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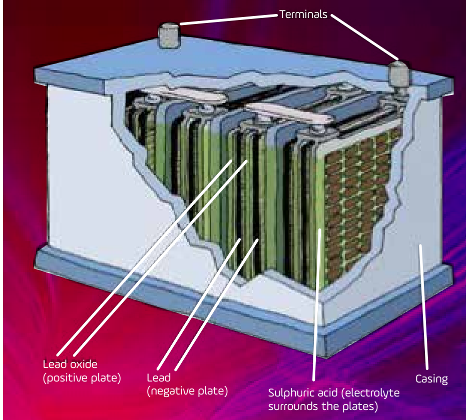
Driving the future further

Overview

The last issue of *The Power of 3* considered some of the many barriers to adequate recycling of lithium-ion (Li-ion) batteries. Not least among these were the plethora of available battery chemistries and components, a lack of standardisation and the fact that so many live and die within the products they power.

One of the most exemplary recycling successes of the past 100 years has been that of lead-acid batteries. Why? Because by law they cannot be discarded, and because all manufacturers use the same basic (and commercially valuable) raw materials and a chemistry not requiring segregation. Thus, lead-acid battery disassembly can be automated, which simplifies the recycling process and helps make it profitable.



The cells of Li-ion batteries, on the other hand, contain many and more various materials, with some of those that are active taking the form of powder coated onto metal foil. All these different materials must be separated from each other during recycling.

Despite the seemingly unstoppable proliferation of Li-ion batteries, it will take market saturation (still many years away), end-of-cycle disposal and cost incentives to ensure viable widespread recycling – and even then, matching the +90% recycling rate for lead-acid batteries may not be achievable.

Recycling rechargeable batteries: an industry imperative – part 2

Cradle-to-grave or re-birthing?

If better technology is the Holy Grail of battery manufacturers, then cradle-to-grave recycling – or even battery re-birthing – may be the Sangraal of those concerned by how many batteries are being produced and the lack of adequate means for their disposal. The environmental impacts of batteries are not limited to the waste stream – they occur during the production, distribution *and* end-of-life phases – but those that end up in landfills and incinerators pose an especially serious health risk to humans and animals.

As *Part 1* revealed, much time, effort and expenditure is being devoted to the cradle-to-grave aspects of the Li-ion batteries that drive electric vehicles (EVs). But what's to say they can't be retired to a less demanding application? Stationary household power storage doesn't need the high recharge rates EVs do, so maybe, rather than buying a Powerwall or similar device, you could park your outmoded Telsa (with the jumper leads permanently attached) to capture the sun's energy, then feed that power, as required, to your refrigerator!

In 2014, in Deptford New Jersey, Jason Hughes did more or less that. Having spent nearly a year 'hacking' the battery of a wrecked Telsa Model S, he reworked it into a stacked array to store energy from his home's solar-power system.

In 2015, Bosch took the idea one step further, announcing a partnership with BMW and Vattenfall known as the 'Second Life Battery Alliance'. Put simply, this involves building a mortuary for car batteries that will double their useful life (to a staggering 20 years!). Gigantic racks will contain hundreds of below-spec EV batteries that can live out their remaining time as municipal power storage.

Recycling whole lithium batteries into less demanding applications is certainly a laudable environmental initiative, but what happens when the market does eventually reach saturation? As millions of batteries head past the point of reincarnation towards their final demise, reprocessing of their components will become an industry imperative. The upside would be the provision of cheaper materials, taking the pressure off the supply of, say, cobalt, which is already problematic.

But, given the many constraints to lithium battery recycling, how *can* the materials they contain be recovered best? Retrieving useful metals from a pile of scrap is not as simple as obtaining the same elements from a pile of rocks. Perhaps the industry needs to reference the technologies that produced the metals in the first place; that is, treating waste batteries as high-grade ore and initiating processes that digest and extract metallic compounds in the battery, just as the original ore was digested.

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Battery innovation

As also mooted in *Part 1*, better lithium battery chemistries, then standardisation of those types that work best, would help simplify future recycling.

One innovation under intense scrutiny for more than two decades is the lithium-sulphur (Li-S) battery, which may eventually carry up to five times the density of high-capacity Li-ion batteries of comparable size. Li-S batteries are cheaper to make, less toxic and safer to operate than Li-ion batteries: crucial considerations in encouraging a switch towards renewable energy sources. Moreover, sulphur is virtually free and Li-S devices could help transform what is essentially a waste product into useful technology. The downside of current incarnations of the Li-S battery is leakage of lithium polysulphide from the electrode into the electrolyte, which causes the battery to fail.

Sony, producer of the world's first commercial Li-ion battery last century, is developing a Li-S battery that it hopes to commercialise by 2020, changing the battery recycling landscape forever in the process.

Last year, too, EU-funded researchers in the 'Lithium Sulfur Superbattery Exploiting Nanotechnology' ('LISSEN') project developed a Li-S battery with lithiated silicon as the anode and a nanostructured sulphur-carbon composite as the cathode. Said LISSEN coordinator Riccardo Carelli:

> *"Our efforts … were directed toward the replacement of all present battery components with materials that have higher performance in terms of energy, power, reliability and safety."*

Prototypes are currently being developed and industrial partners are examining fabrication and scaleability issues.

Meanwhile, researchers at Stanford University have engineered a new carbon material said to significantly boost the performance of energy-storage technologies, including Li-S batteries.

Solar Impulse 2 over San Francisco (Credit: Solar Impulse)

And, finally, a picture worth a thousand words …

Speaking of innovation, right now a unique flying adventure is underway, powered by lithium polymer (LiPo) batteries.

Last month residents of San Francisco's Bay Area were treated to a fly-by of the Golden Gate Bridge by the *Solar Impulse 2*, which aims to circumnavigate the globe, breaking world records and promoting clean technologies as it goes.

A zero-fuel aircraft powered by sunshine but able to fly at night, the *Solar Impulse 2* weighs about as much as a large car but has a wingspan greater than that of a Boeing 747. The more than 17,000 solar cells built into its wings charge an extra-efficient LiPo battery pack designed to be ultra-light, energy-dense enough to power the plane's 17.4-horsepower motors, and durable enough to endure continuous discharging and recharging over very extended periods. In fact, the per-cell energy density of the battery system, designed by Korean company Kokam, is more than twice that of a high-capacity Li-ion battery, although the chemistry of both is basically the same.

Conclusion

From a recycling perspective, a major shift towards new technologies such as Li-S batteries could diminish the value of retrievable metals within other types of lithium batteries, rendering their conversion into reusable materials even less attractive commercially.

That said, the simpler chemistry of Li-S batteries would certainly make for easier and more efficient recycling, to the point, perhaps, where it rivalled the success of lead-acid battery recycling.

For the time being, however, Li-ion batteries remain the gold standard for energy storage – and their comprehensive and efficient recycling is essential from an environmental point of view.

Which Perth-based company is resolving many of these issues right now?

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