Sodium-ion batteries: Should we believe the hype?

They are getting cheaper and better, but so are those made with lithium

by Alex Scott

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An E10X sodium-ion-powered microcar in yellow. E10X, a microcar made by the Chinese firm JAC Yiwei, a joint venture between JAC and Volkswagen, is one of the first mass-produced vehicles to be powered by a sodium-ion battery. Credit: JustAnotherCarDesigner/Wikipedia

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- Increases in the energy density of sodium-ion batteries means they are now suitable for stationary energy storage and low-performance electric vehicles.
- The abundance of raw material for making sodium-ion batteries is one edge they have over lithium-ion batteries.
- A challenge for sodium-based batteries is that they now cost more per kilowatt-hour than lithium-iron-phosphate batteries.

If batteries were runners, sodium ion would be the out-of-shape and out-of-breath athlete that has lost touch with the race leader: lithium ion. Sodium is heavier than lithium, and its ions are larger, resulting in a volumetric energy density that is 20–40% less than that of lithium ion. Consequently, a sodium-ion battery is bigger and heavier than an equivalent one made with lithium, putting it at a distinct disadvantage when it comes to powering electric vehicles (EVs).

And yet the low cost of building sodium-ion batteries makes them contenders in some applications. Throw in other advantages over lithium-ion batteries—including less energy capacity loss at low temperature, less risk of thermal runaway, and a supply chain not controlled mostly by China—and the case for sodium-ion batteries strengthens.

Tens of companies around the world are working on making sodium-ion batteries the preferred choice over lithium-ion ones, especially in applications such as stationary energy storage and low-performance EVs, where high energy density is not a big concern. But the ever-changing dynamics of the battery industry make picking winners and losers a fool’s game.

"We’re matching the performance of [lithium iron phosphate batteries] at roughly 30% lower total cost of ownership for the system."

Mukesh Chatter, cofounder and CEO, Alsym Energy

Sodium-ion supporters are positioning the batteries mainly against lithium-ion batteries with cathodes made from lithium iron phosphate. These LFP batteries are the cheapest lithium-ion variety, but they are also less energy dense than premium lithium batteries with nickel manganese cobalt cathodes.

Jerry Barker, a British battery scientist who cofounded the sodium-ion battery maker Faradion and is the founder and CEO of the LFP start-up Redoxion, says sodium-ion’s best opportunity is as a replacement for lead-acid batteries in combustion engine cars and in stationary storage batteries for energy grids. Here, sodium ion’s emergence is timely. The consulting firm BloombergNEF says the need for stationary energy storage around the world will grow 20-fold in the decade through 2030 and be worth more than $262 billion per year by then.

Sodium-ion batteries can already compete with lithium-ion batteries in stationary applications, according to Alsym Energy, a US firm that makes stationary sodium-ion batteries. “What’s changed now is that the chemistry and manufacturing have finally caught up,” says cofounder and CEO Mukesh Chatter. “We see sodium ion becoming the chemistry of choice for stationary storage applications, where safety and cost outweigh energy density.”

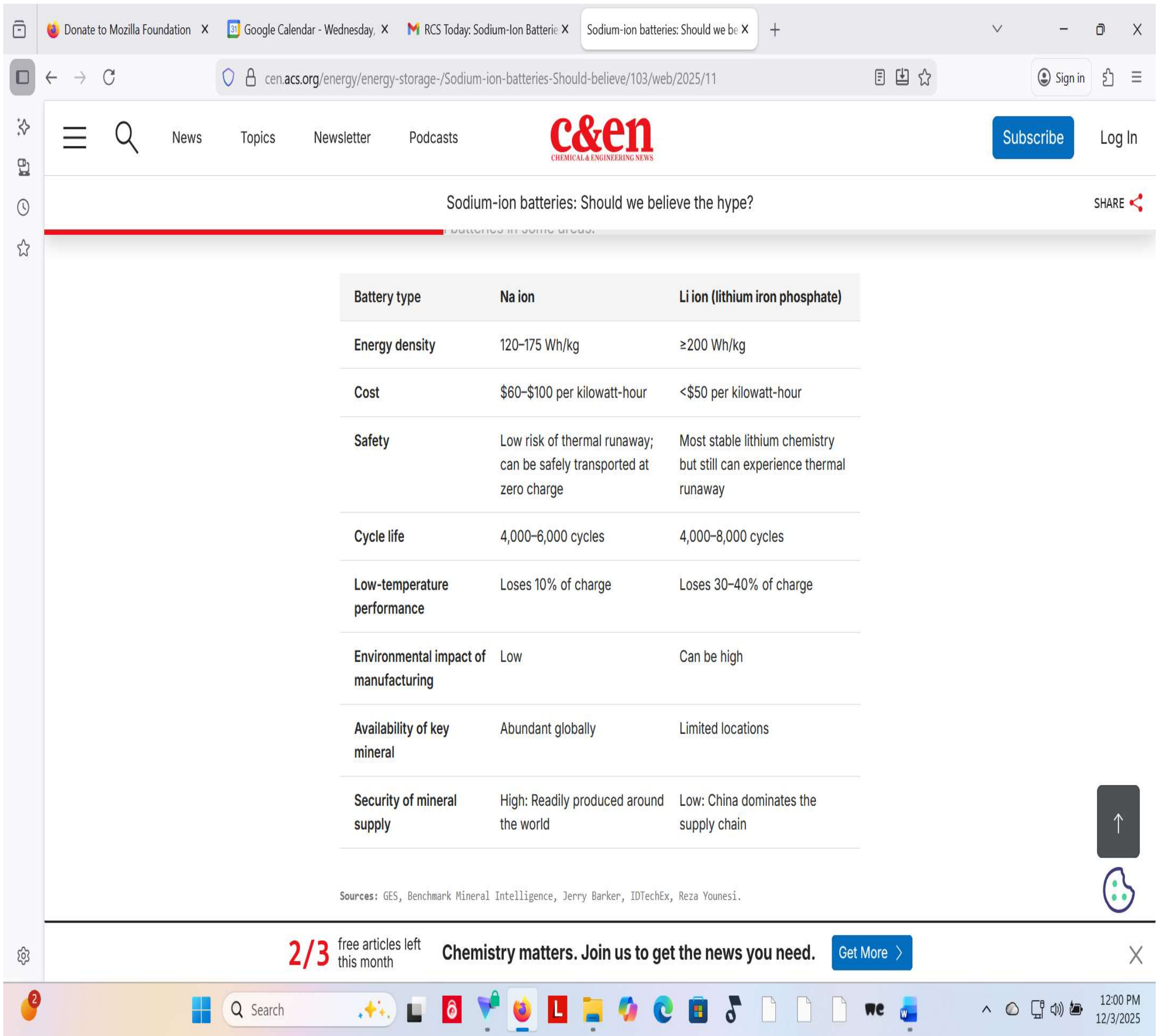
Alsym’s battery matches the performance of LFP at roughly 70% of the cost while eliminating fire risk and dependence on foreign supply chains, Chatter says.

Reza Younesi, cofounder and board member of the Swedish sodium-ion s

Reza Younesi, cofounder and board member of the Swedish sodium-ion start-up Altris and a professor at Uppsala University, agrees that sodium ion can succeed in such applications. “Na ion is no longer a niche technology; it is already being commercialized in China, and there are no fundamental barriers preventing large-scale production elsewhere,” Younesi says.

Sodium vs. lithium

Sodium-ion batteries have lost their cost advantage, but their performance exceeds that of lithium-ion batteries in some areas.



Battery type	Na ion	Li ion (lithium iron phosphate)
Energy density	120–175 Wh/kg	≥200 Wh/kg
Cost	$60–$100 per kilowatt-hour	<$50 per kilowatt-hour
Safety	Low risk of thermal runaway; can be safely transported at zero charge	Most stable lithium chemistry but still can experience thermal runaway
Cycle life	4,000–6,000 cycles	4,000–8,000 cycles
Low-temperature performance	Loses 10% of charge	Loses 30–40% of charge
Environmental impact of manufacturing	Low	Can be high
Availability of key mineral	Abundant globally	Limited locations
Security of mineral supply	High: Readily produced around the world	Low: China dominates the supply chain

Sources: GES, Benchmark Mineral Intelligence, Jerry Barker, IDTechEx, Reza Younesi.

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A global abundance of sodium hydroxide, a raw material for sodium-ion batteries that is produced by the electrolytic splitting of salt, means that the sodium-ion supply chain is largely free from geopolitical risk. Contrastingly, lithium-ion supply is controlled mostly by Chinese firms. And as China has demonstrated with rare earth elements, it is not averse to using its position of dominance for political or economic gain.

As a result, "there is new, growing interest in enabling local production of not only battery cells but also battery materials based on regional supply chains in the [European Union] and US," Younesi says. "This is particularly important for defense and strategic security reasons, and in this context, sodium-ion technology has become increasingly significant."

New chemistries coming down the pipeline, such as doping a sodium-manganese-oxide cathode with scandium to enhance energy density, are further boosting the outlook for sodium-ion batteries. The market research firm Adams Intelligence reckons that over the next 2–7 years, technological advances will help push the energy density of sodium-ion batteries beyond 200 Wh/kg, about where LFP batteries are today. Crucially, it’s a level sufficient for powering low-performance EVs.

Furthermore, “electrolyte improvements, including solid-state options, promise 20–30% cost reductions,” Alla Kolesnikova, Adams’s head of data and analytics, says in an email. “We anticipate sodium-ion could capture some of LFP’s market share by the early 2030s, particularly in cost-sensitive sectors like urban EVs and energy storage. However, sodium-ion is unlikely to displace lithium-ion’s overall dominance in the broader EV market.”

While myriad R&D efforts are underway in the sodium-ion field—including cathodes made of a variety of sodium oxides, sodium iron phosphate, and Prussian blue analogs—there is still no single winning chemistry. “Standardization for sodium-ion cells is therefore still a while away, and this makes OEMs hesitant to commit to such a technology,” Shazan Siddiqi, a senior technology analyst at the market research firm IDTechEx, says in an email, referring to original equipment manufacturers.

Despite lingering uncertainty, companies are eager to enter the business. IDTechEx forecasts that tens of GWh of sodium-ion batteries will be produced in the next few years. “Market leaders like CATL and BYD are the ones to watch out for, as they can quickly bring online some serious sodium-ion supply capability,” Siddiqi says, referring to two big Chinese battery makers. CATL is the acronym for Contemporary Amperex Technology Co. Ltd.

CATL, the world’s largest producer of EV batteries, is hedging its bets by advancing a hybrid battery pack featuring sodium-ion and LFP cells. The sodium-ion cells, which have an energy density of 175 Wh/kg, feature a cathode made of a sodium iron hexacyanoferrate material known as Prussian white. CATL’s goal is to produce a sodium-ion battery with an energy density that exceeds 200 Wh/kg.

CATL claims it has already overcome one negative aspect of sodium-ion batteries: slow charging. In its hybrid battery, the firm says it can charge 80% of the sodium-ion cells in 15 min. At –40 °C, the sodium-ion cells retain more than 90% of their capacity, the company says in an April press release. Contrastingly, at this temperature, lithium-ion batteries retain closer to 60% of their capacity.

Attracted by the market opportunity, one of China’s biggest chemical companies, Sinopec, recently announced a partnership with the South Korean battery giant LG Chem to develop cathode and anode materials for sodium-ion batteries suited to stationary energy storage and low-speed EVs. The companies forecast that, by 2030, China will account for over 90% of global sodium-ion battery production. The companies say they expect China’s sodium-ion battery market to grow from 10 GWh in 2025 to 292 GWh by 2034.

But the market research firm Benchmark Mineral Intelligence warns of hype surrounding sodium-ion. The company estimates that sodium-ion batteries make up less than 1% of the global battery market today and that their market share will at best reach 15.5% in the next 10 years.

One reason for Benchmark's conservative forecast is that the cost advantage of sodium-ion over LFP batteries has evaporated. In a recent webinar, Matthew Bird, a senior editor at Benchmark, said sodium-ion has even become more expensive than LFP.

A few years ago, the cost of producing LFP batteries was $100-plus per kilowatt-hour, and the thinking was that sodium-ion batteries would have an advantage if it could approach the energy density of LFP, Redoxion's Barker says. "But in the past 2, 3 years, there has been an LFP oversupply. So it's sub-$50 per kilowatt-hour now." For the sodium-ion producers trying to compete, "that's really tough," he says.

If sodium-ion continues to be more expensive than LFP, its only advantage will be for applications where characteristics such as safety performance are considered essential.

Then again, Barker says, BYD and CATL say that sodium-ion batteries will eventually cost $10 or $20 per kilowatt-hour. Barker says he doubts such costs are achievable in the near term, but he also knows that making predictions about the zigzag path of the battery business is a no-win game.

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