**The carbon footprint of an Electric Vehicle over its entire lifetime is far less impactful than a petrol or diesel car. That’s not just the view of environmental groups and dedicated electric car makers like Tesla, those are also the findings of none other than the mighty Volkswagen group themselves.**

**But the initial PRODUCTION of an EV currently carries a carbon footprint almost double the size of ICE cars.**

**And the reason for that is the batteries.**

**And a big part of the battery footprint comes from the extraction and processing of lithium.**

**Back in 2011, when Nissan first launched the LEAF electric vehicle for about thirty thousand dollars and Tesla were selling their first ever vehicle – the roadster - for quite a lot more, global sales of electric vehicles totalled 50 thousand units compared to about 58 million internal combustion engine vehicles sold in the same year. Essentially, the electric alternatives were being bought by a small number of committed enthusiasts and very early adopters.**

**At 50 thousand vehicles a year, the environmental impact of lithium ion battery production in real world terms was absolutely tiny, so no-one really took any notice of it.**

**But well over two million electric vehicles were sold worldwide in 2019, with sales growth projected to hit 21 million PER YEAR by 2030.**

**And then there’s the 1.75 billion new mobile phones we bought in 2019, and all the other gadgets like tablets, laptops, power tools and electronic toys that are almost all now powered by lithium ion batteries.**

**The result of all that growth is that what was previously environmentally inconsequential is rapidly becoming a major problem.**

**Bearing in mind that in most cases the overriding mission for EV manufacturers is to move us towards a more sustainable way of life on the planet, then the one thing that fills them all with dread and fear is the risk of being accused of any kind of greenwashing, hypocrisy or just downright dishonesty.**

**As a consequence, the last few years have seen a whole bunch of research and development going on to find ways of minimising the impact that lithium will have in the near-term future and beyond.**

**So, as we head towards Teslas much heralded 2020 battery day sometime in September, what are the latest developments in the world of lithium production and recycling?**

**Hello and welcome to Just Have a Think**

**We’ve got quite a lot of lithium on our planet. It’s reckoned there’s about 230 billion tonnes of it in the oceans for a start, and it makes up about zero point zero zero two percent of the earth’s crust which might not sound like a lot, but the earth is extremely big, so that equates to hundreds of millions of tonnes.**

**Of course, however much we have, it’s still a finite resource, so just like any other raw material we humans plunder from the ground, the less we use in the first place, the better.**

**Our modern utilisation of lithium carries a double-whammy impact on the environment, firstly at the start of its journey, when it gets extracted and processed, and then again at the end of its useful life when it gets disposed of.**

**There are two main ways to obtain industrial levels of lithium today.**

**It’s either pumped up from underground brine reservoirs and extracted by a process of evaporation, or its mined directly from rocks like the fabulously named spodumene, which sounds a bit like a badly conceived fast food start-up company.**

**Brine reservoirs are found in salars, or salt flats, in high locations in hot, dry countries like Chile, Bolivia and Argentina.**

**The mechanics of THIS method are pretty basic. The pumped-up brine is left to sit in absolutely enormous ponds, allowing the heat of the sun to evaporate off all the water and leave behind the various mineral salts, including lithium. The brine typically has a lithium content of anything from a few hundred parts per million, or ppm, up to about 7,000 ppm. That raw material then gets processed into Lithium carbonate, which is a white powder that can be converted into other salts and chemicals or processed again into pure lithium metal.**

**So, here’s the first enviro-wrinkle.**

**As Gali from hyper change discovered in a recent interview with Vivas Kumar, ex Battery Supply Chain Manager for** [**Tesla**](https://www.youtube.com/results?search_query=%23Tesla)**, and now a Principal at Benchmark Mineral Intelligence, just this one installation alone, in the Atacama desert in Chile, is larger than the island of Manhattan. If you overlaid it on a map of London it would look like this.**

**And that’s just one facility. And as they pump up all the brine from underground, they’re using huge volumes of precious water, which escapes into the atmosphere as a function of an evaporation process that can take as long as two years.**

**The only way to ramp up this kind of production is to build more ponds, so it’s not difficult to see that any significant expansion plans here would pretty quickly become unsustainable as the number of EVs on our roads increases by at least a factor of 10 in the next decade.**

**The other way to get at lithium is to mine it. THAT method Involves the extraction of lithium from the spodumene, as I mentioned earlier, but also from these other delightfully named minerals [lepidolite, petalite, amblygonite, and eucryptite].**

**The extracted materials are heated to 1100 degrees Celsius and then cooled to sixty-five C.**

**Then they’re crushed up and mixed with concentrated sulfuric acid before being heated back up a second time and added to sodium carbonate to produce the final output of lithium carbonate, which is crystallized, heated, filtered, and dried.**

**To get pure lithium metal from the carbonate it goes through an electrolytic process with a lithium chloride / potassium chloride mix.**

**That gets fused and electrolyzed at about 450 degrees Celsius, which causes the molten lithium to rise to the surface where it can be collected.**

**The conversion ratio of lithium carbonate to lithium metal is about 5.3 to 1.**

**All of that makes mining extraction a lot more expensive than brine extraction, but you do get a much higher lithium content from mining than you get from the salar brine ponds.**

**The world produced about 77 million tonnes of lithium in 2019, with the South American dominance now being heavily challenged by new mines opening up all the time, particularly in Australia. Unsurprisingly then, the subject of second life re-use and end-of-life recycling is now front and centre in the minds of industry strategists and national policymakers, as well as environmental groups.**

**And how’s that going you might ask.**

**Well…interesting…**

**The commercial world has already realised that there’s a great deal of extra value in second life use for batteries, especially from electric vehicles. EV batteries are proving that they can far outlast the vehicle itself, which means they can be removed and used for static energy storage provision in all sorts of applications, including grid balancing. We looked at some of those technologies in a 2019 episode, so you can jump back to review that one by clicking up there somewhere.**

**But inevitably there comes a time in any battery’s life when it can no longer do anything useful, and that’s where recycling comes into play.**

**Until relatively recently there seems to have been a generally accepted view that recycling rates for lithium ion batteries were really bad, at something like only 5% being repurposed or recycled globally.**

**That figure appears to have been derived from this report**

**published several years ago by Friends of the Earth. The paper actually referred specifically to lithium ion battery recycling in the European Union, and one of its main references was this EU AdHoc working group study from July 2010. At the time Friends of the Earth were spot on with their analysis, and they deserve great credit for raising the issue so early on.**

**But although recycling rates are still far from perfect today, there is evidence that very significant advances have been made over the past decade or so.**

**This report from energy consultants Circular Energy Storage gleaned data from more than 50 major recycling companies around the world to establish the latest figures. Their findings suggested that of the 180 thousand tonnes or so of lithium ion batteries available for recycling in 2019, about 97 thousand tons were recycled. 67 thousand tons of that was processed in China, who dominate what is currently a 1.5 billion-dollar market that’s projected to grow to more than 18 billion dollars by 2030.**

**In second place, perhaps not surprisingly is South Korea, who recycled about 18 thousand tons in 2019.**

**Traditionally, battery recycling has involved a pyrometallurgical process, which is essentially high temperature smelting to produce an alloy of all the metals contained within the battery. That alloy then needs to be processed again to split out the various different metal types. All of which is extremely costly and very energy intensive.**

**More recently the buzz phrase in the recycling fraternity has been Hydrometallurgical processing.**

**Lithium batteries come in various shapes and sizes, so to prepare for hydrometallurgical processing, the packs first have to be physically dismantled to separate out some of the easily removable materials like plastic casings and aluminium trays, all of which get sent to a normal recycling plant.**

**The battery modules themselves then get dumped into a shredder where they’re ground up into tiny fragments in a completely enclosed inert or vacuum environment so that nothing explodes or catches fire, which is a particular party trick of lithium ion batteries.**

**The liquid electrolyte is evaporated off in the process and later condensed back out into a liquid for re-use.**

**Depending on the specific configuration of the batteries, what you get out at the other end of the shredder is a pile of granulated materials like aluminium, lithium, nickel, manganese, cobalt, graphite and copper.**

**The granules then get screened to separate out the aluminium and copper, plus any last bits of plastic from the internal components of the cell packs.**

**That leaves a fine power, which the industry refers to as black mass, containing all the really valuable materials from the battery electrodes, including lithium.**

**The black mass then gets dissolved in an acid bath, before going through a process known as solvent extraction to separate out the different metals, which are then ready to be packaged up and re-used in new battery production.**

**Now I’ve mentioned many times on this channel how, when it comes to civil engineering and energy infrastructure, China JUST DOESN’T do ANYTHING by halves. And I would add the caveat that that unfortunately also applies to fossil fuel production as well as renewable energy, but we’ve covered that dichotomy in other videos. In the context of battery recycling, as we saw earlier, they’re right up there again, leading the world by a considerable margin.**

**But the rest of the industrialised world has taken notice of China’s progress and woken up to the environmental benefits of lithium recycling, and of course the financial rewards that are potentially there for the taking.**

**In January 2019 the US Department of Energy launched a 15 million dollar Research and Development initiative near Chicago, Illinois, called the Argonne ReCell Centre, the first advanced battery recycling R&D facility in America, designed to help businesses develop new recycling methods that can outperform hydrometallurgy and pyrometallurgy, and so enable the US to compete in the global recycling industry and reduce their reliance on foreign sources of battery materials. The ReCell Centre places a lot of attention on developing a new recycling process known as direct recycling, which involves the recovery, regeneration, and reuse of battery components directly without breaking down the chemical structure. The idea is that by maintaining the process value in the original battery components (in other words, removing the useful bits without smashing them to pieces first), then a lower-cost re-constituted material can be supplied to battery manufacturers.**

**A similar initiative exists here in the UK, called ReLiB. It’s a consortium led by The University of Birmingham in collaboration with all of these UK institutions. Their aim is to establish not only a technological infrastructure but also a legal infrastructure to optimise what is currently a very undeveloped and badly regulated industrial sector.**

**And the 2020 global lockdown hasn’t halted progress either.**

**In late July this year a deal was struck between the Australian recycler Neometals, and German manufacturer SMS Group, to create a joint venture called Primobius, which they say will create a Demonstration Plant at SMS’s manufacturing site in Germany to validate Neometal’s proprietary recycling process at industrial scale, followed by ramp up of commercial-scale operations in Europe, which they claim will be the largest Lithium Ion production hub outside China. Neometals say their recycling process also aims to improve on existing methodology by targeting the main lithium ion cathode chemistries of lithium cobalt oxide, nickel manganese cobalt and nickel cobalt aluminium from electric vehicles, energy storage systems and consumer electronics, liberating all of these precious minerals for re-use and reintegration into a circular economy.**

## And only a week or so before research began on this episode, a Singapore-based start-up called Green Li-ion launched their tech business which they also claim will ease the looming e-waste crisis by dramatically increasing the efficiency and profitability of rechargeable battery recycling. Details are pretty scant so far, but I’ll keep an eye on them over the coming months and update you with any significant progress.

**Just like everything else in the renewables world, lithium ion battery recycling is set to become one of the largest and most important global industries as we move towards 2030 and beyond, and no doubt, as usual, the corporate entrepreneurs will move in and hoover up as much of the profit as they can possibly get their hands on, and I know from your feedback that many of you feel this is simply a substitution of one broken economic system for another.**

**I’ll leave that debate for you folks to have in the comments section, but let’s face it, consumer electronics are unlikely to disappear in the near future, and I think it’s generally accepted now that electric vehicles will dominate the market within a decade or so.**

**If that growth is to stand any chance of being anything like sustainable, then global scale initiatives like second life battery use and near 100% recycling will be absolutely essential.**

**Anyway, dive down there as usual and share your thoughts, but that’s it for this week. No video next Sunday I’m afraid due to other project commitments, but we’ll be back on Sunday 30th August with another dive into the world of climate change and sustainable technology.**

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**As always, thanks very much for watching, have a great couple of weeks and remember to Just Have a Think.**

**See you next time.**