



Electric Vehicles – disruptions in the chemicals and refining industries

By Richard Platt and Caleb Chong

Electric Vehicles (EVs) have gained significant momentum in recent years, supported by regulatory incentives, changing consumer perception and the willingness of much of the auto manufacturing industry to throw its weight behind the development of affordable electric models in large numbers.

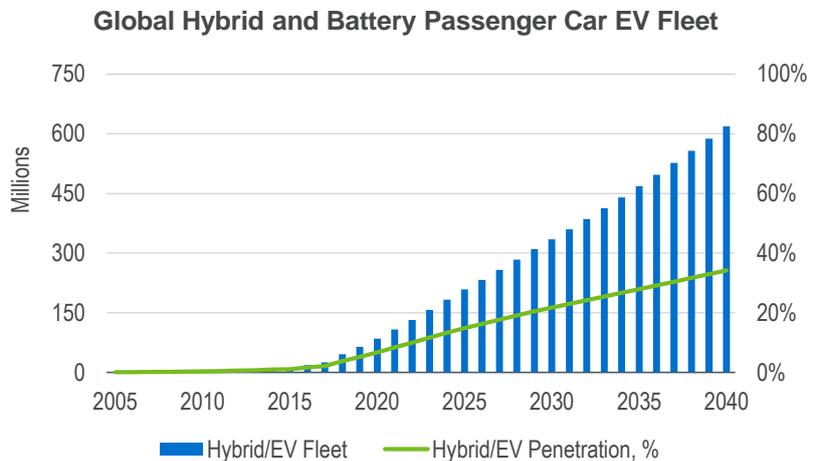
Vehicle fleet electrification could be the biggest disruption to the transport industry since the Ford Model T in the early 1900s, the first widely adopted automobile. Established car manufacturers and new entrants into the industry (e.g. Tesla) are rapidly developing electric models which will challenge the reign of the internal combustion engine as the leading vehicle propulsion system. If developed in conjunction with renewable or nuclear based electricity, EVs have the potential to dramatically reduce carbon emissions from the transport and power industries sector. Enormous impacts would also be felt beyond these industries including:

- A huge increase in the demand for battery raw materials with particular supply challenges relating to cobalt and lithium.
- A slowing demand growth for gasoline and diesel.
- Changing vehicle design creating automotive polymers winners and losers.

So, how will the growth of EVs impact the mining, oil and gas, petrochemical/ polymers industries? Will supply be able to adapt fast enough or become a limiting factor in EVs growth?

EVs will become a major segment of the global vehicle fleet by 2040

The extent of global vehicle fleet electrification is dependent on the interaction of a large number of variables, including the direction of government policy, technological progress, oil price, raw material availability and the wider transition of energy generation towards renewable sources. Under Nexant’s base case forecast, hybrid and EV passenger car penetration is forecast to reach almost 35 percent of the global car fleet by 2040, equivalent to about 600 million cars in use. The base case assumes that cost reduction and driving range progress for battery technology continues at similar rates than in previous years and most short term government targets are met. It assumes that the majority of the electrification is in the passenger car fleet rather than the commercial vehicle fleet.



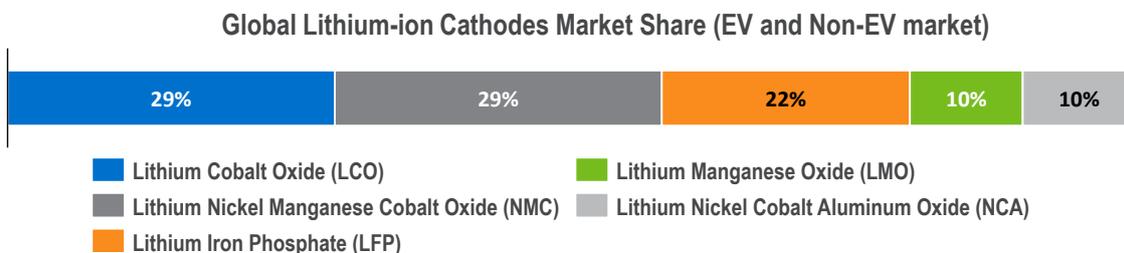
Even in Nexant’s low EV growth scenario, which assumes many of these variables are not supportive of electrification, EVs are still expected to account for a significant segment of the fleet.

Cobalt and lithium are essential raw materials used in batteries

Developments in battery technology have been a key enabler of the commercialisation of EVs with most developments now focused on lithium-ion chemistry. The key advantage of the lithium-ion in comparison to other battery types (lead and nickel based) is a desirable combination of high energy and power density.

Lithium-ion batteries contain varying formulations of oxidized metals in the cathode (e.g. cobalt, nickel and manganese). When the battery is charged, the lithium-ions move from the cathode through the electrolyte to the anode.

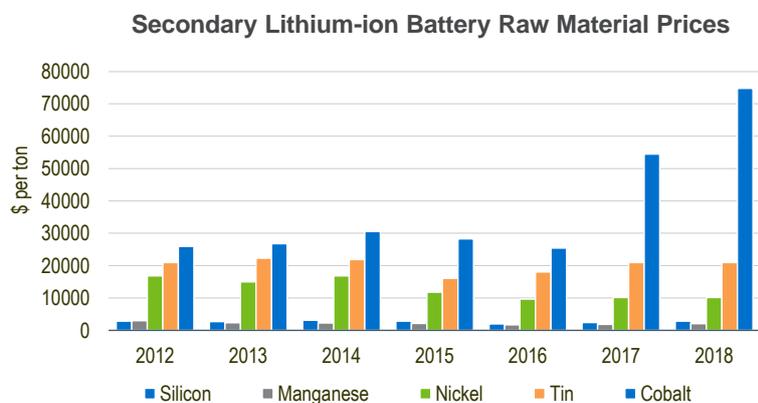
Lithium-iron phosphate (LFP), nickel-cobalt-aluminium (NCA) and nickel-cobalt-manganese (NCM) are the most widely used chemistry for the cathode in automotive batteries. The majority of Lithium Cobalt Oxide (LCO) and Lithium Manganese Oxide (LMO) based batteries are used in general consumer electronics.



The availability of cobalt and lithium are currently of most concern for the development of EV batteries. Lithium is required for all lithium-ion batteries whilst cobalt is required for NCA and NCM.

Cobalt supply may be a limiting factor in the development of EVs

Adjustments to the battery chemistry are typically focused on adjusting the formulation of cobalt, nickel and/or manganese (each with their trade-offs between performance and price). For example, cobalt-based batteries currently provide the best overall performance but cobalt



Sources: London Metals Exchange, U.S. Geological Survey

has reached an average price of over \$70 000 per ton in 2018.

Reducing the overall battery cost by reducing the quantity of cobalt is a major focus for commercially available battery technology and for the next generation of high performance lithium-ion batteries.

The following emerging technologies are a key research focus and have the potential for zero, or reduced cobalt, higher energy density and improved battery performance:

- Solid state lithium-ion battery with lithium anode
- Lithium-air cathode
- Anode conversion materials (lithium-silicon, lithium-sulfur)

Whilst zero- or low-cobalt batteries are developed, cobalt supply may be a limiting factor in growth of EVs due to the heavy dependence on one country, the Democratic Republic of Congo in Africa which accounts for nearly 70 percent of global supply. This has partially led to the high prices and further concerns have been raised due to much of the country's supply being from artisanal mines that are reported to involve child labour. Recycling of cobalt from old smartphone batteries, and in the future EV batteries, may help to somewhat alleviate the supply constraints but are unlikely to satisfy the growing demand.

What part will Lithium Iron Phosphate (LFP) batteries play in EV adoption?

Lithium Iron Phosphate (LFP) is widely available commercially and does not contain cobalt. This is the leading battery technology used in China by the largest manufacturers such as BYD and CATL.

Lithium-ion batteries containing cobalt (e.g. NCA and NCM) are expected to see strongest growth driven by the electrification of passenger cars. When trying to achieve higher driving ranges, which are expected to be required for widespread adoption of electric passenger cars, LFP batteries are less desirable compared to cobalt-based batteries as they are less powerful and have a lower energy density. LFPs battery technology is more accessible, lower cost, more thermally stable and safer than cobalt-based batteries. These factors have helped in its early adoption particularly for public transportation and low range vehicles in cities where journeys are shorter and end at charging points.

Lithium availability is lower risk to EVs growth due to new lithium hydroxide capacity additions

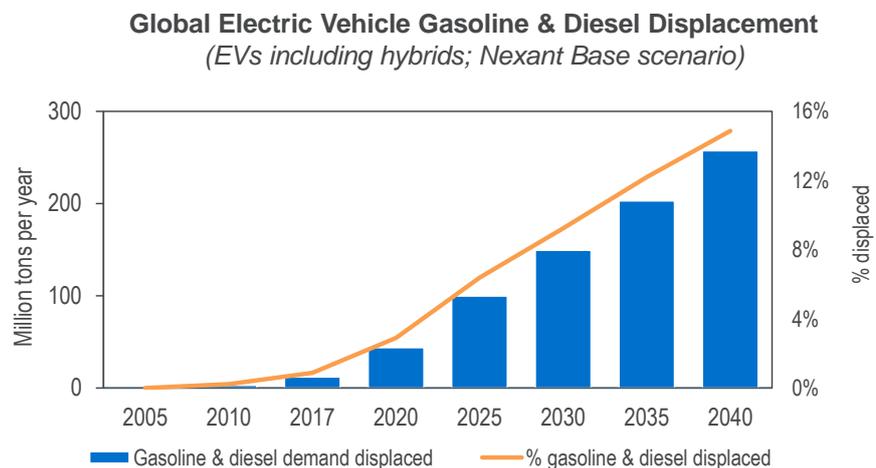
Depending on technology, lithium is used in the cathode and in the electrolyte as lithium hexafluorophosphate. Supply is more fragmented than cobalt and there are less human rights concerns along the supply chain compared to cobalt. However, lithium (carbonate) prices climbed above \$20 000 per ton earlier in 2018, from about the \$10 000 per ton mark the year before.

Lithium is required in the form of lithium carbonate or lithium hydroxide monohydrate. The cobalt based batteries (NCA and NCM) are expected to see strong most growth for EV batteries. Production of these batteries typically requires lithium hydroxide as lithium carbonate can impact cathode quality. Nexant expects lithium hydroxide demand growth to exceed lithium carbonate growth.

Substantial investment in new lithium hydroxide production capacity has been announced and its impacts on the market are discussed in the TECH report [Lithium Extraction Technologies](#).

Electrification of the vehicle fleet will lead to lower gasoline and diesel demand growth

EVs have the potential to displace significant volumes of gasoline and diesel, raising the possibility of major disruption to refined product markets in an industry that has grown accustomed to economic growth and increasing vehicle ownership leading to increased consumption.



At present, the use of hybrid and battery EVs together are estimated to have displaced around 12 million tons of gasoline and diesel from what would have theoretically been consumed in a zero EV world. This is expected to increase to over 250 million tons in 2040 displacing about 15 percent of gasoline and diesel demand forecast under a 'zero EV' scenario.

EVs will create automotive polymers winners and losers

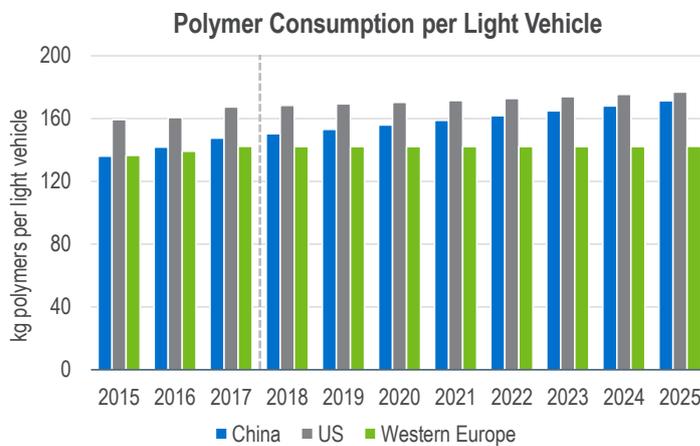
Electrification of vehicles is not expected to significantly impact the overall plastic weight per car however it is forecast to create to automotive polymers winners and losers.

There are approximately 30 000 parts in a vehicle, out of which roughly 10 000 are made of plastic. There are currently about 39 different types of basic plastics and polymers used to make an automobile but polypropylene, polyurethane, polyamides, polyethylenes, ABS and PVC are used most extensively.

In order to meet environmental targets, the fuel efficiency and material composition of vehicles has undergone significant developments in the past few decades. Many of these developments have been driven by lightweighting. Significant fuel efficiency gains can be achieved from reducing the weight of a car; for every ten percent of vehicle weight reduction, fuel economy improves by about six to eight percent. The decline in car weight has been a

result of the substitution of steel and iron parts with high and medium strength steel, Advanced High-Strength Steels (AHSS), aluminium, magnesium, plastics and composites.

Regulatory fuel economy standards such as the Corporate Average Fuel Economy (CAFE) in the U.S. and the standards in the European Union and China will continue as drivers for lightweighting.



The price of oil also plays a role. If the oil price is high, consumers look to more fuel efficient cars, supporting the lightweighting trend and continued growth in plastics consumption.

Despite the lightweighting trend over the last five years the average weight of plastics per car in the U.S. and Western Europe has not increased. Much of the lightweighting by switching to plastics has already happened but

the Chinese have been slower to do so. The weight of plastics per car is expected to continue to increase in China and will be a key driver of automotive polymer demand. China has grown from the fourth largest vehicle producing region in 2005 to become the largest today.

While lightweighting has been a major focus area to meet fuel economy standards, engine efficiency, transmission technology and electrification technology are also major focus areas. Of these, electrification will have the most impact on polymer use in vehicles.

With the combustion engine being replaced by a battery in EVs and no requirement for fuel tank, pumps and other connections, the respective plastic parts will no longer be required in such vehicles. Engineering polymers or elastomers are expected to lose out most where parts are no longer required (e.g. fuel lines). Commodity polymers such as high density polyethylene (HDPE) will lose out where it is used for fuel tanks.

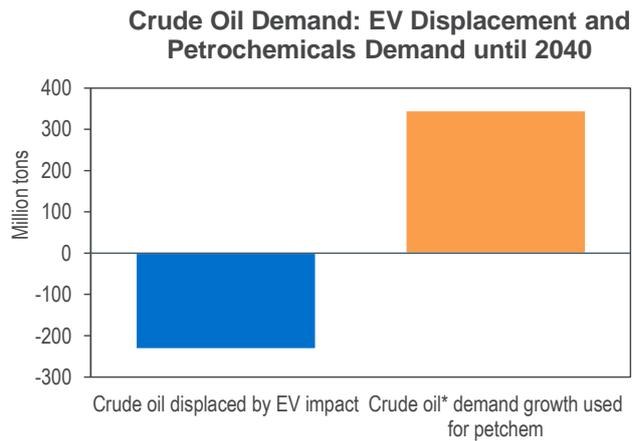
EVs will also provide some opportunity for polymer growth particularly related to battery module, thermal management system and control unit. For example, ultra-high-molecular-weight polyethylene (UHMWPE) in the lithium-ion battery separators in electric vehicles.

With new EV technology and models being developed quickly there will be continued new opportunities for plastics in cars. Partnering with the automotive industry and parts suppliers as new EV models are developed will help determine which plastics or other materials are specified.

Changes to business models will be required

While EVs are not forecast to provide a significant step up in polymer demand compared to conventional vehicles, global polymer demand will grow more quickly than gasoline and diesel demand driven by their uses in the packaging, construction sectors as well as the automotive sector.

Diesel and gasoline demand growth will disconnect from GDP growth as EVs penetrate the vehicle fleet. Gasoline and diesel outlook to 2040 is about 1.0 percent per year, whilst polymers, the main drivers of petrochemicals demand, are expected to see average growth of above 3.0 percent.



This disconnect will create a requirement for refiners to modify their business models towards petrochemical feedstock production and has already helped spur on discussion around for new projects focusing on petrochemical production including ‘Crude to Chemicals’ .

**Only includes petrochemicals produced from refined products (e.g. naphtha) rather than methane, ethane, propane and butane.*

Summary

Under Nexant’s base case scenario, EVs will become a major segment of the global vehicle fleet by 2040 and this will cause significant disruptions through supply chains. Impacts will be felt across the mining, oil and gas, petrochemical/ polymers industries.

A large increase in cobalt and lithium supply is required for EV battery manufacture. Whilst new planned lithium hydroxide capacity additions are expected to meet the increase in lithium demand, cobalt supply may be a limiting factor in the development of EVs. Continued focus to develop battery technology with reduced cobalt content is required along with a large increase in the supply of cobalt.

Electrification of the vehicle fleet will lead to lower gasoline and diesel demand growth. EV’s will also create automotive polymers winners and losers but no significant changes in total polymer consumption in the automotive sector. While EVs are not expected to significantly impact automotive polymer consumption, overall polymer demand from all sectors will grow more quickly than gasoline and diesel demand. This disconnect will create a requirement for refiners to modify their business models towards petrochemical feedstock production.

As EVs offer the potential for the transport sector to decrease emissions the ability of the supply chains that will help drive these developments and adapt to changing requirements will be crucial. Nexant has published several reports assessing the impact of EVs through these value chains.



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