to improve are pulse power capability and power/charge recovery, and CBI and the domestic lead battery industry are working now to improve these metrics. Over the past few years, CBI has been able to foster projects and partnerships to increase charge recovery significantly, with advanced lead battery products being introduced to the market now.

+ KEY FACT

European companies including CBI members Exide Technologies, Clarios, Moll Batterien, Monbat, and Banner provide batteries for automotive applications.

+ KEY FACT

11 Member States feature in the industry.

+ KEY FACT

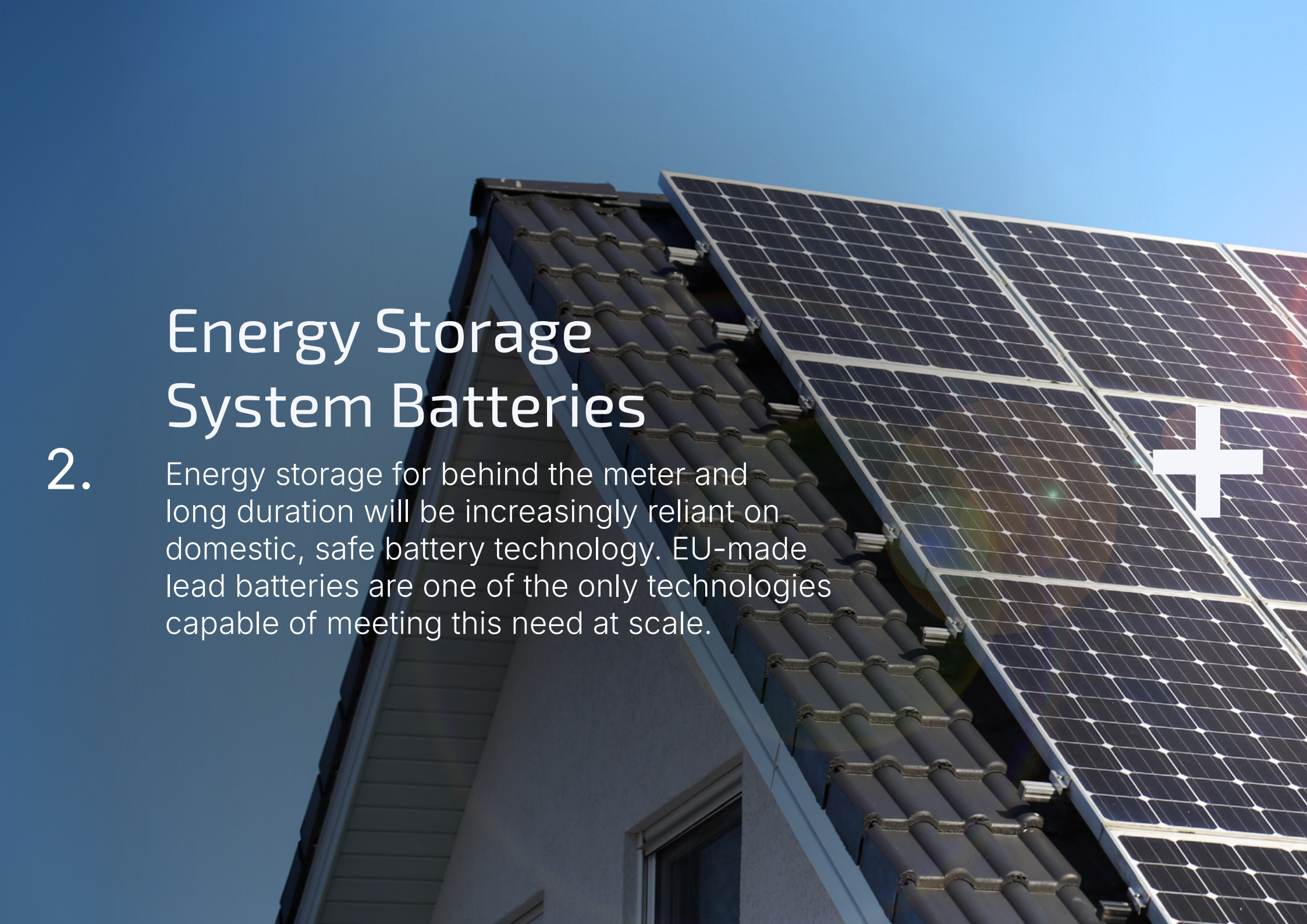
Fully fledged domestic supply chain, no reliance outside of EU.

+ KEY FACT

EU battery manufacturers are the market leaders in the critical safety battery market.

+ KEY FACT

Over 50 million units produced per year.



Energy Storage System Batteries

2.

Energy storage for behind the meter and long duration will be increasingly reliant on domestic, safe battery technology. EU-made lead batteries are one of the only technologies capable of meeting this need at scale.

Energy Storage System Batteries

The energy storage revolution is moving forward along two fronts, electric vehicles, and grid electrification. Grid electrification has caused utilities to move forward with renewable sources, such as solar and wind. Inertia issues related to renewable sources have been solved by the deployment of energy storage systems (ESS) ready to discharge energy and maximise returns.

Lead batteries have served as the go-to solution for decades in stationary battery systems, providing safe, long-lasting systems all over the EU with a long record of uptime and few recorded incidents. However, lithium-based ESS represents 99% of the current market, and dominates the residential and front of the meter markets. Lead systems only currently supply 1% of the market, this is mainly due to the rapid development of front of the meter markets outside of communities and cities. As BTM ESS moves into cities, safe and sustainable storage will become more important.

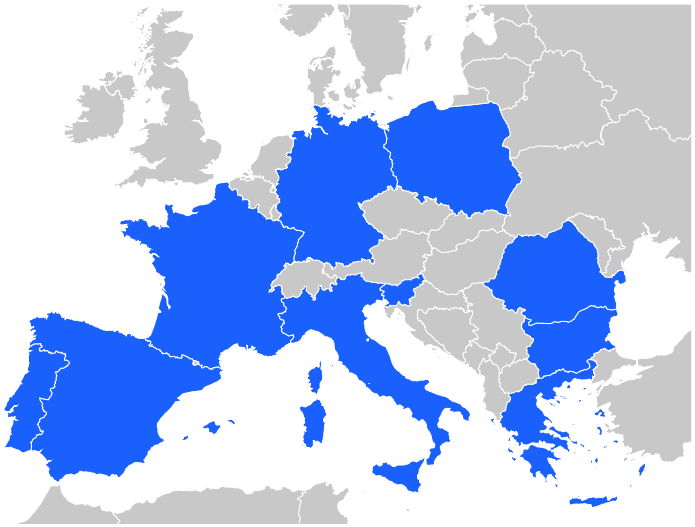


Figure 7. The 11 EU Member States that produce lead batteries for ESS applications.

Lead battery based ESS is poised to provide key solutions in behind-the-meter applications such as:

Residential

Lead batteries offer a safer alternative to lithium-ion, and codes and standards allow them to go where lithium cannot safely go. Lead batteries are excellent alternatives to lithium in residential complexes with only internal space available for ESS.

Commercial and Industrial

Lead batteries are robust and safe across many vibration heavy and temperature extreme environments, with best-in-class fire safety, installation, handling, and commissioning knowledge in the EU. Lead battery stationary systems do not require expensive fire protection, special permits, or cost prohibitive liability insurance.

Long Duration

Lead batteries are highly capable at +10 hours duration, lasting for decades in these duty cycles. As the EU scrutinises seasonal storage, there is a domestically produced, safe solution ready to enable the EU grid to be stable across heatwaves and winter storms.

Application	2025 CBI Roadmap Targets	2035 CBI Roadmap Targets	CBI Research Areas
Residential	▪ +5 year life ▪ 250 €/kWh system cost ▪ 80-100 Wh/L	▪ 10-year life ▪ 175 €/kWh system cost ▪ 140 Wh/L ▪ Maintain safety	▪ Advanced material discovery ▪ Optimised cost ▪ Maximise energy density through bipolar design
Commercial and Industrial	▪ 10-year life ▪ 5000 cycles at 50% utilisation ▪ 350 €/kWh system cost ▪ 80-100 Wh/L	▪ 15-year life ▪ 7500 cycles at 50% utilisation ▪ 275 €/kWh system cost ▪ 140 Wh/L	▪ Advanced material discovery ▪ New Battery Management ▪ System integration optimisation
Long Duration	▪ 15-year life ▪ 5000 cycles at 50% utilisation ▪ RTE of 78%	▪ 20-year life ▪ 10000 cycles at 50% utilisation ▪ RTE of 84%	▪ Understand LDES duty cycles ▪ Maximise benefit from BMS ▪ Advanced material discovery

Table 3.

Summary of CBI performance goals and metric for lead batteries for ESS now and in 2035. RTE = Round Trip Energy Efficiency, BMS = Battery Management System

Over 60 GWh of stationary lead battery storage is produced in EU Member States every year. 11 EU Member States produce lead batteries applicable to key ESS markets. Figure 7 shows the EU Member States supporting domestic ESS through lead battery solutions. This EU industry uses domestically produced raw materials from recycled streams, with over 80% of an average lead battery produced today coming from secondary sources.

Lead batteries are improving in performance, and cycle life and energy throughput have increased by 40% in the past five years. CBI has outlined clear goals for lead batteries for ESS, and new designs, battery management techniques, and advanced materials are pushing lead battery performance to new levels. As shown in Table 3, performance metrics have been developed for lead batteries, focused on improving energy throughput.

+ KEY FACT

European companies including CBI members Exide Technologies, Enersys, Hoppecke, Monbat, and Sunlight Systems provide batteries for ESS applications.

+ KEY FACT

Fully fledged domestic supply chain, no reliance on actors outside the EU.

+ KEY FACT

11 Member States feature in the industry.

+ KEY FACT

Consistent improvements from EU manufacturers – 40% in past 5 years.

+ KEY FACT

CBI has pathways ready for EU lead batteries to be the best solution and maintain sustainability.

3. Motive Power: Sustainable Energy for Warehousing and Logistics

Lead batteries power the e-commerce and materials handling industry across the EU. Innovations are pushing performance to higher levels, allowing this sustainable technology to meet evolving operational requirements.

+ Motive Power: Sustainable Energy for Warehousing and Logistics

E-commerce warehousing, port authorities, and materials handlers across the EU rely on lead batteries to provide motive power for forklifts and cranes vital to their operations. Lead batteries provide a dual-purpose solution, serving as a sustainable, safe, long-lasting battery for these electric vehicles, but also as a counterweight during lifted operation.

For decades, lead batteries have led the charge as the go-to alternative solution to diesel and propane trucks.

The electrification effort has resulted in over 65% of the EU forklift and lift crane fleet relying on battery power propulsion. EU Member States possess well-developed, strong manufacturing footprints for these types of batteries, as well as near closed loop supply chains for the main components of motive power lead batteries. Figure 8 shows the EU Member States with motive power lead battery production. In the EU, 10 Member States produce these types of batteries at multiple sites from companies including CBI members Monbat, Sunlight Systems, Enersys, Hoppecke Batterien, and Exide Technologies. These companies offer a wide array of lead battery and lithium battery products.

State of the art solutions are produced in the EU, using advanced battery monitoring capabilities, new inline devices to lower maintenance, and robust battery engineering to keep lead batteries competitive in the market.

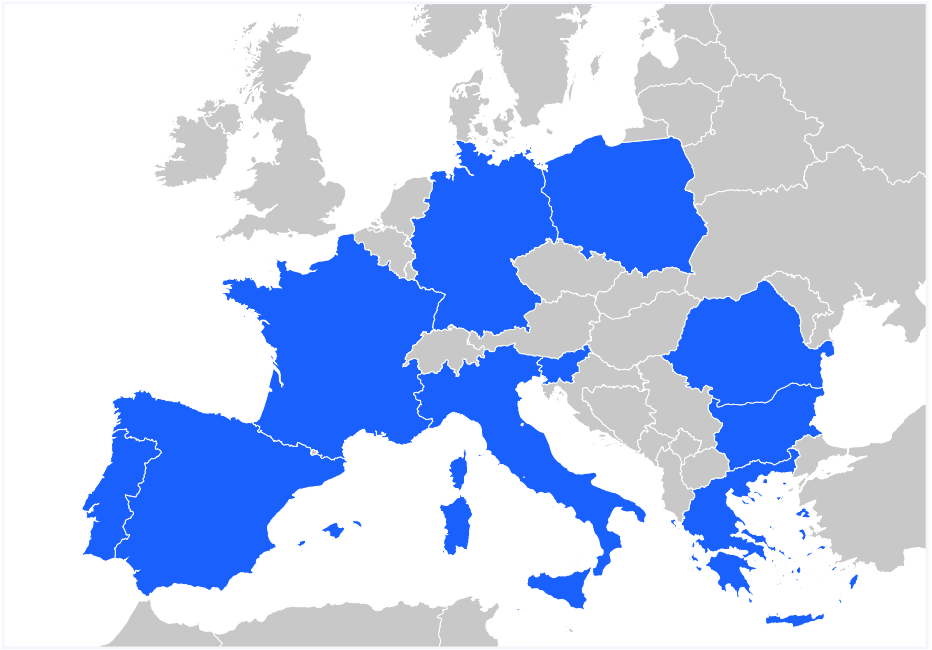


Figure 8. The 10 Member States producing lead batteries for motive power applications.

For decades, lead battery manufacturers have created products capable of meeting customer needs. The onset of 24/7 warehousing has challenged these needs and CBI members in the EU have created new lower maintenance motive power valve regulated batteries using thinner and higher quality electrodes capable of faster recharge and longer life.

Lead batteries remain competitive in the motive power market, providing reliable power as always, now with better performance for opportunity charging and deep cycling.

Application	2025 CBI Roadmap Targets	2035 CBI Roadmap Targets	CBI Research Areas
Motive Power	▪ +5 year life (must hit 5 years for specification) ▪ Low maintenance, better opportunity charging available	▪ 7-year life ▪ Even lower maintenance	▪ Optimised cost ▪ Improve opportunity charging further ▪ Continue to lower maintenance

Table 4.

CBI Performance requirements and future developments of motive power lead batteries now and for 2035.

Motive power improvements for the next ten years will be centred on taking the lead battery product platform in EU and adapting the technology to the continuous use necessary for today and future warehousing and materials handling.

CBI has already seen improvements, and industry leaders in the EU have repositioned lead battery products as attractive solutions by using a combination of EU engineering excellence and well-established domestic manufacturing to offer new products. Since our previous Roadmap opportunity charging times have decreased by 50%, and Valve Regulated Lead Acid (VRLA) AGM products requiring less maintenance are available.

+ KEY FACT

European companies including CBI members Exide Technologies, Enersys, Hoppecke, Monbat, and Sunlight Systems provide batteries for motive power applications.

+ KEY FACT

10 Member States feature in the industry.

+ KEY FACT

Fully fledged domestic supply chain, no reliance outside of EU.

+ KEY FACT

Lead battery producers in the EU produce state of the art solutions supplied throughout EMEA.

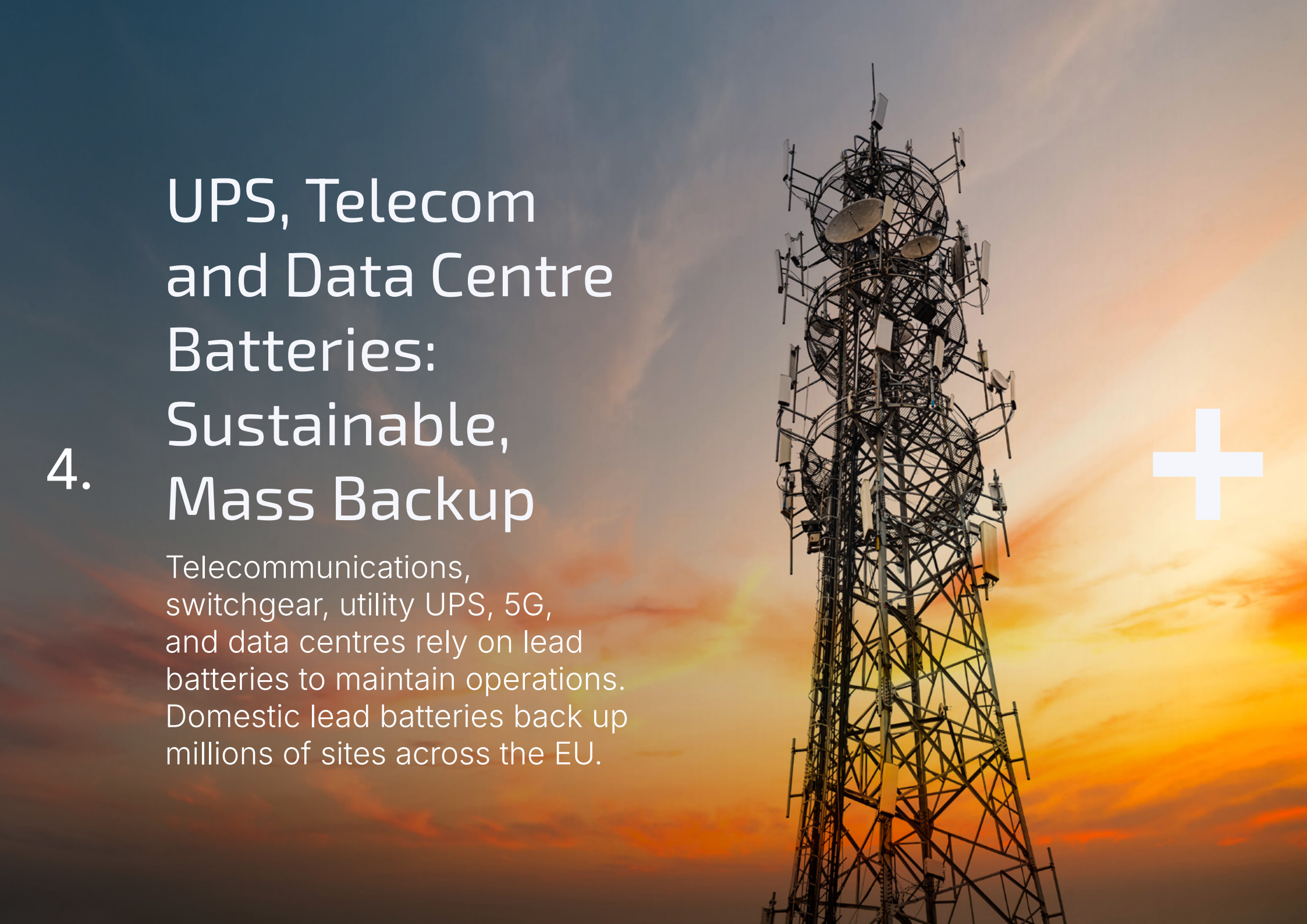
+ KEY FACT

Millions of lead batteries are produced in EU per year.

4.

UPS, Telecom and Data Centre Batteries: Sustainable, Mass Backup

Telecommunications, switchgear, utility UPS, 5G, and data centres rely on lead batteries to maintain operations. Domestic lead batteries back up millions of sites across the EU.



+ UPS, Telecom and Data Centre Batteries: Sustainable, Mass Backup

Lead batteries are employed extensively across the EU, with well **over 5 million current sites using lead batteries in various applications**.

Major conventional applications include:

Small UPS, recloser cabinets for utilities, consumer products such as home UPS	**Oil and Gas pipeline switchgear backup**
Large UPS systems for data centres, financial institutions	**Substation backup, utility**
Telecommunications backup	**Cable and broadband hub backup**
5G network infrastructure backup	**AI data centre and edge computing backup**

UPS systems and other backup systems based on lead battery energy storage have been in use for over 50 years. Consistent improvements in performance capability have occurred using new designs and materials to push lead batteries to over 20-year life in some of these applications. There is a wide range of products, starting with low cost, low maintenance batteries for ruggedised outdoor use to large, maintained batteries with extreme long life, in some cases +20 years. Many of these products are manufactured with more than 75% recycled content, including the active and electrode material, plastic casing, and cover.

Millions of sites use lead batteries for backup, ranging from small utility cabinets to large data centre and substation backup. The EU is a market leader in the production of lead batteries for these use cases, and 11 Member States have manufacturing, as shown in Figure 9.

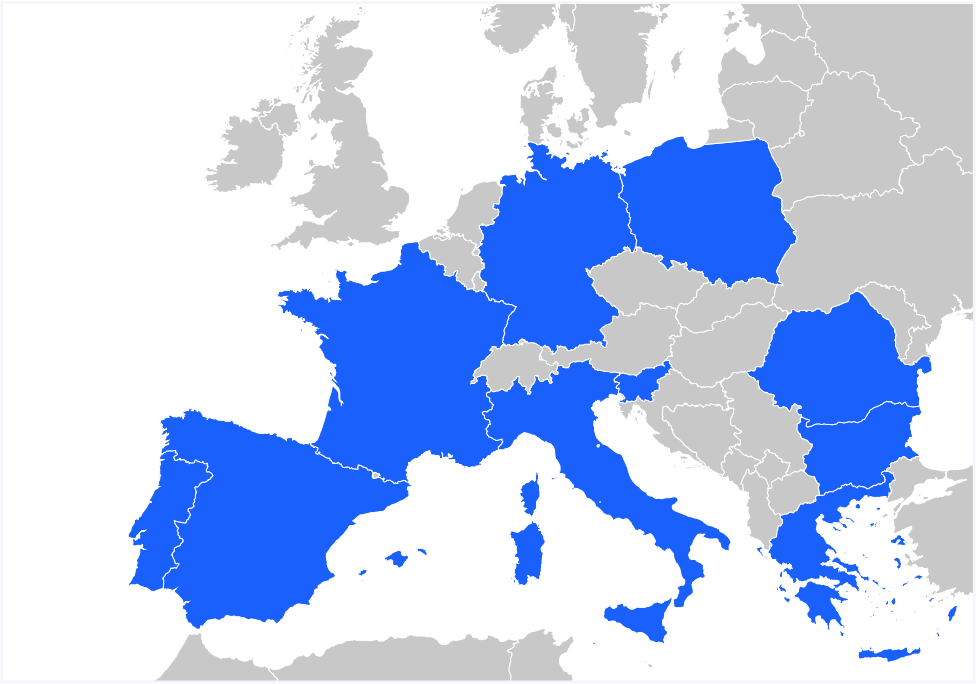


Figure 9. The 11 EU Member States manufacturing stationary lead batteries.

CBI works with many of the EU manufacturers and end-users, working to create better performing domestic battery solutions, especially for high-energy high-power needs for AI data centres. Across three major application spaces – conventional UPS, AI data centres, and Telecom – specific improvement goals and research areas have been developed. Table 5 summarises the current performance vs. projected performance following specific research areas.

Application	2025 CBI Roadmap Targets	2035 CBI Roadmap Targets	CBI Research Areas
Conventional UPS	▪ +5-10 year life ▪ No thermal incidents for years ▪ Maintenance improved, robust design	▪ 10-year life ▪ 175 €/kWh battery cost ▪ Maintain safety	▪ Optimised cost ▪ Improved alloys ▪ Focus on operating in high temperature rooms
Telecom	▪ 15-20 year life ▪ AGM improving footprint	▪ Lower maintenance variants ▪ 15 year life	▪ Catalytic recombiners ▪ Improved monitoring
Data Centre	▪ 10 year life ▪ 80-100 Wh/L	▪ 15-year life ▪ 140 Wh/L	▪ Increase energy density ▪ Maximise benefit from BMS

Table 5.

CBI Performance improvements in development for lead batteries in UPS, Telecom, and Data Centre applications.

Improvements in stationary batteries for UPS, Telecom, and Data Centres over the past five years include lead batteries capable of long service life at less costly, higher temperature-controlled environments. Since the previous Roadmap, new devices – catalytic recombiners, capable of increasing operational life by 20% – have been developed. Further research into these devices and improved materials is under way.

+ KEY FACT

European companies including Exide Technologies, Enersys, Hoppecke, Monbat, and Sunlight Systems provide batteries for stationary applications.

+ KEY FACT

11 Member States feature in the industry.

+ KEY FACT

With a fully-fledged domestic supply chain, there is no reliance outside of EU.

+ KEY FACT

The EU's massive domestic manufacturing base enables secure delivery of important energy storage solutions for dozens of applications without relying on foreign producers.

5.

Safety Critical Batteries: Nuclear Power

Nuclear power is vital to the EU energy landscape, and lead batteries are the only accepted technology to safeguard operations.

+ Safety Critical Batteries: Nuclear Power

Lead batteries are vital to the EU energy landscape, serving as the only accepted technology for backing up safety critical systems in nuclear power plants in the EU.

Figure 10 describes the status of nuclear power across Europe in 2026. Nuclear power accounts for approximately 25% of power generation in the EU (96 GWe), produced by 98 nuclear power plants across 13 of the 27 EU Member States.

CBI member company manufacturers in the EU produce lead batteries to back up critical systems (known as Class 1 or 1E) such as control rod equipment, emergency cooling, and communications and controls systems in nuclear power plants. Lead battery backup systems consist of state of the art, domestically produced, sustainable, and highly robust batteries with 20-year service life and best in class safety. No other technology can meet the requirements necessary for this application.

Type	2025 CBI Roadmap Targets	2035 CBI Roadmap Targets	CBI Research Areas
VRLA AGM	▪ 10-year life ▪ Good packing density ▪ Safe	▪ 12-year life ▪ Higher packing density	▪ Improve life using catalytic recombiners ▪ System optimisation to increase life
OPzS	▪ 20-year life	▪ 25-year life ▪ Improve packing density	▪ Rack optimisation to increase packing density ▪ Improve life using catalytic converters

Table 6.

Summary of CBI research and performance goals for the lead batteries used to back up EU nuclear power plants.

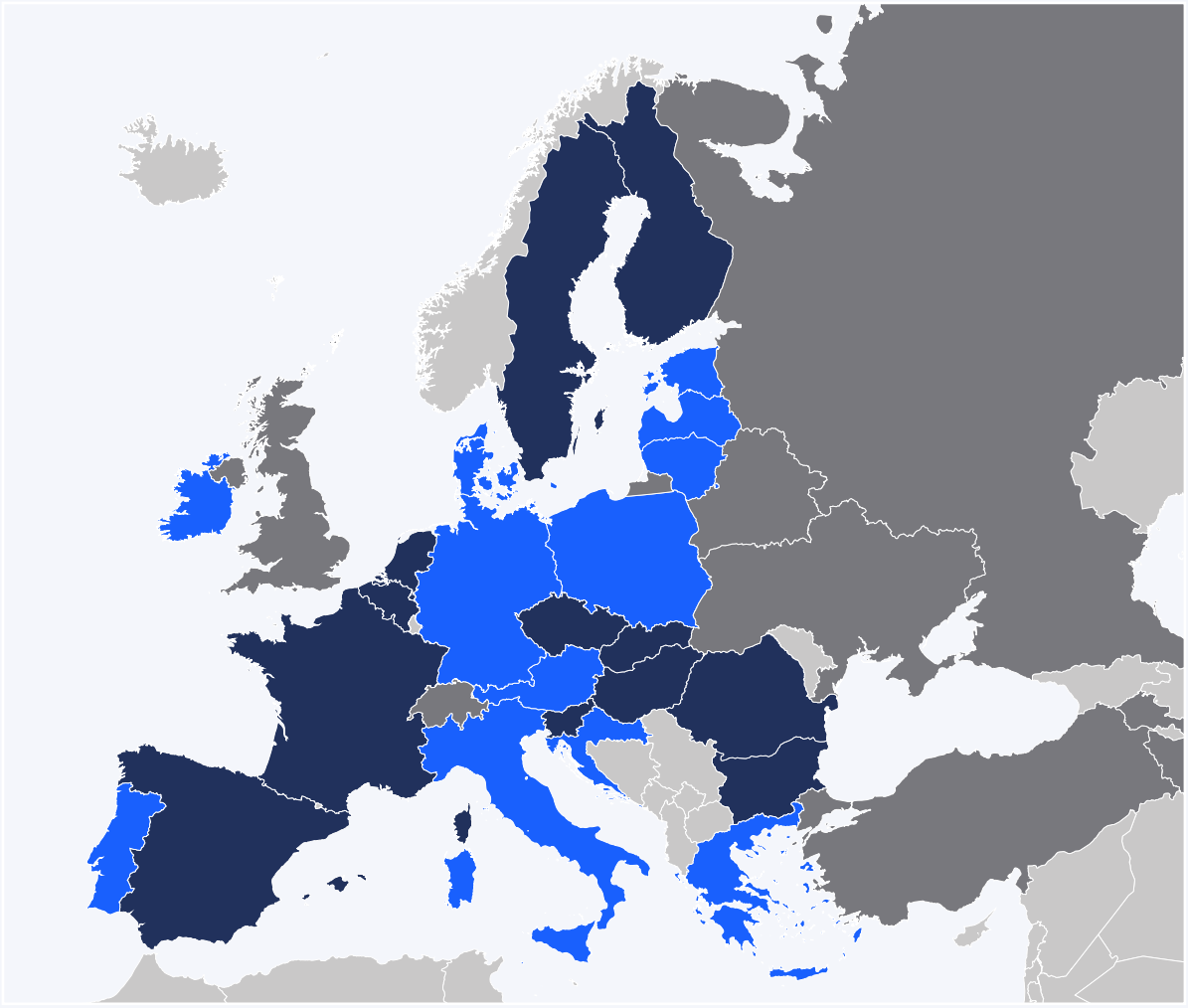


Figure 10. Nuclear power in the EU and Europe. Source: [Nuclear Power in the European Union - World Nuclear Association]

Lead batteries used in these applications are produced by CBI member companies in Germany (Berlin (BAE GmbH), Brilon (Hoppecke)), Portugal (Castanheira (Exide Technologies)), Poland (Mielec (Enersys)), and France (Arras (Enersys)). Figure 11 shows the EU CBI member company manufacturer sites. Two main types of lead batteries are used in the application, VRLA AGM and OPzS (or V). VRLA AGM is more energy dense and capable of providing more power on site for up to 10 years.

OPzS provides extremely long design life of 20 years with cutting edge robustness. CBI has developed goals and research areas for both types, as shown below in Table 6. These types of improvements would improve EU products performance, but **Class 1E critical backup is dependent on long life lead batteries.**

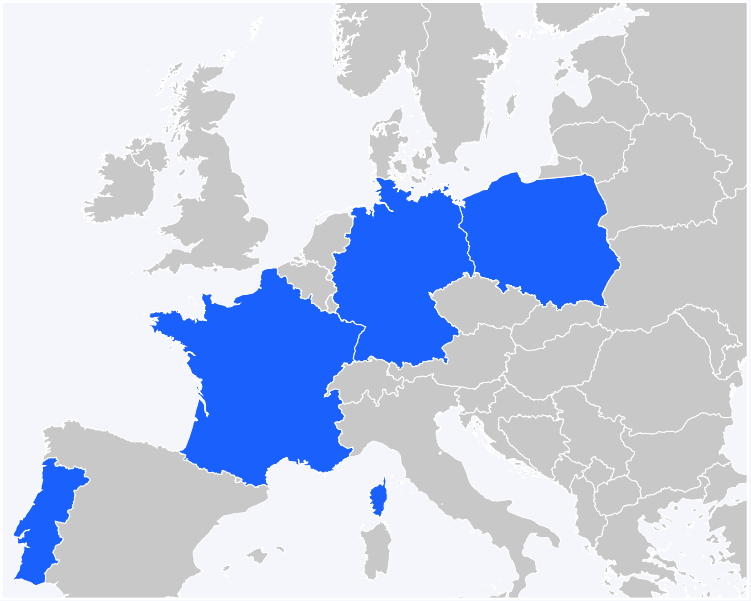


Figure 11. Domestic manufacturing of lead batteries for Class 1E.

+ KEY FACT

Lead batteries are crucial for the safe operation of 25% of EU power generation.[2]

+ KEY FACT

Domestic EU manufacturers are key, providing state of the art, robust solutions. These include Enersys, Exide Technologies, BAE GmbH, and Hoppecke Batterien.

+ KEY FACT

The entire supply chain for the batteries is contained in EU, including battery cases, separators, electrolyte, and racking.

[2] World Nuclear Association, 2026.

Batteries for Defence Applications

6.

EU Defence capability is powered by lead batteries. Militaries across Member States can rely on stable, robust supply chains and state of the art durability all provided by the EU.

+ Batteries for Defence Applications

Lead batteries are vital for many defence systems and applications including nuclear reactor backup in submarines, engine start for tanks and helicopters, and UPS for critical tactical communications. In the EU, **11 Member States produce lead batteries used in defence applications. This amounts to over 5 million units per year.** Figure 12 shows the Member States with production sites. The many types of lead batteries required by defence organisations are manufactured within the EU.

Lead battery supply chains for these crucial defence energy storage applications are completely contained within the EU, while other battery technologies such as lithium-ion rely heavily on foreign supply chains.

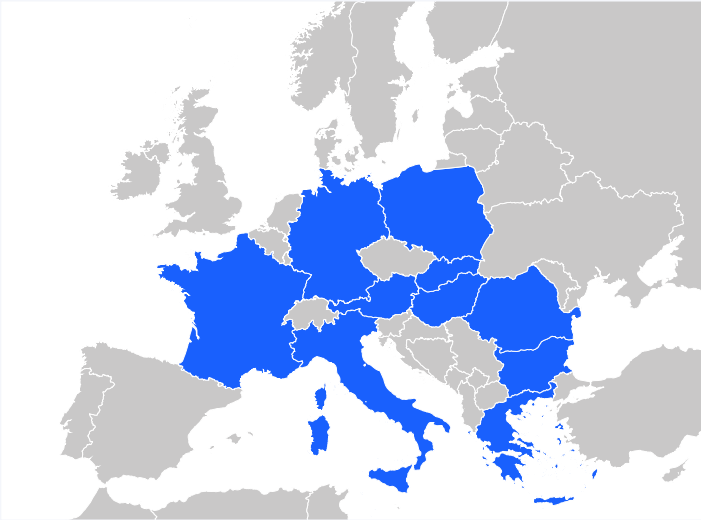


Figure 12. 11 Member States produce lead batteries used in defence applications, including those for submarines, tanks, personnel carriers, aircraft, communications batteries, and batteries used in military marine applications.

Lead batteries are the most durable battery technology used in defence, capable of taking severe mechanical or ballistic damage without compromising soldier safety. Furthermore, in safety critical applications, lead batteries have over 40 years of recorded safe operation.

Military specification dictates requirements around design life, service life, and other performance characteristics and lead battery products are well known as robust, safe solutions. Lead batteries provide energy storage for the following defence segments:

Submarines, all types, serve as energy storage and ballast weight	**Tanks and other military vehicles, starter, and auxiliary batteries**	**Artillery, black start, and electronics support**
Field auxiliary equipment and logistical support systems	**Aircraft, used in numerous craft and in several ways**	**Base microgrids, in-theater, and domestically**
Logistical support systems	**Communications systems, UPS, and Telecom**	**Nuclear Silos, safety critical and auxiliary applications**

CBI has developed clear goals for batteries used in defence applications, and due to the dozens of applications, CBI has focused primarily on universal performance indicators. **Qualitative indicators such as supply chain stability, sustainability, and safety are equally important.**

Application	2025 CBI Roadmap Targets	2035 CBI Roadmap Targets	CBI Research Areas
Military Vehicles/ Tank	▪ 2-year shelf life ▪ High temperature performance ▪ Good deep cycle behaviour	▪ 2-year shelf life ▪ Increased energy density ▪ Improved recharge	▪ Maintain robust performance while maintaining safety ▪ Battery monitoring improvements
UPS and Telecom	▪ 5-20 year life ▪ Cost effective ▪ Robust	▪ Improve life across apps ▪ Increase shelf life	▪ Incorporate BMS ▪ Translate other UPS improvements into military apps
Microgrids	▪ 10-year life ▪ Incorporated into TMS standard	▪ 15-year life ▪ Improved energy density	▪ Continue to optimise PCS and controls integration

Table 7.

Summary of CBI research and performance goals for lead batteries in military applications.

+ KEY FACT

European companies including CBI members Hoppecke Batterien, Enersys, Clarios, and Monbat provide batteries for defence applications.

+ KEY FACT

11 Member States are represented in the industry.

+ KEY FACT

Dozens of applications are served domestically in the defence sector, with the entire supply chain supported by suppliers and vendors in the EU.

+ KEY FACT

Lead batteries provide safe and robust durability across a wide temperature range and mechanical damage range.

+ Concluding Remarks

As demand for battery energy storage continues to grow, Europe will need to embrace all technologies to achieve the ambition of greater electrification beyond 2030.

This Roadmap highlights the importance of supporting all battery technologies to achieve Europe's climate and electrification goals.

Lead batteries are a strong example of a European battery technology with an established manufacturing, collection, and recycling infrastructure across more than 17 Member States. With a 99% recycling rate, the industry operates in a highly efficient closed loop and contributes €7.3 trillion to EU GDP, supporting over 184,000 jobs, including 30,000 direct jobs.

Europe is at the forefront of advanced lead battery research and innovation, with the Consortium for Battery Innovation and its members supporting cutting-edge developments across key applications including automotive, energy storage, motive power, defence, UPS, and nuclear power.

To support Europe's industrial resilience and sustainability goals, policymakers should:

- Support innovation across all battery technologies
- Avoid legislation that "picks winners"
- Ensure a level playing field
- Remove barriers to circularity and recycling

Only by adopting a technology-neutral approach can Europe secure a competitive and sustainable European battery ecosystem.

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