NEWSLETTER
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STORMCROW

The World Gets Even Weirder…

August 26, 2020

In this issue we discuss:

- **New Energy Vehicle Sales Coming Back in China** For the first month in many months, China has seen a YoY increase in the number of new energy vehicles sales. It isn't astronomical, it isn't shocking, but it's something.

- **Nickel and Cobalt Aren't Waiting** There is lot more nickel and cobalt than lithium in modern NMC batteries. What this means is that the bill of goods for feedstock to make cathode active materials is skewed to nickel and cobalt, and so the available inventory kept by most manufacturers was lower. With new energy vehicle sales and production moving up, the prices for cobalt and nickel chemicals have been responding.

- **Even Stranger Days for Lithium** Last month, the low price of spodumene meant that most producers have to be staring that old joke right in the face, that while they are losing money on every sale, maybe they can make it up in volume. Guess what? It's worse this month. That means we have to be getting close to an improvement in spodumene pricing, which should (eventually) lead to higher prices for all things lithium.

- **Rare Earth Excitement** We have been reading a lot of breathless speculation about how China is about to make it 2010 all over again, and shut down Western society by withholding rare earths. For various reasons, we are (highly) skeptical. But what happens if the rare earths do get used to make new energy vehicles? Is there a bottleneck here? Let's take a look.

Jon Hykawy, PhD
President
jon@stormcrow.ca

Tom Chudnovsky
Managing Partner
tom@stormcrow.ca

See the end of report for important disclosures

As a Matter of Introduction…

This is our eleventh (semi)monthly newsletter (we think)! Time flies when you are having fun, or simply forgetting what day it is because every day feels more or less the same during a pandemic. While we never produced a newsletter filled with cautions about the "best cure for high prices being high prices " during the recent lithium heyday that extended through the middle of 2017, those who sat in on Stormcrow talks at conferences know that we were out there saying it. However, we feel even more strongly that the old maxim about the "best cure for low prices being low prices" is every bit as true, and given some pessimism around the battery materials market now, we believe that some realism (along with a little hope) is required.

First, for those who don't know, Stormcrow deals with the markets for critical materials. Generally speaking, what amounts to a critical material is in the eye of the beholder, but we think of them as materials that are essential to making a product with the properties intended by its designers, even if those materials are not anything like the highest-cost item on a bill of materials. As an example, think about lithium in the battery of your cell phone. That lithium costs pennies as a raw material, but if your cell phone manufacturer was forced to do without it then the resulting cell phone would bring with it a very, very different operating experience than it currently does.

Over the coming months, we are going to deal with our views of the market prospects for some critical materials, and interesting facts about others. We will talk a little about technology and the impact, both good and bad, that it can have on demand for critical materials. We hope you find this interesting and worthwhile! Note that when not writing newsletters like this one, Stormcrow Capital functions as a corporate adviser (capital markets / financing / M&A) in the critical materials sector. We are registered as an Exempt Market Dealer in Canada *(additional disclosures included at the end of this note, for those who need help getting to sleep).*

Strange Days

Through July 2020 the markets for battery chemicals in China were mixed. Lithium down, but cobalt and nickel flat to up. The continuing lithium decline is moving us firmly into the land of shuttered production because, we feel, it is getting tough for anyone making the stuff to make real money. Cobalt and nickel chemicals are doing better, probably because inventories of these things were never as large as for lithium, and it is becoming increasingly clear that non-cobalt NMC or NAC batteries are not happening anytime soon:

Battery-grade $LiOH \bullet H_2O$ down 5.1%

Battery-grade Li_2CO_3 down 3.5%

Battery-grade $CoSO_4 \bullet 7\ H_2O$ down 0.6%

Battery-grade $NiSO_4 \bullet 6\ H_2O$ UP 1.1%

Since the end of July, however, nickel sulfate is up a further 2.4% and cobalt sulfate is up a slightly shocking 16.7%(!). Lithium prices are still flat to down. With new energy vehicle sales looking stronger in China, all the movement is likely attributable to inventory levels and restocking.

Speaking of which, the current spot market price for spodumene concentrate in China is now below $400, at USD$390 per tonne. This is grim. It means that companies such as Galaxy Resources are not making much money at all selling their concentrate, if they are getting no more than market rates. Most of the producers outside of Talison and Galaxy probably lose money at these levels. If no one can sell at a profit, then production will be suspended. And if production is suspended and only Chinese spodumene inventory is available, then we should expect that spodumene prices will be moving higher in the next few months.

New Energy Vehicle Sales are UP!!!

So it isn't the beginning of a brave new world, at least not yet, but the sales of new energy vehicles in July 2020 were actually up month-on-month and year-on-year, which has not happened in a while. Data from the Chinese Association of Automobile Manufacturers tells us that July 2020 tell us that 98,000 new energy vehicles were sold, compared to 90,500 in June 2020 and only 72,000 in July 2019.

We expected a bit of a boost to sales coming off the COVID slowdown, and this is hopefully just the beginning. Because, to keep this in perspective, total sales of new energy vehicles

in 2018 were 1.12 million (average of 93,000 per month) and in 2019 were 1.14 million (average of 95,000 per month). This number moves up toward the average over the last two years but doesn't make up for what disappeared in Q1 in China.

Do the Rare Earths Represent Another Bottleneck?

We are not about to suggest that the entire automotive industry will, or should, go haring off after rare earth motors to build their new energy vehicles, but at the right price rare earths are a really good engineering material. A permanent magnet synchronous motor that is built using neodymium iron boron (NdFeB) rare earth magnets is small, light, efficient and requires probably the smallest amount of expensive control electronics. For those who have not played with or seen NdFeB magnets up close, we recommend doing so because, compared to iron magnets, they seem almost magically strong.

What we want to know, though, is whether the rare earths for new energy vehicle (NEV) main motors represents another commercial dead end. We already have one such problem to contend with, that being the use of cobalt in lithium batteries for NEVs. It's painfully clear that if the automobile industry will be forced into building battery electric vehicles (BEVs) to meet regulatory requirements, as opposed to building the right types of hybrids, then the amount of cobalt produced in the world won't suffice. Those waiting for zero cobalt batteries haven't been paying attention, because the push to higher and higher levels of nickel content to raise energy density so that a small pile of batteries can push a car down the road for longer and longer distances means that the batteries lose the ability to carry energy at much faster rates. Cobalt is proving to be stubbornly difficult to engineer out of the battery. We certainly don't need to make our ability to produce NEVs dependent on another material that can't be produced in sufficient quantity. One of those materials is enough.

So let's take a look at the numbers with respect to the rare earths. Let's say there are 100 million light duty vehicles being sold per year around the world, someday relatively soon. Let's further assume that the car companies have done a stellar job, and 20 million of those are NEVs. Most of these need to sell with a reasonable amount of power, and while electric motors are better at producing torque (which is the measure of what really accelerates a vehicle, not the more quoted power; top speed comes from power but acceleration comes from torque) these NEVs still need to be able to travel at highway speeds and pass something. Let's assume that each new NEV ships with 150 hp, about 112 kW.

The old Toyota Prius came with a very strong and very efficient electric motor. From various reports by science and engineering teams around the world, that 50 kW motor

used about 1.34 kg of magnets and cage material in the form of NdFeB. NdFeB is more properly described by the chemical formula $Nd_2Fe_{14}B$. Many people are surprised by the fact that a "rare earth" magnet is mostly iron, and that neodymium is not magnificently magnetic (if it were, the best magnet would be pure neodymium!). But these magnets are really only 26.7% Nd, assuming they are made of nothing but Nd, Fe and B (in reality, there are a bunch of other metals thrown in the alloy, at low levels, including Dy and Tb to allow the magnets to keep working at high temperature).

Using the data from the Toyota Prius, that means that the main motors only in these NEVs would demand 58,240 tonnes of magnet, or 15,550 tonnes of Nd (probably mixed with praseodymium (Pr) since that provides some benefits) metal. If we convert that number to the more commonly quoted oxide, then we would require about 18,100 tonnes of neodymium oxide. That's not insubstantial.

But is it possible? The answer is yes, but it won't be easy. Today (well, last year) there was probably about 45,000 tonnes of Nd and Pr oxide produced in the world. That includes what came from China, California and Australia, plus all the odds and sods from other small mines. Pretty much all that material got used, but a lot of it gets used in applications that are, let's face it, not exactly high value or high priority. If you own a camera drone, then you own some rare earth magnets, but you likely didn't pay much for them. And let's understand that the automotive industry doesn't want to pay top-dollar for its raw materials or components, either. The auto industry is built on some pretty thin margins. Making them thinner is not good business.

In the fiscal year ended June 2020, Lynas produced 4,656 tonnes of Nd and Pr oxide. So we 'only' need another four Lynas's to supply the required Nd and Pr. The previous iteration of Mountain Pass was built to produce 20,000 tonnes per year of total rare earth oxide but only about 3,260 tonnes of Nd and Pr oxide. That means we need 'only' another six Mountain Pass's. Does anyone remember how much fun it was to get those two projects financed and built? And that was in a brief period of very high prices while we are now in a sustained period of low prices. Worse, building three more Lynas's and two more Mountain Pass's will exacerbate those low prices because, along with the needed Nd and Pr, we will also be making boatloads (literally) of La and Ce and Sm and Y and a whole alphabet soup of other elements that will push down their prices, if they can be sold at all, because the demand for these other rare earths is not skyrocketing. Nd and Pr production will increasingly need to carry the entire financial burden of the mine, something that is likely not possible.

But from the point of view of the auto companies, the situation is probably worse. In order to make the magnets for a main motor in a NEV, we need that magnet to be able to operate at fairly elevated temperatures. This is because that motor might have to climb a

hill for ten kilometers at highway speeds while towing a trailer. Rare earth magnets don't like operating at high temperature. If they get too hot, the magnetic field they produce starts to decline. At a critical temperature, the magnet stops being a magnet, permanently. That means your expensive electric motor will produce less and less power until it gives out, altogether. To increase all the temperatures at which these bad things happen, we add two other rare earths to the magnet, dysprosium (Dy) and terbium (Tb). Nature doesn't make this easy, though. Lynas, for example, has deposits that contain a combined 23% Nd and Pr oxide, but only a combined 1% Dy and Tb oxide. Really good magnets for the motors in NEVs might need to contain as little as 4% or as much as 8% Dy and Tb oxide. To be fair, scientists and engineers are working on ways to reduce the necessary Dy and Tb content, but this is far from easy or inexpensive.

Returning to our above example, let's say we need 58,240 tonnes of magnets for the motors for NEVs. If we only need 4% of that to be Tb and Dy oxide, then we need a combined 2,300 tonnes of Tb and Dy metal, or 3,100 tonnes of Dy and Tb oxide. In 2019, the world likely produced a combined 2,100 tonnes of Dy and Tb oxide, meaning that we need to more than double global output. And given the very low levels of Dy and Tb in major deposits like Mount Weld or Mountain Pass, this is going to be a bit more of a problem than existed with respect to Nd. For example, to meet this new need for Dy and Tb oxide, we would need another 55-60 projects like the original Molycorp! Take everything we said about producing too much of some materials and crushing the price and multiply by a very large factor.

In real life, auto companies simply won't do this. They will use rare earth magnets in some models where the efficiency or light weight matter, and they will have to make do with induction motors or other motor designs elsewhere. Yes, there are numerous engineering initiatives that are looking to reduce the use of the rarest rare earths in these applications, but those engineering solutions generally add cost and/or complexity to the solution.

Our conclusion, though, is that worrying about how high the rare earth prices will go as a result of hypothetical widespread adoption of NEVs is a fool's game. The answer is that the materials will be used only so long as the prices for rare earths don't swing wildly. If we can take any lesson from other battery materials such as lithium, the fact that projects won't be built until a shortfall in demand is obvious, is going to lead to cautious behavior by the auto manufacturers. Boom-and-bust price cycles in their commodity prices is just what the auto manufacturers strive to avoid, even if this means avoiding use of the commodity, altogether.

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