Lithium-Ion Batteries-Wave of the Future

It is generally accepted that the burning of fossil fuels is the chief contributor to climate change. To alleviate this problem, we need to turn to alternatives to burning oil, gas, and coal. That alternative is renewable energy i.e. wind, solar, and hydro. This requires generating on-demand electricity to power our cars, our homes, and our industries. However, the sun shines at most 16 hours per day and the wind does not blow all the time. We need to be able to store the sustainably generated energy for use in those times. We turn to batteries to bridge the gap (Xu, 2022, Zhao, E. 2021).

When industry looks at the performance of a battery, they gather key performance indicators (KPIs). These KPIs include energy density (how much energy can the battery store per unit weight), power (how much energy can it deliver per unit time), lifespan (how long will the battery last before it is unusable), safety, and cost. These items need to be examined not only at the point of use but the entire life cycle of the battery (Liu, 2022) .

The two major types of batteries in use today are lead-acid and lithium-ion. Lithium-ion batteries have emerged as the leading type of rechargeable battery for electric vehicles and electronics and renewable energy storage. Lithium-ion batteries have no maintenance requirements whereas lead acid batteries need to be rewatered at regular intervals. Lithium-ion batteries are faster charging, have a longer life and have longer run times than lead-acid batteries. Lead-acid batteries have the possibility of spilling caustic chemicals while in use whereas lithium-ion batteries do not unless they are damaged (Kickham, 2019). Lithium-ion batteries are lighter per unit of energy delivered than lead acid batteries, thus making them ideal for portable uses (landscaping equipment) and where weight reduces energy efficiency (automobiles). Lithium-Ion batteries have the added benefit of not creating greenhouse gases while in use whereas burning fossil fuels do.

There are concerns regarding lithium-ion batteries in the realm of sustainability. (UL Research Institute, 2022, Kim, 2022) Lithium and cobalt are scarce minerals around the globe. There are two primary sources of lithium, mining the hard rock ore (open pit mining) or brine extraction with evaporation ponds (Amato, 2022). Open pit mining has the disadvantage of scarring the land and adding contaminants to the water and soil. Brine extraction uses an inordinate amount of fresh ground water. Brine evaporation ponds are in very arid parts of the globe impacting farming and drinking water for the population.

The above concerns are being addressed in several ways. First, recycling procedures are being developed to extract these minerals from the spent batteries (Patrizio, 2023, Llikainen, 2023). The EU has placed a mandate that lithium-ion batteries must have 63% recycled lithium content by 2027 and 73% recycled lithium content by 2030 (Baum, 2022) . This mandate is increasing the amount of recycling of lithium-ion batteries in the EU. Other nations must follow their lead.

These recycling programs need to be expanded to handle the increased e-waste (Baum. 2022). E-waste can be decreased by recycling programs as well as working to extend the lifespan of the batteries themselves. When lithium-ion batteries are at their end of life in Electric Vehicles (EVs), they can be used to store power for homes for another 10 years before they reach the end of life for that purpose. In addition, China is deigning cars which allow swapping of batteries instead of charging them, a process that can be done in an appropriate “swap station” in three minutes. Keeping the batteries in the hands of the manufacturer/refueling stations allows a 100% battery recycling at their end-of-life (nio.com 2024). Appropriate disposal and reputable recycling programs would address the danger of fires and the dangerous practice in some parts of the world of burning the spent electronic equipment to extract the minerals (Mahran, 2023). Repair fairs extend the lifespan of our electronics by repairing the equipment instead of throwing them out.

Secondly, additional methods are being developed to primarily extract lithium and other metals from brine that requires no fresh water leaching or evaporation ponds. Energy-X has developed an extraction process to remove the lithium directly from the brine without evaporation. This technology is being tested at the Great Salton Sea in California, producing lithium as a byproduct of geothermal energy generation, a renewable energy source. The Department of Energy estimates that there are 3,400 kilotons of lithium available below the Salton Sea, enough to build 375 million batteries (DOE, 2023).

More sustainable batteries are here or on the horizon. Research is being done to substitute other more abundant minerals for lithium and cobalt (Casey, 2024, Herrington, 2021, Shi, 2022). Other materials such as sodium, and organics (carbon, nitrogen, oxygen, sulphur) are being explored as alternatives to lithium. Sodium is abundant, safe, non-toxic, and cheap. It is heavier than lithium which increases the weight of the battery for the same energy output. These batteries are being installed in Chinese auto market currently. Because of the weight, the battery will have lesser range than the lithium-ion battery, but research is proceeding to improve this range.

With these advances in technology, lithium-ion batteries will be the mainstay of our efforts to decarbonize our lives. Improvement in ways to obtain primary sourcing of the material, increasing recycling of the used materials, repairing the equipment, and developing second use technologies will extend the primary life of the batteries we use. This will improve the sustainability of electrification and defeat climate change.

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