**I know I keep going on about utility scale energy storage, and I know I’m often talking about some apparently revolutionary new concept that a research team somewhere in the world has managed to get to perform flawlessly in a small scale mock up in their laboratory, which they think entitles them to use words like “breakthrough” and “gamechanger” in their press releases. And I know that annoys some of you.**

**So, what I thought I’d do today is bring you news of an apparently revolutionary concept whose creators have managed to get to perform very well in a small scale mock up in their laboratory and which they think could become a real breakthrough gamechanger in utility scale energy storage.**

**[look away sheepishly]**

**Hello, and welcome to Just have a think**

**It’s probably worth a quick recap on where we’re at with grid scale energy storage at the moment.**

**So…wind and solar – both intermittent energy sources, yada-yada, we all know that part by now I think. And I think most people now understand that we need some sort of energy storage to capture electrons when they’re available from mother nature and give them back to our grids when the sun’s not shining or the wind’s not blowing.**

**Pumped Hydro is actually the biggest contributor right now, accounting for ninety five percent of all utility scale energy storage in the United States and set to increase rapidly all over the world, especially in good old China which, according to the International Energy Agency, already accounts for fifty percent of all global pumped hydro deployment. But pumped hydro is very expensive and of course it’s limited to areas with a steep incline and with enough space for a reservoir sized body of water at the top and bottom of the hill.**

**Generally speaking, all the new technologies being developed are designed either as a competitor for, or compliment to, lithium-ion batteries. So why do we need an alternative to these things then? Surely, they’ve been working pretty well in small devices and electric vehicles for years, and they’ve been proven to work at very large scale as well.**

**All true. But at utility scale, Lithium-ion batteries are only being used for a discharge time of about four to six hours. And that’s because, although they’re brilliant, and most cost effective, at releasing energy instantaneously and over relatively short periods for stabilising grids through frequency regulation, over longer durations for providing scheduled, base load style electricity over night or over a few days where you don’t really need instantaneous response times, the economics of lithium-ion just don’t stack up so well. And that’s why developers all over the place are scrabbling to bring more cost-effective, longer duration solutions to market, many of which we’ve covered on this channel.**

**So, what’s this latest revelation all about then?**

**Well, how do I put this…? It’s an electrically conductive gloop with the consistency of molasses. Now, hang on, don’t click the back button just yet, stay with me here…**

**This system comes from a team at the Massachusetts Institute of Technology, or MIT, which is a fairly highly regarded academic institution, so it might not be as hair-brained as it sounds.**

**The gloop is the key element in something called a semi-solid flow battery and the full explanation of how it works was published in this paper back in November twenty-twenty-one.**

**Flow technology has been around for a while. It’s a kind of cross between a battery and a fuel cell, and it’s very easily scalable. The typical existing set up consists of two tanks of electrolyte liquid containing solutions of Vanadium. The vanadium ions in each tank have different chemical configurations so that one tank acts as a positive electrolyte and the other tanks acts as a negative electrolyte. In between them there’s a cell stack. The solutions from each tank are pumped into the cell stack where they’re separated by a thin membrane. As the system discharges, the ions in the negatively charged solution release an electron in a process called oxidation. Those electrons move towards an electrode in the cell stack and go out through a circuit to do their useful electrical work before returning to another electrode on the other side of the stack. That electrode feeds the electrons into the positively charged solution which is happy to receive them via a process known as reduction, hence the name Redox. The reduction process frees up positively charged Hydrogen ions which flow across the membrane to maintain the charge balance. The whole thing is completely reversible so that the system can be recharged through hundreds of cycles.**

**The duration of time that flow batteries can discharge, releasing the stored electricity, is determined by the physical volume of positively and negatively charged electrolyte solutions streaming through the stack. In theory, as long as these solutions keep flowing, reacting, and converting the chemical energy to electrical energy, the battery systems can keep providing electricity.**

**But while flow battery technology in principle has shown potential for at least a decade, the vanadium it uses is a scarce and expensive resource, and the base for the electrolytes is a pretty nasty toxic acid solution. Those issues, combined with a somewhat uneven performance, have slowed the implementation of these systems into electricity grids around the world.**

**The team at MIT, led by mechanical engineering PhD grad Thaneer Malai Narayanan, has come up with a rechargeable flow battery based on a combination of abundant and very low-cost manganese dioxide and zinc.**

**The manganese dioxide particles are contained in a kind of paste along with electrically conductive carbon black. The gloop arrives at the stack where it reacts with a conductive zinc solution or zinc plate to cause the electrochemical reaction**.

**There are very good reasons for using this kind of semi solid material instead of just using a liquid. You get much a much higher energy density for a start, plus the paste has a higher surface area on which the all-important electrochemical reactions can take place.**

**But there are drawbacks as well. Because flow batteries, by definition, rely on a flow of fluids around the system, you need a pump to circulate everything, and pumping a paste is a lot more difficult than pumping a liquid. It generally requires a more expensive reciprocating pump instead of the cheaper centrifugal pumps that are commonly used for existing flow batteries. There may also be a need for more pumps at various points in the system and deeper channels to allow this pasty ‘viscoplastic’ material to flow as freely as possible. And the whole thing requires way more energy input, which of course drives up the overall cost of the system**

**MIT Professor of Engineering, Gareth McKinley, who’s been heavily involved in the project, pointed out another pitfall, explaining**

**“These systems have to be able to flow under reasonable pressures, but also have a weak yield stress so that the active Manganese Oxide particles don't sink to the bottom of the flow tanks when the system isn’t being used, as well as not separate into a battery/oily clear fluid phase and a dense paste of carbon particles and Manganese Oxide.”**

**All of which sounds a bit tricky to me!**

**So, the team embarked upon a long journey of experimentation and testing to see if they could find an optimal combination of all the elements in the mix, not just from a physical, mechanical and operational performance point of view, but also carefully considering the economic viability of the system, calculating what’s known as the levelised cost of storage, or LCOS, versus other storage technologies, using what the researchers refer to as technoeconomic analysis based on previously published industry data.**

**Another team member, Emre Gençer, who creates detailed economic models of emergent energy systems at MIT’s Energy Initiative program, explained**

**“Assessing the cost and performance of early technologies is very difficult, and this was an example of how to develop a standard method to help researchers at MIT and elsewhere. One message here is that when you include the cost analysis at the development stage of your experimental work, you get an important early understanding of your project’s cost implications.”**

**Gençer and Narayanan compared their zinc manganese battery to a set of equivalent electrochemical battery and hydrogen backup systems, looking at the capital costs of running them at durations of eight, twenty-four, and seventy-two hours. What they found was that for battery discharges longer than a day, their semisolid flow battery was more cost effective than both lithium-ion batteries and vanadium redox flow batteries, even after the heavy cost of pumping the viscoplastic slurry from tank to stack was factored in.**

**Again though, having said all that, these sorts of developments are not trying to supersede existing technologies like lithium-ion batteries. And they wouldn’t be able to compete with lithium-ion batteries at the shorter duration timescales anyway.**

**What they’re really designed to be is a fully complimentary addition to fill what is currently a gap between short and very long duration energy storage solutions. And the great advantage of a system like a flow battery is that it’s very easily scalable. If you want more storage you simply add more tanks to the existing set up. The only limitation is space, which is why technology like this is unlikely to find it’s way into domestic situations anytime soon. It’s much better suited for large, centralised utility scale grid systems. Narayanan reckons that their research has also indicated other chemistries that could be developed using the semi-solid flow battery method, so who knows, we could be seeing various versions of this novel technology on the electricity grids of the future as societies around the world come to rely more and more on intermittent renewables like wind and solar.**

**I’m quite sure many of you will have a view on this technology and perhaps even on the wider topic of intermittent renewables and energy storage in general. If you do, or if you work in the industry and have some insights you can share, then why not jump down to the comments section below and leave your thoughts there.**

**That’s it for this week though.**

**As always, a big thank you to the folks at Patreon who keep these videos completely independent and ad-free. And a quick shout out to the folks who’ve joined since last time with pledges of ten dollars or more a month. They are**

**Nicholas Choma**

**Gabriela Herculano**

**Vernon Strand**

**Scott Bell**

**John Delcomyn**

**Siem Veenstra**

**Glen Gary**

**Kyle McGovern**

**Thomas Fürst**

**Hank Weiss**

**And**

**Grant Smith**

**And of course, a big thank you to everyone else who’s joined since last time too.**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.  
See you next week**