Batteries in Transition

Innovation, Uncertainty, and the Minerals Behind Them

GREENPEACE

Batteries in Transition

Innovation, Uncertainty, and the Minerals Behind Them

November 11th 2025

Cover image © Jung-geun Augustine Park / Greenpeace

THE ROLE OF BATTERIES

In the energy transition batteries are more than simply technology - they represent change. They are essential for clearer skies, cleaner streets, and a world less reliant on fossil fuels. From the cars we drive to the power grids that light our homes, batteries are at the centre of one of humanity's biggest shifts - the move toward the storage and use of clean energy.

The technologies and materials that power our devices, vehicles, and homes have been changing and improving faster than even experts expected. Each breakthrough opens new possibilities but also raises important questions: Which materials will we rely on? Can innovation reduce our dependence on the extraction of raw materials? Can we ensure progress benefits communities endowed with these materials and protects nature instead of harming them?

In recent years, the pace of change in battery technologies has accelerated considerably. New types of battery chemistries remove the need for different so-called 'critical minerals' whose extraction is commonly associated with major environmental and social impacts. The use of lithium iron phosphate (LFP) batteries (which use neither nickel nor cobalt) has increased dramatically for both electric vehicles and energy storage systems. Other options like sodium-ion (which do not use lithium) are beginning to appear in the market, while "solid-state" batteries and other battery types using different materials yet again are on the horizon.

The journey ahead is more than a race to create better batteries; it's a collective choice about the future we want. It's a future where technology, fairness, and responsibility must work together. Which technologies we invest in today plays an important part in shaping an energy transition that provides the energy we need but also protects critical ecosystems and the hope for a greener, more just future.

WHERE WE ARE IN 2025

Electric car LFP batteries have become mainstream (Figure 1a, Figure 2), especially in China.[1] The recent rapid growth in LFP use far exceeded what was predicted just a few years before, and has caused significant shifts in forecasting the mix of batteries that will be used in the coming years. For example, in 2021 the IEA predicted that approximately 10% of electric Light Duty Vehicles (LDVs) would use LFP batteries by 2040[2] but they subsequently reported that just one year later LFP batteries already made up 27% of LDV battery capacity[3].

---

[1] Global Critical Minerals Outlook 2025, p. 55 (IEA, 2025)
[2] The Role of Critical Minerals in Clean Energy Transitions (IEA, 2021)
[3] Trends in Batteries (IEA, 2023)

For grid energy storage, LFP is already the default chemistry, again having grown rapidly in the last 5 years (Figure 3). Industry values its lower cost and safety advantages.[4]

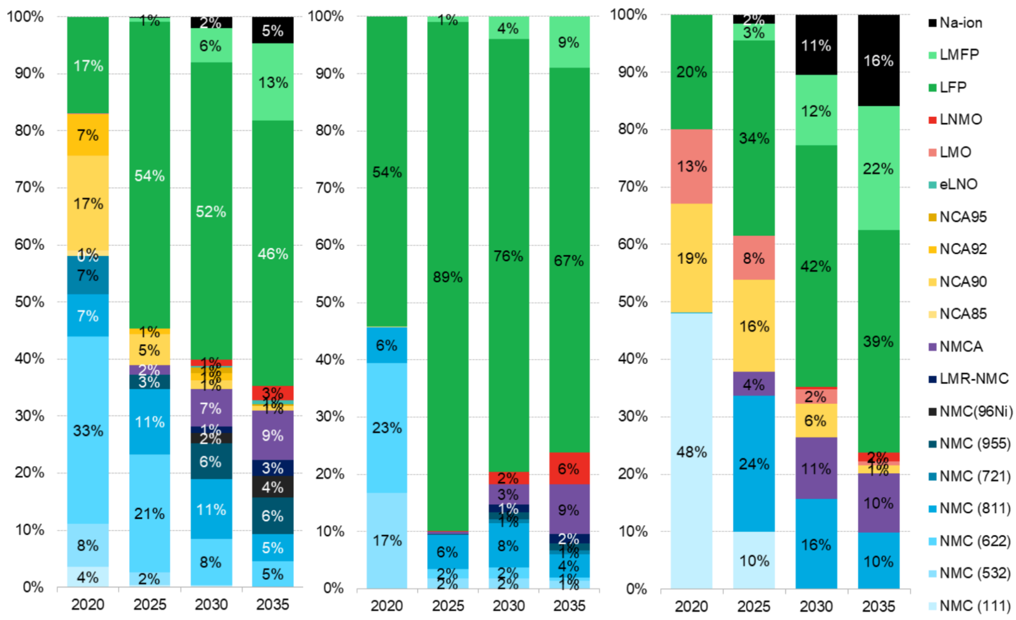

Figure 1: Evolution of global cathode chemistry mix across (a) all passenger electric vehicles, (b) commercial electric vehicles, (c) two- and three-wheeled electric vehicles

Source: BloombergNEF, 2025; Electric Vehicle Outlook 2025, Figures 205, 208, 211.[5] Note: Na-ion refers to sodium-ion; LMFP is lithium manganese iron phosphate; LFP is lithium iron phosphate; LNMO is lithium nickel manganese oxide; LMO is lithium manganese oxide; LNO is lithium nickel oxide; NCA is nickel cobalt aluminum oxide; NMCA is nickel manganese cobalt aluminum oxide; LMR is lithium- and manganese-rich; NMC is nickel manganese cobalt oxide.

FORECASTS FOR 2035

Analysts expect rapid market growth in both electric vehicles (EVs) and energy storage batteries through 2035.[6] But what the exact future mix of different battery types will be is uncertain.

LFP use is expected to continue to expand in mass-market cars and in nearly all energy storage systems (Figures 1, 2, and 3).

[4] Batteries and Secure Energy Transitions (IEA, 2023)
[5] BNEF Electric Vehicle Outlook 2025, Figures 205, 208, 211 (BNEF, 2025)
[6] IEA Critical Minerals Data Explorer, accessed Aug 19, 2025 / Demand by Technology (IEA, 2025)

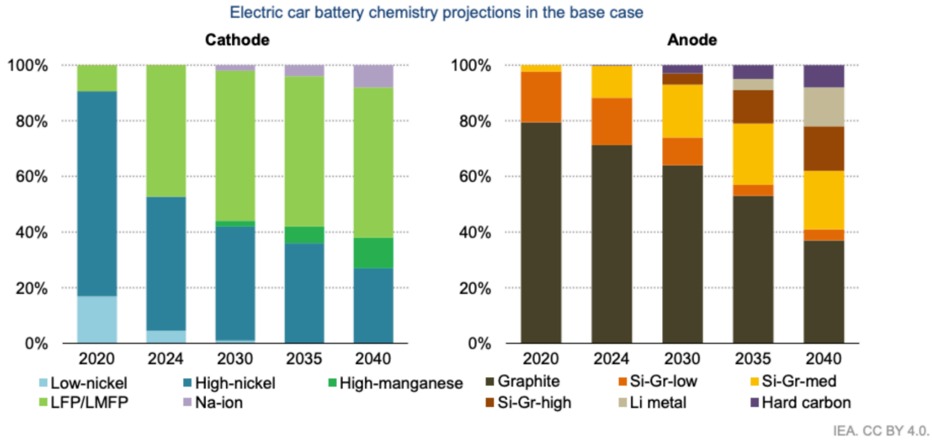

Figure 2: IEA's electric car battery chemistry projections in the base case for cathodes (left) and anodes (right)

Source: IEA, 2025; Critical Minerals Outlook 2025, License: CC BY 4.0. Page 208.[7] Notes: LFP is lithium iron phosphate; EV is electric vehicle; LMFP is lithium manganese iron phosphate; Na-ion is sodium-ion. Low-nickel includes: NMC333 and NMC532 (NMC is lithium nickel manganese cobalt oxide). High-nickel includes: NMC622, NMC721, NMC811, lithium nickel cobalt aluminium oxide (NCA), lithium nickel manganese cobalt aluminium oxide (NMCA), lithium nickel oxide (LNO). High-manganese includes lithium nickel manganese oxide (LNMO) and lithium-manganese-rich NMC (LMR-NMC). Si-Gr is silicon-doped graphite. Si-Gr-low refers to 5% silicon content, Si-Gr-med = 5-50% and Si-Gr-high > 50%.

Sodium-ion batteries, which do not require lithium, are emerging on the market.[8] Due to concerns of supply constraints for lithium in coming decades[9] and the significant environmental and social impacts associated with lithium mining,[10] sodium-ion is one to watch. Sodium-ion battery energy density has been increasing and is reported to be becoming close to that of LFPs.[11] If costs fall as expected, it could take a visible share by the 2030s.[12] For example, 'aggressive sodium-ion' scenarios project that this battery type could take up 40% of passenger EV sales in 2035.[13] Other non-lithium batteries, such as redox flow, could also play a key role for stationary storage.

[7] Global Critical Minerals Outlook 2025 (IEA, 2025)
[8] China's CATL launches new sodium-ion battery brand (Reuters, 2025); Volkswagen-backed JAC Yiwei EV powered by sodium-ion battery starts mass production in China (Car News China, 2025)
[9] Global Critical Minerals Outlook 2025 (IEA, 2025)
[10] Dry Andes more sensitive to lithium mining than previously thought – study (Mining.com, 2024); Contemporary and relic waters strongly decoupled in arid alpine environments, PLOS Water (Moran et al., 2024); Lithium mining is slowly sinking Chile's Atacama salt flat, study shows (Reuters, 2024)
[11] Mine to Grid: Sodium ion (Benchmark Mineral Intelligence, Feb 26, 2025); BNEF Electric Vehicle Outlook 2023 (BNEF, 2023)
[12] Sodium ion Batteries: Hype vs Reality on the Road to Commercialisation Webinar (Benchmark Mineral Intelligence, Aug 19, 2025)
[13] BNEF Electric Vehicle Outlook 2023 (BNEF, 2023) "aggressive sodium-ion" scenario, which ramps to 40% of passenger EV battery sales from sodium-ion by 2035 (Figure 230 & Figure 231)

Solid-state batteries remain a wildcard. Automakers have promised models before 2030, but many experts doubt large-scale rollout by that time.[14]

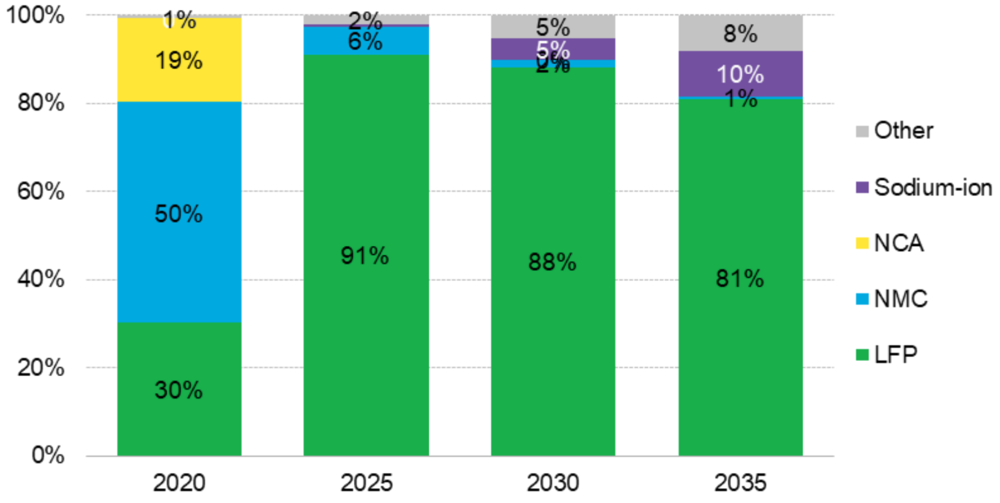

Figure 3: Lithium-Ion batteries dominate the energy storage market

Source: BloombergNEF, 2025; 1H 2025 Energy Storage Market Outlook; Global Energy Storage Growth Upheld by New Markets.[15] Note: ‘Other’ represents capacity built for ‘Other’ applications in BNEF’s Energy Storage Market Outlook, which include long-duration energy storage (LDES). Within LDES, energy storage technologies other than lithium-ion and sodium-ion batteries will play a role; BNEF has not forecast a further breakdown due to uncertainty around commercial scale-up across the many technologies in that group. NCA, NMC, and LFP refer to lithium-ion battery chemistries. NCA is lithium nickel cobalt aluminum oxide, NMC is lithium nickel manganese cobalt oxide and LFP is lithium iron phosphate.

---

[14] Will 2027 be the year of the solid-state electric vehicle battery? (Benchmark Mineral Intelligence, Feb 19, 2025)

[15] 1H 2025 Energy Storage Market Outlook (BNEF, 2025); Global Energy Storage Growth Upheld by New Markets (BNEF, 2025)

WHY THIS MATTERS FOR MINERALS DEMAND, PEOPLE, AND OUR ENVIRONMENT

Different battery chemistries rely on different minerals (Figure 4), and that shapes demand for mining.

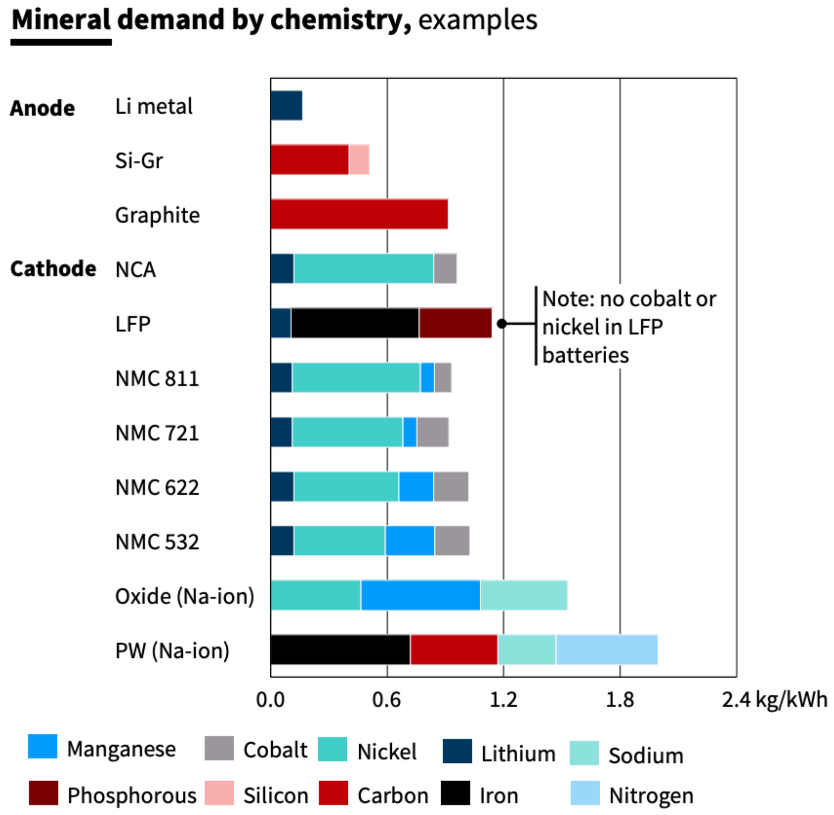

Figure 4: Mineral demand by battery chemistry examples

Source: RMI, 2024; The Battery Mineral Loop.[16] Note on groups: Nickel-based (NMC 111, NMC 532, NMC 622,, NMCA, NCA 85, NCA 90, LMO, LNMO, LCO), Novel nickel-based (NMC 955, NMC 811, NMC 721, NMC 96Ni, LMRNMC, NCA 92, NCA 95, eLNO), LFP (LFP), Novel LFP (LMFP), Sodium-based (Na-ion). Original Source Cited: BNEF Long-Term Electric Vehicle Outlook (2024), IEA Global EV Outlook (2024), RMI analysis. Includes all sectors of battery demand.

Nickel and cobalt: If LFP and sodium-ion batteries grow faster, future demand for these minerals could be significantly lower than forecasts suggested just a few years ago.

Lithium: If sodium-ion emerges as a major chemistry, demand for lithium will be reduced.

[16] The Battery Mineral Loop (Rocky Mountain Institute, 2024)

This uncertainty makes it hard to predict how much of these minerals will be needed, and whether (and to what extent) mining will be needed. Mining has major social and environmental costs, and has very long timelines. Could it be possible the world is taking unnecessary risks, and investing in resources today that it won't need in a decade as technologies change?

> This uncertainty also highlights the importance of scaling up circularity and recycling, and investing in less mineral-intensive alternatives for mobility and energy storage, while ensuring the protection of people and ecosystems.[17]

Image: A scene on the River Lukenie in the Democratic Republic of the Congo. The DRC's rainforests are critical for its inhabitants, who depend upon the rainforests to provide essential food, medicine, and other non-timber products, along with energy and building materials.
© Greenpeace / Kate Davison

[17] CRITICAL TRANSITIONS. Circularity, equity, and responsibility in the quest for energy transition minerals (UN Environment Programme, 2024)

CONCLUSION

One thing is certain: the world will need more batteries to decarbonise our energy and mobility systems. But which minerals will be most in demand, and where the pressure on communities and ecosystems will fall, depends on how quickly different battery types scale up.

For policymakers, campaigners, and communities, the lesson is clear: battery chemistries matter. Supporting recycling, and investing in less mineral-intensive alternatives are essential.

The battery story is still being written, and choices made today will shape its impact on both people and the planet.