Innovations for net-zero energy and materials systems

MARCH 2026

Innovation Brief Series

Sodium-ion batteries

Diversifying beyond lithium-ion with a scalable alternative

Reduce carbon use

Energy Transitions Commission

SYSTEMIQ

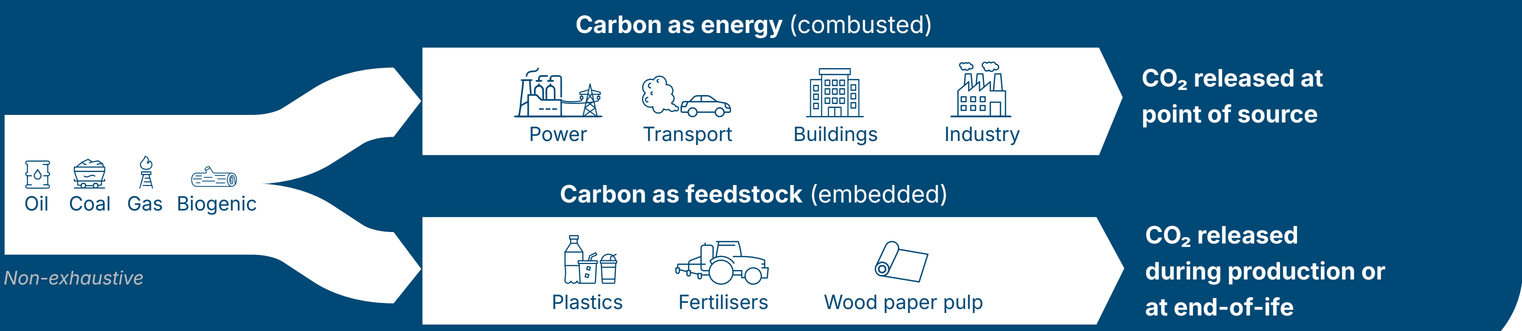
This innovation brief was created by Systemiq and the Energy Transitions Commission as part of the *Carbon in an electrified future* series. Each brief highlights a key technological innovation that can drive electrification, circularity, or carbon sourcing.

Learn more at www.energy-transitions.org/publications/carbon-in-an-electrified-future
www.systemiq.earth/resource-category/carbon-in-an-electrified-future

Sodium-ion (Na) batteries

Carbon sits at the centre of today's energy and materials systems

Carbon is the core component of the fossil fuels and material feedstocks that underpin today's energy and materials systems. When these carbon-based resources are combusted or transformed to produce energy, heat, mobility, and materials, they release carbon dioxide (CO_2). Achieving net zero requires both reducing the carbon entering the system and actively managing the residual carbon that remains.



Three steps towards net-zero energy and materials systems

1 Reduce carbon use
- Increase supply of clean electricity
- Switch to electrification where possible
- Use clean hydrogen when not possible to electrify

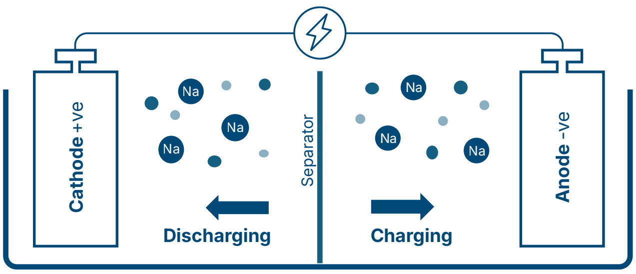
2 Recycle and reuse carbon
- Increase durability and reuse of carbon products
- Scale recycling of carbon products
- Capture and reuse carbon emissions

3 Source sustainably and manage end-of-life
- Prioritise non-fossil carbon inputs and capture of unavoidable emissions
- Secure permanent storage for residual carbon

Sodium-ion (Na) batteries

What are sodium-ion batteries?

Sodium-ion batteries store and release electricity using sodium ions, working similarly to lithium-ion but with different chemistry and performance. Today they typically provide 3–8 hours of stationary storage and enable modest EV ranges (250–500 km).[1]



Key takeaways

A **Sodium-ion batteries can support the scale-up of clean electricity** by providing battery storage that helps balance wind and solar-based systems, though lower energy density compared to lithium-ion limits some applications, including transport.

B **Sodium-ion batteries can lower supply chain risk and costs** compared to lithium-ion batteries as they face lower raw material constraints.

C **Commercial momentum is building**, sodium-ion batteries have entered low-volume commercial deployment, with production projected to grow ~15× by 2030.

A Sodium-ion batteries can support the scale-up of clean electricity

Clean electricity systems built on solar and wind require balancing

- Solar and wind's share of global power systems has grown significantly, driven by an 85% fall in solar costs and an 83% fall in wind costs since 2010.[2]
- Solar and wind are inherently weather-dependent, so power systems must balance variable supply with demand across hours, days and weeks; the optimal balancing mix varies by geography.[3]

Battery storage is critical for clean power system balancing, with lithium-ion dominant and sodium-ion emerging

Balancing needs can be met by different technologies

✓ Can fully meet ✓ Can partially meet

		System operation	Short duration (up to 8 hours)	Medium-long duration (8-50 hours)	Ultra-long duration (50+ hours)
		Inertia, frequency response, voltage control, fault ride through	Predictable and unpredictable daily variations (e.g. cloudy summer days) **55-100% of balancing needs will be short-duration in fully clean power systems**[4]	Supply and demand driven variations (e.g. winter heating peak in Europe; wind supply during Indian monsoon season)	Supply and demand driven variations (e.g. anticyclonic wind drought)
Grid stability technologies	Synchronous condensers	✓			
	Grid-forming inverters	✓			
Dispatchable generation	Hydro, nuclear (Other zero carbon)	✓	✓	✓	✓ (partial)
	Fossil (or bioenergy) + CCS	✓	✓	✓	✓
	Fossil – low/very low utilisation	✓	✓	✓	✓
	Power-to-X (i.e. H_2)	✓	✓	✓	✓
Energy storage	Battery storage (Li-ion, Na-ion)	✓	✓	✓ (partial)	
	Pumped hydro	✓	✓	✓	✓ (partial)
	Other technology (i.e. CAES, liquid air, etc.)	✓	✓	✓	✓ (partial)
Interconnection	Accessing complementary weather patterns and time shifting generation	✓ (partial)	✓ (partial)	✓ (partial)	✓ (partial)
Demand side flexibility	EV (smart charging, V2G)		✓	✓ (partial)	
	Heating load		✓		
	Industrial load		✓	✓	

Lithium-ion batteries make up >80% of all energy storage;[5] *battery pack costs have fallen 77% since 2015, in part driven by market scale from EV demand.*[6]

Sodium-ion batteries are emerging as a key battery storage technology. *They are well-suited for stationary storage, offering advantages such as low-temperature tolerance, long cycle life and enhanced safety.*

Sodium-ion batteries have more limited uses in transportation

Batteries are also used in transport, especially EVs. Today, sodium-ion batteries have more limited transport use because their lower energy density requires more space to deliver the same energy. Advances in energy density could expand future mobility applications.

Sodium-ion has lower energy density, meaning it would require more space to deliver equal energy

Energy density[7]
(unit mass, volume)

Lithium-ion batteries (LFP chemistry): 500 Wh/kg, 600-750 Wh/l

Sodium-ion batteries: 200 Wh/kg, 400 Wh/l

Current transportation use cases by battery type[8]

Enables / Partially enables / Doesn't enable

Increasing range →

	Entry-level Electric Vehicle	Premium Electric Vehicle	Electric buses	Electric trucks	Electric shipping and aviation
Na-ion	Enables	Partially enables	Doesn't enable	Doesn't enable	Doesn't enable
Li-ion	Enables	Enables	Enables	Partially enables	Partially enables

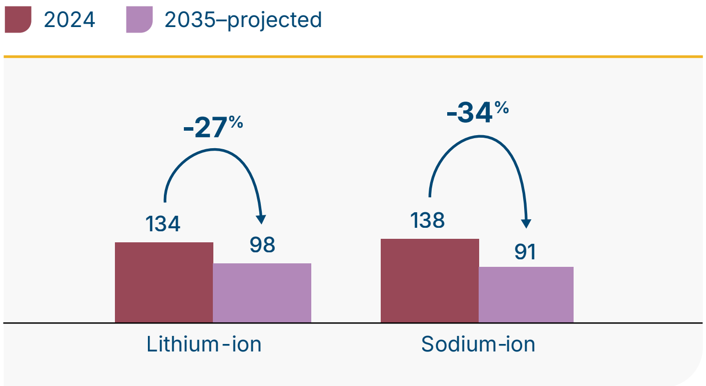
B Sodium-ion batteries use cheaper, more abundant material inputs than lithium-ion batteries

Sodium-ion batteries can reduce supply chain risk and lower costs

- **ION - Sodium is >1,000 times more abundant in the Earth's crust than lithium**, and is distributed globally, while the lithium supply is highly concentrated in Chile, Australia and China.[9]
- **CATHODE -** Cathode chemistries vary; while typical material needs for sodium-ion batteries are higher overall, **costs are overall lower (e.g. iron-based) and avoid critical raw materials** (e.g., some lithium-ion chemistries contain cobalt, nickel).[10]
- **ANODE -** Anodes for sodium-ion batteries are **typically hard carbon which is cost-competitive with graphite anodes** used for lithium-ion anodes.[11]

Sodium-ion batteries could be cheaper than lithium-ion in power systems by 2035

Levelised cost of storage for fully installed 4-hour storage system technologies in China[12] $/MWh



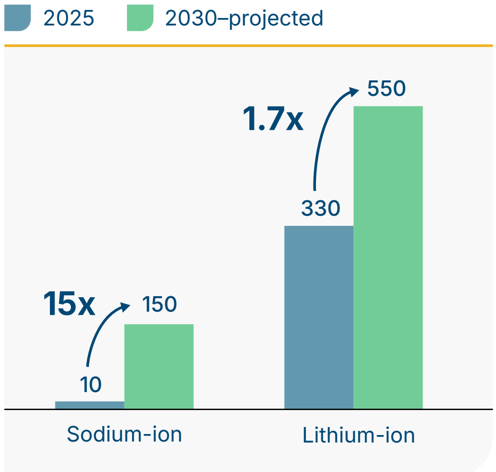
C Sodium-ion batteries are starting to scale – and can play a complementary role to lithium-ion, making up 20% of the stationary storage market in 2030

Sodium-ion battery manufacturing is moving into commercial deployment.

- **Sodium-ion battery technology has advanced** from Technology Readiness Level (TRL) 3–4 (lab-scale pilots) in 2020 to TRL 8 (first-of-a-kind commercial systems) in 2024.[13]
- **Companies are announcing targets to ramp up production,** with scaling concentrated in China.[14]

- BYD began a 30 GWh sodium-ion EV battery plant construction in Xuzhou, China (2024)
- CATL announced 2026 mass market availability for second generation sodium-ion batteries (2025)
- Qingna Technology signed an availability for second generation sodium-ion batteries agreement for a 20 GWh plant project in Sichuan, China (2025)

Estimated global production capacity for stationary storage market[15] GWh



Sodium-ion batteries use materials that are 40× cheaper per tonne of raw materials, 1,000× more abundant than lithium, with comparable life cycles and almost equal tech-maturity. They offer a strong alternative to lithium-ion where density is less critical.[16]

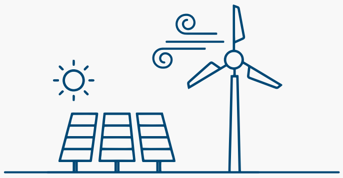
Most favourable | Least favourable

	Raw material price	Resource availability	Lifespan	Energy density (unit mass, volume)	Technology readiness level*
Sodium-ion batteries	500 $/t easier, more sustainable mining[17]	>1,000 times more abundant than lithium	~ Cycle-life similar to lithium-ion batteries	200 Wh/kg 400 Wh/l	8
Lithium-ion Batteries (LFP)[9]	20,000 $/t complex, less sustainable mining	~50 kt Potential global supply gap by 2030[18]	Steady performance in high number of cycles	500 Wh/kg 600-750 Wh/l	9

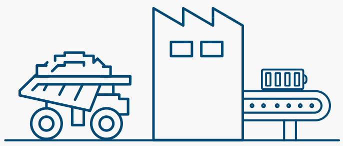
*Technology readiness level (TRL) is a standard scale used to assess the maturity of a technology, from 1 (basic principles observed and documented) to 9 (technology proven in operation and in industrial production)

Sodium-ion batteries: diversifying beyond lithium-ion with a scalable alternative

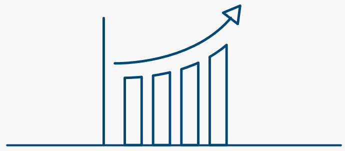
Sodium batteries can:



Support scale-up of wind and solar-based systems by providing a viable alternative to lithium-ion batteries for balancing



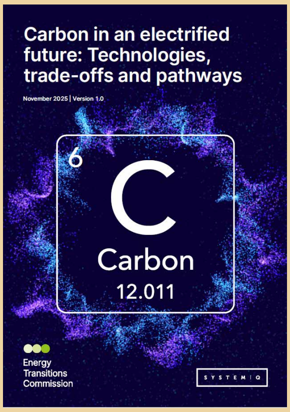
Reduce supply chain risk and material costs by relying on cheaper, more abundant material inputs compared to lithium-ion batteries



Offer near-term scalability, having entered low-volume commercial deployment and with production expected to grow **~15×** by 2030.

Three priorities to scale sodium-ion batteries by 2030

Key priorities	Key players	Key actions
Innovation to drive down costs and optimise performance	• Battery suppliers • Governments	Prioritise focus on continued innovation to lower costs (some manufacturers expect costs could fall to ~$40/kWh as production scales)[19], while **improving performance around energy density** to enable expansion into further mobility applications.
Scale production and material supply chains to lower costs	• Battery suppliers • Investors • Storage developers	Deliver efficient and scalable supply chains across sodium-ion components as the technology expands beyond low volume commercialisation. This includes effectively **scaling the production of hard carbon anodes and sodium-based cathodes**, which currently lack the manufacturing maturity and supplier depth seen in lithium-ion value chains.
Drive industry adoption and partnerships	• Battery suppliers • Storage developers • Renewable developers	Drive partnerships across the value chain between battery suppliers and grid operators, EV manufacturers, and electronics companies, to **unlock early projects** and demonstrate **complementary use cases** of sodium-ion.



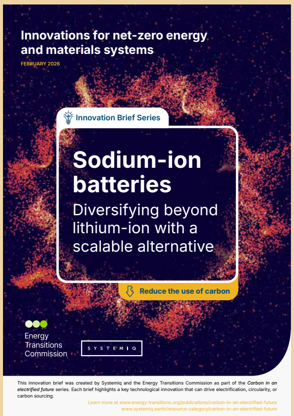
Further reading: Also in this Innovation Brief Series

Electrification will drive the global transition to net zero, powering cleaner industries, homes and transport. But even in a world where electricity dominates, carbon molecules will play a remaining role in producing essential fuels and materials.

This innovation brief is part of the ***Carbon in an electrified future*** series. Each brief highlights a key technological innovation that can drive electrification, circularity, or sustainable carbon sourcing across three steps towards net-zero emissions energy and materials systems.

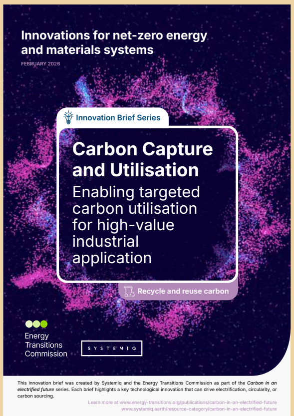
Explore more in the other briefings:

Reduce carbon use | **Recycle and reuse carbon** | **Source sustainably and manage end-of-life**



Sodium-ion batteries
Diversifying beyond lithium-ion with a scalable alternative

Molten Oxide Electrolysis and Electrowinning
Electrifying ore-based steel production



Carbon Capture and Utilisation
Enabling targeted carbon utilisation for high-value industrial application

Alternative Proteins
Unlocking land for nature and biomass

Sources and notes

1. CATL(2025) Naxtra Battery Breakthrough & Dual-Power Architecture: CATL Pioneers the Multi-Power Era
2. IRENA (2024), Renewable Power Generation Costs 2023.
3. European Commission (2023), Flexibility requirements and the role of storage in future European power systems. ; Energy Transition Commission (2021) Making clean electrification possible Note: Limited nuclear capacity for flexible ramping, CAES is compressed air energy storage, LAES is Liquid Air Energy Storage, BESS is utility-scale and behind-the-meter. Emerging tech might include gravitational storage and molten sands storage. Examples of Power-to-X include the production of H2 from electrolysis and re-conversion of hydrogen in power via gas turbines or fuel cells
4. ETC (2025) Power Systems Transformation
5. Huang et al. (2022) Key Challenges for Grid-Scale Lithium-Ion Battery Energy Storage
6. BNEF (2025), Lithium-Ion Battery Pack Prices Fall to $108 Per Kilowatt-Hour, Despite Rising Metal Prices
7. Announced by CATL (2024); BatteryNews (2025) CATL to Produce Second-Generation Sodium-Ion Battery
8. Tepe (2023) Lithium-ion battery utilization in various modes of e-transportation; Koloch (2025) Beyond lithium: A comprehensive use-case-analysis of sodium-ion-battery technology in battery electric vehicles
9. Kevin Brunelli (2023) Fact Sheet: Lithium Supply in the Energy Transition
10. Mingyi He (2024) Review of cathode materials for sodium-ion batteries
11. J. Kuai (2024) Comparison and optimization of biomass-derived hard carbon as anode materials for sodium-ion batteries; Xinlong Chen (2019) High-performance sodium-ion batteries with a hard carbon anode: transition from the half-cell to full-cell perspective. Note: Hard carbon is a non graphitizable form of carbon used mainly as an anode material in sodium ion batteries.
12. BNEF (2024), Lithium-Ion Batteries are set to Face Competition from Novel Tech for Long-Duration Storage: BloombergNEF Research; Energy Storage News (2023), Li-ion BESS costs could fall 47% by 2030, NREL says in long-term forecast update; Pacific Northwest National Laboratory (2023), Energy Storage Cost and Performance Database; IRENA (2017), Electricity Storage and Renewables: Costs and Markets to 2030; ARS Technica (2024), Lower-cost sodium-ion batteries are finally having their moment; SMM (2024), Revolutionizing Energy: China's Sodium-Ion Batteries Set to Outpace Lithium by 2025, Sparking a $14 Billion Market Transformation; Energy Storage News (2024), Rongke Power completes grid-forming 175MW/700MWh vanadium flow battery in China, world's largest; PV Magazine (2024), World's largest vanadium redox flow project completed; Energy Storage News (2024), 'World's largest' compressed air energy storage project connects to the grid in China; Tong, Z., et al., (2021), A review on the development of compressed air energy storage in China: Technical and economic challenges to commercialization; NREL (2024), Energy Storage, Track 9, Session 2: Emerging Sustainable Technologies and Practices;IEA (2024), Clean Energy Technology Guide. CAPEX values in the lower range were taken as CAPEX for China given cheaper manufacturing costs.
13. TRL = Technology Readiness Level, taken from IEA (2024), Clean Technology Guide
14. Adrian Leung (2025) CATL confirms 2026 large-scale sodium-ion battery deployment in multiple sectors; ElectrifyNews (2024) China and the Global Rise of Sodium-Ion Batteries: The U.S. Potential to Lead the Charge for Evs; Marija Maisch (2025) Massive 20 GWh sodium-ion battery manufacturing plant announced in China
15. Statista (2024), Sodium-ion capacity forecast by region worldwide; PV Magazine (2024), Sodium-ion battery production capacity to grow to 10 GWh by 2025, IEA (2024), Global EV Outlook 2024; Woodmac (2023) Global lithium-ion battery capacity to rise five-fold by 2030; IEA (2024) Batteries and Secure Energy Transitions
16. Fraunhofer et al. (2023), ENTEC Study on Energy Storage; Fraunhofer ISI (2023), Alternative Battery Technologies Roadmap 2030+; IEA (2024), Clean Technology Guide; Energy Post (2023), Sodium-ion batteries ready for commercialization for grids, homes, even compact EVs; Altech Batteries (2024), German Sodium Chloride CERENERGY® Solid State (SCSS) Battery Project.
17. Fraunhofer ISI (2023), Alternative Battery Technologies Roadmap 2030+; Fastmarkets (2024), Lithium prices, Business Analytiq (2024), Potassium and Sodium Hydroxide Price Indices; LibreTexts Geosciences, Abundance of elements in earth's crust.
18. Energy Transition Commission (2023) Materials and Resource Requirements for the Energy Transition
19. IRENA (2025) Sodium-Ion Batteries: A technology brief

Copyright © 2026 Energy Transitions Commission and Systemiq Ltd. All rights reserved. No part of this publication may be copied or redistributed in any form without the prior written consent of Energy Transitions Commission and Systemiq Ltd. This document is supplementary to the full report- if reproducing or referencing the content, please use the following citation: "Energy Transitions Commission and Systemiq. (2026). Innovations for net-zero energy and materials systems | Sodium-ion batteries: Diversifying beyond lithium-ion with a scalable alternative".