ENERGY MATERIALS MARKET OUTLOOK

Key supply chain trends facing the North American market

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Benchmark Mineral Intelligence

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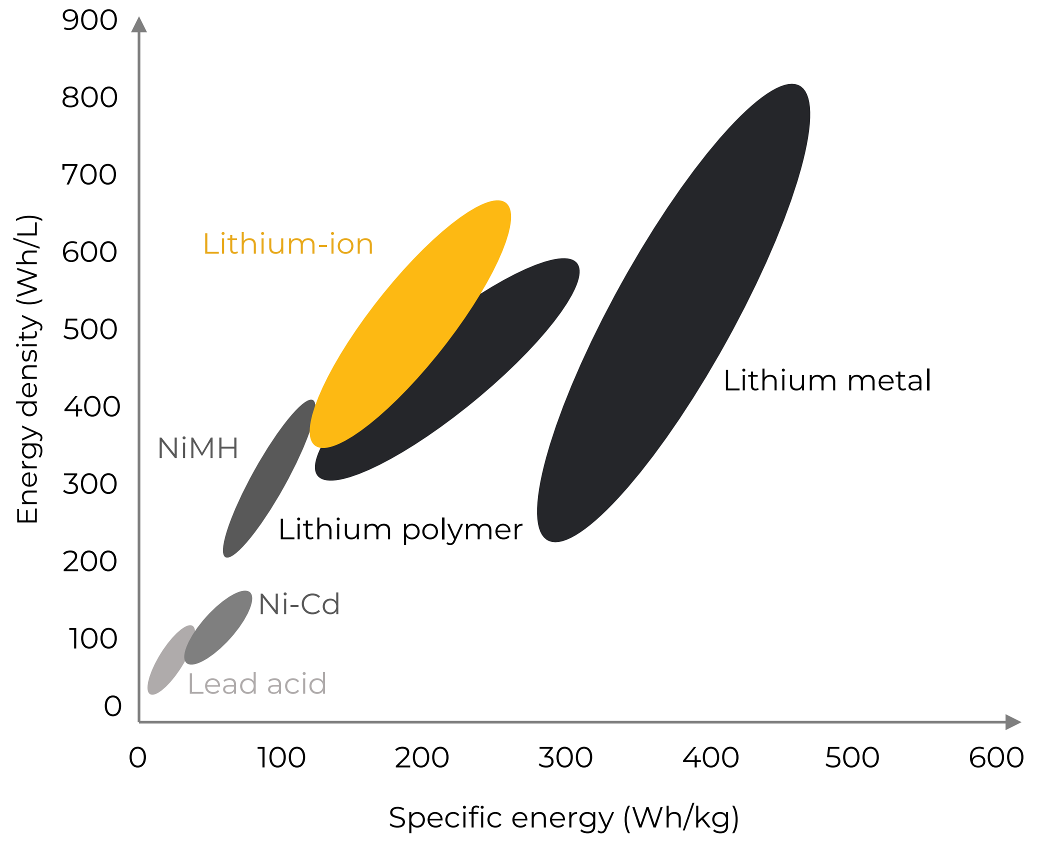
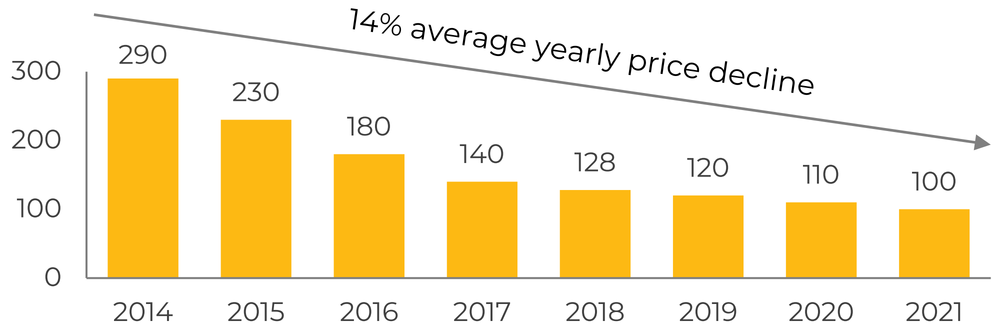
Benchmark Mineral Intelligence: Products & Services

PRICE ASSESSMENTS & MARKET DATA	Lithium (8 Carbonate, 6 Hydroxide, 1 Spodumene) Cobalt (Sulphate, Metal, Hydroxide) Natural Graphite (8 Flake, 3 Spherical Graphite) Synthetic Graphite (4 Needle Coke, 2 Pet Coke)	Nickel (2 Sulphate, MHP) Anode and Cathode prices (6 Anode, 7 Cathode) Lithium Ion Battery Cells Gigafactory Assessment Anode & Cathode Market Assessments	WEEKLY / MONTHLY
FORECASTING, CONSULTANCY & ESG	Lithium Cobalt Nickel Natural & Synthetic Graphite Anode and Cathode	Lithium Ion Battery Database Solid State Batteries Recycling ESG Life Cycle Assessments	QUARTERLY
NEWS ANALYSIS, WEBINARS & EVENTS	News & analysis Supply chain commentary Presentation archive	Quarterly Review Magazine Video Archive In-person events in all regions	REGULAR

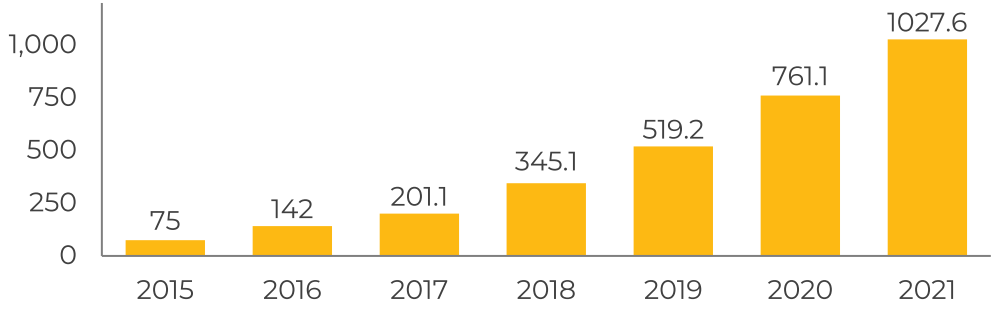
From start up to scale up: The cost and capacity basis has been established, now fine-tuning begins



Price of Lithium-ion Battery Cells



Capacity Deployment



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Source: Benchmark Battery Assessment

North America is facing a generational challenge to sustain clean energy ambitions

1.4m

EVs (BEV + PHEV) are expected to be sold in North America in 2023

122 GWh

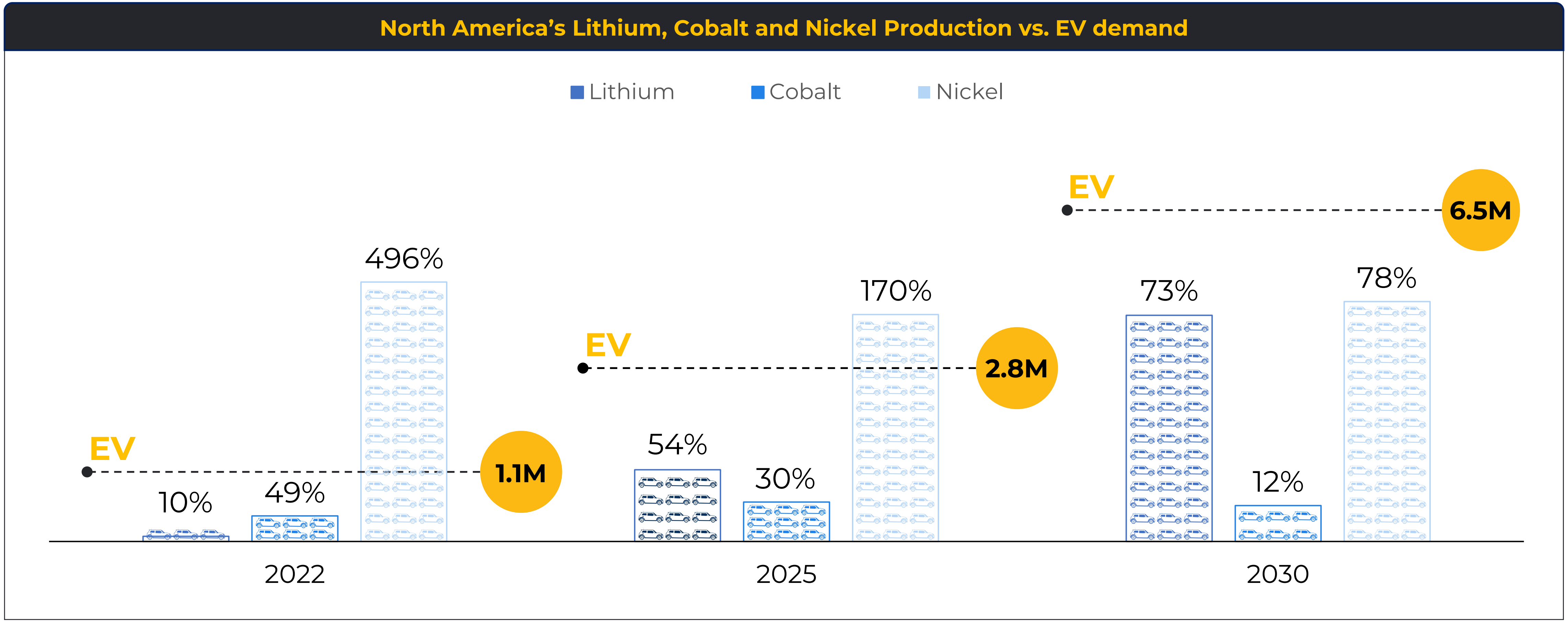
of li-ion battery demand from the region is projected in 2023

61 GWh

of li-ion batteries will be produced in N. America in 2023

+ | - | Li | C | Ni | Mn | Co | …

Raw material foundations are growing in North America, but lots more work to do

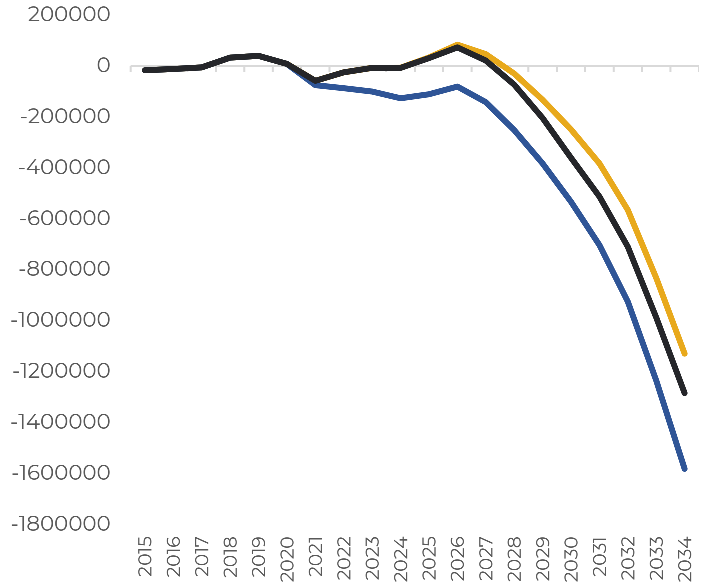


And time is running out - keeping pace with the downstream trajectory will be difficult for less agile upstream markets

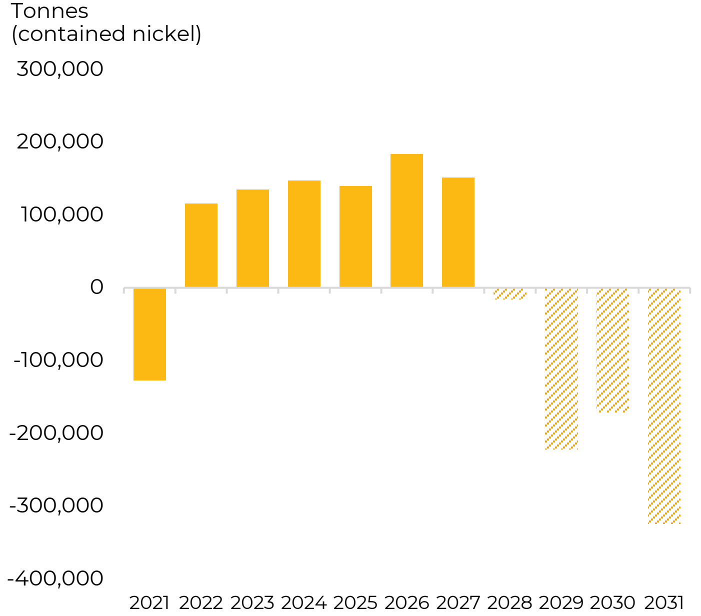
EXTRACTION	CHEMICAL PROCESSING	CATHODE/ANODE PRODUCTION	CELL MANUFACTURING	APPLICATIONS
Li Ni Co C		Cathode Anode		
Market determines price and producers are price takes (Supply/ Demand, Costs, Inventory)	Major raw material costs passed on	Major raw material costs passed on	Major raw material costs passed on	Price Taker (Limited price risk management tools)
RECYCLING				
YEARS TO PRODUCTION				
5 - 25 YEARS	1 - 3 YEARS	2 - 3 YEARS	2 - 5 YEARS	4 - 7 YEARS

A battery raw material cliff edge is on the horizon

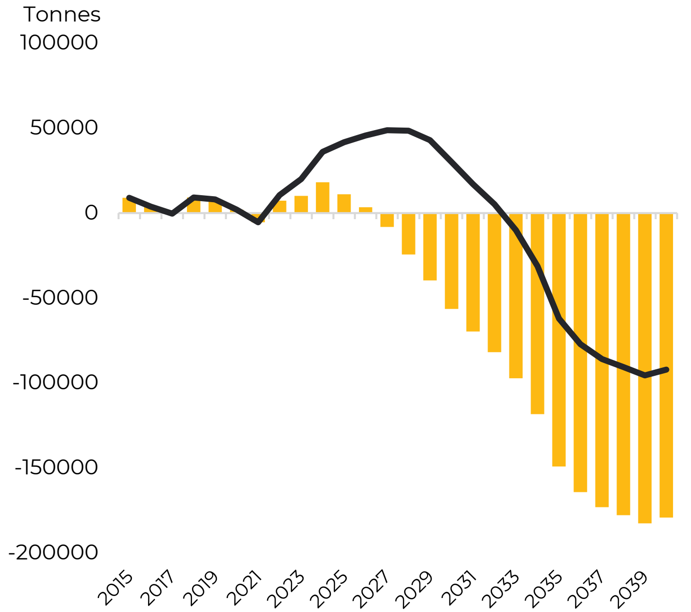
Lithium



Nickel



Cobalt



Money needs to be deployed today to avoid the challenges of the coming decade

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Source: Benchmark Forecasts

Supply chain diversification will be contingent on far more than just financing, permitting & project development

Machinery

Infrastructure

Workforce

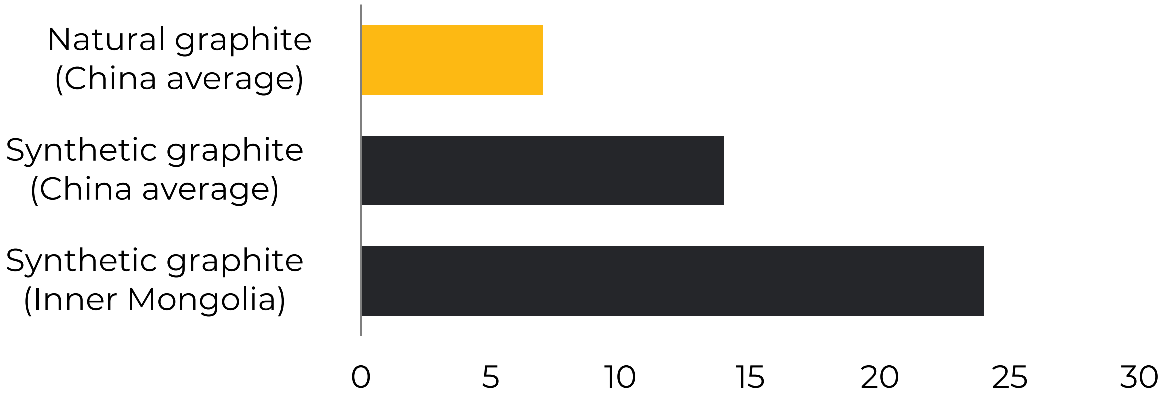
“ We are already seeing intensifying shortages in equipment, infrastructure, refining materials and skilled labour. This is having an inflationary impact on project economics....

Sustainability will form a much greater part of the battery technology optimisation equation

Will energy material selection increasingly be assessed on sustainability metrics?

The high carbon intensity of synthetic graphite anodes is worsened when the graphitisation is carried out in China

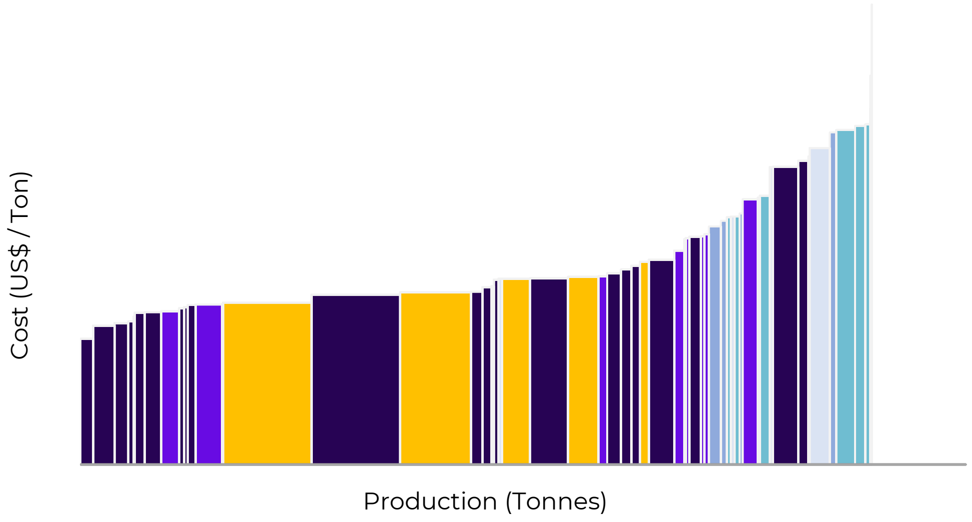
Global warming potential
(kg C02 eq. per kg of graphite anode)



Source: Benchmark Graphite ESG Report

EV economics will ultimately have to absorb higher costs

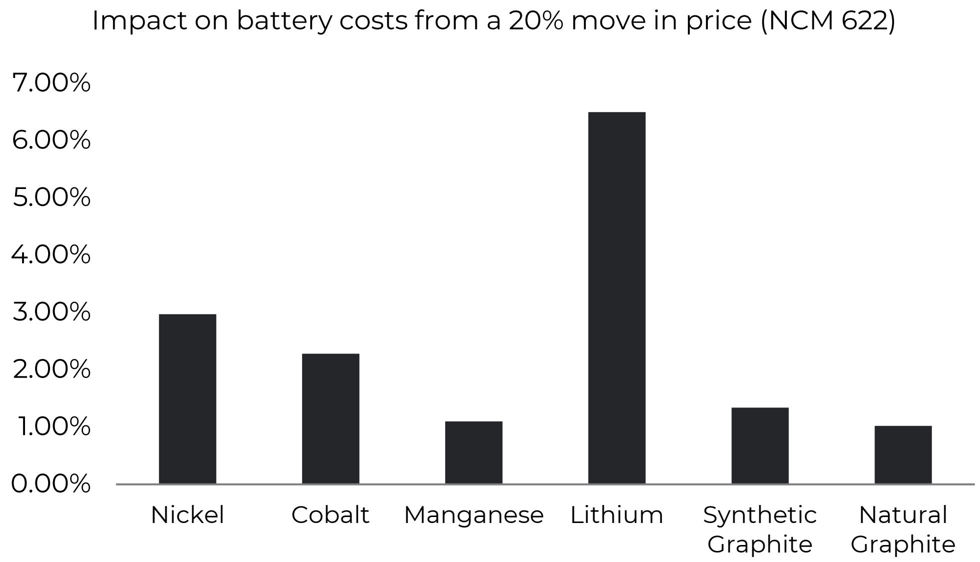
Higher incentive pricing needed to ensure diversified & sustainable supply



New supplies will have to come from higher cost sources of production...

Source: Benchmark Forecasts

This can happen without derailing EV economics

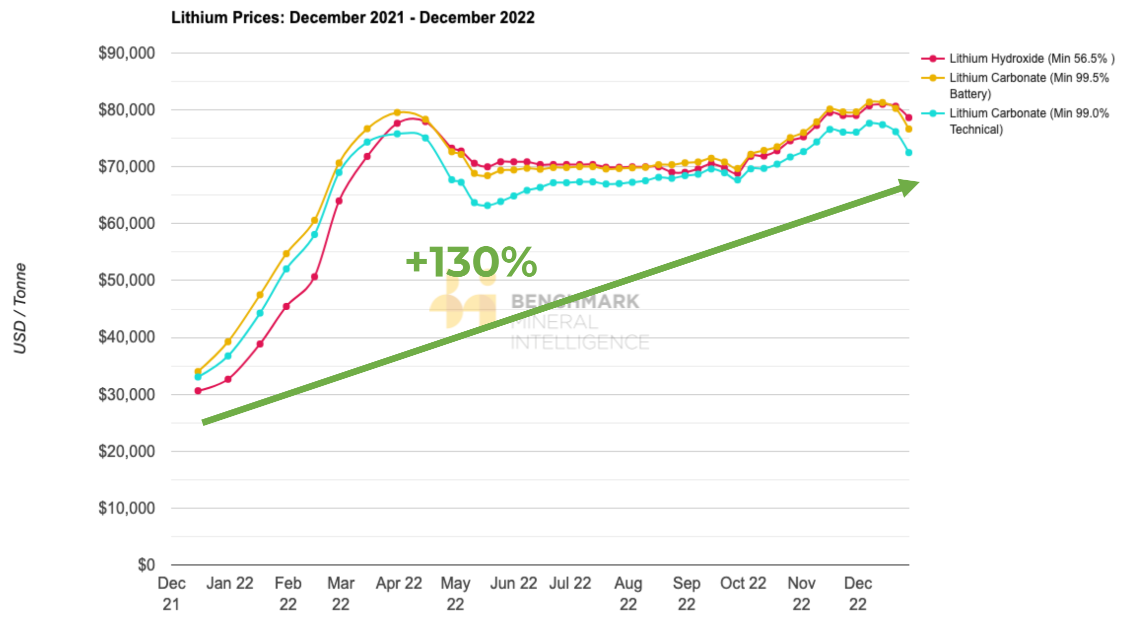


...But if managed correctly this doesn't have to be a disruptive force in battery adoption

Source: Benchmark Battery Cost Model

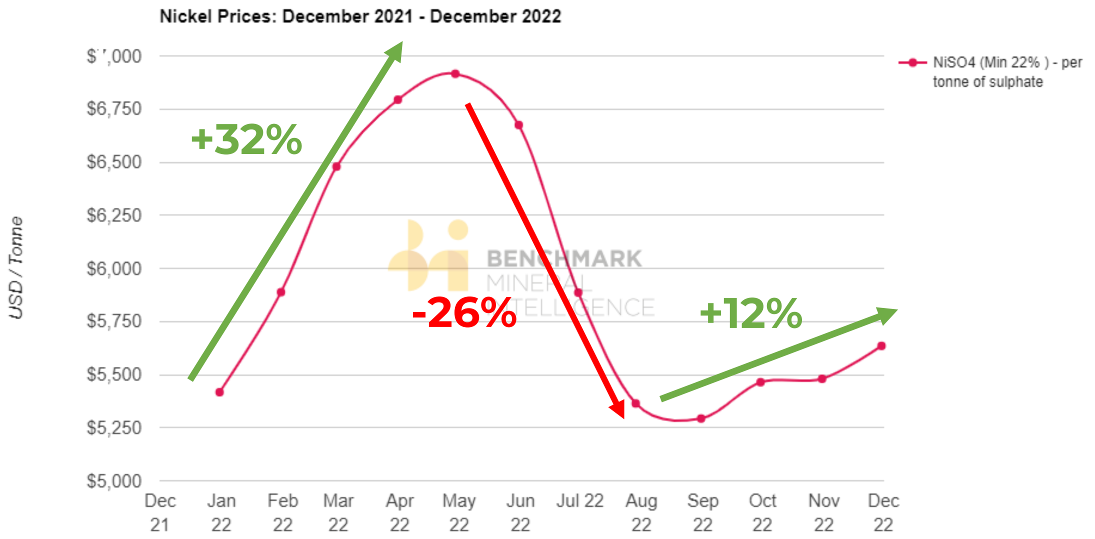
As the supply chain scrambles to keep pace, the threat of price volatility escalates

Benchmark EXW China lithium



Source: Benchmark Lithium Price Assessments

Benchmark NiSO4 (Min 22%)



Source: Benchmark Nickel Price Assessments

This will force further OEM involvement upstream...

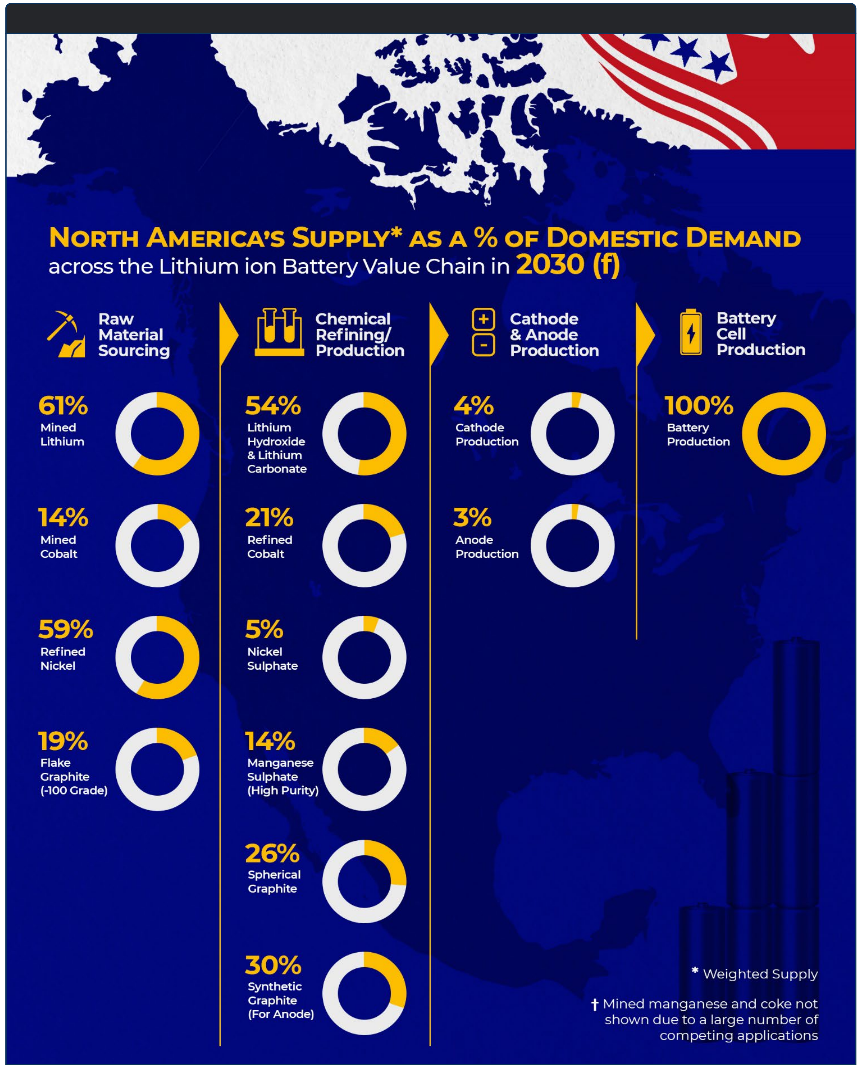
Current supplier | Future supplier | Undisclosed/None

OEM	Mining resources			Battery Materials				Batteries
	Lithium	Nickel	Cobalt	Cathode	Anode	Electrolyte	Separators	
Tesla	Albemarle, Ganfeng, Yahua	Vale BHP Talon metals	Glencore	Sumitomo	BTR, Shanshan, Chinese suppliers Syrah (2024+)	Mitsubishi Chem,Tincl high-Tech	Sumitomo	Panasonic, LGES, CATL
VW	Ganfeng, Vulcan Energy (2026+)	Huayou cobalt Tsingshan	Huayou cobalt Tsingshan	Umicore (2025)				LGES, CATL, SDI
Toyota				Sumitomo				PPES
GM	Controlled Thermal Resources (2024+)	QPM		POSCO (2024+) BASF	POSCO (2024+)			LGES, CATL
Volvo								LGES, SDI, CATL
Daimler								SK On, AESC, LGES, CATL
Stellantis	Vulcan Energy (2026+), Controlled Thermal Resources (2024+)	Terrafame (2025+)						CATL
Ford	Ioneer, Compass, Liontown	Vale, Huayou, BHP						SK On, LGES, CATL
Renault Nissan Mitsubishi	Vulcan Energy (2026+)	Terrafame						LGES, AESC
BMW	Ganfeng, Livent		Glencore, Managem Group					CATL, SDI, AESC

*This table indicates public announcements and is not an exhaustive list. For full details, please contact info@benchmarkminerals.com

Can North American meet localised battery demand?

North America has a long way to go to displace Chinese supply chain dominance



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