The power within: Understanding the switch from nickel manganese cobalt to iron phosphate for grid storage applications

Shawn Wasim, Principal Researcher, Stationary Energy Storage

Rachel Buckley, Vice President of Product Strategy

Webinar

E Source

POWERING WHAT'S **NEXT**

Thursday, March 28, 2024

We understand utilities because we've made them our business for more than 35 years.

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Applying predictive data science to help electric and gas utilities make data-driven decisions that improve their bottom line and increase customer satisfaction

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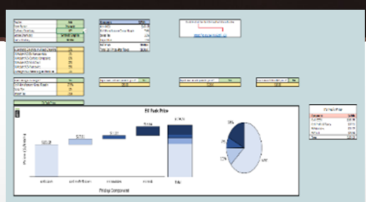
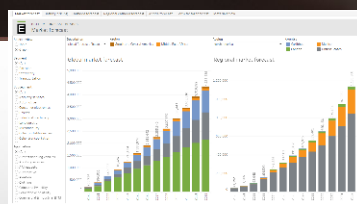
E Source Battery Next

A powerful forecasting and analytics service to help you understand the evolving energy storage landscape



Battery cost model

Improve your understanding of current battery costs, determine pricing sensitivity to key materials inputs such as lithium, and create your own battery price forecasts for the coming decade.



Battery market forecast databases

Receive our forecasts of:

- Battery pricing
- Battery technology adoption
- Battery demand
- Personal and commercial EV production
- Battery production capacity

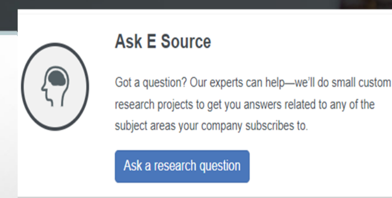
ESS economic models

Access our technoeconomic energy storage system (ESS) models, including:

- Levelized cost of storage (LCOS) model
- Behind-the-meter battery ROI calculator
- ESS project cost model

Quarterly reports

Learn what's happening across the battery value chain and how it will impact the battery technologies and battery prices available to you.



Research and Advisory support

Take advantage of the knowledge from E Source experts by asking questions through the Ask E Source program. Scheduling calls with our analysts to help answer your battery-related questions.

Today's speakers

Rachel Buckley

Vice President of Product Strategy
E Source

Shawn Wasim

Principal Researcher, Stationary Energy Storage
E Source

Live chat Q&A

Ben Campbell

Research Manager, Energy Storage
E Source

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Today we'll cover:

- The shift from nickel manganese cobalt (NMC) to iron phosphate (LFP)
- Battery 101
- Performance characteristics of LFP versus NMC
- Material availability
- Cell costs

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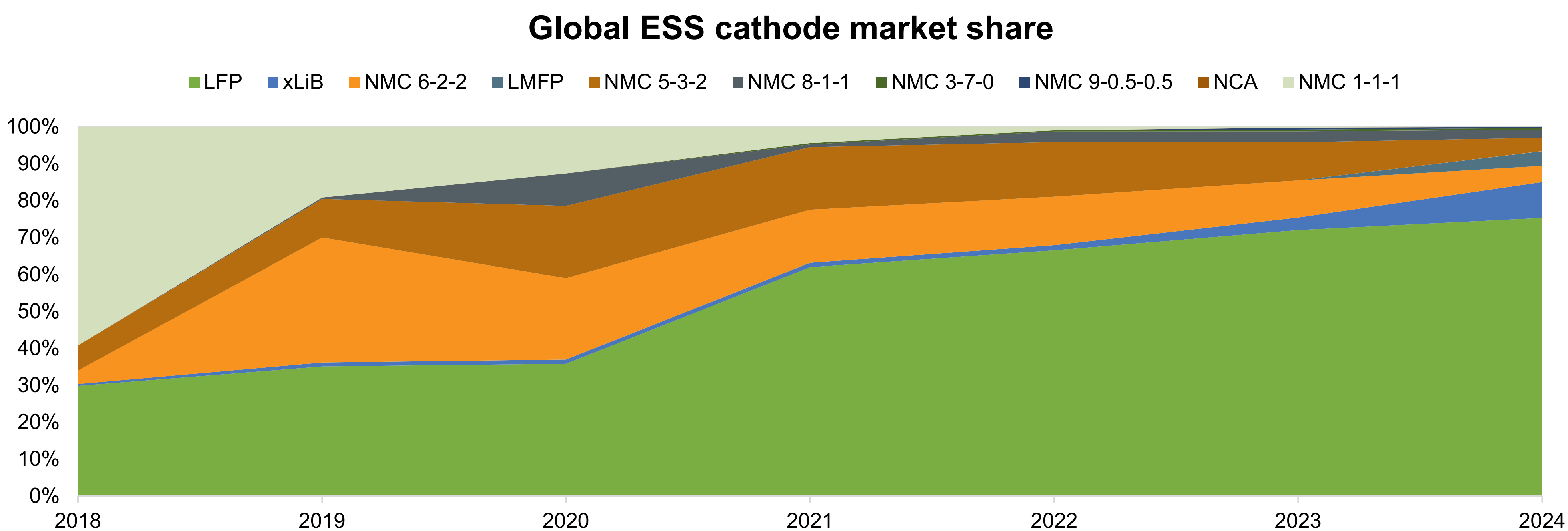
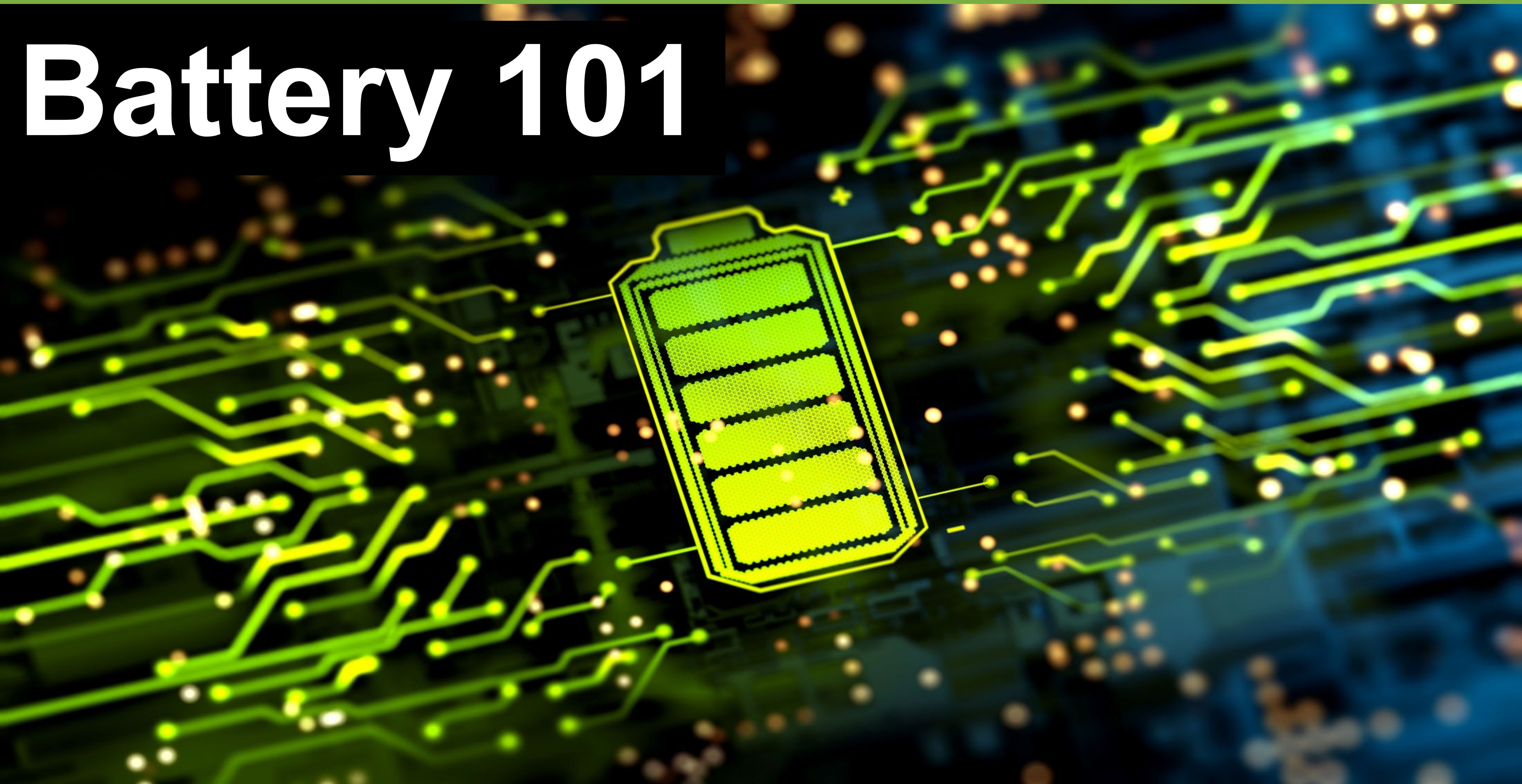
What materials are we using for stationary storage?



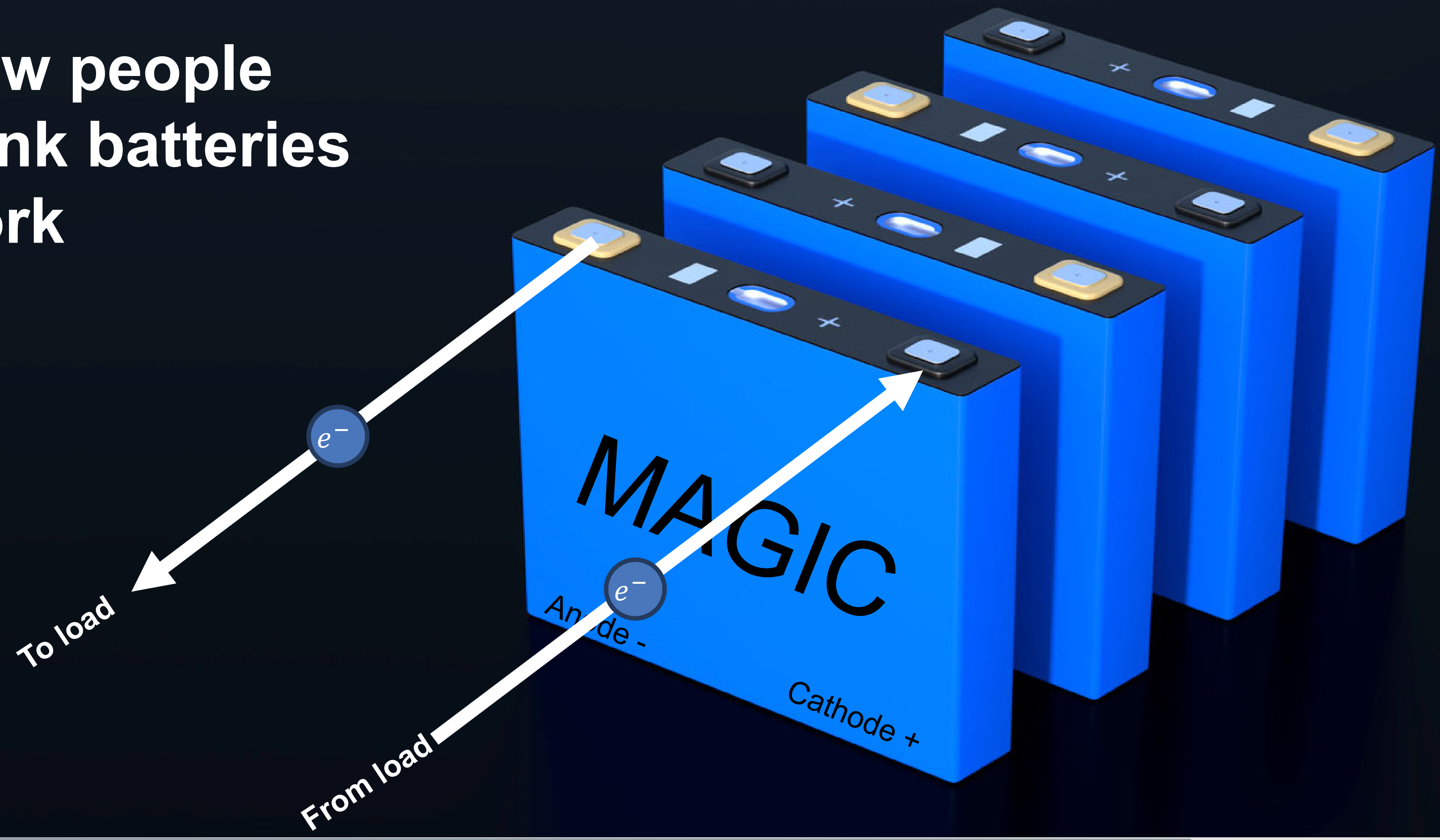
© E Source. **Notes:** LFP = iron phosphate; NMC = nickel manganese cobalt.

LFP has become the dominant chemistry for ESS applications.

Battery 101



How people think batteries work



Building blocks of a cell

	Anode	Cathode
NMC	Lithium, Carbon $LiC_6 = C_6 + Li^+ + e^-$	Metal $NiMnCoO_2 + Li^+ + e^- = LiNiMnCoO_2$
LFP	$LiC_6 = C_6 + Li^+ + e^-$	$FePO_4 + Li^+ + e^- = LiFePO_4$

What does this even mean?

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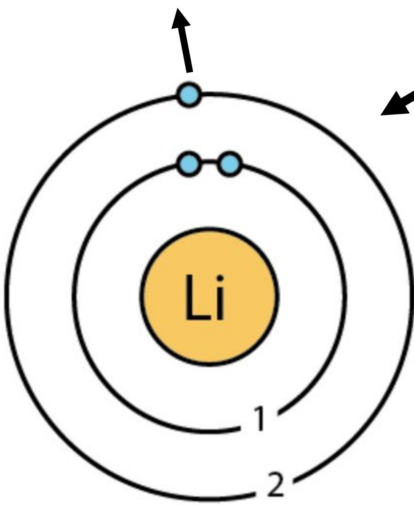
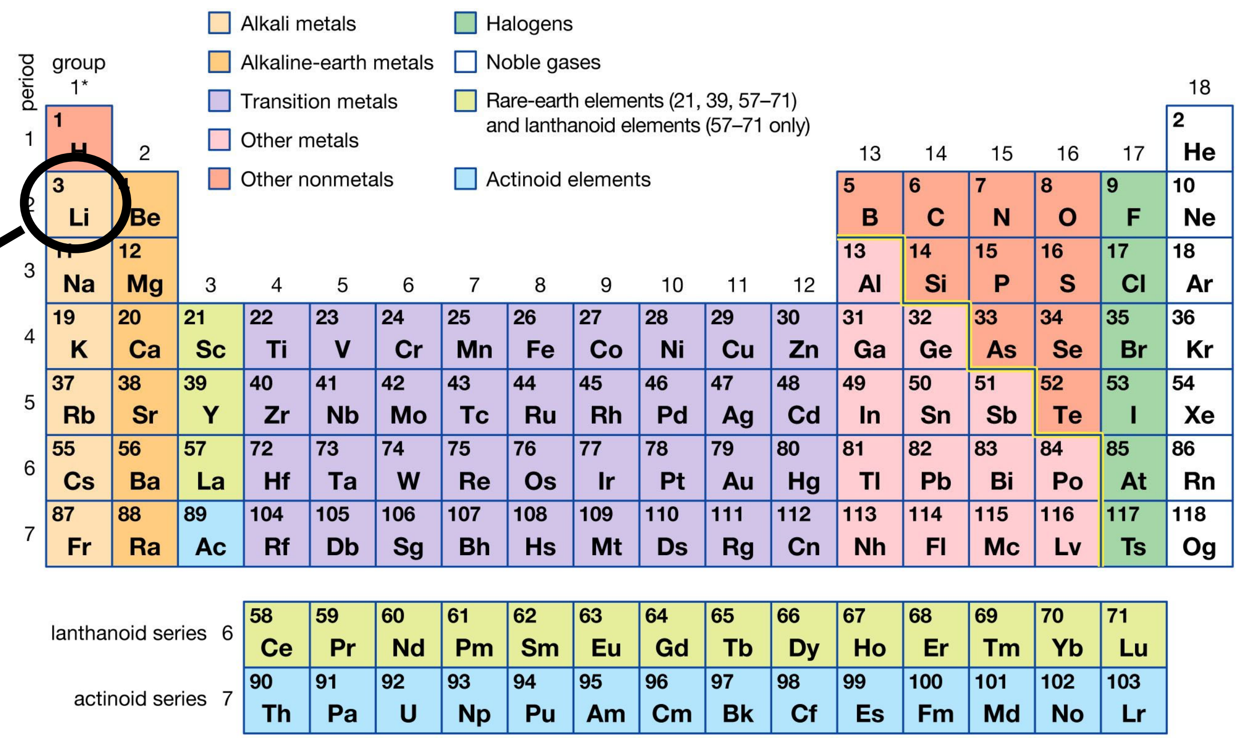
Lithium (Li)

One outer electron on the outside is unstable.



Source: https://images.app.goo.gl/4eDkZQxTMJcdMT8MA

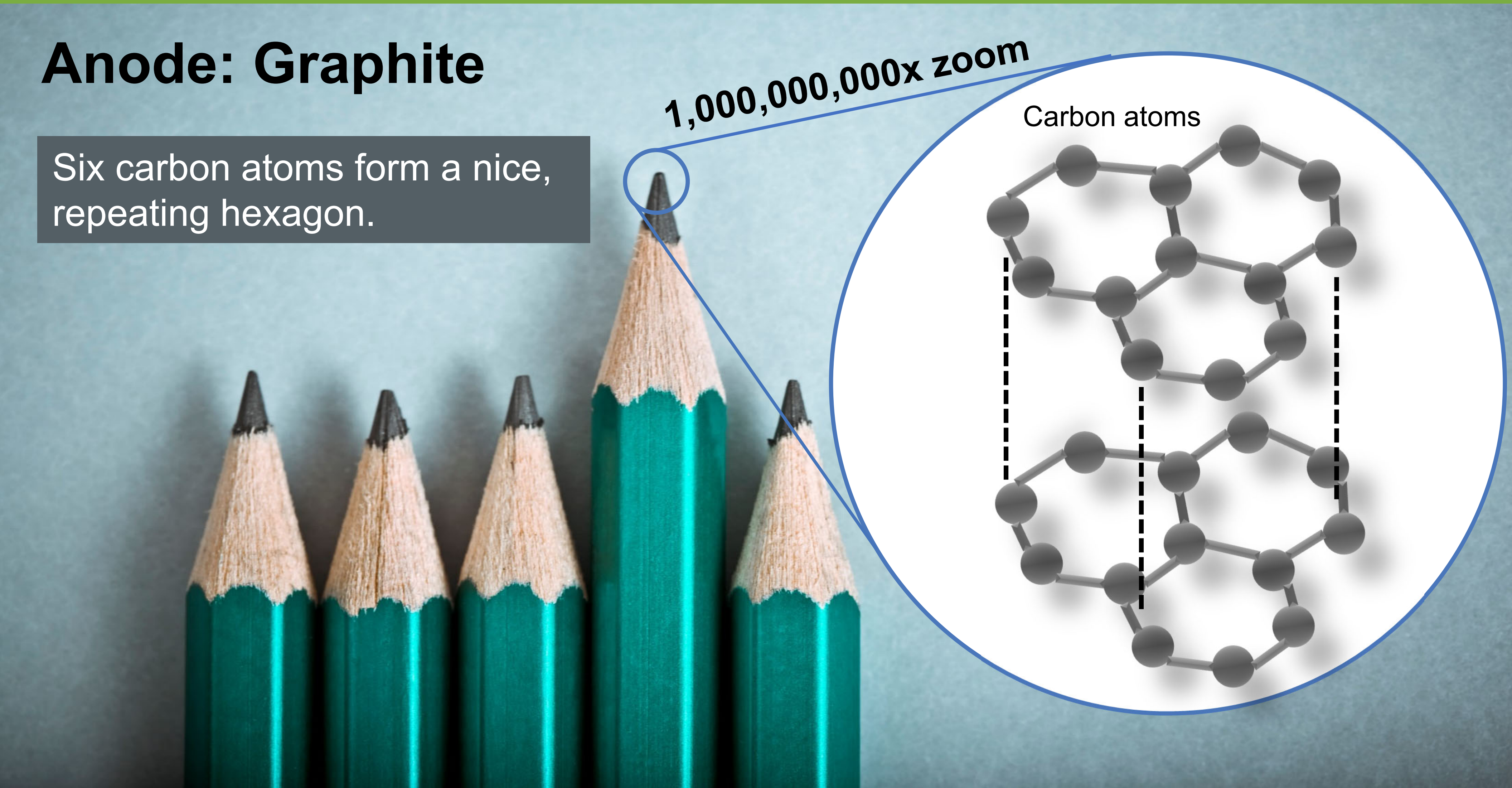
Periodic table of the elements



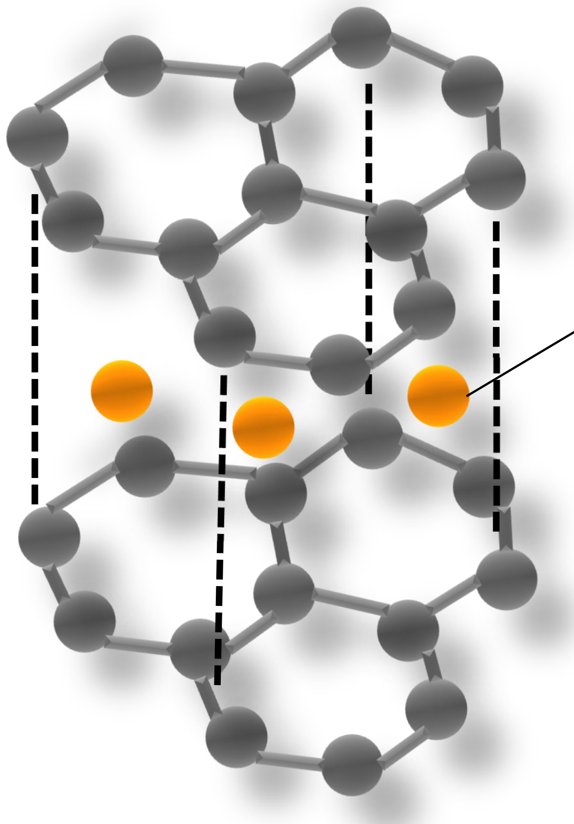
*Numbering system adopted by the International Union of Pure and Applied Chemistry (IUPAC).

Anode: Graphite

Six carbon atoms form a nice, repeating hexagon.

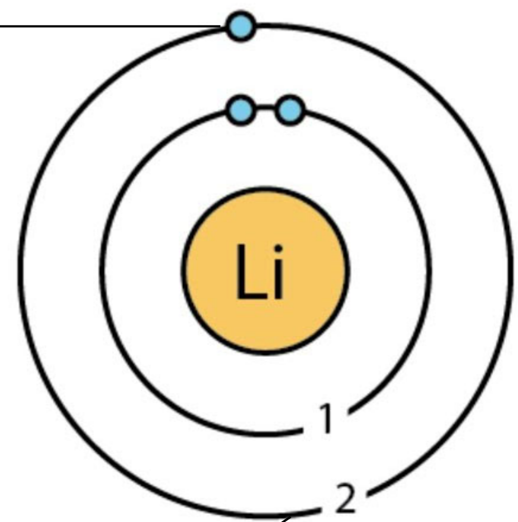


Anode: Graphite



Intercalated Li gets a pathway when a wire to a load is connected. The electron jumps.

$$LiC_6 = C_6 + Li^+ + e^-$$

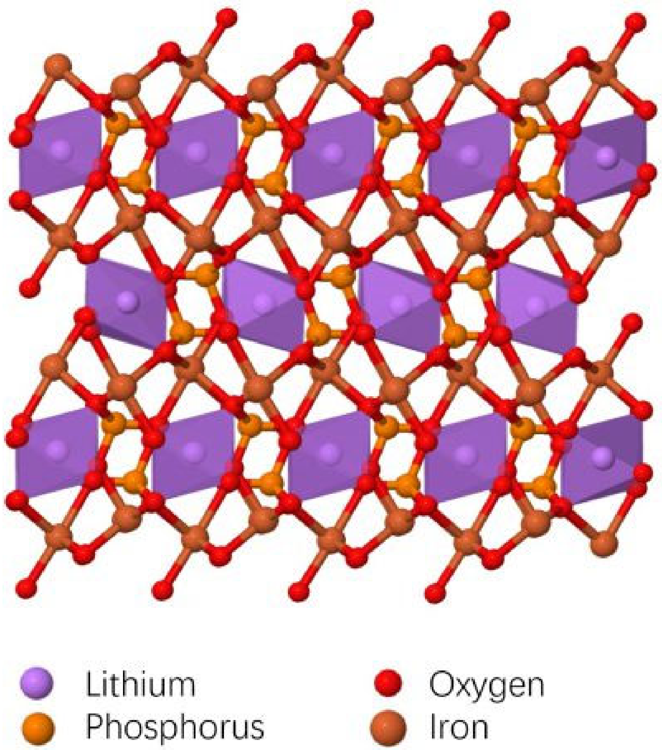


Source: https://images.app.goo.gl/4eDkZQxTMJcdMT8MA

Li becomes an ion.

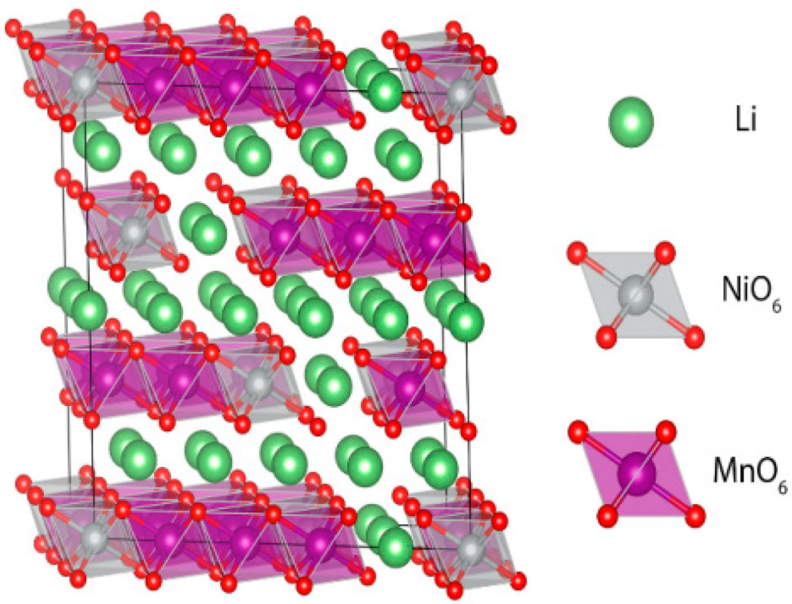
At full charge, Li sits within the graphite.

Cathode: LFP or NMC



Source: Lithium Iron Phosphate-LiFePO4 (chemtube3d.com)

The lithium ion settles in comfortably

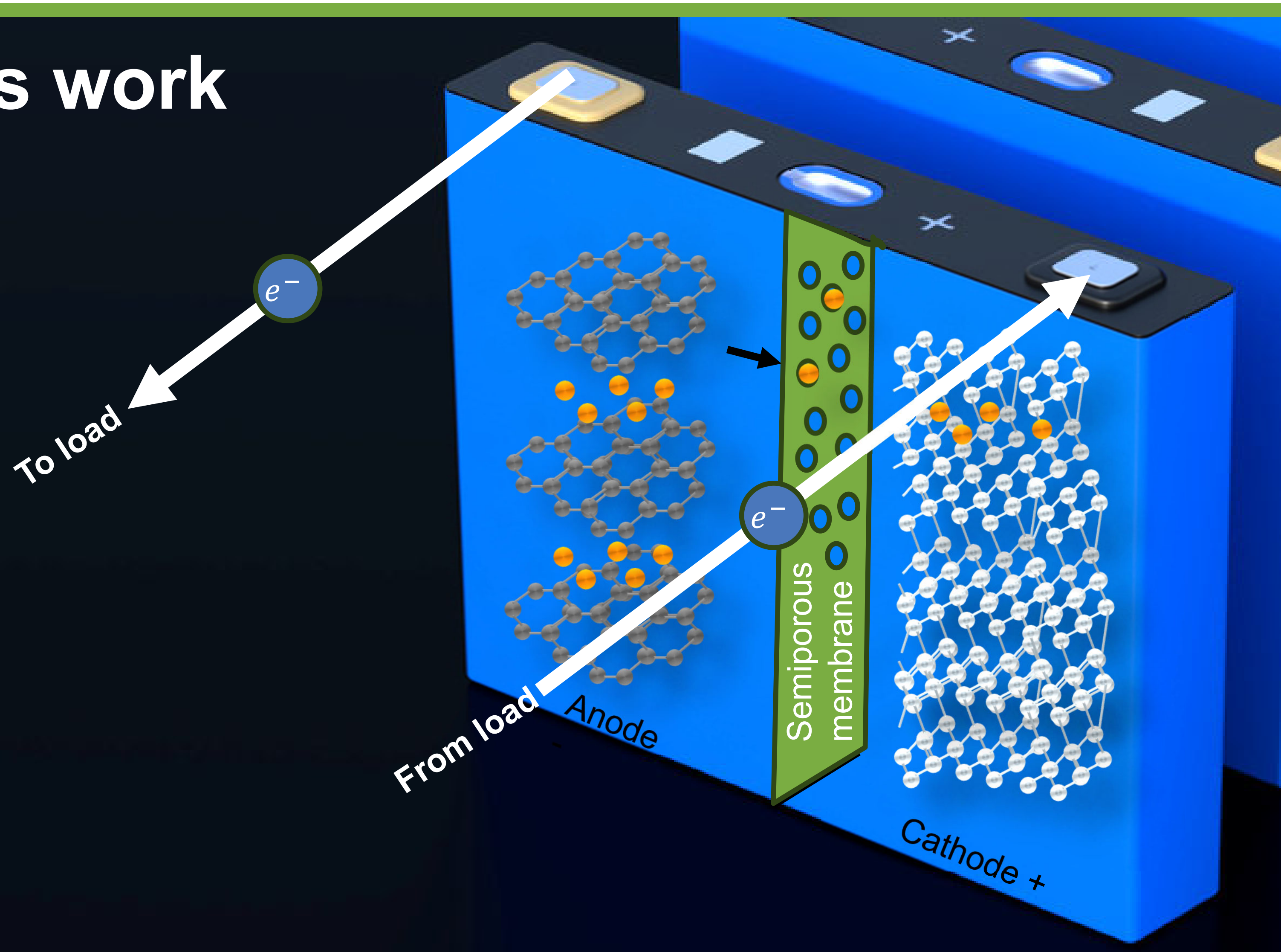


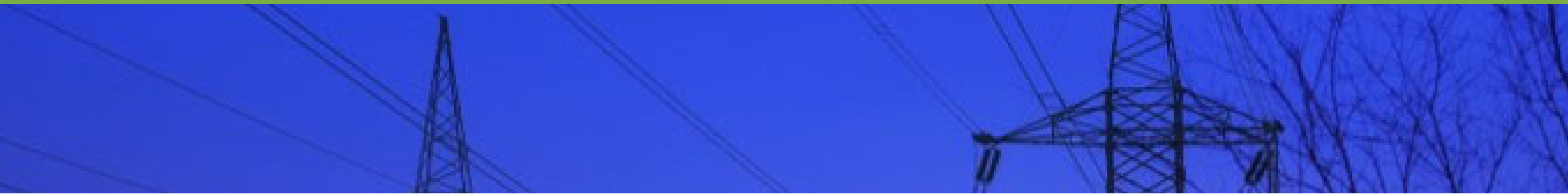
Source: Energies | Free Full-Text | Lithium-Rich Cobalt-Free Manganese-Based Layered Cathode Materials for Li-Ion Batteries: Suppressing the Voltage Fading (mdpi.com)

How batteries work

During Discharge

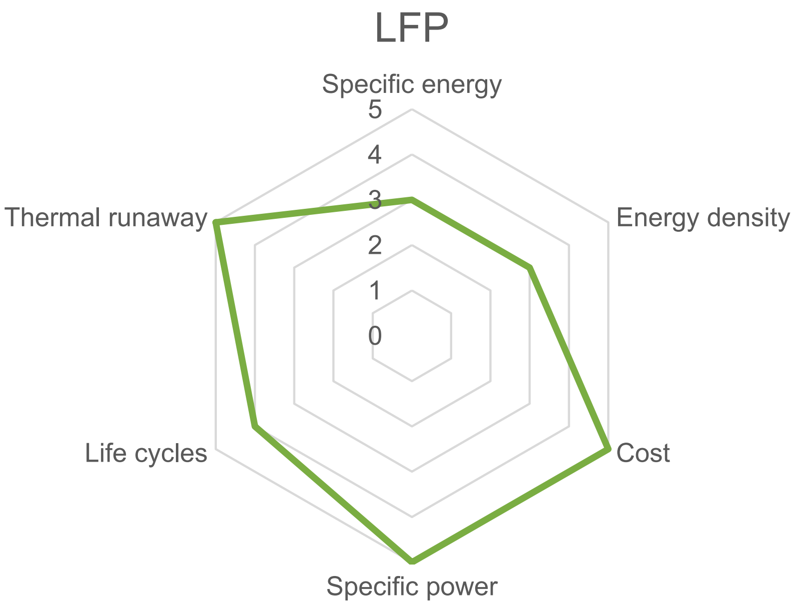
- Electron jumps from Li and goes to the load
- Li atom becomes an ion
- Li-ion moves through the electrolyte into the cathode
- Electron returns from the load into the cathode
- The process continues until all the Li settles into the cathode
- The battery becomes fully discharged

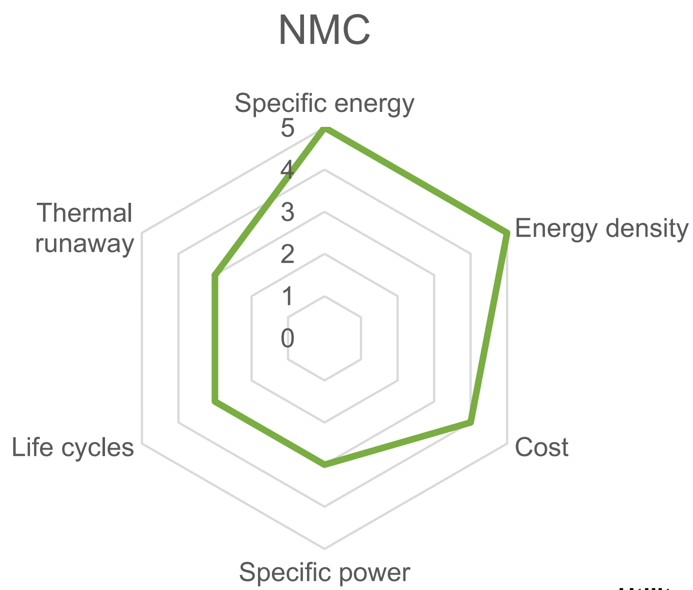




Why is this shift good for utilities?

Metal makes all the difference





			Utility Priority
Specific energy	160 Wh/kg	220 Wh/kg ✓	Low
Energy density	415 Wh/L	535 Wh/L ✓	Low
Specific power	1100 W/kg ✓	512 W/kg	Low
Life cycles	2500–5000 ✓	1500–2500	High
Thermal runaway	270°C ✓	210°C	High
Cost	$227/kWh ✓	$240/kWh	High

© E Source. **Notes:** kWh= kilowatt-hour; L = liter; W = watt; Wh = Watt-hour. Life cycle is defined as the number of charges and discharges.

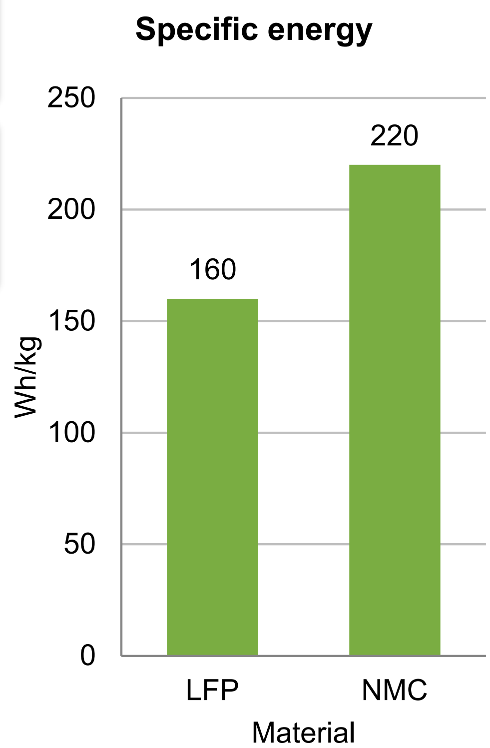
Specific energy and energy density

Specific energy. The amount of energy that a battery can store relative to its weight.

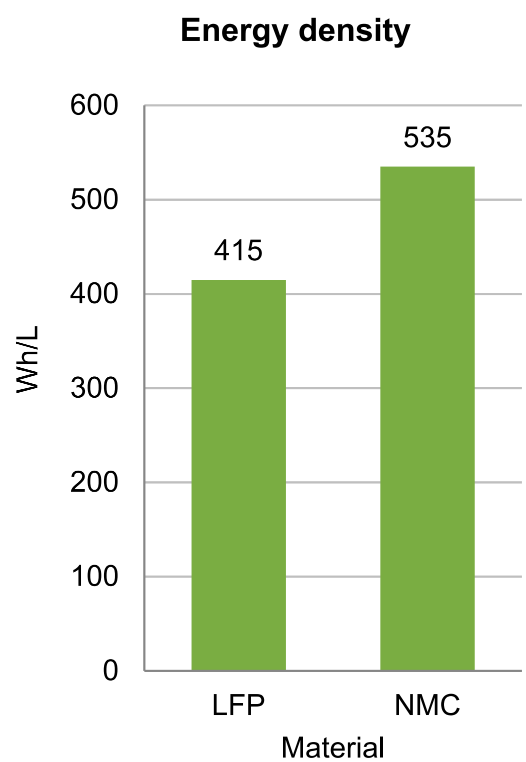
Energy density. The amount of energy that a battery can store relative to its volume.

Does it matter to utilities?

Although NMC material wins across the two categories, the specific energy and energy densities are low priorities for utilities because battery weight doesn't greatly affect stationary storage.



© E Source. **Notes:** LFP = iron phosphate; NMC = nickel manganese cobalt; Wh = Watt-hour.



© E Source. **Notes:** LFP = iron phosphate; NMC = nickel manganese cobalt; L = liter; Wh = Watt-hour.

Does specific energy matter to utilities?

Specific energy isn’t a major concern for utilities because the weight of a battery doesn’t affect the performance of a stationary storage system.

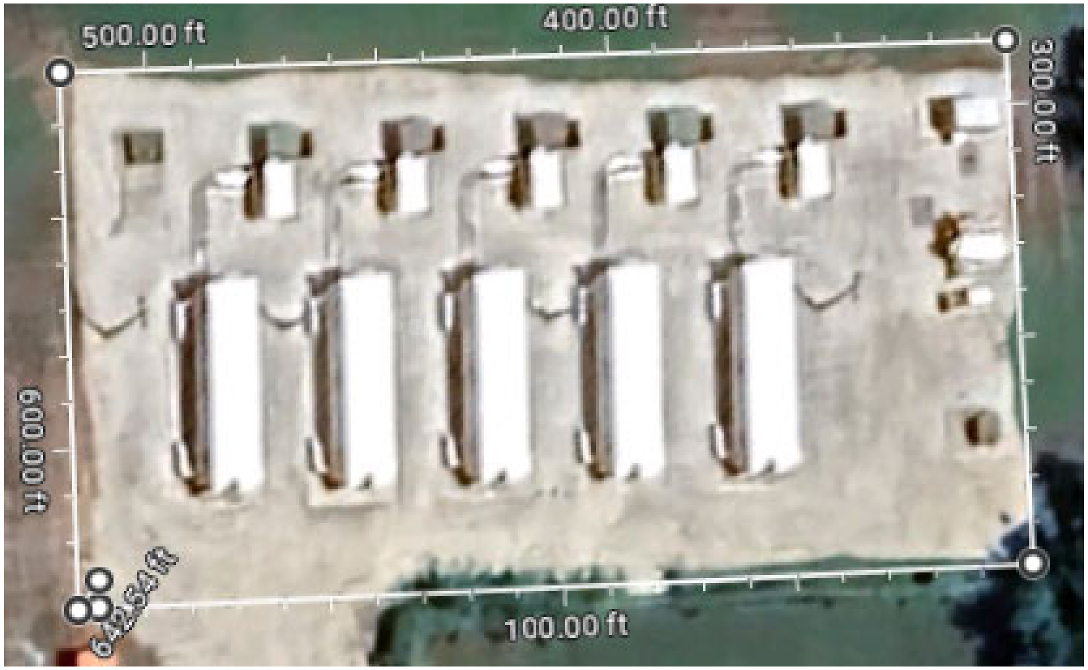
Specific energy **would** be high priority for car manufacturers that want to maximize their vehicles’ range without affecting performance.

Lower impact

Higher impact

Does energy density matter to utilities?

Because of racking, a battery ESS requires very little area.



Source: Google Maps, 30.590933, -97.683110

NMC battery plant

~22,000 sq ft for 10 megawatt (MW)/12 megawatt-hours (MWh)

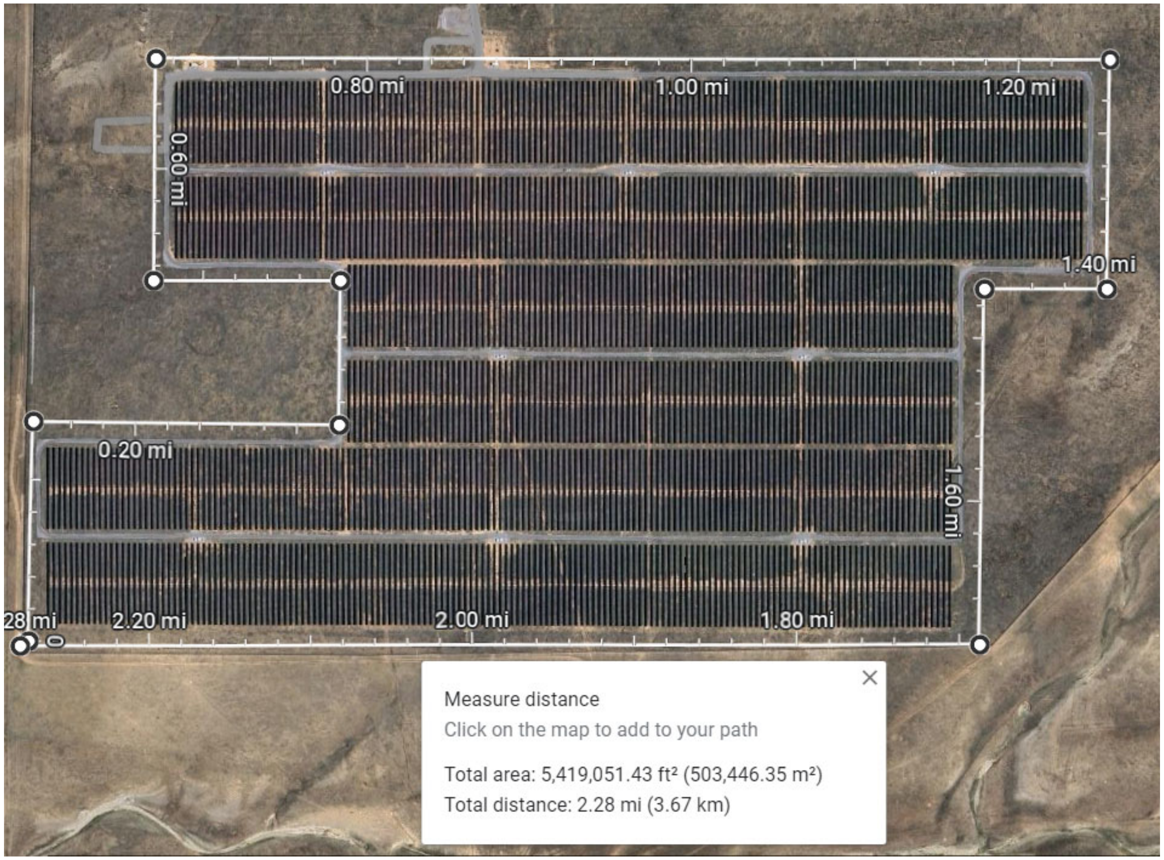
1833 sq ft per MWH

The same size LFP system would require ~28,000 sq ft

Battery ESS land requirement compare to solar

This 10 megawatt (MW) PV system in New Mexico occupies 5.4 million sq feet.

You can fit nearly two gigawatts (GW) of battery ESS in this space!



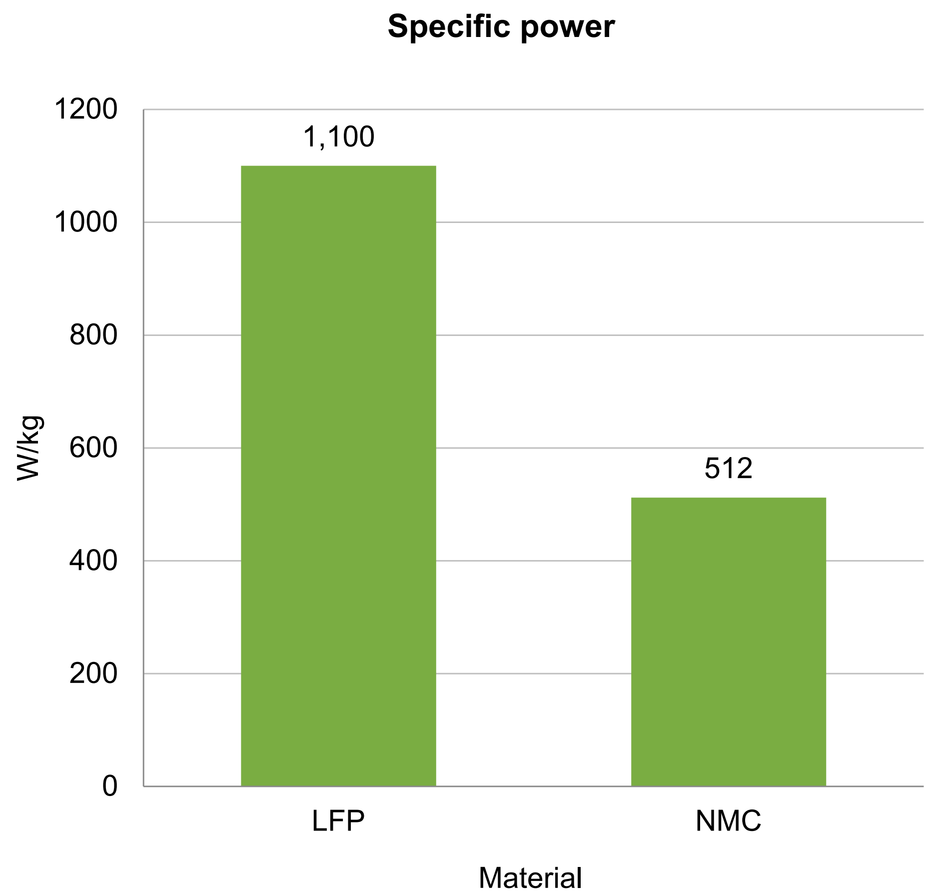
Source: Google Maps, 35.634601, -105.175923

Specific power

Specific power. The amount of power that a battery can deliver relative to its weight.

LFP has more than double the specific power of NMC. And this is a high priority for EV manufacturers.

This is also positive shift for utilities intending to use their batteries for ancillary services, like rapid response and other reserve power applications, that require high bursts of power for shorter durations of time.



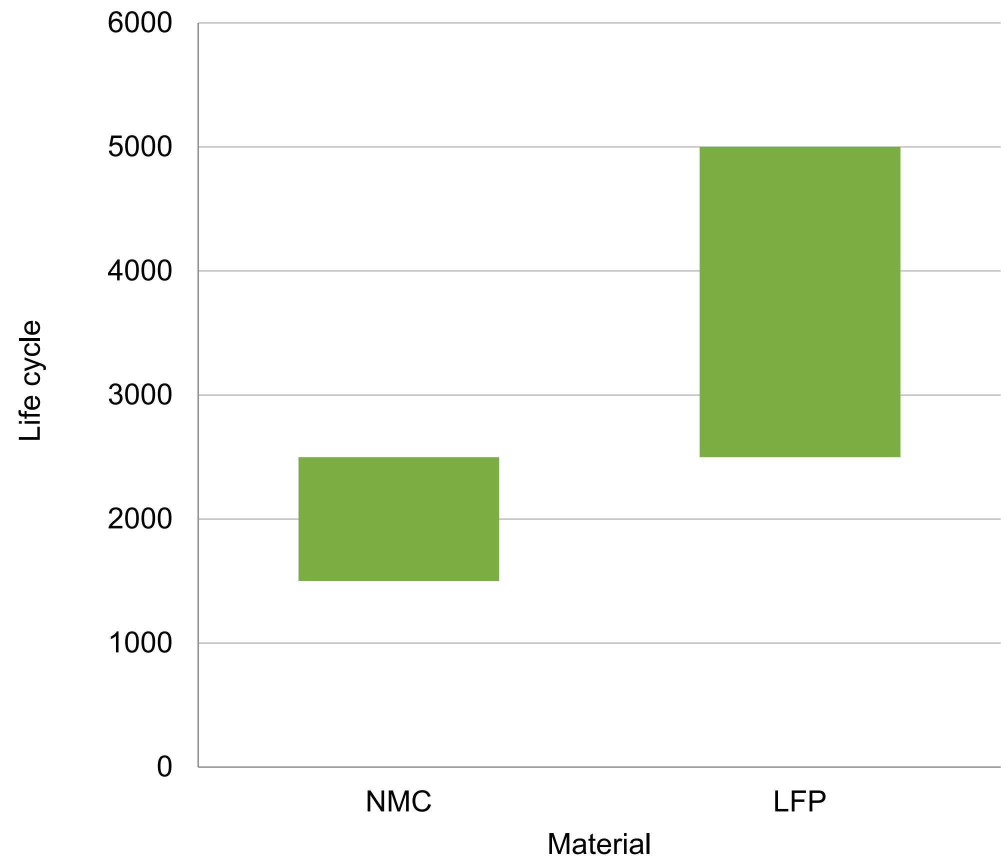
© E Source. **Notes:** LFP = iron phosphate; NMC = nickel manganese cobalt; W = Watt.

Life cycles

Life cycle. The number of charge and discharge cycles a battery can undergo before its capacity drops to levels that aren't useful.

This is a priority for utilities because higher life cycles can contribute to a lower levelized cost of storage over time.

The cost of ownership can be 31% lower when switching to LFP.



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Thermal runaway

Uncontrollable increase in temperature caused when not enough heat is being extracted from the modules.

External reasons

Over-charging

Over-discharging

High C-rates

External heating

Nail penetration

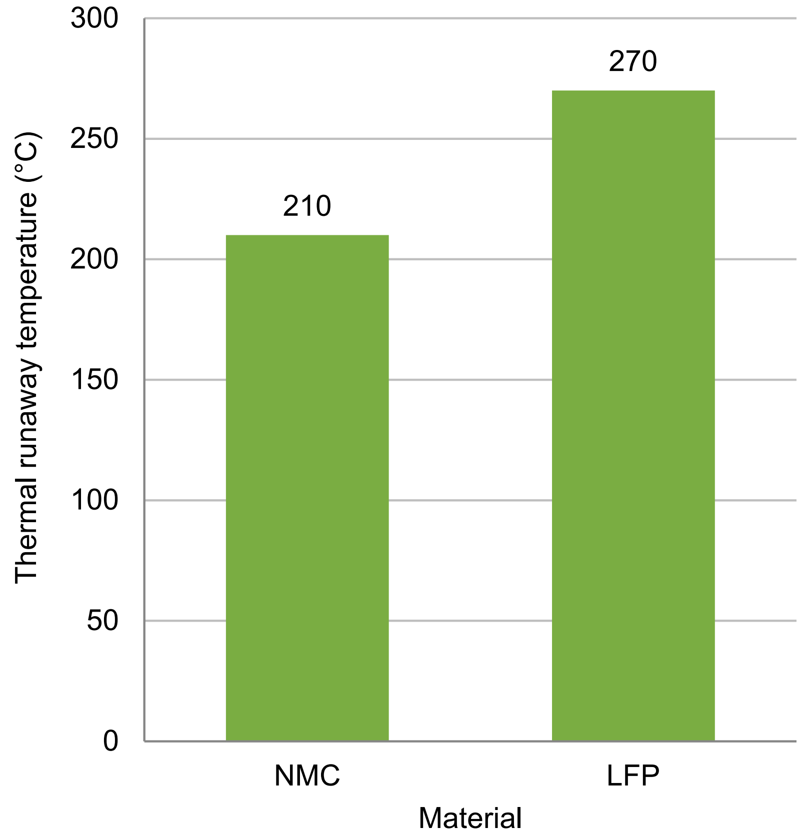
Internal events

Electrolyte decomposition

Separator meltdown

Breakdown of cathode

LFPs are safe and controllable even when HVAC systems fail.



 Notes: LFP = iron phosphate; NMC = nickel manganese cobalt.

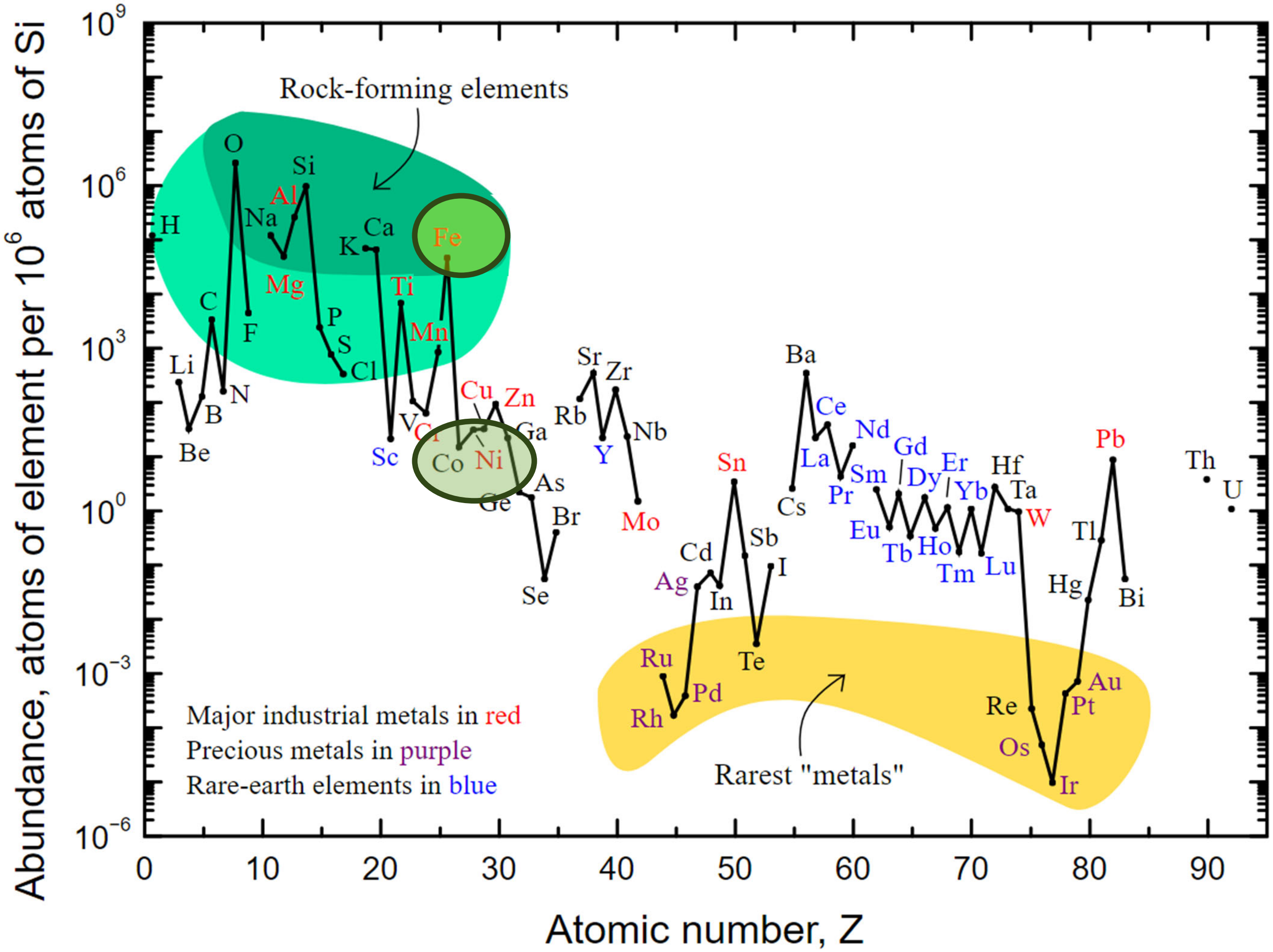
Material availability

Production tonnes per year

- Cobalt: 123,000
- Nickel: 2,250,000
- Manganese: 16,000,000
- Iron: 1,150,000,000

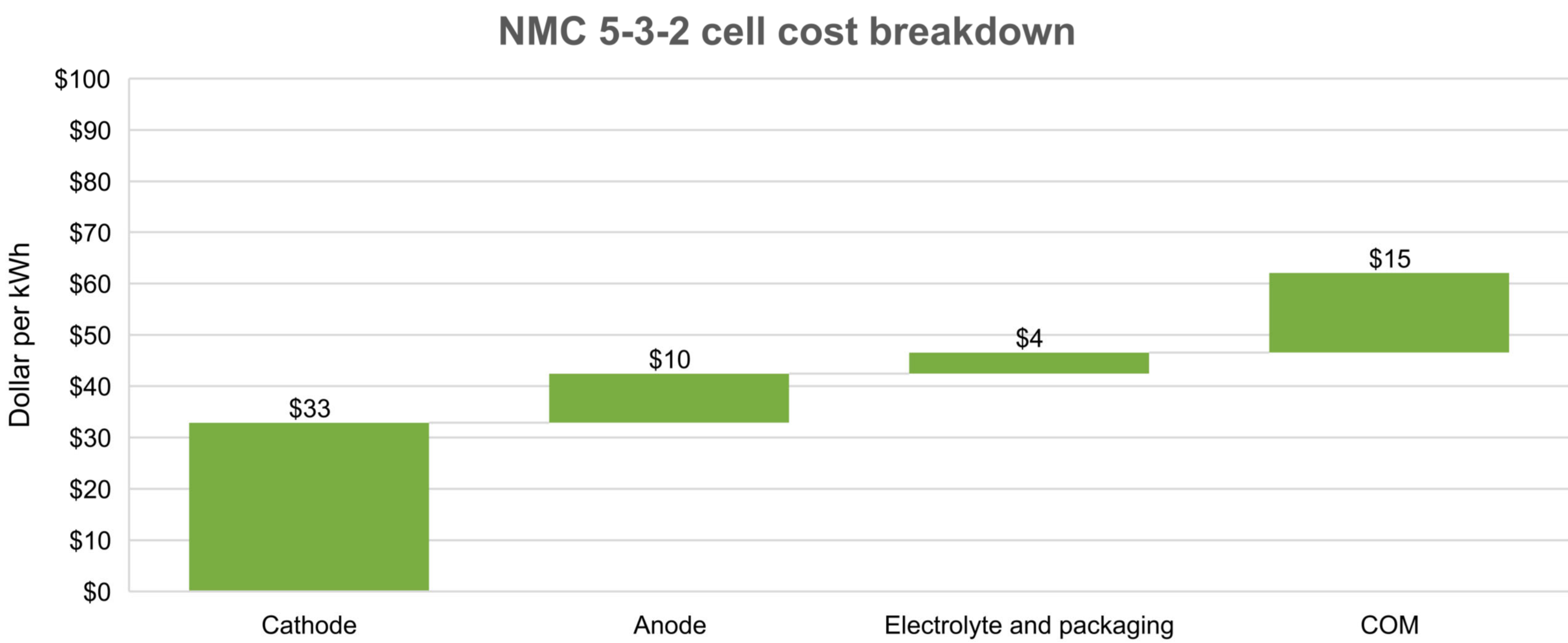
Almost three quarters of the cobalt supply comes from the Republic of the Congo, and inhumane mining practices create availability issues.

Iron ore extraction is spread throughout the world.



Source: Rare Earth Elements—Critical Resources for High Technology | USGS Fact Sheet 087-02

2030 price targets have been met early!



© E Source (H1 2023 China cell pricing from Battery Next Cost Model). **Notes:** COM = Cost of *manufacturing*; kWh = kilowatt-*hour*; *LFP* = *iron phosphate*; *NMC* = *nickel* manganese cobalt.

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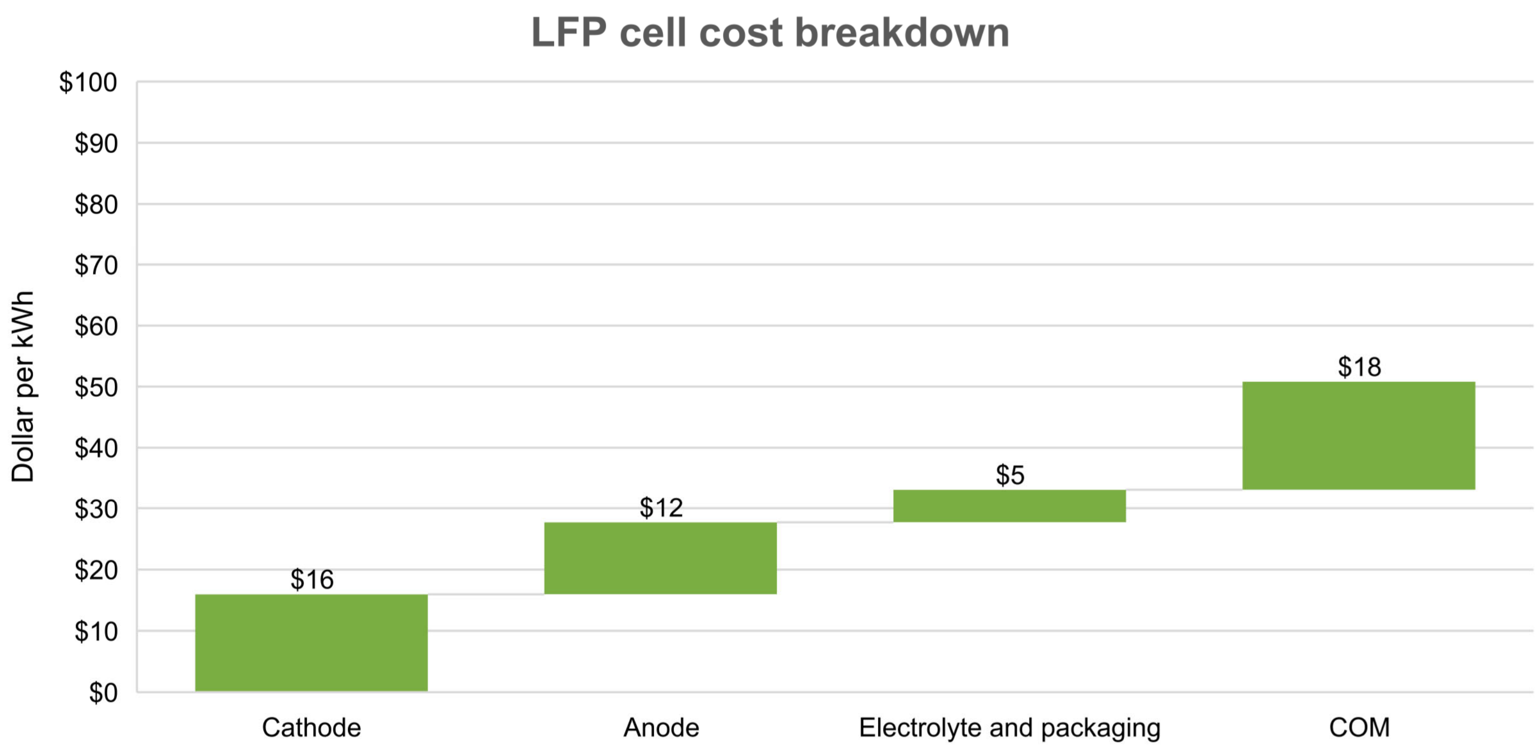

© E Source (H1 2023 China cell pricing from Battery Next Cost Model). **Notes:** COM = Cost of manufacturing; kWh = kilowatt-hour; LFP = iron phosphate; NMC = nickel manganese cobalt.

The shift to LFP is good for utilities

Lower cost

Cheaper and more abundant material means the supply chain can ramp up to higher levels. This will continue to drive costs down even as demand grows.

Safety

Stronger material and chemical composition means that the safety threshold is much higher now, minimizing the risk of fires and other high-cost hazards.

Longer life

The 2x life cycles of LFP relative to NMC means that the levelized cost of storage of newer systems will be much lower.

Programs

High output programs—like rapid response, frequency regulation, and congestion management—will be excellent applications.

Interested in learning more?

- Batteries
- Battery Forecast Database
- EV Forecast Database
- Battery Cost Model H2 2023
- Winter 2023 tech roundup
- $250 per kWh: The battery price that will herald the terawatt-hour age

Questions? Contact the Battery Next team

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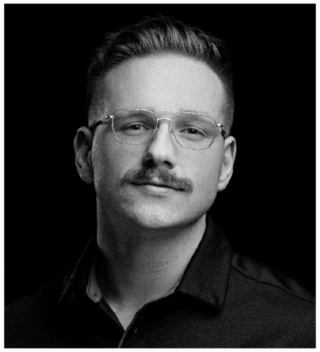

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