WHITEPAPER

A Tale of Two Ions:

How Sodium-ion is finding its place in a Li-ion world

July 2026

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Executive summary

Sodium-ion (Na-ion) is at an inflection point. Early commercialization of sodium-ion batteries is underway. Product launches, utility-scale pilots, partnerships and offtakes both in automotive and stationary, and reportedly ~9 GWh of cell shipments in 2025 suggest the technology is entering a new phase. While manufacturing yield, long-term performance, and bankability remain unproven at scale, the commercial ecosystem is beginning to form.

Na-ion is not a better battery than Li-ion, but represents a different trade-off. Na-ion offers several advantages in raw material availability, power performance, cycle life, operating temperature range, depth of discharge, intrinsic safety, and manufacturing adjacency to Li-ion. Those advantages come with two clear constraints: lower energy density and lower maturity. The question is therefore not whether Na-ion has some superior traits, but where its trade-offs translate into value.

Na-ion's value will be determined by system economics as much as cell economics. At today's scale and maturity, cells remain costlier than LFP despite lower theoretical material-cost potential. Under selected assumptions, costs could fall from ~$60–70/kWh toward ~$40–55/kWh at full scale/maturity, potentially reaching parity for leading manufacturers in the next few years and more broadly after 2030, depending on both Na-ion techno-economic improvements and Li-ion's cost trajectory. But cell-cost parity is neither necessary nor sufficient: lower density can raise packaging and BoP costs, while validated safety, thermal resilience, longer life, wider usable DoD, and higher cycling could deliver superior system economics.

The opportunity is application-selective. Stationary storage (residential, C&I[1], and utility-scale) is the clearest near-term fit, where cycling, power, thermal resilience and safety matter more than maximum energy density. In mobility, early opportunities are likely to emerge faster in applications with less demanding range requirements, such as two- and three-wheel vehicles, compact passenger EVs, urban delivery vehicles and auxiliary battery systems. Recent announcements suggest Na-ion could also extend into selected mass-market passenger EVs, but broader mobility adoption depends on product claims proving out at scale, particularly on energy density, cycle life and cost.

Adoption will be gradual, with Li-ion still dominant through the next decade. The Na-ion market could reach 20 GWh by 2030 and 75 GWh by 2035 in a low-case scaling scenario (~1% of total battery demand) and 150 GWh by 2030 and 460 GWh by 2035 in a high-case scenario (~4-8% of total demand). The wide range reflects substantial uncertainty over both the pace of Na-ion performance and cost improvement, and its ability to scale beyond selected early applications. The likely path is segment-by-segment expansion, as performance data, supply chains, standards, warranties, financing confidence, and bankability assemble around each successive application, particularly outside China. Recent OEM and BESS announcements suggest the upside case is becoming more credible, but sustained market share gains will depend on converting early deployments into proven, repeatable, and financeable use cases.

Coexistence is the base case. Na-ion is shifting from a hedge against lithium supply and price risk into a selective competitor in the applications its chemistry suits. Broader Li-ion substitution across all applications remains a longer-horizon question. The realistic baseline is a multi-chemistry market, with increasing chemistry specialization across applications, regions, and duty cycles; one in which Na-ion becomes a meaningful secondary platform where its attributes matter most, rather than replacing Li-ion altogether.

China is again setting the pace. China currently leads commercialization efforts, with most announced manufacturing capacity, product releases and deployments, and supply-chain investment located there. Chinese battery champions are industrializing the technology from positions of scale, moving from cell announcements toward more mature product specifications, integrated systems, early field deployments, as well as large offtake commitments and partnerships. In the rest of the world, innovation is more startup-led and remains at earlier stages of product validation, manufacturing readiness and bankability. Outside of China, Na-ion therefore represents both a technology opportunity and a second chance to build battery manufacturing capabilities, before the market structure solidifies.

1. Commercial and Industrial

1. Na-ion's signal has changed and so should the central question

After years of being framed as a hedge against lithium price cycles, Na-ion is moving into early commercial formation. Market signals are increasingly tangible:

- **Major Chinese cell-makers** are launching Na-ion product lines alongside Li-ion[i, ii, iii, iv, v]
- **Manufacturing** is scaling, with dedicated Na-ion cell and active materials / electrodes capacity announced in China and beyond[vi, vii, viii, ix, x]
- **Stationary battery storage (BESS) deployment** has moved from lab to pilot / demo and pre-commercial projects
  - Early grid-scale installations (100-1,000 MWh-class projects) in China since 2024[xi, xii, xiii]
  - More recent multi-MWh pilots in USA, and smaller deployments in Europe[xiv, xv, xvi, xvii]
- **Early automotive adoption** is moving beyond concept vehicles into single- and dual-chemistry[2] architectures[xviii]
- **Offtakes, early shipments, and qualification** activity span multiple geographies and players[xix, xx, xxi]
- **Strategic investment and partnership** activity is broadening across the value chain.[xxii, xxiii, xxiv, xxv, xxvi, xxvii]

These developments show that Na-ion has crossed an important threshold: the commercial ecosystem is rapidly forming (**Exhibit 1**).

That acceleration, partly driven by the recent cost increase of Li-ion cathode precursors, has changed the industry conversation. A chemistry once treated as a fallback option is now discussed as a potential breakthrough. The question is often framed as whether Na-ion could rapidly replace LFP to become the next major battery platform. That, however, is not the right starting point.

Li-ion is hard to displace and not going away in the foreseeable future. It remains foundational across EVs and stationary storage, with extraordinary scale and maturity, strong performance, declining costs, and overall bankability. But battery markets are not moving toward a mono-chemistry future either. Mobility is already a multi-chemistry market, with LFP[3] and nickel-based chemistries (mainly NMC[4]) competing across cost, range, safety, and performance. Manganese-richer (LMFP[5], LMR[6]), Na-ion, and eventually solid-state and lithium-sulfur formulations could be adding further future optionality. Stationary storage is LFP-concentrated today, but longer-duration, higher-cycle, safety-sensitive and cold-climate applications — alongside demand for greater supply-chain resilience — will keep testing the limits of a single-chemistry model.

In that context, the useful question is not whether Na-ion replaces Li-ion, but which of three potential roles it is to play, and what each requires:

- **Hedge:** Na-ion's original role was as a diversification option against lithium price volatility, supply-chain concentration and policy risk. That role still matters, but it no longer fully captures the market signal.
- **Selective competitor:** Na-ion is now moving into this role, competing in specific applications where its chemistry trade-offs deliver a marginal advantage or where it can reach cost parity. This competition may also be market-expanding, rather than purely zero-sum.
- **Broad substitute:** Na-ion becomes a broader substitute only if those trade-offs become compelling enough across applications to influence procurement decisions, system design, and financing at mainstream scale.

2. Li-ion and Na-ion in same battery pack
3. Lithium iron phosphate
4. Nickel manganese cobalt oxide
5. Lithium manganese iron phosphate
6. Lithium manganese-rich batteries

EXHIBIT 1

Na-ion momentum accelerating rapidly – ambitious announcements of new product launches, partnerships, & new manufacturing capacity

As of June 28th 2026

Player	HQ	Role/ archetype	Product	Off-takes/partnerships/funding	Manufacturing
CATL	China	Integrated (cell, pack/system)	Naxtra for EVs (175 Wh/kg), TENER Sodium ESS launched Jun '26: NFPP confirmed, >30MWh/module, 15k cycles @ 25°C, >92% cap @ −20°C, 30-yr warranty, LFP enclosure	Changan / AVATR / Deepal / Qiyuan / UNI vehicle rollout; 60GWh CATL-HyperStrong ESS cooperation (over 3-years)	316Ah Na-ion on same enclosure as 587Ah LFP, reducing adaptation costs and system-integration effort; new mfg capacity: Fuding +40GWh, Jining 160GWh planned
BYD	China	Integrated (cell, pack/system)	Reported MC Cube-SIB / blade-style Na-ion ESS concept, Ah and density not disclosed (possibly NFPP, unconfirmed)	Huaihai partnership for Na-ion industrial base; downstream pull likely via BYD / FinDreams EV and storage ecosystem.	30GWh/year Xuzhou Na-ion battery plant operational (current capacity/throughput not disclosed)
Gotion High-tech	China	Integrated (cell, pack/system)	Gnascent Na-ion family: high-energy version claimed at 261 Wh/kg; power version at 162 Wh/kg; 180 Ah ESS version claimed at >20k cycles	No Na-ion offtake announced publicly yet	Existing GWh-scale automated lines reported in Tangshan and Hefei; scaled Na-ion deliveries targeted for Q4 2026
EVE Energy	China	Integrated (cell, pack/system)	NF155L ESS cell based on NFPP; claimed >30k cycles, >1P discharge and −40°C to +60°C operation	No Na-ion offtake announced publicly yet; first Na-ion ESS grid-connected (pilot) at EVE's Jingmen base in Sep. 2025	Early Na-ion project / capacity formation announced; commercial ramp not disclosed
Hithium	China	Integrated (cell, pack/system)	N162Ah Na-ion ESS cell, sodium iron ortho-pyrophosphate, claimed ≥95 Wh/kg, 173 Wh/L, >20k cycles, −40°C–60°C	Hybrid Li/Na ESS and AI/data-center system positioning	Na-ion positioned within HiTHIUM's BESS portfolio; GWh-scale production targeted / disclosed
HiNa Battery	China	Integrated (cell, pack/system)	Na-ion ESS and starter battery; HE240 cell reported >150 Wh/kg, NE170 >100 Wh/kg; chemistry not fully disclosed	Chinese grid and hybrid Li-Na storage deployments, including 100MW/200MWh-class Na-ion project and 200MW/400MWh hybrid Li/Na station with 40MWh Na-ion.	GWh-scale Fuyang production base; expansion target around ~5GWh
Envision Energy	China	Integrated (cell, pack/system)	Claims 180 Ah Na-ion ESS cell; claimed ≥ 20k cycles and −40°C to +70°C ops for data centers and extreme temp.	Positioned within full-scenario storage and AI data-center solutions; no large Na-ion offtake publicly visible yet	Na-ion earlier-stage versus Envision's scaled LFP ESS platform
Peak Energy	USA	Cell integration – Pack/System	Grid-scale Na-ion BESS (passive cooling) platform; own cells development, NFPP; cell Ah and density not disclosed	Jupiter Power 4.75GWh (2027-30); Energy Vault 1.5GWh; RWE/SolarTAC pilot; $10M seed ('23), $55M Series A ('24); GM partnership for BESS cells integration (2028)	US cell engineering center; first giga-scale US factory in 2027; aiming >20 GWh annual capacity by 2030
Alsym Energy	USA	Integrated (cell, pack/system)	Proprietary NFPP+ for BESS; claimed 135 Wh/kg, >10k cycles, >95% RTE	ESS Tech LoI for 8.5GWh of Na-ion cells/modules, pipeline ~$1Bn; 500 MWh partnership with Juniper Energy; $78M round (2024); Re:Build Mfg MOU for US cell production	Moving from product launch to qualification / scale-up; cell-prod. scale-up partnership with Re:Build Manufacturing
UNIGRID Battery	USA	Cell integration – Pack/System	Na-ion cells for BtM/DCs and 12V starter battery; NCO (single crystal); 125 Wh/kg (prod.), 178 Wh/kg (pouch); ~20k-cycle (80% capacity retention) / up to 25-yr[2]	Indexel India 50MWh partnership; Blue Whale SEA rooftop-storage partnership; ~$12M early-stage (2025)	Fabless/foundry (Asia) model 200 MWh/year, with plans to reach 1 GWh/year pace within 2026; international cell shipments
Altris	Europe	Cell OEM	Proprietary Prussian White / PBA Na-ion cell platform; Ah and cell density not disclosed	Clarios / InoBat auto collaboration; Polarium ESS devel.; Draslovka CAM line partnership; $40+M total funding	European CAM and cell scale-up pathway; Draslovka line supports early CAM supply
Tiamat	Europe	Cell OEM	High-power Na-ion cells; generally positioned around polyanionic / phosphate-family chemistry	Stellantis Ventures investment; European industrial ecosystem support; €20+M funding round (2024)	Planned 5GWh Na-ion factory near Amiens, with smaller first phase
Reliance Industries Limited	India	Integrated (cell, pack/system)	Faradion platform; historically layered oxide; ~140–160 Wh/kg, current Reliance commercial specs not disclosed	Reliance acquisition of Faradion IP; potential integration into Reliance's Indian battery / energy-storage platform.	Commercialization intent via Reliance's new-energy manufacturing ambitions; pipeline not disclosed
Clarios	USA	Integrated (cell, pack/system)	Low-V auto platform; cold-start to −25°C, low resistance, high power density; Ah/density not disclosed	Expanded JDA with Altris; InoBat (Slovakia) assembling first prototype cells	Serial low-V production before 2030 at dedicated EU or US site; part of $6B US plan ($1B to next-gen batteries)
Moonwatt	Europe	Cell integration – Pack/System	Distrib. Na-ion BESS for PV, ~80 kWh modular units, passive-cooling, DC and AC-coupled; based on 3rd party NFPP	€8.3M seed, €1.2M RVO DEI+ grant; 2027 orders open; pilot commissioned (500kWh, 93–94% solar-to-grid efficiency)	Stated GWh-scale ambition

Key: (role/archetype in battery value chain in general, not specific to Na-ion) — Integrated (cell, pack/system) · Cell OEM · Cell integration – Pack/System

1. Based on TENER Sodium launch at Intersolar Europe / The Smarter E, Munich, June 22–23, 2026: ~3.75 MWh per module (~42 t) in an 8-unit configuration delivering >30 MWh (~89 Wh/kg system-level, BCG calculation), vs. ~50 MWh (~149 Wh/kg) for the equivalent LFP configuration — a ~40% system-level energy density gap. Stated cycle life: 15k cycles at 25°C and >10k cycles at 45°C, both at 70% SOH **2.** 5,000 full-depth cycles demonstrated at >95% retention; **Note:** additional companies with recent announcements incl. BAIC, REPT BATTERO, Eleven Energy, BIWATT, Phenogy, etc.; **Source:** BCG analysis

Viewed through that lens, Na-ion's future is less a question of replacement than of progression. The technology has already moved beyond a pure hedge against lithium risk, and is becoming a selective competitor in applications where its chemistry is well suited[xxviii]. Broader substitution remains a longer-horizon possibility, conditional on further chemistry development and industrial maturity (**Exhibit 2**).

EXHIBIT 2

Na-ion is moving from hedge to selective competitor — with broad substitution a longer-term, conditional outcome

	Hedge **Buy optionality** **2020 – 2025**	**Selective competitor** **Win the niches** **2025 – 2030+**	**Broad substitute** **Take on Li-ion** **2030+ (conditional/potential)**
Strategic role	Create optionality against lithium price volatility, supply concentration and future technology disruption	Enter selected applications where Na-ion's properties create a clear advantage versus Li-ion	Compete with Li-ion across broader segments if/where Na-ion proves cost, performance and bankability
Market posture	R&D, pilots, demos and limited production runs; mostly strategic positioning and capability building	Early commercialization in targeted niches; offtakes, partnerships and first deployments build scale	Large-scale manufacturing, mature supply chains and repeatable deployments across multiple segments
Where Na-ion fits	Hedge against LCE volatility; diversify away from China-heavy lithium supply chains; prepare for future chemistry shifts	Niches where safety, power, temperature resilience, siting flexibility or Li-free chemistry matter more than peak density — e.g. auxiliary batteries, lower segments, C&I, data centers, selected BESS	Broader BESS, mobility (across segments) and industrial applications, if Na-ion closes the cost / density gap and proves system-level advantages
What must be proven	Technical feasibility, early performance, manufacturability and basic safety validation	Competitive application-level economics; reliable field performance; supply-chain scale-up; customer qualification; early bankability	Cell and system cost advantage across segments; mature bankability; lender / insurer acceptance; repeatable warranties; scaled supply chain

Na-ion today at inflection point: after years framed as a hedge against lithium price cycles, Na-ion is moving into commercial formation

Note: Timing indicative; pace will vary by region, application and chemistry; broad substitute role is only potential and conditional to several assumptions related to Na-ion performance and economics (as well as for Li-ion as benchmark) materializing over the coming years
Source: BCG analysis

The Incumbent Still Sets the Terms — Li-ion at a Glance

Few technologies have reshaped an industrial landscape as rapidly as Li-ion. In less than two decades, Li-ion has become the default battery platform across electric mobility[xxix], stationary energy storage[xxx], power tools, and consumer electronics.[xxxi] Global Li-ion demand reached ~1.7 TWh in 2025, up 38% year-on-year, on trajectory to exceed ~3.6 TWh/yr by 2030 and ~5.7 TWh/yr by 2035.

Li-ion ecosystem remains overwhelmingly China-centric: China dominates (LFP) cell manufacturing[7] and much of the upstream and midstream value chain. The US, EU and India are seeking to localize and diversify supply chains, a difficult catch-up effort after a decade of China compounding scale, know-how and supplier depth. Japan and Korea have also spawned globally competitive Li-ion (NMC) supply chains, rooted in their history as major producers of consumer electronics.

Li-ion's position rests on more than scale. Its chemistry already satisfies the core requirements of the largest battery markets. In mobility, Li-ion delivers a combination of energy density, cost, safety, durability, and charging performance sufficient for everything from entry-level vehicles to premium-long range vehicle platforms. In stationary storage (LFP dominated), Li-ion has achieved a similar fit, combining low system cost, relatively long cycle life, and established safety practices. As a result, battery adoption is no longer constrained primarily by chemistry performance, but increasingly by economics and infrastructure availability.

A hurdle for potential challengers is that Li-ion continues to improve. Cell cost[8] decline has been extraordinary[xxxii] (though partially reliant on depressed raw materials pricing, particularly lithium carbonate, and recent overcapacity), energy density continues to rise, manufacturing yields are improving, and chemistry variants are set to extend the performance frontier further. At the same time, years of deployment have built the operating history, warranties, financing confidence, and supply-chain depth that make projects bankable at scale. The result is an incumbent with extraordinary momentum, backed by industrial ecosystems and supply chains with strong incentives to keep expanding Li-ion demand.

The opportunity for Na-ion or any other alternative is not driven by Li-ion failing to meet major market needs. The openings for alternative chemistries lie first at the margins: where customers seek lower upfront costs or better system level economics and total cost of ownership, greater safety, wider operating windows (particularly in extreme cold or hot climates) or supply chain diversification. At the other end of the spectrum, demand for ever-higher energy density and performance continues to push beyond today's base Li-ion frontier. Na-ion addresses some of the former challenges, but not the latter. Its path is therefore likely to begin in the gaps where today's Li-ion position is strong but not yet optimal.

7. China dominance in Li-ion value chain: ~70% of global battery manufacturing, ~95% of battery-grade graphite, ~70% of refined Li supply, ~85% of cathode (~95% LFP).
8. Average Li-Ion (weighted average of chemistries, and manufacturing and selling region) cell price decline by ~40% between 2020 and 2025, with ~5% year-on-year between 2024 and 2025. LFP, in particular, reached \$40–45/kWh in China in Q4 2025, aided by LCE prices at historic lows near \$9k/t (~40% decrease since 2020).

2. Na-ion is a different trade-off, not a better battery

Na-ion is not simply a cheaper version of Li-ion. Although it shares Li-ion's battery architecture and most manufacturing steps, it uses a fundamentally different chemistry, which gives rise to different performance trade-offs, safety behavior, system-design implications, raw-material base, and supply-chain structure.[xxxiii, xxxiv] The question is not whether those differences make it better than Li-ion, but which applications value them more.

A fundamentally different ion

The difference starts with the ion itself. Sodium is roughly 3x heavier than lithium and over 2x larger in ionic volume. It's also the 6th most abundant element in Earth's crust, ~1,000x more common than lithium. The consequences cascade: graphite found in Li-ion batteries does not host sodium effectively, ion transport and kinetics shift, materials compatibility changes, and lower energy density – both gravimetric and volumetric – creates structural headwinds. These properties push Na-ion toward a different materials set including hard carbon anodes, aluminum collectors on both electrodes, and sodium-specific cathode families. They also shape cell-level behavior, from voltage curve and degradation profile to the thermal characteristics and safety envelope. This in turn drives system-level choices around BMS logic, PCS architecture, and thermal management solutions.

Cathode family matters

Several Na-ion cathode families are emerging, each emphasizing different trade-offs.[xxxv] Broadly speaking, layered oxide Na-ion cathodes occupy a position similar to NCM in the Li-ion world, while the polyanion chemistries most closely resemble the value proposition of LFP. Layered oxides offer high energy density among Na-ion options. As such, they are attracting automotive interest, while also remaining relevant for stationary storage where footprint and system-level density matter. Polyanion routes (~80% of cathode production as of 2026[xxxvi], dominated by NFPP[9]) offer stronger stability, safety, and cycle life, making them attractive for stationary storage. A third family, Prussian-blue analogues, offers power and cycling at low cost, but manufacturing and consistency challenges remain.[xxxvii] Nuances exist within each family and continue to push the performance frontier. For example, next generation layered oxide variants (e.g., chromium-based $NaCrO_2$) now claim to combine high power density and much longer cycle life, qualities that have historically been difficult to achieve simultaneously.[xxxviii, xxxix] More broadly, recent product announcements suggest that the traditional energy-density versus cycle-life trade-off may be improving, although underlying chemistries are often not disclosed and performance claims still require independent validation at scale. Overall, the market has not yet converged on a dominant Na-ion architecture, nor should we expect that. While the present diversity creates room for innovation, it also introduces uncertainty around manufacturing scale-up, qualification pathways, and bankability.

Na-ion properties: Three advantages and two constraints

Na-ion's performance profile differs from Li-ion in many ways, but not all characteristics matter equally. Three advantages underpin most of the chemistry's potential value proposition: supply chain optionality, operating performance, and safety. Two constraints, energy density and maturity, remain the primary barriers to broader adoption.[xl, xli, xlii] Together, these trade-offs (**Exhibit 3**) have significant implications for cell- and system-level performance, economics, and applications.[xxxii] These implications are explored in the next chapter.

9. Sodium Iron Pyrophosphate

EXHIBIT 3

Na-ion's value proposition rests on three advantages and two constraints, with system-level trade-offs determining where it can win

Category	Dimensions	Nature	Evidence	Description	Na vs Li-ion	Key nuances and system-level implications
Supply chain optionality	Raw materials base	Intrinsic	Proven	Drops lithium, graphite and copper for abundant soda-ash-linked Na-precursors, hard carbon for anode and aluminum as current collector	Advantage	Resilience / optionality is the value; midstream (cathode, hard carbon, electrolyte) still nascent; BoM cheaper in $/kg, density/scale drive material intensity — defining cell cost competitiveness vs Li-ion
	Manufacturing adjacency	Industrialization	Proven	Shares most process steps and equipment with existing Li-ion lines; re-tooling required on existing Li-ion lines	N/A[1]	Adjacent mfg. not drop-in: LFP lines line-refurbishment costs/time, re-qualification, yield loss; at system level BMS/EMS, pack-voltage string design, thermal/fire strategy need redesign (not drop-in)
Operating performance	Temperature range	Intrinsic	Proven	Holds capacity and charges safely across a wider hot/cold operating window (physically grounded)	Advantage	Wider operating window enables simpler / passive thermal architecture (lower aux load / TMS cost[2]); independent testing flagged RTE could be more SOC/temp-sensitive than LFP
	Cycle life	Intrinsic	Emerging	Claims of 10,000-15,000+ (@25 degC, 70% SoH) cycles depending on cathode chemistry, matching or beating top-tier LFP	Mixed	Based on accelerated-test and vendor data, needs multi-year field tests; nuances from cathode chemistry; pot. fewer augmentation cycles, less oversizing, lower O&M; enables capacity/leasing models
	Depth of discharge (DOD)	Intrinsic	Emerging	Full cycle life at 100% DoD vs Li-ion's 80-90% limit, Al collectors don't dissolve and hard carbon avoids plating	Advantage	Less oversizing and lower SOC-buffer requirements; repeated 100% DoD cycle life requires further validation and PCS customization due to voltage drop at low SoC, but advantage is physically grounded
	Power	Intrinsic	Proven	High C-rate from fast kinetics; fits frequency response, UPS, data centres	Advantage	High C-rate delivers the required MW from less installed MWh; no over-building energy to hit a power rating (frequency response, UPS, data centres); better $/kW — where SOC/temp/duty preserve power
	Round-trip efficiency (RTE)	Intrinsic	Emerging	NFPP vendors claim >95% (LFP-class)	Mixed	Low-SOC and cold-temperature efficiency losses (if applicable) may require SOC buffers and tighter dispatch controls, reducing usable MWh and weakening deep-cycle arbitrage economic
Safety	Safety	Intrinsic	Proven	More abuse-tolerant (thermal and mechanical) chemistries; cells can be transported and stored at 0 V	Advantage	Still use organic electrolyte; benefit is cathode chemistry specific, but overall better vs incumbent; no converged global standards yet; lenders/EPCs default to Li-ion protocols, limiting cost benefits
Energy density	Energy density	Intrinsic	Proven	90-175 Wh/kg vs LFP 160-210 or NMC 240-300+, highly dependent on chemistry; carries penalty vs Li-ion	Disadvantage	Structural limit (larger ion, lower voltage); system savings must offset BESS' BoP and logistics penalties; mobility faces range, payload trade-offs — favoring short-range and power-oriented segments first
Maturity	Maturity	Industrialization	N/A	No converged designs/chemistries, standards or bankable operating history yet, ecosystem and supply chain still nascent; dedicated mfg growing	Disadvantage	Cell claims must translate into pack, field, warranty, insurer and lender confidence (hence bankability)— which takes time to validate

Cell chemistry creates the advantages and trade-offs; system design and use-case economics determine where Na-ion wins

Proven · Emerging · N/A · Advantage · Mixed · Disadvantage

1. This is an advantage vs other Li-ion competitors, but not an advantage vs Li-ion per se | Legend: Nature = where the dimension comes from: Intrinsic = set by Na-ion's chemistry/physics, Industrialization = set by the production ecosystem and scale-up. **2.** Roughly 5–8% of system cost
Legend: Evidence = how settled the dimension is: Proven = demonstrated/locked, Emerging = expected from the chemistry, not yet proven at scale, N/A = not a single dimension (maturity cross-cutting across whole tech); Na-ion vs Li-ion = net direction shown separately: Advantage/Mixed/ Disadvantage
Source: Na-ion brief (May 2026); BCG analysis

Advantage #1: Supply chain optionality

Raw materials base. Na-ion cells remove lithium, which is exposed to price volatility[10] (particularly for lithium carbonate), long mine-development cycles, and concentrated refining capacity in China. Instead, they build on abundant and cheaper Na-precursors linked to mature commodity chemical supplies, e.g., soda ash. Through hard carbon, Na-ion cells also eliminate exposure to graphite, currently characterized by a highly concentrated supply chain. Finally, Na-ion entirely removes copper as current collector, replaced by aluminum at both electrodes (**Exhibit 4**). These substitutions strengthen Na-ion's raw material availability case, but they do not yet translate into a fully diversified battery-grade supply chain. Production of cathode active materials, hard-carbon anodes and sodium electrolyte salts remains nascent and thus far concentrated in China; hard carbon production faces cost and scale-up bottlenecks[11], electrolyte salts lack scale, and manufacturing yields still trail LFP. Converting the raw-material advantage into competitive cells remains a missing link, particularly outside China. Chinese ecosystem players are already scaling active-material manufacturing and developing alternative hard-carbon anode supply routes. However, at present the broader Na-ion materials ecosystem remains nascent and highly concentrated.[xiv]

EXHIBIT 4

Na-ion chemistry enables re-use of several existing LFP capabilities, while reducing raw material concentration risk

	Lithium(Li)-Ion	Sodium(Na)-Ion
1 Cathode Active Material	☆ Lithium carbonate and iron phosphate; exposed to lithium price volatility (highly illiquid market)	Soda ash, iron phosphate (for NFPP), nickel-manganese-iron precursors (NFM); lower material criticality, with sodium ~1,000x more abundant than lithium
2 Cathode Foil	Aluminum-made, with thickness varying with form factor and energy density	Aluminum-made, with thickness varying with form factor and energy density
3 Anode Active Material	☆ Natural/mined or synthetic (from needle coke) graphite	Hard carbon sourced from biomass or resin/coal-based routes (latter emerging); reduces graphite dependency, though supply chain remains less mature
4 Anode Foil	Copper-made, with thickness varying with form factor and energy density	Aluminum-made; eliminates copper exposure and reduces raw material cost volatility
5 Electrolyte	Lithium salts (lithium hexafluorophosphate - LiPF6)	Sodium salts (NaPF6), broadly similar electrolyte platform and manufacturing process, but requires reformulation[1]
6 Separator	Polyethylene (PE) or polypropylene (PP), depending on cell-design and performance requirements	Polyethylene (PE) or polypropylene (PP), depending on cell-design and performance requirements
7 Housing/Structural Materials	Steel or aluminum casing, copper for cell interconnection/cabling	Same mechanical design principles and mfg lines (in principle); lower energy density reduces GWh throughput and increases capex amortization per kWh

☆ Key differentiation of components

1. Similar chemistry using organic carbonate-based solvents, comparable additives, and analogous conducting salts. But not a direct drop-in substitution: concentration, additive package, SEI formation, stability window, gas formation, moisture sensitivity, and compatibility with hard carbon/cathode materials all need to be re-optimized. **Source:** BCG analysis

10. Lithium carbonate (LCE) exhibited volatility over the last 5 years and particularly over the last 6 months: it peaked to ~$89k/t in Nov 2022, decreased to ~$14k/t in Jan 2024 and remained relatively low for roughly 2 years, going from lows of ~$8.8k/t to highs of ~$16.5k/t at Dec end (2025 during that period), then it spiked again to reach ~$29.7k/t in May 2026, and dropped again to ~$22.4k/t as of 26th Jun 2026. On the other side, soda ash has fluctuated between $0.2-0.6k/t in the last 5 years, with max of $0.2k/t over the last 1 year.
11. Hard carbon is produced by carbonizing non-graphitizable carbon-rich precursors, including biomass such as coconut shells, wood and agricultural residues, as well as synthetic precursors such as resins and pitch. The supply base remains nascent, with commercial formulations often undisclosed, and characterized by shipping constraints, uneven organic quality and volatile pricing. However, recently some companies started pursuing synthetic routes, incl. resin-based and coal-based production pathways.

Manufacturing adjacency. Na-ion shares most manufacturing steps with Li-ion, a meaningful advantage over more radical technologies. But process-adjacent is not drop-in: switching chemistry from Li to Na-ion on the same line comes with refurbishment costs, re-qualification requirements, and yield impact. Competitive production requires institutionalizing the recipes, tolerances, formation protocols, quality control, and supplier consistency that drives yield, overall equipment effectiveness (OEE), and cost. Some manufacturers are fitting lower-energy-density Na-ion cells into large-format enclosures already used for higher-capacity LFP cells. This can enable partial reuse of module layouts, enclosures, and downstream assembly architectures, limiting integration frictions despite the lower energy stored per cell.[xlvi] In modules and containers, BMS and controls must also be recalibrated around Na-ion's voltage profile, state of charge (SOC) behavior, degradation, and safety envelope.

Advantage #2: Operating performance

Temperature range / operating window. Selected Na-ion chemistries can retain more usable capacity and support charging across a wider temperature range (-40C to +70C) than incumbent Li-ions, particularly in cold conditions where Li-ion must derate to limit plating risk.[12] This is especially relevant for cold-climate mobility, where superior low-temperature capacity retention versus Li-ion can help preserve winter range and charging performance.[xlvii, xlviii] Na-ion can also tolerate higher operating temperatures. This creates the potential for simpler thermal architectures, including passive cooling systems, which are particularly appealing for stationary applications. Simpler thermal management may also reduce mechanical noise from cooling equipment — a tangible community-siting benefit for urban, residential, and constrained-site installations.

Cycle-life and durability. Na-ion products are posting strong cycle-life performance potentially across cathode families. Some OEMs are reporting 10-15+k cycles with 70-80% state of health (SOH) retention at +25C, depending on chemistry.[13] Where long life and predictable degradation are proven, Na-ion could support new ownership models, including leasing or storage-as-a-service contracts tied to capacity, uptime and availability rather than upfront equipment sales. While many of these claims still require independent field validation, the implication is clear: Na-ion products' longer life cycle can reduce augmentation requirements, maintenance costs, and system oversizing.

Depth of discharge (DoD). Selected Na-ion cells may support wider usable state of charge (SOC) windows and deeper discharge (close to 100%) than incumbent Li-ion cells (80-90%). Where validated, this can increase usable energy per nameplate capacity and reduce oversizing requirements.[14] However, the full-system implications of wide DoD are more nuanced. Na-ion's continuously sloping voltage profile — unlike LFP's flat discharge plateau — enables more precise BMS state of charge estimation throughout the discharge window, a potential operational advantage. At very low SOC, however, cell voltage can fall significantly, requiring more complex PCS architectures to extract that last portion of stored energy efficiently (e.g., dedicated bidirectional DC-DC voltage regulation, which stabilizes output voltage across the full SOC window). [xlix, l] The implication is that Na-ion's high usable DoD is a system-level feature, not a cell-level one, and as such, the economics must be evaluated at full system level.

Power. Selected Na-ion designs offer strong power response and high discharge (C-rate) capability thanks to fast kinetics.[15] These properties are relevant for grid frequency response, UPS, data center, and start-stop batteries. In selected applications, they can reduce system oversizing and improve lifetime economics.[16] Selected Na-ion chemistries offer high-rate capability, enabling faster charging and discharging and potentially increasing asset utilization through more frequent cycling and revenue stacking.[xxxii]

Round-trip efficiency (RTE). The fast kinetics behind Na-ion's C-rate capability also support competitive round-trip efficiency. For example, NFPP vendors claim >95% (LFP-class), though some independent testing shows efficiency falling at low SOC and low temperatures.[li]

12. Na^+ can benefit from lower solvation and desolvation energy than Li^+, supporting low-temperature ion transport, while hard-carbon anodes avoid graphite-specific lithium-plating constraints. Selected Na-ion cathodes can also offer stronger thermal stability, although performance varies by electrolyte, interface and cathode chemistry.
13. Hard carbon's 3D anode structure handles sodium insertion with less mechanical strain than graphite handles lithium, and polyanion/layered-oxide Na-ion cathodes experience less per-cycle structural fatigue than their Li-ion equivalents. NFPP polyanion cells have demonstrated 10,000 cycles above 80% SoH in accelerated tests at 45degC (claiming 20,000+ cycles in operating conditions), potentially above many LFP benchmarks, if validated in operating conditions; latest generation Na-ion products claim 10,000 - 15,000 + full-DoD cycles at 70% 50H retention, exceeding NMC and matching top-tier LFP. Vendor data for Sodium Chromium Oxide cells show 5,000 full-depth cycles at >95% retention — ~20,000 expected cycles and 25-year service lives, in line with solar-asset horizons and making cells potentially suitable long-term leasing arrangement.
14. One contributing factor is the ability of many Na-ion designs to use aluminum current collectors on both electrodes, avoiding the copper-dissolution pathway that can arise in Li-ion cells under severe over-discharge. This also enables certain Na-ion cells to tolerate storage or transport at 0 V. However, cycle-life performance under repeated 100% DoD operation remains chemistry- and product-specific.
15. Although the sodium ion is larger, its weaker solvation and lower desolvation energy give higher ionic conductivity and faster charge transfer in the electrolyte, supporting high C-rate capability
16. Independent testing (TUM/RWTH Aachen) found Na-ion rate capability broadly comparable to LFP across the full SOC range, but resistance and impedance far more sensitive to SOC and temperature, with energy-efficiency losses roughly twice as high below 50% SOC (and worse under constant power). The resistance penalty didn't fully carry through to rate capability or round-trip efficiency, partly because cell self-heating offsets it. These were specific 2024 commercial layered-oxide cells, so results shouldn't be over-generalized — but the lesson holds: SOC window, temperature and duty cycle determine what the cell actually delivers

Advantage #3: Safe operations

Safety. Most Na-ion cells still use flammable organic electrolytes, so venting and fire risk are not eliminated. However, Na-ion chemistries can generally tolerate greater thermal and mechanical abuse before critical failure. This is supported by lower cell energy, more stable cathode structures, and a lower propensity for cathode oxygen release under abuse.[17] Na-ion can also be transported and stored at zero state of charge (0 Volts), simplifying handling and reducing logistics risk[18]. At system level, Na-ion can enable simpler thermal management and fire mitigation architectures, with potential benefits for permitting, fire code compliance, site layout, and insurance. Recent commercial product disclosures point to further intrinsic cell-level safety improvements. Most notable are significantly lower thermal runaway surface temperatures versus standard Li-ion, reducing peak thermal event severity, and meaningfully lower cell expansion forces and gas generation under abuse conditions. Both of these reduce mechanical and pressure stress on system containment.[lii]

The set of advantages, however, must overcome two important constraints.

Constraint #1: Energy density

Energy density remains Na-ion's largest structural disadvantage. Sodium is heavier and bulkier than lithium, limiting both gravimetric and volumetric upside. The hierarchy of chemistries and their respective energy densities is: NMC/NCA ~240–300+ Wh/kg; LFP 160–210 Wh/kg; LMFP (target) ~210–240 Wh/kg; best-in-class Na-ion ~155–175 Wh/kg (potentially layered-oxide, undisclosed/unverified); polyanion/NFPP Na-ion 90–120 Wh/kg. This cell-level gap persists at system level, with equivalent Na-ion BESS containers carrying a meaningful energy density penalty compared to LFP today.[liii] The latest layered-oxide performance claims suggest a potentially good compromise between NMC-like energy density and LFP-like safety / cost logic — but they still require validation and commercial proof. In mobility, lower energy density constrains both the pace of EV adoption and the range of addressable segments such as longer-range passenger and heavy-duty vehicles. In stationary storage, lower relative energy density most acutely affects footprint, transport costs and complexity, and balance-of-plant costs. System level savings from safety, cooling, cycle life, or supply-chain resilience must be large enough to offset these penalties. Lower energy density also reduces effective GWh throughput versus LFP lines[xxx], requiring more cells and processing capacity per delivered GWh and weakening manufacturing economics.[19]

Constraint #2: Maturity

Maturity remains Na-ion's second major constraint after energy density. The picture is uneven: Na-ion benefits from strong LFP manufacturing adjacency, but materials ecosystems are still immature, chemistries and standards have not yet converged, and bankable field evidence remains limited, especially outside China. The most promising claims must still translate from cell specs into pack performance, project economics, field operation, warranty confidence, insurance review, and lender diligence. While pre-commercial projects are already being deployed, testing and validation will still require time before broader market adoption. The gap is most acute outside China, where deployment remains at the pilot and demonstration stage. Commercial pipelines are building but final investment decisions have not yet been taken at scale. And the bankability stack, including field data, warranties, insurer acceptance, lender protocols, is still being assembled.

Implications

These properties make Na-ion better in specific places but less attractive in others. The strategic case is therefore not to replicate LFP with a different cell, but to design around Na-ion's distinct trade-offs across materials, thermal architecture, safety envelope, and operating strategy. If performance claims are validated at scale, Na-ion can create a differentiated system-level value proposition wherever its advantages are large enough to overcome the density and maturity penalties. The next chapter examines where that proposition can compete economically.

17. Na-ion cathodes give up lattice oxygen less readily than nickel-rich Li-ion, the reaction that drives the most violent thermal runaway)
18. Sodium does not interact with aluminum collectors the way Lithium does with copper at very low voltage
19. Lower cell throughput on the same line results in higher depreciation and amortization costs impact on unit economics

3. The economic case for Na-ion and where it can compete first

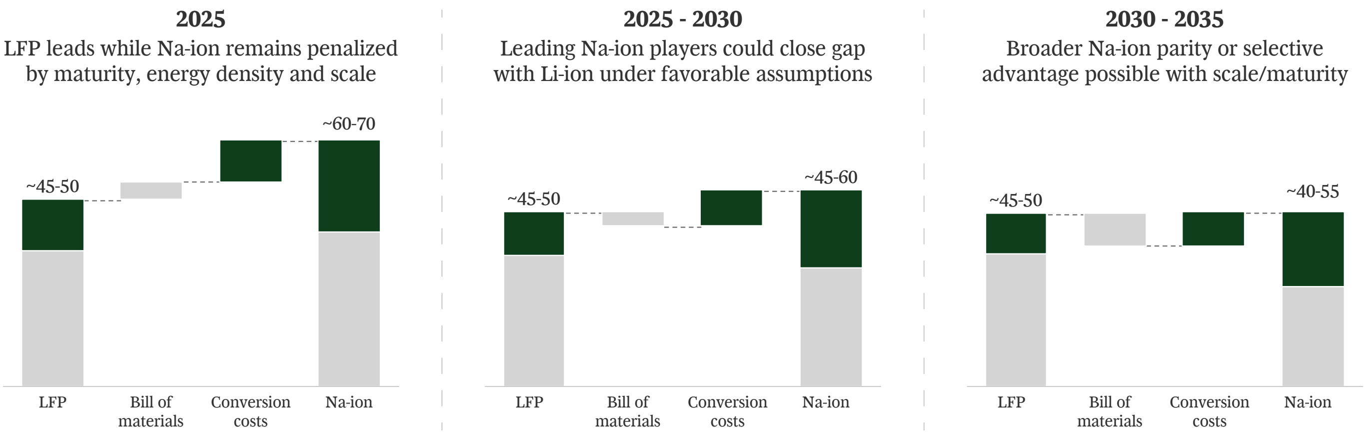
Multiple studies and industry reports find that Na-ion remains more expensive than LFP today, but could approach ~$40–60/kWh at cell level. This means it could potentially undercut LFP as manufacturing scales and energy density improves, particularly under tighter lithium or graphite supply conditions.[liv, lv, lvi, xxxiv, lvii] Based on expert inputs and BCG's own analysis, Na-ion cells sit today at roughly $60–70/kWh against ~$45-50/kWh for LFP in China — a gap that is narrowing faster than many forecasts anticipated. With specific learning curve and scale assumptions, Na-ion cell cost could fall 10-40% over the coming years (down to $45-60/kWh this decade, $40-55/kWh post 2030). Cost parity with LFP is plausible well within this decade for leading manufacturers, and likely across the broader industry after 2030 (**Exhibit 5**). Parity estimates are conditional both on lithium-carbonate prices staying high (potentially above $20k/t) and on Na-ion improving density, active-material supply (particularly hard carbon[lviii] and electrolyte[x,lix]), manufacturing yields, and scale. Some early data points suggest leading manufacturers may already be operating below this range, potentially reaching ~$50–60/kWh at cell level and with potential to reach parity in this decade[lx]. These figures are not yet representative of the broader industry. However, cell-cost parity is neither necessary nor sufficient for competitiveness. Lower energy density raises packaging and balance-of-plant costs, and weak warranty confidence can erode TCO even when the cell wins on price. The reverse holds too: a Na-ion cell that costs more than LFP can still create system value where it improves safety, extends life, tolerates temperature extremes, reduces cooling complexity, or enables higher cycling.

EXHIBIT 5

LFP cells ~30% less expensive in 2025, with Na-ion potentially reducing gap to reach cost parity by 2030-35

As of June 28th 2026

LFP vs Na-ion cell cost breakdown in China (factory costs, excl. shipping, tariffs, margin), $/kWh



- 2030-35 cost parity relies on several assumptions on industry development related to mfg. scale, energy density, lithium carbonate price outlook
- Figures reflect cell-level costs, while Na-ion system-level efficiencies and cost savings can be also part of its value proposition
- Na-ion numbers reflect an indicative blended view across chemistries, incl. polyanions and layered oxides (polyanions and layered oxides)

Bill of materials | Conversion costs

Note: According to CarNewsChina.com Leading Na-ion manufacturers reportedly achieving ~$51–59/kWh at cell level in early 2026 — below the industry average, but not yet representative of broader market pricing
Source: BCG analysis

Na-ion's favorable properties and trade-offs resolve, economically, into four levers:

- **Cell cost:** long-term upside from material substitution, conditional on scale of the supply chain, manufacturing yield and energy density (which impacts materials intensity, and manufacturing throughput and economics)
- **System cost:** the density penalty offset by wider SOH window, higher usable DoD, simpler thermal and fire mitigation, less expensive cooling systems for BESS, and structural savings for packs in vehicles (though fully exploiting wide DoD may require more complex PCS architectures, a cost that must be weighed against the system-level value of higher usable energy)
- **Operating value:** longer cycle life, fewer augmentation cycles, lower auxiliary load, faster charge and greater temperature resilience, depending on the ability to maintain high cell performance levels (e.g., RTE)
- **Risk and bankability:** warranty confidence, insurer comfort, lender and OEM-qualification acceptance — the gate between technically attractive and actually deployable.

The sections below trace where that happens, first in stationary storage and then in mobility, before sizing the total impact.

Stationary storage: Where system design changes

Stationary storage is where the levers stack most naturally. It is not a generic utility-scale LFP replacement, where cost, scale and bankability set a high bar. Instead, Na-ion enables a different system design (thermal architecture, SOC windows, dispatch and warranty logic built for the chemistry, not inherited from LFP). Three settings stand out:

1. **In cold- and hot-climate** projects, a wider cell/system operating window can reduce heating and cooling requirements, potentially enabling passive thermal architectures. This can lower the auxiliary load and thermal-management system costs. These typically comprise 5–8% of system cost today, rising as cell costs decline, with auxiliary consumption potentially exceeding 15 MWh/year per MWh of capacity in warm climates[lxi]. The potential impact can be material at utility scale[xxxii]. One leading NFPP developer and integrator claims a range of substantial cost-related benefits : ~20% lower lifetime cost than LFP, ~33% slower degradation over 20 years lifespan (less overbuild), ~90% lower cooling auxiliary load[lxiii], removing significant incident causes by design (often caused by BoP[lxiv]), reducing maintenance costs, and the potential to deliver savings of up to $75/kWh at system level on a net present value basis.[lxv]
2. **At safety-sensitive, constrained sites** (residential, C&I, urban, indoor, data-centre-adjacent, fire-code-strict) the safety case translates into risk and bankability value by easing permitting, spacing and insurance. In a small but growing number of early deployments, alternative chemistries such as redox flow batteries[lxvi] or NiZn[lxvii] were chosen over LFP on precisely these grounds, though such cases remain isolated today. In high-cycle, high-power duties (UPS, AI data centers, frequency response, ride-through) longer cycle life and wider usable DoD reduce cost per delivered MWh, lower augmentation needs and reduce the overbuild otherwise required to compensate for degradation and partial discharge. Where validated, this can improve footprint and lifetime economics at equal usable energy.
3. **Where long cycle life is validated,** Na-ion could also enable new ownership and revenue models. Leading commercial systems now claim 25-30 years at 70% SoH[20], with at least one manufacturer backing this with a 30-year product warranty explicitly designed to match wind and solar asset lifespans. However, these figures are based on accelerated testing and remain to be validated under real-world operating conditions at scale. Such durability could support zero-down leasing or storage-as-a-service models, shifting the business proposition from an upfront equipment sale toward recurring revenues tied to capacity, uptime, or customer savings.

The preferred Na-ion chemistry split remains unresolved across OEMs, with lack of clarity on real formulations making direct comparisons complex. NFPP offers an LFP-like route built around safety, cycle life, and thermal stability, while layered oxides generally prioritize density and may benefit from automotive synergies, though recent claims point at stronger safety properties and cycle-life performance. Some players are keeping optionality across both chemistries. If the strongest cost and density claims prove out, Na-ion could move beyond niche applications into the mainstream BESS segments that LFP dominates today.

20. State of Health

Mobility: Selective before broad

Mobility follows the same logic, but fewer of these advantages apply at once, making adoption more selective. Early adoption will be density-tolerant and value-specific: 12V auxiliary and start-stop batteries; 48V auxiliary and mild-hybrid systems; two/three-wheelers; low-speed and small urban vehicles; short- and mid-range passenger cars; battery-swap and cold-climate variants. These are all places where cell cost, safety, or cold performance matters more than range. In automotive, common Na/Li pack envelopes are beginning to emerge, reducing module and pack assembly friction with established Li-ion platforms. This simplifies hybrid Na/Li architectures (where sodium carries power, cold performance, and cost-sensitive range while lithium preserves energy density) and creates swap-compatible alternatives to Li-ion packs.[lxvii, lxix] Early-stage and limited HD truck pilots are also emerging in China, where Na-ion's cold-temperature resilience and safety profile have been reportedly tested successfully in logistics and freight applications[lxx]: however, heavy-duty commercial EV platforms remain more challenging because of energy-density penalties become more material at higher payload requirements. Similarly, longer-range passenger EV platforms remain most challenging targets because energy density is the decisive constraint: broad substitution is unlikely without material gains in density, cost, and field validation.

Market sizing: Real volume, limited immediate Li-Ion substitution

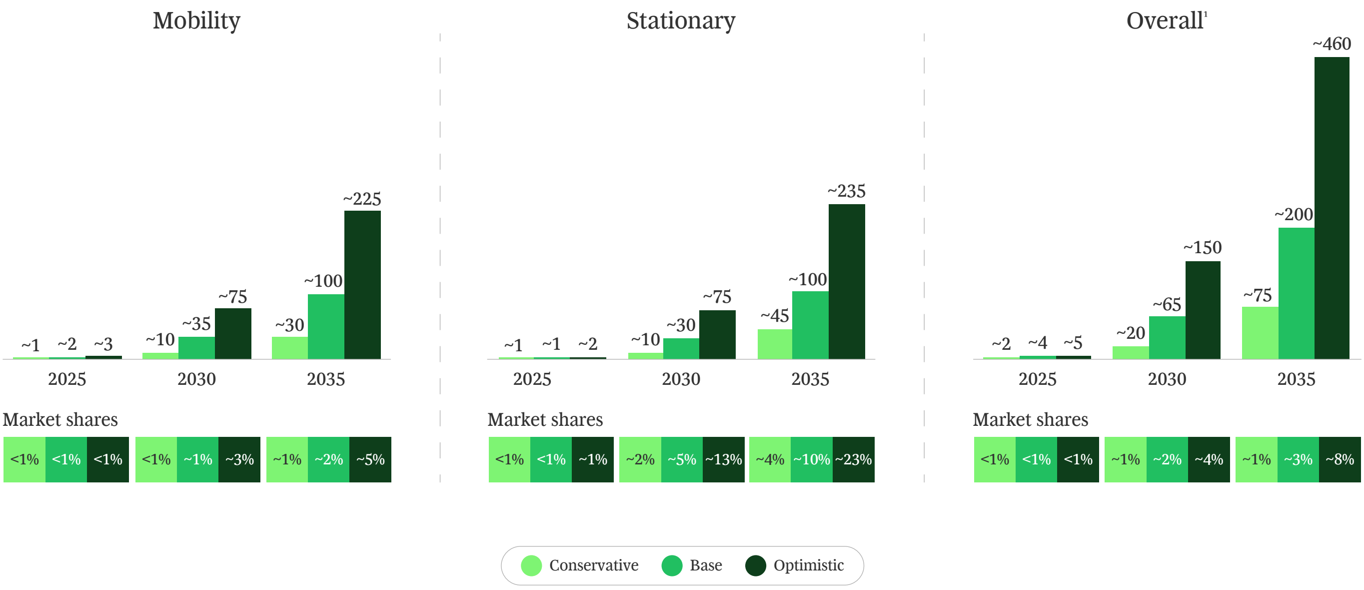
Adoption is likely to remain application-selective. BCG projects that Na-ion could reach 20-150 GWh by 2030 and 75-460 GWh by 2035 under conservative and optimistic scenarios. This represents a 64-97% 5-year CAGR, and 47-57% 10-year CAGR. Such growth is meaningful in absolute terms, but remains a minority share of total battery demand (1-4% of total battery demand in 2030 and 1-8% in 2035). By 2035, penetration of Na-ion in mobility is expected to represent 1-5% versus 4-23% for stationary applications (**Exhibit 6**). Demand remains highly uncertain, as reflected in the wide range of 2030–35 demand scenarios. The eventual outcome will depend on how quickly Na-ion delivers bankable system-level value, whether recent performance claims — particularly on energy density and cycle life — are validated at scale, and how fast its supply chain and ecosystem mature.

EXHIBIT 6

Na-ion projected to gain selective share across segments, both in stationary and mobility applications

As of June 28th 2026

Global annual Na-ion demand (GWh/yr)



Note: Illustrative scenarios reflecting different assumptions on technology evolution, cost competitiveness, and market adoption, 2025 figures estimated from sodium-ion battery shipments (~9GWh in 2025), reflecting uncertainty across scenarios on actual installations in that year vs shipped; Figures based on unconstrained supply scenario
Source: S&P; Benchmark Mineral Intelligence; BCG analysis

Battery markets can shift rapidly when an alternative chemistry proves a better market-product fit. LFP displaced NMC in stationary storage and won major EV share on lower cost, higher safety, stronger thermal behavior, and longer cycle life, even at lower energy density. It first entered via less demanding duties in Western markets before climbing toward the mainstream over the following few years. Na-ion could potentially follow a similar pattern. However, today LFP has already solved the principal cost, safety, thermal, and cycle-life challenges and built scale, bankability, and a still-improving performance frontier. The bar for Na-ion is therefore higher than the one LFP faced — it must displace a scaled, cost-competitive, bankable incumbent in a market far larger than the one LFP grew into. Matching LFP's share gains would demand a much greater absolute build of Na-ion capacities and capabilities, including materials, manufacturing, and validation, against the inertia of entrenched supply chains and qualified designs. The projections thus describe selective penetration, not large-scale substitution over the next decade.

On the supply side, third-party estimates of Na-ion's announced 2030 manufacturing capacity converge at roughly 400–600 GWh.[lxxi, lxxii, xxxii] This represents real momentum, but a small fraction of Li-ion's ~6 TWh committed capacity pipeline. More than 95% of the Na-ion pipeline is concentrated in China. So far only ~9 GWh of cells were shipped in 2025, up from 3–4 GWh in 2024, according to industry reports [lxxiii], likely reflecting a mix of qualification volumes, pilot deployments, early commercial orders and some inventory build-up, rather than fully mature end-market demand. Manufacturing adjacency may allow Na-ion to scale faster by leveraging existing Li-ion equipment and know-how, although the conversion is not frictionless.

Implication

Na-ion's adoption will progress in stages. Cell economics still trail LFP, system-level economics await field validation, and energy-density limits favor layered, application-by-application entry. Na-ion's chemistry creates real options. But how much value those options unlock depends on system design, application fit, and whether insurers and project financiers develop the confidence to underwrite it. Broad Li-ion substitution within the next decade is unlikely given cost, density, and bankability trajectories today. Chapter 4 examines the industrial conditions that must hold for Na-ion to scale.

4. Necessary conditions for Na-ion to scale

Na-ion's next constraint is increasingly about scale-up and execution, and less about fundamental R&D. Reaching meaningful share of the battery demand means the whole ecosystem must mature in parallel: materials, manufacturing, design, field data, warranties, and financing. Four conditions must be in place for this to happen.

The product and its manufacturing must be cost competitive. Sodium abundance is just the starting point. Na-ion has to win on cost and performance at the cell or system level. It has the potential to do so through: scaled, diversified supply of battery-grade hard carbon, electrolyte salts and cathodes, higher energy density, Na-ion native system design, and manufacturing that reaches LFP-grade yield and quality. Process adjacency to Li-ion helps, but does not deliver this on its own.

Chemistry must overcome an entrenched and still-improving incumbent. Na-ion is chasing a moving target. LFP continues to improve on manufacturing efficiency, energy density and fast charging. LMFP is advancing. And cell-to-pack architectures keep reducing system costs, helping preserve LFP's bankability and cost competitiveness despite recent and potentially sustained raw-material cost increases, including LCE. Li-ion also benefits from a deeply established value chain, with hundreds of billions of dollars already invested across mining, refining, cell manufacturing, and gigafactories globally (though overwhelmingly in China), and substantially more capital still to come. Na-ion must therefore scale quickly in applications where its differentiated attributes genuinely matter. It is competing not only against an improving cell chemistry, but against an industrial ecosystem that is already built, optimized, and increasingly difficult to displace.

Trust must be earned, and that takes time. Its strongest claims (cycle life, safety, thermal and low-temperature performance) need long-term independent field data validation across real duty cycles before OEMs qualify Na-ion and insurers and lenders finance it at an acceptable cost of capital. Locked-in commitments also lengthen the lag time to adopt a new chemistry. Once a cell is designed into a platform or project it is qualified, contracted, and warranted for years, so switching windows are infrequent and cycles long. Common enclosures and form factors with LFP are already emerging in stationary storage. In mobility, swap-compatible pack designs and dual-chemistry architectures pairing sodium and lithium cells within a shared envelope serve the same purpose. Both reduce integration friction and compress at least the mechanical qualification cycle, without requiring full re-engineering or re-certification of existing platforms. Bankability does not transfer from LFP, however. Na-ion can borrow Li-ion's process learning, but not its operating history.

Policy must be conducive. Against an incumbent this entrenched, neutral market conditions may favor Li-ion by default, so Na-ion's scale-up outside China depends on policy that actively makes room for the alternative chemistry. Such favorable policies may include research grants and R&D co-funding, scale-up subsidies and incentives for pilots and FOAK[21], stable demand signals, local-content rules and origin incentives, public procurement, and funded standards, testing and certification. Early policy momentum in the EU[lxxiv] and US[lxxv] is tangible but, understandably at this stage of maturity, modest relative to the broader Li-ion support ecosystem. Without that orchestration, a Na-ion that looks competitive and bankable on paper can still stall, because the marginal buyer has little reason to choose it over a cheaper, proven, fully financed Li-ion system.

Na-ion's path forward will vary by geography. In China, manufacturing, integration, qualification, and deployment can move quickly on the existing Li-ion battery base. Elsewhere worldwide the binding constraint is less feasibility than the absence of a full bankability stack, in addition to a mature supply chain — spanning upstream supply (materials, equipment, suppliers), project delivery (integrators, standards, certification), and commercial confidence (warranties, insurers, and financing). Early projects matter as data-generating assets that shape degradation curves, safety cases, and lender confidence. Na-ion's scale-up turns on whether the ecosystem can convert promising chemistry into repeatable, financeable, cost-competitive systems.

21. First-of-a-Kind

5. What stakeholders should do now

Na-ion is a strategic opening for markets diversifying battery supply chains. But outside China the prize is partial resilience, not independence, won only if capabilities are built early. The posture should be selective anticipation: move early where Na-ion can materially improve system performance or costs, but avoid broad bets where LFP or NMC can remain structurally ahead.

- **Utilities, BESS developers, IPPs and C&I energy users should build bankability through targeted pilots:** Safety-sensitive or space-constrained sites, climate extremes, passive-cooling designs, and high-cycle duties where Na-ion can demonstrate differentiated system value should be prioritized.

- **System integrators and EPCs should design around Na-ion, not copy LFP:** Thermal architecture, fire strategy, BMS/EMS logic, PCS design, augmentation, O&M, and warranties must reflect Na-ion operating characteristics.

- **Na-ion startups outside China should focus on differentiated entry points and routes to scale:** They should establish depth in one or two applications where incumbents have structural disadvantages, pursue public co-funding and early offtake anchors, and seek industrial partnerships or consolidation. The competitive bar is high given the scale, capital, and momentum already assembled by the Chinese incumbent giants.

- **Ex-China incumbent cell producers should keep Na-ion under active assessment:** LFP will likely continue dominating mass-market applications, but Na-ion could matter in localized BESS and resilience-driven niches. An acceleration scenario is plausible, but ex-China adoption will run on longer cycles given bankability challenges. The priority now is monitoring, selective partnerships and qualification work to preserve the option to scale.

- **Automotive OEMs should preserve optionality as future platforms are defined:** They should selectively qualify Na-ion for auxiliary and start-stop batteries, density-tolerant urban vehicles, cold-climate variants, and dual-chemistry architectures.

- **Financiers, insurers and testing bodies should build the bankability layer:** This includes degradation models, safety tests, warranty templates, O&M standards, and lender protocols. Cost of capital can shape competitiveness as much as cell cost.

- **Governments and policy-makers could focus on enabling the broader Na-ion ecosystem:** They could help to scale hard carbon, electrolyte salts, cathodes, test labs, safety standards, certification and early deployment support.

A caution on Na-ion for governments and policy-makers around the globe:

- **The prize is industrial leadership, not a cheaper cell:** Na-ion is a chance to build a position in a strategic industry, not just to adopt a battery.

- **The window for policy intervention may be short:** China already leads early Na-ion technology development, supply-chain scale-up, and market deployment, much as it has come to dominate LFP. Waiting for the technology to mature before acting risks arriving too late to shape the domestic ecosystem or capture industrial value.

- **Outside China, the industry rests more on startups than Li-ion incumbents:** Focused challengers are pushing Na-ion toward industrialization, while larger diversified players treat it as one option among several. Without access to capital, industrial partnerships and public procurement anchors, these startups may scale slowly or not at all, with the window to build a competitive domestic position closing fast.

- **Aim for resilience, not independence:** Equipment, know-how, and IP remain concentrated, so the realistic prize is reduced exposure, not full autonomy. Capturing it will depend on deliberate policy design, including local-content and origin-based incentives such as those emerging in the EU, the US, and India.

The common thread is timing. Na-ion's economics and chemistry are not yet settled — but the players and regions that build data, standards, and supply-chain positions now are the ones best placed to own the industry when it scales.

6. Closing note: from signal to scale

Sodium-ion has moved from credible chemistry to commercial reality. New product launches, manufacturing lines, deployments, and offtake agreements are accumulating, and the pace of announcements and commercial progress in 2025-26 alone signals that the industry is entering a new phase. Cell economics and bankability still lag LFP, but these are industrialization challenges, not fundamental limits — and they are being addressed, progressively, through supply chain and manufacturing scale, field data and ecosystem development. The most plausible destination is a meaningful and growing role in an increasingly multi-chemistry battery mix, with Na-ion gaining ground through specialization, where system-level economics, application fit and operating context make the case that a single incumbent chemistry cannot. The industry will not resolve uniformly or simultaneously. China starts from a position of substantial advantage, built on its LFP industrial base, integrated supply chains, and the scale and momentum of its leading players. Some applications will tip before others, and bankability will be built project by project. How large Na-ion's role ultimately becomes, and who captures it, will depend on execution and timing: the leading positions are already being built.

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Acknowledgements:

We would like to thank Thomas Weber (Managing Director & Partner, Paris) · Minjee Kim (Managing Director & Partner, Seoul) · Alex Xie (Managing Director & Senior Partner, Beijing) · Eric Li (Managing Director & Partner, Beijing) for their valuable guidance and contribution in shaping this paper.

Note: This report is based on public-domain information available as of **28th June 2026.** Information published after this date has not been incorporated, and subsequent developments in sodium-ion batteries may impact the conclusions, claims, or market outlook presented herein.

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