NICKEL'S ROLE IN ELECTRIFYING CARS

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As discussed in "Going green? The unexpected investments helping to reduce vehicle emissions", globally around 15% of the world greenhouse gas (GHG) emissions come from the transportation sector. Unsurprisingly, this is an area where policymakers are keen to curb the polluting activity. In order to meet future emission targets, electric vehicles are likely to become a greater part of the vehicle offering. We expect passenger electric vehicle (EV) sales to rise from close to 5% of all vehicle sales to close to 50% by the year 2040.

Nickel batteries

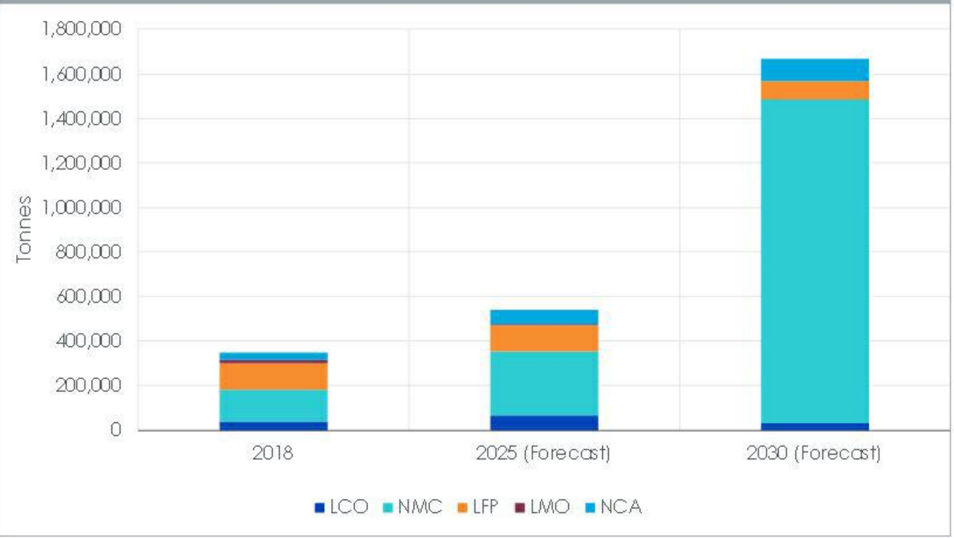
EVs are powered by rechargeable batteries. This battery type provides a reversible chemical reaction, allowing both their discharging and charging processes. During the battery discharging process, the electrical current flows from cathode (+) to anode (-), while the reverse process occurs during charging. Lead acid batteries have been used in conventional internal combustion engine vehicles and are relatively inexpensive. Nickel metal hydride (NiMH) batteries are another mature battery technology. These batteries have higher specific energy[1] than lead acid batteries and this allows vehicles using them to be lighter. However, NiMH batteries have lower charging efficiency than other forms of batteries and have issues of self-discharge (up to 12.5% per day under normal room temperature conditions). These two batteries are now considered obsolete with regard to the main source of energy for battery electric vehicles.

Nickel in battery cathodes

The lithium-ion (Li-ion) battery is currently the dominant technology powering electric vehicles today and is likely to remain so for the next decade. There are many variants of Li-ion batteries, but manufacturers focus on variants that have excellent longevity. These batteries have even higher specific energy than NiMH. But this doesn't mean that nickel chemistries have come to the end of the road in battery technology.
There are four principal components of a lithium-ion battery: cathode and anode active materials, electrolytes, and separators. Within lithium-ion battery technology, various cathode chemistries exist at a commercial level such as Lithium Cobalt Oxide (LCO), Lithium Manganese Oxide (LMO), Lithium Iron Phosphate (LFP), Lithium Nickel Manganese Cobalt (or NMC) and Lithium Nickel Cobalt Aluminium Oxide (or NCA). Nickel is thus one of the key cathode active materials utilised by lithium-ion batteries (present in NMC and NCA).

By 2018, the NMC cathode was already the dominant cathode material in the lithium-ion batteries having overtaken LFP that year. NMC is expected to continue to grow, accounting for more than half of all cathode solutions by 2025 and then close to 90% by 2030 (Figure 1).

Figure 1: Cathode active materials in lithium-ion batteries



Source: Avicenne Energy 2019. Lithium Cobalt Oxide (LCO), Lithium Nickel Manganese Cobalt Oxide (NMC), Lithium Nickel Cobalt Aluminium Oxide (NCA), Lithium Manganese Oxide (LMO) and Lithium Iron Phosphate (LFP).

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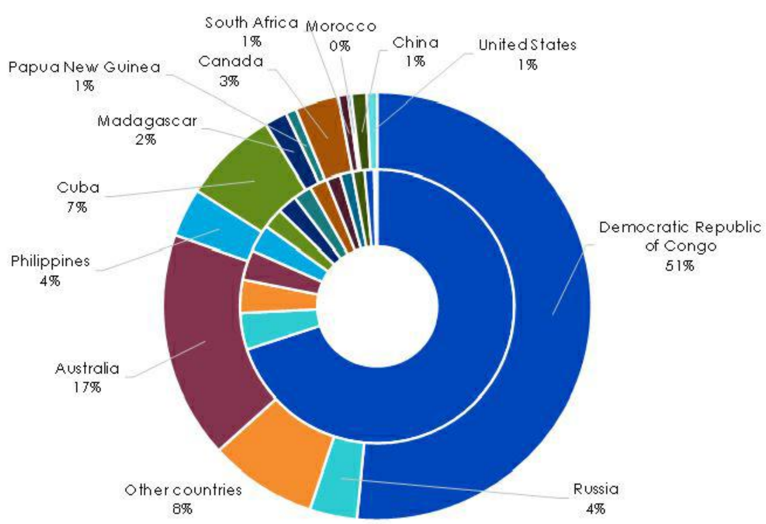
Towards higher nickel weighting

Not only are cathodes with nickel becoming more popular, the nickel content of those cathodes is increasing. Due to price volatility and the risky supply chain of cobalt, manufacturers have been keen to diversify away from the metal, favouring higher nickel loadings in the chemistry. Most of the world's supply and proved reserves of cobalt come from the Democratic Republic of the Congo (Figure 2). The country is notorious for human rights violations in mines including the use of child labour in many of the country's artisanal mines. Sourcing cobalt that is completely free from this risky supply chain is difficult.

Figure 2: World cobalt mine production and reserves (2019)



Source: US Geological Study, WisdomTree, data available as January 2020

Outer circle: reserves. Inner circle: 2019 production.

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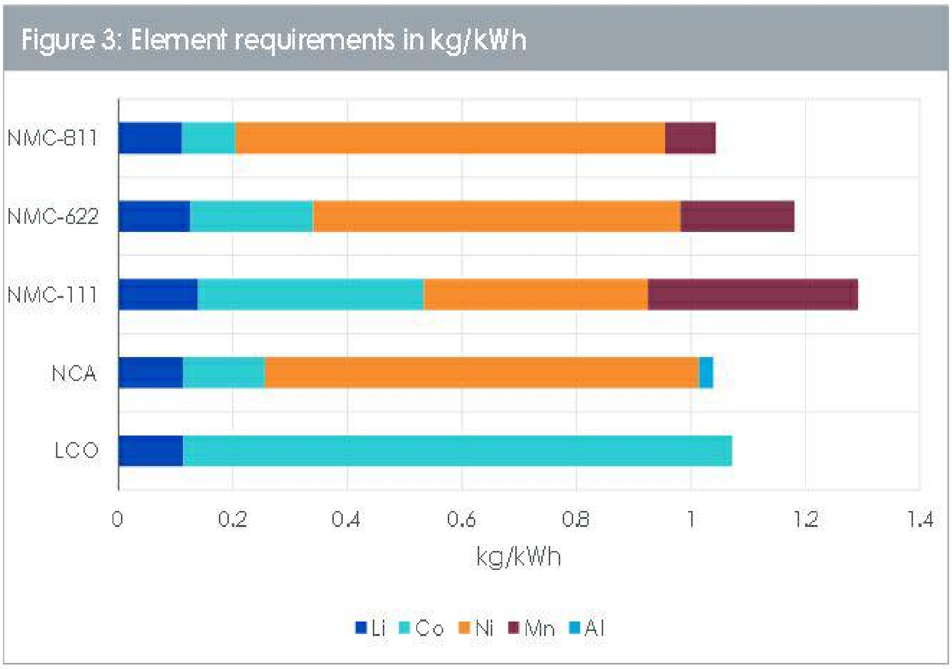
In addition, increasing nickel content of the cathodes can promote higher energy densities. This can help improve range and reduce weight of vehicles.

The move to higher nickel chemistries is underway. A few years ago, in the NMC cathode each of the three atoms - nickel, manganese, cobalt - were applied in equal proportions, known as NMC-111. Manufacturers are increasingly finding a path to a nickel weighting of eight parts relative to one-part manganese one-part cobalt, known as NMC-811. We aren't currently there yet, although six-parts nickel, two¬-parts manganese, two-parts cobalt (NMC-622) is commercially ready and being utilised. The International Energy Agency estimates that in 2019 16% of electric vehicles manufactured were utilising NMC-622 cathodes (up from 7% in 2018).

Figure 3 highlights how NMCs with higher nickel loading can be lighter than other cathodes. NCAs which have a similar weight to NMC-811 are mainly manufactured by Panasonic and used in Teslas. They also have a similar nickel content to NMC-811.



Source: Research Interfaces who have plotted data from "Lithium-Ion Battery Supply Chain Considerations: Analysis of Potential Bottlenecks in Critical Metals" by Fu et al. Li- lithium, Ni – nickel, Co- cobalt, Mn – Manganese, Al – Aluminium.

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Challenges in increasing nickel content

In the NMC cathode, nickel is the main cathode active material and manganese and cobalt help with chemical and structural stability. Therefore, maintaining the chemical and structural stability is the key challenge when migrating to higher nickel chemistries. Several manufacturers claim they are close to commercialising NMC 811 and the market expects some time around 2025 this solution will be the mainstay.

Higher purity nickel market likely to remain tight

We see these shifts in battery cathode chemistries as positive for nickel demand. Currently, batteries constitute less than 5% of nickel demand. But that is likely to rise to close to 30% of nickel demand by the year 2040 according to Wood Mackenzie. That will mean that trends in battery demand will have an increasing influence over nickel prices, shifting away from stainless steel as nickel's main price driver today. The stainless-steel market uses both Class 1 (high-purity) and Class 2 (low-purity) nickel. Historically only Class 1 has been suitable for battery grade chemistries. The tightness in the Class 1 market will likely be more acute for that reason. The nickel that underlies the London Metals Exchange futures contract is Class 1. In Indonesia there are projects to produce a nickel cobalt compound using a process called high-pressure acid leaching (HPAL) that is suitable for batteries, which would utilise ore that was previously considered Class 2 ore. However, these projects are facing large cost overruns and delays and therefore there is a lot of uncertainty about the availability of this material in the future.

[1] Specific energy or massic energy is energy per unit mass. It is also sometimes called gravimetric energy density.

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