Emergence of the North American Battery Supply Chain

Trends identified in June 2024 Capacity Update that remain today…

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DoD Battery Analytics & Assessment

Major Effort: DoD Supply Chain Risk Assessment

MITRE worked with DoD to conduct a multiyear assessment of the risks to the DoD's ability to procure cost effective advanced batteries to support operational capabilities. The study assessed thousands of companies, hundreds of facilities, in dozens of countries, and leveraged numerous commercial and government data sources. The assessment used a rigorous set of criteria and categories to arrive at aggregate assessments of risk.

Additional MITRE-led DoD Battery Analyses & Studies:

- Alternative Approaches to Improving Supply Chain Security
- Battery Standardization Opportunities and Challenges
- Service-by-Service Usage and Risk Assessments
- Mid-Term Scenarios for Supply Chain Resiliency
- North American Market Growth Assessment
- Enhanced Leveraging of Commercial Solutions
- Unique DoD S&T Needs Analysis
- Others

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China plays a major role across the Li-ion Supply Chain

China Market Share*

3 **Li** Lithium 6.94

25% | 63% | NMC 64% | LFP 99%

China expanding in Li by investing in Australian and South American mining

No domestic LFP production capacity

28 **Ni** Nickel 58.6934

4% | 32% | $NiSO_4$ 80%

25 **Mn** Manganese 54.938044

3% | 90% | $MnSO_4$ 92%

Mining / Extraction | Refining | Processing

27 **Co** Cobalt 58.933194

China 5% | 65% | $CoSO_4$ 86%

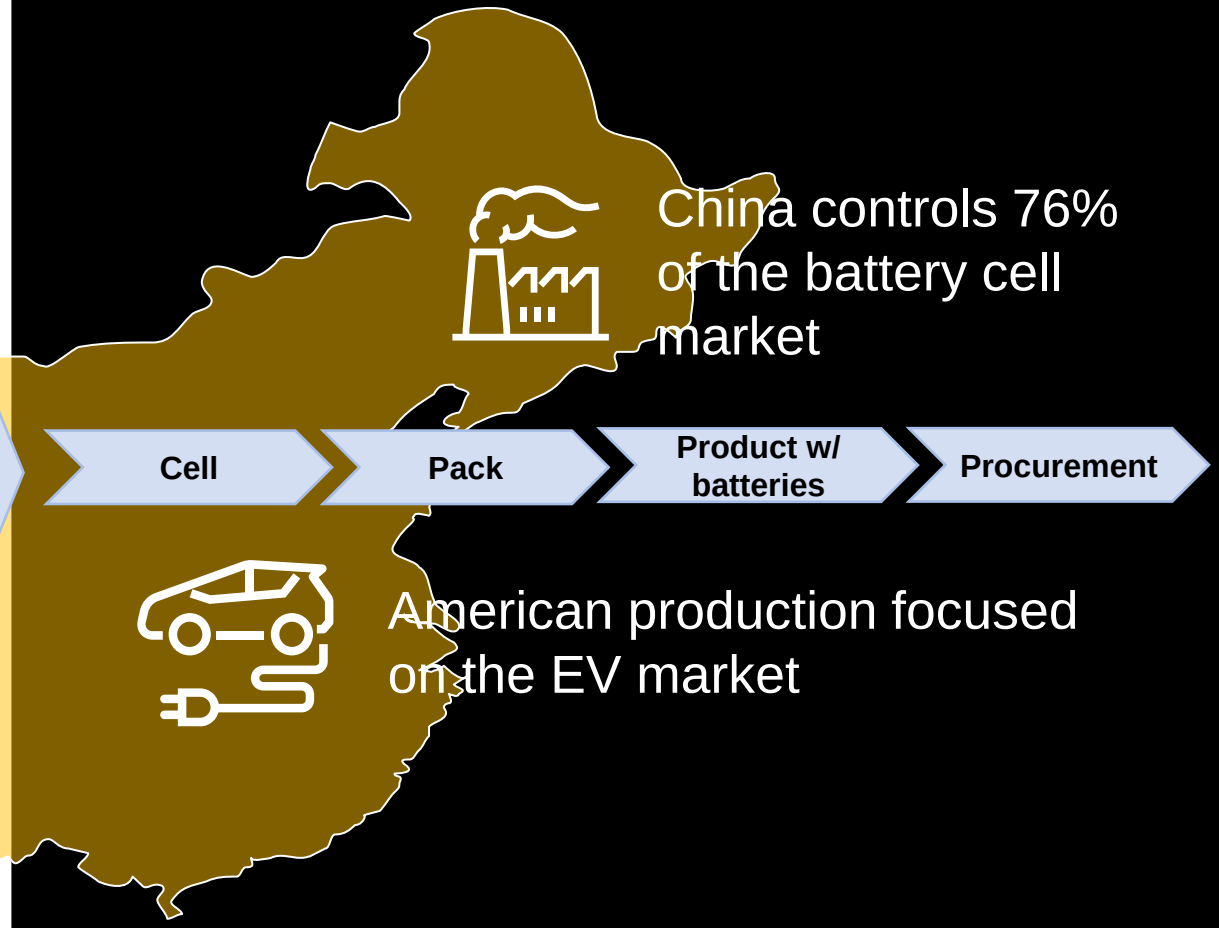
DRC 65%

More than 70% of DRC cobalt is controlled by Chinese companies

6 **C** Carbon 12.011

Graphite

67% | Natural 99% | Synthetic 80% | Anode 96%



**Original MITRE assessment from June 2024 leveraging numerous sources

Enduring DoD Risks across 2022 & 2024 Assessments

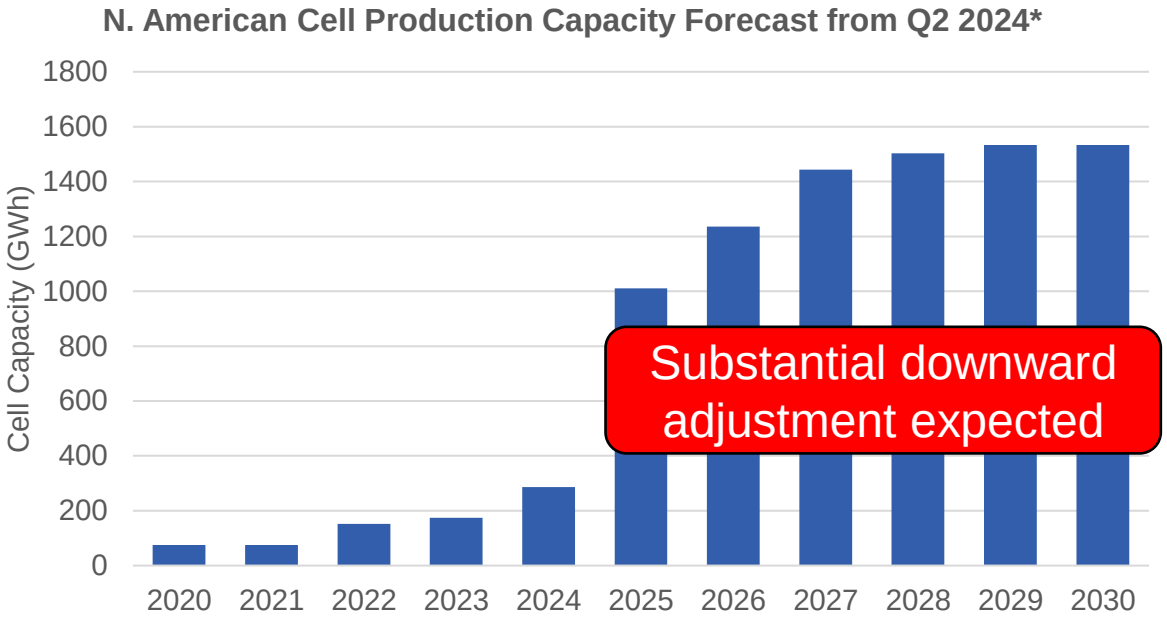
- Specific materials like refined graphite, anodes, nickel and manganese sulphate supply are expected to fall short of demand in the short term
- High concentration of industries in specific geographic regions
- Large market share controlled by a small set of companies
- Highly specialized workforce outside of the US
- Long lead times to expand or stand-up production
- Quality considerations that are costly, time-consuming, and/or environmentally hazardous

N. American cell production surging to support EVs

Cell production is the centerpiece spurring the buildout of supporting industries and capabilities across the value chain

The US was on track for > 1 TWh of capacity by 2030, but…

- **At least 4 Battery cell manufacturing projects (approx. 48 GWh) have been cancelled** across N. America from Q3 2024 to today**
- BloombergNEF's new 'risk-adjusted' outlook expects **only 50% of announced <u>global capacity</u> by the end of 2025, and 67% of announced by the end of 2035*****

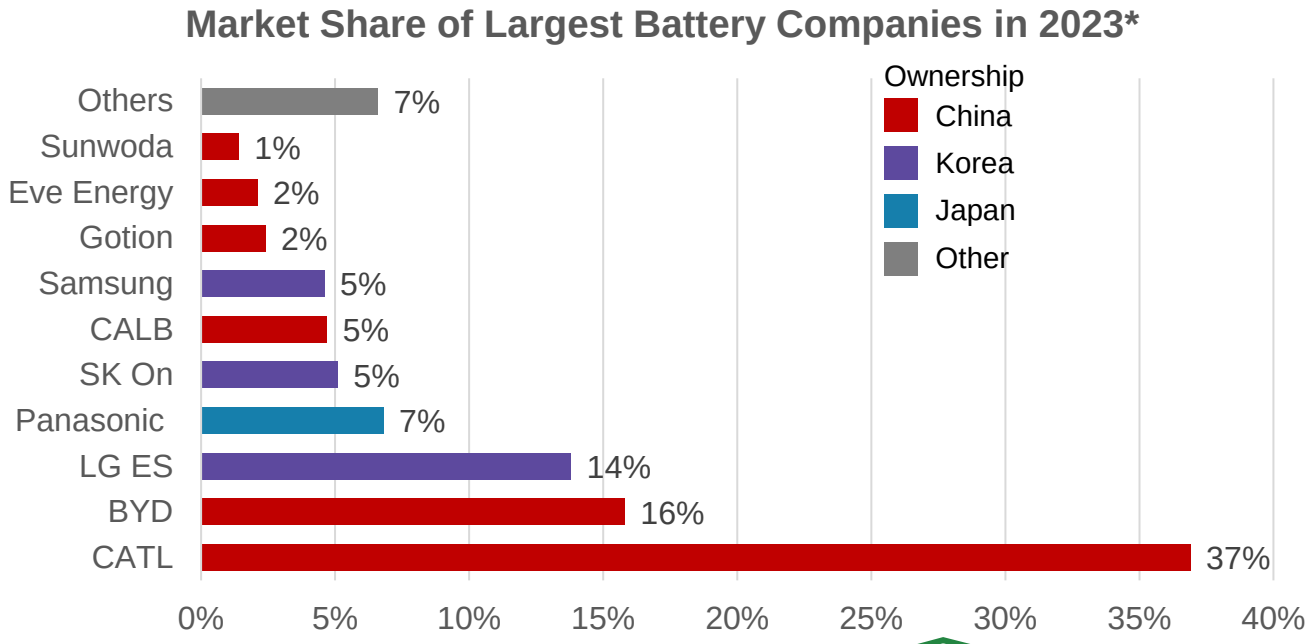


*Source: Wood Mackenzie EVBSC, Q2 2024

**Source: Argonne National Laboratory, May 2025

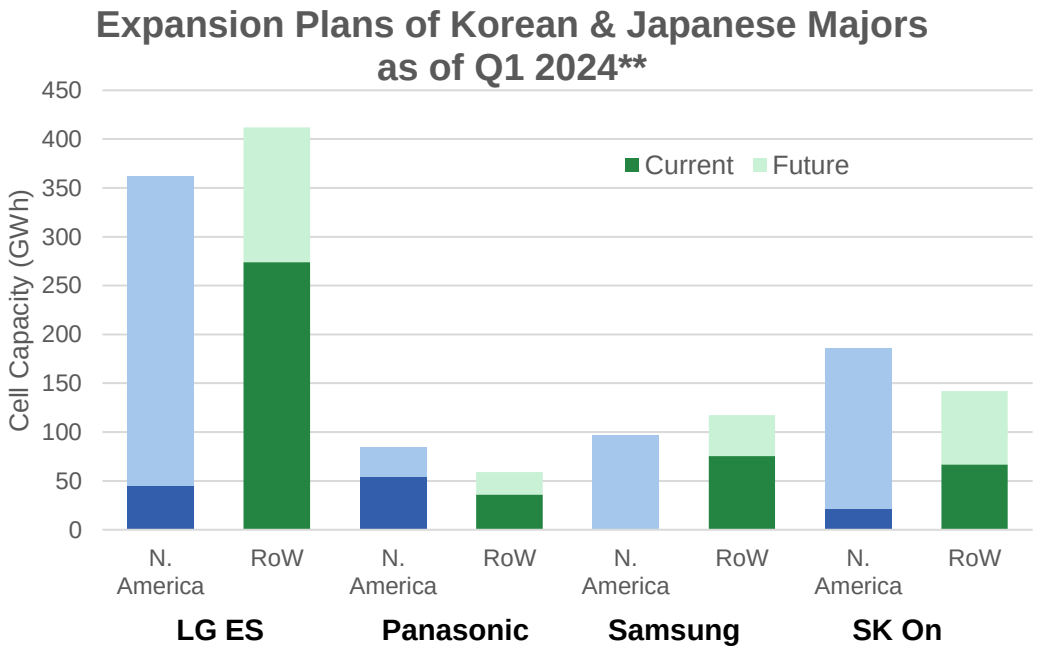
***Source: BloombergNEF, 14May2025

Expansion is led by Korean and Japanese cell producers



Largest battery companies in the world are all Chinese, Korean, or Japanese. North American battery companies not currently in top 10.

Massive planned North American capacity additions by top Korean and Japanese battery companies. Often in partnership or joint ventures with U.S. automakers to qualify for IRA credits.

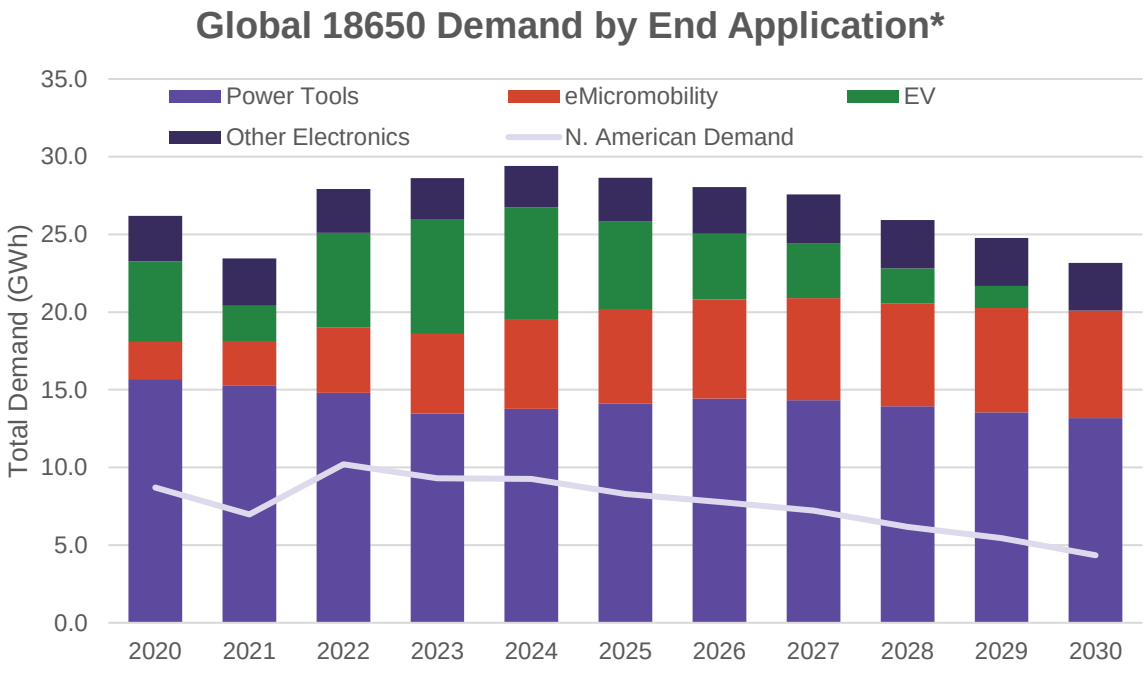


RoW = Rest of World

*Source: CNEVPOST – 6Dec2023 based on SNE Research

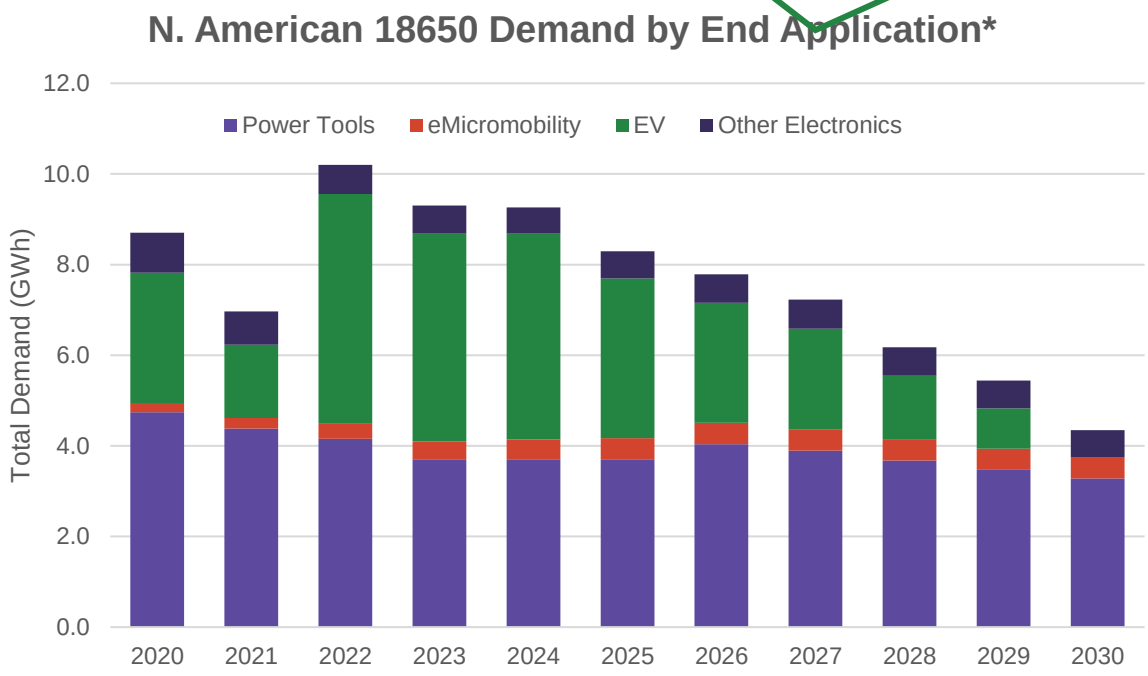
**Source: Wood Mackenzie

18650 cells will remain essential for DoD systems while N. American demand projected to fall faster than global



North American 18650 demand has been skewed towards EVs driven by Tesla, but market forecasters expect them to transition.

Globally, demand for 18650 cells is slowly falling as they are replaced by larger cell formats such as 21700 in many applications.



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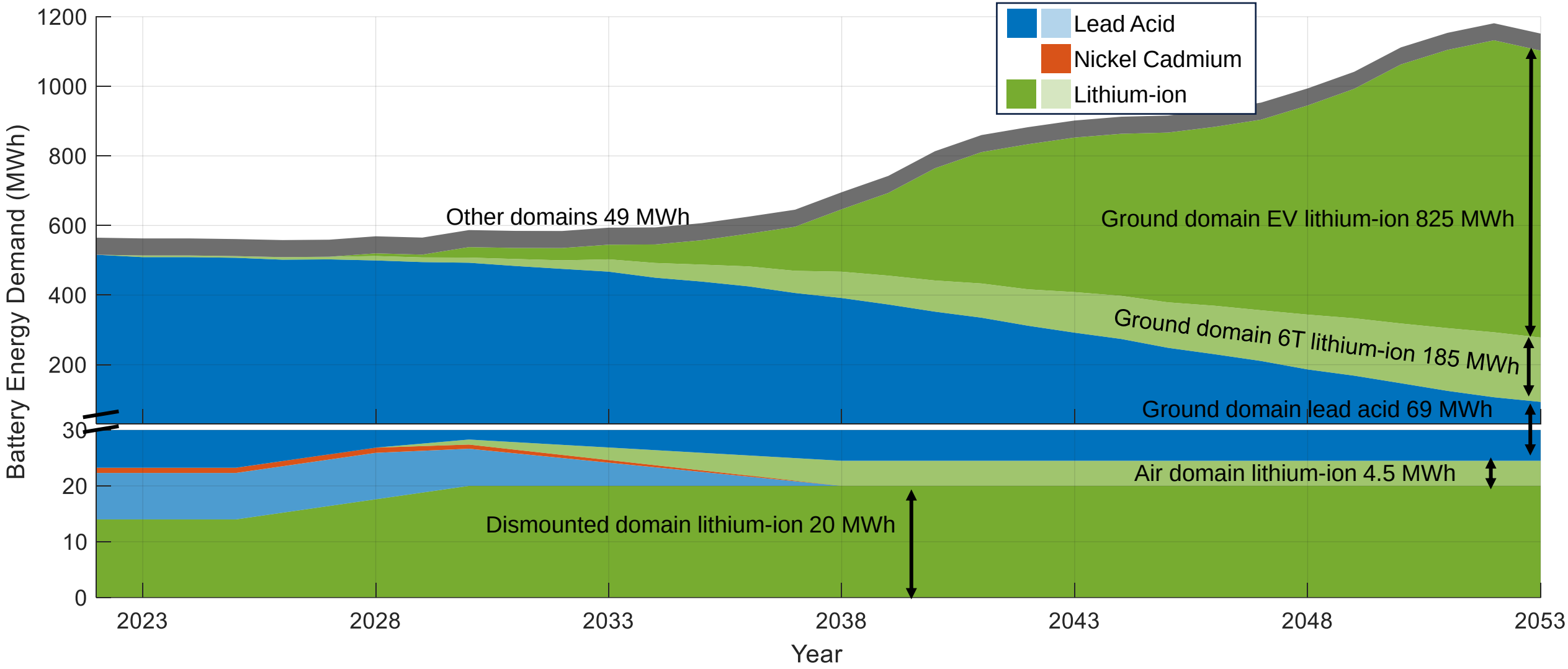
*Benchmark Minerals Intelligence, April 2024

Aggressive DoD Electrification Scenario (projected in 2024)



Under more aggressive electrification scenarios, li-ion demand could rise to greater than 1GWh /year

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DoD Lithium-ion Battery Cathode Chemistry Trends

Current DoD Landscape

- Mostly low nickel NMC especially in 18650 cells
- Emerging usage of LFP with growth expected to continue
- Some LCO, especially in specialty applications

Future DoD Landscape

- NMC in areas such as soldier portable and unmanned systems
- Increased usage of LFP especially in hybridized vehicles
- Continued use of LCO for certain applications

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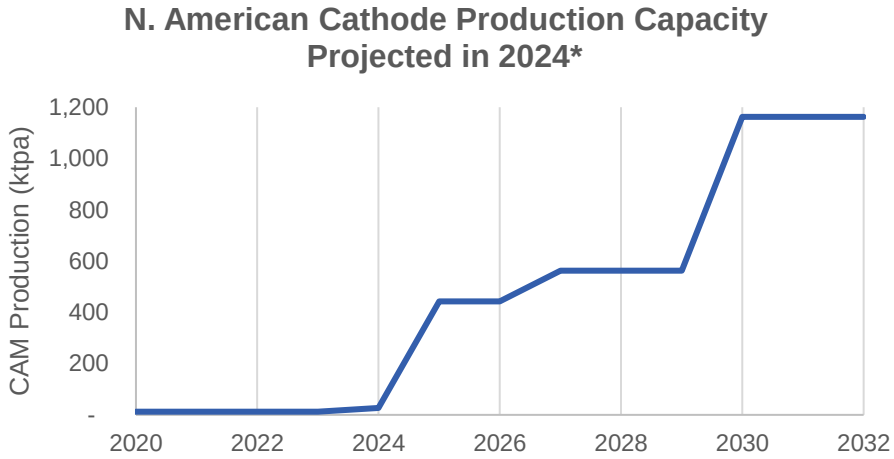
Major investments driving N. American cathode and anode production capacity, meeting significant share of 2030 demand

NMC and LFP Cathodes

Far more investment into cathode sector, particularly NMC, than anode sector. Facilities operated by a mixture of:

- Korean companies such as LG Chem, EcoPro BM, Posco Chem, US startups such as 6K, NanoOne, Ascend Elements,
- and European chemical producers such as BASF and Umicore.

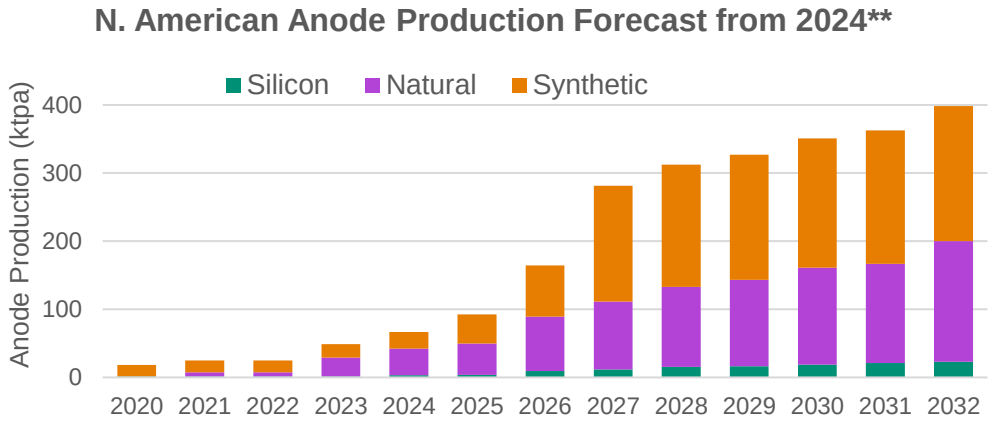


At least 3 projects (totaling 400 ktpa) have been cancelled since the start of Q3 2024***

Graphite Anodes

Anodes make up a smaller share of total battery cost and attract less investment

- N. American industry tends towards synthetic graphite production
- Natural graphite projects often rely on mining in African countries such as Mozambique and Madagascar
- US is also seeing substantial investment into silicon anodes



At least 2 projects (totaling 46 ktpa) have been cancelled since start of Q3 2024***

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*Source: Wood Mackenzie, 2024

**Source: Woods Mackenzie and Benchmark Minerals Intelligence, 2024

***Source: Argonne National Laboratory, May 2025

N. American refineries will struggle to meet demand. US will need to rely on friend-shoring.

- Uneven investments in new capacity across the battery relevant materials
  - Lithium has attracted the most investment thus far
  - Battery/minerals recycling presents an opportunity to supplement refining capacity for high value materials like copper and cobalt as/if that market matures
- Extremely slow buildout of mining capacity means the US will be dependent on foreign sources for many raw materials
  - Canadian projects will supplement US capacity in nickel, cobalt, and graphite in a mining friendly jurisdiction
  - Direct Lithium Extraction (DLE) approaches with Brines (e.g., Smackover Formation) may complement extraction of sedimentary clay (e.g., McDermitt Caldera)

N. American production capacity will far exceed DoD demand within a few years, even in materials with limited investment

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U.S. Automakers are committing to long-term off-takes and JVs with many foreign companies

OEM	Lithium	Manganese	Nickel	Cobalt	Cathode	Anode	Electrolyte	Batteries
Tesla	Albemarle, Ganfeng, Yahua,		Vale, BHP, Talon Metal	Glencore	L&F, Sumitomo	BTR, Shanshan, Syrah	Mitsubishi Chem, Tinci High-Tech	Panasonic, LGES, CATL
GM	Lithium Americas, CTR,	Element25	QPM, Ascend Elements	Glencore, Ascend Elements	Posco, BASF, LG Chem, Redwood	Posco, Nouveau Monde		Ultium (LGES), CATL
Stellantis	CTR	Element25	Terrafame, Kuniko, GME	Terrafame, Kuniko, GME	Umicore			CATL, ACC
Ford	SQM, Albemarle, Ioneer		Vale, Huayou, BHP		~~Ecopro BM,~~ Redwood	Westwater, Syrah		SK On, LGES, CATL

**non-exhaustive list of supply chain investments for critical minerals as of 6/19/24 based on public announcements.*
Red indicates HQ outside of North America

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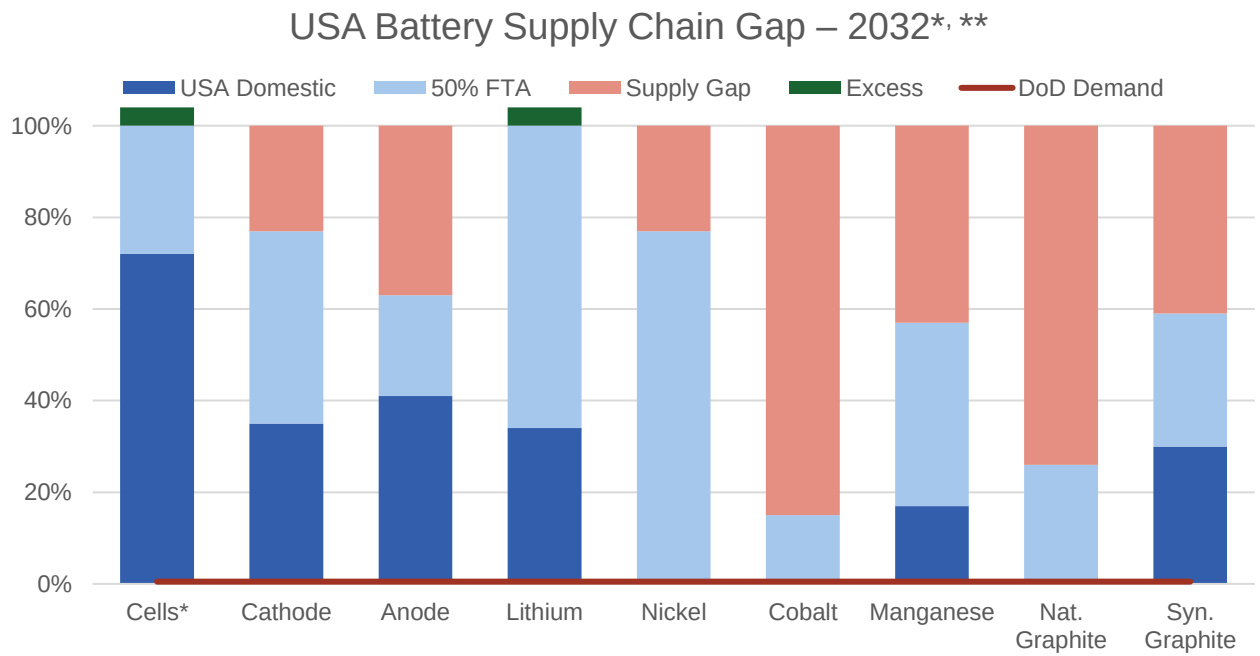
Opportunities are emerging but challenges persist in securing DoD lithium-ion battery supply chains

Key Takeaways

- The US and broader N. American battery supply chain was undergoing a massive buildout across multiple sectors, **though projections are correcting downward**
- DoD will struggle to leverage industry expansion without early involvement and support to influence cell manufacturers decision making on form factors
- US supplies of raw and refined nickel, cobalt, and natural graphite will remain limited, but DoD demand is tiny compared to EV industry

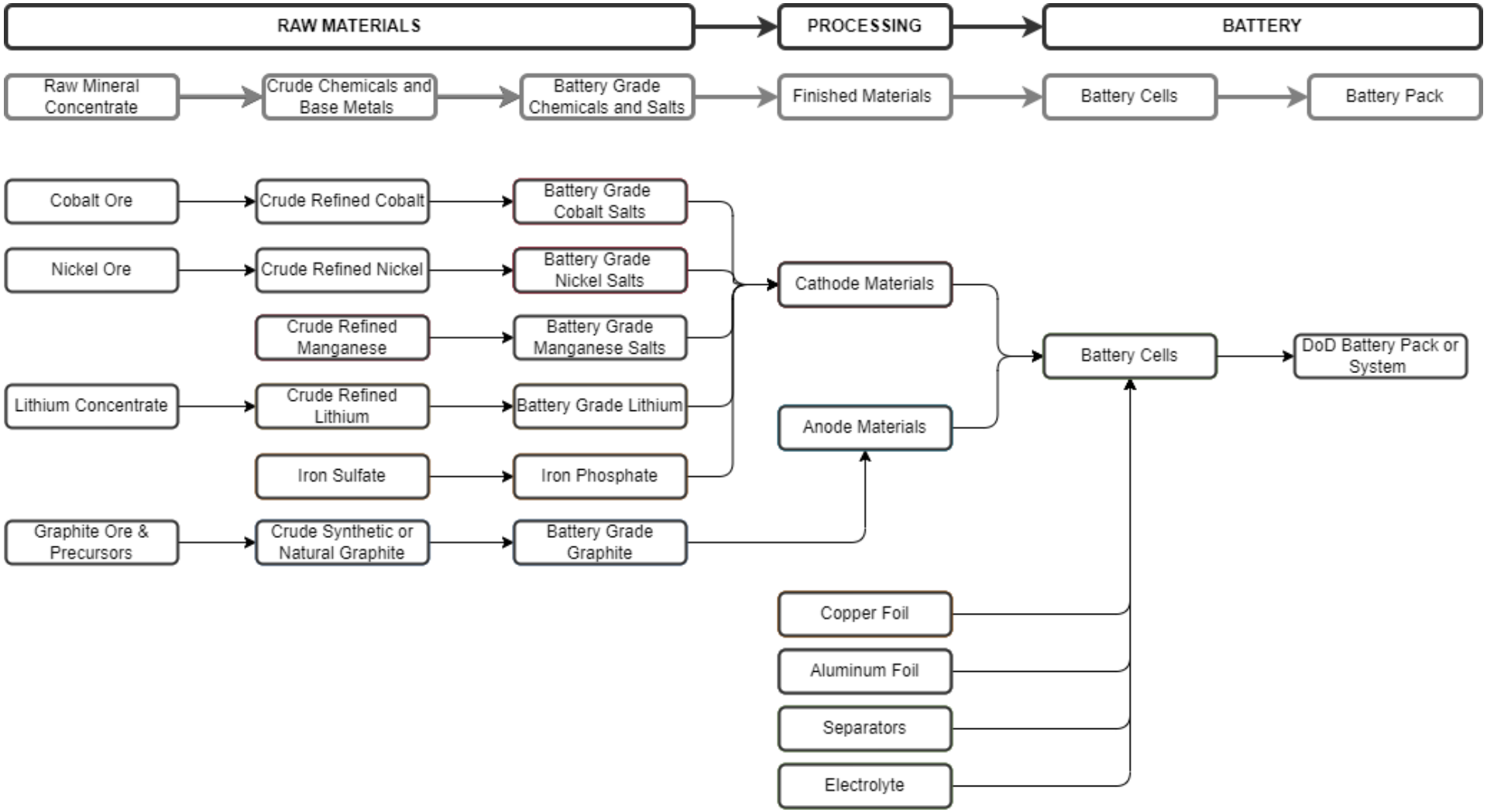


**cell supply may not meet DoD form factor requirements*

**Original MITRE assessment from June 2024 leveraging numerous sources

BACKUP

Battery Value Chain Mapping (simplified)



DoD Advanced Battery Supply Chain Risk Assessment Risk Ratings

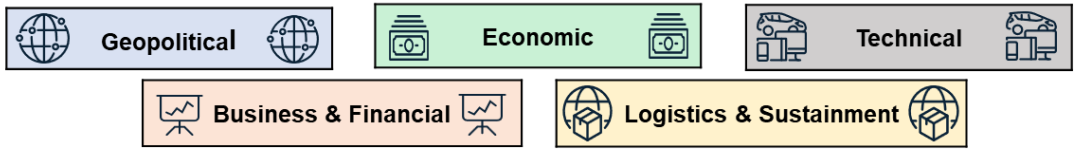
Ratings reflect the **risk appetite / tolerance** level of the DoD.

Provides **consistent assessment** across companies and time.

Establishes **common understanding** of what is meant when a risk is assessed as a high vs. medium.

Risk Level	Score	Abbr.	Definition
High	81 < 100	H	The supply chain risks in this area have a **severe impact** on the DoD's ability to procure advanced Li-ion batteries for military platforms and weapons systems, to the extent that one or more critical platforms or systems will not have the batteries needed for mission success. **Little to no confidence** that DoD will have the ability to procure or continue to procure needed advanced Li-ion batteries.
Medium - High	61 < 80	MH	The supply chain risks in this area have a **significant impact** on the DoD's ability to procure advanced Li-ion batteries for military platforms and weapons systems, to the extent that one or more platforms or systems access to the batteries needed for mission success will fall below minimum acceptable levels. **Low confidence** that DoD will have the ability to procure or continue to procure needed advanced Li-ion batteries.
Medium	41 < 60	M	The supply chain risks in this area have a **moderate impact** on the DoD's ability to procure advanced Li-ion batteries for military platforms and weapons system, to the extent that one or more platforms or systems access to the batteries needed for mission success will fall well below minimum acceptable levels. **Reasonable confidence** that DoD will have the ability to procure or continue to procure needed advanced Li-ion batteries.
Low – Medium	21 < 40	LM	The supply chain risks in this area have a **minor impact** on the DoD's ability to procure advanced Li-ion batteries for military platforms and weapons system, to the extent that one or more platforms or systems access to the batteries needed for mission success will fall below goals, but still be well above minimum acceptable levels. **Strong confidence** that DoD will have the ability to procure or continue to procure needed advanced Li-ion batteries.
Low	1 < 20	L	The supply chain risks in this area have a **little to no impact** on DoD's ability to procure advanced Li-ion batteries for military platforms and weapons system. **High confidence** DoD will have the ability to procure or continue to procure needed advanced Li-ion batteries.

Risk Categories



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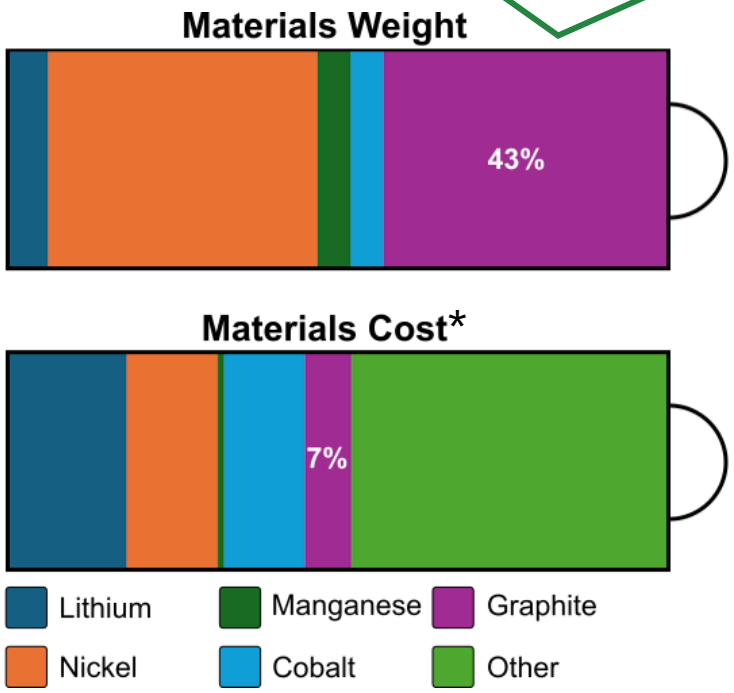
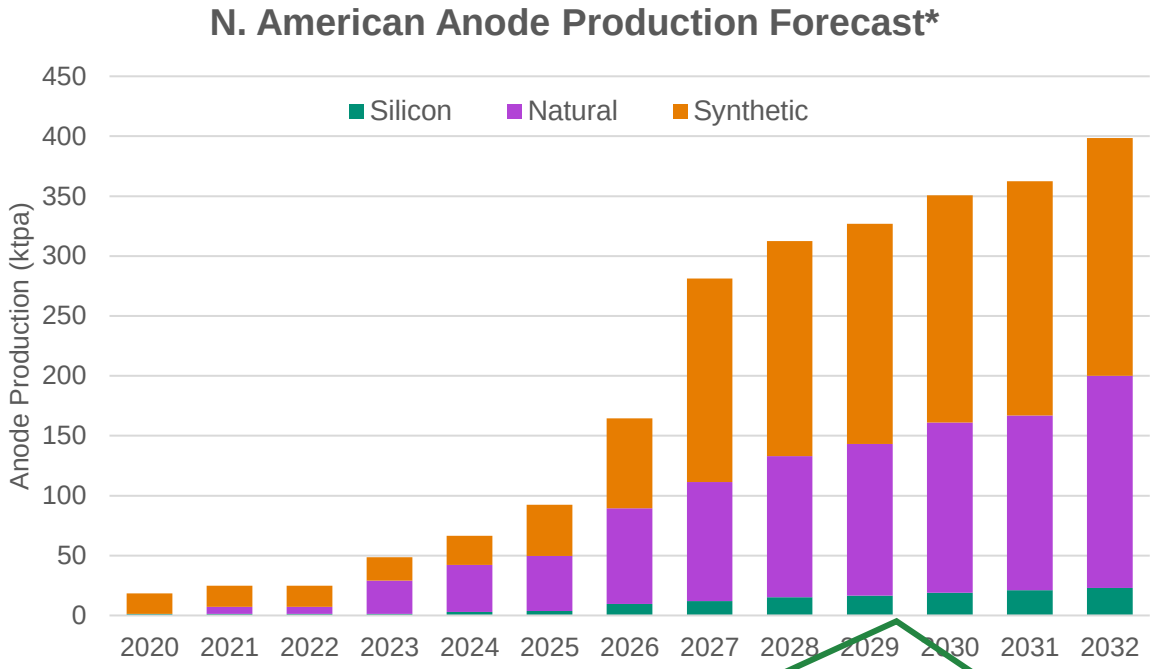
Buildout in N. American Anode production is more uncertain and coming later

Nearly all Li-ion batteries use graphite anode materials but commercial interest is limited: Graphite accounts for over 40% of the materials weight in a cell but makes up only 5-10% of the cost.





- Production forecasts show ramp in anode production towards end of decade
- Largest area of capacity growth is synthetic graphite, preferred by EV makers

At least 2 projects (totaling 46 ktpa) have been cancelled since start of Q3 2024**

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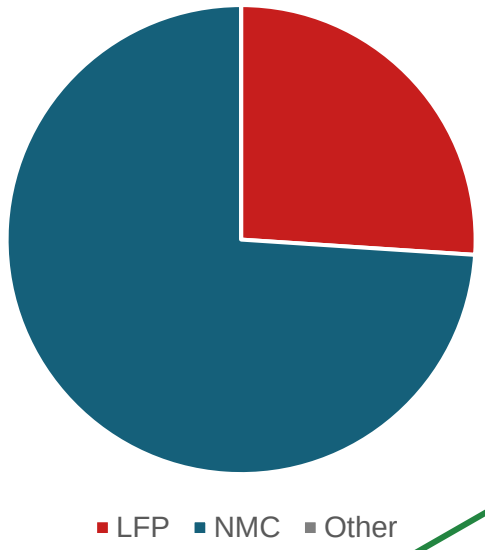
*Source: Wood Mackenzie and Benchmark Minerals Intelligence **Source: Argonne National Laboratory, May 2025

NMC(A) chemistries are dominant in N. American market, but their global market share is projected to shrink

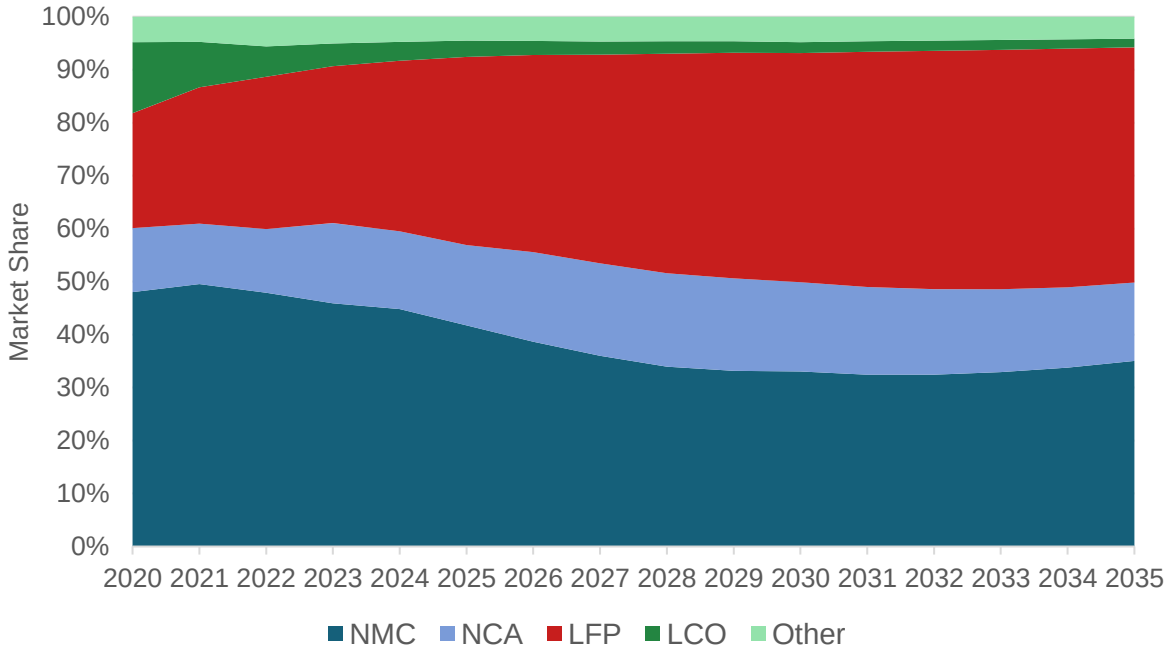
Projected 2030 N. American Production Share*



- North American cathode production expansion plans are focused mainly on NMC
- Some LFP production is projected for later in the decade.
- There is only small scale LCO production in North America without planned expansions.

- EV industry uses multiple NMC and NCA blends to optimize for performance and cost
- LFP and LMFP are seeing widespread adoption, especially in Asia and Europe

Global Battery Cathode Chemistry Demand**



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*Source: McKinsey Battery Insights

**Source: Wood Mackenzie and Benchmark Minerals Intelligence, 2024