

Introduction to sodium-ion batteries and their subvariants

Are they actually as promising (for 12V batteries) as everyone says?

Why is suddenly everyone interested in sodium-ion batteries?

Litona



MIT Technology Review **Roundtables**
Subscriber Exclusive Series

Why 2026 Is the Year for Sodium-Ion Batteries

WEDNESDAY, FEBRUARY 25 | 1PM ET

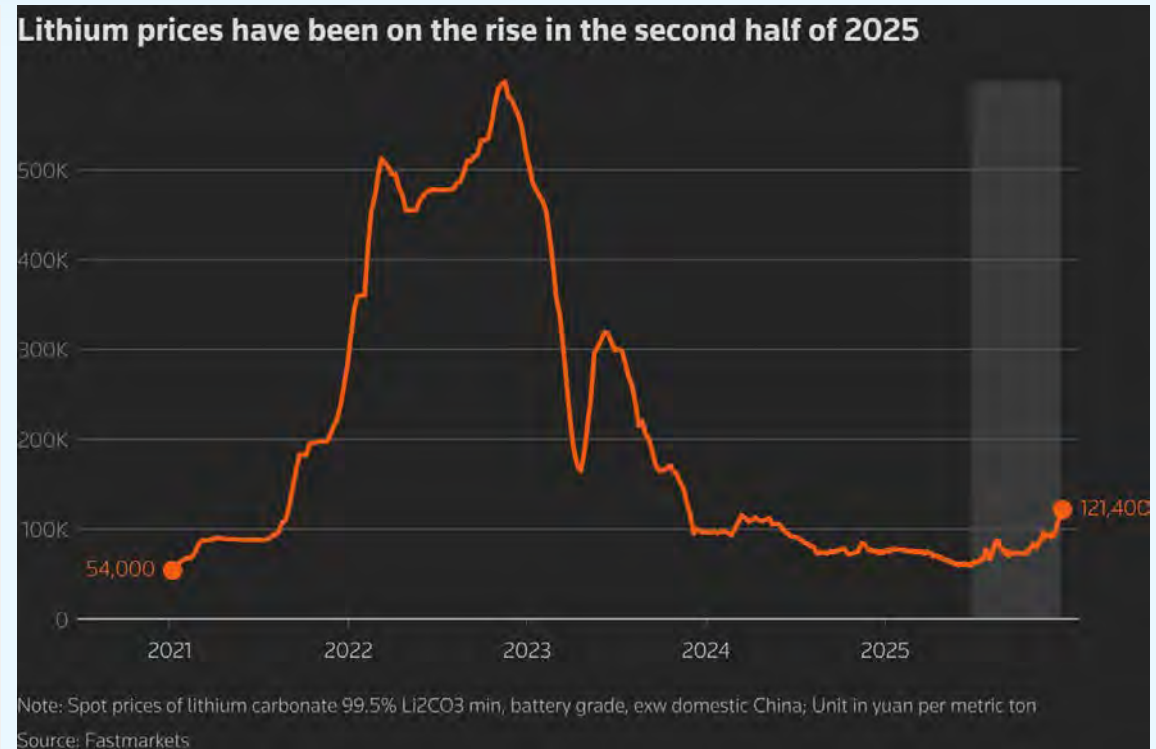
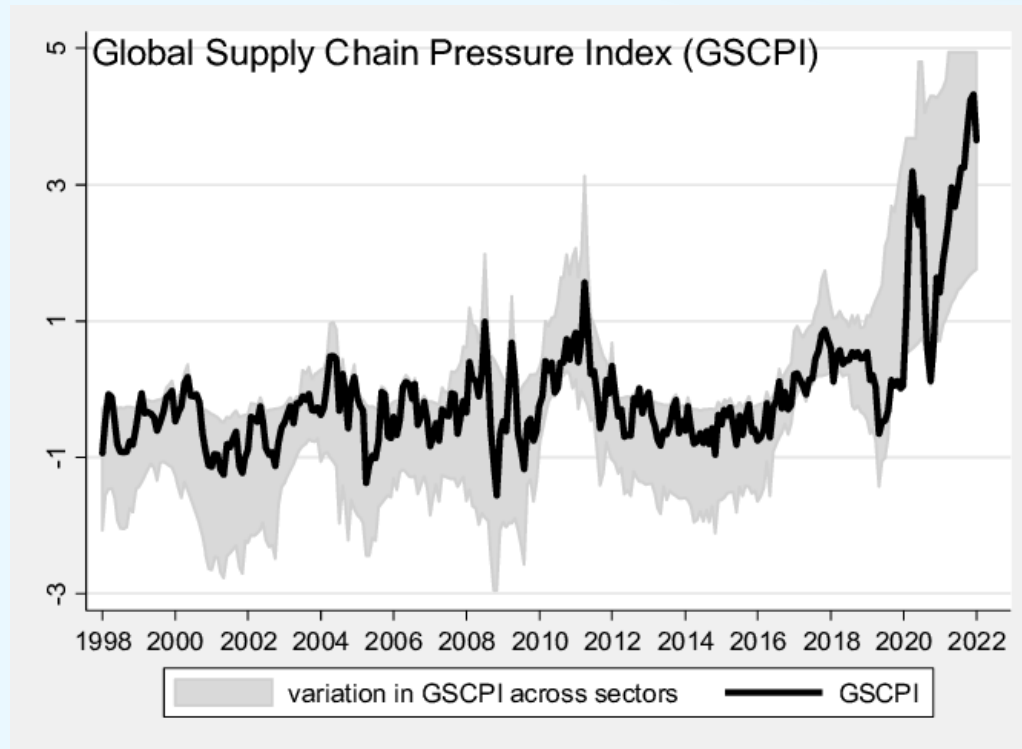


 **Mary Beth Griggs**
Science editor

 **Caiwei Chen**
China reporter

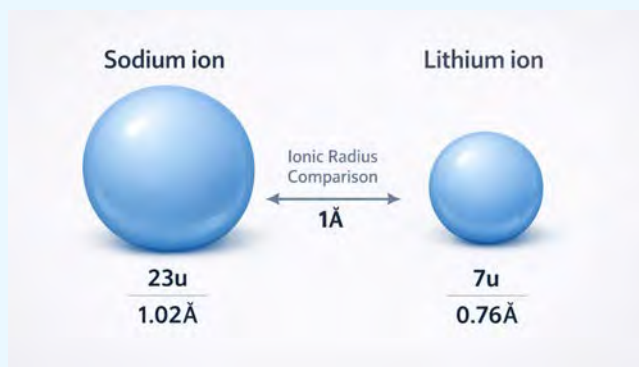
 **Casey Crownhart**
Senior climate reporter

Why is suddenly everyone interested in sodium-ion batteries?



Why is everyone interested in sodium-ion batteries?

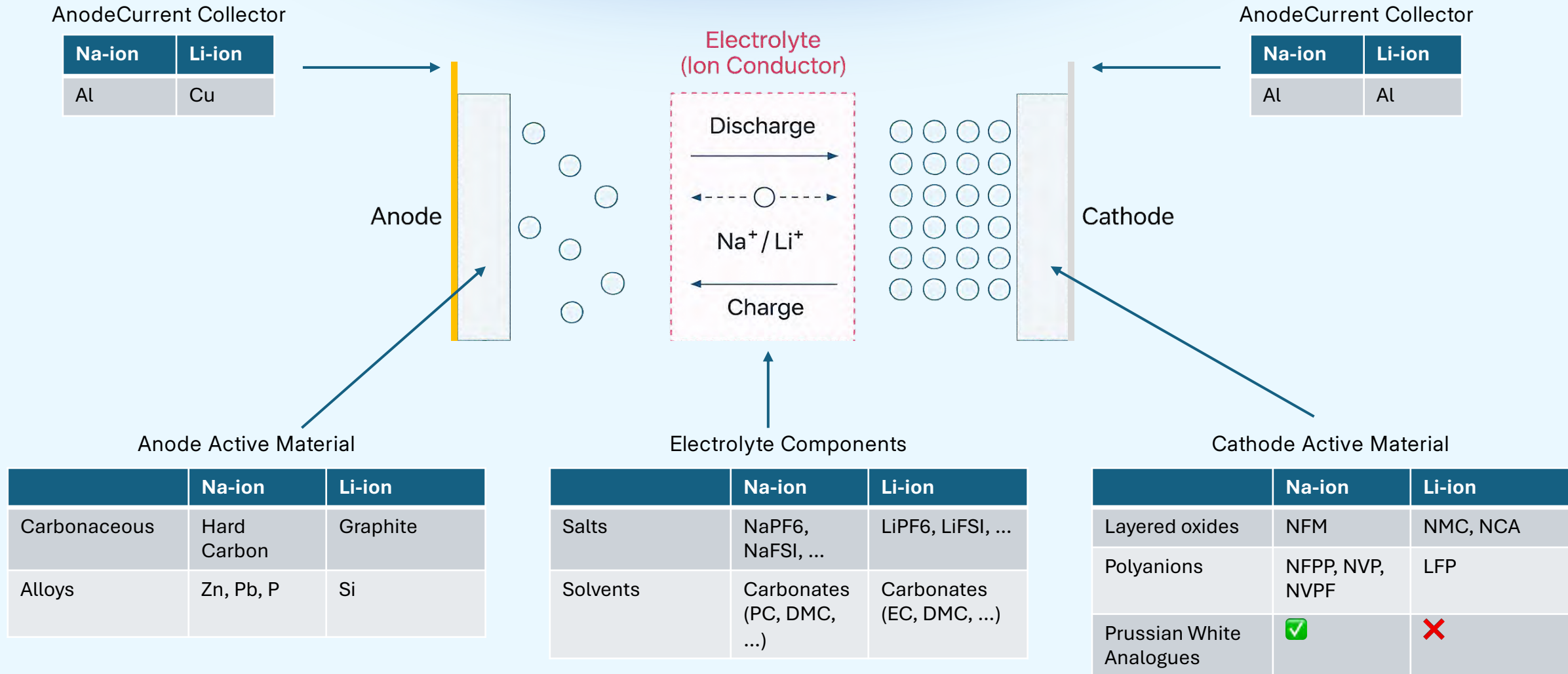
- ▶ Na has similar properties to Li
- ▶ Na is 1000x more abundant
Potentially decreasing cell costs
- ▶ Drop-in technology
Existing Li-ion machinery can produce Na-ion cells
- ▶ Technological benefits
Higher temperature tolerance, 0V storage/shipping, etc.



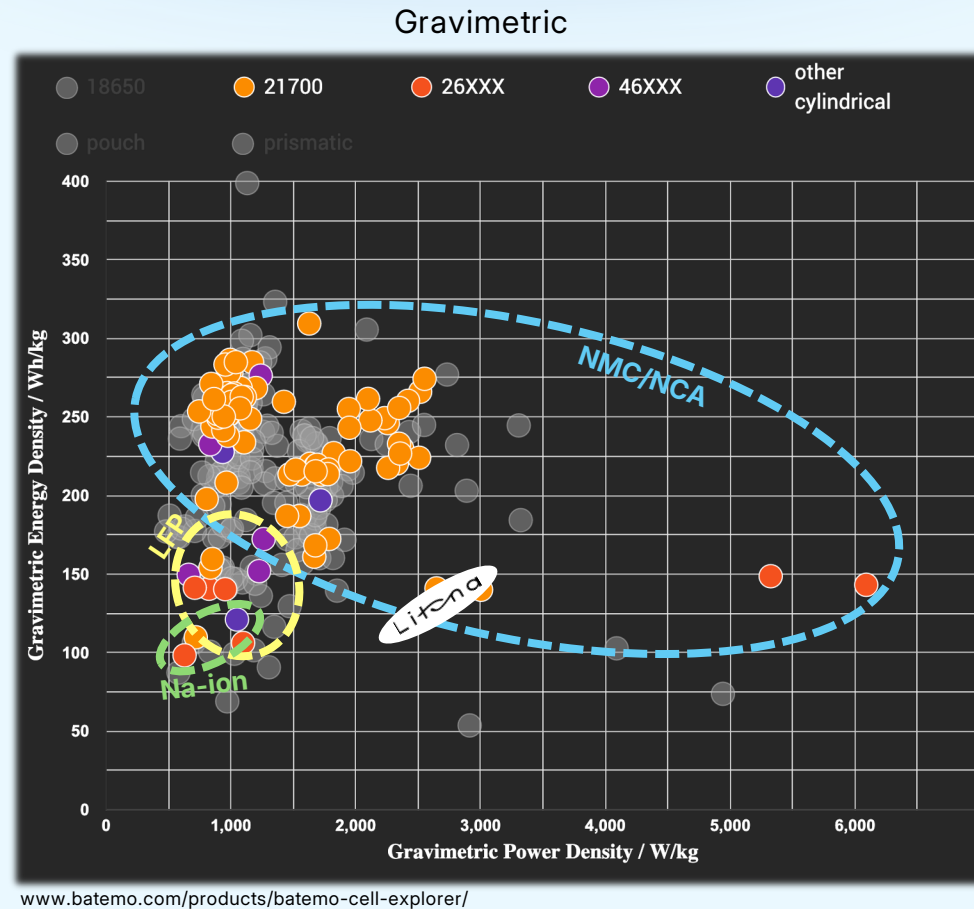
PERIODIC TABLE OF THE ELEMENTS

Element (Ion)	Abundance in earth's crust / wt%	E^0 (A^{+aq}/A) / V vs SHE	Shannon's ionic radius / Å	Stokes radius of ion (in PC) / Å	Atomic mass
Lithium (Li^+)	0.002	- 3.04	0.76	4.8	6.94
Sodium (Na^+)	2.4	- 2.71	1.02	4.6	22.99

Working principles: Na-ion vs. Li-ion

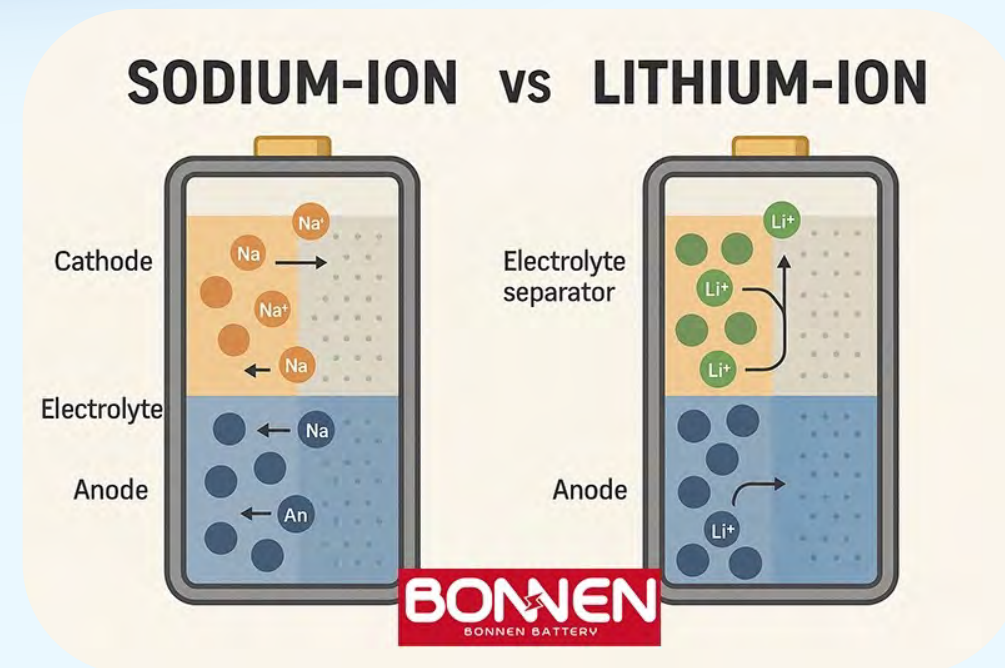


Energy and power density: Na vs. Li



Sodium-ion batteries: The perfect alternative to Li-ion batteries?

- ▶ „They use no critical raw materials“
Na is 1000x more abundant than Li
- ▶ “They are cheaper”
 Na_2CO_3 is up to 100x cheaper than Li_2CO_3
- ▶ „They are good at low temperatures”
- ▶ „They are safer than Li-ion”
- ▶ ... „but their voltage profile is very wide and unfavourable”



Are these sayings
even true?

▶ „They use no critical raw materials“
Na is 1000x more abundant than Li

Cathode material

LFP (LiFePO_4)

NFM111 ($\text{Na}_{0.33}\text{Ni}_{0.33}\text{Fe}_{0.33}\text{Mn}_{0.33}\text{O}_2$)

NFPP ($\text{Na}_4\text{Fe}_3(\text{PO}_4)_2(\text{P}_2\text{O}_7)$)

NFS ($\text{Na}_2\text{Fe}_2(\text{SO}_4)_3$)

NVP ($\text{Na}_x\text{V}_2(\text{PO}_4)_3$)

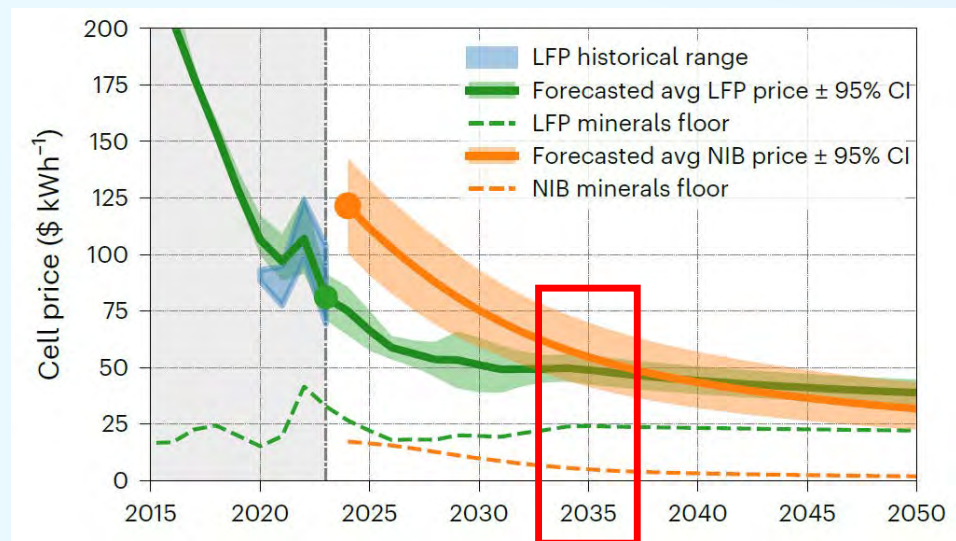
Prussian White ($\text{Na}_x\text{Mn}[\text{Fe}(\text{CN})_6]$)

Sodium-ion batteries do NOT always
only use abundant and cheap materials



"They are cheaper"

Na_2CO_3 is up to 100x cheaper than Li_2CO_3



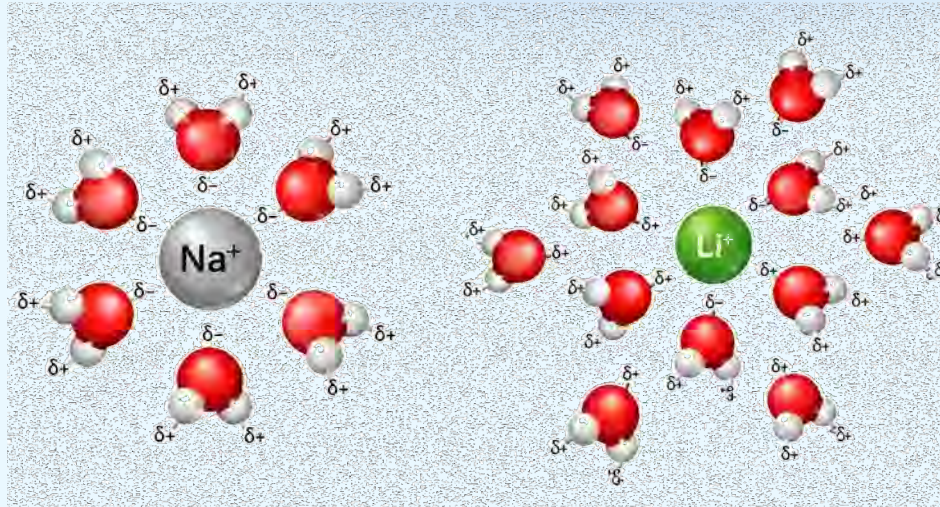
Source: Yao et al. Critically assessing sodium-ion technology roadmaps and scenarios for techno-economic competitiveness against lithium-ion batteries. Nat Energy 10, 404–416 (2025).

Sodium-ion batteries are not automatically cheaper – it depends on the active materials used, the application, the scale and the current Li price

Cathode material	Capacity (mAh/g)	Potential (V vs. Na ⁺ /Na)	Spec. energy (Wh/kg)	Price (\$/kg)	Price (\$/kWh)
LFP (LiFePO ₄)	160	3.4	544	4.70	8.64
NFM111 (NaNi _{0.33} Fe _{0.33} Mn _{0.33} O ₂)	140	3.2	448	5.28	11.79

► „They are good at low temperatures“

Smaller
solvation
radius



	EC	PC
Melting point	36.4 °C	-48.8 °C
Viscosity (25 °C)	~1.9 cP (40 °C)	2.47 cP (25 °C)
Dielectric constant	89.78	64.92
Graphite-compatible	yes (SEI)	no (graphite exfoliation)
Hard carbon (Na-ion)	yes	yes

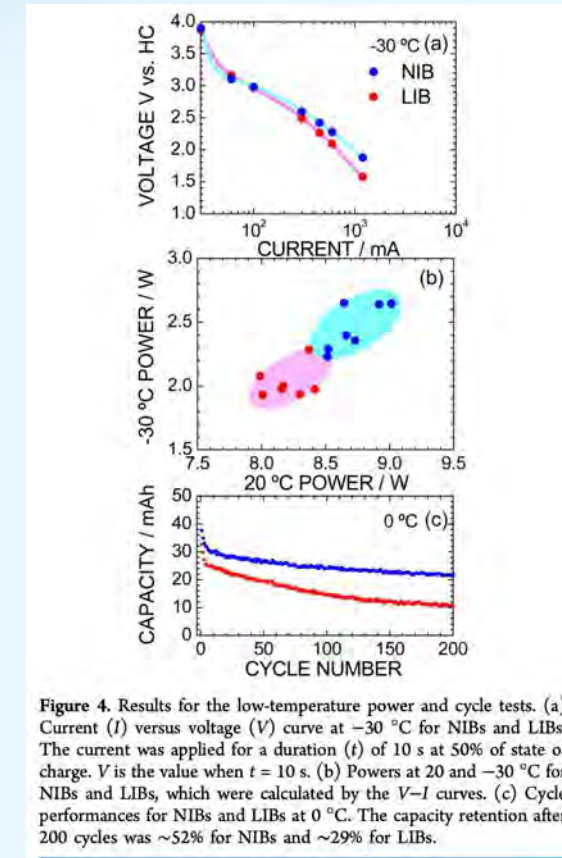
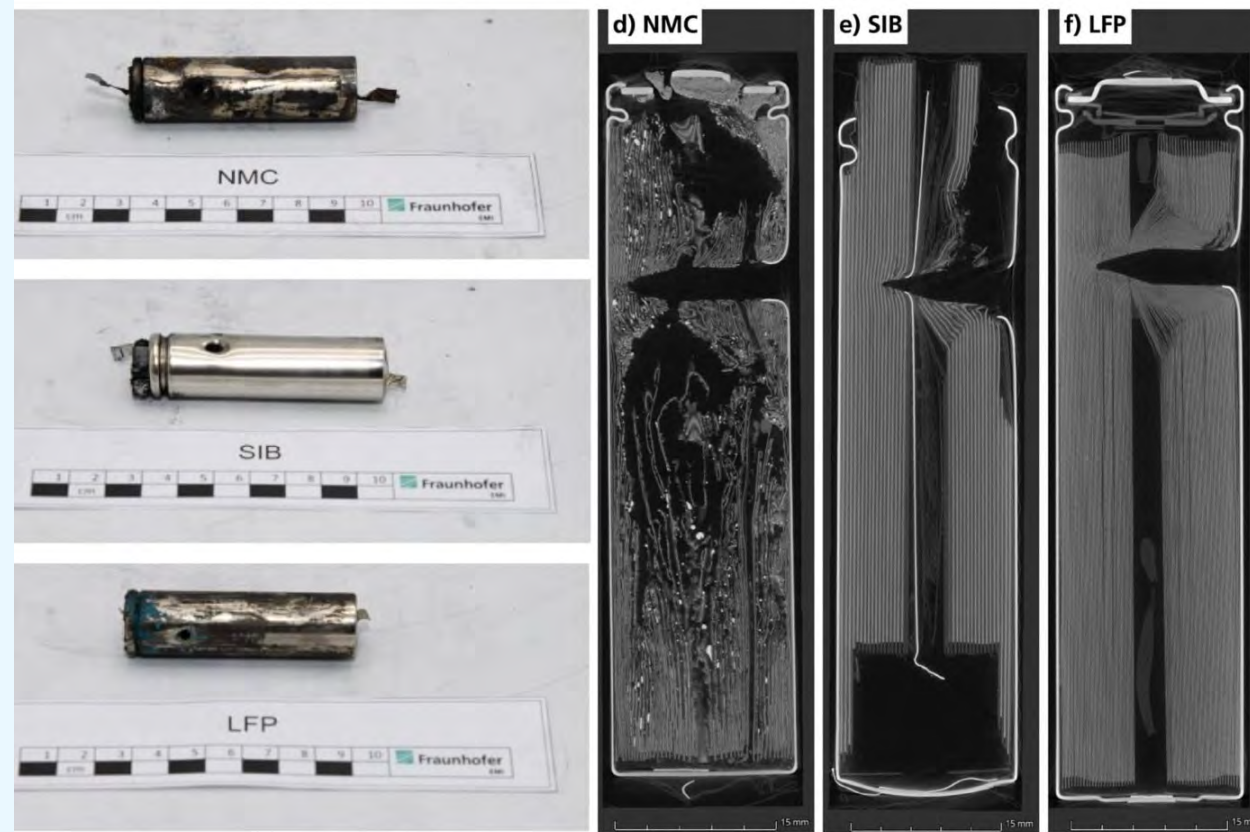


Figure 4. Results for the low-temperature power and cycle tests. (a) Current (I) versus voltage (V) curve at -30 °C for NIBs and LIBs. The current was applied for a duration (t) of 10 s at 50% of state of charge. V is the value when $t = 10\text{ s}$. (b) Powers at 20 and -30 °C for NIBs and LIBs, which were calculated by the V - I curves. (c) Cycle performances for NIBs and LIBs at 0 °C . The capacity retention after 200 cycles was $\sim 52\%$ for NIBs and $\sim 29\%$ for LIBs.

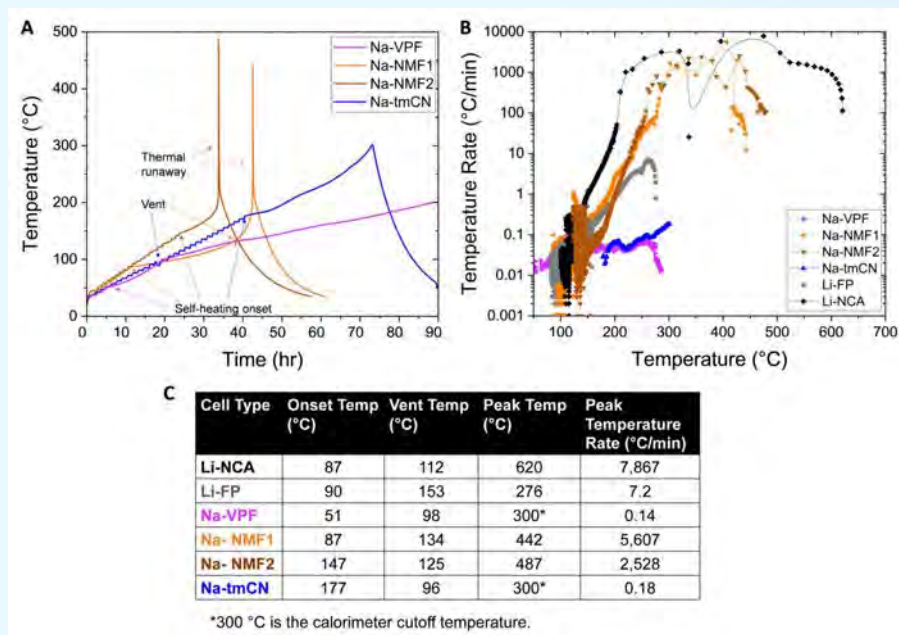
Yes, but it depends on the active materials, the cell architecture/design and the electrolyte

▶ „They are safer than Li-ion“

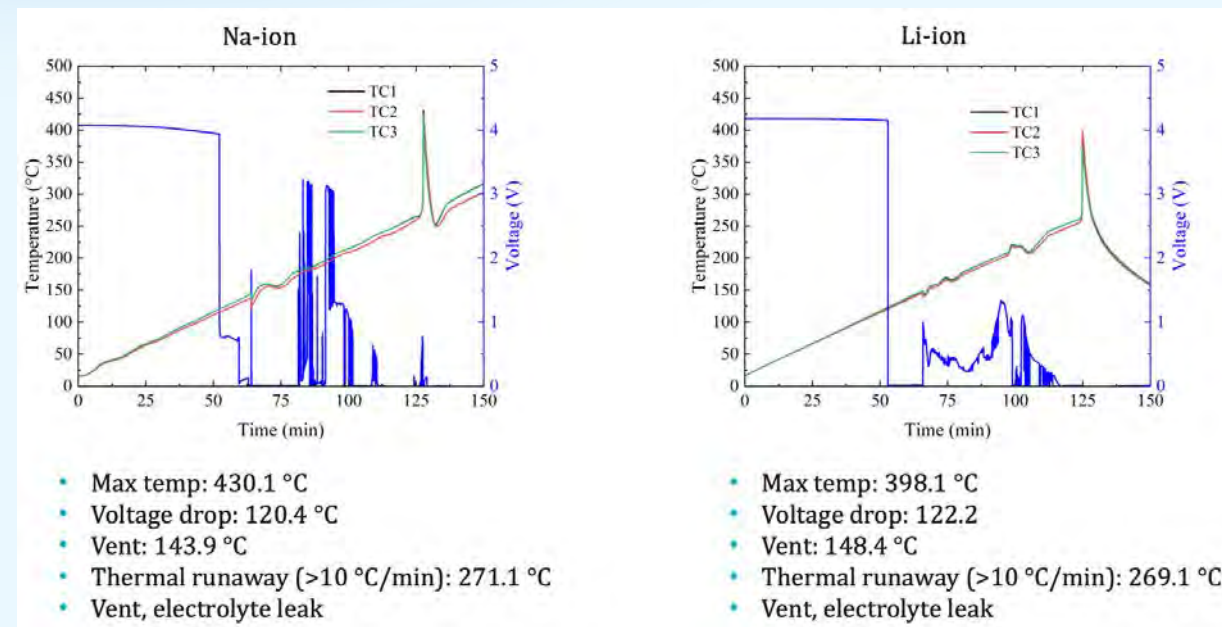


Source: Pfaff et al Journal of Power Sources Advances 36 (2025) 100188

► „They are safer than Li-ion“



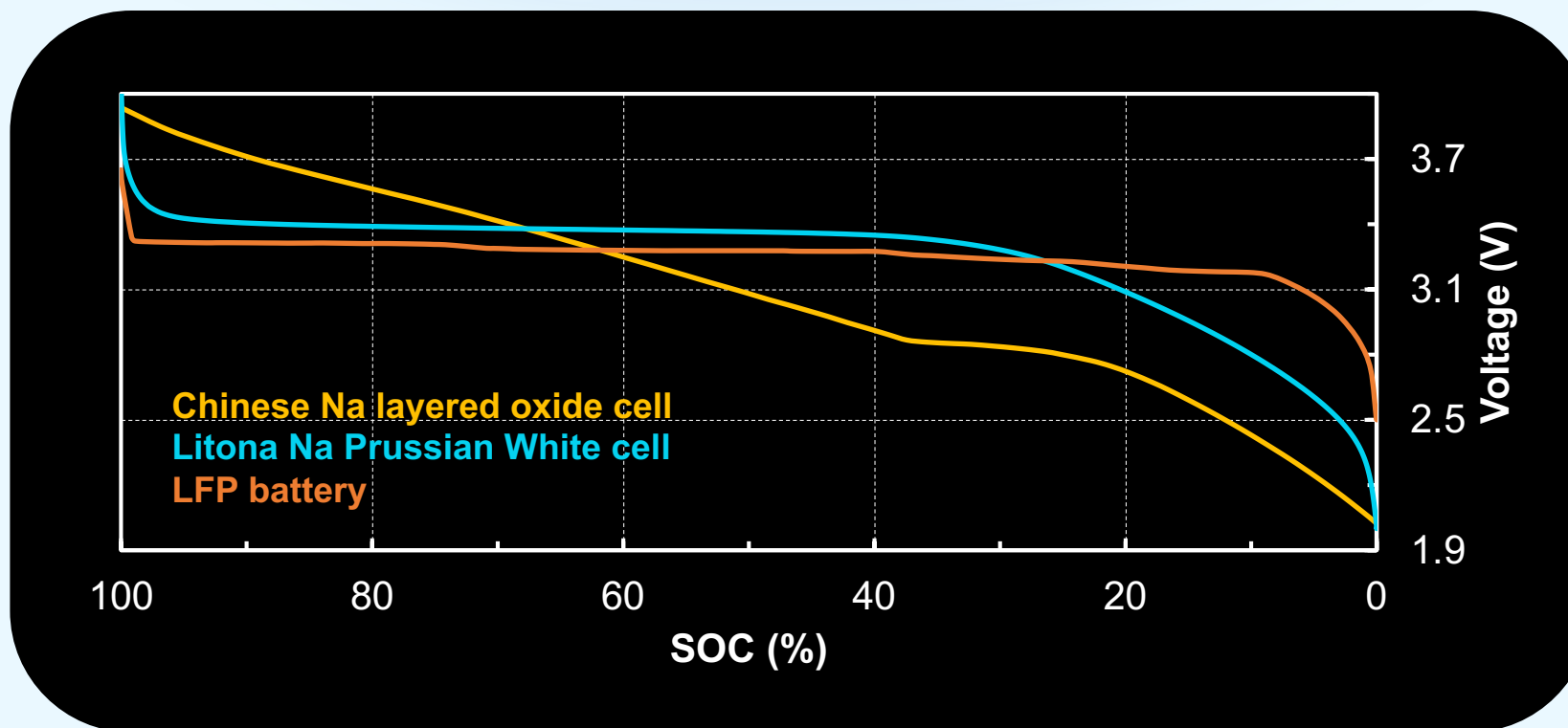
Source: Energies 2025, 18(3), 661; <https://doi.org/10.3390/en18030661>



Source: MULTI-SCALE SAFETY EVALUATION OF EMERGING BATTERY TECHNOLOGIES Nathan B. Johnson, Alex M. Bates, Lorraine Torres-Castro Sandia National Laboratories 2024 USDOT Battery Safety Meeting

They can be safer. But they do not have to be.

► ... „but their voltage profile is very wide and unfavourable“



Sodium-ion batteries show different voltage profiles depending on the active materials used

Sodium-ion ≠ Sodium-ion.

Every material class has its own advantages and disadvantages.

Material classes	LFP (Li-ion)	Prussian White	Prussian Blue	Layered Oxides	Polyanions (NFPP)
Companies	CATL, BYD	Litona	(Natron Energy)	CATL, HiNa	EVE Energy
Specific Capacity (mAh/g)	160	150	85	132	104
Average Voltage (V vs. Na/Na ⁺)	3.4	3.5	3.5	3.1	2.9
Compaction Density (g/cm ³)	2.4 - 2.5	1.3 - 1.6	1.3 - 1.6	3.1 - 3.2	1.8 - 2.2
Cycle Lifetime	Good	Good	Good	Medium/bad	Very good
Applications	High Power / Medium Energy Batteries	High Power / Medium Energy Batteries	High Power Batteries	High Power / Medium Energy Batteries	Long Lifetime Stationary Batteries

Litona Na-Ion Battery Cells with Prussian White – ideal for 12 V Automotive Applications

Litona

- ▶ **Based on low-cost materials**
In contrast to Nickel-containing Na layered oxides
- ▶ **Up to 160 Wh/kg, comparable with LFP-cells**
Without compromising on safety
- ▶ **High power density**
Up to 50 C
- ▶ **Increased stability at low temperatures**
Voltage and capacity retention



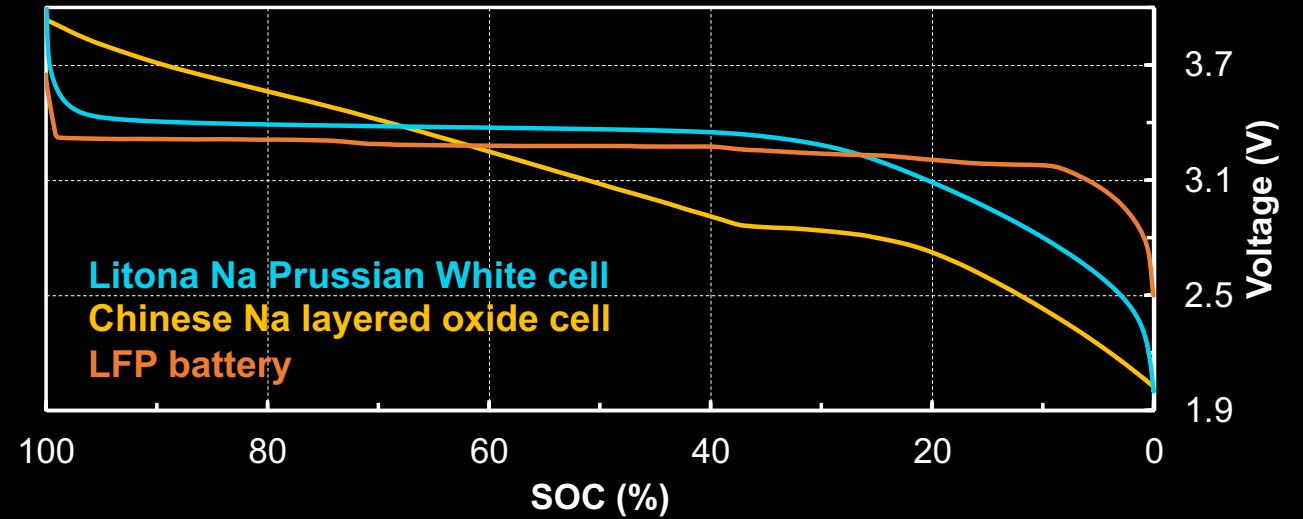
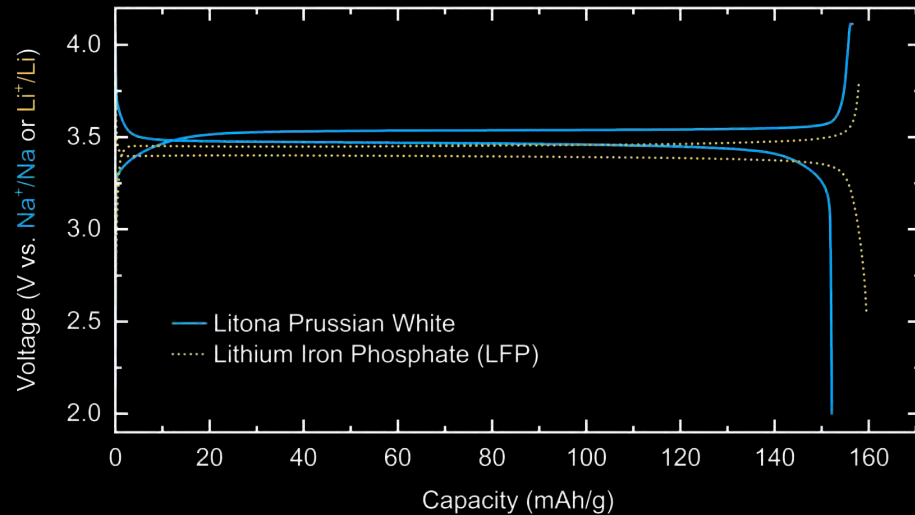
Prussian White is leading the price/kWh race between different cathode material classes

Cathode material	Capacity (mAh/g)	Potential (V vs. Na ⁺ /Na)	Spec. energy (Wh/kg)	Price (\$/kg)	Price (\$/kWh)
LFP (LiFePO ₄)	160	3.4	544	4.70	8.64
NFM111 (NaNi _{0.33} Fe _{0.33} Mn _{0.33} O ₂)	140	3.2	448	5.28	11.79
NFPP (Na ₄ Fe ₃ (PO ₄) ₂ (P ₂ O ₇))	110	3.1	341	3.05	8.94
NFS (Na ₂ Fe ₂ (SO ₄) ₃)	110	3.8	418	2.94	7.03
NVP (Na ₃ V ₂ (PO ₄) ₃)	115	3.4	391	8.39	21.46
Prussian White (Na₂Mn[Fe(CN)₆])	160	3.4	544	3.10	5.70

Source: Material prices from Shanghai Metals Market, battery-grade where available (accessed January 2026). \$/kWh calculated as: Price (\$/kg) ÷ Specific energy (kWh/kg).

- Does not contain any non-abundant, expensive materials
- Facile and fast synthesis
- European production

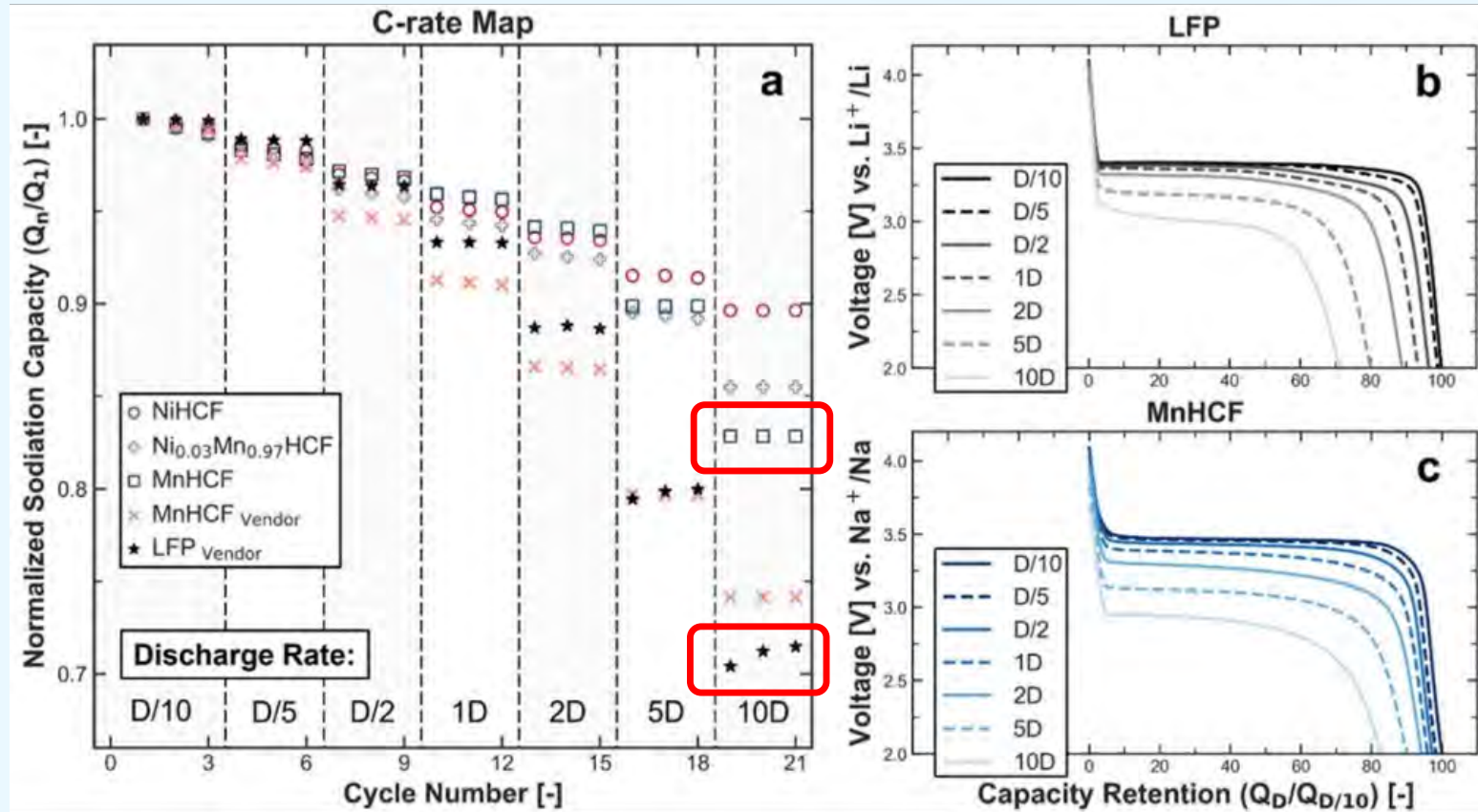
Litona Na-Ion Prussian White cells show a flat voltage profile



LFP drop-in

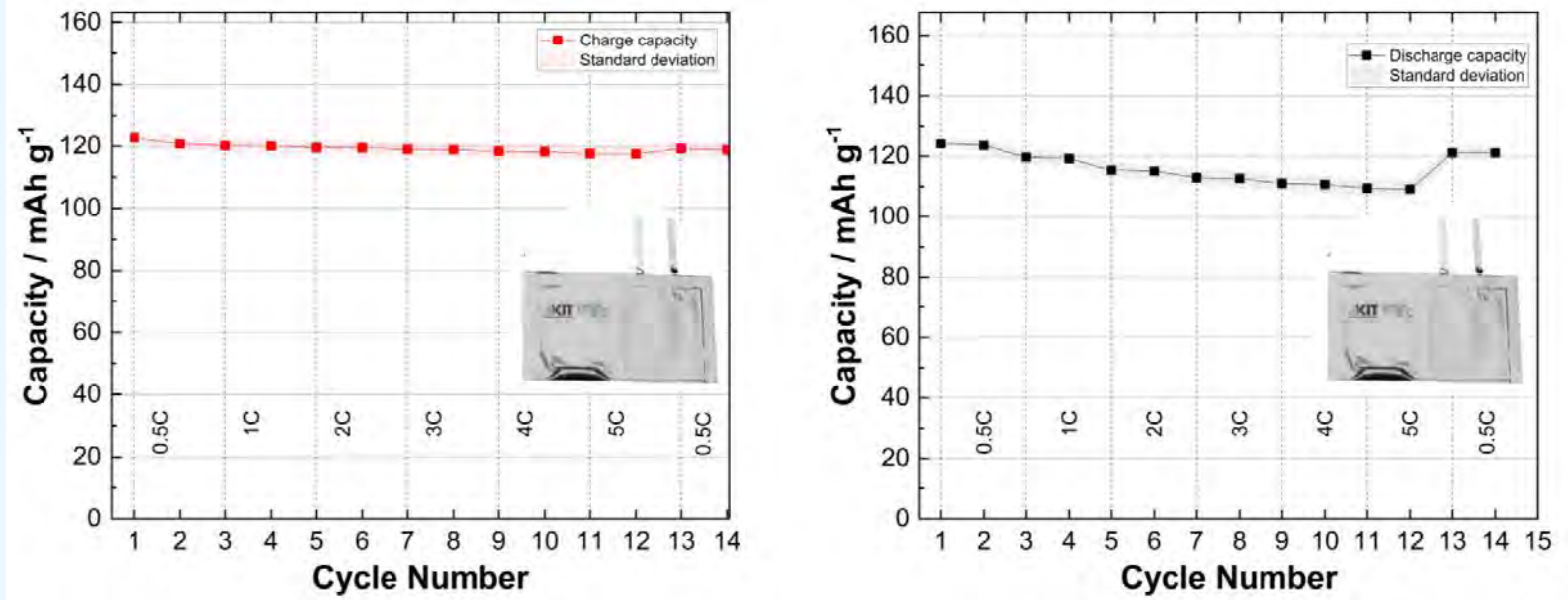
Can use existing LFP electronics due to similar voltage profile

Prussian White (MnHCF): Superior capacity at high c-rates compared to LFP

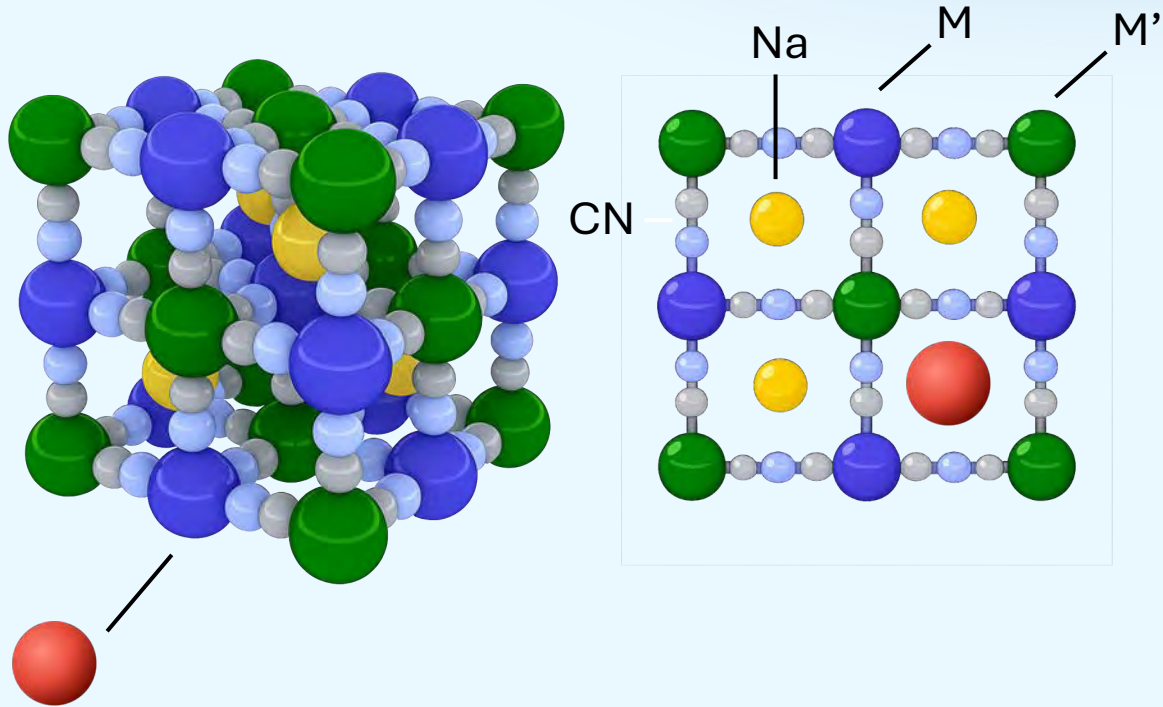


- (a) Discharge rate maps for Prussian and LFP in half cells at 30 °C. Voltage-capacity profiles for the discharge part of the cycle for (b) LFP and (c) MnHCF.
- Na and Li half cells were assembled with 1 M NaPF₆ and 1 M LiPF₆ in PC + 2 wt% FEC, respectively.

Prussian White || Hard Carbon cells: Suitable for power demanding applications



(a) Charge and (b) discharge rate maps for Prussian White || Hard Carbon Single-layer pouch cells.

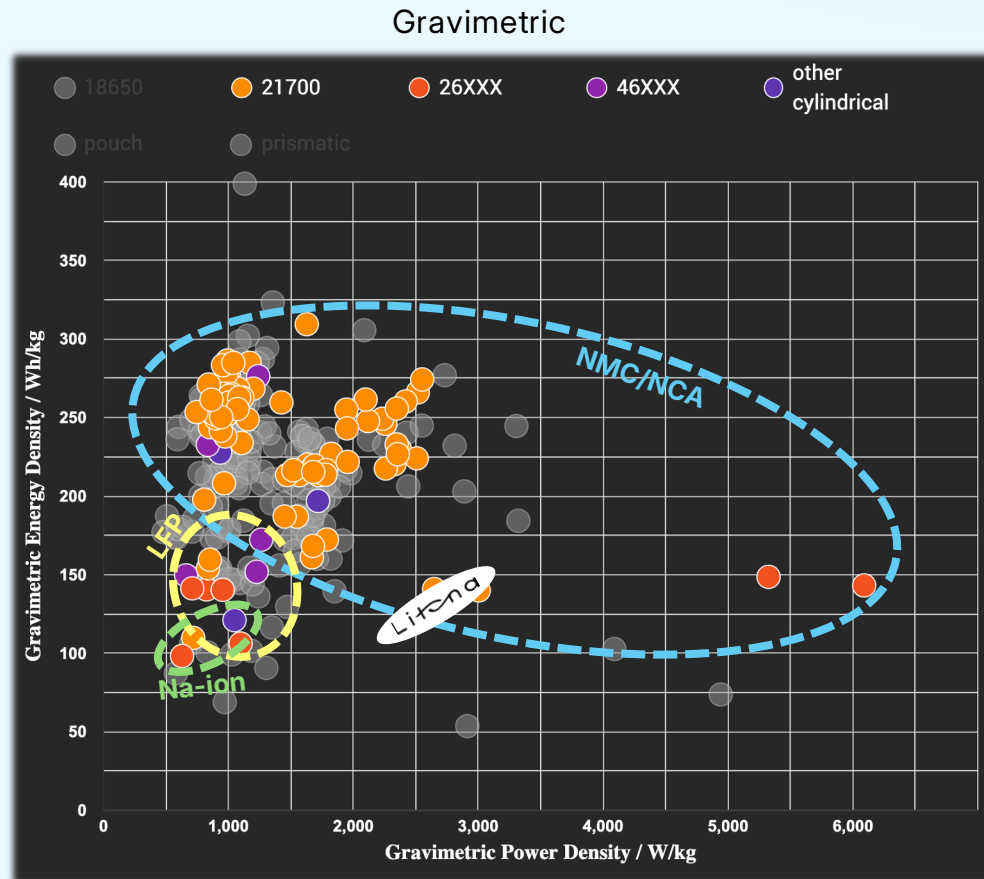


- Prussian White i.e. $\text{Na}_x\text{M}'([\text{M}(\text{CN})_6]_{1-y} \cdot z \cdot \text{H}_2\text{O})$
- Water is approximately 15-16% of the weight of the material
- Removing it from the material is crucial for good cell performance

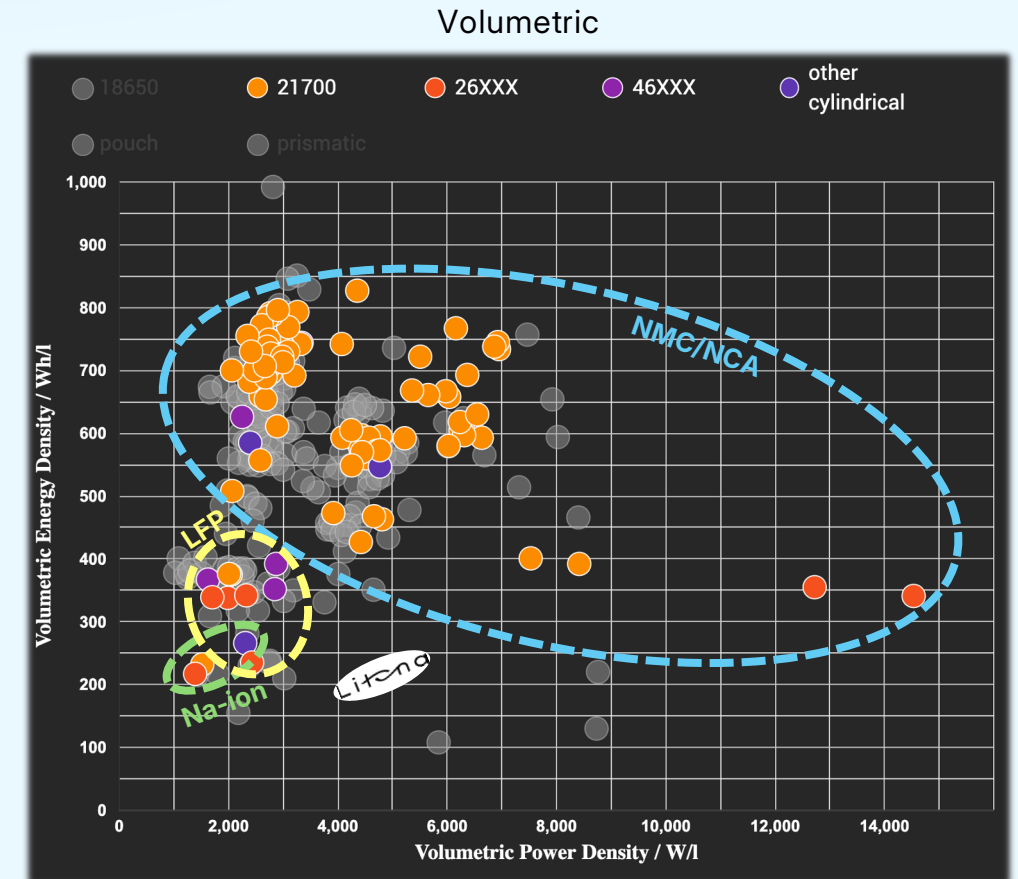
Litona knows how it can be removed effectively

Conceptual Simulation of a Litona 46XX Cylindrical Cell for 12 V Auxiliary Batteries

Method: Benchmarking a simulated Litona 46XX cylindrical cell against all cylindrical cells tested by BATEMO to date (excluding the 18650 format).



www.batemo.com/products/batemo-cell-explorer/

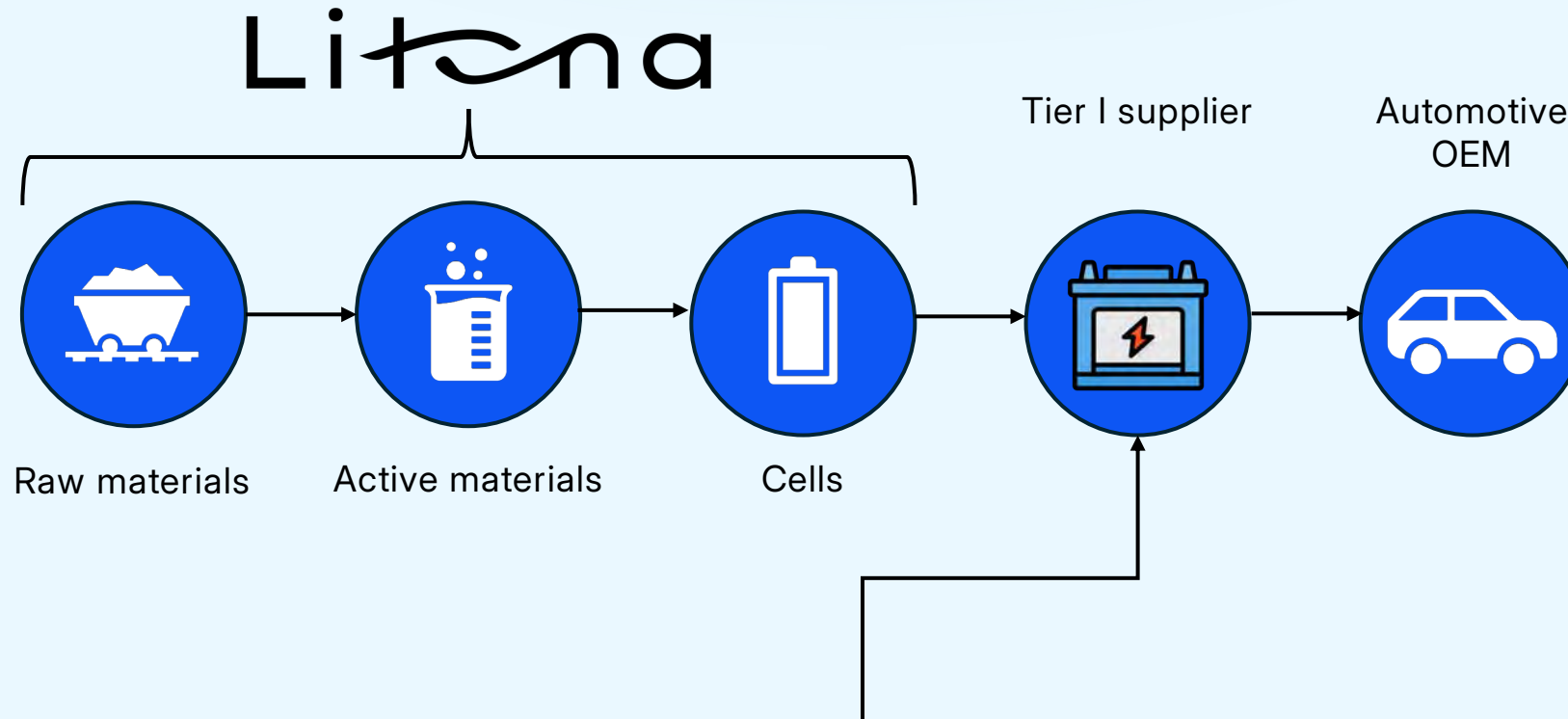


Is Na-ion actually as promising as everyone says? **Yes, but ...**

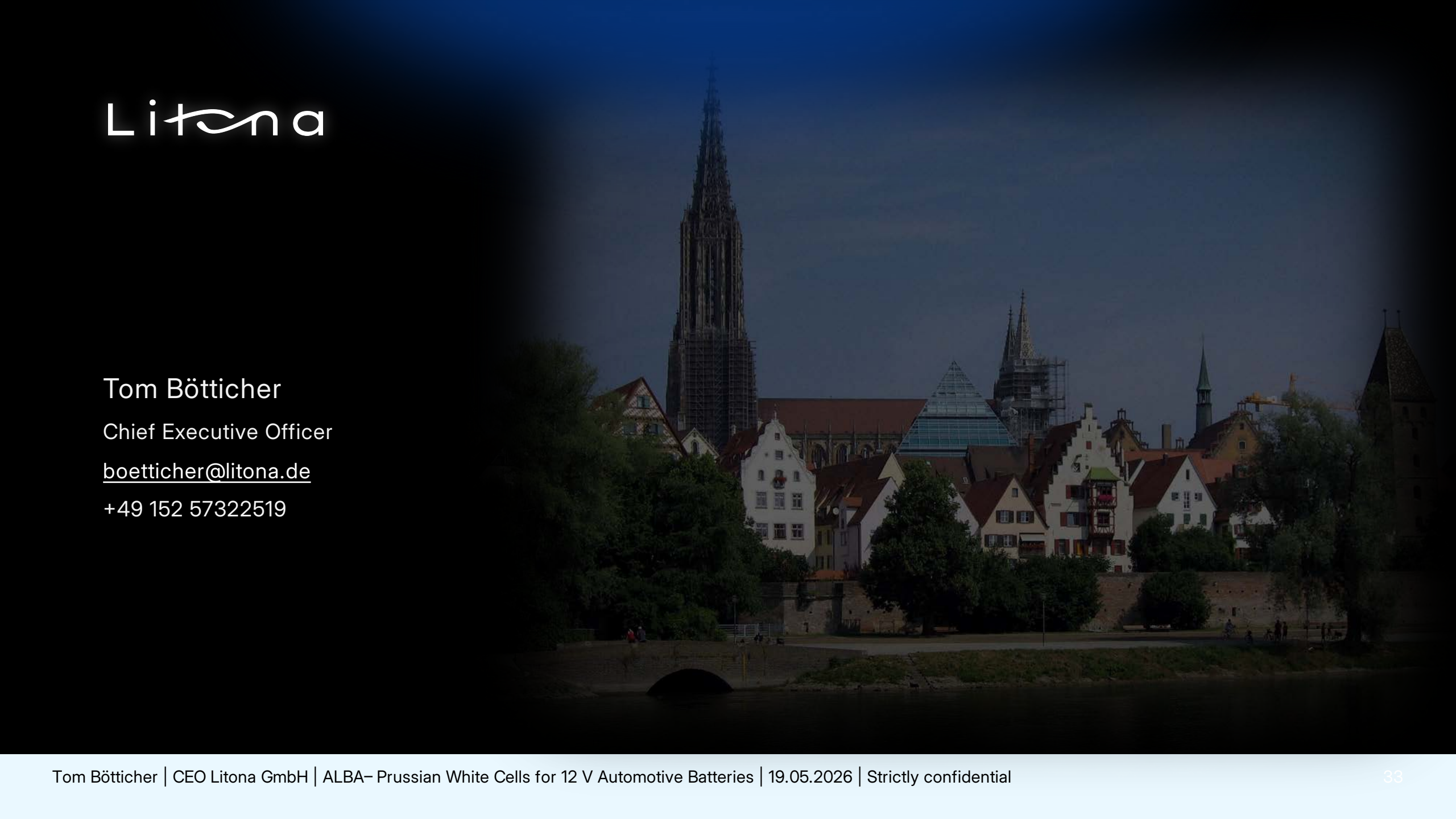
Let's not view Na-ion batteries as a replacement for Li-ion/Lead-acid batteries, but rather as a new technology with its own unique characteristics that can open up new markets and applications.

We are searching for Tier I suppliers as partners for commercialization

Litona



Is that you? Get in touch with me: **boetticher@litona.de**

The background of the slide is a photograph of the Regensburg Cathedral (Regensburger Dom) and the surrounding city of Regensburg, Germany. The cathedral's tall, ornate spire is the central focus, rising above the city's rooftops. The city is built on a hillside overlooking a river, with various historic buildings and a stone wall visible. The sky is a clear, deep blue.

Litona

Tom Böttcher

Chief Executive Officer

boetticher@litona.de

+49 152 57322519