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Energy resilience of households in a prepared union -

the potential of a sodium battery-based solution

STUDY

European Economic
and Social Committee

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and Social Committee

Energy resilience of households in a prepared union – the potential of a sodium battery-based solution

Final report

General information

STUDY FOR	*The European Economic and Social Committee (EESC)*
REQUESTING SERVICE	*Secretariat of the Consultative Commission on Industrial Change (CCMI)*
STUDY MANAGING SERVICE	*Foresight, Studies and Policy Assessment Unit*
DATE	*6 April 2026*
MAIN CONTRACTOR	*Milieu Consulting*
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IDENTIFIERS

		ISBN	doi
STUDY			
print	*QE-01-26-008-EN-C*	*978-92-830-7051-1*	*10.2864/0111431*
PDF	*QE-01-26-008-EN-N*	*978-92-830-7050-4*	*10.2864/2097251*

Executive summary

Ensuring adequate electricity energy storage is essential for maintaining electrical grid security and industrial production, by balancing supply from increasingly renewable energy generation, safeguarding against power shortages and blackouts, and reducing energy dependencies (one of the strategic challenges currently facing the EU).

Sodium-ion batteries present a strategic opportunity for Europe to expand independent energy storage capacity due to their reliance on abundant, low-cost materials, lower energy-intensive production, and potential to reduce import dependency compared to lithium-ion battery technologies. Developing this emerging technology and its associated supply and production chains could support the establishment of a new European battery industry, strengthening resilience, circularity, and strategic autonomy in support of the energy transition.

This study was commissioned by the Foresight, Studies and Policy Assessment Unit (FSA) of the European Economic and Social Committee (EESC), under Directorate B, at the request of the Secretariat of the Consultative Commission on Industrial Change (CCMI). The project combined a systematic literature review with stakeholder engagement, including surveys and structured interviews, to validate findings and gather primary insights on the feasibility and potential role of sodium-ion batteries.

The study aimed to support a deeper analysis of the future adoption of sodium-ion batteries by assessing the current state of household and business energy storage (primarily lithium-ion batteries) and evaluating the potential of sodium-ion battery technologies to meet a 72-hour energy preparedness goal, relative to lithium-based solutions as well as to assess the opportunity to develop a sodium-battery industry in Europe.

Lithium batteries

In 2023, global lithium-ion battery manufacturing nameplate capacity was estimated at approximately 2,500 GWh/year, although utilisation was 35% of this capacity[1]. 750 GWh (30%) were deployed in electric vehicles (EV) batteries and 130 GWh (5.2%) were deployed in battery energy storage systems (BESS). Production capacity remains highly geographically concentrated, with China accounting for 83% of global capacity.

At the global level, demand for lithium-ion batteries is expected to reach approximately 4,700 GWh/year by 2030, driven primarily by the EV market, alongside an estimated 840 GWh of installed BESS capacity. As of 2024, Europe had approximately 61 GWh of installed household and business BESS capacity, with total installed capacity projected to reach around 400 GWh by 2029. This is between 2.5% and 4% of the 10,000–16,300 GWh of total battery capacity required to meet the 72-hour self-sufficiency goal for households alone as outlined below.

The EU's position within the global lithium-ion battery value chain remains limited. Lithium-ion batteries account for 86% of energy storage systems deployed in Europe, yet the EU is highly dependent on non-EU countries for battery raw materials and components. The EU accounts for around 2% of global lithium supply, 2.9% of global cathode material production, and below 3% of global battery manufacturing capacity. Long-term growth of lithium-ion battery production in the EU is constrained

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[1] Utilisation may be lower than nameplate capacity for several reasons including: yield losses (scrap, defects, etc.), downtime for maintenance, process bottlenecks, supply bottlenecks, limited capacity during ramp-up periods, deliberate overcapacity to meet demand, mismatches between type of capacity and type of demand (e.g., chemistry type such as lithium iron phosphate vs nickel manganese cobalt or pouch types such as cylindrical vs prismatic).

by limited domestic availability of critical raw materials, such as lithium and cobalt, as well as restricted access to global reserves.

Europe currently hosts 257 GWh/year of installed lithium-ion gigafactory capacity (including the EU but also the UK and neighbouring countries), with a further 649 GWh planned by 2030. However, many projects face uncertainty due to volatile raw material markets, rapid technological change, increasing responsible-sourcing requirements, and rising production costs, with delays and suspensions already observed. Furthermore, the high environmental and social impacts associated with extraction and processing of lithium remains a concern in the EU.

Lithium-ion whole-system battery costs have declined significantly. Between 2010 and 2023, average lithium-ion battery costs fell from around USD 1,400/kWh (EUR 1,190/kWh) to approximately USD 140/kWh (EUR 119/kWh), representing a ten-fold reduction. As of 2025, lithium- iron phosphate (LFP) battery cells have reached as low EUR 40 – 68 /kWh.

Despite significant investment**, the EU remains a minor player in the global lithium-ion battery value chain and is highly dependent on non-EU countries for raw materials**, components, and finished batteries. Without policy intervention, forecast rapid demand growth, currently expected to be met largely by lithium-ion technologies, is likely to further increase this dependence.

Sodium-ion batteries

Sodium-ion batteries operate on similar principles to lithium-ion batteries, using a sodium-salt electrolyte in carbonate or ether solvents. They have lower energy density, typically 17–49% below lithium-ion depending on cell chemistry, which increases the necessary system size and physical footprint. However, rapid improvements in electrochemical storage performance recently are expected to make them competitive with currently available lithium-ion batteries.

Nevertheless, sodium-ion batteries offer several technical advantages, including improved inherent safety (lower risk of thermal runaway), operation at lower temperatures, reduced environmental impact, and the use of more abundant and widely available raw materials, with potential cost benefits.

As a result, sodium-ion batteries are widely viewed as a complement to, rather than a substitute for, lithium-ion battery technology, particularly in applications where cost, material security, safety, and sustainability are prioritised over maximum energy density. The market remains at an early stage but is growing rapidly, particularly in stationary energy storage and mobile applications where energy density is less critical. There is broad consensus that automotive applications are unlikely to be the primary market in the short term, even though sodium-ion batteries are now technically viable for electric vehicles. Instead, near-term deployment is expected to focus on grid-scale and household BESS.

In Europe, sodium-ion batteries could support the storage of excess renewable electricity to meet peak demand. Several producers are developing BESS products for commercial and domestic use, although much of the underlying technology is currently sourced from outside the EU. Future applications may expand to electric vehicles as energy density improves, as well as mini- and micro-scale stationary storage for buildings and critical infrastructure.

Sodium-ion batteries benefit from lower-cost and more abundant raw materials than lithium-based alternatives, as sodium is widely available in Europe and is less expensive to extract and refine. Over the 10 years, the technology has progressed from laboratory-scale research to a commercially credible option. Estimated sodium-ion battery costs range from EUR 68–89/kWh, which is now overlapping with current LFP lithium-ion battery costs. However, cycle life remains a key uncertainty: while lithium-ion battery technologies typically achieve 6,000 to 10,000 cycles, sodium-ion battery durability varies widely by chemistry, with some formulations already demonstrating strong stability and others still lagging behind more mature lithium-ion systems which can achieve above 12,000 cycles.

While sodium-ion batteries are not yet fully cost- or technically competitive with lithium-ion, rapid development and recent commercialisation are improving their viability, and lower raw-material costs offer potential for future cost reductions and greater supply-chain control. However, **scaling up EU production and supply chains faces several challenges, requiring targeted policy support and investment to remain competitive and to secure supply chains.**

Domestic and business battery capacity

Most residential battery systems currently installed in the EU are in the range 5–10 kWh. These are generally the most cost-effective and aligned with household electricity production (e.g., rooftop PV) and demand over 24 hours.

To achieve 72-hour electricity self-sufficiency (excluding space heating), a typical household would require a 20–25 kWh battery system. Under ENTSO-e 2040 scenarios, this applies to around 34% of households.

Households with an electric heat pump would require significantly larger systems, in the range of 75–150 kWh depending on dwelling size. Around 50% of households are expected to have a heat pump by 2040.

Households combining a heat pump, electric cooking and an electric vehicle would require approximately 90–175 kWh of battery capacity. By 2040, 66% of households are projected to own an electric vehicle, many of which will also have heat pumps.

To meet 72-hours of energy demand, an average household without heat pump would require a EUR 6,500 investment, at a 300 EUR/kWh battery price. A household with a heat pump would require a EUR 33,700 investment and household with heat pump and electric car a EUR 39,900 investment.If only ~2% of households installed batteries sized for 72-hour autonomy, the ENTSO-e 2040 preparedness scenarios (developed to project the long-term energy demand and supply, which forecast between 250 and 300 GWh installed EU household battery capacity by 2040) would be met. Extending a 72-hour requirement to all households would imply 10,000–16,300 GWh of total battery capacity, equivalent to 3.5–5.5 years of current global battery production for household demand alone.

Planned European sodium-ion battery manufacturing capacity is currently below 10 GWh/year by 2030, equating to only ~0.1% of the annual capacity required for all households to meet a 72-hour household storage scenario. **As a result, for European-produced sodium-ion batteries to make a meaningful contribution to 72-hour preparedness goals, very substantial manufacturing scale-up would be required.**

Sodium battery market

As of 2023, global sodium-ion battery manufacturing capacity was estimated at 42 GWh/year, with 99.4% located in China, despite global demand of only around 4 GWh. This imbalance reflects the sector's transition into a rapid scale-up phase, with manufacturers expanding capacity in anticipation of future demand. The International Renewable Energy Agency (IRENA) estimates that global production capacity had already increased to around 70 GWh/year by 2025, while demand is projected to grow to over 120 GWh/year by 2034.

Globally, around 30 sodium-ion battery production plants are operating, planned or under construction, with the potential to exceed 100 GWh/year by 2030. The majority of these are located in China. Production facilities exist or are planned across Europe, Asia, North America and Australia, although industrial-scale manufacturing is currently dominated by China, which benefits from a large, mature battery industrial base and a strong first-mover advantage.

Key players in China include Contemporary Amperex Technology Co. Limited (CATL), alongside BYD and HiNa Battery Technology, which together represent a substantial share of installed capacity.

European sodium-ion battery production remains limited, though companies such as Faradion, Tiamat and Altris AB are seeking to scale up manufacturing. While sodium itself is abundant in Europe, battery-grade purification and associated supply chains are underdeveloped, limiting near-term production potential. In the United States, supply-chain security and sustainability concerns are driving increased research and development (R&D) activity in sodium-ion batteries.

Globally, investment in sodium-ion battery technology is focused on cost reduction, performance improvement, supply-chain development and lowering environmental impacts. In Europe and North America, public-private research consortia play a key role in advancing cell chemistry and industrial readiness. Stakeholders highlight R&D priorities including hard-carbon anodes and layered oxide cathodes, which remain critical performance bottlenecks but offer scope for improvement. Solid and gel polymer electrolytes are approaching commercial maturity. Stakeholders interviewed for this study recommended focusing on next-generation solid-state sodium-ion batteries as a potential route to technological leadership.

While large-scale production in Europe could be achievable by 2030, applications requiring long-duration energy storage (>10 hours) are likely to require an additional 5–10 years of development. Given that gigafactories typically take at least five years to reach full output and often face delays and lower-than-planned yields, most investments required to meet 2030 demand have already been decided. Scaling sodium-ion batteries to gigafactory level remains technically complex, requiring tight integration of multiple processes and stable product specifications. As a result, **competition to reach key technological and manufacturing milestones is intensifying and is likely to shape future market leadership**.

Material availability and industrial symbiosis

Sodium is widely distributed across Europe, particularly along coastlines, and does not rely on highly concentrated or geopolitically sensitive deposits, making it a more accessible and lower-cost resource than lithium. Battery-grade sodium can technically be sourced from saline deposits, sedimentary rocks or seawater, offering Europe the potential to rely on domestic resources. Europe is already largely self-sufficient in salt extraction, with production volumes more than sufficient to meet current and future demand, including potential battery applications according to one stakeholder response. Low material costs, diverse sources, established infrastructure and European self-sufficiency therefore make **sodium a low-risk and geopolitically stable raw material for enhancing household and grid energy resilience**.

However, while the raw sodium value chain exists, production capacity would need to scale rapidly as sodium-ion battery manufacturing expands. Although desalination plants could theoretically supply sodium from brine, this may not be economically attractive, as virgin sodium is abundant and low-value in comparison. Furthermore, brine purification is costly, battery producers may be geographically distant from coastlines, and there are potential permitting constraints. **As a result, desalination is unlikely to play a significant role in near-term sodium supply for batteries, but it could do in the longer-term.**

Despite resource security advantages, sodium-ion batteries still require other critical or strategically sensitive materials, which introduces some dependencies similar to those seen in lithium-ion batteries in the short-term. Certain cathode chemistries may use nickel, cobalt or vanadium, although quantities may be lower and iron-based cathodes offer a pathway to avoid critical raw materials altogether. Hard carbon, used in anodes, currently has a limited supply chain concentrated in China and Japan but, as a bio-based material derived from wood or agricultural waste, it presents opportunities for EU-based production and supply-chain strengthening. Additional materials include manganese for sodium permanganate additives, for which EU supply chains are underdeveloped, and aluminium for sodium tetrachloroaluminate ($NaAlCl_4$) solid electrolytes, which is currently readily available in Europe.

Conversion of lithium manufacturing facilities

Sodium-ion batteries are considered to be a "drop-in" technology for existing lithium-ion gigafactories, as the two technologies share similar cell designs, electrochemical principles and manufacturing processes. This creates the potential for rapid conversion of existing production lines with relatively limited additional investment.

Sodium-ion batteries use largely the same components and follow the same production steps as lithium-ion batteries with sodium replacing lithium as the charge carrier. As a result, existing infrastructure, equipment and workforce skills can be reused, requiring only minor process adjustments. Stakeholders indicated that LFP production lines in particular could be converted to sodium-ion within weeks, provided key raw materials such as hard carbon and sodium ferric pyrophosphate (NFPP) are available. One academic stakeholder noted that this has already been demonstrated commercially, with InoBat producing sodium-ion batteries on a former lithium-ion battery production line.

Europe currently has 257 GWh/year of installed lithium-ion battery gigafactory manufacturing capacity. Adjusting for the lower energy density of sodium-ion batteries (assumed at 66% of lithium-ion), this equates to around 170 GWh of potential sodium-ion battery manufacturing capacity. This is equivalent to roughly 70% of currently announced global sodium-ion battery manufacturing capacity plans, and 57-68% of the ENTSO-e 2040 EU capacity scenario. This is sufficient to support 72-hour self-sufficiency for 1-1.7% of EU households.[2]

However, stakeholders also highlighted important limitations. Due to lower cell energy density, output (in GWh) from a sodium-ion battery production line would be less than an equivalent lithium-ion battery production line, assuming the same tonnage throughput, reducing revenue potential. In addition, prismatic cells are generally preferred for sodium-ion batteries, meaning factories designed for pouch or cylindrical formats would require more substantial modifications. Sodium's high sensitivity to moisture may increase the need for heating, ventilation and consequently energy use, as well as process control requirements, particularly during electrode drying and formation.

While **sodium-ion batteries offer strong potential for rapid manufacturing scale-up using existing lithium-ion battery manufacturing infrastructure,** technical, economic and format-specific constraints mean that conversion must be assessed on a plant-by-plant basis.

Conclusions and challenges

Overall, sodium-ion batteries offer a promising complement or replacement to lithium-ion batteries for improving EU energy preparedness, especially in stationary household and business energy storage

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[2] Note that utilised capacity is often significantly lower than installed nameplate capacity

applications that prioritise raw material availability, cost stability and safety aspects of implementation over energy density. While sodium-ion batteries are already commercialised, the technology is not yet fully mature and European manufacturing capacity remains limited.

In the longer term, sodium-ion offers strategic advantages by reducing dependence on critical raw material imports, lowering geopolitical exposure, and supporting decentralised energy resilience aligning with the EU's preparedness union strategy.

However, realising these benefits would require substantial capital investment, risk tolerance, strong coordination, long-term planning and sustained policy and financial support to compete with a rapidly scaling Chinese industry that currently holds much of the intellectual property (unlike examples such as solar, where the EU had an early R&D lead).

Nevertheless, Europe retains opportunities to become competitive, particularly in next-generation sodium technologies (e.g. gel or solid-polymer electrolytes) and through reaching key outstanding milestones, such as establishing a hard-carbon supply chain, that could shape future markets.

Although other regions, notably China, currently hold a significant first-mover advantage, sodium-ion technology is not yet fully mature and key milestones that determine market leadership are not decided. Given Europe's existing manufacturing, R&D, skills base and raw-material potential, as well as the need to avoid repeating past energy-technology dependencies (e.g. solar and lithium-ion), there is a strong case for targeted public intervention should the EU choose to develop this emerging market segment and maintain global competitiveness.

Market forces alone are unlikely to be sufficient to develop a European manufacturing industry. Targeted public intervention such as coordinated pilot deployments, applied R&D and scale-up funding, accelerated development of upstream materials (e.g. hard carbon), and clearer sodium-specific regulatory frameworks will be critical.

If these enablers are addressed in a timely and coherent manner, next-generation sodium technologies could become a meaningful pillar of Europe's energy resilience and help avoid the dependency patterns seen in earlier clean-technology transitions.

The key challenges for scaling sodium-ion batteries in the EU are identified and outlined in the table below:

Table 0-1 Key challenges for scaling sodium-ion batteries in the EU

Challenge	**Description**
1) Market uncertainty and offtake risk - Bankability, warranties and investor confidence	Despite strong long-term expectations, near-term demand in Europe is not guaranteed, particularly for domestic and commercial and industrial (C&I) systems. Many producers are therefore confined to pilot-scale deployment, awaiting clearer offtake signals. A central challenge is financial credibility rather than technical feasibility. Sodium-ion batteries lack long-term field data at scale, which constrains the availability of robust warranties, insurance products and project finance. Lenders and installers benchmark against mature lithium-ion battery technologies with proven degradation curves, service pathways and resale values. Without bankable performance guarantees, sodium-ion projects face higher financing costs and slower uptake

Challenge	**Description**
2) Structural barriers to scale-up	Moving from pilot to industrial scale remains challenging due to capital intensity, process integration complexity and yield optimisation risks. Key innovators in sodium-ion chemistry, often small and medium sized enterprises, struggle to bridge this gap without targeted applied-R&D support, demonstration infrastructure and industry /academia / government collaboration frameworks. Without this, innovation and proprietary information risks being lost via acquisition by larger non-EU players.
3) Standards, certification and regulatory misalignment	Commercialisation slowed by the absence of harmonised safety, transport and performance standards specific to sodium-ion chemistry. Existing battery regulations and dangerous-goods classifications largely mirror lithium-ion risk profiles, failing to reflect sodium-ion's lower intrinsic hazard and different handling characteristics. This regulatory lag increases validation costs, complicates permitting, and creates uncertainty for manufacturers, utilities and insurers, despite the technology being technically mature enough for deployment.
4) Ecosystem readiness beyond the cell level	While cell chemistry has advanced rapidly, balance-of-system readiness lags behind. Gaps persist in sodium-specific inverters, power-conversion systems, energy-management systems, and grid-code-compliant integration solutions. Voltage-window differences and control-logic adaptations also introduce engineering challenges, particularly for larger-scale systems. This ecosystem immaturity slows deployment even where cells themselves are available.
5) Conversion limits of existing lithium-ion manufacturing assets	Although sodium-ion battery technology is described as a "drop-in" technology, conversion of existing plants is not universally straightforward. Lower energy density reduces GWh output per line, affecting revenue economics. Other technical challenges include sodium's high sensitivity to moisture, which may require factory adaptations such as additional heating or ventilation and therefore energy use, which must also be overcome on a plant-by-plant basis.
6) Upstream processing and material-grade readiness	While sodium itself is abundant, battery-grade sodium compounds, hard carbon and certain cathode materials currently face supply-chain immaturity in Europe. There is a risk of shifting dependencies from lithium to other inputs which are also primarily produced outside of Europe (e.g. hard carbon, manganese compounds, cathode active material (CAM) processing), until European upstream capabilities are established at scale.
7) Household-level deployment constraints	In residential markets, sodium-ion battery technology faces practical, non-technical hurdles, including: larger space requirements than lithium-ion battery technology, and tighter installation constraints, and compatibility challenges with existing inverters and grid codes. Consumer perceptions, installer familiarity, and sensitivity to upfront cost further exacerbate these barriers.

Challenge	Description
8) Skills, permitting and policy coordination gaps	Stakeholders highlight slow and uncertain permitting, uneven skills availability, and fragmented policy signals as structural constraints. The absence of a clear EU-level strategy, and / or signals, for scaling sodium-ion manufacturing exacerbates delays. Unlike lithium-ion battery technology, sodium-ion battery technology does not yet benefit from a strong, coordinated industrial narrative translating R&D success into large-scale deployment.
9) Strategic positioning versus lithium-ion battery incumbency	Sodium-ion battery technology faces the challenge of competing for attention, capital and industrial capacity in a battery ecosystem optimised for EV-driven lithium-ion battery growth. Limited automotive original equipment manufacturer (OEM) interest, EV-focussed gigafactory designs, and aggressive pricing of imported lithium batteries constrain sodium-ion's ability to secure priority investment.

Summary of key figures for lithium-ion and sodium-ion batteries

Key comparative figures for lithium-ion and sodium-ion batteries are presented in Table 0-2. Data are drawn from multiple sources using different methodologies. While this may result in some discrepancies, sources and assumptions have been transparently documented throughout the report.

Table 0-2 - Comparison of key figures for lithium-ion and sodium-ion batteries

	Lithium-ion batteries	**Sodium-ion batteries**
Global production capacity	2,500 GWh/year (2023)	70 GWh/year (2025)
Global Market value	~84 EUR billion (2025 – forecast)	0.13-0.23 EUR billion (2024)
European production nameplate capacity (2025)	257 GWh	<1 GWh
European production nameplate capacity (2030)	649 GWh	6-8 GWh
Current global demand	880 GWh (2023)	4-10 GWh (2024-2025)
Projected global demand (2030)	4,700 GWh/year	40-140 GWh/year*
Target installed Global BESS capacity	840 GWh (2030)	No data
Installed European BESS capacity	61 GWh (2024)	No data

	Lithium-ion batteries	**Sodium-ion batteries**
Target installed European BESS capacity	400 GWh (2029)	No data
Percentage of energy storage systems deployed in Europe	86-93%	<1%
Raw material costs (2010)	EUR 4,230 – 12,690 per tonne (lithium carbonate)	EUR 114 – 140 per tonne (trona)
Battery cell cost (2025)	EUR 40 – 68 /kWh (LFP) ~52 EUR/kWh (NMC)	EUR 68 – 89/kWh
BESS costs	EUR 600 /kWh	EUR 170–300/kWh
Energy density	170-250 Wh/kg	>175 Wh/kg
Mid-tier cycle life range	6,000-10,000+	2,500-4,000 (sodium–sulphur, polyanionic, PBA)
Upper-tier cycle life range	12,000	5,000+ (TIAMAT, HiNa, Reliance/Faradion), >10,000 (CATL NFPP)
Safe operation temperatures	60°C	100°C

*Range dependent on source – demand may be lower than forecast nameplate capacity resulting in underutilisation.

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Abbreviations and Glossary

Abbreviation	Description
AAM	Anode active material
BESS	Battery energy storage systems
BMS	Battery management system
CAGR	Compound annual growth rate
CAM	Cathode active material
CAPEX	Capital expenditures
CCMI	Consultative Commission on Industrial Change
CRM	Critical raw material
DOE	Department of Energy
EESC	European Economic and Social Committee
EPC	Energy performance certification
ESS	Energy storage system
EU	European Union
EUR	Euro
EV	Electric vehicle
FSA	Foresight, Studies, and Policy Assessment Unit
GW	Gigawatt
GWh	Gigawatt hour
HCs	Hard carbons
IEA	International Energy Agency
IP	Intellectual property
IRENA	International Renewable Energy Agency
LFP	Lithium iron phosphate
mln	Million
MWh	Megawatt hour
$NaAlCl_4$	Sodium tetrachloroaluminate
$Na\text{-}NiCl_2$	Sodium–nickel chloride
NFPP	Sodium ferric pyrophosphate
NMC	Nickel manganese cobalt
OEM	Original equipment manufacturer
OPEX	Operating expenses
PBAs	Prussian blue analogues
PV	Photovoltaic
R&D	Research and development
SME	Small and medium-sized enterprise
TRL	Technology readiness level
USD	US Dollar
VW-JAC	Volkswagen Group and Anhui Jianghuai Automobile
Wh/kg	Watt hour per kilogram
Wh/L	Watt-hours per litre
ZEBRA	Sodium-nickel chloride

1. Introduction

1.1 Report overview

This project, “Energy resilience of households in a prepared union – the potential of a sodium battery-based solution” (EESC-FSA-2025-07) was awarded to Mileu, WSP and CE Delft under the Interinstitutional Framework Service Contract EPRS/DIRB/SER/23/016. The contract commenced on 24 November 2025. This report presents the information obtained from a literature review and stakeholder engagement. The report comprises the following sections:

- Section 1 – Introduction: Study context, aims and objectives
- Section 2 – Methodology followed for the project
- Section 3 – Domestic and business lithium-ion battery energy storage
- Section 4 – Sodium battery comparison
- Section 5 – Calculations for EU 72-hour preparedness goal
- Section 6 – Sodium battery market overview and forecast
- Section 7 – Raw material availability and industrial symbiosis
- Section 8 – Drivers, barriers, challenges and opportunities
- Section 9 – Case studies
- Section 10 – Conclusions
- Appendices
    - Appendix A – Detailed methodology for data gathering
    - Appendix B – Stakeholder information (metadata)
    - Appendix C – Stakeholder survey questions
    - Appendix D – Detailed calculations for capacity to meet 72 hour preparedness goal
    - Appendix E – Global sodium-ion battery-related manufacturers in 2025
    - Appendix F – References

1.2 Study context

Europe’s energy transition and the rise of intermittent renewables[3] are accelerating the demand for batteries. However, most of the global supply chain remains concentrated outside Europe, particularly in China. While global expansion has lowered battery prices through economies of scale, European manufacturers face high energy and labour costs, limited access to critical raw materials, and the challenge of building large-scale supply chains. EU initiatives such as the Battery Regulation 2023/1542[1] and the Critical Raw Materials Regulation (EU) 2024/1252[2] aim to strengthen sustainability standards and foster domestic refining, manufacturing, and recycling. However, Europe’s competitive position in battery production remains fragile.

Sodium batteries offer a strategic opportunity as they rely on abundant, low-cost materials, require less energy to produce, and can reduce import dependency. Developing this emerging technology, as well as its supply and production chain, could help establish a new European battery industry, enhancing resilience, circularity, and strategic independence in support of the energy transition.

This study was commissioned by the Foresight, Studies and Policy Assessment Unit (FSA) of the European Economic and Social Committee (EESC), under Directorate B, which oversees the EESC’s studies programme. The Requesting Service was the Secretariat of the Consultative Commission on

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[3] Renewable energy sources whose output fluctuates unpredictably due to weather (e.g., solar, wind)

Industrial Change (CCMI) which monitors and analyses industrial transformation in line with the values of the European economic and social model.

The study completes the CCMI's opinion on the sodium battery industrial sector, published on 16 December 2025[3]. The opinion examined the development potential of sodium battery technologies as a sustainable and cost-effective complement to lithium-ion batteries, and their role in enhancing Europe's energy resilience and industrial competitiveness. The work forms part of the EESC's ongoing studies programme and reflects the CCMI's mandate to assess industrial change and promote sustainable solutions for Europe's future. The work was prompted by the EU's growing investment in sodium technologies, the need to evaluate industrial readiness for sodium battery production, recent energy and material security challenges, and the policy momentum surrounding the EU's Preparedness Union Strategy[4] and the Blue Deal[5].

1.1 Aims and objectives

The study's aim is to support the EESC's work on industrial change and energy resilience by assessing the potential of sodium battery technologies for household and business storage to meet a 72-hour energy preparedness goal.

The study objectives are to:

- Identify the current state of household and business energy storage (e.g., lithium-ion batteries).
- Identify the potential of lithium and sodium battery industries as solutions for the future.

The specific topics that this report addresses are:

- Households and businesses that would need to be covered EU-wide to meet 72-hour self-sufficiency.
- Current number of houses and businesses that are equipped with lithium batteries.
- Trends over the past 15 years.
- Current cost of the lithium-based solutions existent in the market.
- Current industry capacity of lithium batteries (manufacturing) and installed capacity for home and domestic (local) batteries.
- Global figures for existing sodium battery industries, and where are they located.
- Future prospects (notably total storage capacity needed) and how much time they will take to become operational.
- The potential capacity of production of sodium batteries in Europe. How much sodium is available in Europe for the production, and where is it located. Which existing industries could rapidly be converted or include sodium batteries in their portfolio.
- Potential for a virtuous circle between desalinisation processes and sodium battery manufacturers to boost potential.
- The types of factories that would need to be put in place (e.g., for a level of 5% to 10% of the market share, and the scale that would be possible). The necessary factors for their implementation (e.g., financing, de-risking).[4]
- The average cost of sodium battery equipment to reach 72-hour sufficiency. How it compares to a lithium battery.
- The estimated life span of a sodium battery for household or business energy storage purposes. How it compares to a lithium battery.

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[4] This analysis includes a benchmark perspective, considering what other actors are investing, their production capacity and what type of use they plan for the batteries (private households, vehicles, etc.).

2. Methodology

2.1 Task 1: Literature review

The project team conducted a systematic review to identify evidence relevant to the research questions for objectives 1 and 2. Further details on the methodology followed for the literature review are presented in Appendix A.

Search terms were developed using keywords and Boolean operators to ensure comprehensive coverage, using search engines Google Scholar and Google to compile approximately 100 sources. Additional materials were provided by the EESC and supplemented with sources already known to the team. The process yielded a diverse set of academic studies, policy documents and datasets, primarily from EU institutions and Member States.

All collected sources underwent a structured screening process. Titles, abstracts and conclusions were reviewed, and each source was assessed for relevance and robustness.

- Relevance captured the likelihood that the source contained useful data.
- Robustness considered credibility and scientific soundness.

Only sources rated medium-to-high on both criteria were retained. Of 92 sources screened, 58 met the threshold for inclusion. All shortlisted sources were published within the last decade, with non-EU research included only where pertinent.

For the shortlisted 58 sources, data extraction was carried out using an Excel template designed to organise information efficiently and highlight evidence gaps. This structured extraction produced the core evidence base for the report and directly informed the development of subsequent stakeholder interviews by identifying areas where further insight was required. Further targeted searches using well known search engine such as Google and CoPilot were used to address further data gaps.

2.2 Task 2: Stakeholder engagement

The stakeholder consultation aimed to validate and expand on findings from the earlier literature review by gathering primary insights on the feasibility and potential role of sodium batteries. Further details on the methodology followed for the stakeholder engagement are presented in Appendix A.

Stakeholders were mapped to ensure diversity across organisation types, sectors and geographies. In total, 98 stakeholders were identified, including sodium-ion and lithium-ion battery manufacturers, component suppliers, industry associations, raw material producers, desalination experts, salt-processing industries, academics, and investors. The stakeholders represented 17 EU Member States, with additional organisations from relevant non-EU countries and major global markets to capture broader technological and commercial perspectives. See Appendix B for a breakdown of stakeholders by type.

A structured survey was deployed via EU Survey to collect comparable primary data on current and expected battery use in the EU, focusing on energy preparedness and the emerging role of sodium technologies. The survey findings were used to corroborate and supplement evidence gathered from the literature review.

To deepen insights, a targeted set of 19 stakeholders was invited for interviews, selected based on organisational relevance, value-chain position, geography and the quality of their survey responses. Six participated, offering in-depth perspectives that informed the report's analysis and supported the development of detailed case studies.

2.3 Task 3: Case studies

Case studies were selected from across the EU to examine developments in the sodium-battery sector. The case studies provide an overview of each project or company, their position within the value chain, the current status of their activities, and expectations for future development and time to operation. They also outline the key drivers behind the projects' or companies' work, the challenges they face, and any factors that could support both progress and the wider industry:

- **Nobian** – A chemical production company, specialising in electrochemistry to develop and test a new reactor to produce sodium tetrachloroaluminate ($NaAlCl_4$) used as an electrolyte in sodium-based batteries.
- **Altris AB** – A Swedish sodium-ion cell material company which developed the first Prussian White synthesis while exploring sodium-ion battery materials that can be produced domestically in Europe.
- **Moonwatt –** A European energy storage startup, developing and deploying stationary energy storage systems based on sodium ferric pyrophosphate (NFPP) sodium-ion battery chemistry.

2.4 Task 4: Report

This report was formulated based on the outputs from Tasks 1, 2 and 3. The report was developed based on the results from an in-depth literature review and through stakeholder engagement via a survey and targeted interviews.

The report will be used by the EESC to produce evidence-based recommendations to inform the CCMI's opinion and future EESC initiatives, supporting both industry development and citizen preparedness across Europe.

A 0.85 conversion rate from USD to EUR has been used throughout the report to enable comparison between reported data.

3. Domestic and business lithium-ion battery energy storage

3.1 Section overview

This section focuses on the current and future forecast for energy storage systems within Europe, based on lithium battery technology estimates. The section has been structured into the following sections:

- **Current industry capacity:** the current industrial capacity of lithium batteries (EU focus and global overview).
- **Current number of houses and businesses**: number of houses and businesses equipped with storage batteries.
- **Trends**: including trends over the past 15 years, future prospects and challenges for sodium battery uptake.
- **Costs**: current (and future) cost of the lithium-based solutions on the market.
- **Forecast**: the number of households and businesses that would need to be covered EU-wide to meet a 72-hour self-sufficiency goal and associated costs.

3.2 Current production capacity of lithium-ion batteries

In 2023, global lithium-ion battery production nameplate capacity[5] reached an estimated 2,500 GWh/year (0.008% of global electrical capacity)[6] although the utilisation[7] of this capacity was around 35%[8] in 2023.

In 2023, of the utilised capacity, approximately 750 GWh (30%) were deployed in electric vehicle (EV) battery installations and approximately 130 GWh (5.2%) towards battery energy storage systems (BESS).[9]

As of 2025, 257 GWh production nameplate capacity of lithium-ion gigafactories is in Europe (including the UK, Norway, Switzerland, Serbia, Türkiye).[6]

Looking at the production nameplate, capacity remains highly concentrated geographically[7]:

- China accounts for 83% of global capacity.
- The European Union represents 8%.
- The United States accounts for 5%.
- The remaining 4% is located primarily in Japan and the Republic of Korea.

The EU's position in the global supply chain for lithium and related battery materials remains limited:

- Lithium-ion batteries represent 86-93% of energy storage systems deployed in Europe.[8] [9] [10]

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[5] Nameplate capacity refers to the theoretical maximum output; this is not necessarily equal to the actual day-to-day output.

[6] As of 2023, global electrical capacity was at 30.1 million GWh (https://www.iea.org/world/electricity).

[7] Utilisation may be lower than nameplate capacity for several reasons including: yield losses (scrap, defects etc.), downtime for maintenance, process bottlenecks, supply bottlenecks, limited capacity during ramp-up periods, deliberate overcapacity to meet demand, mismatches between type of capacity and type of demand (e.g., chemistry type such as lithium iron phosphate vs nickel manganese cobalt or pouch types such as cylindrical vs prismatic)

[8] Source states utilisation at 33%, but reports EV and BESS installed capacity at 750GWh and 130 GWh respectively, which is 35% of total nameplate capacity.

[9] BESS is a static electrochemical system that stores electricity from the grid or a generation source and releases it later to supply power or deliver grid services as required (https://docs.nrel.gov/docs/fy19osti/74426.pdf).

- The EU is dependent on non-EU countries for the "supply of raw materials, particularly for the manufacture of lithium-ion batteries, as its share is limited, accounting for only approximately 2 % of global supply", meaning 98% of the global supply sits outside the EU, as of 2023.[11]
- The EU accounts for 2.9% of global cathode material production for lithium batteries.[12]
- Estimates of EU lithium-ion battery manufacturing capacity vary, ranging from below 1%[13] to approximately 3%[14] of global capacity.

These data show dependency on suppliers outside the EU for both raw materials and processed components essential to battery manufacturing.

Long-term growth of lithium-ion battery production in the EU is constrained by the limited availability of critical raw materials (such as cobalt and lithium) within Europe[10], as well as restricted access to global reserves. The distribution of many of these critical materials are concentrated outside the EU; for example, 50% of global lithium reserves are located in Chile and 50% of global cobalt reserves are located in the Democratic Republic of Congo. Furthermore, processing capacity of lithium remains concentrated, primarily in China (83%).[15] Such concentration increases the EU's exposure to geopolitical risks, supply disruptions, and market volatility. These vulnerabilities may prevent the expansion of battery manufacturing capacity within the EU. Furthermore, the high environmental and social impacts associated with extraction and processing of critical raw materials remain a concern.[16] [17]

3.3 Installed lithium-ion BESS capacity

In Europe, as of 2024, there was a total of 61 GWh of installed BESS capacity (compared to the 130 GWh of global capacity installed in 2023).[18] 16 GWh of new BESS were installed in 2023 and 22 GWh were installed in 2024. 400 GWh of total installed capacity are estimated to be in place by 2029.[19]

Of the 16 GWh installed in in 2023, approximately 12 GWh corresponded to 'behind-the-meter' installations, including residential and commercial systems, the majority of which were lithium- based.[20] Most battery systems are installed for energy trading on balancing markets. In the three years to 2024, three million home batteries were connected to European grids.[21]

Most household BESS systems are currently used in conjunction with photovoltaic (PV) cells to store the generated solar power. Germany represents one of the most advanced European markets for household BESS and PV. In 2017, approximately 61,000 PV-battery storage systems were installed in Germany, corresponding to a storage capacity of 400 MWh. By the end of 2017, the number of installed systems had increased to 75,000, reflecting rapid consumer uptake and strong market growth in the residential sector.[22]

The distribution of technologies installed in 2021 and 2023 was dominated by lithium-ion batteries as shown in Table 3-1.

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[10] Note however that there are several emerging lithium projects in Europe that may partially reduce import dependency in the medium to long term: https://www.reuters.com/world/europe/eu-announces-list-47-strategic-metals-projects-2025-03-25

Table 3-1 Breakdown of battery types used in BESS systems in 2021 and 2023

Battery type	Year	Percentage of BESS
Lithium-ion	2021	93%
Lead-acid		3%
Redox-flow		1%
Other technologies		3%
Lithium-ion	2023	90%
Lead-acid systems		8%
Sodium-based technologies		2%

Notes: 2021 source: Konsta Kuronen, (2024) Next generation battery technologies for stationary energy storage. See: https://lutpub.lut.fi/bitstream/handle/10024/167866/MastersThesis_Konsta_Kuronen.pdf?sequence=1

2023 source: Marek Bielewski et al., (2024) Clean Energy Technology Observatory: Battery Technology in the European Union - 2024 Status Report on Technology Development, Trends, Value Chains and Markets. See: https://publications.jrc.ec.europa.eu/repository/handle/JRC139392

3.4 Supply / demand forecast for lithium-ion batteries

The global lithium-ion battery market has rapidly expanded in recent years. A 2023 market report anticipated that, between 2020 and 2025, the market value was expected to more than double from 44 billion USD (37.22 billion EUR) in 2020 to 99 billion USD (84 billion EUR) projected for 2025.[23]

A 2020 report projected that for 2025, around two-thirds of the materialised production capacity[24] is likely to originate from Asian-affiliated companies, with European companies accounting for slightly more than one-third, although data post-2025 was not identified to confirm this.[25] Responses from stakeholders and other information obtained in literature suggest that China continues to dominate the lithium battery market.

At the global level, demand for lithium-ion batteries is expected to reach 4,700 GWh/year by 2030, driven mostly by the EV market. Furthermore, by 2030, there is expected to be an installed BESS capacity of 840 GWh.[26] Current assessments indicate that for battery demand, Europe is expected to exceed 1,000 GWh per year by 2030, surpassing anticipated domestic production levels. Meeting this demand from domestic sources would require the domestic EU manufacturing capacity for lithium-ion batteries to expand at highly ambitious annual growth rates of approximately 31–68%.[27]

The European Commission has estimated that overall battery demand will increase fourteen-fold by 2030 compared to 2018 levels, with the EU representing approximately 17% of global demand.[28] The estimates suggests that the number of lithium-ion batteries in circulation is also expected to increase dramatically, multiplying by a factor of 700 between 2020 and 2040.[29]

According to the new-automotive battery tracker, there are 257 GWh production nameplate capacity of lithium-ion gigafactories in Europe (including the UK, Norway, Switzerland, Serbia, Türkiye) with 649 GWh of capacity due by 2030 as presented in Table 3-2.[30]

Table 3-2 Current and planned gigafactory capacity

Row labels	GWh capacity (2026)	GWh capacity (2030)
Announced M.O.U.	0	32
Operational	257	649
Permitting stage	0	148
Status unclear	0	27
Suspended	0	50
Under construction	30	643
Total	**287**	**1,549**

However, planned projects face several uncertainties, including volatility in raw material supply, rapid technological evolution, increasing requirements for responsible sourcing, and rising production costs. **Delays and project suspensions have already been observed in several European projects, underscoring the need for coordinated policy support and stable investment conditions**.[31] [32]

To address future supply needs, four major industrial projects focused on sustainable lithium mining and development in Europe were announced as of 2021, representing a combined investment of nearly EUR 2 billion. These initiatives aim to meet up to 80% of the EU's projected lithium requirements.[33] It is understood that several of these investments have subsequently been cancelled.

Policy measures are also being deployed to support the expansion of industrial capacity. The Net-Zero Industry Act seeks to increase domestic production of battery cells and cathode and anode active materials (CAM/AAM) to 40% of EU demand by 2030.[34] The Critical Raw Materials Act establishes targets for achieving 10% domestic extraction capacity, 40% refining capacity for battery materials, and 25% recycling capacity by 2030.[35][36] The recently published Battery Booster Strategy[37] also has developed six pillars to help support the EU through financial backing and investment, aiming to increase battery manufacturing.

Overall, demand for batteries is growing rapidly. Lithium-ion is, and is likely to continue to be, the dominant chemistry driven by electric vehicles. European production capacity is growing rapidly but remains structurally dependant on external suppliers for raw materials, notably China, and lags behind in production capacity, supply-chain maturity, and raw material security. Europe is investing in domestic lithium battery supply, such as a recent EUR 2.2 billion financing package for Vulcan Energy Resources Limited to develop lithium and renewable energy project in Germany [38] but domestic supply will take time to scale and will not remove structural external dependencies in the short-medium term.

3.5 Cost trends

3.5.1.1 Past trends for lithium-ion batteries

There has been clear significant downward trajectory in battery costs in recent years. Between 2010 and 2023, the global average cost of lithium-ion cell costs decreased from approximately 1,400 USD/kWh (1,190 EUR/kWh) to 140 USD/kWh (119 EUR/kWh), representing a ten-fold reduction over the period.[39] Cost reductions have been driven by:

- Improvements in cell chemistry and energy density.
- Economies of scale in manufacturing.
- Optimisation of production processes.
- Increased supply chain maturity.

Table 3-3 presents data on battery cell types and their costs in 2019 compared to 2025.

Table 3-3 comparison of battery costs and ranges from different sources.

Year	Battery cell type	Cost/range
2019[40]	Lithium iron phosphate (LFP) batteries	229 EUR/kWh
	Nickel-manganese-cobalt (NMC) lithium-ion batteries	169 EUR/kWh
2019(b)[41]	NMC batteries	145-289 EUR/kWh
	LFP batteries	225-335 EUR/kWh
2025 [42]	NMC batteries	52 EUR/kWh
	LFP batteries	40 EUR/kWh
2025[43]	LFP batteries	EUR 44 – 68 /kWh

Lithium carbonate is a precursor material for lithium battery production. As of 2023, the cost of lithium carbonate peaked at 15,000 USD (12,690 EUR) per tonne, with approximately 70,000 tonnes sold in 2023.[44]

In Europe, as of 2024, the cost of producing lithium batteries was 40 % higher than in China and the USA, primarily due to high electricity and labour costs.[45] In the US, supply chain security and sustainability concerns are driving interest in sodium-ion battery development. The US Inflation Reduction Act includes funding and tax incentives for sustainable energy storage systems including next-generation batteries such as sodium-ion. Furthermore, initiatives including the LIFT and LENS Consortia support sodium-based battery research.[46]

3.5.1.2 Future lithium-ion battery projections

Current projections indicate that manufacturing innovations and process optimisation are likely to drive substantial cost reductions in lithium-ion battery technologies. Estimates suggest that lithium-ion battery costs may decrease globally by up to 40% by 2030 from 2023 levels, reflecting improvements in cell chemistry, production efficiency, and supply chain integration.[47] Table 3-4 below shows a comparison of the projected costs of lithium-ion battery pack applications between 2030 and 2050[48]. The reasons for the cost differences between battery types may be due to ‘aggressive’ pricing in the EV sector.

Table 3-4 Expected cost differences of lithium-ion battery in different uses between 2030 and 2050[49].

Use	2030 cost (USD/kWh)	2030 cost (EUR/kWh)	2050 cost (USD/kWh)	2050 cost (EUR/kWh)
Stationary BESS	235	199	130	110
EV batteries	85	72	50	42
Heavy-duty truck batteries	195	165	100	85

Despite expected downward cost trends, future price developments remain uncertain. Two opposing dynamics are expected to influence the market: The increased demand of lithium-ion batteries and declining availability of cell component materials (increase in price) and rapid technological advancements (decrease in price).[50] At present, it is unclear how these factors will interact. They may counteract one another, resulting in a stabilised cost trajectory, or one may dominate, leading to either accelerated cost reductions or renewed price increases. Looking at market estimates however, it is expected that due to overcapacity, a continued decrease in costs are likely to be observed.[51]

4. Sodium battery overview

4.1 Section overview

This section comprises the following sections:

- **About sodium batteries:** context on sodium batteries.
- **Uses:** current and future use cases for sodium batteries.
- **Costs:** the average costs of sodium-ion batteries compared to lithium-ion batteries.
- **Lifespan and energy density**: the estimated lifespans of sodium-ion batteries compared to lithium-ion batteries and developments in energy density.

4.2 About sodium batteries

There are several variations of sodium batteries, including high-temperature molten-sodium systems such as sodium-sulphur batteries, sodium-nickel chloride (ZEBRA) batteries, sodium batteries with aqueous electrolytes, and room temperature sodium-ion batteries with organic electrolytes.[52] This report focuses on room temperature sodium-ion batteries as they represent the most commercially relevant segment of sodium-based storage. Current EU research, pilot deployments, and near-term market opportunities are centred on room-temperature systems for household and business energy storage.

Sodium-ion batteries function similarly to many other battery technologies, particularly lithium-ion batteries. They comprise three main components: the cathode, anode, and electrolyte. Cathode materials in sodium-ion batteries typically use layered oxides, polyanionic compounds, or Prussian blue analogues (PBAs) while anodes comprise hard carbons (HCs) and alloying materials. Electrolytes are often a sodium salt dissolved in carbonate or ether solvents.[53] The interactions between each of these components can influence the costs, energy density, cycling life, and overall practicality of sodium-ion technology as discussed in sections 4.4, 4.5 and 4.6.

Sodium-ion batteries can hold less energy per unit weight / volume than lithium-ion batteries; however, they have several technical advantages compared to lithium-ion technology, notably improved inherent safety (less susceptible to thermal runaway/fires), use of more abundant and relatively available materials, lower operating temperatures and the ability to operate in lower environmental temperatures, reduced environmental impact and potentially better affordability. Sodium-ion batteries can safely be stored or transported at 0% charge, unlike lithium-ion batteries which typically arrive at 30-50% state of charge. While battery manufacturers have to account for recharging the cells upon arrival, it does make them inherently safer by avoiding fire hazards.

Sodium-ion batteries have emerged as a technology to complement lithium-ion batteries, particularly for applications where cost, raw-material security and sustainability considerations outweigh the need for maximum energy density.

4.3 Uses

The market for sodium-ion batteries is in its infancy but is rapidly growing, particularly in mobile applications. To demonstrate, the first commercially available mobile sodium-ion battery powered product (a cordless screwdriver) became available in 2024[54], and as of 2026, Contemporary Amperex Technology Co. Limited (CATL) and Changan announced the first mass-produced sodium-ion battery powered passenger vehicle to be available from mid-2026[55], with additional products likely to follow. Sodium batteries are currently used in two key applications: **stationary energy storage** and **mobile**

applications. There is broad consensus that automotive applications are unlikely to be the primary market in the short term, even though sodium-ion batteries are now technically viable for electric vehicles. Instead, near-term deployment is expected to focus on grid-scale and household BESS. Further information on these sectors is provided below. Information on additional, niche, current uses and future uses is also provided.

4.3.1 Stationary energy storage

Sodium-ion batteries are well suited for use in stationary energy storage applications due to their thermal stability, low fire risk, and tolerance to extreme temperatures[56]. The rapid expansion of renewable energy and data centre industries means that demand for grid-scale as well as decentralised energy storage (e.g., domestic or business applications) is surging. Sodium-ion batteries could enable households, industries and communities to store excess renewable energy for periods of peak demand.[57]

The first stationary sodium-ion BESS was installed in China in 2019.[58] Several stakeholders commented that sodium-based systems are increasingly being used in energy storage applications, including peak-shaving solutions for grids and data centres, and stationary storage installations for large-scale, household, residential, commercial, grid-scale systems for self-consumption and cost sensitive mobility solutions.

In Europe, the development of BESS is underway, with several producers commenting that they are developing products for the market, mostly using technology purchased outside of the EU. Producers have also recently started developing BESS for use in commercial and domestic applications, however one manufacturer commented that households generally have more space constraints, making the currently lower energy density, and thus larger footprint, of sodium-ion batteries compared to lithium-ion batteries more of a barrier than in industrial applications.

4.3.2 Electric mobility

There is clear potential for sodium-ion batteries to be used in affordable shorter-range electric mobility applications, such as light means of transport and entry-level cars.[59] [60] In these applications where energy density is not as crucial for performance as longer-range vehicles, the natural abundance and lower cost of sodium compared with lithium could give sodium-ion batteries a distinct cost and sustainability advantage.[61]

Survey responses from stakeholders, including battery manufacturers, an investor and an academic institution, noted that current sodium batteries have been developed for several mobility products including starter batteries (12V/18V – to replace lead batteries), automotive ancillary systems,[62] light electric vehicles, light commercial vehicles, low-speed vehicles, two- or three-wheel, non-mobility electric vehicles, and experimental electric vehicles (an alternative to lithium iron phosphate (LFP) technologies). Other highlighted uses include mobile applications such as power tools.

4.3.3 Future uses

Survey responses from several battery manufacturers and an investor further highlight expansions of sodium battery technologies into new and emerging fields. Future applications are expected to include further developments in electric vehicles, particularly as the technology matures and energy-density improvements continue. Furthermore, sodium batteries are expected to support innovative technologies such as mini and micro-scale stationary energy storage for residential and commercial buildings, as well as for critical infrastructure including hospitals and data centres. Moreover, according to stakeholders, advances are expected in long-duration energy storage which may further enhance the strategic relevance of sodium-based systems.

According to stakeholders, growth areas are anticipated in advanced mobility applications across land, air, and maritime sectors, as well as in robotics and connected devices. Finally, sodium batteries are expected to replace LFP technologies in several mainstream applications, particularly in stationary storage and selected electric-mobility segments where cost, safety, and sustainability considerations create favourable conditions for substitution.

4.4 Costs

4.4.1 Raw material cost

The raw material inputs for sodium-ion batteries are considerably less expensive and in greater abundance than lithium equivalents. For example, in 2010 the cost of trona (precursor for the production of sodium carbonate) was approximately USD 135-165 (EUR 114 – 140) per tonne whereas with lithium carbonate can be between USD 5,000-15,000 (EUR 4,230 – 12,690) per tonne with significant volatility.[63] [64]

Sodium is more abundant than lithium in the earth's crust.[65] Therefore the accessibility and overall cost of extraction and purification of sodium is lower[66] [67] meaning that sodium is widely considered the ideal contender to replace lithium in many applications, despite some of its current technical limitations.[68]

Raw material for sodium-ion batteries is approximately 20% of the cost of raw material for lithium-ion batteries overall.[69] It is also more abundant and more easily integrated into a circular economy than lithium, leading to price stability and lower geopolitical risk.[70] This upstream cost advantage is evident in component level comparisons. One source notes that sodium-ion batteries can offer 20-30% lower production costs compared to LFP.[71] Volatile lithium or graphite prices would also accelerate competitiveness, whereas increased nickel costs which are relevant for certain sodium-ion battery cathode designs, as well as lithium-ion, and continued falling price of lithium-ion technologies could slow progress.[72]

4.4.2 Cell costs

This subsection discusses the cell cost rather than the entire BESS. Over the last ten years, sodium-ion batteries have moved from primarily laboratory-scale and research and development technologies to a commercially credible option. Cell costs are approximately 40% of total BESS costs, depending on product/project.[73] Early benchmarks already indicated that sodium-ion batteries could be cost-competitive to lithium-ion batteries with one estimate from 2019 citing the cost of sodium batteries at approximately 223 EUR/kWh.[74] More recent estimates show considerable decreases in cost with multiple sources placing sodium-ion cells at between USD 80-105/kWh (EUR 68 – 89/kWh),[75] [76] with an estimate by the International Renewable Energy Agency (IRENA) placing the range as low as USD 40-80/kWh (EUR 34 - 68/kWh).[77] In comparison, LFP battery cells have reached USD 52-81/kWh (EUR 44 – 68 /kWh) in many markets. This range overlaps with sodium-ion battery cell estimates.[78]

Despite this, one academic institution noted that the market for sodium-ion batteries is not yet developed. As a result, costs remain higher and less predictable compared with established lithium-ion battery technologies. Although sodium-based electrolyte precursors are inherently less expensive than lithium equivalents, this is not recognised in practice as the current demand for sodium-ion technologies remains low compared to lithium-ion due to the market having not yet reached economies of scale. As a result, the price of sodium-ion electrolytes is currently estimated to be almost double that of lithium-ion electrolytes.

Cell costs per kWh of storage capacity can be broken down to battery components and materials. A 2019 report reported that the cost breakdown by component is comparable with LFP technology.[79] Also estimated in the same report were the material costs for single cells including sodium-ion battery, LFP and nickel manganese cobalt (NMC). One cost breakdown of a Faradion 12Ah sodium-ion pouch cell estimates total material costs at USD 150/kWh (EUR 128/kWh), with the largest cost contributions coming from the cathode (28%), anode (26%), cell manufacturing process (18%), followed by the current collectors (13%), electrolyte (12%), and separator (3%).[80]

According to one academic institution, electrolytes currently have a significant impact on overall price with electrolytes accounting for 12-15% of total cell production costs. However, this cost disadvantage is only considered temporary and is expected to diminish as commercial deployment and demand increase.[81]

A further cost advantage stems from component substitution. Sodium-ion batteries can use aluminium foil as the current collector on both electrodes, unlike lithium-ion batteries which require copper foil. Battery-grade aluminium strip costs approximately USD 70/m (EUR 59/m) which is significantly cheaper than copper foil priced at USD 210/m (EUR 178/m), removing a key cost barrier present in lithium-ion battery manufacturing.[82]

One study which forecasted the price development of sodium-ion cells based on component substitution and technological roadmaps shows a drop in price of sodium-ion batteries from around USD 125/kWh (EUR 106/kWh) in 2025 to around USD 35/kWh (EUR 30/kWh) in 2045[83]. Another study estimates that cell cost could fall rapidly with IDTechEx expecting sodium-ion battery prices to reduce to an average of USD 40/kWh (EUR 34/kWh) by 2030.[84] Projections by the IEA (2025) estimate sodium-ion cell costs could fall to around USD 50/kWh (EUR 42/kWh) by 2030, compared to about USD 100/kWh (EUR 85/kWh) for LFP lithium-ion today.[85] Lithium-ion prices could also reduce by 40% between 2023 to 2030.[86]

4.4.3 Whole BESS cost

At the whole system level, sodium-ion BESS are increasingly cost-competitive with lithium-ion solutions for stationary applications. Although sodium-ion batteries have lower energy density than lithium-ion, this does not pose a significant issue for stationary storage, as systems are floor-mounted and not weight-constrained according to one battery manufacturer in a stakeholder interview (although they may take up more physical space – see section 5). As a result, system-level costs are driven primarily by balance-of-system components, installation, and project scale rather than cell energy density.

According to one battery manufacturer, for domestic applications, current turnkey costs for sodium-ion BESS are estimated at around EUR 300/kWh, which is broadly comparable to lithium-ion systems at similar scales. This value was used in calculations in section 5. Residential systems tend to be more expensive per kWh due to limited economies of scale and higher costs for inverters, power electronics, and installation. However, given the early stage of residential sodium-ion deployment, cost estimates remain uncertain and project-specific.

The same manufacturer noted that, at the commercial and industrial scale, sodium-ion BESS with current turnkey system costs are estimated in the range of EUR 170–300/kWh when fully installed, including batteries, inverters, battery management systems (BMS), and associated electrical and mechanical infrastructure. In comparison, one report stated the current battery prices for a 20 kWh household battery is approximately 600 EUR /kWh for lithium-ion (See section 5 for more detail on battery size)[87]. This wide range reflects variation in project size, site conditions, integration requirements, and procurement models. Installations in the 1–4 MW range are reported to achieve total system costs below EUR 100,000 per MW, indicating strong cost competitiveness at scale.

For large-scale and utility-scale projects, additional cost optimisation opportunities arise through bulk procurement, standardised system design, and streamlined installation. However, at these scales, cost transparency becomes more limited, as turnkey contracts often bundle battery supply and installation services. According to a battery manufacturer, the pool of contractors capable of delivering multi-megawatt, fully integrated BESS remains relatively small, which can influence pricing and project timelines.

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Summary

At the raw material level, sodium-ion batteries have a clear advantage over lithium-ion batteries due to the high abundance and low cost of sodium, resulting in raw material costs estimated at around 20% of those for lithium-ion and lower exposure to price volatility and geopolitical risk. At the cell level, costs have fallen as sodium-ion battery technology has progressed to early commercial deployment, with recent estimates of USD 40–105/kWh (EUR 68–89/kWh), comparable with current LFP lithium-ion cell costs of USD 52–81/kWh (EUR 44–68/kWh) (see Table 4-1). However, limited production volumes mean sodium-ion cell prices remain less predictable.

At the whole-system (BESS) level, sodium-ion batteries are already cost-competitive with lithium-ion for stationary storage, where lower energy density is not a constraint; stakeholder evidence suggests turnkey sodium-ion BESS costs are comparable at the residential scale and potentially lower at commercial and industrial scales. Overall, while lithium-ion benefits from a more mature and predictable market, sodium-ion batteries show strong inherent cost advantages that are expected to increase as manufacturing scales up.

Table 4-1 - Costs summary table

	Sodium-ion batteries	**Lithium-ion batteries**
Raw material costs	EUR 114 – 140 per tonne (trona)	EUR 4,230 – 12,690 per tonne (lithium carbonate
Cell costs	EUR 68 – 89/kWh	EUR 44 – 68 /kWh (LFP)
BESS costs	EUR 170–300/kWh	EUR 600 /kWh

4.5 Energy density

Sodium-ion batteries have between 17-49% lower energy density than lithium-ion batteries (depending on cell chemistry) which increases system sizing and physical footprint.[88] However, ongoing electrochemical improvements are expected to increase material and cell-level energy density.

Between 2010 and 2024, sodium-ion batteries had a 57% improvement rate in electrochemical storage compared to other long duration energy storage. This is in comparison with battery technologies such as vanadium redox flow batteries which had the second biggest improvement at 34%.[89]

Analysis by Yao et al. (2023) shows that Sodium-ion batteries could reach cost parity with LFP in the 2030s across a wide range of supply conditions, with energy density improvements identified as the most influential factor.[90]

Tiamat have achieved a battery with an energy density of 0.068 kWh/kg and 135 kWh/m3 for sodium batteries which have been used for the calculations in section 5.[91]

Commercial progress on improving energy density is accelerating. CATL's first generation sodium battery has 160 Wh/kg energy density, and a target to exceed 200 Wh/kg with the next generation by 2030[92]. In April 2025 CATL announced its commercially available Naxtra chemistry reporting:

- 175 Wh/kg gravimetric energy density, the highest sodium-ion figure published to date.
- >10 000 full cycles to 80 % state-of-health.
- 5 C charge rate[93] (approximately15 min to 80 % state of charge) and 90 % power retention at -40°C.

For comparison, currently available lithium-ion batteries have an energy density of 170-250 Wh/kg.[94]

Next-generation sodium-ion battery designs have surpassed 190 Wh/kg in prototype pouch cells.[95]

Further improvements are anticipated through initiatives such as the SPRINT programme, which aims to reduce costs (around EUR 0.04/kWh/cycle), increase energy density (>200 Wh/kg, >420 Wh/L), enhance power performance (>500 W/kg), extend cycle life (>5,000 cycles), and ensure safer, leak-free operation.[96]

Sodium-ion batteries exhibit inherently better thermal and structural stability than lithium-ion batteries, reducing the risk of overheating and fires. While lithium-ion batteries typically operate safely up to around 60°C, sodium-ion batteries can operate up to temperatures of approximately 100°C.[97]

Summary

Sodium-ion batteries currently have 17-49% lower energy density than lithium-ion batteries, which leads to a larger battery system size and therefore an increase in the space required to host it. However, sodium-ion batteries have seen rapid improvement with a 57% increase in electrochemical storage performance between 2010-2024, outpacing many other long-duration storage technologies. Sodium-ion is expected to reach energy density targets including >200 Wh/kg, making it competitive with currently available lithium-ion batteries, while having a wider range of safe operating temperatures.

4.6 Lifespan

4.6.1 Cycle life ranges

Cell cycle life is one of the most important differences between sodium-ion and lithium-ion technologies, however, reported values vary widely depending on the chemistry of the cell, depth of discharge, operating conditions, and technology maturity. Lithium-ion chemistries are more mature and retain an advantage in terms of proven longevity with lifecycles typically in the range of 6,000-10,000+ cycles. Some LFP cells can approach 12,000 cycles under controlled conditions.[98]

Sodium-ion batteries are less mature at commercial scale and, according to some sources, demonstrate shorter cycle life. One source reported that sodium-ion cells achieved 500-1,500 cycles compared with 2,000 for lithium-ion in the same source. However, sodium-sulphur batteries using polyanionic and PBA cathodes have shown to reach 2,500-4,000 cycles in commercial products. Leading sodium-ion battery manufacturers, for example CATL, have achieved a cycle life of over 10,000 cycles, while TIAMAT, HiNa, and Reliance/Faradion each respectively report above 5,000. Rapid improvements in cycle life mean that sodium batteries are already technically competitive with LFP batteries. According to one battery manufacturer's survey response, NFPP technologies used in their systems can exceed 12,000 cycles. The broad range in cycles reflects the lack of maturity and rapid developments of the technology.

4.6.2 Lifespan variations

Lithium-ion batteries have been the benchmark for durability, and sodium-ion systems have struggled to reach the same level of performance due to the larger sodium-ions which can destabilise electrode structures. However, recent advancements in sodium-ion materials and electrode engineering are reducing this disadvantage. The improvement is particularly noticeable in the case of stationary energy storage where energy density is less crucial than durability, safety and material cost for which sodium batteries are experiencing improvements.[99]

The longevity and durability of sodium-ion batteries varies depending on cell chemistry which is also a clear indicator of the speed at which the technology is evolving. Some chemistries have already demonstrated strong stability (reduced degradation), while others are still behind leading lithium-ion formulations. For example, polyanionic materials and PBAs offer considerable cycling stability and safety performance. In contract, layered-oxide based sodium-ion batteries generally have a shorter lifecycle compared to lithium-ion batteries and show weaker ageing behaviour[100] due to the structural instability caused by the larger ionic radius of sodium.

Other sodium-based chemistries, however, achieve significantly higher lifespans. Sodium–nickel chloride ($Na-NiCl_2$) systems, a more established high-temperature chemistry, can deliver around 4,500 cycles, <15 years typical; calendar life around 10 years.[101] [102] According to one battery manufacturer, NFPP technologies used in their systems can achieve up to 20 years of service life, making it well-suited to daily cycling applications in homes.

Summary

Cycle life performance varies for both sodium-ion and lithium-ion battery technologies depending on differences in chemistry, maturity, and operating conditions. Ultimately, lithium-ion batteries remain the benchmark for cycle life performance, consistently delivering high lifespans across most chemistries, depicted in Table 4-2 - Lifespan comparisons below. Sodium-ion batteries, however, are experiencing rapid development with newer chemistries (sodium-sulphur, polyanionic, and PBA) reaching parity with mid-tier life cycle ranges of lithium-ion batteries. Leading manufacturers of sodium-ion batteries have reported life cycles comparable to LFP batteries, and some emerging sodium-based systems are approaching or exceeding 10,000 cycles.

Recent advances in electrode design and materials engineering have also improved durability, particularly for chemistries such as PBAs, polyanionic materials, and $Na-NiCl_2$, which can deliver around 4,500 cycles and 10–15 years of service life.

Table 4-2 - Lifespan comparisons

	Sodium-ion batteries	Lithium-ion batteries
Mid-tier cycle life range	2,500-4,000 (sodium–sulphur, polyanionic, PBA)	6,000-10,000+
Upper-tier cycle life range	5,000+ (TIAMAT, HiNa, Reliance/Faradion) - >10,000 (CATL NFPP)	12,000

5. Calculations for EU 72-hour preparedness goal

In a quantitative analysis, the required battery capacity for households (with and without heat pumps and electric vehicles) and critical businesses (healthcare facility, school, supermarket and hotel) were calculated. These businesses were selected since they are critical and at this moment do not have back-up power such as generators. For example hospitals and datacentres often already have back-up generators. The goal was to determine the required battery capacity to supply electricity for 72-hours, in line with the preparedness goal. The methodology and full results are presented in Appendix D.

Businesses

Four business use cases, based on previous studies from CE Delft[11], were analysed with a surface area of between 1,600 m^2 and 9,000 m^2, and a yearly energy demand of 120,000 to 490,000 kWh. To be able to store electricity for their electricity demand, the use cases require a battery capacity between 280 and 1,200 kWh for direct electricity demand, and a battery capacity of 400 to 1,750 kWh if a heat pump is installed.

This energy demand is used to determine weight and size of the battery systems, as presented in Table 5-1. For the cost estimate a lower price than for household batteries was assumed, due to the size of the systems, and based on stakeholder input. Therefore, a price of 500 EUR/kWh (current lithium-ion) towards 250 EUR/kWh (potential future sodium prices) has been used.

An estimate of required battery capacity on EU scale could not be made, due to limited information on the amount of these companies, their relative size per business and energy consumption of these use cases in Europe.

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[11] CE Delft (2025) – Study of time dependent grid tariffs for large consumers. https://cedelft.eu/publications/study-of-time-dependent-grid-tariffs-for-large-consumers/

Table 5-1 – Business energy demand, capacity, weight size and cost of sodium-ion BESS

						Weight (kg)		**Size (m3)**		**Cost (EUR)**	
	Surface area	**Yearly standard electricity consumption**	**Heat demand (kWh thermal)**	**Direct electricity demand for appliances etc. (kWh)**	**Electricity demand with heat pump-system (kWh)**	**Appliances only**	**Appliances + HP**	**Appliances only**	**Appliances + HP**	**Appliances only**	**Appliances + HP**
Hotel	4,500 m^2	490,000 kWh	880,000 kWh	**1,200**	1,750	**18,100**	25,700	9.1	12.9	**310,000 - 650,000**	440,000 - 870,000
Healthcare facility with night care	6,000 m^2	410,000 kWh	1,100,000 kWh	**950**	1,700	**14,000**	25,100	7	12.7	**240,000 - 470,000**	430,000 - 850,000
Supermarket	1,600 m^2	120,000 kWh	100,000 kWh	**280**	400	**4,100**	5,600	2.1	2.8	**70,000 - 140,000**	95,000 - 191,000
Large school	9,000 m^2	350,000 kWh	790,000 kWh	**380**	1,050	**5,500**	15,400	2.8	7.8	**90,000 - 190,000**	260,000 - 530,000

Households

Calculations have been made for the required battery capacity for a typical European household, all calculations can be found in Appendix D. From these, it is estimated that:

- A 20 to 25 kWh battery system is required to supply electricity for 72-hours for a household with regular electricity demand (domestic appliances - no heating); which is approximately 34% of the households in 2040 according to ENTSO-e scenarios.
- A 75 to 150 kWh battery system is required for a household with an electric heat-pump (depending on the house size); an estimated 50% of all households will have a heat pump in 2040.
- A 90 to 175 kWh battery system is required for households with a heat-pump, electric cooking and electric car. In 2040, an estimated 66% of all households will own an electric car, of which a significant part will also own a heat pump.

Most current systems in the EU are 5 to 10 kWh, which are often the most economically feasible and in line with the household's electricity production (e.g., from solar PV) and demand. The expected incremental uptake will start with households with solar-PV, enabling lower energy cost and curtailment. With a further increase in rooftop solar, the growth of household battery storage is expected to grow in line. To meet the 72 hour preparedness goal with a battery system, a significantly larger system would be required. This system will be significantly more expensive for households and would be idle for most of the time. With a regular battery system (5-10 kWh) households could supply 36 hours (average household) or 12 hours (with heat-pump) of electricity.

If only approximately 2% of households were to install 72-hour-volume batteries, the expected 2040 scenarios of the ENTSO-e[103] (which includes projected market growth) would be met.[12] Implementing a 72-hour target for all households would mean an additional increase in installed battery capacity, and 3.5 - 5.5 years of all current global production capacity just to meet household demand. The total required battery capacity would be 10,000 up to 16,300 GWh.

Currently, plans for sodium-battery plants in Europe are made for less than 10 GWh/year production capacity by 2030 (see section 6.6). The current planned production capacity could only realise a small portion of the required battery capacity (0,1% yearly). Therefore, for European-produced sodium batteries to significantly support the 72 hour preparedness goals, significant manufacturing scaling up would be required. This magnitude of scale-up would be challenging to meet based on the challenges highlighted throughout this study.

The average battery capacity, weight and size of household BESS. We have used an energy density of 0.068 kWh/kg and 135 kWh/m^3 for sodium batteries.[104] The current battery prices for a 20 kWh household battery is approximately 600 EUR/kWh for lithium-ion.[105] At the moment battery cost for sodium and batteries are comparable, and thus we have assumed this price as the high value in our range. However, battery costs have decreased significantly in the previous years. Sodium battery price projections predict a potential further reduction towards 40 USD per kWh. For a rough estimate a price of 300 EUR /kWh has been used as the lower range value. This represents a future battery price, potentially also for sodium batteries, although there is considerable uncertainty.

Table 5-2 – Size and weight of household sodium batteries

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[12] Forecast is not directly linked to the future production potential in the EU but to the current global production potential.

	Battery capacity (kWh)	Weight (kg)	Size (m^3)	Potential dimensions (m)	Cost indication (EUR)[13]
Total - traditional household	21.8	321	0.16	0.5 x 0.25 x 1.3 m*	6,500 – 13,100
Total - household with heat pump	112.4	1.653	0.83	0.5 x 0.25 x 6.6 m or. 1 x 1 x 0.8 m**	33,700 – 67,400
Total - household with heat pump and EV	133.0	1.956	0.99	0.5 x 0.25 x 7.9 m or. 1 x 1 x 1 m**	39,900 – 79,800
Total - household with EV	42.4	624	0.31	0.5 x 0.25 x 2.5 m or. 0.5 x 0.5 x 1.25 m***	12,700 – 25,500

*Similar volume to a small bookshelf
**Similar to half a large shower cubicle
***Similar volume to an under-counter refrigerator or washing machine

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[13] Assumed range of battery prices between 600 EUR/kWh (current lithium-ion and also representative for sodium) and 300 EUR/kWh (potential future price for sodium due to technical development and larger scale production).

6. Sodium battery market overview and forecast

6.1 Section overview

This section has been broken down into the following sub-headings:

- **Global sodium battery industry and locations:** The global figures for existing sodium battery industries, and where they are located.
- **Investments and research initiatives:** Other actors investing in or developing production capacity and the type of use planned for the batteries (private households, vehicles, etc.).
- **EU production capacity:** The potential capacity of production of sodium batteries in Europe.
- **Future developments and time to operationalisation:** Future prospects for the implementation of sodium-ion batteries with a focus on total storage capacity needed and how much time it will take to become operational.

6.2 Current global market

As of 2023, global production capacity of sodium-ion batteries was reported at 42 GWh/year of which 99.4% was in China, despite demand only being estimated at 4 GWh.[106] IRENA estimated that global manufacturing capacity had grown to 70 GWh/year in 2025.[107] The discrepancy between production capacity and demand is likely due to several reasons, the first being that the sodium-ion battery industry has only recently entered a rapid growth phase and several battery manufacturers are rapidly scaling up production capacity in anticipation of surging demand. The second reason for this discrepancy is that it is common for reported maximum capacity to be significantly higher than utilisation for a variety of reasons, such as downtime for maintenance, supply bottlenecks, and yield losses. For comparison, production capacity of lithium-ion batteries was estimated to be 2,500 GWh/year while utilisation of this capacity was around 33% in 2023.[108]

Survey input from one battery manufacturer and updated market data confirm that global sodium-ion manufacturing capacity in 2026 is in the tens of GWh/year and scaling rapidly. One battery manufacturer commented that, depending on whether online, announced, or ramping facilities are included, global nameplate[109] capacity is trending toward around 70–100 GWh/year or more.

The same manufacturer also commented that, although China remains the dominant production base, Europe and North America have growing activity, primarily through pilot lines and early-scale factories. However, they currently represent only a small share of total output.

Current market valuations of the sodium-ion battery industry vary between sources, with estimates ranging from USD 0.15 billion to 0.54 billion (EUR 0.13 billion – 0.46 billion) as of 2026, as shown in Table 6-1.

Table 6-1 - Global sodium-ion battery market estimates

Market segment	Current valuation (EUR billion)	Projected valuation (EUR billion)	Compound annual growth rate (CAGR)
Sodium-ion battery market[110]	0.4 (2025)	0.85 (2030)	16.6%
Sodium-ion battery market[111]	0.13 (2024)	1.21 (2033)	28.5%

Market segment	Current valuation (EUR billion)	Projected valuation (EUR billion)	Compound annual growth rate (CAGR)
Sodium-ion battery market[112]	0.23 (2024)	2.34 (2034)	26.1%
Sodium-ion battery materials market*[113]	1.78 (2024)	24.36 (2034)	30%

** includes the value of all intermediate materials and products*

6.3 Forecast market growth and sectoral uptake of sodium-ion batteries

Global sodium-ion battery demand is projected to grow substantially over the coming decades, driven by both EV adoption and stationary energy storage requirements. Overall, the number of gigafactories worldwide is forecast to grow from 240 facilities today to around 400 by 2030, of which 85-90% are expected to still produce lithium-ion batteries, while sodium-ion batteries are expected to represent around 5% but a rapidly increasing proportion of gigafactories as the technology enters large scale commercialisation.[114]

Estimates suggest that global demand for sodium-ion batteries, which stood at approximately 4 GWh/year in 2024, could exceed 120 GWh/year in 2034 with a compound annual growth rate (CAGR) of 40%. This would see sodium-ion chemistry projected to reach 7% of the global battery market share in 2030 and 14% in 2040.[115] Other market analyses support this upward trend as shown in Table 6-2.

Table 6-2 - Comparison of sodium-ion battery annual demand forecast

Literature source	Annual demand (current)	Annual demand (projected)	Compound annual growth rate (CAGR)
Marek Bielewski et al. (2024)[116]	4 GWh (2024)	120 GWh (2034)	40%
Marija Maisch (2023)[117]	10 GWh (2025)	70 GWh (2033)	27%
Shazan Siddiqi (2025)[118]	10 GWh (2025)	>90 GWh (2035)	No data
Konsta Kuronen (2024)[119]	N/A	40-140 GWh (2030)	No data

There are approximately 30 sodium-ion plants currently operating, planned or under construction globally that could provide >100 GWh/year in total capacity by 2030. These plants are mainly located in China which is expected to drive the uptake of sodium-ion batteries.[120] To meet growing demand for sodium-ion batteries, global battery manufacturers have announced a combined production capacity of 240 GWh/year by 2030.[121]

By 2033, sodium-ion batteries are expected to achieve meaningful access across both grid and automotive applications, reaching around 7% of global grid and stationary energy storage deployments and approximately 6% of the passenger EV market.[122] Furthermore, the International Energy Agency (IEA) expects that the share of sodium-ion batteries will reach 5% of annual battery volumes in 2030, mainly for vehicles with low energy requirements.[123]

6.4 Regional overview of sodium-ion battery production

Planned and existing sodium-ion battery production facilities are distributed globally across Europe, Asia, North America and Australia.[124] Industrial-scale sodium-ion cell manufacturing is being advanced primarily by major established lithium-ion battery manufacturers in Asia, but also by technology-focused entrants to the market in Europe and Asia.[125] China currently dominates the sector, with the largest, most mature industrial base and the highest number of commercial-scale facilities, although there are a diverse range of companies spanning Europe, Asia, North America, and Australia. The leading producers of sodium-ion batteries, the regions they operate within, and their role in the value chain are outlined in Appendix E.

While over 99% of production capacity is currently estimated to be in Asia-Pacific, according to one market report the region currently captures only 47% of the global sodium-ion battery market share.[126] The region is however expected to remain the fastest-growing region with a projected 20% CAGR from 2025 through to 2030.[127] The same report estimates that Europe currently accounts for roughly one-quarter of global market share for sodium-ion batteries.[128]

6.4.1 China

As noted by IRENA, the majority of global predicted growth in the sodium-ion market will be in China, driven by industrial scale deployment and strong investment appetite.[129] China is leading this drive by implementing national strategies targeting over 50% of global sodium-ion manufacturing capacity with numerous gigafactory-scale projects already operational and under construction.

CATL is emerging as the global leader in sodium-ion development, other major players in China include BYD and HiNa Battery Technology, which together, represent a large part of installed global capacity providing China a significant first-mover advantage.[130] In 2021, HiNa and two subsidiaries of CTG worked in partnership, alongside local authorities, to build the first 1 GWh sodium-ion battery production plant in Fuyang. Phase 1 came online in December 2022, and the companies have subsequently planned for expansion of the plant's capacity to reach 5 GWh by an unspecified date.[131] Also in 2021, CATL revealed its first-generation sodium-ion cells (described in section 4.5) and a 40 GWh phase-one plant which was due to come online in December 2025 to build passenger-EV packs. CATL's public goal is to shift up to half of its current LFP volume to sodium-ion by 2028.[132]

6.4.2 Europe

Current production capacity of sodium-ion batteries in Europe is minimal, but European companies such as Faradion , Tiamat and Altris AB are currently seeking to scale up production of sodium-ion battery technologies.[133] The current status and potential of EU production capacity is explored in more detail in section 6.6. Similarly, while there is plenty availability of sodium in Europe, the supply chain for battery-grade purification and logistics is currently lacking, which is further detailed in section 7.2.

6.4.3 United States

In the United States, there is limited information on installed production capacity, but supply chain security and sustainability concerns are promoting research and development in sodium-ion batteries. This is supported by Department of Energy (DOE) initiatives (LIFT and LENS consortia) and funding from the Bipartisan Infrastructure Law and Inflation Reduction Act.[134]

6.4.4 Australia

Despite having limited production capacity currently, Australia is well positioned to become a strategic resource hub for sodium-ion batteries due to its large sodium reserves and policies such as the Critical Minerals Strategy.[135] The strategy illustrates that the Australian government is seeking to diversify away from lithium and rare earths dependency, towards alternative chemistries such as sodium, which is backed by several funding programmes for advanced battery technologies, including sodium-ion batteries.[136]

6.5 Investment and research initiatives

Investment into sodium-ion battery technology is accelerating across the automotive, stationary storage, manufacturing, and research sectors. Several companies are increasing their production and research efforts, including car manufacturers, industrial battery makers, utilities, and research organisations, who are all showing growing interest in the BESS market. The main areas for investment in capacity and usage of sodium batteries are described below.

6.5.1 EV supply chains and pivot to static BESS markets

Several automotive Original Equipment Manufacturers (OEMs) have announced sodium-ion vehicle models which overall reflects a growing confidence in readiness of the technology, including BYD's Seagull which features a 300 km range priced at approximately USD 11,600 (EUR 9,814). Another notable model by the Volkswagen Group and Anhui Jianghuai Automobile (VW-JAC) joint venture is the Sehol EX10 which achieves a 250 km range. [137]

These developments indicate that commercial sodium-ion EVs are beginning to enter the lower-range, cost-sensitive segment. This is particularly visible in China, where both BYD and VW-JAC are based and where early commercialisation is taking shape, driven by what industry observers describe as "aggressive investments".[138]

However, there is a general consensus that the automotive industry will not be the primary market for sodium-ion batteries in the short term. Even though sodium-ion is now demonstrably technically viable for EVs, most assessments still conclude that the main application area is considered to be (grid- and household scale) stationary storage.[139] This suggests that, while some OEMs initially pursued sodium-ion for mobility applications, a strategic shift is now underway toward industrial and grid-scale storage as performance and cost effectiveness continue to improve. This shift is already emerging in the market. For example, Volvo Cars has become the first automaker to invest directly in sodium-ion, joining Altris' Series B round specifically to co-develop Prussian white packs for stationary storage, illustrating how OEM interest is beginning to extend beyond vehicles into static BESS applications.[140]

6.5.2 Existing supply chains, investment and technological advantages

Globally, across OEMs, investment in sodium-ion research and development is aiming to address cross-cutting challenges. These challenges include supply chain constraints, cost reduction, enhancing performance and reducing environmental footprint.

The roll-out of sodium-ion batteries for these applications in Europe is currently limited. European OEMs and research consortia are focussing on strengthening domestic battery supply chains in sodium-ion technology. However, most of the leading players are in Asia. Manufacturers in China hold significant first-mover advantage including technical knowledge gained from first-hand experience in scaling up production.[141] These companies also hold proven manufacturing capability at scale and have established relationships with other OEMs including component manufacturers.[142] One report found that 300 MWh worth of grid-scale sodium-ion batteries had already been installed across projects in China as of Q1 2025 with more under construction, showing the maturity of the technology.[143]

Leading global players such as CATL, BYD, Natron and HiNa are benefitting from more mature supply chains and are able to rapidly scale capacity at GWh levels.[144] At an even further advantage are those with advanced intellectual property portfolios and relationships with utilities, OEMs, and national laboratories.

6.5.3 Research initiatives and development funding

Alongside the growth driven by OEMs, public-private research consortia are also playing a central role in sodium-ion development from a chemistry improvement and supply chain maturity perspective. Key initiatives include:

- The US Department of Energy’s partnership with the LENS Consortium has committed to long-term funding including USD 50 million (EUR 42.3 million) over five years to accelerate sodium-ion battery innovation.[145]
- EU public investment in battery R&D&I was EUR 300 million in 2022, a four-to-six-fold increase compared to 2019.[146]
- In the EU, Horizon Europe and the European Battery Alliance are both prioritising alternative chemistries (such as sodium-ion), alongside lithium-ion.
- The EU-funded SPRINT project, currently budgeted at EUR 7 million over 46 months, is accelerating the development of safe, low-cost quasi-solid-state sodium-ion batteries for stationary storage, targeting major improvements in cost, energy density, cycle life and commercial readiness.[147]
- Also in the EU, SOLSTICE is an EU-funded research project developing sodium-zinc (Na-Zn) molten-salt batteries designed for large-scale grid energy storage.[148]
- In Germany, an industrial partnership has been formed between Altech Chemicals and Fraunhofer IKTS which aims to commercialise “the sodium alumina solid state (SAS) battery” for grid-scale energy storage.[149]

One stakeholder noted that in regions like China, provincial governments often provide long-term financing for factories. In contrast, European manufacturers must secure commercial bank debt, which is harder to obtain.

These R&D programmes are primarily aligned with grid-scale energy storage objectives, which overall reflect a general priority for low-cost, flexible storage solutions.

6.6 EU production capacity

It is difficult to estimate an overall sodium-ion battery production capacity for the EU from literature sources. According to the Joint Research Centre, in 2023 the planned production capacity in the EU for Sodium-ion batteries by 2030 was 6 GWh/year (of the expected 186 GWh/year global capacity estimate at the time).[150]

Since that report was published, European companies such as Tiamat and Altris AB have scaled up production of sodium-ion battery technologies.[151] However, these appear less mature than the manufacturing plants currently emerging in Asia, according to one battery manufacturer.

One battery manufacturer reinforced this by mentioning that there is early-stage EU activity (pilot lines and industrial ramps) mainly in France and northern / central Europe, often focused on materials and initial cell manufacturing. It was emphasised that overall EU cell capacity is still limited today, but momentum is building. From the research below, it is estimated that the EU has planned approximately 8 GWh/year by 2030. Further information can be found on companies in Appendix E.

6.6.1 Tiamat[152] (France)

Tiamat is a forerunner when it comes to sodium-ion batteries in the EU and commenced production in 2023 with a capacity of 1.2 GWh/year. It was the first company to put a sodium-ion battery powered product on the market in 2024 (a cordless screwdriver).[153] Tiamat has announced additional plans to expand to a production capacity of 6 GWh/year, at the latest by 2030.[154]

6.6.2 Altris AB[155] (Sweden)

Altris was founded in 2017, spun out from Uppsala University and has since received investment from several sources, including Volvo Cars (Sweden), InnoEnergy[156], Northvolt[157], Molindo and the Swedish Energy Agency.[158] One investor contacted for this study shared that in 2026 Altris is planning limited production of approximately 200MWh based on Altris' proprietary PBA cathode. An academic institution also outlined that there is an ongoing partnership between Altris and Draslovka[159], designed to upscale production of sodium cathode material on an industrial scale. Furthermore, the same academic institution highlighted that there is an existing partnership between InoBat[160], Altris and Clarios[161] to produce sodium battery cells on a large scale.

6.6.3 Heiwit S.p.A.[162] (Italy)

Heiwit S.p.A. is currently raising capital to develop a sodium-ion battery manufacturing facility with a gradually increasing capacity of up to 1 GWh/year in Italy.

6.6.4 Moll Batterien[163] (Germany)

According to an investor's survey response, Moll Batterien in Germany is preparing for a plant capacity of 1 GWh in 2026. In Moll Batterien's press release it is stated that it has committed to an investment of 80 million euros with the creation of 120 jobs initially.[164]

6.6.5 European production forecast

Market reports indicate that there are regional growth opportunities within Europe.[165] One report expects OEMs to contribute to an expected +3.8 % CAGR in Germany, France and the UK in the next 2-4 years. The Nordics (Sweden, Norway and Finland) are expected to have further gains.

One model predicts that the battery capacity demand for sodium-ion batteries in Europe is expected to reach up to 205 GWh/year for small EVs and 220 GWh/year for large EVs by 2070.[166]

6.7 Future prospects and time to operationalisation

Progress in sodium batteries relies primarily on R&D efforts aimed at improvements in energy density, increasing specific capacities, and refining electrode architecture. According to stakeholders, emphasis is currently placed on advancing hard-carbon anodes and layered-oxide cathodes[14], both of which remain central bottlenecks due to challenges around material consistency and scalable production but hold potential for performance gains.

Meanwhile, sodium-ion batteries using gel or solid polymer electrolytes are approaching maturity and have already been deployed in some mobility applications.[167] One of the surveyed battery manufacturers recommended that Europe should focus on the next generation of sodium batteries based on solid electrolytes, which could allow the EU to take the lead in a new disruptive technology.

Current industry interest suggests that large-scale production and technological maturity could be achieved in Europe by 2030, although the development of sodium-ion systems suited for long-duration (>10 h) energy storage may require an additional five to ten years.[168]

Gigafactories typically require at least five years from planning through construction to reach full production capacity, meaning most investment and siting decisions for meeting 2030 battery demand have already been made.[169] Industry experience for lithium batteries shows that production start-up is often delayed by one to two years and final output is frequently lower than planned.[170]

While individual cell-manufacturing steps are understood, scaling them to gigafactory level is complex. Success depends on the seamless integration of many linked processes and a stable, well-validated product design. Even small specification changes or parameter deviations can cascade through the production chain, affecting performance and yield. As a result, achieving timely, cost-competitive ramp-up is less about a few major levers and more about solving numerous small technical issues and understanding how each one influences the broader system.[171]

There is significant competition to reach key milestones in sodium-battery development which are likely to define the market in the future.[172] Table 6-3 below presents likely future developments in the sector and why this matters for global competition.

Table 6-3 - Future outlook for sodium-ion battery technologies (2026-2030).

What to watch	**Why it matters**
Energy-density race to 200 Wh/kg	CATL and Faradion both target that milestone by 2027.
Stationary storage	High-cycling batteries (e.g. Natron’s 50,000-cycle, 15-minute-recharge packs) could become the preferred option for 2-hour grid and data-centre roles where longevity and power are more important than energy density.
China’s small-EV segment	Lower performance (e.g., city EVs) will likely adopt sodium packs first (range approximately 250 km), creating mass-production volumes.
Hard carbon supply chain	The remaining major cost challenge is the production of low-cost anodes derived from bio-waste or petroleum coke. Whoever scales this manufacturing process most efficiently will set the industry cost benchmark.
Rapid scale-up[235]	With mass production underway and over 100 GWh of cumulative capacity now financed across three continents, the technology is on track for substantial scale-up. If cost and durability targets are met during 2026 field deployments, the chemistry could achieve a double-digit share of the grid-storage and short-range e-mobility markets well before 2030.[235] [173]

Adapted from source: Ibad Ather (2025) Sodium-ion batteries in 2025: a snapshot of the fast-emerging “post-lithium” option. See: https://synergyfiles.com/2025/06/Sodium-ion-batteries-in-2025-a-snapshot-of-the-fast-emerging-post-lithium-option/

7. Material availability and industrial symbiosis

7.1 Section overview

This section has been broken down into the following sub-headings:

- **European sodium availability:** How much sodium is available in Europe for the production, and where it is located.
- **Desalination and battery synergy potential:** The potential for sodium battery production through synergies with desalination plants.
- **Critical raw materials used in sodium-ion batteries:** Dependencies on other critical materials.
- **Industrial synergies:** Existing industries which could rapidly be converted or include sodium batteries in their portfolio.

7.2 European sodium availability

7.2.1 Sodium extraction

Sodium is extremely abundant in nature. According to IRENA, sodium is roughly 1,000 times more abundant than lithium in the earth's crust and nearly 60,000 times more abundant in seawater, highlighting its long-term availability and security of supply.[174] It is the second most abundant element and accounts for 2.9% of the earth's crust, compared with 0.0021% for lithium.[175] Its presence in seawater is approximately 1.08×10^4 mg/L.

Sodium is widely distributed along coastlines and does not require extraction from highly concentrated deposits in politically sensitive regions making it a more accessible and less expensive resource than lithium. Furthermore, sodium, at the grade required for battery manufacturing, can be sourced from saline deposits, sedimentary rocks and seawater allowing Europe to rely on local resources.[176]

In Europe, the raw sodium material value chain for sodium-ion batteries exists but production capacity will need to scale up rapidly as sodium-ion cell manufacturing and demand expands. Supply chains will therefore need to adapt to meet these demands.

According to an industry association, Europe is largely self-sufficient for salt extraction, with an industrial capacity of around 77 million tonnes per year, with actual production of approximately 50 million tonnes in 2023.[177] Stakeholders stated that this level of production is more than sufficient to meet existing and new demand, including potential battery related applications. Extra-European trade is limited; Europe typically imports only 2-4 million tonnes per year, mainly driven by seasonal de-icing needs, underscoring that European demand is largely met by European sources. Salt prices are low relative to transport costs, reinforcing the regional nature of supply and enhancing resilience against global supply shocks.[178]

Sodium is available in Europe through four principal salt sources, which are widely distributed geographically:

- **Underground rock salt (halite):** This represents around 36% of European salt production. It is extracted from extensive underground deposits formed by ancient, evaporated seas. Key producing countries include Germany, France, Italy, Poland, Romania, Spain, Turkey, and the UK. Total European rock salt capacity is approximately 22.9 million tonnes per year. These deposits offer very large reserves and long mine lifetimes, making them particularly suitable for long term strategic uses such as energy storage materials.

- **Brine (solution mined or natural brines):** Accounts for a significant share of sodium supply, particularly for industrial uses and it is produced by dissolving underground salt deposits or tapping natural brine springs. Major production locations include Germany, France, the Netherlands, Poland, Romania, Spain, Italy, Austria, and the UK. European brine production capacity amounts to roughly 27.5 million tonnes (NaCl equivalent). Brine is already widely used in the chemical industry and can be directly converted into high purity salt suitable for battery requirements. Other raw materials can be extracted from brine, these include calcium, lithium, boron, phosphorus, and vanadium.
- **Vacuum (evaporated) salt:** Accounts for around 20% of European salt production. It is produced by evaporating purified brine in closed systems, resulting in very high purity NaCl (>99.8%). Main producing countries include Germany, France, the Netherlands, Poland, Spain, the UK, Austria, Switzerland, and Turkey. This type of salt is already used in high purity applications, including chemical, pharmaceutical, and technical uses, and is particularly relevant for sodium battery technologies.
- **Solar (sea and lake) salt:** Represents around 11% of European production. It is produced via solar evaporation of seawater or saline lakes. It is concentrated mainly in Mediterranean and Atlantic coastal regions, including France, Spain, Italy, Greece, Portugal, Croatia, and Turkey. While more climate dependent, solar salt adds source diversity and geographical redundancy to sodium supply.

The industry association further highlights that even large-scale deployment would consume only a fraction of current salt output. The diversity of sources, high production volumes, established infrastructure, and European self-sufficiency make sodium a low risk, geopolitically stable raw material for enhancing household and grid energy resilience within the EU. A battery manufacturer emphasised that sodium is highly available in Europe, sourced from sea salt, brines, rock salt deposits and existing sodium chemical value chains, noting that the real challenge is battery-grade purification and logistics, not raw availability. Another battery manufacturer noted that Europe lacks an industrial value chain for refined sodium products, whether sourced from seawater or land-based mining.

7.2.2 Desalination and alternative sodium sources

A potential source of sodium is from desalinisation plants which produced over 140 million m^3 of brine per day in 2019 globally, with brine containing high concentrations of sodium.[179] While the majority of desalination plants are in arid areas such as the Middle East and Northern Africa[180], data from the European Marine Observation and Data Network shows that there is significant desalination capacity in Europe, particularly in countries around the Mediterranean.[181] Table 7-1 illustrates that within the EU, Spain has the largest capacity of seawater and brine desalination plants, followed by Italy, Cyprus, Malta and Greece. This shows that there is the possibility for these countries to supply significant amounts of sodium for the production of sodium batteries.

Table 7-1 - Capacity of seawater and brine desalination plants in the European Union (top 5 countries by capacity)[182]

Country	**Total capacity in m^3 per day**
Spain	2,859,069
Italy	531,611
Cyprus	331,825
Malta	301,299
Greece	183,092

Another example of industries that have potential synergies with sodium batteries are chemical industries that produce sodium-rich by-products. For example, sodium sulphate could be retrieved from industrial wastewater from industries such as caustic soda manufacturing, chemical production, textiles, and pharmaceuticals[183]. This leans into a circular economy model, through reducing environmental and disposal costs in those industries as well as reducing the demand for raw materials in sodium-ion battery manufacturing.

This industrial symbiosis is already taking place in other chemical manufacturing sectors; for example, Covestro, a plastic manufacturer, at its Krefeld-Uerdingen site in Germany obtains NaCl from chemical processing and reuses this on site, reducing the demand for virgin salt by around 19,000 tonnes/year[184].

7.2.3 Suitability for battery production

It is important to note that brine from desalination plants does not just consist of water and sodium but can also contain other compounds or chemicals including cleaning chemicals and heavy metals.[185] Therefore, the viability of desalination plants feeding into sodium battery manufacturing depends on the economic viability of processing brine by removing these contaminants and refining the sodium in the brine to an acceptable grade.

7.2.4 Suitability for battery production

One battery manufacturer cautioned that seawater-derived sodium may present challenges due to impurities, whereas extraction from specialised water sources, (similar to lithium) brine could be viable by leveraging existing processing infrastructure.

Several stakeholders highlighted how the suitability depends on specific battery chemistries. One academic institution added that for some sodium-ion systems (e.g., Altris Prussian white batteries), all required raw materials including iron, sodium, carbon and nitrogen, are already available within Europe. A battery manufacturer has also stated that sodium is a secondary product of the lithium extraction, generated in very large quantities, which keeps costs low.

Stakeholders generally agreed that there is potential for sodium from desalination plants to be used for the production of sodium batteries. One battery manufacturer argued that future desalination plants should be designed with this perspective from the outset.[186] However, several battery manufacturers noted significant limitations to using brine from existing desalination plants:

- Sodium from desalination brine requires significant purification to meet ‘battery grade’ specifications.[187]
- Virgin sodium is abundant and relatively low value, meaning that there is little economic incentive for desalination plants to purify, store and transport sodium from brine. Battery producers may not be located near desalination plants therefore it may need to travel large distances which can be economically infeasible.[188]
- There are potential permitting constraints around the reuse of sodium from desalination plants.[189]

7.3 Critical raw materials used in sodium batteries

In addition to sodium, sodium batteries also currently require the use of critical raw materials for production which can lead to some of the dependencies seen with lithium batteries. The following critical materials were identified for sodium batteries:

- Nickel, vanadium and cobalt could be used in cathode active materials, as highlighted by an investor and academic institution. These materials are also used in lithium-ion batteries and face the same limitations. However, dependency may be reduced as the amount used in sodium batteries may be less than in lithium-ion batteries. There is the potential to switch to iron-based cathodes which are under development (and being used in some cases) which are not reliant on critical raw materials.

- Hard carbon is used in the anode active materials, as highlighted by an investor and battery manufacturer. Hard carbon availability is limited, with the supply chain mainly being in China and Japan. However, hard carbon is a bio-based material, derived from wood or agricultural waste, meaning that there are opportunities to strengthen regional supply chains within the EU and reduce strategic reliance on imported anode materials. Establishing production should be feasible in the EU, allowing a more competitive and resilient supply chain compared with battery-grade graphite.
- For sodium permanganate (used as an additive in electrolytes), manganese is required, as highlighted by a battery manufacturer. The supply chain for this material is not yet developed in Europe.
- For $NaAlCl_4$ (which is used as a solid electrolyte, or precursor to composite solid electrolytes), aluminium should currently be readily available in Europe as highlighted by a raw material manufacturer.

A research institution and battery manufacturer stated that critical raw materials may be needed depending on the cathode material but did not provide further information on the material types.

Stakeholders stated that the dependencies of the sodium battery market could shift to cathode precursors (chemistry-dependent), hard carbon, electrolyte salts/additives, separators/solvents/binders, and BMS electronics. They emphasised that the sodium battery market will reduce lithium-related constraints but not remove strategic dependencies on other components such as BMS electronics which are often currently developed outside of Europe. For example, China, Japan, and South Korea dominate the global BMS market due to the dominant EV battery manufacturing ecosystem and integrated supply chains. [190]

7.4 Potential for conversion from lithium to sodium-ion battery manufacturing

This section reviews the potential for existing industries to rapidly pivot to the production of sodium batteries. The primary candidate that would be suitable for this rapid upscaling is the lithium-ion battery sector, as sodium-ion is considered a “drop-in” technology to the existing lithium-ion battery gigafactories.[191] The similarities between the two technologies could enable a smooth transition with relatively little new investment to convert either entire plants or individual production lines to sodium-ion battery production. This is for the following reasons:

- First, the cell components and the electrochemical reaction mechanisms of sodium-ion batteries are largely identical to those of lithium-ion batteries, with the exception of sodium being used instead of lithium for the charge carrier.[192] The cell design is also similar between the two battery types, and it is partially because of this similarity that sodium-ion batteries are gaining momentum, as the production methods are well known and proven.
- Second, sodium-ion batteries can be manufactured using the same production steps (electrode production, cell assembly, formation) and using existing infrastructure, equipment, and skills used for manufacturing lithium-ion batteries, with only minor modifications needed to the production process.[193] This means that existing lithium-ion battery manufacturers would be able to transition to sodium-ion batteries with minimal additional capital cost requirements.

One battery manufacturer highlighted that most LFP production lines in particular can be transformed to sodium-ion battery production lines within around two weeks if required. This means that de-facto production capacity can be rapidly scaled up, provided that key raw materials, such as NFPP and hard carbon, are available. Additionally, one academic institution highlighted that this conversion had already been carried out by InoBat, which is now producing sodium-ion batteries on the same line that used to produce lithium-ion batteries.

According to the new-automotive battery tracker, there are 257 GWh of installed annual capacity of lithium-ion gigafactories in the EU.[194] Assuming an energy density of 66% (midpoint of 17-49% reduced energy density[195]) compared to lithium, this equates to 170GWh of capacity that could be readily converted to sodium battery capacity. This is equivalent to 70% of the 240 GWh of planned capacity announced by companies globally.

However, it should be noted that while the manufacturing steps are almost identical, there are several critical steps, such as electrode drying and formation procedures, which may prove challenging in terms of cost, limitations of equipment and process optimisation.[196]

Stakeholder feedback confirmed that, while most lithium-ion battery factories could be converted to sodium-ion, there are a number of limitations to consider:

- A battery manufacturer commented that, because of the lower cell density, the output in GW from a sodium-ion battery line will be a third to a half lower than an equivalent lithium-ion battery line, which would have a significant impact on the revenue generated.
- Two battery manufacturers commented that prismatic cells are preferred for sodium batteries, meaning that plants which are designed to manufacture pouch or cylindrical cells would not be able to adapt easily and would require significant changes in the production process.
- A battery manufacturer commented that, while the investment cost to convert to sodium-ion batteries is low, sodium is very sensitive to moisture and that careful control of this could require additional heating or ventilation and as a result increased energy consumption.
- A battery manufacturer noted that adjustments would have to be made to calibration equipment and software, however these are minor differences.

8. Drivers, barriers, challenges and opportunities

8.1 Section overview

This section outlines the main drivers, barriers, challenges and opportunities for the deployment of sodium-ion batteries and the opportunities to promote them. It also outlines the financing, cost structures and investment risks associated with scaling up sodium-ion battery facilities.

8.2 Technology characteristics

- **Driver - Improved lifespans -** Earlier sodium-ion battery technologies were hampered by faster degradation and shorter cycle life due to the larger size of sodium-ion batteries. However, recent innovation has significantly extended lifespans. Advances in hard-carbon anodes now reduce mechanical strain during cycling, more stable electrolytes improve long-term performance, and strengthened cell structures (including better separators and binders) help maintain physical integrity across repeated charge–discharge cycles.[197] However, current lifespan performance continues to lag behind lithium-ion batteries.
- **Driver – Low temperature performance -** Sodium-ion batteries can operate reliably to -40°C, offering a technical advantage for cold-climate markets.[198] Currently Nordic incentive schemes are accelerating uptake of home-energy systems designed to operate reliably to -30°C.
- **Driver – Safer handling and transport -** Modern sodium-ion chemistries address historical fire-safety issues seen in older ZEBRA and Na-S systems which operate at high temperatures. They can also be fully discharged to 0V, making them intrinsically safer to ship and manage than lithium-ion batteries which must be partially charged for transportation by law.[198]
- **Barrier – Lower energy density -** Sodium-ion batteries still trail high-performance lithium-ion batteries in energy-intensive, weight-sensitive uses (e.g., EVs). Material-level constraints (sodium's heavier atomic mass and larger ionic radius) result in lower electrochemical performance.[199] [200] [201]
- **Driver – Improved inherent safety –** Sodium-ion batteries are generally safer than lithium-ion batteries because their chemistry is less prone to thermal runaway. They also maintain stable performance across a wider temperature range, which reduces internal stress and failure risks often observed in lithium-ion cells under similar conditions.[202]
- **Barrier – Need for advanced electrolytes -** Scaling sodium-ion batteries requires innovations such as improved electrolytes and added manufacturing steps like pre-sodiation[14] that allow high charge-discharge rates over a wide temperature range, with long cycling and long lifespan. While these enhancements improve performance for large-scale storage, they introduce extra cost and complexity compared with drop-in lithium-ion processes.[201]

8.3 Supply chains and raw materials

- **Driver – Material security** – One of the strongest drivers for sodium-ion battery development in Europe is raw-materials security. The deployment of critical raw material (CRM)-free batteries such as sodium-ion batteries would significantly reduce dependence of the EU from third country suppliers for lithium and other critical raw materials.[203] Research is being conducted to remove remaining or shifting material dependencies.

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[14] This involves introducing sodium into the negative electrode from an additional sodium source due to its insufficiency in the electrolyte and the positive electrode, allowing it to reach a defined capacity.

- **Barrier – Other material dependencies –** Although there would be reduced dependency on some raw materials such as lithium and some electrode materials, one manufacturer argues that the dependencies may shift towards other critical materials such as hard carbon and manganese compounds as well as components such as battery managements systems which continue to be produced outside of Europe and are also a dependency for other battery types such as lithium-ion.
- **Barrier – Immature and fragmented supply chains –** Although a wide set of materials can be used in sodium-ion batteries, the current supply chain is nascent and inconsistent, with limited standardisation.[204] Industry is converging on fewer chemistries (e.g., hard carbon for anodes and layered oxides, polyanionics and PBAs for cathodes) but the ecosystem remains fragmented.[205]
- **Barrier – EU supply-chain gaps –** Multiple stakeholders emphasised that the European sodium-ion battery supply chain is not yet mature enough to support rapid scale-up. An investor identified the creation of a reliable upstream chain (particularly for sodium and sodium compounds) as one of the core challenges alongside technology industrialisation and cost reduction. A battery manufacturer reinforced this in its survey response, arguing that Europe must first secure domestic raw-material production. Another manufacturer argued that the lack of supply of sodium-specific inverters is a key barrier.
- **Barrier – Raw material bottlenecks and processing costs** – According to a battery manufacturer's survey response, raw-material supply remain a key bottleneck. Volatile lithium carbonate prices could make sodium-ion more cost-competitive, yet sodium-ion batteries require more units to match energy density, which could increase processing costs to meet the same capacity as lithium-ion batteries. Nevertheless, converting most lithium-ion lines is seen as feasible with relatively modest changes, mainly to humidity control, provided Europe secures upstream materials such as hard carbon and NFPP.

8.4 Regulatory

- **Driver – Mature regulatory environment** – Europe is a significant market, with countries including Germany, the UK and France currently leading development.[206] The EU's strong regulatory, industrial and sustainability environments together create enabling conditions for sodium-ion battery development and adoption. For example, the EU's Critical Raw Materials Act incentivises the production and scale-up of materials that can substitute strategic raw materials such as battery-grade lithium, with battery-grade sodium being a clear candidate.[207] In addition, the EU Battery Regulation[208] implements lifecycle-footprint metrics into product approvals, pushing OEMs toward lower-carbon, lower-CRM chemistries such as sodium-ion batteries in affordable / suitable industries, including urban vehicle segments and stationary BESS. Sodium-ion batteries have 35–40% lower embedded carbon compared with current lithium-ion batteries.[209]
- **Barrier – Lack of harmonised standards and policy clarity –** Commercialisation continues to be slowed by the absence of harmonised global safety and performance standards, which complicates validation processes and elevates integration risk for utilities and industrial users.[210] One battery manufacturer noted that dangerous-goods classifications[15] have not yet been updated to reflect the characteristics of sodium-ion batteries, leaving a regulatory gap that impacts market readiness. Similar uncertainty affects permitting, where unpredictable processes and complicated funding pathways continue to impede project development. An academic institution argued that technical issues are now secondary and that the sector urgently requires governmental and industrial

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[15] For example, ADR – European Agreement concerning the International Carriage of Dangerous Goods by Road and RID – Regulations concerning the International Carriage of Dangerous Goods by Rail which classify most batteries as Class 9 dangerous goods due to fire and thermal-runaway risks

commitment to build the giga-scale production capacity needed for sodium-ion batteries to reach maturity. A manufacturer echoed this sentiment, saying that the absence of a European strategy to scale sodium-ion manufacturing is a barrier.

- **Barrier – Indiscriminate battery regulations –** Two battery manufacturers argued that Europe should update regulatory standards (e.g., transportation requirements) to reflect the lower risk profile of sodium-ion batteries compared to lithium-ion batteries, enabling more agile innovation and deployment. Several manufacturers also stressed the need for active governmental support to develop genuinely "Made in Europe" manufacturing, additionally one manufacturer argued that EU-origin labelling is a key enabler of competitiveness.
- **Barrier – Permitting and skills –** Stakeholders highlight additional structural barriers: a battery manufacturer pointed to slow and uncertain permitting as a major constraint, whereas an academic institution offered a different perspective, arguing that the slow pace of EU policymaking itself, rather than permitting, skills, or energy costs, is the primary bottleneck. They noted that lithium-ion battery technologies faced these same issues and still scaled successfully, suggesting that sodium-ion could too with the right policy support.

8.5 Market

- **Barrier - Cost competitiveness and external market pressure** – A recurring theme across stakeholders was that cost remains the defining challenge. One battery manufacturer cited limited strategic government backing, insufficient raw-material capacity and strong price pressure from China. Another manufacturer echoed this, adding difficulties in financing new assets and matching the cost level of imported products from China. Furthermore, battery manufacturers highlighted related financial constraints in Europe including high (and volatile) energy prices, high operating costs, high personnel costs, and the difficulty of achieving bankability against aggressively priced LFP alternatives. One battery manufacturer also emphasised that cathode active material (CAM) production is strategically important for Europe but financially unviable with current market prices. They suggest targeted EU incentives (e.g., minimum recycled material requirements or adjusted raw material import rules) to strengthen the economics of domestically produced CAM and to enable broader manufacturing expansion.
- **Barrier – No guarantee of market –** Whilst the market is widely expected to grow rapidly for sodium-ion batteries, it is not guaranteed, particularly in Europe therefore many producers are starting with pilot-scale to test demand. The development of a market and certainty of offtake (buyers) is required before investment can be made to scale. Policy-makers could support the development of this market.
- **Barrier - Limited OEM interest and inflexible industrial base –** According to a battery manufacturer's survey response, a key risk includes limited automotive OEM interest in sodium-ion batteries. They state that structural barriers exist; for example, European gigafactories have been built around EV-orientated lithium-ion lines, which sodium-ion battery technology cannot currently compete with.
- **Barrier - Structural bottlenecks in scale-up –** Persistent structural obstacles remain, particularly in transferring technologies from pilot to industrial scale and ensuring meaningful SME participation. These bottlenecks require applied R&D, targeted investment in technological infrastructure and stronger industry–academia collaborations.[211]

8.6 Policy and governance

- **Driver - Global policies supporting sodium-ion –** Emerging regional policies including the EU's Net Zero Industry Act, US IRA tax credits, and China's multi-GW storage targets are expected to boost major global manufacturing expansion.[212] The EESC already considers sodium-ion batteries a strategic complement to lithium-ion batteries and calls for decisive EU-level action to build a sovereign, competitive sodium-ion battery industry.[213]
- **Driver - Workforce, skills and social inclusion –** If the industrial pathway for sodium-ion batteries is accompanied by investment in workforce development, mobility and SME participation, it could be a key driver of socially inclusive and regionally balanced growth. This includes cultivating talent to foster knowledge and avoid brain drain from the EU.[214] A battery manufacturer reinforced that workforce training is a central enabler for technology scaling.
- **Driver - EU initiatives supporting coordination and innovation –** EU governance platforms such as the European Battery Alliance, European Raw Materials Alliance, the European Innovation Partnership on Raw Materials, and the European Technology Platform on Sustainable Mineral Resources are helping align actors, mobilise investment and coordinate innovation, providing a solid institutional foundation for sodium-ion battery scale-up.

8.7 Household batteries

- **Barrier - Cost sensitivity in domestic BESS markets –** According to one manufacturer, household-scale sodium-ion battery economics are highly sensitive to capital expenditures (CAPEX) and operational expenditures (OPEX), and the perception of it. Business models depend on tightly managed installation costs and realistic long-term operating expenses, making financial structuring more delicate than in utility-scale systems. Residential customers benchmark directly against 'aggressively priced' LFP.
- **Barrier - Larger system footprint and installation constraints –** Two battery manufacturers noted that current household sodium-ion battery systems are slightly bulkier than LFP for the same usable energy. This is due to a 17–49% lower energy density for sodium-ion batteries currently, meaning that for a sodium-ion battery system to have the same capacity as LFP, it would also have to be larger. This affects where units can be placed, how they are mounted and the range of properties they are compatible with, creating a practical and commercial constraint for installers and investors.
- **Barrier - Integration and compatibility challenges** – A battery manufacturer highlighted continued integration hurdles, including inverter and energy management system compatibility, charge-discharge control, commissioning and compliance with national grid codes. These add engineering and validation complexity for manufacturers and installers.
- **Barrier – Limited proof of concept and warranty –** As noted by a battery manufacturer, as a newer chemistry, sodium-ion batteries lack the widespread installer confidence and proven performance of lithium battery technologies. Financial support (e.g., funding / loans) depends on demonstrable field data, clear certifications, reliable warranties and well-defined service pathways, all of which remain under development. For sodium-ion battery technology to scale in households, its advantages (particularly intrinsic safety, cycle life and real-world performance) must be clearly quantified and communicated.
- **Barrier - Safety, installation rules and compliance requirements –** Even with strong intrinsic safety of sodium-ion batteries compared to lithium-ion batteries, household deployment relies on robust BMS protections, high-quality enclosure standards and strict adherence to installation rules. These remain essential to pass certification and maintain investor confidence.

8.8 Commercial and industrial-scale

- **Driver – Space flexibility** – A battery manufacturer highlighted that commercial and industrial (C&I) users face a different challenge profile compared with households. C&I sites typically have fewer space constraints, allowing additional cabinets or containers. Although this is not the case for all businesses where space constraints may be a priority factor in decision-making.
- **Barrier – Engineering complexity –** According to stakeholders, larger-scale commercial systems face more complex engineering requirements, including peak-shaving, tariff optimisation and backup-power management. Permitting and grid-interface requirements are also heavier because larger power levels trigger stricter commissioning, protection and approval processes. Although return on investment is often clearer in C&I markets, procurement processes usually demand stronger guarantees, contractual agreements, and proven lifecycle evidence. Integration into complex commercial load profiles, combined with stricter permitting and protection requirements, creates additional friction for sodium-ion battery adoption at industrial scale.
- **Barrier – Infrastructure gaps –** A battery manufacturer noted that grid system components such as power conversion systems (PCS) often need adaptation to match sodium-ion battery voltage windows, an area that the EU electronics sector may not yet have prioritised to the same extent as other regions such as in China which is progressing faster across both cell design and ecosystem integration. This creates integration delays that slow European deployment of larger-scale batteries relative to competitors from China.

8.9 Financing, cost structures and investment risks

This subsection outlines the key financing considerations, cost structures and investment risks.

- **Barrier – Securing blended finance and accurate cost estimation –** The construction of any type of gigafactory entails significant costs which usually necessitates blended finance from various funding sources, including:
  - Government grants.
  - Multilateral and policy bank support.
  - Commercial banks and private capital.
  - Equity.

  Successful implementation and scaling of sodium-ion battery technology relies on credible project financing plans that cover the relevant material costs. The importance of project bankability and funding was echoed by an EU-based raw material supplier to the battery supply chain. Costs that need to be considered by lenders and investors include:
  - CAPEX: land acquisition, machinery purchase, and infrastructure development.
  - OPEX: costs for materials, utilities, labour and equipment maintenance.
  - Revenue projections: calculated expected income based on market demand and production capacity.[215]

  As such, strong CAPEX/OPEX models are needed along with realistic commissioning and ramping-up assumptions to support lender confidence.
- **Barrier – Bankable offtake and financing mis-alignment –** Bankable offtake[216] is essential but can be challenging; financing requires a steady flow of revenue with a 'credit-worthy' offtaker for a period of time that allows debt repayment. However, this might not align with needs of OEMs which often have shorter time horizons that align with the lifespan of the production line. An academic institution noted that securing offtake agreements will enable sodium-ion battery companies to secure funding from banks and investors. Similarly, a battery manufacturer emphasised the importance of public procurement-driven demand and bankable offtake to enable

scaling. As such, stakeholders need to consider closely the allocation of risks in offtake agreements, including ability to sell to third parties on the market. Additionally, the sizing of long-term take or pay arrangements and termination compensation in various scenarios should also be considered.[217]

- **Driver – Increasing warranties to reduce lending risk –** Another key consideration is the development of warranties for sodium-ion batteries. The EBRD noted that warranty periods for lithium-ion batteries have increased over time from around four to ten years and that a similar evolution would be a key risk reduction measure for investment decisions, particularly for lenders.
- **Driver – Risk reduction through strategic partnerships –** One way of reducing risks is by setting up strategic partnerships: joint ventures with OEMs allow developers to attract investors through credible backing from OEMs with equity and offtake agreements. Further, the joint ventures structure supports the spreading of risk, limits CAPEX and brings in specialist knowledge. Some examples include ACC (joint ventures between Stellantis, Mercedes-Benz and TotalEnergies) and joint ventures models between Northvolt-Volkswagen and Northvolt-Volvo. It is important to note however that the joint ventures model also introduces a level of dependency on external partners with potential limitations to project control and funding.[218]
- **Barrier – Input commodity price volatility –** Another key consideration is that battery economics face uncertainty from volatility in input commodities; managing market price fluctuation is a key concern for the viability of the gigafactory model. Some approaches to managing and controlling input commodity costs include full 'pass through', whilst others include long-term discounts (i.e., retaining exposure to price fluctuations but with a discount) and cap-and-floor pricing structures (i.e., limited the impact of price fluctuations in both directions).[219]
- **Barrier – Multi-contract delivery and construction cost management –** Gigafactories typically need to involve multi-contract builds as the nature and complexity of the facilities rarely allow construction and commissioning to be fronted by a single entity such as an engineering, procurement, and construction contractor.[16] Instead, construction is undertaken through a blend of contracts which increase the complexity and risk of delays and underperformance as no single contractor is responsible.
- **Barrier – Intellectual Property (IP) and licensing –** A further risk involves IP and licensing with gigafactories involving numerous proprietary innovations that rely on a wide range of external suppliers and partners that require compliance with third party patents and licences. One example of this may be that the IP for the casing of a battery module is owned by the OEM rather than the battery manufacturer which would require the gigafactory developer to assess carefully if that developer is also selling completed batteries to third party customers. As such a robust IP strategy that is supported by clear contractual arrangements is needed, and this also needs to promote innovation and protect interests of all stakeholders.
- **Driver – Site selection rationale –** Investors and developers need to consider strategic site-specific factors including the availability of power, water, transport links, proximity to suppliers, and the availability of a skilled local workforce.[220]

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[16] An EPC contractor is responsible for designing the project, sourcing all equipment and materials, and building the facility - delivering it to the client as a finished, operational asset.

9. Case studies

9.1 Section overview

This section outlines three case studies at various stages of the value chain. It outlines the project aims, its current position, drivers for their delivery and challenges they are facing.

9.2 Nobian

9.2.1 **Project** outline

Nobian is a European leader in salt, essential chemicals and energy storage, using their competencies in salt production and electrochemistry to convert salt into essential chemicals, to be used in everyday products.

Based on its filed patent application, Nobian is working in collaboration with Exergy Storage, the University of Twente and ISPT on the STARBATCH project.[17] The aim of the project is to develop and scale-up a new technology to produce a battery chemical for sodium-based battery manufacturing, specifically sodium tetrachloroaluminate ($NaAlCl_4$), used as an electrolyte or catholyte that enables sodium-ion conduction and reversible aluminium cycling in sodium-based battery systems. Nobian's role in the project is the development and testing of a new reactor to produce $NaAlCl_4$, and collaboration in the drafting of a conceptual process design and economic analysis. The project's aim is to demonstrate that $NaAlCl_4$ can be produced more sustainably and efficiently at lower temperatures by mixing sodium chloride, aluminium, and chlorine in the new reactor.

Parallel to the work on the STARBATCH project, Nobian has also joined the SLDBatt[18] consortium to accelerate sustainable battery technology development, the largest R&D initiative in the Netherlands focused on long-duration storage of renewable electricity. Within this programme, Nobian is collaborating closely with Exergy Storage, who will be responsible for testing the materials in their batteries.

9.2.2 Current status

Under the STARBATCH project, a pilot plant with a TRL 6 (a prototype system demonstrated in an operational scale), is planned to be operational with a 40 litre reactor by September 2026, followed by a testing programme.

Under the SLDBatt consortium with Exergy Storage[19], Nobian is working towards building a commercial plant with the potential of producing tens of thousands of tonnes per year, where sizing depends on market conditions. With such a large-scale reactor, several gigafactories can be supplied with material.

There are numerous European parties working on sodium-based battery systems that utilise a $NaAlCl_4$ electrolyte. For example, Switzerland-based Horien[20] already produces sodium metal chloride batteries and, whilst it is on a commercial scale, the volume produced has not yet reached gigascale,[21] with most

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[17] https://www.nobian.com/nl-nl/duurzaamheid/case-studies/starbatch-project-voor-duurzame-batterijproductie

[18] https://www.sldbatt.nl/ldes-technology/

[19] https://exergy-storage.nl/

[20] https://saltbattery.horien.com/

[21] Industrial, technological, or infrastructural projects, typically delivering a gigawatt of power or processing capacity.

deployment in applications such as power back-up systems. Other sodium-battery start-ups and companies in Europe are using the $NaAlCl_4$ electrolyte, and are in contact with Nobian, to test its material on a number of sodium battery technologies that are targeting the rapidly growing (large-scale) energy storage market

9.2.3 Drivers

Sodium, chlorine and aluminium are all raw materials that are mined, produced and / or readily available in Europe to manufacture sodium metal chloride batteries. The development and wide use of such batteries could provide Europe with a good strategic independence from lithium-ion batteries, alongside sodium-ion batteries outside of Europe.

Sodium-based batteries using $NaAlCl_4$ are also advantageous as they do not self-ignite. As such, extra safety precautions are not required compared to lithium-ion batteries. As there is less safety risk, it is possible to have more cells within a container, essentially making energy density per square metre higher. Additionally, the containers can be stackable, which is an important aspect for developers who are paying premium prices for land.

The potential of these sodium batteries is expected to benefit stabilisation of the electricity grid which is becoming key in the European energy transition, as well as companies, local / microgrids, and energy storage for industrial, and solar parks. Such batteries could also be used by households to store for instance solar energy. The importance of energy storage is also apparent for rapid scale up of data centres and other AI infrastructure.

9.2.4 Timeline to operationalisation and commercialisation

The STARBATCH project was initiated in October 2024, and the scaling up of the process technology is expected to lead to commercial production before 2030.

It is expected that it will take 4-5 years for the development and operationalisation of a demonstration plant, with an additional 4-5 years to scale up to a large giga-factory. Nobian decided to start with a small pilot plant, although, a large reactor can be developed immediately. However, in this case, considerations need to be made on the certainty of the market, as the size of the reactor will depend on what the market is requiring.

9.2.5 Challenges

In most places in Europe, particularly in the Netherlands, the transportation of chlorine is restricted due to its hazardous nature under Directive 2008/68/EC on the inland transport of dangerous goods, and the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR).[221] [222] Due to the use of chlorine in the synthesis of the $NaAlCl_4$ electrolyte, reactors should typically be close to a chlorine production site, deploying electricity-intensive electrolysis processes. In making this happen, several boundary conditions must be resolved or in place:

- Competitive energy costs, including grid fees and other levies.
- Sufficient local grid capacity and access to infrastructure.
- Rapid and predictable permitting procedures.
- Financing – the government can provide assurance and support to attract investment, alongside government subsidies.
- Access to raw materials, e.g., continued permits for salt supply and aluminium.

In summary, Nobian’s work seeks to strengthen the EU supply chain for safe, non-flammable, long duration sodium batteries by using fully European raw materials and scalable electrochemical processing. Well-coordinated policies could facilitate these developments and help secure this technology for Europe.

9.3 Altris AB

9.3.1 Project outline

Altris AB[22] is a Swedish sodium-ion battery material company originating from research at Uppsala University. Altris was formed from research at Uppsala University in 2015, when Master's student Ronnie Mogensen, together with Associate Professors Reza Younesi and William Brant, developed the first Prussian white synthesis while exploring sodium-ion battery materials inspired by the work of John B. Goodenough. This formed the scientific basis that later evolved into the company.

Altris aims to integrate into Europe's growing battery manufacturing landscape and collaborate with European cell producers. Sodium-ion batteries using Altris materials could therefore be produced in existing gigafactory lines once market offtake agreements are secured, enabling a quick deployment of a European sodium-ion battery supply chain.

9.3.2 Current status

Altris' cathode material production is advancing toward near-term industrial operation, with 100 MW of internal cell development capacity and a pilot Prussian white manufacturing line now scaling in the Czech Republic. In January 2026, Altris and speciality chemicals producer Draslovka announced a strategic partnership to establish Europe's first industrial-scale sodium-ion cathode value chain. As part of this agreement, Draslovka will provide EUR 19.3 million in in-kind investment to support the scale-up of Altris' patented sodium-ion CAM. The partnership will enable fully integrated production at Draslovka's facility in Kolín in the Czech Republic, with planned output of up to 350 tonnes of CAM annually. This facility represents a pilot-line manufacturing development rather than a gigafactory and is expected to reach full operation in 2027, subject to sufficient capital availability.

In addition, Altris has extended an existing collaboration with Clarios, a BESS manufacturer, through a new Joint Development Agreement focused on advancing sodium-ion battery technology. As part of this expansion, Clarios has increased its equity investment in Altris and both companies are also working with InoBat on prototype automotive sodium-ion battery: the batteries are being assembled at InoBat's facility in Slovakia, using Altris' technology, and tested in Clarios' laboratories in Hannover. The partnership framework also includes Clarios' plan to begin batch production of low-voltage sodium-ion batteries by 2030 at a European or US facility.

9.3.3 Drivers

9.3.3.1 Abundant, European-available raw materials

Altris' Prussian white is based upon iron and therefore does not rely on critical raw materials like nickel, cobalt, copper or other more expensive materials. As such, sodium-ion batteries that use the Prussian white CAM from Altris are at the advantage of using elements that are abundant and available in Europe, supporting a secure and localised supply chain which are also more resilient to geopolitical risks. Since geopolitical shocks such as the Russia-Ukraine war and more recently trade conflicts between the US and China, Altris has received a new level of interest in sodium-ion batteries.

9.3.3.2 Cost and sustainability advantages

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[22] https://www.altris.se/

Sodium-ion chemistry presents lower material costs and is a more sustainable alternative to that of lithium-ion chemistry, particularly in applications that are higher-volume and lower density. For many end-users, cost dominates decision making and sodium-ion is expected to improve long-term affordability. Sodium-ion lifecycles may need to improve in line with lithium-ion to consider lifetime costs.

9.3.3.3 Manufacturability

Sodium-ion batteries can be manufactured in existing lithium-ion battery production lines which Altris notes as being a 'drop-in' solution.

9.3.3.4 Commercial signals

European interest in sodium-ion batteries has grown following the entry of major global players to the sodium-ion space, particularly CATL's announcement that they were developing sodium-ion batteries in 2019-2020. This established credibility for the technology.

9.3.4 Timeline to operationalisation and commercialisation

Altris' timeline to full operationalisation is comparatively short. Its Czech cathode production line is expected to become fully operational within 2027. Cell manufacturing could begin almost immediately if formal offtake commitments are secured, due to the compatibility of Altris' materials with existing European battery manufacturing facilities. As a result, commercial sodium-ion batteries based on Altris' Prussian white CAM could reach the market quickly, subject to investment and buyer alignment.

9.3.5 Challenges

Altris notes that sodium-ion battery manufacturing does not present major technical barriers, as commercial production is already established in other regions and can be readily replicated by European OEMs. As a result, the company's short-term trajectory is shaped primarily by financing conditions and the availability of offtake agreements, rather than technical constraints.

This includes a decline in investor confidence following the Northvolt case which created a shock in European battery finance, and generally the space has become a risk for venture capital and banks. As a result, raising capital for new chemical factories and manufacturing facilities is currently challenging.

Additionally, as Europe currently lacks the level of depth of cell producers compared to Asia, Altris has fewer partners available to them that are capable of producing sodium-ion batteries at scale.

Further, offtake agreements are essential for investment confidence, but these are difficult to obtain in Europe which has created a bottleneck to scaling. This is linked back to the caution around financing and the current low level of risk appetite. Although customers are showing interest in sodium-ion batteries, there is a lack of incentive to invest ahead of commercial maturity when inexpensive batteries from China are available.

Finally, a lack of government-backed support mechanisms is one of the key barriers in supporting emerging European sodium-ion technologies. Government authorities often buy off-the-shelf cells rather than supporting development projects to bring new products such as Altris.

9.4 Moonwatt

9.4.1 Project outline

Moonwatt[23] is a European energy storage startup based in Amsterdam, founded in September 2024. It is developing and deploying stationary energy storage systems (ESS) based on NFPP sodium-ion battery chemistry, with a primary focus on commercial, industrial and broader stationary storage systems.

Moonwatt intends to onshore or nearshore part of the integration into BESS products in the medium term, provided it receives sufficient financial support and customers have either a willingness or incentive to buy European products. This alignment between industry policy, market demand, and strategic investment will enable Europe to strengthen its competitiveness in the sodium-ion battery value chain.

9.4.2 Current status

Cell manufacturing and most integration activities currently take place in Asia, driven by capital efficiency and cost considerations. Moonwatt is not currently planning to manufacture cells in Europe, but is considering onshoring to Europe as a possible future step if customers accept EU-landed pricing compared to imports from China.

9.4.3 Drivers

NFPP sodium-ion chemistry requires fewer critical raw materials compared to other battery types, as lithium and copper are not used in NFPP cells. The main materials are sodium, iron, phosphate, and aluminium (used for both the cathode and anode current collectors). The materials are widely available, globally abundant, and highly commoditised, indicating a lower dependence on constrained international supply chains. The bill of materials is estimated as low as around USD 5/kWh (EUR 4/kWh), reflecting the accessibility and low cost of its key inputs.

Although NFPP systems are currently around 30–40% more expensive than LFP, they are already competitive on a total cost of ownership basis as they do not require active cooling, reducing the operational expenditure. Without active cooling, there is a lower auxiliary power consumption, further reducing lifetime operational costs.

Moonwatt has noted that NFPP provides strong cycling performance, sometimes surpassing LFP. Moonwatt has stated that NFPP can exceed 12,000 cycles and achieve up to 20 years of service life, making it suited to daily cycling applications in homes.

9.4.4 Timeline for operationalisation and commercialisation

NFPP sodium-ion batteries are already being deployed at scale globally, particularly in China, with hundreds of MWh already installed. Moonwatt considers the technology significantly more mature than commonly assumed in Europe.

Moonwatt is set to deploy, a sodium-ion battery energy storage pilot solar plant, using its own battery technology in the Netherlands 2026, and plans for commercial deployment in 2027.[24]

According to Moonwatt, NFPP sodium-ion is expected to outperform LFP by 2027, based on cost per kWh cycled over total cycle life. By 2028–2030, NFPP is projected to beat LFP on absolute EUR/kWh price, making it cheaper even before factoring in cycle life.

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[23] https://www.moonwatt.com/

[24] https://www.moonwatt.com/news/20260128

9.4.5 Challenges

For households, the main challenges with NFPP sodium-ion batteries are their low energy density, at only one-half to one-third that of lithium LFP. As a result, residential systems require a larger space to deliver equivalent capacity, making space a limiting factor. A second challenge is cost, as NFPP sodium-ion batteries currently range from USD 90–120 (EUR 77-102) per kWh, making them two to three times more expensive than LFP. However, the sodium-ion cost curve (particularly for NFPP) is declining quickly, so this difference is not expected to last long-term.

For businesses, the challenges are largely the same as households, with low energy density, and current cost levels apply across residential, commercial, and even utility-scale projects. The only meaningful difference highlighted is price sensitivity. For households, cost is important but not always the primary factor, whilst for commercial and industrial projects, cost becomes more significant.

Financing is one of the greatest barriers to developing sodium-ion battery manufacturing capacity in Europe. In regions such as China, provincial governments often provide long-term financing for factories, whilst European manufacturers must secure commercial bank financing, which is harder to obtain, as commercial banks typically require a long-term, guaranteed customer pipeline before financing production capacity. This creates a major challenge for new technologies, such as:

- Customers are reluctant to commit to multi-year purchase agreements.
- Without customer commitments, banks refuse financing.
- Without financing, factories cannot be built.

10. Conclusions

The following conclusions are made to present answers to the research topics set out in the specification to the contract for this study.

10.1 Sodium battery capacity and cost for 72-hour sufficiency

- Sodium-ion battery costs have fallen sharply: 2019 estimates put sodium-ion batteries at 223 EUR/kWh, while recent figures show USD 80 – 105/kWh (EUR 68 – 89/kWh).
- Cost parity with LFP is emerging: LFP cells are USD 52–81/kWh (EUR 44 – 68/kWh), meaning cost ranges now overlap. However, commercialisation is limited: Despite inexpensive precursors, sodium-ion battery costs are not fully competitive because demand and awareness is low and economies of scale have not been reached. According to one stakeholder, today, sodium-ion electrolytes cost nearly double lithium-ion equivalents.
- For home storage, turnkey domestic sodium-ion BESS are approximately 300 EUR/kWh in the future, roughly on par with lithium-ion at similar scales. Larger system costs depend more on installation, balance-of-system components, and project scale.
- To meet 72-hours of energy demand, an average household without heat pump would require a EUR 6,500 investment, at a 300 EUR/kWh battery price. A household with a heat pump would require a EUR 33,700 investment and household with heat pump and electric car a EUR 39,900 investment. The required battery capacity (20 up to 130 kWh) is significantly larger than most system currently being installed (5 to 10 kWh) often in combination with power generation units (e.g. solar PV). Uptake is therefore likely to be limited, as the high upfront investment offers little return: the battery must be kept fully charged for rare disruptions, unlike smaller systems paired with solar that regularly utilise most or all of their capacity during normal operation.

10.2 Current lithium industry capacity and deployment in Europe

- Global lithium-ion battery production capacity reached around 2,500 GWh/year in 2023, but only 35% of this capacity was utilised; around 130 GWh (5.2%) were stationary BESS.
- The industrial manufacturing capacity of lithium remains low in Europe, ranging from below 1% to approximately 3% of global capacity.[223] [224].
- Lithium-ion batteries account for 86% of all BESS deployed in Europe. Sodium-based technologies account for less than 2%.
- As of 2024, there was a total of 61 GWh of installed BESS capacity in Europe.[225] 400 GWh of total installed capacity is estimated by 2029.[225]
- Europe installed 16 GWh of installed BESS in 2023, with 12 GWh installed 'behind the meter' (mainly residential and commercial), the majority being lithium-based.
- In the three years to 2024, three million home batteries were connected to European grids. [225]

10.3 Trends over the past 15 years

- There has been a downward trajectory in battery costs for both lithium-ion and sodium-ion batteries in recent years. Between 2010 and 2023, the average cost of lithium-ion batteries decreased from approximately USD 1,400/kWh (EUR 1190/kWh) to USD 140/kWh (EUR 119/kWh), representing a ten-fold reduction over the period. As of 2025, lithium-ion batteries have a cost as low as EUR 40 – 68 /kWh (LFP). Over the same time span, sodium-ion batteries have decreased to EUR 68 – 89/kWh. Estimates suggest that battery costs may decrease by up to a further 40% by 2030.

- Sodium-ion batteries currently have a lower energy density than lithium-ion (17–49% lower, depending on chemistry) affecting system size and footprint. Recent developments include improved energy densities. Ongoing electrochemical advances are expected to further improve this.
- Some commercial LFP cells reach over 12,000 cycles, a result of decades of optimisation and highly mature supply chains that sodium-ion battery manufacture has not yet had time to match. Whilst sodium-ion batteries typically cannot yet meet the same level of performance; recent developments show that sodium battery cycle lives are approaching that of LFP. Some stakeholders suggest that current cycle lives are already comparable. Sodium-ion batteries can have a lifespan exceeding 10 years which is comparable with lithium-ion battery technology.

10.4 Global sodium-ion industry

- Global sodium-ion battery production capacity reached 42 GWh/year in 2023, with 99.4% located in China, while demand was only 4 GWh as manufacturers are rapidly scaling up production capacity in anticipation of surging demand. Globally, capacity is rapidly scaling, with estimates of 70 GWh/year as of 2025 and plans being announced for up to 240 GWh/year globally by 2030, primarily in China.
- China leads the sector, hosting the largest and most advanced industrial base and the majority of commercial-scale facilities, although activity is emerging across Europe, Asia, North America, and Australia.
- Around 30 sodium-ion battery plants are operating, planned, or under construction worldwide, which could potentially provide >100 GWh/year by 2030, with China expected to continue driving global uptake.

10.5 Future prospects and time to operational capacity

- China is already advanced in sodium-battery development and manufacturing. Even if Europe benefits from access to raw material supplies, this does not necessarily guarantee competitiveness, as technological maturity, scale, and industrial integration may allow global competitors to remain more cost-competitive. Nevertheless, compared to other technologies such as solar and lithium-ion batteries, sodium-ion offers strategic autonomy as Europe can secure access to domestically available raw materials. Were Europe to invest in a competitive sodium-ion battery industry, it should draw lessons from the experience with lithium-ion batteries and solar panels to avoid similar scale-up and competitivity challenges and external raw material dependency.
- Large-scale production in Europe could be feasible in the long term. However, gigafactories need at least five years from planning to full output, meaning most investment decisions for meeting 2030 demand are already locked in.
- Industry experience from lithium-ion batteries shows start-up delays of 1-2 years and lower-than-planned initial production capacity are common.
- Scaling cell manufacturing to gigafactory level is highly complex, requiring tight integration of many interdependent processes and stable, well-validated product designs. Even minor design or parameter changes can cascade through production, impacting performance, yield, and ramp-up cost-competitiveness.
- There is intense global competition to achieve critical technological milestones, which will shape the future sodium-ion battery market.
- Gel and polymer electrolyte sodium-ion batteries are nearing maturity and are already deployed in some mobility applications. Stakeholders advise that Europe should prioritise solid-electrolyte sodium-ion batteries to gain leadership in emerging disruptive technologies.

10.6 Potential EU production capacity and scale needed (for 5% to 10% of the market share)

- Estimates suggest planned production capacity in the EU for sodium-ion batteries by 2030 is between 6-8 GWh/year.
- If global sodium-ion battery capacity by 2030 reaches 240 GWh/year as planned, for the EU to reach a 5 to 10% market share of the global sodium-ion battery market, capacity would have to reach 12-24 GWh/year, or an increase of 4-6 GWh/year for 5% and 16-18 GWh/year for 10% compared to current planned EU capacity, respectively.
- Europe has material availability and industrial base but, in the absence of a clear political strategy, risks missing timing and scale advantages compared to other international competitors such as China.

10.7 Sodium availability in Europe

- Sodium suitable for battery manufacturing can be sourced from saline deposits, sedimentary rock, and seawater. Sodium supply is geographically widespread across Europe. Europe is self-sufficient for salt extraction, with an industrial capacity of around 77 million tonnes per year, with actual production of approximately 50 million tonnes in 2023[226] which is more than sufficient to meet existing and new demand, including potential battery related applications.
- In Europe, raw sodium material value chains for sodium-ion batteries exists but production capacity will need to scale up rapidly to meet rapidly expanding market. Supply chains are not yet developed for this scale.
- Although sodium batteries reduce reliance on lithium, they remain dependant on other critical materials. Future dependencies may shift toward cathode precursors (chemistry-dependent), hard carbon, electrolyte salts / additives, separators, solvents / binders, and battery management system electronics. Efforts are underway to develop European production and supply chains for these inputs, but strategic dependencies will persist in the short term.

10.8 Potential for synergies with desalination

- Europe has substantial desalination capacity, particularly across Mediterranean countries, providing a potential source of sodium for battery manufacturing.
- Desalination brine contains impurities, including chemicals, heavy metals, and cleaning agents, so using it for battery-grade sodium depends on whether purification and refinement can be achieved economically and technically. Sodium from specialised brine sources (similar to lithium brines) may be more viable by leveraging existing processing infrastructure.
- Stakeholders generally agree that desalination plants could supply sodium for batteries, and future plants could be designed with this in mind. However, battery producers emphasised the following constraints:
    - Brine-derived sodium requires significant purification to reach battery grade.
    - Virgin sodium is abundant and low-cost, removing economic incentives for brine purification.
    - Geographical mismatch between desalination plants and battery factories reduces feasibility.
    - Permitting barriers may hinder reuse of sodium from brine.
- Industrial by-products may offer alternative sodium sources. Industries such as caustic soda, chemicals, textiles, and pharmaceuticals generate sodium-rich waste streams (e.g., sodium sulphate), and some successful recovery examples already exist. However, this has not been investigated for battery production.

10.9 Industries able to convert rapidly to sodium-ion

- Sodium-ion battery manufacture is a near "drop-in" replacement for lithium-ion battery manufacture (particularly LFP), making the lithium-ion battery gigafactory base the most suitable platform for rapid scale-up of sodium-ion battery manufacturing.
- Cell architecture and electrochemistry are highly similar between lithium-ion and sodium-ion batteries (same components, similar reactions, same design principles) helping sodium-ion battery production gain momentum due to familiar, proven production methods.
- Manufacturing processes are almost identical, requiring only minor modifications to shift from lithium-ion batteries to sodium-ion batteries (electrode production, cell assembly, formation), enabling low-cost conversion using existing equipment.
- LFP lines can be converted in as little as two weeks, according to one stakeholder, provided that key materials like NFPP cathodes and hard carbon are available. An example cited was InoBat, which has converted an LFP line to sodium-ion battery production.
- The EU has 257 GWh of installed lithium-ion battery capacity. Assuming 66% energy-density equivalence, 170 GWh of sodium-ion battery capacity could be rapidly converted from lithium-ion, equivalent to 70% of globally announced sodium-ion battery capacity plans by 2030. However this is dependent on the specific technologies being used at each facility.
- Conversion challenges include:
  - Lower cell energy density means sodium-ion lines produce one third to one half less output by GWh compared to the same production capacity for lithium-ion, reducing revenue potential.
  - Preferred prismatic cell formats for sodium-ion batteries limit easy conversion for factories built for pouch or cylindrical lithium-ion batteries.
  - Sodium's moisture sensitivity requires stricter control and higher energy use during production.

10.10 Enablers for sodium-ion deployment

- Given strong international competition and faster scaling in other regions, timely de-risking and coordinated public support may be critical to avoid delayed market entry for sodium ion batteries.
- Gigafactory projects require substantial blended financing, typically combining government grants, multilateral and policy bank support, commercial lending, private capital, and equity investment.
- Bankability is critical. Lenders and investors assess CAPEX (land, machinery, infrastructure), OPEX (materials, labour, utilities, maintenance) and realistic revenue projections. Strong financial models and credible commissioning / ramp-up assumptions are essential.
- Offtake agreements are a major hurdle. Long-term, creditworthy off takers are needed for debt repayment, but OEMs often operate on shorter planning cycles. Clear demand pull from public procurement, capacity markets, and bankable offtake is vital.
- Risk allocation in offtake contracts must be carefully structured, including third-party resale rights, sizing of take-or-pay volumes, and termination compensation.
- Warranties are increasingly important. As seen with lithium-ion (now offering around 10-year warranties), longer warranty periods would help de-risk sodium-ion investments for lenders.
- Strategic partnerships and joint ventures (e.g., ACC with Stellantis / Mercedes / TotalEnergies; Northvolt–Volkswagen; Northvolt–Volvo) help spread risk, provide technical expertise, and strengthen investor confidence, though they introduce dependency and reduce developer control.
- Input-commodity price volatility is a key economic risk. Mitigation strategies include full cost pass-through, long-term discounted pricing, and cap-and-floor structures.

- Gigafactory construction typically involves multi-contract delivery, increasing complexity and risk since no single EPC takes full responsibility. Projects are often split into packages to manage cost-overrun exposure and completion support.
- IP and licensing risks are material: multiple proprietary technologies can require compliance with third-party patents. Developers must ensure robust IP strategies, particularly when OEMs own IP for modules or components.
- Site-specific factors (including access to power, water, transport links, suppliers, and skilled labour) must be carefully evaluated for project viability.
- Policy frameworks, developed primarily for lithium-ion batteries require reframing / adaptation to support alternative chemistries such as sodium-ion technologies with different risk profiles.
- European supply-chain and skills base needs development for cell materials but also balance of system equipment.

10.11 Key investors, capacities and use cases

- Investment in sodium-ion batteries is accelerating globally, across automotive, stationary storage, manufacturing, utilities, and research sectors as interest in BESS grows.
- Automotive activity is increasing, with early commercial sodium-ion powered EVs entering the low-range, cost-sensitive market, driven largely by rapid investment by China.
- However, EVs are not expected to be the primary market in the near term; consensus is that stationary storage will dominate. OEM interest is shifting accordingly, with EV OEMs pivoting their battery development partnerships towards static applications.
- Existing supply chains and technology leadership favour Asia, particularly China, where manufacturers benefit from first-mover advantages. Leading global players (e.g., CATL, BYD, Natron, HiNa) benefit from mature supply chains, scalable GWh-level manufacturing, advanced IP portfolios, and strong utility / OEM links.
- China already has around 300 MWh of grid-scale sodium-ion battery projects installed (as of Q1 2025), demonstrating market maturity ahead of Europe.
- Public-private R&D programmes are accelerating development globally:
  - US DOE–LENS partnership: $50 million over five years for sodium-ion innovation.
  - EU Horizon Europe and the European Battery Alliance prioritise alternative chemistries.
  - EU SPRINT project targets safer, low-cost quasi-solid-state SIBs for grid storage.

10.12 Summary

Overall, sodium-ion batteries offer a promising complement or replacement to lithium-ion batteries for improving EU energy preparedness, especially in stationary household and business energy storage applications that prioritise raw material availability, cost stability and safety aspects of implementation over energy density. While sodium-ion batteries are already commercialised, the technology is not yet fully mature and European manufacturing capacity remains limited.

In the longer term, sodium-ion offers strategic advantages by reducing dependence on critical raw material imports, lowering geopolitical exposure, and supporting decentralised energy resilience aligning with the EU's preparedness union strategy.

However, realising these benefits would require substantial capital investment, risk tolerance, strong coordination, long-term planning and sustained policy and financial support to compete with a rapidly scaling Chinese industry that currently holds much of the intellectual property (unlike examples such as solar, where the EU had an early R&D lead).

Nevertheless, Europe retains opportunities to become competitive, particularly in next-generation sodium technologies (e.g. gel or solid-polymer electrolytes) and through reaching key outstanding milestones, such as establishing a hard-carbon supply chain, that could shape future markets.

Market forces alone are unlikely to be sufficient to develop a European manufacturing industry. Targeted public intervention such as coordinated pilot deployments, applied R&D and scale-up funding, accelerated development of upstream materials (e.g. hard carbon), and clearer sodium-specific regulatory frameworks will be critical.

If these enablers are addressed in a timely and coherent manner, next-generation sodium technologies could become a meaningful pillar of Europe's energy resilience and help avoid the dependency patterns seen in earlier clean-technology transitions. Key challenges are summarised in Table 10-1.

Table 10-1 Key challenges for scaling sodium-ion batteries in the EU

Challenge	Description
1) Market uncertainty and offtake risk - Bankability, warranties and investor confidence	Despite strong long-term expectations, near-term demand in Europe is not guaranteed, particularly for domestic and commercial and industrial (C&I) systems. Many producers are therefore confined to pilot-scale deployment, awaiting clearer offtake signals. A central challenge is financial credibility rather than technical feasibility. Sodium-ion batteries lack long-term field data at scale, which constrains the availability of robust warranties, insurance products and project finance. Lenders and installers benchmark against mature lithium-ion battery technologies with proven degradation curves, service pathways and resale values. Without bankable performance guarantees, sodium-ion projects face higher financing costs and slower uptake
2) Structural barriers to scale-up	Moving from pilot to industrial scale remains challenging due to capital intensity, process integration complexity and yield optimisation risks. Key innovators in sodium-ion chemistry, often small and medium sized enterprises, struggle to bridge this gap without targeted applied-R&D support, demonstration infrastructure and industry /academia / government collaboration frameworks. Without this, innovation and proprietary information risks being lost via acquisition by larger non-EU players.
3) Standards, certification and regulatory misalignment	Commercialisation slowed by the absence of harmonised safety, transport and performance standards specific to sodium-ion chemistry. Existing battery regulations and dangerous-goods classifications largely mirror lithium-ion risk profiles, failing to reflect sodium-ion's lower intrinsic hazard and different handling characteristics. This regulatory lag increases validation costs, complicates permitting, and creates uncertainty for manufacturers, utilities and insurers, despite the technology being technically mature enough for deployment.
4) Ecosystem readiness	While cell chemistry has advanced rapidly, balance-of-system readiness lags behind. Gaps persist in sodium-specific inverters, power-conversion systems, energy-management systems, and grid-code-compliant integration solutions. Voltage-window differences and control-logic adaptations also introduce

beyond the cell level	engineering challenges, particularly for larger-scale systems. This ecosystem immaturity slows deployment even where cells themselves are available.
5) Conversion limits of existing lithium-ion manufacturing assets	Although sodium-ion battery technology is described as a “drop-in” technology, conversion of existing plants is not universally straightforward. Lower energy density reduces GWh output per line, affecting revenue economics. Other technical challenges include sodium’s high sensitivity to moisture, which may require factory adaptations such as additional heating or ventilation and therefore energy use, which must also be overcome on a plant-by-plant basis.
6) Upstream processing and material-grade readiness	While sodium itself is abundant, battery-grade sodium compounds, hard carbon and certain cathode materials currently face supply-chain immaturity in Europe. There is a risk of shifting dependencies from lithium to other inputs which are also primarily produced outside of Europe (e.g. hard carbon, manganese compounds, cathode active material (CAM) processing), until European upstream capabilities are established at scale.
7) Household-level deployment constraints	In residential markets, sodium-ion battery technology faces practical, non-technical hurdles, including: larger space requirements than lithium-ion battery technology, and tighter installation constraints, and compatibility challenges with existing inverters and grid codes. Consumer perceptions, installer familiarity, and sensitivity to upfront cost further exacerbate these barriers.
8) Skills, permitting and policy coordination gaps	Stakeholders highlight slow and uncertain permitting, uneven skills availability, and fragmented policy signals as structural constraints. The absence of a clear EU-level strategy, and / or signals, for scaling sodium-ion manufacturing exacerbates delays. Unlike lithium-ion battery technology, sodium-ion battery technology does not yet benefit from a strong, coordinated industrial narrative translating R&D success into large-scale deployment.
9) Strategic positioning versus lithium-ion battery incumbency	Sodium-ion battery technology faces the challenge of competing for attention, capital and industrial capacity in a battery ecosystem optimised for EV-driven lithium-ion battery growth. Limited automotive original equipment manufacturer (OEM) interest, EV-focussed gigafactory designs, and aggressive pricing of imported lithium batteries constrain sodium-ion’s ability to secure priority investment.

Appendix A – Detailed methodology

Task 1: Literature review

Searching

Sources were identified via a systematic review, using search terms informed by the research questions set out in the specification for objective 2, and with relevant terms that the project team developed for objective 1. Search terms were developed using standardised keywords and Boolean operators to ensure comprehensive coverage. Targeted searches supplemented these results where data gaps were identified.

The following search terms were run in search engines to yield relevant results.

- **Domestic Storage Capacity:** ("household" OR "business" OR "home" OR "domestic" OR "local") AND ("battery") AND ("storage" OR "capacity" OR "energy storage" OR "scenario")
- **Global Figures and Locations:** ("global" OR "world*") AND ("sodium" OR "Sodium-ion" OR "Na-ion") AND "battery" AND ("industry" OR "market" OR "sector" OR "production") AND ("location" OR "geography" OR "map")
- **Sodium availability and industrial conversion:** ("sodium" OR "Sodium-ion" OR "Na-ion") AND "battery" AND ("Europe" OR "EU" OR "European Union") AND ("production potential" OR "manufacturing capacity" OR "scalability") AND ("sodium resource*" OR "sodium reserve*" OR "raw material*" OR "mineral availability" OR "salt resource*") AND ("location*" OR "geological source*") AND ("industrial conversion" OR "retrofit" OR "existing industries" OR "convert plant*" OR "portfolio expansion")
- **Desalination / Industrial Synergy:** ("desalination" OR "saltwater" OR "industry*") AND ("sodium" OR "Sodium-ion" OR "Na-ion") AND "battery" AND ("synergy" OR "symbiosis")
- **Factory Requirements and Market Share:** ("factory" OR "manufactur*") AND ("requirements" OR "scale") AND ("sodium" OR "Sodium-ion" OR "Na-ion") AND "battery" AND ("market share") AND ("financing" OR "de-risking" OR "investment")
- **Cost and Lifespan:** ("cost" OR "price*" OR "CAPEX" OR "market cost") AND ("sodium battery" OR "Sodium-ion" OR "lithium battery" OR "lithium-ion") AND ("72-hour" OR "energy autonomy" OR "preparedness") AND ("compare" OR "comparison")

The search terms were entered into search engines Google Scholar and Google. The first 10-15 results that were deemed relevant for each search term from the titles were logged with the aim of identifying up to 100 sources in total. Duplicates were removed. Sources included academic literature, policy documents and datasets from Member States and EU institutions.

Further to this, several sources were provided by the EESC. These and others known to the project team were also included among the identified sources.

Screening

The titles, abstracts, contents and conclusions of this collated literature were screened to select the most appropriate evidence to carry forward for full review and data extraction. Sources were ranked with a score based on the following criteria:

- **Relevance** - Did the source seem like it was going to contain relevant data (high / medium / low)? If low, it was not considered any further).

- **Robustness** - Did the source have credibility? Is it a peer reviewed academic article or government article (high), or grey literature (medium), taking into consideration how the research may have been funded? If the source did not give confidence that it was supported by scientific evidence, or similar, a low rating was given to the source.

Sources were taken forward for extraction if they scored a high-medium or a high-high rating.

Out of the 92 sources identified from the screening process, 58 were taken forward for extraction. 16 of the sources screened had both high reliability and high relevance.

All sources identified were published within the last 10 years. The primary focus was on EU-based studies. However, research from outside the EU, where highly relevant or recommended by stakeholders, was also taken forward.

Data extraction and analysis

For the 58 sources that were shortlisted, data extraction took place to compile the information for the data requirements. Data was logged into an Excel workbook to capture the necessary data under each heading and allow for efficient organisation and filtering. A standardised template was used to capture the data, which allows for filtering and the identification of knowledge gaps.

The information from this research formed the basis of this report and highlighted data gaps that were used to formulate the stakeholder interviews.

Task 2: Stakeholder engagement

Overview

The purpose of the stakeholder consultation was to:

- Assess the feasibility of sodium batteries as a low-cost, sustainable energy storage option for households and businesses.
- Examine how sodium technologies could contribute to the EU's Preparedness Union Strategy, particularly the minimum 72-hour self-sufficiency target for households.

This builds on the information gathered from the literature review in Task 1 of this project. This task was used to gain insights and feedback on information which may not be available in the data identified in the literature review. This task also contributed to identifying potential case studies which were developed under task 3 of this project.

Identification of stakeholders

Stakeholders were mapped by organisation type (e.g., original equipment manufacturers (OEMs), suppliers, industry associations), topic (e.g., sodium batteries, desalination), and Member State to ensure diversity and comparability.

In total, 98 stakeholders were identified. A full list of stakeholders, including organisation name, organisation type, country they operate within, and whether an individual contact detail was obtained is provided in Appendix B.

Stakeholders included sodium-ion and lithium-ion battery OEMs, component and materials suppliers, developers, industry associations representing battery manufacturers, authorities, raw material producers (e.g., sodium / lithium industry), desalination industry experts, salt-processing/producing industries, academic and research institutions, and investors and finance professionals.

Table B-1 in Appendix B provides the distribution of stakeholders identified by type.

Stakeholders operating across 17 Member States were identified and were approached as part of the consultation (primarily via a written survey, with a subset invited to participate in interviews). Additionally, stakeholders from adjacent non-EU countries with relevant R&D or production capacity were identified (Switzerland, Norway, UK, Liechtenstein, Luxembourg and North Macedonia), alongside those in other important global markets (e.g., US, China, India, Singapore, Canada). Table B-2 provides a summary of the geographic distribution of stakeholders identified.

Survey

The aim of the survey was to facilitate primary data collection from Member States and industry contacts, to understand current and future battery use in the EU in terms of energy preparedness, and specifically the role of sodium batteries within this context. The findings of the survey were used to validate and supplement the results of the literature review.

The survey was conducted using *EU Survey*. The survey questions and introductory text provided to stakeholders is presented in Appendix C.

Interviews

In total, 19 stakeholders were contacted for interviews to gather additional insights on the survey responses and to support the case studies presented in section 8.9. The selection aimed to ensure a broad mix of organisation types, roles across the value chain, and geographic coverage. Stakeholders were prioritised based on organisation type, their survey response quality (including any data gaps to discuss), geography and their suitability as potential case studies. Of those contacted, six stakeholders agreed to be interviewed.

Appendix B - Stakeholder information

Table B-1 Distribution of stakeholders identified by type

Stakeholder type	**Count**
(Re)Processors	9
Academic institutions	11
Authorities	5
Battery material producer/suppliers	8
Household battery providers	2
Industry associations	14
Investors	1
Lenders	3
Lithium / other battery OEMs	14
Raw material / desalination industry associations	6
Research organisations	9
Grid operator	1
Sodium battery OEMs	15
Total	98

To clarify table B-2, some stakeholders are counted more than once in this table because they operate in multiple Member States or countries. Stakeholders for whom it was unclear in which Member State(s) they operate, or that represent the EU as a whole, have been classified separately as EU-wide. Similarly, stakeholders for whom it was not clear in which country they operate, or where they represent countries beyond Europe, have been classified as international.

Table B-2 Geographic distribution of stakeholders

Country	**Count**
Member States	(108)*
Austria	3
Belgium	6
Czech Republic	2

Country	Count
Denmark	3
EU-wide	25
Finland	4
France	10
Germany	19
Greece	1
Ireland	1
Italy	4
Netherlands	8
Poland	4
Portugal	2
Romania	1
Slovenia	1
Spain	6
Sweden	8
Non-Member States	(34)*
Canada	2
China	1
India	1
International	6
Liechtenstein	1
Luxembourg	1
North Macedonia	1
Norway	2

Country	Count
Russia	1
Singapore	1
Switzerland	5
UK	6
USA	6

*Includes double-counting of countries as described above

Appendix C - Stakeholder survey questions

Survey questions and background information issued to stakeholders on 16/01/2026 is presented below.

Background information

We are contacting you to get your views and to share information on whether and how sodium batteries can play a key role in energy preparedness and self-sufficiency of households and businesses in the EU. This is a key area where EU policy interventions could help to enhance the self-sufficiency of households in the event of an emergency.

This study was commissioned by the Foresight, Studies and Policy Assessment Unit (FSA) of the European Economic and Social Committee (EESC), within Directorate B, which is responsible for overseeing the EESC's studies programme. The request was made by the Secretariat of the Consultative Commission on Industrial Change (CCMI), which has commissioned WSP to assess the development potential of sodium battery technologies as a sustainable and cost-effective complement to lithium-ion batteries, and to examine their role in strengthening Europe's energy preparedness and industrial competitiveness.

The study is driven by several factors, including the EU's increasing investment in sodium battery technologies, the need to assess industrial readiness for their large-scale production, recent challenges related to energy resilience and security, and growing policy momentum linked to the EU's Preparedness Union Strategy and the Blue Deal.

As part of this project, we are gathering information on past, current and future **household** and **business** energy storage trends across the EU. Industrial or grid energy storage are beyond the scope of this study. The study also seeks to investigate the future potential of sodium batteries as a solution for energy preparedness as well as potential for virtuous cycles with other industries.

The specific objectives of this study are to:

Provide data and analysis on the industrial, economic, and technological potential of sodium batteries within the EU.

Assess the potential capacity of production of sodium batteries, in terms of sodium availability, location, and the potential for existing industries to integrate sodium batteries, and what facilities would need to be put in place to implement this.

Assess the feasibility of sodium batteries as a low-cost, sustainable energy storage option for households and businesses. E.g., by identifying key barriers.

Examine how sodium technologies could contribute to the EU’s Preparedness Union Strategy, particularly the 72-hour self-sufficiency target for households.

Generate evidence-based recommendations to inform the CCMI’s opinion and future EESC initiatives, supporting both industry development and citizen preparedness across Europe.

Note on handling of data: All evidence and data obtained from this survey will be treated in strict confidence, and will be stored securely, only accessible to the immediate project team. We will anonymise all information provided, unless you give your explicit consent for us to name your organisation in our report. Please let us know about any specific requirements you have regarding confidentiality of your response in the survey.

If you do not have completely accurate information, please provide your best estimate.

The survey can be found in the following link:
https://ec.europa.eu/eusurvey/runner/Potential_of_a_sodium_battery_solution_for_energy_resilience

If you are unable to answer any given question, please just move on to the next question.

If you have any questions, please do not hesitate to reach out directly to the project manager (harry.doyle@wsp.com)

Mandatory questions are marked with an *

This survey will close at 6:00 pm CET on 30th January 2026.

Questions

Section 1 – About you:

- *Name: [Open text]
- *Organisation: [Open text]
- *Stakeholder type:
    - Company
    - Industry/trade association/institution
    - National authority/agency
    - European authority/agency
    - Academic/research institution
    - Raw material supplier
    - Sodium extraction/desalination
    - Battery producer / manufacturer
    - Battery supplier
    - Financial sector
    - Other [free text]
- *Geography: [drop-down list]
    - EU
    - International
    - [A list of the 27 EU Member States will be added here]
    - Other [free text]
- *Do you consent to your company being named in the final report, or would you prefer to be referenced only as part of a stakeholder type? *Please note that no specific information or viewpoints will be attributed to individual companies.* [tick-box]
    - Yes – I am happy for my company to be named in report
    - No – I would prefer for my input to be attributed to a stakeholder type.

- Specific request [free text]

Section 2 – Potential of sodium battery industries

This section focuses on sodium battery technologies, their applications, and their potential role in household and business energy storage, as well as wider industrial implications. In your response, please refer to published information where available. **You may skip questions if you are unable to answer them.**

1. What are the current main applications of sodium battery technologies (e.g., grid-scale, household, business, electric vehicles), and how do you expect these applications to evolve (e.g., over the next 10-25 years)? [free text]
2. What are the main technical and practical challenges associated with installing sodium batteries for **households**? (e.g., space requirements, safety, costs, system integration) How does this compare with challenges for **businesses**? [free text]
3. What is your best estimate of the current global manufacturing capacity for sodium batteries, and where are the main production locations? How does this compare to the 42 GWh/y global capacity estimate in 2023, of which 99% is produced in China. [free text]
4. Are you aware of current development of sodium battery production capacity, or plans to do so, in the EU? If so, where and what capacity? [free text]
5. What are the key challenges and risks associated with developing sodium battery production in the EU? (e.g., regulatory framework, energy costs, skills, permitting). [free text]
6. What enabling conditions would be necessary to support the deployment and scaling-up of sodium batteries in the EU? (consider whether lessons can be learned from the development of EU lithium battery production) [free text]
7. What is your best estimate of the availability of sodium as a raw material in Europe, and where are the main sources located [free text]
8. In your view, is there potential for a circular, symbiotic or "virtuous" link between industrial processes that produce sodium as a by-product (e.g., desalination) and sodium battery manufacturing in Europe? What are the main barriers to establishing such links?
9. Are there other critical raw materials required for the production and supply of sodium batteries, and to what extent does this depend on international supply chains? [free text]
10. Which kinds of existing battery manufacturing facilities could potentially be adapted to include sodium batteries in their product portfolio? What are the main challenges associated with this conversion (e.g., technical, economic, regulatory)? [free text]

Section 3 – Sodium battery-related case studies

This section aims to gather information on existing and past sodium battery-related projects to better understand the practical challenges associated with their production, manufacture, supply, and use. We are particularly interested in case studies from different EU Member States that reflect a range of value chain actors, geographic contexts, and end-use applications.

Examples of relevant case studies include (but are not limited to):

- Manufacturers or R&D organisations focused specifically on sodium battery technologies
- Manufacturers or suppliers producing both lithium- and sodium-based batteries, including hybrid technologies

- Sodium extraction or processing companies exploring business cases for the use of sodium by-products in battery production
- Discontinued or unsuccessful sodium battery projects, where lessons learned may be identified

11. Are you aware of any sodium battery-related projects or case studies that could be examined to gain further insight into the challenges encountered and how these challenges have been (or could be) addressed? Please provide details [free text]
12. If available, please provide contact details or reference documents for the projects or case studies mentioned above. [free text]

Appendix D – Calculations for capacity to meet 72-hour preparedness goal

Approach

In this analysis use cases have been used from previous studies:

- Calculations with two profiles for average 'small' and 'large' household. All data is from recent work on household profiles, related to household batteries.[25]
- Four use cases for medium-sized businesses: supermarket, large school, healthcare and hotel. These cases were selected since they are vital for the functioning of society and often do not have emergency power units at the moment.

We have calculated both on individual household/business level what our estimate is for the battery sizes to supply 72-hours of battery capacity. For households we have also made an estimate of total EU-wide required battery capacity

Households

For households calculations have been made on the required battery capacity for a single household to meet the 72-hour preparedness target. Secondly, these results has been extrapolated for 2040 to estimate total battery capacity in Europe if all households install batteries to meet 72-hour of their electricity demand during winter.

Results individual households

Calculations have been made for two average households in the Netherlands; a large scale household (detached or semi-detached household) and a small household (apartment). We have calculated the average electricity consumption in January; used since it is a cold winter month. We have calculated the average electricity consumption per hour and secondly for 72-hours. The results are included in the table below. The large household has a total of 5,000 kWh electricity usage for the heat pump and the small household 2,200 kWh yearly. The EV's charge 1,800 and 2,600 kWh yearly.

Table 0-1 – Average electricity consumption in January for the households

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[25] CE Delft, Home and community batteries (2024). https://cedelft.eu/publications/home-and-community-batteries-opportunities-bottlenecks-and-policy-recommendations/

Average electricity consumption per hour	**Large household**		**Small household**		**Average small and large household**
	Per hour (kWh)	**For 72-hour goal (kWh)**	**Per hour (kWh)**	**For 72-hour goal (kWh)**	
Household usage	0.4	32.0	0.4	28.5	
Solar	-0.1	-8.4	-0.1	-8.4	
Heat pump - space heating	1.6	112.6	0.7	47.7	
Heat pump - tap water	0.2	12.2	0.1	5.2	
Cooking	0.0	1.6	0.0	1.6	
Electric vehicle	0.3	24.9	0.2	16.3	
Total – household without EV of HP	0.3	23.6	0.3	20.1	21.8
Total – household with heat pump	2.1	150.1	1.0	74.7	112.4
Total – household with EV, without HP	0.7	48.5	0.5	36.4	42.4
Total – household with heat pump and EV	2.4	175.0	1.3	91.0	133.0

An important assumption is that this battery capacity is fully charged at the moment an incident occurs. This is definitely not certain as often the state-of-charge in normal operating conditions differs between 20% and 90% of battery capacity. To meet the preparedness goals average households require a batter capacity of:

- 20 to 25 kWh for regular households, without an heat pump or EV.
- 75 to 150 kWh for households with an heat pump and electric cooking, depending on the house size.
- 35 to 50 kWh with EV. For a scenario occurs in which electricity is lost, it is likely that transport will be limited and thus less charging is required.
- 90 to 175 kWh for households with an heat pump, electric cooking and electric car, depending on the house size.

At this moment, most batteries systems sold are between 3 and 12,5 kWh. For most households, a battery system of 5 kWh (average household) up to 10 kWh (if a household has a lot of solar and electricity demand from for example EV) is logical. To reach a 72-hour self-sufficiency goal a significantly larger battery is required, of which a very large portion will not be used for almost all the time. Thus significant additional cost needs to be made, for battery capacity that will be idle most of the time for households. Two additional considerations need to be made:

- The battery needs to be fully charged at the moment a disruption takes place to be able to supply electricity for the calculated 72-hours electricity demand. A battery that needs to stay fully charged at all moments will have some energy losses.
- Often an extra module is required to supply electricity to the household if power from the grid is lost. This module is required to arrange power flows with in the house and manage voltage level. Prices differ between EUR 500 up to EUR 1.000 for such a system for current lithium-battery systems. The costs are expected to be comparable for sodium-battery systems.

We have calculated the average battery capacity, weight and size. We have used an energy density of 0.068 kWh/kg and 135 kWh/m3 for sodium batteries.[26] The current battery prices for a 20 kWh household battery is approximately 600 EUR /kWh for lithium-ion.[27] At the moment battery cost for sodium and batteries are comparable, and thus we have assumed this price as the high value in our range. However, battery costs have decreased significantly in the previous years. Sodium battery price projections predict a potential further reduction towards 40 dollar per kWh. For a rough estimate we have also used a price of 300 EUR /kWh as the lower value of our range. This represents a future battery prize, potentially also for sodium batteries, although there is a lot of uncertainty.

Table 0-2 – Size and weight of sodium batteries

	Battery capacity (kWh)	Weight (kg)	Size (m3)	Potential dimensions (m)	Cost indication (EUR)[28]
Total - traditional household	21.8	321	0.16	0.5 x 0.25 x 1.3 m	6,500 – 13,100
Total - household with HP	112.4	1.653	0.83	0.5 x 0.25 x 6.6 m or 1 x 1 x 0.8 m	33,700 – 67,400
Total - household with HP and EV	133.0	1.956	0.99	0.5 x 0.25 x 7.9 m or. 1 x 1 x 1 m	39,900 – 79,800

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[26] Voß, P. et al. (2025) 'Benchmarking state-of-the-art sodium-ion battery cells – modelling energy density and carbon footprint at the gigafactory-scale', *Energy & Environmental Science*. doi:10.1039/D5EE00415B.

[27] CE Delft (2024) Home and community batteries. Opportunities, bottlenecks and policy recommendations. See: https://cedelft.eu/publications/home-and-community-batteries-opportunities-bottlenecks-and-policy-recommendations/

[28] Assumed range of battery prices between 600 EUR/kWh (current lithium-ion and also representative for sodium) and 300 EUR/kWh (potential future price for sodium due to technical development and larger scale production).

	Battery capacity (kWh)	Weight (kg)	Size (m3)	Potential dimensions (m)	Cost indication (EUR)[28]
Total - household with EV	42.4	624	0.31	0.5 x 0.25 x 2.5 m or. 0.5 x 0.5 x 1.25 m	12,700 – 25,500

Extrapolation EU-wide

Looking at the two EU scenario's from the ENTSO-e[29], we find relevant data for the penetration of EV's and heat pumps which determine the required size of batteries. We assume 202 million households in the EU-27. ENTSO-e describes these scenario's as:

- Distributed Energy (DE) is driven by a willingness of the society to achieve energy autonomy. This translates into a strong decentralised drive towards decarbonisation which implies a maximization of renewable energy production and a strong decrease of energy imports.
- Global Ambition (GA) emphasises a transition driven by a global move towards the Paris Agreement targets. This implies the development of a wide range of renewable and low-carbon technologies (many being centralised) and the use of global energy trade as a tool to accelerate decarbonisation.

Table 0-3 – ENTSO-e scenarios for electric passenger cars in 2040 and 2050

	Scenario distributed energy		Scenario global ambition	
	2040	2050	2040	2050
Electric vehicle	66%	92%	54%	80%
Hydrogen vehicle	5%	7%	13%	17%
Other	29%	1%	33%	3%

Table 0-4 – ENTSO-e scenarios for household heating in 2040 and 2050

	Reference	Distributed Energy		Global Ambition	
Year	2019	2040	2050	2040	2050
Hybrid heat pump	2%	5%	7%	11%	13%
Electric heat pump	13%	50%	63%	37%	50%
Methane boiler	37%	12%	3%	14%	5%
Hydrogen boiler	0%	2%	3%	5%	5%

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[29] ENTSO-e (2024) – Ten-year net development plans. https://2024.entsos-tyndp-scenarios.eu/download/

	Reference	Distributed Energy		Global Ambition	
Other technologies	48%	31%	25%	33%	28%

We can use average battery capacity from Table 0-1 and the number of households with EV and heat pumps for our EU-wide calculations.

Table 0-5 – Total battery capacity with 100% penetration of household batteries, to supply 72-hours of electricity demand

	Number of households - estimate		**Average battery capacity estimate (kWh) – see Table 0-1**	**Total battery capacity 2040 - estimate (GWh)**	
	Distributed energy	**Global ambition**		**Distributed energy**	**Global ambition**
Households EV	32.4 mln	70.7 mln	42.4	1,379 GWh	3,001 GWh
Households EV + heat pump	101.2 mln	37.4 mln	133.0	13,469 GWh	4,980 GWh
Households without EV or heat pump	68.2 mln	93.8 mln	21.8	1,490 GWh	2,048 GWh
Total				16,337 GWh	10,030 GWh

This short analysis gives an estimate of the total battery capacity if all households need a battery system that can theoretically supply them with electricity for 72-hour. Households require a 20 - 150 kWh battery system. In 2040 the total required battery capacity would be 10,000 GWh up to 16,300 GWh for all EU countries.

We can compare this 10,000-16,3000 GWh for 100% households with a 72-hour-battery systems with current developments:

- The ENSTO-e scenario's predict a total estimated power of 119 to 148 GW for 2040 for EU-27. Most prosumer batteries have a 0.5-capacity factor (2 kWh per 1 kW power), thus an estimated 250 to 300 GWh capacity. If 100% of the households install a 72-hour-battery system, the installed capacity of household batteries would need to increase from 250-300 GWh up to 10,000-16,300 GWh. For 100% of households to meet 72-hour goal, 40-50 times the ENTSO-e scenarios estimates would be required.
- The current battery world production capacity is approximately 3,000 GWh in 2024, mostly lithium and for electric vehicles[30]. Thus, building all battery systems to reach 72-hour preparedness goal would require 3.5 up to 5.5 years of the current global battery production capacity (lithium and sodium).

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[30] IEA (2025) – The battery industry has entered a new phase. https://www.iea.org/commentaries/the-battery-industry-has-entered-a-new-phase?utm_source=chatgpt.com

- At this moment plans for sodium-battery plants in Europe are made for approximately 10 GWh/year production capacity towards 2030. The current planned production capacity thus could only realise a small portion of the required battery capacity. Therefore, for sodium batteries to significantly support the 72-hour preparedness goals significantly additional scaling up is required.

Businesses

We have analysed four medium scale businesses which can be seen as essential. The use cases are based on previous studies from CE Delft[31]. We have not included use cases which often already have back-up power like hospitals or telecommunication. The four selected uses cases with surface area and energy demand are displayed in the table below.

Table 0-6 – Characteristics of the four researched use cases

	Surface area	Yearly standard electricity consumption	Heat demand (kWh thermal)
Hotel	4,500 m^2	490,000 kWh	880,000 kWh
Healthcare facility with night care	6,000 m^2	410,000 kWh	1,100,000 kWh
Supermarket	1,600 m^2	120,000 kWh	100,000 kWh
Large school	9,000 m^2	350,000 kWh	790,000 kWh

We have calculated the average electricity consumption in January, as a representative winter month. Charging of EV's from employees has been excluded in the analysis. The average electricity consumption has been calculated for the current energy demand and for a scenario in which heat is supplied via a heat pump-system for these specific use cases. This analysis gives an indication of the required battery capacity.

Table 0-7 – Results of average 72-hours electricity consumption in January

	Direct electricity demand for appliances etc. (kWh)	Electricity demand with heat pump-system (kWh)
Hotel	1,200	1,750
Healthcare facility with night care	950	1,700
Supermarket	280	400
Large school	380	1,050

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[31] CE Delft (2025) – Study of time dependent grid tariffs for large consumers. https://cedelft.eu/publications/study-of-time-dependent-grid-tariffs-for-large-consumers/

This energy demand is used to determine weight and size of the battery systems, as presented in Table 0-8. For the cost estimate we assume a lower price than for household batteries, due to the size of the systems. Therefore, a price of 500 EUR/kWh (current lithium-ion) towards 250 EUR/kWh (potential future sodium prices) has been used.

Table 0-8 – Estimated battery sized, weight, size and cost (1/2)

	Battery capacity (kWh)		**Weight (kg)**		**Size (m3)**	
	Appliances only	**Appliances + HP**	**Appliances only**	**Appliances + HP**	**Appliances only**	**Appliances + HP**
Hotel	1,200	1,750	18,100	25,700	9.1	12.9
Healthcare facility with night care	950	1,700	14,000	25,100	7.0	12.7
Supermarket	280	400	4,100	5,600	2.1	2.8
Large school	380	1,050	5,500	15,400	2.8	7.8

Table 0-9 – Estimated battery sized, weight, size and cost (2/2)

	Size (m3)		**Cost (EUR)**	
	Appliances only	**Appliances + HP**	**Appliances only**	**Appliances + HP**
Hotel	9.1	12.9	310,000 - 650,000	440,000 - 870,000
Healthcare facility with night care	7.0	12.7	240,000 - 470,000	430,000 - 850,000
Supermarket	2.1	2.8	70,000 - 140,000	95,000 - 191,000
Large school	2.8	7.8	90,000 - 190,000	260,000 - 530,000

These use cases are more difficult to extrapolate for the entire EU, since there is no data available on the number of hotels, supermarkets etc. Secondly it is uncertain how the 72-hour-preparedness goal will be formed in practice; and thus, which percentages of these businesses will need/place a large-scale battery system.

Appendix E - Global sodium-ion battery manufacturers in 2025

This table presents a list of key global sodium-ion battery manufacturers operating as of 2025. The manufacturers are listed alphabetically and were compiled by WSP using a combination of data from literature, stakeholder survey responses and interviews. It is not intended to be comprehensive.[227]

Company	Year founded	Headquarters	Energy density (Wh/kg)[228]	Cycle Life[229]	Role in sodium-ion value chain	Manufacturing capacity (MWh/ annum)	Sodium battery chemistry
Altris AB	2017	Uppsala, Sweden	160	N/A	Develops Prussian White cathode materials and full sodium-ion batteries for stationary storage backed by Volvo Cars Tech Fund	100 (3,000 planned)	Anode: hard carbon Cathode: PBA Electrolyte: organic
AMTE Power (LionVolt)	2013	Thurso, Scotland, UK	N/A	N/A	Developer of advanced cell technologies, including sodium-ion, pilot production for automotive and energy storage.	N/A	N/A
BenAn Energy Technology	2016	Shenzhen, China	N/A	N/A	Manufactures aqueous sodium-ion battery systems for energy storage; multiple product generations.	N/A	N/A
BYD	1995	Shenzhen, China	N/A	N/A	Developing pilot sodium-ion batteries for EVs and energy	N/A	N/A

Company	Year founded	Headquarters	Energy density (Wh/kg)[228]	Cycle Life[229]	Role in sodium-ion value chain	Manufacturing capacity (MWh/ annum)	Sodium battery chemistry
					storage in Xining, China, with 30 GWh capacity.		
CATL (Contemporary Amperex Technology Ltd.)	2011	Ningde, Fujian, China	175	>10,000	Global battery leader; launched Naxtra brand in 2025 for mass-market sodium-ion batteries. 40 GWh expected by December [230].	N/A	Anode: hard carbon Cathode: Prussian white Electrolyte: organic
China Three Gorges Corporation (CTG)	1993	Wuhan, Hubei, China	N/A	N/A	Hydroelectric power plant, subsidiaries involved with building the world's largest sodium-ion battery plant, with an initial production capacity of 1 GWh in partnership with HiNa Battery Technology.	N/A	N/A
Clarios	1885 (Johnson Electric Service Company)/2019 (Clarios)[231]	Wisconsin, USA	N/A	N/A	To accelerate the development of this technology, Clarios has partnered with Altris, to bring advanced Na-ion solutions to the low-voltage automotive market[232]	N/A	N/A

Company	**Year founded**	**Headquarters**	**Energy density (Wh/kg)**[228]	**Cycle Life**[229]	**Role in sodium-ion value chain**	**Manufacturing capacity (MWh/ annum)**	**Sodium battery chemistry**
Draslovka	1906	Prague, Czech Republic	N/A	N/A	Draslovka has partnered with Natron Energy to develop, commercialise, and produce high-quality Prussian blue for sodium-ion batteries. They are also actively involved in the development of sodium-ion batteries, through a strategic partnership with Altris.	N/A	N/A
Faradion (Reliance Industries Subsidiary)	2011 (acquired 2021)	Sheffield, UK / India	160-190 (lab)	around 4,000	Pioneer in sodium-ion battery tech; working with Reliance to scale production in India. 30 GWh sodium-ion hub in Jamnagar, slated for late-2025 commissioning.	1,000 planned	Anode: hard carbon Cathode: oxide Electrolyte: organic
Heiwit S.p.A.	N/A	Varese, Italy	N/A	N/A	A start up with the intention to decarbonise the energy system through sodium batteries. A 1GWh farm is aiming for a 2026 start.	N/A	N/A
HiNa Battery Technology	2017	Zhongguancun, Beijing, China	140-155	≥4,500	One of the leading manufacturers of cylindrical sodium-ion	5,000 planned	Anode: hard carbon

Company	Year founded	Headquarters	Energy density (Wh/kg)[228]	Cycle Life[229]	Role in sodium-ion value chain	Manufacturing capacity (MWh/ annum)	Sodium battery chemistry
					batteries. 1 GWh battery production line online since 2022[233].		Cathode: oxide Electrolyte: organic
Indi Energy	2019	Roorkee, Uttarakhand, India	N/A	N/A	IIT Roorkee spin-off; develops sodium-ion batteries using hard carbon anodes from bio-waste.	N/A	N/A
InnoEnergy	2010	Eindhoven, Netherlands	N/A	N/A	InnoEnergy is actively supporting Altris, by providing financial backing and strategic partnerships. This partnership is part of a broader effort to advance sodium-ion battery technology and diversify the energy storage landscape,	N/A	N/A
InoBat	2019	Bratislava, Slovakia	N/A	N/A	InoBat is a company focused on the development and manufacture of sodium-ion batteries for EVs. In January 2026 InoBat entered a partnership with Clarios and Altris to produce	N/A	N/A

Company	Year founded	Headquarters	Energy density (Wh/kg)[228]	Cycle Life[229]	Role in sodium-ion value chain	Manufacturing capacity (MWh/ annum)	Sodium battery chemistry
					sodium battery cells in industrial scale.		
MOLL Batterien	1946	Bad Staffelstein, Germany	N/A	N/A	MOLL Batterien is set to establish a sodium-ion battery manufacturing plant in Lichtenfels, Bavaria, with an initial capacity of 1 GWh.	N/A	N/A
Moonwatt	2024	Amsterdam, The Netherlands	N/A	N/A	Moonwatt utilises “string battery” architecture which leverages advanced sodium-ion batteries stored in a “passive-cooled” hermetically sealed enclosure.”	N/A	N/A
Natron Energy	2012	Santa Clara, California, USA	Around 80 (pack)	>50,000	Established at Stanford University. Develops sodium-ion batteries using polybenzimidazole (PBA) electrodes paired with an aqueous electrolyte. In 2024, Natron revealed plans to build a 24 GWh factory in North Carolina.	600 planned	Anode: PBA Cathode: PBA Electrolyte: aqueous
NGK Insulators	1919	Nagoya, Japan	N/A	N/A	Pioneer in sodium-based batteries; expanding into sodium-ion for grid-scale storage.	N/A	N/A

Company	Year founded	Headquarters	Energy density (Wh/kg)[228]	Cycle Life[229]	Role in sodium-ion value chain	Manufacturing capacity (MWh/ annum)	Sodium battery chemistry
Nobian	1918/2021	Amersfoort, The Netherlands	N/A	N/A	Nobian is involved in the STARBATCH project, which aims to create a new production process for sodium-based batteries. This is a collaboration with Exergy Storage, the University of Twente, and ISPT, and focuses on producing sodium tetrachloroaluminate ($NaAlCl_4$) more sustainably and efficiently than current methods.	N/A	N/A
Rechargion	2021	Pune, India	N/A	N/A	Developing of sodium-ion battery technology. Opened India's first dedicated Na-ion call fabrication pilot plant[234].	N/A	Anode: hard carbon Cathode: olivine Electrolyte: organic
Tiamat	2017	Amiens, France	140-160	>5,000	European sodium-ion startup, focusing on high-power cells for EVs, scooters, and stationary storage. Plant site permitted	5,000 planned	Anode: hard carbon Cathode: NVPF

Company	Year founded	Headquarters	Energy density (Wh/kg)[228]	Cycle Life[229]	Role in sodium-ion value chain	Manufacturing capacity (MWh/ annum)	Sodium battery chemistry
					taking capacity from 0.7-5 GWh from 2025-2029.[235]		Electrolyte organic

Appendix F - References

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**European Economic
and Social Committee**

Rue Belliard/Belliardstraat 99
1040 Bruxelles/Brussel
BELGIQUE/BELGIË

www.eesc.europa.eu

Printed by the EESC-CoR Printing and Distribution Unit, Belgium

EESC-2026-20-EN

Publications Office
of the European Union

ISO14001
CERTIFIED
VINÇOTTE

EMAS
Verified
environmental
management

Print
QE-01-26-008-EN-C
ISBN 978-92-830-7051-1
doi:10.2864/0111431

PDF
QE-01-26-008-EN-N
ISBN 978-92-830-7050-4
doi:10.2864/2097251

EN