The Power of 3
Driving the future further
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"Where have all the batteries gone?
Time keeps passing ...
Where have all the batteries gone?
Gone to landfill, nearly every one!
When will we ever learn?
When will we ever learn?"

~ with apologies to Peter, Paul & Mary

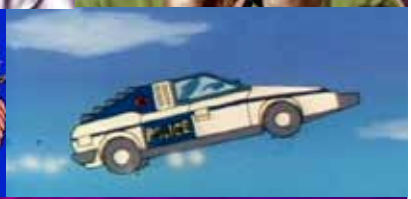
What's the solution for our wasteful society?

Is recycling the answer?

Every year, more than 40 million tonnes of 'e-waste' is generated globally but at present only 15 per cent or so finds its way back into the system for recycling.

Overview

The science fiction of the previous century has become reality in the 21st. Remember Maxwell Smart's 'shoe phone', Dick Tracy's wearable-tech, Inspector Gadget's getaway vehicles or, indeed, the Star Trek communicator? Of course, recall depends on one's age, but no-one can deny that today all of these former fantasies, and more, are available in some form or other.



But concomitant with the surge in the supply of – and burgeoning demand for – everything from smart and smarter phones and thin and thinner laptops/tablets to the nimblest of drones, vertical-take-off-and-landing aircraft and fast and faster electric vehicles (not to mention renewable energy storage and the like) is the fact that the supply of the primary raw materials essential to powering these innovations simply cannot keep up with demand.

The dynamics for lithium-ion batteries (LIBs) are similar, with global recycling rates of less than 10 per cent – and of the metals that *are* recovered, lithium lags far behind the rest.

With the current acute shortage of cobalt, and international embargos on any such material produced in the Congo, demand for this energy metal for battery production alone is destined to outstrip supply in the foreseeable future. And there are growing concerns that lithium production too may not keep up with demand in years to come.

So, why are LIB recycling rates in particular so low? A major reason, of course, is that we've become a society of consumers, living in the moment with little thought or concern for how our behaviour affects the planet now or in the future. This disposable lifestyle is fuelled by ever-decreasing prices for portable electronic items deemed desirable, not to mention their built-in obsolescence. Neither creates much incentive to recycle what's no longer considered useful ... guilty consciences aside (and also in short supply). For the vast majority, it's easier to dump devices past their use-by-date into the rubbish that goes to landfill, including the LIBs that power them (see *The Power of 3*, issues 5 & 6).

Recycling International discusses a new analysis by Creation Inn, a London-based business development consultancy with expertise in energy storage and circular economy:

> *The total volume of recycled lithium could reach 5,800 tonnes – or 30,000 tonnes lithium carbonate equivalent (LCE) – in 2025...*

That's just 9 per cent of the world's total supply of LIBs. While the outlook for cobalt is somewhat better – it's anticipated that 22,500 tonnes from recycled batteries will reach global markets in 2025 – the recycling volumes for both lithium and cobalt will still be relatively low.

> *Long service lives [of the batteries], positive prospects for second use and poor collection of portable batteries are said to be the main reasons behind this...*

Another is the recycling technology itself. At present, only a handful of countries, among them South Korea and China in particular, are researching and developing the ability to recycle many of the materials found in e-waste (including LIBs). Even here, though, lithium, one of the elements most critical to powering electronic devices and electric vehicles, is recovered at very low rates. The issue lies in smelting the complex metal mixes emanating from e-waste and batteries before their recovery and refining. Because lithium is volatile, it ends up in flux or discharges as unrecoverable vapour. But that may be about to change.

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Again, China leads the world

Creation Inn suggests that, of the 9 per cent of lithium expected to be recycled globally mid the next decade, more then 66 per cent (191,000 tonnes) of that will be in China, which is seeking to fuel its rapidly expanding battery-material industry (see *The Power of 3*, issue 19)**.**

In China too, recycling of batteries containing cobalt is expected to result in a 76 per cent recovery rate for that element by 2025.

But, while the Chinese labour to ensure sustainability nationally, the country's recent ban on importing many categories of solid waste has exacerbated the recycling dilemma for Europe and America, two of the fastest growing markets for LIBs outside of Asia. This makes it imperative that the rest of the globe recognises the value in used batteries and a new industry is established in the western world.

China has long been a dumping ground for the world's waste [photo courtesy of PhysOrg].

Closing the loop on the energy-metal cycle

Creating a new industry to recycle energy metals requires more than merely regenerating metals from e-waste and LIBs. What's needed is a comprehensive sustainability plan that includes re-birthing the products from which those energy metals were recovered.

In the case of LIBs, the ultimate circular economy could be realised via the use of hydrometallurgical techniques that generate complex metal solutions – from which battery cathode materials can be directly precipitated. Unlike commonly used pyrometallurgical processes (in which high temperatures are used to extract and purify metals), hydrometallurgical processes (involving the use of aqueous chemistry instead) can recover lithium as well as other strategic metals from recycled and residual materials.

Saving LIBs, and hence lithium and cobalt, from landfill will vastly improve the sustainability of these two elements in the supply chain, and in so doing quash the greatest threat to continued production of smart phones, tablets, EVs *et al.* It will also promote despatch of these new and desirable devices via drones, Uber-copters and various autonomous delivery vehicles.

And finally ...

Speaking of autonomous delivery vehicles, check out this cutie. Built of ultra-light materials, about half the width of a normal car, designed to travel on roads like other vehicles, and destined for neighbourhood use only, Nuro (the vehicle) is the brainchild of Dave Ferguson and Jiajun Zhu, formerly principal engineers with Google's self-driving car project. Other team members hail from the likes of Apple, Uber, Tesla and GM, so Nuro (the company) boasts sound credentials.

Which Perth-based company plans to combine LIB recycling with the re-birthing of battery cathodes?

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