Are recycled battery metals as effective as those newly mined?

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Many aspects of modern life depend on a steady supply of energy. 'Moore's Law'1 has led to us think we can almost always expect more computing power, and we may see similar expectations for the future of energy storage. The critical focus in 2022 is: where will we source all of the required metals?

Energy storage may progress on multiple paths

Think of three different possible use cases:

1. **A high-performance electric vehicle.** Here, the primary focus would be on energy density and range, with an assumption of being able to charge on a regularly scheduled cycle, for example, while the owner sleeps at night. The battery can be large and somewhat heavy, but these specifications would depend largely on other details about the specific vehicle. Size and weight certainly wouldn't be unlimited.

2. **Stabilising the supply of an electric grid powered by intermittent sources.** The world sees the benefit of zero-emission power sources like wind and solar, but we know that the wind isn't always constant and the sun isn't always shining. Extremely large batteries that can effectively store energy for days, if not weeks, could be useful here. On the spectrum, size and weight would not necessarily be a concern here since the battery itself is stationary.

3. **A custom-designed battery aimed to power a small device.** Efficiency and weight could be the primary concerns in the case of a wearable health monitoring device, for example.

Since the range of use cases is so varied, we would expect a diverse array of solutions for energy storage. Lithium-ion technology has been dominant for roughly three decades, but the future could support many different technologies.

Thinking about battery life? Focus on the cathode

When we change the batteries of a remote control or a smoke alarm, we see the + and the – signs:

- The negative sign or terminal can be called the 'anode'.
- The positive sign or terminal can be called the 'cathode'.

Every battery needs to get electrons moving in order to provide power. In use, electrons move from the anode to the cathode, and when charging they reverse. It is well known, however, that batteries cannot be charged and re-charged on an infinite basis, and the source of issues with this tend to emanate from the cathode.

A lot of the research in battery development has gone into what elements and what types of structures work best in the cathode. If we are talking about an NMC 811 configuration, for instance, this refers to Nickel-Manganese-Cobalt, with 8 units nickel, 1 unit manganese and 1 unit cobalt. This covers certain economic and sourcing concerns, while also balancing safety and energy density needs. As the atomic structure within the cathode comes under stress from use and re-use, this is where we notice that the battery life and charging performance may not match what we witnessed when it was brand new2.

Are metals agnostic to their source?

The nickel, manganese and cobalt to be used in a battery could come from a variety of places. It might come directly from mines, having never been used before in another battery. Similarly, it might come from a mixture of recycled products, recognising that it isn't always a simple matter to mine more of these materials.

Is there a difference? That is, should one expect to qualitatively notice lower performance if the source of the battery metals is recycled? Logically, the atoms of the distinct metals should be the same regardless of their source, but it certainly bears testing3.

Redwood Materials is a firm dedicated to sustainable battery metals production and sourcing an ever-increasing amount of the necessary input from recycled content. The Materials Research Group at Argonne National Laboratories recently tested the performance of high-nickel cathodes, like the NMC-811 that we discussed earlier, to see if they could identify a performance difference between freshly sourced metals and recycled metals4.

The results from this test indicated that the performance of Redwood's recycled materials was not distinguishable from that of new metals when used within battery construction5. We cannot say that this will immediately lead to an explosion of battery recycling from this point forward, but it is an important step, adding to the credibility that if performance and safety are paramount concerns, these can be achieved just as well with recycled materials.

Conclusion: recycling has interesting supply chain implications

Anyone following global battery production would note at a certain point that China is the major player, currently responsible for making roughly 78% of cathode materials6. We must remember that the metal ores don't just come out of the ground and go into a battery—there is a lot of processing that has to be done. On the current path, this share could increase to 90% by 2030, even with the US making efforts to invest and expand its own internal capabilities. China has built an advantage; given that the supply chain is domestic to their market, they have centralised expertise and can more quickly and economically break down raw materials and scrap metals and get them into the necessary cathode structure. China is on a path to get to a similar place with battery minerals and production to where Taiwan is today with semiconductors7.

Redwood Materials is an example of a US company taking rather interesting steps, going from simply selling raw materials to other suppliers to progressing towards the production of its own cathode materials. The firm has even announced a $3.5 billion investment over 10 years in the Reno, Nevada area where it plans to produce enough cathode material for 100 gigawatt hours of battery cells by 2025, roughly equal to what CATL, China’s dominant producer, made last year8.

While the demand to recycle is high, as the market is pushing sustainable solutions across many industries in 2022, there are risks at this early stage of the industry’s development. One risk is whether a company like Redwood can scale up the production of very pure metals, as the purity does make a difference in the battery performance. The structure of the metals in the cathodes need to be very precise. Then, there is the issue that many electric vehicles are quite new, so there is not yet a huge volume of car batteries to recycle. Battery recycling occupies an interesting, early point in its historical development, and we believe that it could be an important link in the broader energy storage value chain as the trend grows in the future9.

1 Moore’s Law (Gordon Moore, 1965) observes that the number of transistors on microchips will double roughly every two years. This phenomenon suggests that computational progress will become faster and more efficient over time.

2 Source: Barber, Gregory. “Recycled Battery Materials Can Work as Well as New Ones.” WIRED. 13 October 2022.

3 Source: Barber, 13 October 2022.

4 Press Release: “U.S. Department of Energy’s Argonne National Laboratory verifies performance of Redwood cathode from recycled content.” Redwood Materials. 13 October 2022.

5 Press Release: Redwood Materials. 13 October 2022.

6 Source: Barber, 13 October 2022.

7 Source: Barber, 13 October 2022.

8 Source: Barber, 13 October 2022.

9 Source: Barber, 13 October 2022.

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