Charging ahead: How Australia is innovating battery technology

By Jonathan Knott on 16 February 2018

The Conversation

Paul Jones/UOW, Author provided

Lithium-ion remains the most widespread battery technology in use today, thanks to the fact that products that use it are both portable and rechargeable. It powers everything from your smartphone to the "world's biggest battery" in South Australia.

Demand for batteries is expected to accelerate in coming decades with the increase in deployment of electric vehicles and the need to store energy generated from renewable sources, such as solar photovoltaic panels. But rising concerns about mining practices and shortages in raw materials for lithium-ion batteries – as well as safety issues – have led to a search for alternative technologies.

Many of these technologies aren't being developed to replace lithium-ion batteries in portable devices, rather they're looking to take the pressure off by providing alternatives for large-scale, stationary energy storage.

Australian companies and universities are leading the way in developing innovative solutions, but the path to commercial success has its challenges.

Australian alternatives

Flow batteries

In flow batteries the cathode and anode are liquids, rather than solid as in other batteries. The advantage of this is that the stored energy is directly related to the amount of liquid. That means if more energy is needed, bigger tanks can be easily fitted to the system. Also, flow batteries can be completely discharged without damage – a major advantage over other technologies.

ASX-listed battery technology company Redflow has been developing zinc-bromine flow batteries for residential and commercial energy storage. Meanwhile, VSUN Energy is developing a vanadium-based flow battery for large-scale energy storage systems.

Flow batteries have been receiving considerable attention and investment due to their inherent technical and safety advantages. A recent survey of 500 energy professionals saw 46% of respondents predict flow battery technology will soon become the dominant utility-scale battery energy storage method.

Redflow ZBM2 zinc-bromine flow battery cell. *Redflow*

Ultrabatteries

Lead-acid batteries were invented in 1859 and have been the backbone of energy storage applications ever since. One major disadvantage of traditional lead-acid batteries is the faster they are discharged, the less energy they can supply. Additionally, the lifetime of lead-acid batteries significantly decreases the lower they are discharged.

Energy storage company Ecoult has been formed around CSIRO-developed Ultrabattery technology – the combination of a lead-acid battery and a carbon ultracapacitor. One key advantage of this technology is that it is highly sustainable – essentially all components in the battery are recyclable.

Ultrabatteries also address the issue of rate-dependent energy capacity, taking advantage of the ultracapacitor characteristics to allow high discharge (and charge) rates.

These batteries are showing excellent performance in grid-scale applications. Ecoult has also recently received funding to expand to South Asia and beyond.

Ecoult Ultrabatteries photographed during installation on site. *Ecoult*

Repurposed storage solutions

Rechargeable batteries are considered to have reached their “end of life” when they can only be charged to 80% of their initial capacity. This makes sense for portable applications – a Tesla Model S would have a range of 341 km compared to the original 426 km. However, these batteries can still be used where reduced capacity is acceptable.

Startup Relectrify has developed a battery management system that allows end of life electric vehicle batteries to be used in residential energy storage. This provides a solution to mounting concerns about the disposal of lithium-ion batteries, and reports that less than 5% of lithium-ion batteries in Europe are being recycled. Relectrify has recently secured a A$1.5m investment in the company.

Relectrify's smart battery management system. *Relectrify*

Thermal energy storage

Energy can be stored in many forms – including as electrochemical, gravitational, and thermal energy. Thermal energy storage can be a highly efficient process, particularly when the sun is the energy source.

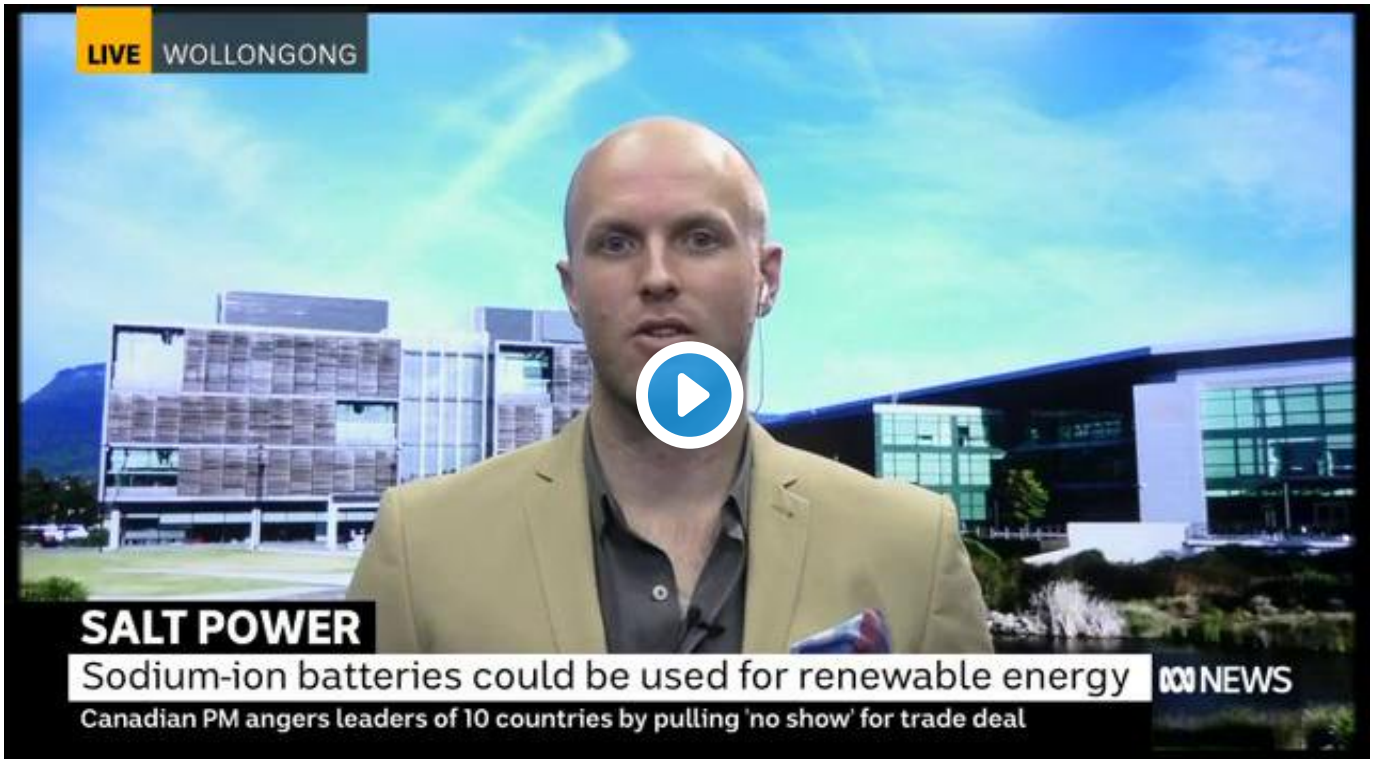
Renewable energy technology company Vast Solar has developed a thermal energy storage solution based on concentrated solar power (CSP). This technology gained attention in Australia with the announcement of the world's largest CSP facility to be built in Port Augusta. CSP combines both energy generation and storage technologies to provide a complete and efficient solution.

1414 degrees is developing a technology for large-scale applications that stores energy as heat in molten silicon. This technology has the potential to demonstrate very high energy densities and efficiencies in applications where both heat and electricity are required. For example, in manufacturing facilities and shopping centres.

Research and development

Sodium-ion batteries

At the University of Wollongong I'm part of the team heading the Smart Sodium Storage Solution (S^4) Project. It's a A$10.5 million project to develop sodium-ion batteries for renewable energy storage. This ARENA-funded project builds upon previous research undertaken at the University of Wollongong and involves three key battery manufacturing companies in China.



We've selected the sodium-ion chemistry for the S^4 project because it sidesteps many of the raw materials issues associated with lithium-ion batteries. One of the main materials we use to manufacture our batteries is sodium chloride – better known as "table salt" – which is not only abundant, but also cheap.

We'll be demonstrating the sodium-ion batteries in a residential application at University of Wollongong's Illawarra Flame House and in an industrial application at Sydney Water's Bondi Sewage Pumping Station.

Sydney's iconic Bondi Beach – the location for the demonstration of sodium-ion batteries. *Paul Jones/UOW*

Gel-based zinc-bromine batteries

Gelion, a spin-off company from the University of Sydney, is developing gel-based zinc-bromine batteries – similar to the Redflow battery technology. They are designed for use in residential and commercial applications.

The Gelion technology is claimed to have performance comparable with lithium-ion batteries, and the company has attracted significant funding to develop its product. Gelion is still in the early stages of commercialisation, however plans are in place for large-scale manufacturing by 2019.

Challenges facing alternatives

While this paints a picture of a vibrant landscape of exciting new technologies, the path to commercialisation is challenging.

Not only does the product have to be designed and developed, but so does the manufacturing process, production facility and entire supply chain – which can cause issues bringing a product to market. Lithium-ion batteries have a 25 year headstart in these areas. Combine that with the consumer familiarity with lithium-ion, and it's difficult for alternative technologies to gain traction.

One way of mitigating these issues is to piggyback on established manufacturing and supply chain processes. That's what we're doing with the S^4 Project: leveraging the manufacturing processes and production techniques developed for lithium-ion batteries to produce sodium-ion batteries.

Similarly, Ecoult is drawing upon decades of lead-acid battery manufacturing expertise to produce its Ultrabattery product.

Some challenges, however, are intrinsic to the particular technology.

For example, Relectrify does not have control over the quality or history of the cells it uses for their energy storage – making it difficult to produce a consistent product. Likewise, 1414 degrees have engineering challenges working with very high temperatures.

Forecasts by academics, government officials, investors and tech billionaires all point to an explosion in the future demand for energy storage. While lithium-ion batteries will continue to play a large part, it is likely these innovative Australian technologies will become critical in ensuring energy demands are met.

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Ian • a month ago

Every battery technology has its own characteristics . Lithium batteries are lightweight, and have good depths of discharge and can have high cranking amps compared with overall storage capacity. These are distinct advantages for mobile applications. Flow batteries can have unlimited storage capacity (kWh) and can discharge completely and for long periods of time - perfect for stationary storage applications. Why do the manufacturers see their products as an alternative to lithium, why emulate the limitations of lithium batteries, and hobble their technology, why not promote the positive characteristics of flow batteries, the huge storage capacity, the safety profile and the robustness of depth of discharge? These things have characteristics similar to pumped hydro storage but can be far more distributed and scalable. Redflow's ZBM is nice but they could be building a device with tanks the size of Olympic swimming pools. Tesla's big battery is made up of countless torch batteries - very heroic, but flow batteries could be much larger and possibly much cheaper.

4 • Reply • Share ›

Hettie → Ian • a month ago

Why? Because lateral thinkers are few, because there is an established paradigm for what batterit's "should" do, and because...dunno.
You'd think that in an area which is up there for innovation, the lateral thinkers and paradigm shifters would be plentiful. Perhaps it's the money guys who can't see past the end of their noses.

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solarguy → Ian • a month ago

For the residential market flow batteries could over take Li-Ion, if the cost becomes on par or below. And there are different size electrode stacks to choose from e.g. 3,5,6kw. These can be selected for the customers needs for power and storage tanks can then be sized for how much storage is required

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Mike Dill • a month ago

As noted in the end of the article, Lithium has a huge headstart, and is still dropping down the cost curve. I think it is great that we are looking at other chemestries, but I expect that, just like VHS vs Beta, the fact that another technology might be 'better' will be overlooked based on cost.
I personally would like a flow battery in my garage, but the price needs to be there for me, and it currently is not.

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Gordon Bossley • a month ago

A good place and time perhaps for a question I've been sitting on for a while. Will there be a time when it makes sense to invest in a blend of storage units?

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My_Oath • a month ago

There are also the LiTi batteries being developed by Australian lithium producer Neometals. They have a titanium anode instead of graphite - with an 80% charge time of 6 minutes and the virtual elimination of thermal runaway risk.

There are 3 stages to battery development - button cell teting, pouch cell testing and 18650 cell testing. The LiTi cells have passed the first 2 with flying colours and CSIRO is currently making a batch of 18650 cells for testing.

Apart from the above benefits, LiTi also has the advantage of being easier to bring to production. It will be a matter of retooling the graphite anode production to titanium - if the LiTi chemistry passes all further hurdles.

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Sir Pete o Possums Reek • a month ago

Thanks great overview !

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Askgerbil Now • a month ago

While it is always interesting to focus on new inventions and the making of ever more technologies, it would be good to hear of research that looks at a future in which there are millions of "waste" lithium-ion batteries with a view to perfecting a process that can economically rebuild new-from-old "waste" batteries.

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Warwick Sands • a month ago

I saw this idea proposed

I saw this idea proposed
https://electrek.co/2018/02...

Interesting idea if it works out.

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Gordon Bossley • a month ago

I was going to excitedly rabbit on about the "Chemical Looping Energy on Demand System" being developed in Newcastle, but their web page has a dodgey certificate, and it's making me wonder if it's one of those "too good to be true, so it's probably not true" situations! Story about it below...

https://www.iothub.com.au/n...

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Steve Woots • a month ago

Given the way the government is trying to drag us backwards in the energy space, it's a relief that some good work is still happening.

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Hettie ➦ Steve Woots • a month ago

The Gov't can squark all it likes. The economic reality is that renewables are faster and cheaper to build than fossil fueled generators, cost virtually nothing to run, emit no CO2 , and are more reliable than fossils.
Yes, they have down time, but that is almost entirely predictable, and wide geographic distribution pretty much smooths out wind variation, while wind often covers the hours of darkness.
And now, storage.
If the Gov't would only be up front about the fact that they are running scared of losing our biggest export, and accept that coal is moribund, so better we work on developing other exports, we would all be better off.
Remember when UK entered the Common Market, as it was then called?
With 10 years of lead time, Australia did NOTHING to develop other markets for food exports.
NZ, in a similar bind, did lots. When the time came , they were ready, sailed through. Australia screamed "Foul!" and suffered the consequences of Coalitionn stupidity.
Deja vue, anyone?

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Hettie • a month ago

A question. Yes, another one.
Around how many kWh would a repurposed EV battery, that was replaced because it now supported a range of only say 350 km, supply in a domestic setting?
Such info seems essential to understand the value.

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Peter ➦ Hettie • a month ago

Range is lost because a full charge is not possible. But, at, say, 5km/kWh, a 350km range is about 70 kWh. The other issue is the power possible, which may also have dropped, meaning no more fancy acceleration in the car, but house loads would still be manageable.

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Hettie ➦ Peter • a month ago

Thanks, Peter. I do love a clear explanation

Thanks, Peter. I do love a clear explanation.
So such a battery would supply house power for several overcast days, because lighter intervals between showers allow some solar output.
Looks like a marketing opportunity that is being missed.
Although I suspect most EV owners also have solar. Some adaptation to domestic use would be needed though.
How long would an EV battery be expected to last in the car?
All interesting stuff.

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Peter → Hettie • a month ago

There is another issue, which is charging such a large battery from solar PV in winter.

For example, last July, my 3kW system harvested about 161 kWh from 25 June to 24 July or about 5.4 kWh/day, or about a fortnight to charge the battery completely from discharge.

In mid-summer, I collected 18 kWh on 22 Dec 2016, so 4 days from the 3kW system. My best mid-summer figure is about 22.5 kWh

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Hettie → Peter • a month ago

Interesting. May I ask, where in Australia are you?
Here in Armidale, 31 degrees South, 1,000 m above sea level, roof facing 4 degrees west of *solar* north, 24 degree pitch, the best output from new 5 kW system was 35 kW, in late October. Lowest was Monday this week. Rained all day, but still, 12.5.
Average 2018 - 29.8
Since Oct 10 '17 - 28.5
That daily average can only get lower now until June 22, but it far exceeds my expectations. Must remember to check the output for the week around March 22, as that should approximate a daily average. Given average cloud conditions, of course.
I must admit, questions about batteries are idle curiosity, since the system pays the power bills and most of the loan repayments, without a battery. But friends do ask, and I like to be able to answer.

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Peter → Hettie • 25 days ago

Another issue is the clearness of the air at the location, which determines how much solar radiation reaches the surface. I believe that inland in Australia, the air is much clearer than near the coast, but I do not have any data for inland towns (and not much for coastal towns).

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Hettie → Peter • 25 days ago

Good point. Lots of wood heaters here, and the lower parts of town have serious wood smoke pollution issues. There are regulations, but council is pretty slack about cracking down on even the most delinquent citizens.
I'm relatively high up, above the inversion layer that afflicts the valley for much of the winter.
In summer the air is very clear. With a population of approx 25,000, we don't have any traffic congestion. 10 minutes max to get from one corner of the city to the opposite. On the odd occasion when I go to Sydney, I find the stink of vehicle exhaust quite nauseating

. That has to reduce pv output.
Just BTW, 33.5 kWh output yesterday. Sunny but cooler.
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Peter → Hettie • 24 days ago
With 5kW (not 3kW, which is what I have), I would have harvested 11.2 kWh yesterday.
Best this month was 27 kWh on 5 Feb (assuming 5 kW system)
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Hettie → Peter • 22 days ago
Just realised that 27 would equate to 45 from a 5 kW system
Wow!
Reply • Share ›

Peter → Hettie • 22 days ago
No. The 27kW is from a 5 kW system. (I think I edited my comment to make it clear).
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Hettie → Peter • 22 days ago
Disqus must have caught it before the edit.
I was thinking that your west facing panels must be doing REAL good.
Total overcast here, output 1317. 10:08 hrs. Rain last night > nice clean , cool panels.
Must get out in the garden. Growth is feral, especially the weeds.
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Peter → Hettie • 22 days ago
Panels are flat on a 5° pitched roof, facing North (well, more exactly 9° East of North).
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Hettie → Peter • 22 days ago
Oops. My bad. Now who was I chatting with who has no north roof, panels facing east and west?
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Peter → Hettie • 22 days ago
East or west is not too bad. You get the peak earlier in the east and later in the west. (Maybe do both)
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Hettie → Peter • 21 days ago
Would have liked to do that, but the roof space was nor quite big enough.
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Hettie → Peter • 24 days ago
Interesting to comepare notes, despite the differences in system size and climate conditions.
Raining here today, but 12 .6 by 15:10. , and current output 1314w.
Because the system was connected so close to the Spring Equinox, I am hangin' out for the Autumn equinox. Then I'll have data for the better half of the year. The following 6 months of course will be the semester of truth. What does it produce in the shorter days?

But then, summer is the rainy season here, winter is dry. Cool panels do better. Pitch is better for winter sun.... so many variables!
Get yourself some more panels.

Reply • Share ›

Peter → Hettie • 24 days ago

More panels: yes eventually. I may want to go to 6kW (and I think I have to talk to Powercor above 5kW).

NASA have a web-site: https://eosweb.larc.nasa.go... which provides data based on location. I do not know if the data is general, determined by latitude, or specific, influenced by local readings or satellite data, though.

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Hettie → Peter • 24 days ago

Could be inverter issues too. And do you get one of the very high FITs that were around a few years ago. Changing the system would kill that.

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Peter → Hettie • 23 days ago

I do not know about inverter issues.

FIT is 11.3¢/kWh (was 5¢/kWh), so no worries about the high FIT (which today stops people updating/upsizing). Flat rate was 29.8¢/kWh, so I have paid 18.5 to 24.8¢/kWh for "storage" on the grid. Rate is now be 34.1¢/kWh, so to export then import 1kWh costs 22.8¢.

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Hettie → Peter • 23 days ago

It pays to shop around for the best deal. There are big differences in rates, discounts, FITs, even standing charge. Not stuff to do in your head. Rather, it will do your head in!
For each retailer, one way to simplify is to work out how many FIT HOURS it takes to pay the standing charge.
For me, it's 11. That's with Powershop. Then, as you have already, the effective cost to buy in, assuming you export as much as you import.
It's like trying to nail a jellyfish to the wall.
The inverter issues I mentioned are chiefly that in erters have a capacity limit. So what works fine for 3 kW setup may be inadequate for 5 or 6 kW.
Life wasn't meant to be easy.
Must go. AirBnB guest coming in 1.5 hrs. Still things to do.
Cheers.

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Peter → Hettie • 23 days ago

Re: Inverter issues - I have micro-inverters, so no problem there. Supply charge: 11.5 times FIT (up 14% this year).

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Hettie → Peter • 22 days ago

Right. Microinverters good!
As I have no shadow issues, was advised extra cost not worth it.

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Peter → Hettie • a month ago

Geelong - 38°S. It makes a difference, but probably more in winter, because the solar altitude at midday in mid-winter is 29° in Geelong but 38° in Armidale.

The basic take-away point is that house-load, PV system size and battery size must be considered together. The house load is the given.

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Peter → Hettie • a month ago

We may have to wait for batteries to grow old of course.:-)

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