Lithium Volatility, Trade Fragmentation, Product-as-a-service, And Other Elements Of An Antifragile Batteries Recycling Business

China International Battery Recycling Week, April 2024

STERLING ACUMEN

Building and scaling critical minerals supply chains for the energy transition.

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Agenda

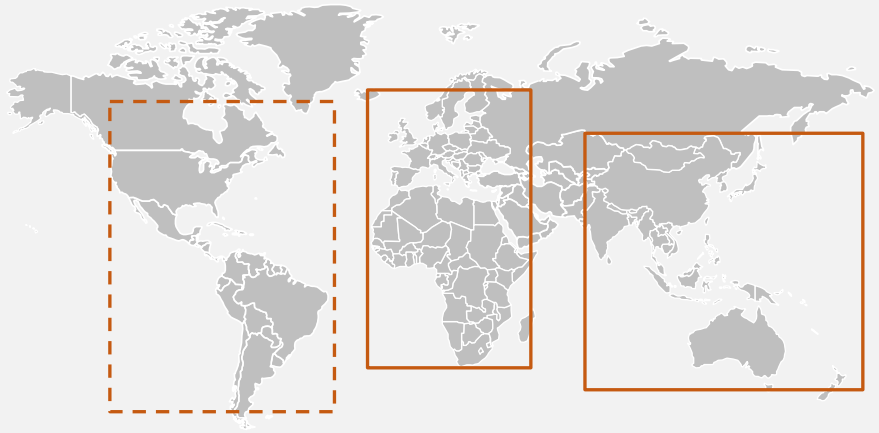
- Presenting Sterling Acumen
- State Of The Li-Ion Battery Industry: Is Decoupling Really Happening? Where Is The Trade Flow Really Diverted?
- Benefiting From Trade Fragmentation: Create Optionality In New Onshoring Markets
  - Offer Redundancy In Existing Integrated Supply Chains
  - Offer Supply Chain Solutions To Recycled Metals' Users
- Benefiting From Lithium Volatility: Hedge Or Forgo Lithium Exposure In Black Mass
  - Lithium risk profile and management through derivatives and contract terms
  - Early extraction from black mass for quick sale vs opportunity to innovate
- Benefiting From Technology To Enable Greater Productivity
- Wrap up

Presenting Sterling Acumen

We Help Participants In The Critical Minerals Value Chain From Mining to Manufacturing Build Resilient And Sustainable Supply Chains

- Unique blended experience in physical commodities (mining to manufacturing), capital markets, and risk management. Legal, financial and commercial problem solver
- Original ability to transfer knowledge, we come-up with creative and novel solutions, and take effective actions
- We craft and execute bespoke engagements depending on clients' needs and position in the value chain
- Independent, not conflicted. We take on engagement only if we can dedicate time and attention
- Outreach capability upstream and downstream
- Great partnerships builders
- Dispute resolution (arbitration and mediation work)

Our Work Covers All Relevant Regions As We Grow



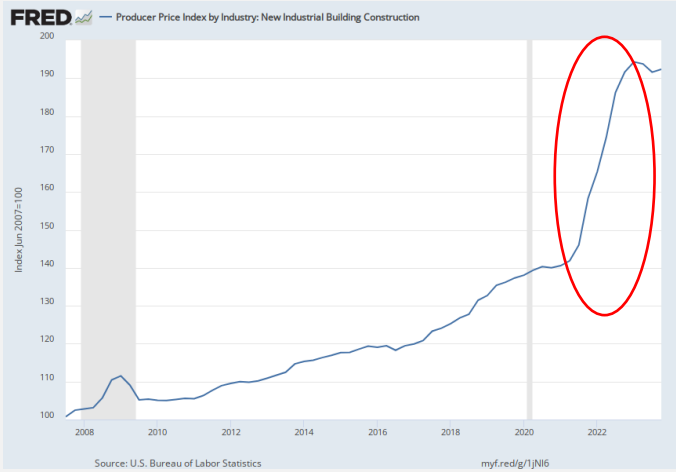
- Illustrative engagements :
  - Commercial and financial transactions due diligence
  - Risks assessment and mitigation
  - Contracts negotiations (e.g., offtakes, sourcing and marketing, structuring, partnerships deals)
  - Strategy and growth acceleration
  - Let's talk!

State Of The Li-Ion Battery Industry: Is It A Case Of Decoupling Between Different Regions?

State Of The Li-Ion Battery Industry: Is Decoupling Really Happening?

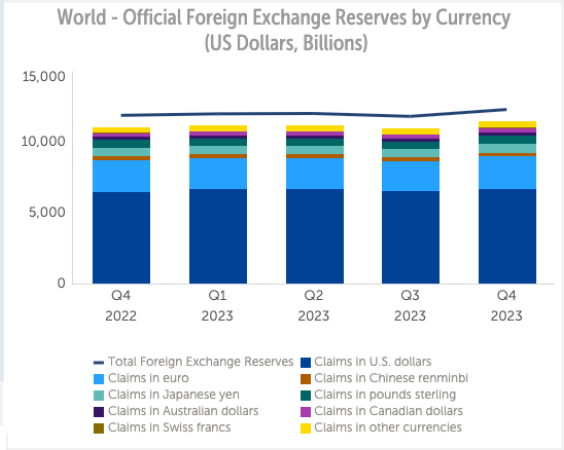
- ✓ Several industrial sectors are decoupling throughout the world, for example reshoring manufacturing efforts in the auto and green industry through policies such as US IRA and EU Net-Zero Industry Act
- ✓ It's the end of USD dominance as settlement currency in international trade
- ✖ However, economic indicators show that there has been little decoupling so far e.g., Trade data and FX reserves data

- ✓ Regulation enables localisation of manufacturing value-adding steps e.g., li-ion batteries giga factories…
- ✖ …except when it doesn't e.g., precursor materials manufacturing due to environmental hurdles and lengthy permitting processes
  - New up and coming playgrounds are getting attention and funding e.g., Morocco, Turkey, and Mexico

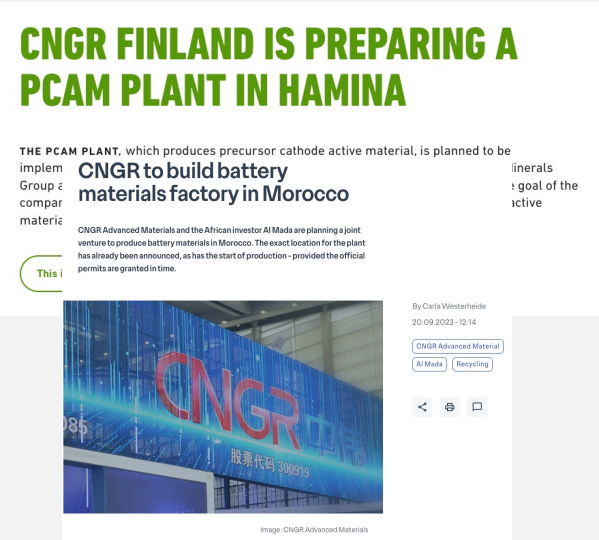


Source: US Bureau of Labor Statistics, retrieved 9 Apr 24, Index 2007 = 100

Source: Brad Setser



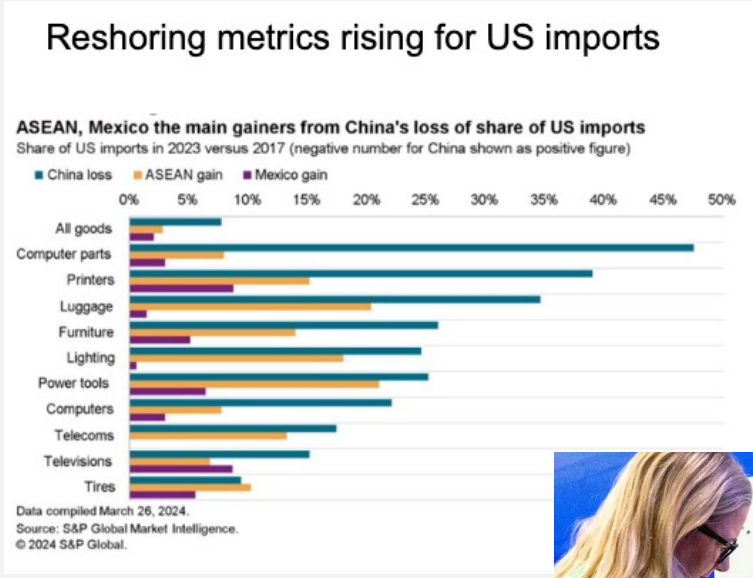
Source: IMF Data



State Of The Li-Ion Battery Industry: Is Global Trading Facing Significant Onshoring? Where Is The Trade Flow Really Diverted?

- ✓ Reshoring production is a de-risking strategy for a number of supply chains in US and can provide near-term advantages for a country's growth and employment
- ✖ However, trade data shows that trade flows are not diverted away from China *back* to the US, rather towards several *other* jurisdictions which will benefit from this movement

  When onshoring is difficult, 'allyshoring' make supply chains more reliable. With critical raw materials needed to deliver on green energy objectives, the European Commission has started to build a series of partnerships
  - E.g., Canada and Ukraine in 2021, Kazakhstan and Namibia in 2022, Argentina, Chile, Zambia, the Democratic Republic of Congo and Greenland in 2023, and Rwanda in 2024
  - Similarly, with the US Minerals Security Partnership



Source: S&P Global Markets Intelligence, April 2024

EU – DRC – Zambia Sign Strategic Partnership, Oct. 23
© European Union

Benefiting From Trade Fragmentation: Create Optionality In New Onshoring Markets

Create Optionality In New Onshoring Markets For Batteries Recycling Businesses

Offer *Redundancy* For Existing (Integrated) Supply Chains

Reducing Dependence On A Single Supply Chain Creates Opportunity for Redundancy

- Weak refining to shredding coverage ratios outside of China make the case in the near term for brick-and-mortar build of recycling solutions provided permitting is cleared
- Similarly to CATL, XTC, EcoPro and others expanding internationally to establish active materials production plants in Europe and US, Asia based recycling companies will expand internationally by 2030
- However, a number of OEMs embrace regionally integrated recycling solutions to 'close the loop'
  - Mercedes x Primobius (Neometals) in Germany
  - Stellantis x Orano in France
  - Volkswagen x PowerCo x Umicore in Europe
- Moreover, some markets will probably call for localised solutions, either home grown like India, or home catering like Saudi Arabia, SEA and some African nations already involved in either secondary cars dealerships or aluminium and copper scrap recycling e.g., Nigeria, Ghana
- Aim at higher growth markets which also happen to be new onshoring (allyshoring) areas i.e., new emerging countries vs advanced economies

Refining-To-Shredding Coverage Ratio Shows Structural Weakness Outside Of China

Black Mass Refining to Shredding Coverage Ratio

	2023e	2029f	2034f
China	71%	70%	67%
Europe	15%	44%	24%
US	1%	14%	13%
Rest of the World	14%	31%	31%
Global	40%	52%	47%

Source: Capacity data Fastmarkets, as of Q1 2024.
Integrated and non-integrated capacity by region.

- A wave of defaults or mergers and acquisitions likely awaits novel black mass producers if scrap feeds lower than expected and/ or EoL batteries hit the secondary market later than expected (2030)
  - Opportunity in the short / medium term to monetise black mass in time and on spec until ecosystem is built

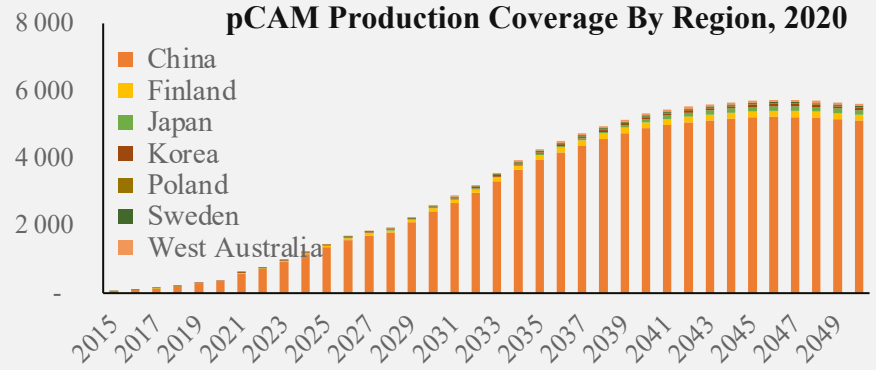
Create Optionality In New Onshoring Markets For Batteries Recycling Businesses

Offer *Supply Chain Solutions* To Recycled Metals Users

Invest In Inexpensive / High Reward Recycling Options

- A brick-and-mortar replica of recycling factories is a valid but expensive strategy. A less costly approach would be to offer supply chain solutions in any combination of the following:
  - Stockpile management inclusive of stable recycled salts / metals
    - Warehousing around gigafactories / active materials suppliers
  - Alliance with mining companies for a 'greener credential' against 'supply chain adherence' deal
  - Alliance with onshore battery grade metal salts upgrading facilities, a few examples in Europe in the Lithium space:
    - Rock tech lithium, AMG lithium, Aurora, Viridian
- Framework agreements (instead of JVs or licensing deals) with new supply chain hubs participants in South Korea, Australia or Canada, navigating degrees of compliance to regulations / share compliance hurdle:
  - US IRA: FEoC (Foreign Entity of Concern)
  - EU CMRA: 65% limit on origin concentration at any step of the value chain + 25% recycling rate + 40% locally processed
  - EU Battery Passport
- EU / other jurisdictions' producer extended responsibility rule and China State Council Action plan of March 2024, where does production go after retirement?
  - Import of retired power batteries and recycled materials

Significant Gaps Remain In New Battery Value Chains To Take Advantage Of



Source: Roskill, Wood Mackenzie, Sterling Acumen, as of 2020

- pCAM manufacturing remains the missing link in the li-ion battery production value chain across many geographies offering an opportunity to tie-up / close the gap for up-and-coming markets
  - Uncertain evolution given environmental license hurdle
  - Caustic soda dependency and sodium sulfate disposal
- Alliance with (p)CAM producers for a 'fill the gaps' solution to OEMs
  - Early Lithium extraction and processing e.g., CNGR and Doosan
  - pCAM standardisation
  - Incorporate drying process in CAM process step instead of pCAM

Benefiting From Lithium Volatility: Hedge Or Forgo Lithium Exposure In Black Mass

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Use Contract Terms Alongside Derivatives To Manage Lithium Price Risk

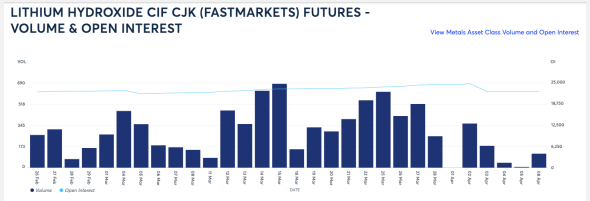
Price Risk, Lithium Leading In BG Raw Materials

	Li Carbonate	Co Sulfate	Ni Sulfate
Volatility '18 – '24	0.017	0.015	0.011
Annualised Vol.	0.271	0.231	0.170
Volatility, past 2yrs	0.020	0.012	0.011
Annualised Vol.	0.319	0.195	0.178
Implied Volatility	n.i.		

Source: Fastmarkets MB-LI-0029, MB-CO-0017, MB-NI-0244

- Lithium seems to be the most volatile of all compound of raw materials in Li-ion batteries
- Lithium is the only metal in EV compound exclusively driven by electrification demand
- No real spot price outside of China most is contract based with fixed or average (monthly, quarterly) or collar pricing. China is a mix of spot and contract
- Developing new supply chains cannot be based on Chinese domestic prices (levels) alone: allow adjustments in term sheets basis Chinese domestic variation rather than outright exposure on ex-works or even CIF /FOB China port prices

Lithium Hedging Nascent In COMEX, GFEX



Contract	opening pi	highest pri	lowest pric	Latest pric	ups and di	Bid price	Buying voli	selling pric	Sales volur	Volume	Open inter	Closing pri	Settlement	Yesterday's	Settlement
lc2404	112400	115550	112400	115000	2600	113000	105	116700	10	526	5892	--	--	113000	112400
lc2405	113600	116300	113600	114950	2200	114800	1	115100	1	3633	21823	--	--	113100	112750
lc2406	114100	116800	114100	115650	3450	115100	2	115800	4	855	12731	--	--	113600	112200
lc2407	114850	117350	114650	116050	2400	116050	3	116100	3	128127	188083	--	--	114150	113650
lc2408	115500	117800	115300	116850	2700	116500	1	117300	1	1396	18452	--	--	114550	114150
lc2409	115850	117750	115300	116850	2500	116950	1	117100	1	1112	8179	--	--	114750	114350
lc2410	115200	117400	115200	117000	3000	116800	2	117400	1	124	5346	--	--	114700	114000
lc2411	115250	117600	115250	117150	3050	116750	1	117200	1	2462	14893	--	--	114750	114100
lc2412	116000	118250	115650	117250	2800	116900	2	117550	1	342	4845	--	--	114650	114450
lc2501	115950	117700	115800	117200	2900	117000	1	117350	1	573	6133	--	--	114850	114300
lc2502	116800	117350	116100	116100	1550	116200	1	117950	1	170	675	--	--	114450	114550
lc2503	116750	118000	116350	116950	2300	115950	1	117000	39	88	217	--	--	114800	114650

- Derivatives market in the making, level of engagement as shown in open interest and volume is increasing in CME and GFEX
- Approximately 25% of the open interest is trading companies
- Good mix of participants in both GFEX and COMEX including producers, smelters
- Singapore stock exchange and LME: no significant trade volumes *yet*
- Long/ Short different indices (sulfates vs metals) creates basis risk for black mass producers with potential losses

Benefiting From Lithium Volatility: Hedge Or Forgo Lithium Exposure In Black Mass

Extract Lithium Early If Possible And Embed Optionality In Term Sheets

Monetise Lithium in Black Mass Conscious Of Price Indices Exposure

Black Mass Price Simulation

	Metals Components			BM Contract(***)		BM Market	
Metal	Contained in Batt. Scrap	RR	Market Price (*)	Contractual Payable	Contract Price	Market Payable(**)	Spot Price
	Kg/Ton	%	USD/Kg	%	USD/Kg	%	USD/Kg
Ni	200.00	95%	16.30	67%	2,075	50%	1,548.79
Co	80.00	95%	29.59	67%	1,507	50%	1,124.26
Li	345.74	94%	14.03	67%	3,054	4%	182.34
			10,477		6,636		2,855

(*) Feb '24 average: LME Cash Official, MB-NI-0244, MB-CO-0005, MB-CO-0017, MB-LI-0029
(**) Feb '24 average: Fastmarkets Payables, MB-BMS-0004, MB-BMS-0005, MB-BMS-0009
(***) Assumes 100% yield, no bonus/ penalties

Black Mass Price Sensitivity

LCE Price	LCE RR 45%	65%	80%	85%	90%	95%
7.00	4,312	4,636	4,879	4,960	5,041	5,122
11.31	4,761	5,285	5,679	5,810	5,941	6,072
23.25	6,005	7,083	7,890	8,160	8,429	8,698
60.74	9,913	12,727	14,837	15,541	16,244	16,948
80.00	11,921	15,628	18,407	19,334	20,261	21,187

Use Contractual Terms Negotiations To Extract Maximum Value From Black Mass

- Aim at high Lithium recovery rate (>95%) in contract to avoid free metal situation
  - Implied lithium recovery rate indicated as high as 85% at low price levels?
- Use early extraction of Lithium from black mass for different commercial routes and risks isolation:
  - CNGR and Doosan in South Korea
  - Rocktech Lithium and Electra in Canada
  - Ascend and Elemental in Poland
- Nickel metal volatility is also an issue (volatility and basis risks)
  - Increase black mass salability through higher Nickel content
  - Characterisation as a product
- Build lithium production long positions with partner mining companies to dampen volatility
- There is finally a relationship between lithium price level and volatility, and RnD / innovation in batteries

Benefiting From Technology To Enable Greater Productivity

Benefiting From Technology To Enable Greater Productivity

This Is Not About Recycling Technology Rather Productivity Applied To Recycling Processes

Innovations (Optimisations?) Marginally Improving Productivity

- Reverse logistics
- Industry 4.0 /5.0
- Data and traceability
- Process optimisation: churn scrap fast in and out of shredding plants – working capital optimal management
- Product optimisation: reduce lithium usage in batteries, increase energy density, increase reliance on electrolyte performance vs cathode (Carbonate vs Hydroxide and Industrial Grade vs Battery Grade)
- pCAM product standardisation
- Integrate recycling solution with battery mechanical treatment processing steps e.g., at scrapyards / EV dismantlers and potentially capture a greater scope of recyclable material

Innovations That Will Benefit From Chaos (Materialising Market Risks)

- Aim for ‘internet’ like inventions: gear RnD towards creativity that will benefit all, not one silo, one industry or one geography
- Sell a service rather than a product i.e., recycling capacity and product in one depending on where OEMs are in their targets
  - Compliance or other
  - Traceability for recycled content
  - High quality black mass (mechanical process innovation vs just integration)
- Be a ‘solution’ provider with second life repurposing offer coupled to recycling service
  - LFP
  - State of health and deep discharge services / data management
  - Price optimiser toggle: sale for second life vs recycle
- Get yourself exposed to local RnD / tech solutions: provide (inexpensive) support and prototyping

Wrap-up

Takeaways

- The advent of manufacturing and trade onshoring efforts across regions provide for the need to create recycling businesses that will be resilient and even benefit from adverse shocks and volatility
- Be part of new onshoring solutions for recycling businesses:
  - Reducing dependence on a single supply chain creates opportunity for redundancy, specially at a time of low hydrometallurgy to shredding regional capacity ratio (asset heavy)
  - Create service-level supply chain solutions where gaps are identified and stubborn (asset light strategy)
- Extract more value from black mass through lithium price volatility management
  - Start with attention to contract terms and choice of price indices, market hedging tools, and
  - An early lithium extraction from black mass if available
- Technology innovation still has room to develop towards more productivity
  - Optimisation is not innovation, support prototyping locally as gateway to volume
  - Facilitating toggle decision making for second life vs recycling not getting enough attention

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