Osterwald Rathbone & Partners
Finance & Strategy

Are Battery Electric Vehicles Always the Greener Choice?

Part 3:
Examination of Resource Constraints in Vehicle Battery Production with Current Technology

By Rachel Lennox-Warburton | Annelisa Hussey | Matteo Bianciotto

This article is the final instalment of a three-part series addressing whether electric vehicles are always the greener choice.

- Part 1 of this series, by analysing the energy mix of countries across the globe, addressed the implication of hydrocarbon-fuelled electricity grids limiting how 'green' BEVs may be in actual practice.
- Part 2, by considering geography and mileage, directly compared the lifetime emissions of popular BEVs with their petrol equivalents.
- In turn, this third component focuses on the beginning and the end of the BEV lifecycle, from extraction of critical elements, combined with complex manufacturing processes required for production, to what happens once the vehicles are taken off the road.

New Era, New Problems

In 1894, the horse-drawn transport system was on the brink of causing crises in cities across the globe. As an example, dependence on animals for everyday transport and delivery of goods meant that there were approximately 100,000 horses around the city of New York, producing a staggering 2.5 million pounds of manure each day. The issue was not only across the Atlantic, The Times newspaper predicted that “in 50 years every street in London will be buried under nine feet of manure”. Today, after the arrival of motorised vehicles, the idea of worrying about London being buried in horse manure seems absurd. The ‘Great Horse Manure Crisis’ has since become analogous to insurmountable problems being made redundant by the introduction of new technology.

Today the world is on the brink (or arguably in the middle) of a new 'insurmountable' crisis, namely risks related to climate change. With a large contribution of greenhouse gas (GHG) emissions being a result of our dependence on internal combustion (IC)-based transportation systems, many governments are promoting battery-powered electric vehicles (BEVs) as the new technological solution, but do they truly live up to their claims of 'zero-emissions'?

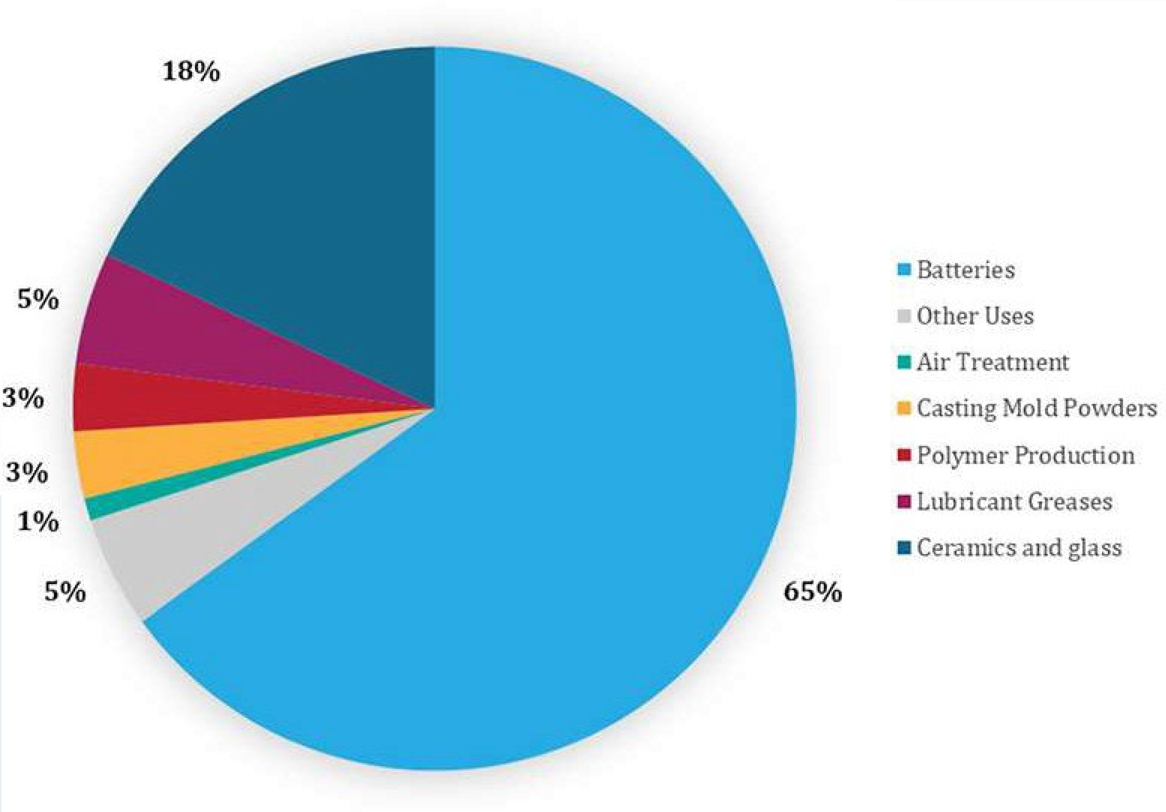
Critical Resources

As introduced in Part 2 of this series, some of the largest emissions of GHGs from 'zero- emission' BEVs comes from battery production with medium sized BEVs producing 7,900kg CO2 during production. This is in part due to the energy mix at the origin of production, with batteries produced in the US resulting in 50-65% less GHGs than those produced in China, according to 2018 data from the International Council on Clean Transportation. As China moves to reduce its electrical grid’s dependency on hydrocarbon fuels and as battery manufacturing begins to accelerate in Europe in the next 10-20 years, CO2 emissions from manufacturing will begin to decrease. There will still be a significant environmental impact, however, from the mining and extraction of minerals vital to BEV design.

Whereas conventional cars are powered by IC engines, BEVs are run on lithium-ion (Li-ion) batteries. IC engines are built from metal alloys and silicon and use widely understood manufacturing techniques, such as casting and forming. In contrast Li-ion batteries are complex pieces of technology which rely on multiple battery cells containing cathodes, anodes, electrolytes and a separator. Each step involves critical materials where the resource base is limited but demand continues to increase. Li-ion batteries contain a significant number of elements that fall under this category including lithium, manganese, cobalt, aluminium, copper and graphite.

The production of Li-ion batteries in 2019 consumed 65% of the global production of lithium and cobalt. In the same year global production of cobalt, nickel and manganese exceeded 2% of total existing reserves, according to the US Geological Survey.

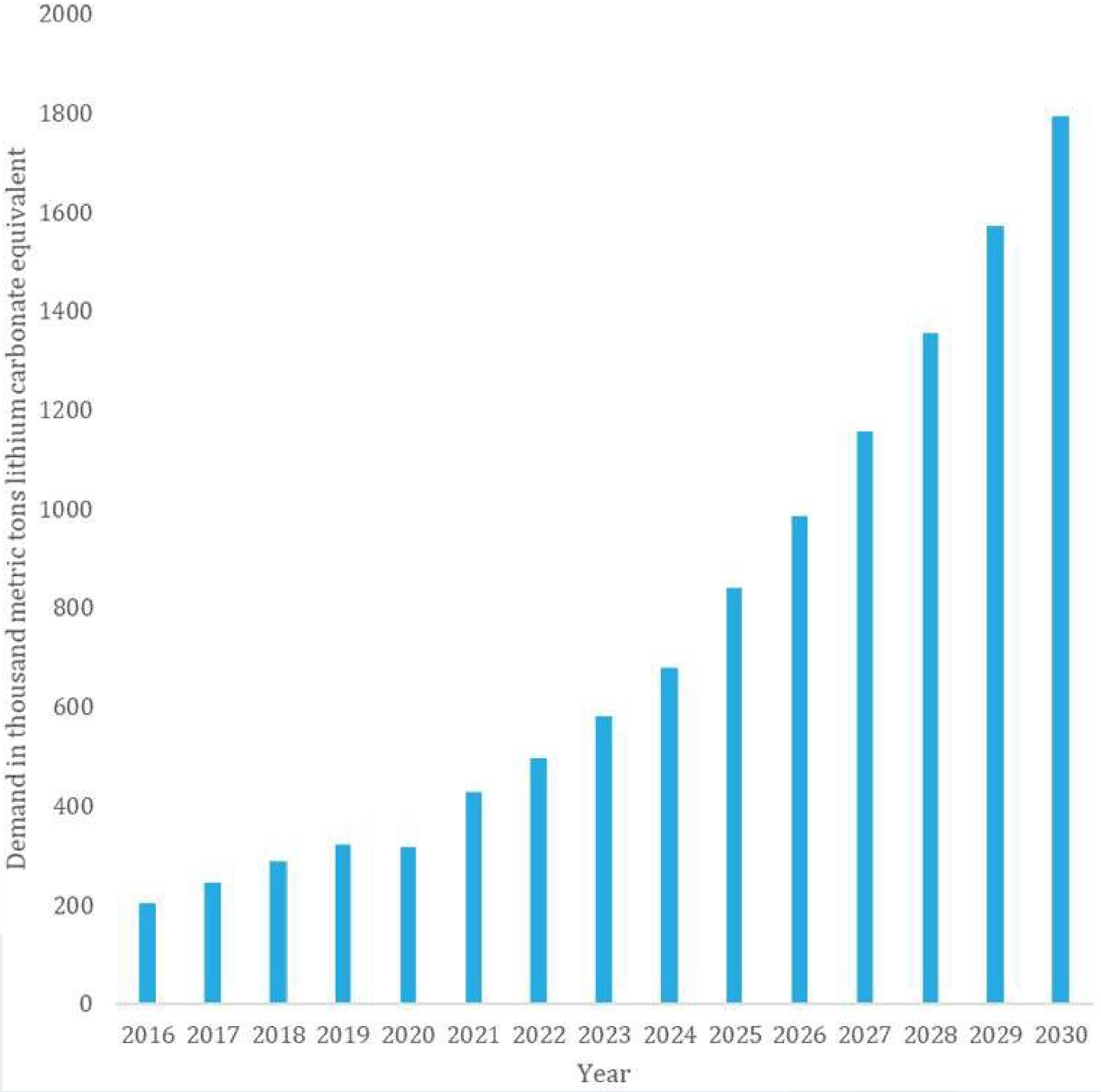
Figure 1: 2019 Lithium consumption by application



Source: US Geological Survey

Whilst 2% may seem like a relatively small number, the rapidly increasing demand for BEVs will have drastic consequences on depletion of remaining proven reserves of said critical elements. The graph below shows the predicted evolution of demand for lithium carbonate equivalent as BEV sales increase to 2030.

Figure 2: Demand for lithium carbonate equivalent 2016 to 2030

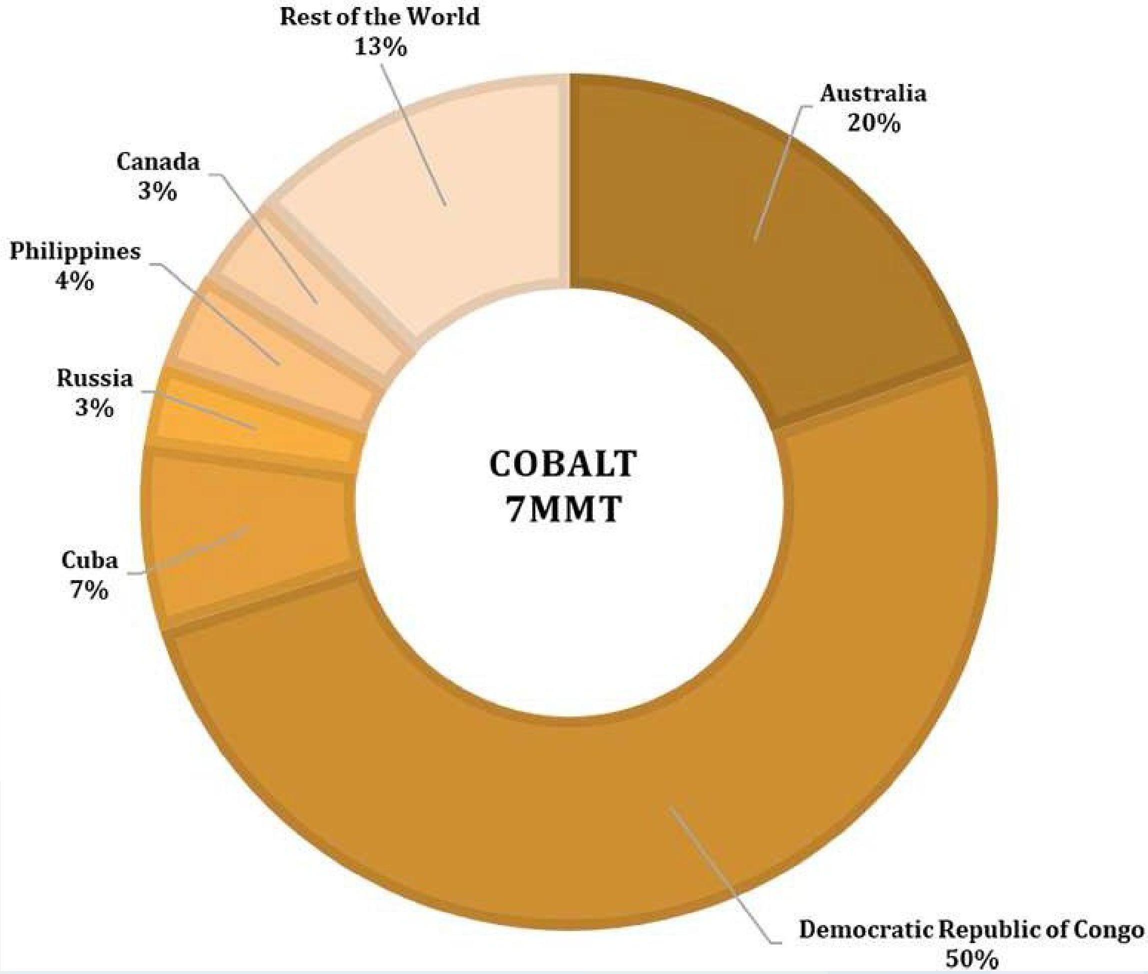


Source: Statista

In 2020 worldwide reserves of lithium were estimated to be 21 million metric tonnes (MMT). Current estimates published by Statista suggest that demand for lithium carbonate will total 10.5 million metric tonnes between 2020 and 2030, depleting a staggering 50% of current total reserves within a single decade whilst demand continues to grow. These projections suggest that by 2030, 95% of this demand will be the result of Li-ion battery production, which by that time, will have reached 2 MMT per year.

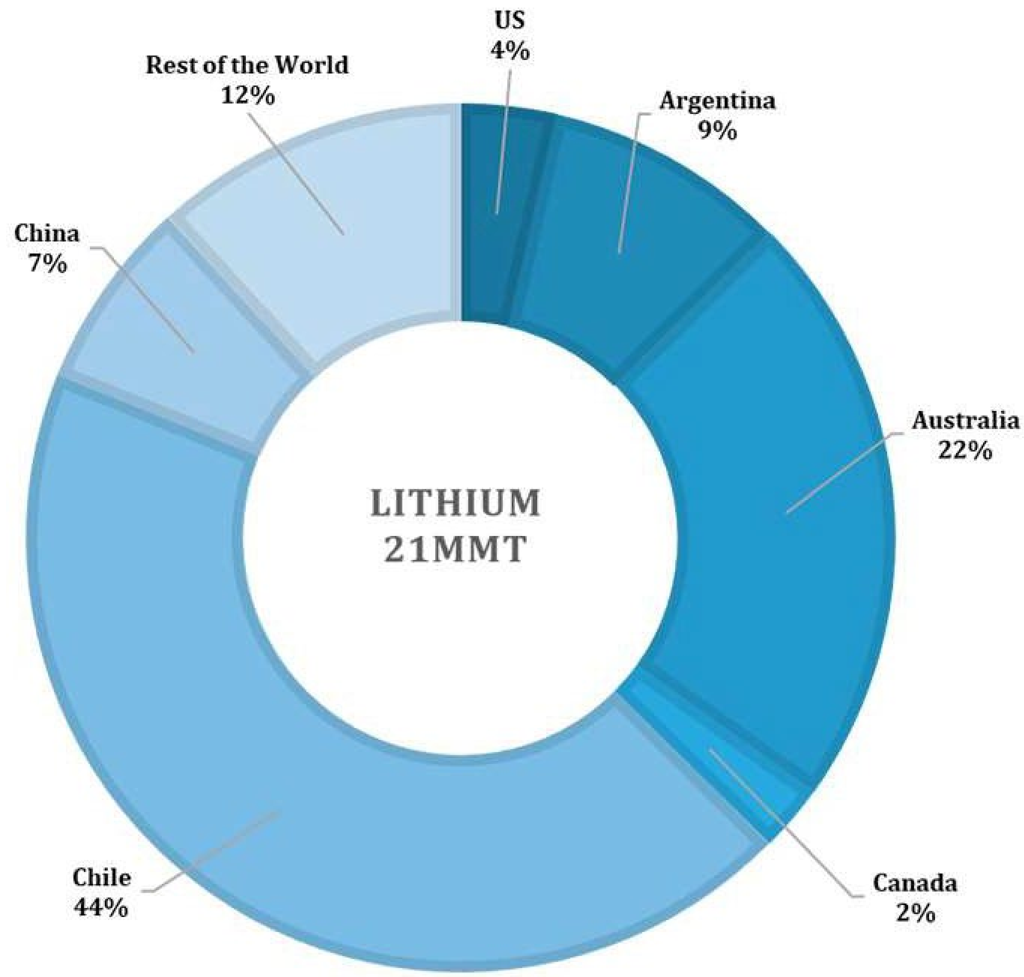
What defines an element as being critical is not only whether reserves are limited but also the likelihood of supply disruption. Reserves of key metals currently used in Li-ion batteries are concentrated in only a few countries. The Democratic Republic of the Congo dominates cobalt mining; lithium production and extraction is dominated by Chile.

Figure 3: Share of global cobalt reserves by country in 2020. Total reserves 7 million metric tons



Source: US Geological Survey

Figure 4: Share of global lithium reserves by country in 2020. Total reserves 21 million metric tons



Source: US Geological Survey

Whilst 'Big Oil' has a reputation for holding large political sway and causing environmental damage, less light is shone on the damage caused by the extractive industries required in the production of BEV batteries which have earned a reputation for frequently violating human rights and degrading the environment, according to The Washington Post. Cobalt mining in the Democratic Republic of Congo has well documented (Union of Concerned Scientists report, 2021) negative impacts on the environment, community health and human rights.

Engineering Technology (E&T) published by the Institute of Engineering Technology (IET) has also shown that SQM Mining, the leading producer of lithium in Chile, has directly damaged local environments and fragile water supplies. SQM has itself been investigated for money laundering, tax evasion and illegal campaign financing (Deutsche Welle report, 2018).

Deep-sea mining has been cited as the future of BEVs in providing an alternative source to the necessary critical materials such as cobalt and nickel. To put it very simply, deep-sea mining uses robotic machinery to excavate mineral rich rocks from the seabed, pumping them to the surface for extraction. Whilst in the past this has been written off as an extremely costly solution, diminishing reserves and improvements in technology are making it more attractive. Deep-sea mining could potentially provide access to new reserves in unexplored oceans but there is currently limited research into the damage to the marine ecology that is almost certain to occur.

Decommissioning of BEVs

Unlike conventional IC engines, Li-ion batteries are considered to be hazardous waste. Thus disposal is not straightforward. So what happens to them once the wheels stop turning?

Currently there is an emerging market for repurposing used Li-ion batteries. For smaller vehicles, Li-ion batteries are expected to last the life of the vehicle and, whilst dependent on several factors, they could potentially still have 70-80% of their capacity remaining after the end of the useful life of the vehicle. These 'spent' Li-ion batteries are currently being used around the world to provide streetlight and back-up power for elevators. Another possibility is storing intermittent renewable power.

Some reports estimate second-life battery capacity will reach 275GWh per year by 2030 (*Deutsche Welle* report, 2018). Even if a battery is re-used, however, eventually its component materials need to be recycled or disposed of responsibly.

Since Li-ion batteries contain a wide range of materials in each cell compared to conventional batteries, recycling is a far more complex process. The active materials are in the form of powder, coated onto metal foil and these different materials must be separated from each other during recycling.

Although batteries can be recycled, it's not easy due to the sophisticated chemical procedures involved and existing methods have negative environmental considerations including potential contamination of soil and water.

Not only are the chemical procedures complex but there are currently many different designs and types of Li-ion batteries. This means that the range of materials involved is too wide to enable development of universal recycling systems. Different processes have to be developed for addressing recovery of specific materials from each different battery type.

These complex processes are not currently economically attractive. According to the Institute of Energy Research, in 2019 the cost of fully recycling a Li-ion battery was about EUR 1 per kilogram; however the value of the raw minerals reclaimed from the process was only about a third of that. Considering lithium alone, extraction via recycling was five times more expensive than lithium sourced from mining.

Whilst it is difficult to estimate the number of recycled batteries on a global basis, some reports suggest that current worldwide recycling capacity is 300,000 BEV batteries per year. That is 10% of today's BEV sales but only 1% of expected annual sales in the early 2030s.

Governments are aware that the issue of recycling needs to be addressed. The Chinese Ministry of Industry published detailed guidelines for setting up recycling facilities of BEV batteries in 2019. It requires BEV makers to set up recycling channels and services outlets where old batteries can be collected, stored, and transferred to specialist recyclers. Similar policies are now in place in Europe. The *Faraday ReLib* Project in the UK commenced in March 2018 with the aim "to ensure that the UK has the facilities and regulations required for the safe, economic and environmentally sound management of the materials contained in lithium-ion batteries at the end of their first life".

Regardless of whether policies highlight the importance of recycling Li-ion batteries, they do not negate the technological hurdles faced in developing the mass recycling processes that are necessary to ensure critical resources are reused.

BEV Policy

Despite dwindling critical resources, GHG-heavy production processes and the lack of any viable mass recycling or disposal facilities, BEVs are still being heralded by governments across the globe as a holy grail solution to 'net zero' transportation networks. This is shown through a push of BEVs through policy and incentive schemes.

One of the ideas behind encouraging BEVs through policy is that, by increasing production volume of BEVs, manufacturers will find ways to improve efficiency and the cost of production will go down. Part 2 of this article series showed that BEVs are currently around EUR 10,000-15,000 more expensive to purchase per vehicle than their petrol equivalents.

This represents an increase in cost that is not necessarily recouped throughout the lifetime of each vehicle. Whilst more efficient manufacturing and economies of scale can lower the costs for battery production there will be a limit as to savings which can be realised, given the higher costs of mining and associated synthesis of critical battery materials.

Another incentive for promoting electric vehicles is in reduction of air pollution in cities where fewer diesel and petrol cars will have a favourable impact on local community health. This, however, comes at a cost. Whilst China is at the forefront of promoting BEVs, as discussed in Part 1 of this series, it remains heavily reliant on coal as a source of electricity generation. China produces 700 grams of CO_2 per kWh of electricity generated. In China's case CO_2 emissions are merely being transferred from transport heavy cities to suburban power generation plants and manufacturing facilities. One must also consider the exploitation of human rights, environmental damage and community health in areas local to mineral extraction sites, all of which are costs of developed countries improving their own environmental impact and community health.

What Will be the Next Crisis?

When the 1894 'Great Manure Crisis' was solved by the advancement of IC engines it was unknown what impact this technology would later have on climate, pollution and community health. Although the initial crisis was solved, the solution simply delayed and altered the environmental issues faced. With the increasing production of BEVs, concerns with material resources and recycling are well known. An apathetic belief that there will simply be a new technology to solve this problem, however, could lead to dire unexpected consequences.

The push towards BEVs as a component of achieving 'net-zero' goals is reliant on numerous and imminent technological breakthroughs covering:

- Alternative and renewable energy sources to 'clean' energy grids;
- Improved battery design to limit dependence on critical elements;
- New mining techniques to access mineral reserves; and
- Recycling technology to reduce demand on limited resources.

All of the above needs to be achieved within the next decade to avoid being buried in a sea of early-generation BEV batteries which resulted in limited positive change to GHG emissions and even more limited resources left for the next generation. The hope is that in the years to come these technological breakthroughs come to fruition and much like *The Times* of 1894, show this article to have been overly cynical. However, the scepticism remains that the promotion of BEVs by governments is an easy political solution which scores publicity points for working towards 'net-zero', whilst putting the real onus, cost and guilt onto consumers.

OSTERWALD RATHBONE & PARTNERS
FINANCE & STRATEGY

44 Southampton Buildings
London WC2A 1AP
United Kingdom

T: +44 20 3994 0133

www.or.partners