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MINING RESEARCH
NICKEL MARKET
SUPPLY & DEMAND
PRICE FORECASTS



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Outlook for Nickel

- ❖ **Nickel production has moved from sulphides to laterites to meet demand.** Sulphides used to represent the primary source of nickel ore but production is declining as existing reserves become depleted. Future nickel supplies rely on laterites, which now represent the majority of the world reserves. Sulphide ores are easier to process compared to laterite ores which require hydrometallurgical processing such as HPAL. However, atmospheric leaching solutions have been successfully developed that optimise the action of sulphuric acid with lower energy consumption and capex.
- ❖ **Demand from EV battery manufacturers is remodelling the nickel market.** Nickel is used mainly in corrosion-resistant alloys, with around 70% of global production currently used to produce stainless steel. Historically there has been an increase of around 4 - 5% annually in consumption (to the current 2.3Mtpa) as the population of the world becomes increasingly more urbanised, which creates greater demand for stainless steel. The growing demand for nickel as a battery metal has prompted a strong recovery in the nickel price.
- ❖ **Rapidly growing EV market.** Environmental concerns and green legislation are creating a dramatic increase in the adoption of EVs globally. Morgan Stanley believes that by 2050, four out of every five cars sold will be a battery-electric vehicle. Changes in the chemistries of the cathodes of the favoured NCM batteries will require a lot more nickel. Research house Bernstein has forecasted that replacing the world's fossil-fuelled cars with EVs by 2050 would require 3.5 times the current known global nickel reserves.
- ❖ **Growing supply gap estimated to climb to 1.79Mtpa by 2035.** Mounting concerns are being expressed by Tesla and others involved in the EV supply chain. Nickel supply is already constrained and the lack of investment in nickel projects worldwide during the downturn has resulted in a shortage of new supply which can come on stream quickly. The market could be further challenged by Indonesia, one of the biggest suppliers to China's steel industry, which has just reconfirmed its intention to ban nickel ore exports from 2022.
- ❖ **US\$21,400/t needed to incentivise investment in new projects.** The long-term consensus pricing for nickel remains at c.US\$16,400/t. However, analysis from Wood Mackenzie suggests that the nickel price needs to rise to US\$21,400/t to incentivise long-term investment in new projects. A chronic supply deficit in the future could become a clear possibility, given the growing demand from EV battery manufacturers. Market watchers are well-used to the wild swings in the nickel price, however, despite the recent battery fever, nickel prices are still a long way adrift from the past high of around US\$51,000/t seen in 2007.

INTRODUCTION

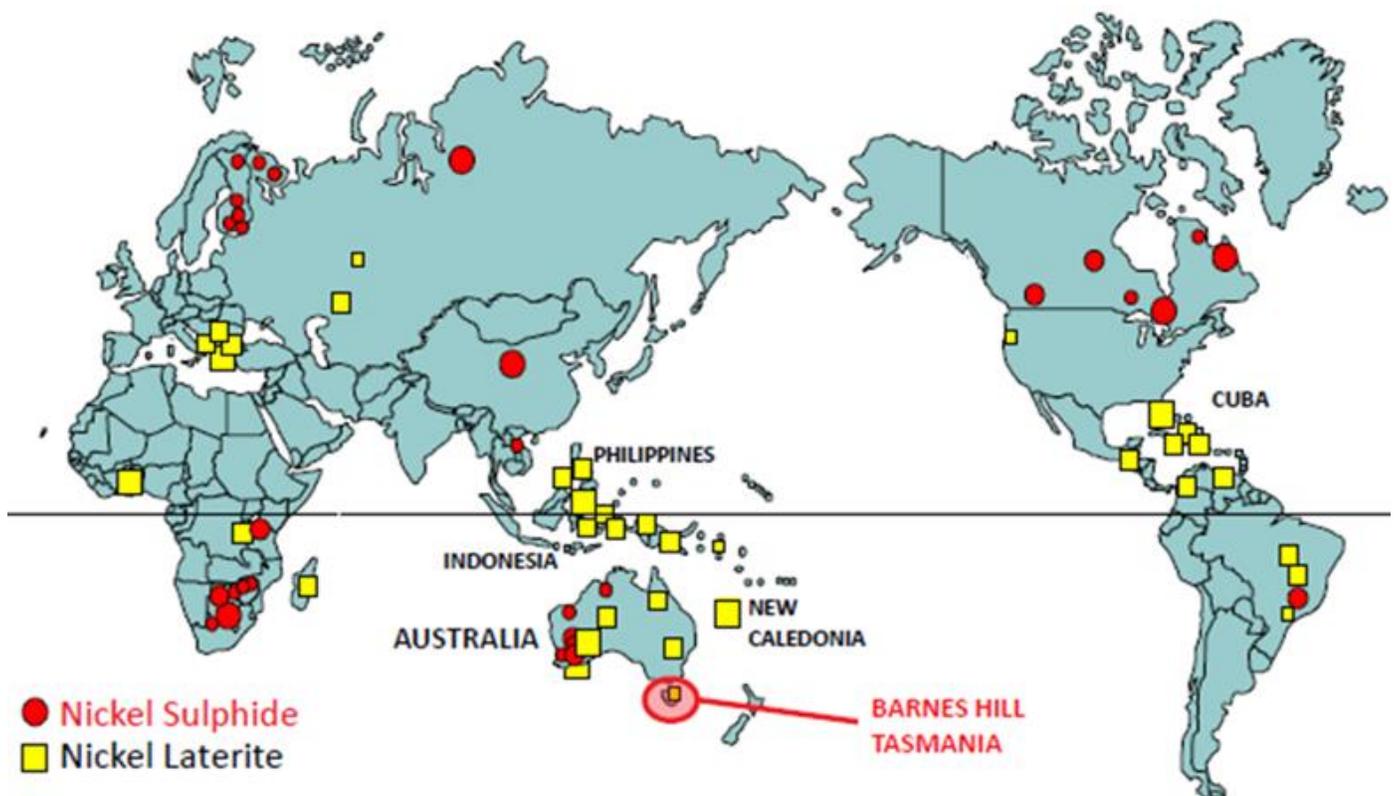
Nickel is a shiny silvery-white metal which does not tarnish in air. The metal has been in use since 3,500BC, however it was not until 1751 that the chemical element itself was isolated. The element's name means Old Nick and stems from German mining mythology as the old timers were unable to recover copper from copper-nickel ores and so saw nickel to be the Devil's metal.

Nickel is a high value, relatively low tonnage of production compared with other major base metals like copper. The metal is used mainly in corrosion-resistant alloys with around 70% of global nickel production currently being used to produce stainless steel for the construction, automobiles or consumer products industries. A further 14% goes into other steel and super alloys, with an additional 7% used in plating and coins and 6% for batteries.

Demand for nickel from the battery market for the rapidly growing electric vehicle (EV) sector looks set to reshape the industry over the next ten years. Market commentators believe that the stainless industry is set to remain the largest consumer of nickel, but with a big growth in demand forecast to come from the EV battery market. In this report we have sought to analyse future nickel supply and demand dynamics and investigate price forecasts in the market.

SUPPLY

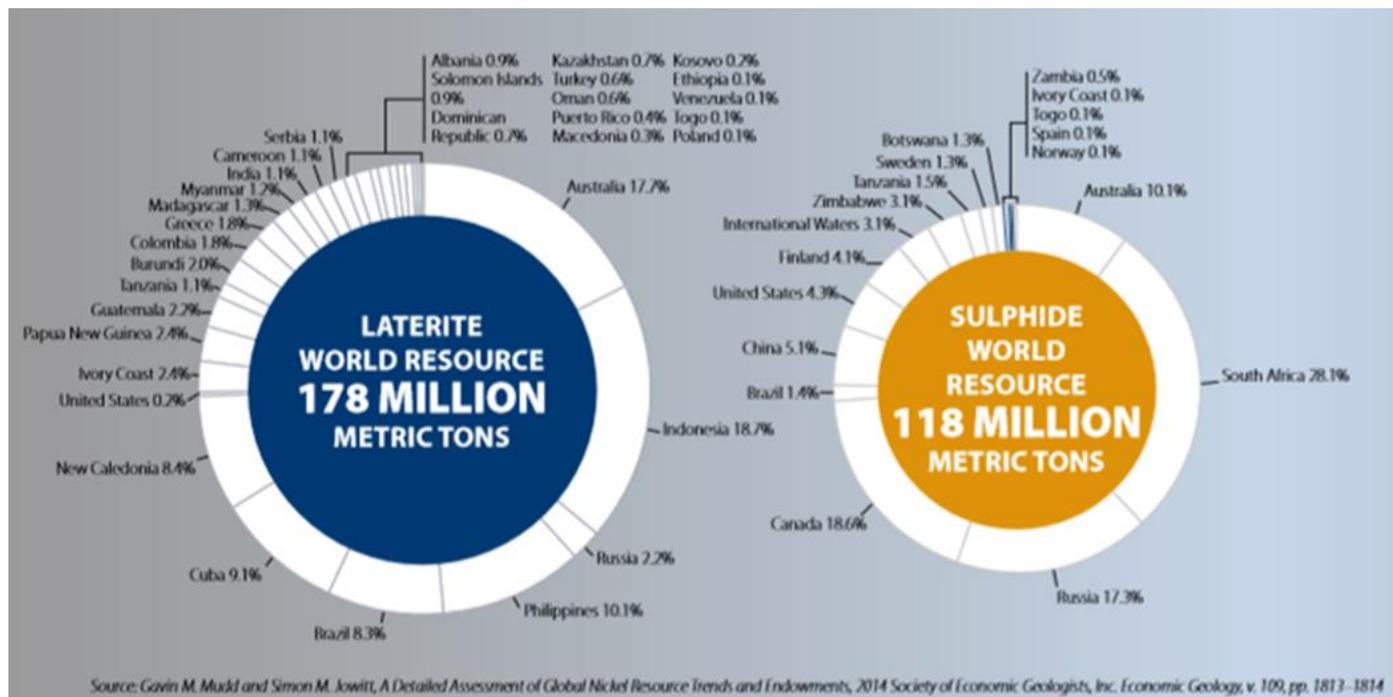
Global nickel reserves are estimated at 89 million tonnes (Mt) with the majority coming from just a handful of countries, namely: Indonesia (24%), Australia (21%), Brazil (11%), Russia (8%) and New Caledonia (7%). Nickel is found as either as magmatic sulphide or laterite (oxide) deposits with world mineral resources estimated to be around 300mt (sulphide 118Mt and laterite 178Mt).



*Global distribution of major nickel projects.
Source: TME/NQ Minerals plc*

Sulphides

Nickel sulphides were the dominant source of supply; however, production has remained flat for a decade due to declining head grades and lower production at some major mines. As shallower nickel sulphide deposits have become worked out, mines have needed to be driven deeper to access further reserves making them less economic. Exploring these deep deposits can be expensive and so insufficient investment in nickel sulphide exploration combined with smaller discoveries has meant that there are few new large sulphide projects in the pipeline. The lack of growth in nickel sulphide production has led to a reliance on nickel laterites, which are more plentiful and thought to account for almost three-quarters of all crustal nickel deposits.



World nickel resources. Nickel Institute

Laterites

Nickel laterites are mainly found on the surface in tropical regions of the world such as Indonesia, New Caledonia and the Philippines as well as in now much-drier Australia. They are formed as the result of the weathering of ultramafic rocks (high temperature igneous rocks) which serves to concentrate the grade of the nickel. Key parameters affecting their composition include: the degree of weathering, drainage of groundwater and tectonic setting. In the main these nickel laterites are large tabular bodies that are only a matter of tens of meters deep, but that can be hundreds of metres in length.

Class 1 Ni & Class 2 Ni

Not all nickel processing is the same and it is estimated that more than 70% of all nickel currently produced is unsuitable for the EV battery market. Basically, there are two classes of nickel. Class 1 nickel is high purity nickel which is used in high quality stainless steel, non-stainless alloys and batteries. Class 2 nickel includes nickel pig iron (NPI) and ferronickel and represents low purity nickel for low quality stainless steel.

NPI is a low-grade ferronickel invented in China as a cheaper alternative to pure nickel for the production of stainless steel. This applies a well-proven process for the treatment of saprolite-dominant laterites, which are smelted to produce a low-grade ferronickel that is then sold directly to stainless steel producers. It does seem that the growing volumes of low-grade nickel feed are serving to unlock Class 1 nickel for other applications.

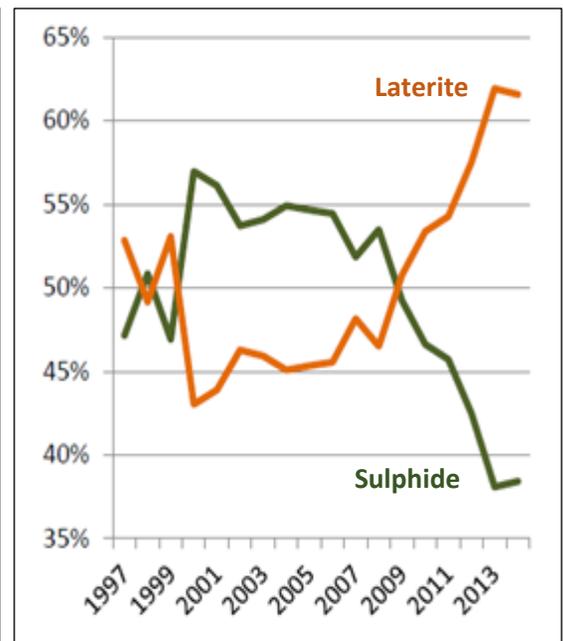
Production

In recent years, production of refined nickel has fallen as stainless-steel producers, mainly in Asia have been preferred to use lower cost NPI. Although mine production has increased in countries that supply direct shipping ore (DSO) to NPI operations, mine production in countries supplying refineries has tended to decrease. So, the growth in NPI has clearly curtailed the usage of Class 1 in stainless steel. At the same time there has been an increase in the production of nickel chemicals, particularly nickel sulphate which is used in the production of batteries.

Country	Mine production (t)		Reserves (t)
	2017	2018 ¹	
Indonesia	345,000	560,000	21,000,000
Philippines	366,000	340,000	4,800,000
New Caledonia	215,000	210,000	-
Russia	214,000	210,000	7,600,000
Australia	179,000	170,000	19,000,000
Canada	214,000	160,000	2,700,000
China	103,000	110,000	2,800,000
Brazil	78,600	80,000	11,000,000
Cuba	52,800	53,000	5,500,000
Guatemala	53,700	49,000	1,800,000
Colombia	45,500	43,000	440,000
Finland	34,600	46,000	n/a
South Africa	48,400	44,000	3,700,000
Madagascar	41,700	39,000	1,600,000
USA	22,100	19,000	110,000
Other countries	146,000	180,000	6,500,000
World total	2,160,000	2,300,000	89,000,000

¹ estimate

World mine production and reserves.
Source: Mineral Commodity Summaries 2019,
US Department of the Interior.



Changing share of world nickel production by ore type. Source: Wood Mackenzie & Royal Nickel Corporation.

Processing

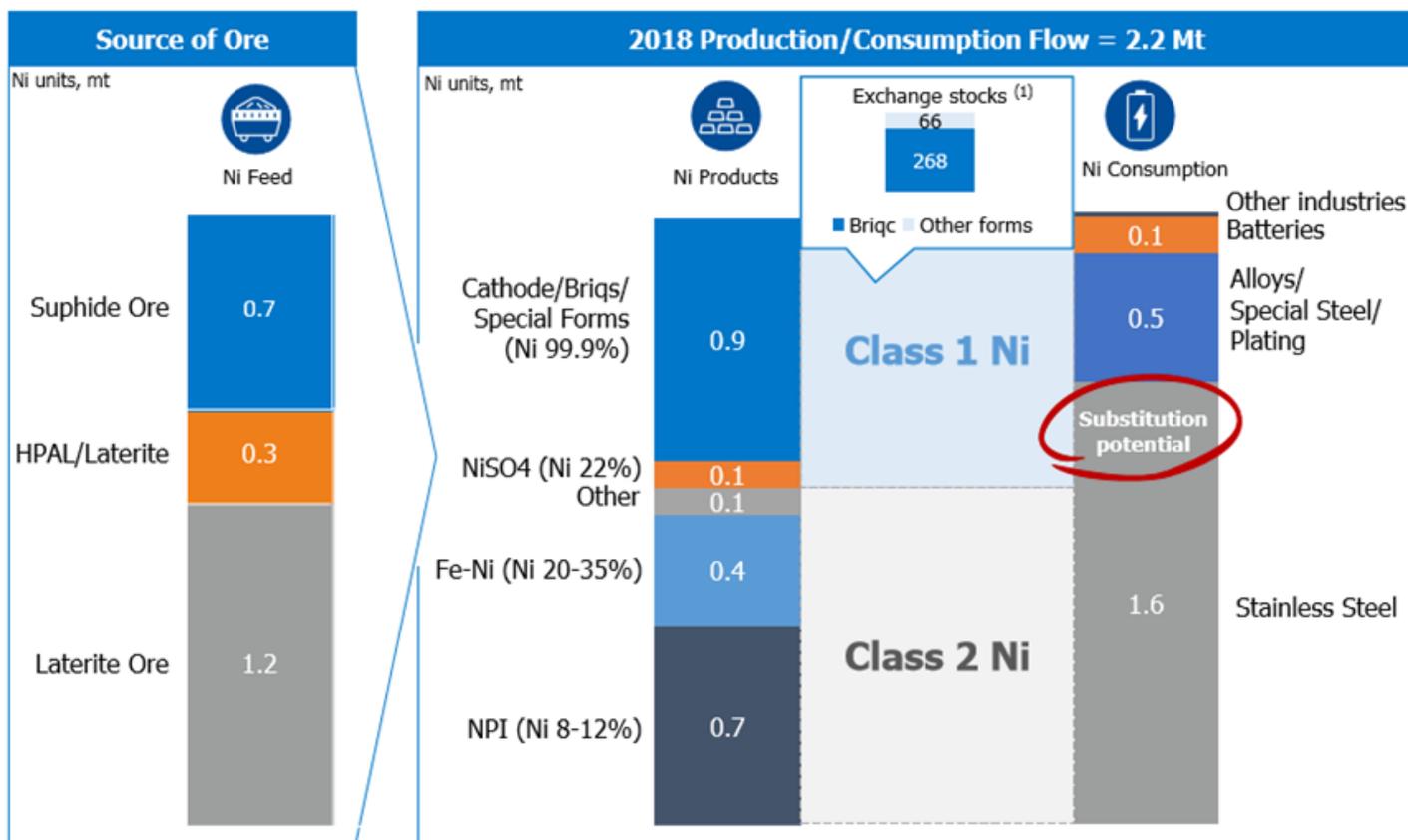
Sulphide ores are easier to process through conventional smelting and refining compared to laterite ores which require hydrometallurgical processing such as High Pressure Acid Leach (HPAL). Certainly, HPAL is known as the most effective aqueous treatment, but the process requires specialised equipment and high operating temperature (245 - 270°) and pressure (4-5MPa). However, there has been substantial investment in R&D concerning the processing of laterites which has led to the successful development of atmospheric leaching solutions that are able to optimise sulphuric acid leaching but come with lower energy consumption and capital costs.

Sulphuric acid represents the largest single cost in the treatment of nickel-cobalt and is a cost barrier which challenges laterite development. Companies have been dealing with this challenge in a variety of ways. NQ Minerals (NQ) recently invested in Tasmania Energy Metals (TME) which owns the Barnes Hill Nickel-Cobalt Project in Tasmania. Together, the two companies are evaluating the commercial and financial viability of developing an integrated facility which would allow the pyrite/precious metals concentrate from NQ's Hellyer Gold Polymetallic Tailings Project in Tasmania to be roasted with the SO₂ waste gas used to create sulphuric acid. Over 70 leach tests have been performed on Barnes Hill ore using column, vat, atmospheric and heated tank leaching. Such a move would allow production of a portfolio of battery metals products and also result in the tremendous value contained in NQ's pyrite/precious metals concentrate being unlocked. The project is planned to produce nickel as a 22.2% nickel sulphate for battery applications, as well as also producing 17.7% cobalt carbonate and 35.2% manganese carbonate as other salts for sale into the EV industry.

DEMAND

Historically there has been an increase of around 4 - 5% annually in nickel consumption (to the current 2.3Mtpa) as the population of the world increasingly becomes more urbanised, which creates greater demand for stainless steel whether it be for use in the construction, automotive, consumer good or medical industries.

However, it is the growing use of nickel as a battery metal which seems to have prompted the nickel price to move back up after many years in a bear market that ran from 2008 to 2017. Wood Mackenzie reckon that stainless steel industry's consumption of nickel will continue to grow by 4% per annum and 2% for special alloys, but those growth rates are forecast to be eclipsed by a 33% annual growth for EV batteries.



Nickel source, production and consumption. Source: Nornickel presentation

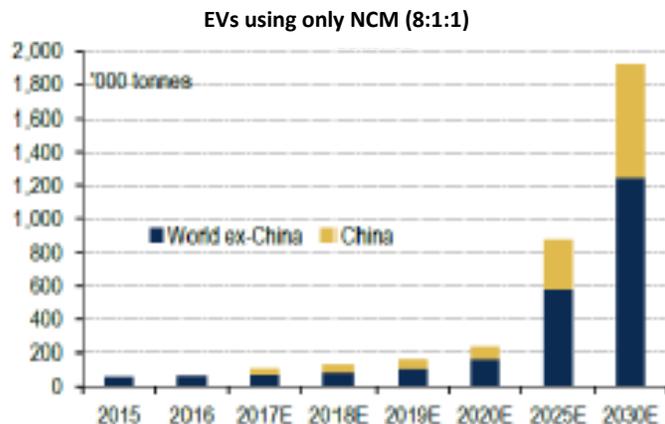
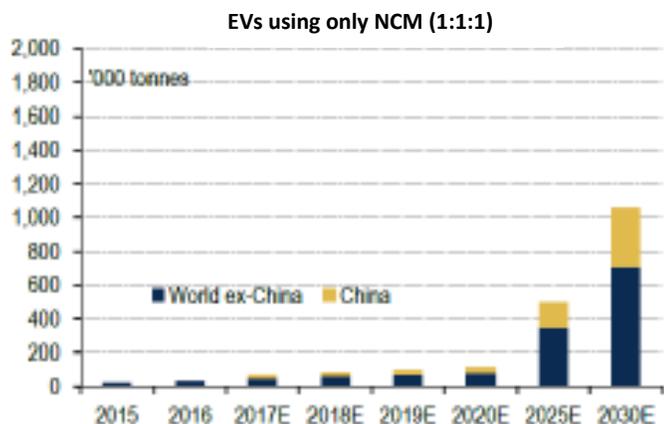
EV batteries

Nickel is seen as one of the critical metals for use in batteries as nickel has the necessary energy density and also comes at a much lower relative cost than other effective battery metals. In the past, the use of batteries was confined to consumer electronic products, but the rapid rise in EVs, which require much larger batteries, has been begun to focus the spotlight well and truly on nickel. Industry analysts project a significant increase in global nickel consumption for batteries in both the EV and energy storage markets.

Moving forward, it does increasingly seem that the prospects for nickel will be driven by EVs which look set to remodel demand. Certainly, concerns about pollution and environmental benefits are creating a dramatic increase in the adoption of EVs globally, with rapidly rising demand on the back of green legislation being embraced by many countries including the UK, India, Germany, France, Norway and China. Morgan Stanley believes that by 2050, four out of every five cars sold will be a battery-electric vehicle.

Increasing nickel content

The majority of the world’s automakers favour nickel, cobalt, manganese (NCM) batteries, where the cathode combination is typically one-third nickel, one-third cobalt and one-third manganese known as 1-1-1. The industry has been working hard to achieve technological advances to reduce the amount of the pricey component of cobalt in favour of using more nickel. Next generation NCM batteries are seen with a cathode composition 80% nickel, 10% cobalt and 10% manganese which are known as 8:1:1 or 811.

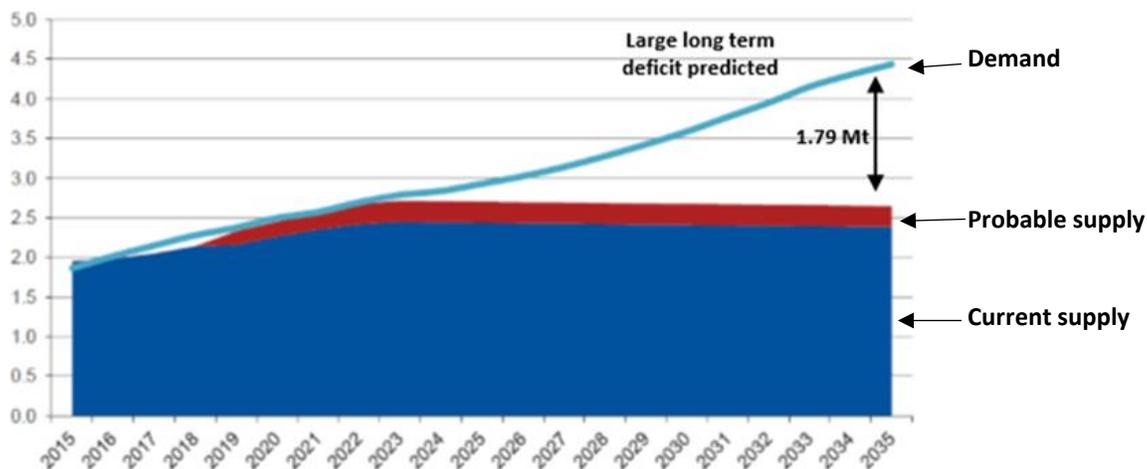


Nickel demand with vehicles using only NCM (1:1:1) and NCM (8:1:1) batteries. Source: Merrill Lynch/Amur Minerals

High energy density NCM 811 battery cells are fast being seen as the future of EV batteries. Better energy density will allow motor manufacturers to either use either less batteries in a vehicle with the same range and a lot less weight; or be able to provide better range with the same volume and weight footprint. NCM 811 battery cells are also seen as being able to reduce the cost per kWh (which equates to range) down to such level which will importantly allow the production of entry-level compact electric cars with a decent range. Such a battery for powering a light passenger EV requires around 50kg of nickel. Although last year only 6% of nickel was used in EV batteries (vs 70% for stainless steel), according to the research house Adams Intelligence, EV manufacturers have used 57% more nickel this year.

Supply gap

The truth is that nickel supply is already constrained as demand is growing on the back of strong market fundamentals. Industry commentators forecast that nickel demand for batteries could well outpace that for stainless steel. Within the next five years, Bloomberg sees demand for the Class 1 nickel outstripping supply, due to the rapidly growing consumption by the EV industry. Market watchers seem to be forecasting a tight nickel market over the short to medium term plus a large long-term deficit. Metals research house CRU Consulting has estimated that this growing supply gap could climb to 1.79Mt by 2035.



Nickel supply gap. Source: CRU Consulting/Amur Minerals

Certainly, there seem to be mounting nickel supply concerns being expressed not only by Tesla but also by companies in the EV supply chain across China and South Korea. Original projections of 30 million EVs by 2030 have been dramatically escalated with some now forecasting in excess of 200 million such vehicles by that time, which would require supply of 2Mtpa more nickel than produced today. Whilst, according to research house Bernstein, replacing the world's fossil-fuelled cars with EVs by 2050 would require 3.5 times the known nickel reserves.

It is important to realise that at the end-of-life, many EV batteries will go into a secondary market for energy storage applications, as the batteries can collect and discharge energy for another 7-10 years after the EVs have been taken off the road and stripped down. This means that those batteries will not be recycled into the car market initially and so new nickel demand will represent a requirement for primary nickel units for many years into the future.

NICKEL PRICE

So far this year, nickel has been the best performing metal with the strong market fundamentals fuelling price recovery. The price has risen 46% to the current US\$16,080/t. Exciting price action in August 2019 saw three-month prices on the London Metal Exchange hit a 16-month high of US\$16,690/t, the best since April 2018. Whilst the highly traded nickel contract on the Shanghai Futures Exchange climbed to CNY124,890/t (US\$17,733/t).



Nickel price chart since 2004. Source: Market Insider

Metals needed to power electric EVs have seen a spike in demand since 2017. Lithium, cobalt and graphite prices have all seen some lofty increases. Market watchers are only belatedly just starting to see the beginnings of a similar effect on the nickel price, despite the metal being a core component in EV battery cathodes.

There are number of reasons behind nickel's recent renaissance. Firstly, nickel stocks have seen a dramatic fall over recent years and are currently at their lowest level for probably seven years. Secondly, traditional demand for stainless steel remains robust. Thirdly, EV forecasts have been ratcheted up which suggests a looming supply shortage. If that was not enough, Indonesia has recently reconfirmed plans to ban nickel ore exports again in the future.

There have been mounting concerns about the supply of nickel from Indonesia, which is the second largest nickel ore exporter behind the Philippines. In recent months, Jakarta has announced the reinstatement of a ban on unprocessed nickel ore exports in 2022, just as battery makers are seeking supplies of nickel to meet mushrooming EV demand. Such a move is designed to generate wealth within the country by mandating value adding to nickel production locally by encouraging the development of initiatives including stainless steel production.

Indonesia is a major supplier to the China's world dominating steel industry and this ban would severely restrict output of Chinese NPI. Indonesia first tried to ban unprocessed ore exports in 2014 but by 2016 had resumed shipments to resolve its growing budget deficit. This time around such a ban might be more sustainable as the stainless-steel operation on the island of Sulawesi in Indonesia (which has received billions of dollars of investments by Chinese steel conglomerates) is now better developed.

PRICE FORECASTS

Investors are well-used to the wild swings in the nickel price, and now the growing new battery market suggests that a chronic supply deficit in the future is becoming a clear possibility. The long-term consensus pricing for nickel remains at around US\$16,400/t. In recent weeks, investors have already seen the nickel price test and surpass the sort of levels that the investment banks like Macquarie (US\$17,000), Morgan Stanley (US\$16,556) and Scotiabank (US\$15,432) had pencilled in for 2021.

The bear market for the metal over recent years means that there has been insufficient investment in nickel projects worldwide, which explains the lack of new supply that can come on stream quickly. Analysis from Wood Mackenzie's suggests that the nickel price needs to rise to US\$21,400/t to act as an incentive for sufficient long-term investment in new projects. Similarly, UBS have determined that almost two-thirds of the forty or so nickel projects that are deemed to be at an advanced stage need a long-term nickel price of US\$20,000/t to deliver a 15% IRR. Advanced stage means that such projects have either been advanced through a Feasibility Study, are expansions of existing operations or mothballed projects being restarted. Certainly, over the next ten years, there is likely to be little nickel production coming on stream from greenfield projects due to the long lead times. Despite the recent battery fever, nickel prices and forecasts are still a long way adrift from those of the past when the metal peaked at over US\$51,000/t in March 2007.

About the author

Dr Michael Green is an independent analyst specialising in growth companies and resources companies. He gained a BSc and PhD in Mining Engineering from Nottingham University. Having been involved in consultancy work, he began working in the London financial market in the 1980s as a Resources Analyst with stockbrokers Buckmaster & Moore and then HSBC-owned Greenwell Montagu Securities. Subsequently, he was involved in analysing a wide range of growth companies and became Head of Research at stockbroker Everett Financial which specialised in the small cap market. Since, 2006 Michael has been an independent analyst. UK-based DOC Investments Ltd provides research and investor relations.

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