# INDUSTRY REPORT //Lithium

Lithium Market Update 2021 The Worst is Actually Behind Us

#### We discuss:

- It Was the Best of Times, It Was the Worst of Times... We could do worse for words than borrowing from Dickens, but we really experienced a tale of two markets between 2016 and 2020. Demand continued to grow, it was a supply response that turned things on its head. We firmly believe better days are here to stay for lithium.
- Clumps and Lumps Supply of lithium chemicals, like supply of most mine-derived commodities, will arrive in big, discrete clumps with the commissioning and ramp of new projects. Timing is always going to be a little suspect, but we can't do much better than rely on the forecasts from respectable companies as to their supply plans.
- Demand Stays Strong People seem to like extreme positions. Let's lay out our much more wishy-washy take. We will not all be driving a battery electric car by 2030, and we doubt that governments really have the courage to outright ban the sale of internal combustion vehicles. However, we also believe that vehicle electrification is an unstoppable trend because it has the dual benefits of reducing emissions while making personal vehicles less expensive, if done properly. Demand for lithium is not going to decline, it just isn't going to rise as rapidly as some analysts would like, that's all.
- Our 2021 Price Deck We haven't released one of these for a while. Some are going to be disappointed it doesn't show lithium prices going up to \$30,000 a tonne, and too bad for them because that's not realistic. What it does show, based on reasonably conservative demand forecasting and the stated production goals of junior and senior producers, is a sustainable long-term supply dynamic and relatively stable pricing. That would be great for the industry.

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Jon Hykawy, PhD President jon@stormcrow.ca

Tom Chudnovsky Managing Partner tom@stormcrow.ca

### Summary

Much has happened since our last big lithium market update, most notably the pandemic. Sales of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) has continued at a solid pace. But while various levels of government have continued to offer encouragement in the form of subsidies to automotive manufacturers that continue their plans to roll out more BEVs and PHEVs, there have been a few discouraging signs, as well.

We remain fixed in our belief that vehicle electrification is an unstoppable trend, for the simple reason that the cheapest way to make a car is to put a small battery in it and call it a day. We also continue to reject the position that BEVs are the only right and true way for the industry to proceed, for the simple reason that a BEV still requires a buyer to make compromises, and compromises make for lousy marketing campaigns.

Nonetheless, one of the things that we have believed for years is that the electric vehicle supply chain will be mature when it can reliably supply chemicals like lithium to the cathode material manufacturers, battery producers and automobile manufacturers reliably and at a reasonably steady price. As we will show, the good news (if we take current and erstwhile producers at face value and project solid but not ridiculous gains for BEVs and PHEVs in the market) is that prices won't be descending back to the levels of 2019 again. The bad news, if there is any, is that those prices also won't be rocketing back to the levels of 2016 and 2017 anytime soon, either. And stability in pricing is not a bad thing.

## What a Year(s)

It isn't really possible to discuss 2020 without mentioning the pandemic. That disruption had a significant effect on sales of all types of products and will likely have a deep and ongoing impact on the structure of global supply chains. But the simple fact, especially for critical materials such as those used in the manufacture of electric vehicles, is that there just aren't that many places in the world that can produce these materials economically, so geographically diversifying your supply chain might not be possible. In addition, reliable and consistent production of these types of materials takes a lot of effort, experience and vigilance, and is best done by companies that know how. Also, we need to acknowledge that these markets are never really going to be as gigantic as, for example, the market for iron ore or the market for copper. A few good, although not necessarily the absolute best, projects and suppliers are all that is likely needed to keep the lithium market humming along.

But the juniors in the lithium industry constantly want (latent) demand to shoot past supply levels and push prices up and up and up. In 2016 and 2017, they got

their wish. The then-current major producers had already taken the position that they would consider increasing capacity only when demand justified doing so and, to a degree, were also hamstrung by regulations around their projects. Thus, they had little opportunity to significantly increase capacity before they were faced with enough orders that supply couldn't be guaranteed.

Now, unlike in a lot of other critical materials that are described as "essential" or "irreplaceable", lithium actually is, or at least it is in a lithium battery. A lithium battery without lithium is not a lithium battery. It won't have the same voltage, a problem in itself. If it's a secondary (rechargeable) battery, then it won't have anything like the same energy density or power capacity. Yes, I guess the consumer electronics industry could revert to using nickel-metal hydride batteries, but who wants to have a modern cell phone that needs to be recharged every couple of hours and that just can't perform anything like our current cell phones? Without lithium in the battery, a number of industries would have serious decisions to make.

So, when supply proved insufficient, the neediest buyers bid up price. Average (remember, AVERAGE) price for technical-grade lithium carbonate in 2014 was about USD\$4,961 per tonne. In 2017, that rose to USD\$16,476 per tonne. The actual daily price peak during this boom was about USD\$25,000 per tonne in late 2017. The price of other lithium chemicals, especially the purer and more carefully processed battery-grade materials, were even more expensive.

Year	Tech CO3	Batt CO3	Tech OH	Batt OH
2009	\$ 4,558			
2010	\$ 4,410			
2011	\$ 4,348	\$ 5,015		
2012	\$ 5,333	\$ 5,612	\$ 5,527	
2013	\$ 5,375	\$ 5,879	\$ 5,979	
2014	\$ 4,961	\$ 5,620	\$ 5,587	
2015	\$ 6,532	\$ 7,817	\$ 6,854	
2016	\$ 16,078	\$ 18,930	\$ 19,955	\$ 21,148
2017	\$ 16,476	\$ 18,635	\$ 17,703	\$ 18,807
2018	\$ 13,542	\$ 15,092	\$ 16,087	\$ 17,538
2019	\$ 7,276	\$ 8,456	\$ 8,968	\$ 9,957
2020	\$ 4,619	\$ 5,448	\$ 5,514	\$ 6,232

Figure 1 – Average Lithium Chemical Prices (USD/tonne, converted from RMB and corrected for tax)

Source: Asian Metal

There were more than a few people in 2016 that would have told you that we were "experiencing a new paradigm", that lithium prices would be doing nothing but

moving up and to the right, forever. The argument they made is simple, that the amount of lithium contained in a battery is tiny so that the added cost to a finished battery pack from quadrupling or quintupling or even trevigintupling (that's 23x, for those keeping score) the price of lithium just doesn't matter, because if you need it then you need it! It's a simple argument that also happens to be spectacularly wrong because it ignores the other side of the equation, the question of how many groups could make the same lithium. If the price rises by a factor of 4x, 5x or 23x, then there is that much more incentive for someone else to make the chemicals and line up to sell them for less than the current market price to gain market share. If enough groups can eventually make lithium chemicals (or any other critical commodity) and we reach oversupply, then we can sit back and watch prices slide back to subsistence levels.

So, welcome to the period 2018-2020. Supply of feedstock, especially spodumene which is the standard mineral feedstock for making lithium, rose dramatically. New supply had its expected negative effect on pricing and then more than a few of these producers were then forced to curtail their output in one way or another. Even so, prices for technical-grade lithium carbonate dipped almost to USD\$4,000 per tonne in mid-2020. This was a low-enough price for the chemical that miners producing spodumene feedstock were mostly selling at a loss, if they were trying to fit into this market. Those higher-cost suppliers dropped out of the market, at least temporarily, and we would expect a decline in supply to push prices higher.

In spite of that, there were "experts" out there who, apparently, owned (a) a subscription to one of the pricing services, (b) a copy of Excel, (c) a printer and (d) a ruler and pencil, who dutifully plotted out a graph of plunging prices and woefully concluded prices had further to fall in 2020. Well, no. Again, most companies are not stupid enough to continue to try to sell product at a loss and make it up on volume, as the old joke goes. Instead, those suppliers did cut their losses and curtail output. As expected, prices have picked up since, demand remains robust and lithium chemical prices are looking much better.

In fact, it's worth pointing out that demand did not flag, at any point in the cycle. This is precisely a story of supply falling behind, and then running ahead, of demand. We can see this if we look at tallies for things like BEV and PHEV purchases in the world. Not that BEV and PHEV batteries are the sole driving force for lithium demand, but they play a major role. And there has been no problem with BEV and PHEV demand during this period:

Year	2015	2016	2017	2018	2019	2020		
China	212,457	340,444	581,058	1,082,765	1,062,287	1,162,116		
Europe	189,420	207,338	250,853	386,519	568,259	1,372,014		
USA	115,188	161,263	202,218	366,041	327,645	296,928		
Other	40,956	51,195	107,509	186,860	161,263	153,584		
Global	558,020	760,239	1,141,638	2,022,184	2,119,454	2,984,642		

Figure 2 – BEV and PHEV Demand (Unit Vehicles)

Source: IEA, Stormcrow

## **Keeping 'em Guessing**

As the great Yogi Berra is quoted as saying, "It's tough to make predictions, especially about the future." We are not inclined to disagree. But there is an accepted way to try going about it.

First, you need a model that is based on data. It's possible for us to get data on the pricing of various grades of lithium chemicals. Unfortunately, all lithium chemicals are not equal, so one company's "battery-grade" can be quite a bit different than another company's "battery-grade", but at least these data provide us a starting point.

Similarly, we need ideas about how much was produced. Fortunately, that isn't impossible. It would be really hard to make a living as a stealth miner of 20,000 tonnes a year lithium carbonate equivalent (LCE, the usual way contained lithium is described), since most companies actually want to sell their products. So we can enumerate and tally up the production from all the mines and all the sources, and we can cross-check these values with the work of others and sources like the US Geological Survey. Lo and behold, these sources mostly agree because, as we said above, very few companies are trying to keep their production of lithium chemicals a secret.

We also need to know what latent demand might look like. This a bit more conceptual. Obviously, REAL demand can't exceed REAL supply. But there are stockpiles out there, which can get drawn down in times of booming demand and restrained supply. We can tally up the BEVs and PHEVs made in various places, or at least look at the tallies from others. We can look at numbers and models of cell phones sold. We can make estimates for use in certain industries like ceramics and aluminum based on past measurement, industry metrics and trends. We can, basically, get as granular as we want and have the money to try to be.

Then we look at the relationships between price and those data. Specifically, I look at correlations, to start. I like to know that the data are pushing the prices in

the right direction. For example, if supply is constrained and it looks like demand might have exceeded supply during some period, it would be nice (actually, necessary) to see that price went up. That represents a negative correlation, price going up as excess supply goes down. If it's a strong correlation, near -1, then that relationship may have a great deal of predictive ability.

But that doesn't mean the relationship between the two is linear. In fact, in the case of excess supply and price that relationship probably isn't anything like a linear one. As an example, for my data on the space the correlation coefficient back to 2010 between excess supply available during a year and average technical-grade lithium carbonate price is -0.819, suggesting that 67% of the variation in price of technical-grade lithium carbonate is explained by changes in scarcity of the material. So that's good. But if you plot excess supply against price, the graph looks like an asymptotic curve as price seems to flatten out with lots of excess supply but rises dramatically as demand nears or exceeds available production.

Now, more complications regarding our analysis. Do you look just at the scarcity of the chemical in the same year as the price in which you are interested, or at the scarcity during the previous year or even in the coming year? If a product is sold on a contract basis, it's entirely possible (and happens all the time in marketing) that the scarcity this year heavily influences price next year, because the contracts for delivery next year are being written now! And if you include more than one variable in your analysis, you must also ensure that those variables are not heavily cross-correlated. That is, a big change in one variable doesn't necessarily result in a corresponding big change in the other variable, or you can end up double-counting the effect.

The formula I generally use to predict lithium prices relies predominantly on two variables, and the equation contains five unknowns that allow us to tailor the function to historical values. Because we can rely on no more than a decade worth of lithium pricing (no one really cared that much about lithium before 2009 or so, and the market has dramatically changed since) we can't have much more than five unknowns or we are basically just customizing a curve to fit the data we have, and that curve likely has no predictive value. However, in the case of the pricing for technical-grade lithium carbonate, as an example, we think we have done ok. Here is a plot of actual and our fitted prices for the years over which we tried to fit the data:



Figure 3 – Actual versus Estimated Technical-Grade Lithium Carbonate Prices (USD/tonne)

Our estimates are usually within a few hundred dollars of the actual average price for the year. There are good reasons for why estimated prices should likely undershoot the real price on the way up and overshoot on the way down, and good reasons for why the real price should oscillate a bit after a supply shock. Problem is, if we introduce terms and variables for that, we run out of data points to use to generate the correct coefficients and the resulting expression, again, likely has no predictive value. We prefer to try to model to get the magnitude of change broadly correct and leave it at that.

So, let's say that we can generate expressions we are confident in for each of the chemicals (technical-grade lithium carbonate and lithium hydroxide, battery-grade lithium carbonate and lithium hydroxide). Now we can use these formulae, fitted to historical data, to generate predicted prices into the future. But there are some pitfalls to doing this that we all need to understand.

One source of error is that our expression is built with historical data. If that expression contains, as a variable, total LCE demand in a given year, for example, our expression will likely provide very reliable predictions providing demand doesn't wander outside the historical margins. But future lithium demand will almost certainly be higher than ever before, so we are required to extrapolate to a demand level that has never before been seen. If pricing, for example, was historically linear with respect to total demand, there is no guarantee that much higher levels of demand would elicit the same linear response in price, much less with the same slope.

Source: Stormcrow (2021)

Another source of possible error is more obvious. Excess supply is one important variable in many of our expressions describing historical lithium pricing. To calculate excess supply, or lack of, we need to know both supply and demand. To work out what future supply will be, all we can do is take the junior and senior producers at their words. That is, if a company says that 20,000 tonnes LCE will begin to be produced in 2023, they are credible and have reasonable prospects of deploying the money to get into production, then we must assume that some fraction of 20,000 tonnes of annual production will be output in 2023 and rise to the nameplate value over time. But at least someone, somewhere, has put a line in the sand and declared that they will produce some amount of product on some schedule. And if a company decides to shutter production during a period of low pricing, all bets are off.

Predicted demand has no guardrails at all, though. Anyone is free to make as outrageous a claim as they would like regarding demand. For example, it wasn't that long ago that there were individual analysts and what are usually considered respectable and reliable firms suggesting that we might have a million tonnes of lithium demand by 2025, driven by huge growth in BEV sales. My response at the time was to laugh and ask what mines on Mars would be shipping all that lithium back to Earth, because there was simply no possible way for spodumene mines here to scale up to a million tonne LCE annual production rates by 2025. Or for the auto manufacturers to gear up to meet those projected sales of BEVs. Or many other combinations of impossible things.

Some sources of demand are safe and predictable. With the possible exception of COVID-induced shocks to manufacturing output in 2020, the use of lithium in the making of certain types of glass and ceramics is something that can, we believe, be predicted reliably. Other areas of demand are in decline and simply don't much matter. For example, the use of lithium in the aluminum industry (as part of the molten salt used in production of metal, not as an alloying metal) is essentially declining to zero.

The most widely varying predictions are for use of lithium in batteries related to the automotive industry. In 2020, some 3.0 million BEVs and PHEVs were sold (according to the IEA) compared to a total number of 56.0 million vehicles sold globally (according to the German VDA), so market share was 5.1% in 2020. Some enthusiastic predictions suggest market share figures for EVs as high as 30% or 40% by 2030. The IEA notes, in its projections regarding EV adoption, that government support for EVs is crucial to continuing to gain market share and the announcement of more and more models from the manufacturers is necessary and encouraging.

What we will say is that the final arbiter in this transition will be the consumer. If the offerings are compelling, then the consumer will make the switch away from

internal combustion vehicles (ICVs). If not, then whatever models are offered by the auto manufacturers will not sell and market share will not rise. A somewhat discouraging assessment was recently released by the University of California Davis, following a study of BEV and PHEV owners in California between 2015 and 2019. In California, perhaps the most EV-friendly jurisdiction in the US, 18% of BEV and 20% of PHEV owners in this period switched back to ICVs. The main reason was, because of their living arrangements at the time, that the owners simply found it difficult to charge their EV. While anyone with a detached home and an electrical outlet in their garage can charge an EV, even if only slowly, many people do not have the luxury of living in a detached home. A BEV or PHEV without access to convenient charging is just another problem, one that many people do not need to confront.

We believe that the number of electric vehicles sold will lag most projections, primarily because of the current nature of BEVs and because of infrastructure. Long-range BEVs are, without question, substantially more expensive than their ICV analogues to purchase. While the argument has been made that battery costs will decline so rapidly that this will not remain true for much longer, this argument seems flawed. Tesla, for example, have made more BEVs than any other western firm, but their margins on vehicle sales have remained stubbornly low in spite of significant scale factors being accrued through these early days. Given that the large battery in a Tesla represents a major portion of vehicle cost, this would suggest to us that their battery costs are not collapsing.

In addition to being more expensive, a modern BEV requires the buyer to make operational compromises when compared to an ICV. The buyer must accept the fact that if they either forget to charge their BEV or wish to drive a very substantial distance in a single day then they will need to factor additional charging time into their journey. Compared to a 5-minute diversion to fill up with gasoline or diesel fuel at any number of available locations, this is not a palatable prospect. Requiring a buyer to spend more to get less is usually not a winning marketing position.

We project that BEV and PHEV sales, which reached 3.0 million vehicles in 2020, will soar to 5.3 million by 2025 and 9.3 million by 2030. This is phenomenal growth for such an expensive and long-lived item as a vehicle, a global market share of 11% by 2030. We are assuming a degree of cowardice on the part of governments that have been making plans to "ban" the sales of ICVs by certain dates. That is, we assume that governments never actually ban ICVs in western democracies and will choose to let their citizens make the decision for themselves. That is, we expect that these governments will ultimately want to avoid being blamed for something unpopular and choose to be re-elected, instead.

BEVs will, we believe, become the standard in configurations where the batteries are small and the BEV is to be used almost exclusively for travel within a city. Such small-battery BEVs are the least expensive way to build a vehicle, and they make sense when the average daily commute is a relatively short distance. In the developed world, where car sales are stagnating and even reversing in some jurisdictions, such vehicles represent an opportunity to change the value proposition of owning a personal vehicle.



Figure 4 – The Most Popular BEV in China (Wuling Hongguang Mini)

Source: Wuling

The more flexible option will be a PHEV of sorts, one where the small on-board battery is augmented with a range extender, either an internal combustion engine turning an alternator or a fuel cell generating electricity directly from (hydrogen) fuel. Medium- and heavy-duty vehicles will, we believe, be almost entirely these sorts of range-extended battery electric vehicles, led by a surge in the use of hydrogen-fueled medium- and heavy-duty vehicles in China.

## Figure 5 – A Range-Extended SUV (Li ONE EREV)



Source: Li Automotive

What all this does for us is suggest dramatic growth in lithium demand, but demand that can be satisfied by existing junior and senior lithium companies and their plans for new production through 2030.

Some selected data from our projections:

	2020e	2021f	2025f	2030f
Rechargeable Batteries	174,149	191,968	282,040	473,740
Total	343,006	370,133	491,890	751,077
Available Supply	363,500	411,400	814,000	884,000
Excess Supply	20,494	41,267	322,110	132,923

# Figure 6 – Selected Supply and Demand Data for Lithium (tonnes LCE)

Source: Stormcrow (2021)

With these figures in mind and understanding that supply entering the market does so in fairly large and discrete lots, price projections depend heavily on the timing of market entry for new supply. However, one possible scenario based on what we feel are projections by credible companies as to the availability of new supplies is:

Figure 7 – Price Forecasts for Lithium Chemicals to 2030	(USD/tonne)	
	(000), 000000,	

	Year	 2021f		2022f		2023f		2024f 20		2025f	2025f 202		2026f 2027f		2028f		2029f		2030f	
Tech Grade CO <sub>3</sub>		\$ 6,948	\$	6,091	\$	5,290	\$	5,088	\$	5,186	\$	5,379	\$	5,632	\$ 5,877	\$	6,173	\$	6,491	
Batt Grade CO <sub>3</sub>		\$ 8,151	\$	7,046	\$	5,977	\$	5,706	\$	5,816	\$	6,053	\$	6,369	\$ 6,673	\$	7,044	\$	7,444	
Tech Grade OH		\$ 8,444	\$	7,197	\$	5,962	\$	5,813	\$	5,975	\$	6,248	\$	6,625	\$ 6,999	\$	7,445	\$	7,941	
Batt Grade OH		\$ 9,338	\$	7,959	\$	6,592	\$	6,428	\$	6,608	\$	6,909	\$	7,326	\$ 7,739	\$	8,233	\$	8,781	

Source: Stormcrow (2021)

We want to re-emphasize this important point: the movement in lithium market price is largely dependent on the excess supply available to the global market. Delaying or eliminating sources of supply can dramatically impact lithium chemical prices, as we have recently experienced with the shortage in 2016-2017 and the significant surplus in 2019-2020.

# Conclusions – The Worst is Very Likely Behind Us

Our models and projections suggest that the recent nadir for lithium chemical prices likely occurred in 2020. We are not likely to see prices that low at any time through to 2030. Indeed, our price projections are likely pessimistic, as it is far more likely that plans for production by credible companies will be delayed for market or technical reasons than that we will have a surprise source of additional

production enter the market. Our forecasts are most dependent on excess supply, so delaying the entry of new sources of production will raise prices.

If you read nothing but mainstream media accounts or the more breathless brokerage research, you can be forgiven for believing that making lithium is a can't-lose proposition, with endless increases in demand on the horizon and prices moving higher and higher, forever. In fact, it's worth realizing a few facts. First, it's hard to get to the point where a company can reliably produce a product that is technically consistent enough to qualify for use in the battery industry. Second, the biggest potential source of demand growth for lithium batteries is the automotive sector, but we still have little to no proof that, without subsidies, buyers will flock to buy BEVs tomorrow. Third, lithium is not scarce, so those making lithium today need to contend with the knowledge that if prices rise too high, new producers are likely to enter the market. And fourth, making cars is a slim-margin business, so if lithium prices rise too high then auto producers will be forced to thrift or avoid using lithium altogether, because making passenger cars is not the same as building fighter jets for the military; there is no argument that they will do it regardless of the costs.

In spite of all the above, though, there is room for a few new entrants into the lithium production club, and those companies can perform well, financially, providing their costs are kept under control. This is one of the most exciting critical materials markets out there, and we look forward to watching it develop in the years to come.

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