Helsinki flow battery technology

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Residential, commercial and grid-scale battery technologies are being called upon to firm up record amounts of intermittent renewable energy coming online, stabilize utility grids amid rising energy demand, and provide reliable backup power during extreme weather events.

Lithium-ion batteries are the most well-known and most-used in this space but come with challenges on cost, safety, materials availability and more. With these pain points garnering attention among the general public, there’s plenty of room for non-lithium batteries to disrupt the market. Flow batteries are emerging as a lucrative option that can overcome many of lithium-ion’s shortcomings and address unmet needs in the critical mid- to long-duration energy storage (LDES) space.

With most energy transition technologies, cost is still king. Innovators in the flow battery space have been working hard to develop options that compete with both lithium-ion and vanadium, the dominant flow battery chemistry available on the market today.

That work seems to be paying off. In an August 2024 report “Achieving the Promise of Low-Cost Long Duration Energy Storage,” the U.S. Department of Energy (DOE) found flow batteries to have the lowest levelized cost of storage (LCOS) of any technology that isn’t geologically constrained. DOE estimates that flow batteries can come to an LCOS of $0.055/kWh. To put that into perspective, lithium-ion will only get to $0.070/kWh and needs three times more money to get there.

Two other infamous pain points of lithium-ion batteries are fire risk and supply chain constraints. In water-based flow batteries, all active battery materials are immersed in water. That means zero fire risk. On the supply chain front, those same active battery materials can be made using abundant sources available through domestic supply chains and therefore not impacted by supply chain disruptions, mineral shortages, volatile commodity prices, or geopolitical tensions.

With noted advantages and commercial-scale potential, what’s keeping flow batteries from mass adoption? So far, the market is associated mainly with vanadium-based systems. Vanadium is a critical mineral that is mainly imported from China and Russia, so it comes with many of the same cost and supply chain challenges as lithium-ion.

Flow batteries that use domestically produced organic material would change the calculus and emerge as true competitors to lithium-ion. What has made it hard is that organic materials typically degrade quickly under strong reducing or oxidizing conditions – in other words, when charging and discharging a battery. The first to find a stable organic reactant that can be manufactured on a huge scale for low cost will be able to catapult flow batteries into prominence as the preferred energy storage technology for mid- and long-durations of storage.

Flow batteries are already in use at scale around the world – Rongke Power connected the world’s largest flow battery to the grid in China in 2022 and CellCube has several North American flow battery installations providing grid services in partnership with G& W Electric. Most recently, a 500 MW flow battery project – which would make it the world’s largest – was announced in Switzerland.

Flow batteries’ scalability and safety make them ideal options for backup power, particularly in utility markets prone to extreme weather or public safety power shut offs (PSPS). In some markets, energy storage installations can also help defer expensive upgrades to grid infrastructure. When deployed by utilities, flow batteries can also provide grid services during times of peak demand, reducing reliance on fossil-fuel power sources and helping maintain affordable, reliable service for customers.

Looking at safety more closely, fire risks associated with lithium-ion batteries have leaders in communities that are home to storage facilities considering moratoriums on these sites. Truly fire-safe options like flow batteries are an ideal alternative for densely-populated suburban and urban areas. They can be deployed at scale quickly to ensure more communities can experience the benefits of clean energy technologies.

Each of these trends represents an opportunity for flow batteries to disrupt energy storage. But first, the general public, utilities, and regulatory groups need to be aware of these technologies and their benefits. Developers should position flow batteries as non-flammable, safer alternatives, particularly in urban and suburban areas where there are massive opportunities for energy storage that cannot be filled by lithium-ion batteries.

Regulators and policymakers have a role to play here too. Siting and installation rules should be re-examined and revised with flow batteries in mind. In many markets, fire codes still do not distinguish between lithium-ion and flow batteries. Of course, strict codes for fire safety are very important, particularly in densely populated areas, but non-flammable options like flow batteries deserve appropriate standards that account for their safety advantages.