

Next Generation Battery Emerges

By John Benson

February 2024

1. Introduction

Frequently a new product in the energy industry takes off like a rocket, finding many new applications in a few years, selling in huge volumes and spawning many new companies. That is the up-side. The down-side is they frequently also spawn their competition. In this case the former is the lithium-ion battery, and the latter is an emerging competitor: the sodium-ion battery.

This was inevitable. Lithium and Sodium are both Alkali Metals, column 1 of the Periodic Table of Elements, and they are only one row apart, so they share many characteristics. Lithium is actually very common, but current demand for lithium-ion batteries is stretching the supply to the limit and driving up pricing. Sodium is much more common than lithium, so it is unlikely that any surge in demand for these would ever significantly elevate pricing. That is only where advantages of sodium-ion batteries start.

1.1. Key Advantages of Sodium-Ion Batteries

Abundant and Widespread: With sodium being one of the most abundant elements on Earth, it presents an advantage over the less common lithium. This abundance translates to stable pricing and consistent availability.¹

Economic Viability: Sodium's significant cost advantage stems from its abundance and straightforward extraction methods, making it a game-changer for large-scale energy storage solutions.

Technological Benefits: Sodium's larger ion size can offer faster ion diffusion in specific materials. Moreover, Na-ion batteries accommodate a broader spectrum of electrolytes, including some non-flammable options, promising enhanced safety.

Safety Comes First: While both sodium and lithium are reactive, sodium's reactivity profile is typically deemed safer, especially concerning battery production and recycling.

Greener Impact: Embracing eco-friendly design principles, some Na-ion batteries employ saline solutions as electrolytes. Their recycling processes are also projected to be more sustainable.

2. Recent Activity

To date sodium-ion batteries have lower energy density than Li-ion batteries, but that may be changing. Researchers are starting to spin sodium-ion chemistries out of existing Li-ion chemistries.

¹ About Sodium-Ion Batteries, Sodium Battery Hub, <https://sodiumbatteryhub.com/about-sodium-ion-batteries/>

2.1. Increased Energy Density for Sodium-Ion Batteries

Researchers at the US Department of Energy's Argonne National Laboratory have developed and patented a new cathode material for sodium-ion batteries. This should enable a significantly higher energy density than other sodium-ion cells - but still lags somewhat behind lithium-ion technology.²

In a modification of the familiar NMC cathodes for lithium-ion batteries, the Argonne laboratory's development is a sodium-nickel-manganese-iron oxide (NMF). Compared to other sodium-ion technologies, the cathode offers a much higher energy density, which is sufficient to give electric cars a range of around 180 to 200 miles (290 to 320 kilometers) per charge.

In NMC cathodes, the atoms are arranged in layers. This structure makes it easy to insert and extract lithium ions between the layers. Based on the findings from a total of ten years of research work with sodium-ion batteries, the team led by senior chemist Christopher Johnson has developed a layered oxide cathode specifically for sodium-ion batteries.

The layered structure of the NMF cathode should enable the efficient insertion and extraction of sodium ions, according to the Argonne National Laboratory in the press release. And because the cathode material does not contain cobalt, the "cost, scarcity and toxicity concerns associated with this element" should also be mitigated.

The researchers also want to have eliminated another disadvantage of earlier sodium-ion batteries: their short service life. With the new cathode material, sodium-ion cells achieve a similar number of charge/discharge cycles as their lithium-ion counterparts. "We have now transitioned from the laboratory phase and are poised to subject our cathode to testing within battery cells similar to those in an actual electric vehicle battery," says Johnson. These tests will be conducted at Argonne's cell analysis, modelling and prototyping facility.

The advantages of sodium as a battery material are well known: Sodium is far more abundant in nature and is easier to mine than lithium. As a result, it costs only a fraction of the cost per kilogram and is significantly less susceptible to price fluctuations or disruptions in the supply chain. "Our estimates suggest that a sodium-ion battery would cost one-third less than a lithium-ion one," says Johnson. In addition, the cathode material contains predominantly iron and manganese alongside sodium.

There is an issue that the research team cannot physically resolve: Sodium metal is around three times heavier than lithium. This increases the weight of the battery and thus reduces the range. Johnson emphasizes that while the sodium-ion battery may not appeal to those looking for long ranges, it could attract price-conscious consumers, particularly city dwellers whose daily commute rarely exceeds 200 miles (300 kilometers).

² Chris Randall, Electrive, "US researchers increase energy density of sodium-ion batteries," Sep 1, 2024, <https://www.electrive.com/2024/01/09/us-researchers-increase-energy-density-of-sodium-ion-batteries/>

With the higher energy density of the cathode, the US researchers have already taken an important step towards making sodium-ion batteries attractive to more vehicle segments. According to the press release, Johnson's team is already developing new materials for the other two main components of a battery – the electrolyte and the anode – to increase the energy density even further.

Author's comment: The added weight for sodium vs. lithium is an issue with EVs, but not so much for battery energy storage system (BESS) applications.

3. Sodium Ion Battery Production

There are several news items regarding this section title.

3.1. Acculon Energy's New Sodium-Ion Battery Series

*Acculon Energy, a leading US battery company, has recently announced the series production of its sodium-ion battery modules and packs. Acculon Energy's new sodium-ion battery represents a major leap in battery technology, offering a sustainable and efficient alternative to traditional battery systems...*³

With a scaled production capacity of 2GWh scheduled for mid-2024, Acculon Energy is poised to meet the growing demand for safe, reliable, and sustainable energy solutions. Their sodium-ion batteries are designed to cater to a wide range of electrification programs, offering a compelling value proposition for OEM customers.

3.2. Farasis Energy's Sodium-Ion Batteries Power First EV

*Farasis Energy has achieved a significant milestone in the electric vehicle (EV) industry by rolling out the world's first EV powered by sodium-ion batteries. This groundbreaking development signals the dawn of a new era in battery technology, with the JMEV EV3 (Youth Edition, image below) leading the charge as the first A00-class EV equipped with these innovative batteries.*⁴



Author's comment: Although Farasis Energy is based in Germany, the A00 class EVs are China's smallest:

*In China, passenger cars of different sizes are divided into six levels: A00, A0, A, B, C, and D, with A00 describing micro-sized models with a wheelbase of 2m to 2.3m each and A0 describing small-sized models with 2.3-2.5m wheelbases.*⁵

³ Sam Krampf, Sodium Battery Hub, "Acculon Energy's New Sodium-Ion Battery Series," Jan 5, 2024, <https://sodiumbatteryhub.com/2024/01/05/acculon-energy-sodium-ion-batteries-launch/>

⁴ Sam Krampf, Sodium Battery Hub, "Farasis Energy's Sodium-Ion Batteries Power First EV Rollout," Jan 11, 2024, <https://sodiumbatteryhub.com/2024/01/11/farasis-energy-sodium-ion-ev-rollout/>

⁵ Shazan Siddiqi, Electric Vehicles Research, "Microcars Are the Smaller, Greener Future..." Feb 24, 2023, <https://www.electricvehiclesresearch.com/articles/28757/microcars-are-the-smaller-greener-future-of-urban-commuting>

Note that BYD, the largest EV Maker in the world (and based in China) is building a major Sodium-Ion Battery manufacturing plant – go through the link below.

<https://sodiumbatteryhub.com/2024/01/05/byd-sodium-ion-battery-plant-china/>

Back to reference 4.

The JMEV EV3 offers a range of 251 km, catering to the needs of younger drivers for daily commuting and city travel. Farasis Energy's sodium-ion batteries showcase impressive benchmarks, with an energy density of 140 to 160 Wh/kg and excellent safety credentials. The batteries' low-temperature performance effectively addresses the range challenges faced by EVs in colder climates, a common issue that has been a significant barrier to EV adoption in many regions.

Farasis Energy is not resting on its laurels; the company is already planning the launch of its second-generation sodium-ion batteries in 2024. With energy densities projected to reach 160-180Wh/kg and further plans to increase this to 180-200Wh/kg by 2026, Farasis Energy is setting the pace for the industry.

3.3. Altris Receives \$7.6M for Sodium-Ion Battery Plant

Altris, a leading developer of sodium-ion batteries, has recently secured substantial financial support of \$7.6 million from the Swedish Energy Agency. This endorsement not only underscores the potential of sodium-ion battery technology in the sustainable energy sector but also propels Altris towards becoming Europe's premier sodium-ion battery supplier.⁶

The Swedish Energy Agency's backing is part of the Industrial Leap and NextGenerationEU programs. This investment is earmarked for the establishment of a pilot plant dedicated to the production of sodium-ion battery cells that are both sustainable and safe...

In November 2023, Altris made headlines with the introduction of a sodium-ion battery cell that achieved an energy density exceeding 160 Wh/Kg. This breakthrough positions the technology as commercially viable, particularly for applications like sustainable energy storage systems.

With the Swedish Energy Agency's support, Altris is set to take a significant stride in its commercialization journey. The forthcoming pilot plant in Uppsala, Sweden, aims to refine the development and production of sodium-ion battery cells. The ultimate goal is to reach gigascale production capacity in collaboration with industry partners.

3.4. UNIGRID: Major Orders for Sodium-Ion Batteries

UNIGRID Battery, a spin-off from the University of California, San Diego, has achieved a significant milestone by receiving its first commercial MWh-scale purchase orders for their advanced sodium-ion batteries. Founded in 2021, the company is rooted in the pioneering Ph.D. research of Dr. Darren H. S. Tan and Dr. Erik A. Wu, under the guidance of Professors Zheng Chen and Shirley Meng, who are well-known in the battery field.⁷

⁶ Sam Krampf, Sodium Battery Hub, "Altris Receives \$7.6M for Sodium-Ion Battery Plant," Jan 11, 2024, <https://sodiumbatteryhub.com/2024/01/11/altris-secures-7-6musd-for-sodium-ion-battery-tech/>

⁷ Sam Krampf, Sodium Battery Hub, "UNIGRID Battery: UC San Diego Spin-Off Secures Major Orders for Advanced Sodium-Ion Batteries," Dec 19, 2023, <https://sodiumbatteryhub.com/2023/12/19/unigridd-sodium-ion-battery-orders/>

UNIGRID has identified a substantial market opportunity in North America's residential energy storage system (ESS) market, particularly for behind-the-meter applications similar to Tesla's Powerwall. The company's first-generation cylindrical cell is a response to a massive market gap that current battery technologies cannot fill. CEO Darren H. S. Tan emphasizes the appeal of sodium-ion batteries as a less expensive and safer alternative, free from the uncertainties of the lithium supply chain.

The company's innovative approach includes using a tin anode instead of hard carbon, significantly enhancing the volumetric energy density of sodium-ion batteries. This advancement makes them competitive with, and in some cases superior to, lithium iron phosphate (LFP) batteries. CTO Erik A. Wu highlights the advantages of the tin alloy anode in sodium-ion batteries, overcoming common failure modes found in silicon-based batteries.

UNIGRID's advanced sodium-ion batteries have undergone third-party testing and validation, and the company is on track to deliver MWh quantities to customers in 2024. The team is ramping up production in San Diego, California, to meet the growing interest and demand...

Final author's comment: Although the UNIGRID website is currently rather limited, I've posted a link to it below.

<https://www.unigridbattery.com/>