LITHIUM RESEARCH NOTE

Part of Benchmark's lithium price assessment subscription

July 2019

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BENCHMARK MINERAL INTELLIGENCE

Lithium's price paradox

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The introduction of new supply has seen a gradual correction in the lithium market over the past 18 months, but despite the majority of new chemical projects being slow to deliver, share prices and investor sentiment remain tied to short-term price trends rather than underlying market fundamentals.

With capital markets failing to confront the growing prospect of major supply deficits as the electric vehicle (EV) revolution gathers pace, Benchmark Minerals addresses a deceptive narrative that has engulfed the market and asks how the industry can create a more reflective price mechanism

The unsustainability of lithium's record high price spike was exposed in early-2018 as the industry began to feel the effects of the race to new production which had occurred in Australia's spodumene sector.

By mid-2018, with four new hard rock operations set for production, spodumene had overtaken brine as the leading source of chemical feedstock production. The number of active mines had climbed from 1 in 2016 to 9 by the end of 2018.

The false narrative which emerged from these expansions and spilled over into 2019 was that the industry was awash with battery-grade lithium chemicals, sufficient to support rapid electrification over coming years.

While the supply response has addressed the relatively minor growth of today, it is still far from meeting the needs of tomorrow's EV expansions.

A correction in pricing – although it should be mentioned that lithium chemical prices finished H1 2019 at 50% higher than at the end of 2015, on average – has unsurprisingly seen leading producers report weaker financials than when the market was at its peak.

More worryingly, however, this has caused investor sentiment to turn, sending share prices into a nosedive for many and creating a growing shortfall of capital to fund the next generation of lithium expansions.

Spectators that flocked to the market in 2016 on the promise of an EV super-cycle have left before the warm up, let alone the main event.

While a downturn in prices has reflected a necessary correction towards near-term market fundamentals, it fails to represent the increasing possibility of another major deficit in the market by the early-2020s, creating a deceptive narrative in both share prices and surrounding markets.

NEW SUPPLY REALITIES

According to **Benchmark Minerals**' latest Q1 lithium forecast update (email info@benchmarkminerals.com for more information), lithium chemical production is set to grow from around 285kt in 2018 to 350kt in 2019.

While this represents major growth in an industry which was only 160kt back in 2015, it still lags far behind the expansion targets laid out at the peak of the market.

Since 2016, a total of 5 new lithium chemical (conversion) plants have come into production. Another 3 have expanded production capacity to meet market growth.

China's 2019 lithium expansion targets

	Company name	Target capacity (tpa)	Due for completion	Current status	Utilisation rate
Tier 1	Ganfeng	20,000	2018	Production	>90%
	Ganfeng	17,500	2018	Production	>90%
	Tianqi	24,000	2019	Commissioning	-
	Livent	9,000	2019	Production	>90%
	Albemarle	20,000	H1 2019	Production	<60%
Tier 2	General Lithium	16,000	Q4 2018	Production	75%
	Yahua	20,000	Q4 2018	Construction	-
	Lanke	20,000	Q4 2019	Construction	-
Tier 3	Jiangte Motor	25,000	Q2 2018	Production	28%
	Qinghai Lithium	10,000	2019	Construction	
	Dingsheng	10,000	Q2 2019	Commissioning	-
	Zhiyuan	13,000	2018	Production	60%
	Guangxi Tianyuan	25,000	Q3 2019	Construction	-
	Minmetals Salt Lake	10,000	Q2 2019	Commissioning	-
	Tangshan Xinfeng	20,000	Q3 2019	Construction	-
	Ganzhou Yuanhuitong	10,000	Q3 2019	Construction	-
	Sichuan Siterui	5,000	Q1 2019	Construction	-
	Jiangxi Yunwei	10,000	Q3 2019	Construction	-
	Inner Mongolia Zhili	15,000	Q4 2019	Construction	-
	Zangge	10,000	2019	Construction	-
	Liaoning Hongjing	20,000	2019	Construction	-
	Wuli Jinhaiwan	20,000	2019	Construction	-
	Hebei Tianyuan	12,000	2019	Construction	-
	Nanshi	10,000	2019	Construction	-
	Youngy	20,000	2019	Construction	-

Source: Benchmark Mineral Intelligence

Of these expansions, only three have come into production on schedule and at full capacity – Ganfeng's Xinyu and Ningdu plants and Livent's three-stage, 9kta lithium hydroxide expansion.

Outside of the tier one producers in China, new capacities have either been delayed or put on hold as market conditions turned. To date, General Lithium and Jiangte Motor are the only non-tier 1 Chinese producers to execute major (>10ktpa) new capacity, and these were both delayed by several months.

More major expansions outside of China are in the pipeline for later this year, but as is often the case, timelines for the ramp up of these projects have been vague, with majors building in a buffer for expected delays.

These delays and misleading timelines add to the myth of oversupply. If all expansions had been taken at face-value at the height of the market, we would see almost an additional 500,000 tonnes of lithium chemical capacity by 2020. In reality this figure will be less than 40% of this number.

What's more, the type and quality of this new production capacity only perpetuates the smoke and mirrors state the industry has floated in for the past four years.

As with any new lithium chemical production, only a proportion of this material will likely be sold into the battery sector from the outset. Even leading producers have problems meeting specs in the initial stages of production.

Even more pressing, however, is the type of lithium production these plants are targeting.

Of the additional 65,000 tonnes of lithium chemical production that is expected to reach the market in 2019, over 75% is being targeted at lithium hydroxide.

Rapidly changing cathode chemistry requirements means the growth outlook for carbonate vs hydroxide continues to shift, as do the competitiveness of various supply chains to support these chemical expansions.

DISPELLING COST CURVE MYTHS

A symptom of the emergence of new spodumene resources has been the question of which feedstock is the most economic source of lithium chemical production.

For a generation the low-cost benefits of brine extraction, coupled with an industry dominated by lithium carbonate, saw South American projects cement themselves firmly at the low-end of the industry cost curve.

The potential shift away from lithium carbonate as the primary chemical used in lithium ion battery cathodes, and changes to the Chilean royalty structure, have however put this position in doubt over recent years.

The ability to produce lithium hydroxide directly from spodumene - rather than via lithium carbonate, as is required in the brine process – means the cost curve for lithium hydroxide production can take a distinctly different shape than that of carbonate.

In turn, this challenges the previously held belief that brine is the more competitive source of production and could see spodumene prove the favoured feedstock of tomorrow's lithium ion battery industry.

Inherent in this hypothesis, however, is firstly that the battery market will rapidly adopt the high-nickel, hydroxide-dependent cathode chemistries (a proposition that looks increasingly unlikely in the near-term) and secondly, that all spodumene producers are integrated lithium chemical suppliers.

Back in 2016 when Greenbushes was the only spodumene game in town, this of course was the case through Albemarle and Tianqi's ownership.

Fast forward to 2019, and none of the new spodumene assets are fully owned by chemical converters, although the vast majority of output is tied into offtake with leading chemical producers.

These offtake arrangements have often been structured to allow for a return for spodumene producers, which in many cases are still operating at above their target cost levels.

As a result, you are left with the cost of feedstock material proving prohibitive to China's chemical converters taking hydroxide production costs below brine alternatives, even when bypassing the carbonate production route.

While this makes for an interesting hypothetical exchange, it is largely irrelevant in the longer-term context of the demand side story.

The question in the lithium market is no longer whether spodumene or brine resources will be developed – both are needed to take us anywhere near the growth estimates of the next 2-3 years. The new questions is what other channels of supply will be developed to take us close to the demand forecasts for 2025 and beyond.

A QUESTION OF TIMING

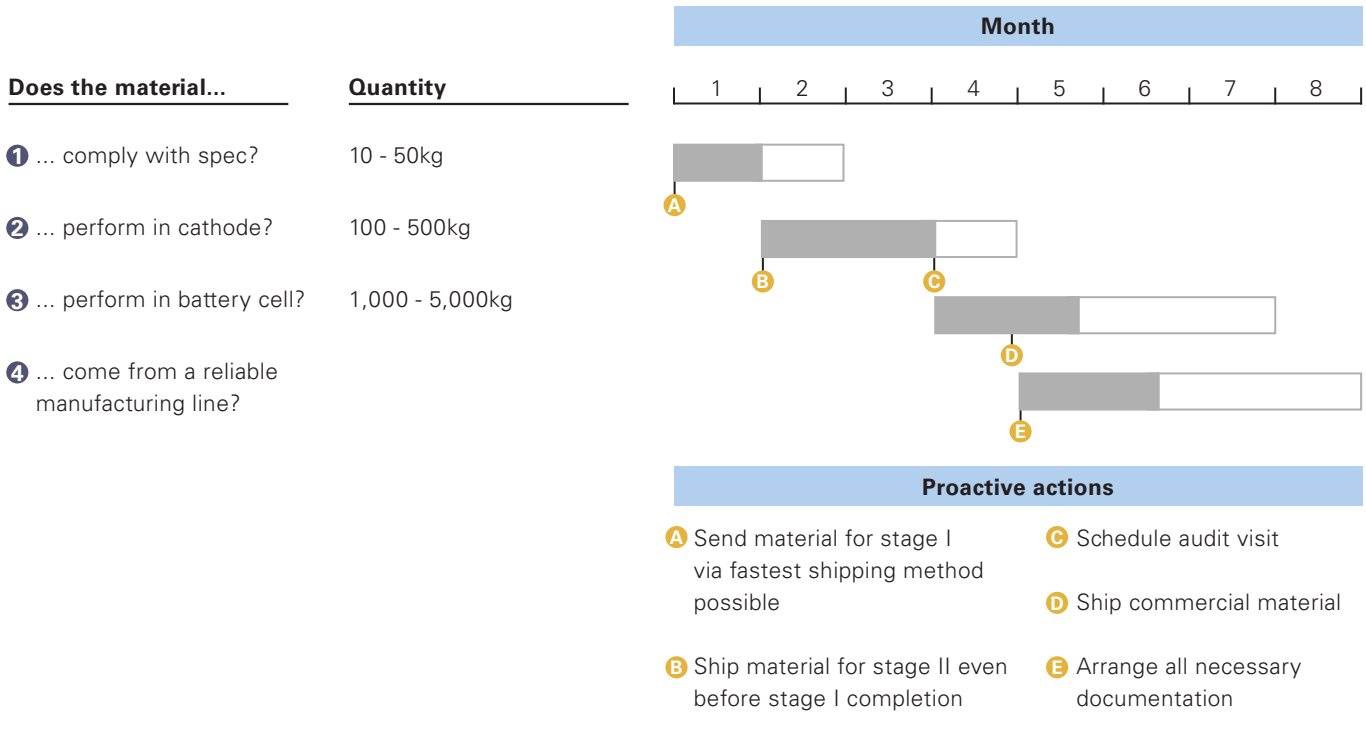
The timing of the surge in lithium ion battery production continues to play a role in limiting the development of new lithium resources.

While the development of a new mine can take 3-4 years when the money is in place, the development of new integrated battery-grade chemical conversion capacity is even longer.

This makes the coming 12-18 months even more critical in addressing the bottlenecks lined up for 2023 and beyond.

Money needs to start flowing into the lithium market quickly, or the road to electrification will be stunted by lithium supply, in even the most conservative of forecasts.

Example raw material qualification process and timeline - best case scenario



Source: Benchmark Mineral Intelligence

In **Benchmark Minerals'** models, lithium supply has to increase at a 19% CAGR over the next 6 years to meet 2025 demand. Even at the height of the market, the industry only managed to grow by 11% per year, on average, from 2015-2018.

And even when this money does arrive and new projects are established, qualification of new material sources is not going to happen overnight.

No new material is going to find its way into a Chevrolet Bolt, Tesla Model 3, or any other model charged with leading the cause of wide-spread electrification, without a significant lead time of contract negotiations, testing and qualifications.

With all of this in mind, the financing of new projects needs to happen now, a process which the current industry pricing environment is prohibiting.

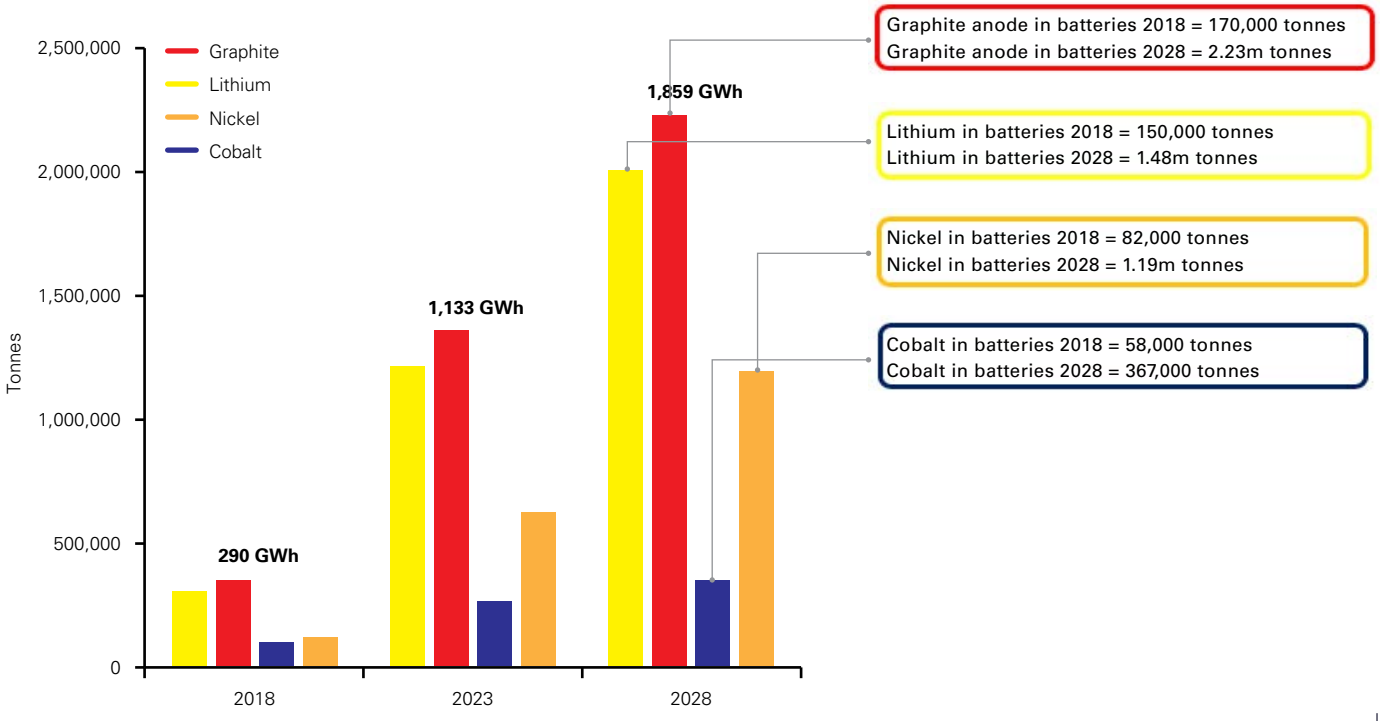
It is prohibitive both in the literal, market dynamic sense, but also in the process of price transparency allowing investors to efficiently allocate capital.

And the risk surrounding price transparency threatens to get worse before it gets better.

Despite the positive potential for the introduction of derivative contracts into the market, the negative risks of derivate contracts with no liquidity could be far greater. As has been seen in the world of cobalt, a derivative contract can often add more confusion than clarity.

The profound impact of the megafactories on raw material demand

Assuming a 100% utilisation rate, these are the numbers....



Source: Benchmark Mineral Intelligence

Providing greater visibility on pricing has been central to **Benchmark Minerals**' business from day one. Working with the supply chain to develop an accurate and reflective price assessment mechanism that is useful to the industry, first and foremost.

The development of other financial instruments in the market can only be effective if tied to an accepted industry price. **Benchmark Minerals** provides that price and the next stages for market evolution will be the integration of these prices as formal benchmarks in contracts.

It is only when this integration occurs that a true spot market can emerge, and more visibility will give investors the confidence to address a growing problem for the entire battery supply chain.

As of June 2019, the **Benchmark Minerals** Lithium ion Battery Megafactory Assessment stood just shy of 2 TWh capacity by 2028. To put that in context, that would equate to 1.5m tonnes lithium demand just from these operations if they were to reach full capacity, compared to total lithium ion battery demand of 150,000 tonnes LCE in 2018.

These new facilities will not all reach the market on time and at their expected capacity levels, but regardless this will see a step change in consumption rates.

For those consumption rates to be met, the lithium market must overcome the disparity between the short and long-term realities in lithium pricing.