Comment

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The mass adoption of the electric vehicle and the roll out of energy storage systems is underway. Look no further than acceleration of recent electric vehicle (EV) sales and headlines around energy storage systems being sold globally. Over the past five years approximately 5 million EVs have been sold. In the past twelve months 1 million EVs have been sold and over the next twelve months we are on pace to sell another 1.5 million EVs.

Battery storage facilities are being connected to wind farms and solar at an exponential rate.

Equity research, media, conferences and commentators alike have primarily focused on the need for lithium, cobalt, graphite and copper in the new energy paradigm. While it is true that each of those commodities stands to materially benefit from the electrification of the automobile and energy storage market, nickel is often overlooked as a key battery metal with interesting supply-demand dynamics in the coming years.

Changing cathode chemistry

Two chemistries of lithium ion batteries dominate electric vehicle batteries – Nickel-Manganese-Cobalt “NMC” and Nickel-Cobalt-Aluminum “NCA”. As between the two chemistries, NMC is used by nearly every automobile maker in the world save it for Tesla. For at least the next decade, the evolution of the lithium ion battery and its NMC chemistry is towards a more nickel rich cathode. The original NMC chemistry started off at a 1-1-1 ratio between nickel-manganese-cobalt, moving on to 5-3-2, and in the future it is anticipated that as technology advances we will see a nickel rich NMC chemistry that evolves in to a 6-2-2 and then on to an 8-1-1 and beyond, with the first number (6 or 8) representing nickel percentage of the cathode. Unlike other battery metals, nickel stands to benefit twice as much from the adoption of the EV and the roll out of energy storage systems:

1) nickel will benefit from an increased nickel rich battery chemistry; and
2) it will benefit from increased EV and energy storage systems sales.

Each battery metal has its own unique dynamic that regulates timing and quantity of new supply to enter the market - for lithium much of the debate centres around brine versus hard rock, for cobalt the focus tends to be around the fact that it is a byproduct metal with much of world production coming from the Democratic Republic of the Congo (DRC) and so on. As pointed out above, on the demand side nickel is leveraged to EV adoption through both battery chemistry advancements and battery sales, on the other hand, nickel is further differentiated from other battery metals in its inability to respond quickly on the supply side due to the fact that bringing on a new large scale nickel mine can often run in to the billions of dollars.

Nickel – the often forgotten battery metal

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1) nickel will benefit from an increased nickel rich battery chemistry; and
2) it will benefit from increased EV and energy storage systems sales.
Combine that with the fact that nickel projects had massive cost overruns in the last cycle (in fact one can argue that nickel projects destroyed more value than any other commodity in the last cycle), many of those very projects struggle even today, and you have the real prospect that investors will not provide the capital to build new nickel mines any time soon thus ensuring a tight nickel market in years to come.

**EVs disrupting nickel market**

Today nearly 70% of nickel is used as an alloying input in to steel production. This will change dramatically over the next decade. According to CRU the current global primary nickel demand is approximately 2.2 million tonnes per annum for 2018 and expected to grow to 2.8 million tonnes by 2023. Nickel usage in batteries is expected to grow from 70,000 tonnes in 2017 to 240,000 tonnes by 2023 growing at a CAGR of 20% over that time frame. In a recent Bank of America note, the bank projected that 13.6 m EVs sold in 2025 would result in the need for 690,000 tonnes of new nickel supply by 2025. Distilling new nickel demand in the coming years is challenging, however, demand models are driven by two primary inputs, namely 1) EV adoption rates; and 2) your view on chemistry shifts towards a more nickel intensive battery chemistry.

Nickel is one of the most ubiquitous elements in the earth's crust after iron ore, however, it is found in tiny concentrations usually around 1-2% which means that significant amount of material must be mined in order to produce any significant quantities of nickel product. Nickel is produced in two main forms. The first is nickel pig iron “NPI” - sometimes referred to as ferronickel “FeNi” - which is primarily iron with nickel content ranging from 2% to 25% depending on the producer. Ferronickel is only suitable for use in stainless steel production. The other primary form of nickel is pure metallic nickel in varying forms such as cathode, briquettes, powder and oxide. Typically this form of nickel is greater than 98% purity and suitable for all applications of nickel usage. Nickel chemicals such as NiSO4 can be manufactured by utilising pure nickel product and dissolving it in acid then crystallising the nickel salt or it can also be manufactured by refining nickel ores and crystallising pure nickel sulphate. The majority of all nickel supplied globally is in the form of NPI or FeNi. This concentration is anticipated to further increase through 2025.

Lithium ion batteries utilising nickel rich cathodes require high purity nickel as a building block, typically in the form of nickel sulphate. Nickel sulphate can be produced by a variety of processes, however, depending on the source of nickel the cost and economics of producing nickel sulphate can vary significantly. The problem with the majority of today’s nickel production is it is NPI or FeNi and that most of it is not suited for production of nickel sulphate powder to be used in the batteries that power EVs and energy storage systems.

About two thirds of the world’s nickel resources are in the form of laterites which result in NPI or FeNi and one third are in the form of sulphides. Until the late 1990s approximately 70% of the world’s refined nickel came from sulphide deposits with the balance from laterite deposits. However, as known sulphide deposits depleted and/or became more costly to access (many are underground) nickel production turned to laterite deposits which are more abundant and easier to mine.

In 2005 with the world facing an impending shortage of nickel required to feed Chinese industrialisation the Chinese adapted old decommissioned technology (pig iron blast furnaces) to treat nickel bearing iron ore (laterite) and produce very low grade FeNi (2% Ni). The adaption of these decommissioned furnaces and subsequent construction of bigger and more efficient furnaces led to a massive increase in output of low grade FeNi that became known as NPI (nickel pig iron). This raw material was adopted in China for utilisation in the manufacture of stainless steel and reduced the strain on pure nickel demand in 2007/08 resulting in a price crash of nickel from a high of $54,000/MT in early 2007 to well below $10,000/MT in 2016. In essence, the Chinese introduced massive ferronickel production (up to 500,000 tonnes/year in contained Ni production which represents 25% of the global market) in a short time using what the West would consider uneconomical and inefficient production. Early NPI production was energy intensive and highly polluting. Over the past decade this technology has been constantly refined to the point where 8-10% Ni content NPI is now the standard and costs and efficiencies are on par with more sophisticated FeNi production facilities utilised by Western organisations.

The emergence and widespread adoption of NPI by China resulted in a crash in nickel prices and economic failure of many nickel projects that were launched in the early 2000’s. Traditional nickel producers could not compete with cheap and abundant supply of NPI and the market became significantly oversupplied as a result of new projects (Goro, Ambatovy, Ravensthorpe, Ramu, Coral Bay and Taganito to name a few). The result was a buildup of nickel inventory (reaching close to 900,000 MT in late 2016 according to CRU) which continued to remain as a market overhang depressing prices and curtailing much required investment in new capacity outside of NPI.

**Chinese moving away from NPI**

Chinese companies (most notably Tsingshan) have recently announced that they intend to invest in new non-NPI production based on laterite sources to address the expected demand from lithium ion batteries required for EVs. Most of these announcements have been focused on the production of high purity NiSO4 and CoSO4 and touted what industry participants believe to be wildly unrealistic capital numbers for build out.

Western companies have invested over $20 Billion in the last 15 years in non-NPI production at an average cost of $70,000 per tonne of annualised nickel produced with varying results. Ramu commissioned in 2012 at a construction cost of $2.1 billion is the only high pressure acid leach (HPAL) operation constructed in the last 25 years to exceed nameplate capacity. Goro, Ambatovy, Murrin Murrin and Ravensthorpe all were built over budget and have all failed to produce at above 80% of design capacity over a sustained basis. Other projects such as Taganito, and Coral Bay have fared
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Production of NiSO₄ from laterite ores is not significantly different than production of class I metal as HPAL operations dictate that the metals present in the orebody (Ni, Co, Zn, etc.) form sulphate solutions under the presence of high temperature, high pressure and free acid. A high pressure acid leach process is where the acid is typically sulphuric acid resulting in nickel sulphate (NiSO₄) being present. Recovering the nickel in the form of metal, sulphate crystal, mixed hydroxide or mixed sulphide is not challenging or difficult once it has been placed into the solution and purified and concentrated. The technology to achieve this is not the issue with HPAL operations.

If you consider that at a minimum four Ambatovy/Goro sized operations will be required by 2023 to meet the increased demand for primary nickel for lithium ion batteries, and each of these operations required approximately 10 years from announcement of commencement to commissioning, then you have to believe that there will be a significant period of nickel shortage that awaits. The NPI explosion of 2005 was based on proven decommissioned technology that was heavily subsidised (environmentally and energy wise). Applying the same logic to HPAL for the next 5-year horizon is not practical. The complexity of the equipment and chemistry is significant in HPAL and the design and construction phase for a new plant alone will be 5-7 years.

Tsingshan’s statement that their operation will be producing by 2021 (in just 3 years) lacks sufficient details to support this claim. MCC (China Metallurgical) the EPC that built and operates Ramu is being referenced for the expansion of Ramu from 35,000 t/y Ni to 70,000 t/y which is estimated to cost $1.5B and no time frame given.

SMM is looking at building their third HPAL operation in Indonesia and publicly suggested it could cost in the range of $2B. CleanTeq has announced a $1.5B price for constructing a greenfields 30,000 t/y HPAL plant in Australia utilising MCC (Metallurgical Corporation of China). It is therefore difficult to understand how Tsingshan can announce a 50,000 t/y greenfields HPAL operation in Indonesia for $700 million using the same company – MCC - which is quoting much higher capital cost for two other technologically similar projects. Information is lacking to support Tsingshan’s estimate and schedule.

The equity markets seem to believe that China can recreate the success of NPI and apply it to cheap and fast construction and successful operation of HPAL. If this is true, then yes China will be able to secure all the nickel it requires to fuel its EV revolution. However, unlike NPI, cheap and fast HPAL has never operated in any form. New nickel production to fuel the EV revolution will come from a handful of sulphide deposits (such as Turnagain or Dumont) or from the abundance of laterites in Indonesia, Philippines, Australia and New Caledonia. However, this production will not be introduced at capital intensity of $15,000/MT of annualised nickel (i.e. $750 million capex for 50,000 tpa Ni production versus $5 billion (plus) spent by Goro/Ambatovy for identical capacity). The economic facts do not support these claims even with subsidised construction labour and materials.

In order to produce 1 kg of Ni from a laterite ore, you typically have to treat 100 kg of ore. If you treat that 100 kg with acid (whether it is HPAL, atmospheric, heap leach) you produce 99 kg of acid containing iron waste. This must be dealt with as it cannot be used as another by-product. FeNi and NPI do not have this issue, neither do most NIS operations. But laterite operations making class I nickel (efficiently) do.

Vale has announced $500 M required to address tailings management at their Goro facility. Ambatovy employs one of the most sophisticated tailings management systems in Madagascar that meets current OECD standards. It is unlikely that Indonesia or the Philippines will allow massive HPAL operations to dispose of acidic tailings in an irresponsible manner where the environment is permanently impacted. Indonesia, Philippines and New Caledonia will all require environmental responsibility in order to approve the size of projects contemplated to feed the EV beast. Environmental responsibility requires significant investment, you cannot just discharge untreated acidic waste into the ocean or dump it on land and expect global acceptance. Congo has shown us how that works when applied to labour standards.

In order for the 200-400 kt, let alone 600 kt, of new nickel production required in the next 10 years to be realised, nickel prices will have to support the investment (even Chinese investment). Current nickel prices are not enough to incentivise new production and Western companies have all suffered the consequence of investing billions in new nickel capacity only to watch the collapse of commodity prices destroy the economics of these projects. Investors following battery metals should study closely the nickel market dynamics which, while complex, yield a unique and potentially profitable way to play the adoption of the electric vehicle and roll out of energy storage systems.