



FLOW BATTERIES IN THE DISPATCHABLE RENEWABLES MIX
Australian Energy Storage Conference May 2018 Keynote Presentation

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REDFLOW ZBM2 ZINC BROMINE FLOW BATTERY

Unique 10kWh energy storage module for long term, long time-base energy delivery



Technology Comparison

	ZBM2	Lithium-ion	Lead-acid
Competitive total cost of ownership	✓	✓	✓
No material loss of output capacity with age	✓	✗	✗
High ambient operating temperature does not reduce operating life	✓	✗	✗
Daily 100% discharge without damage or reduced operating life	✓	✗	✗
Low risk of thermal runaway in a fire	✓	✗	✓

Features

- Small enough to go where other flow batteries can't
- Scalable from one unit up to grid scale
- No damage if totally empty or if turned off
- Cloud-enabled advanced and smart BMS
- Recyclable HDPE plastic core
- Re-usable water-based zinc bromide electrolyte





RESIDENTIAL DEPLOYMENTS (Industrial Strength Home Storage)

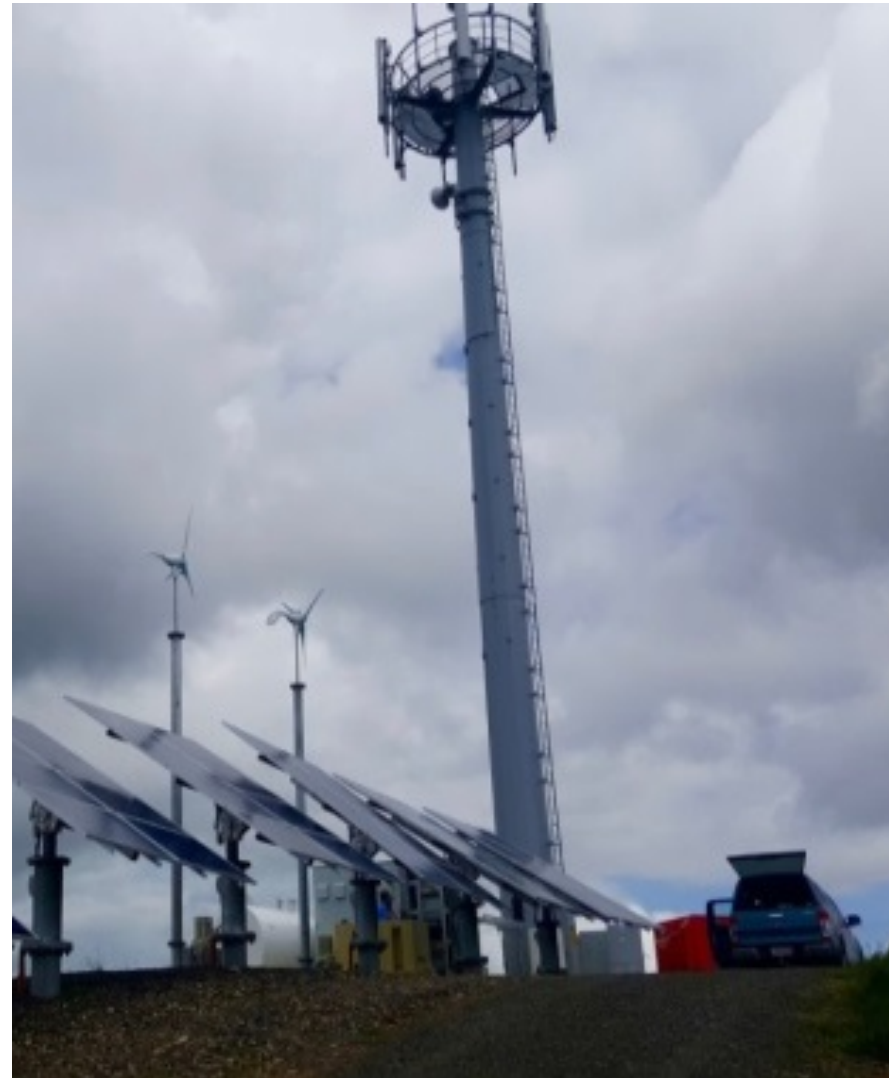


On-Grid 20 kWh / 7kWp solar time-shift + backup



Off-Grid 60kWh battery + 18kWp solar

TELECOMMUNICATIONS DEPLOYMENTS (Lead-Acid Replacement)



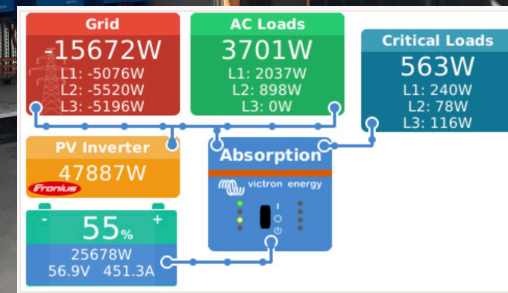
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COMMERCIAL AND INDUSTRIAL DEPLOYMENTS (Long Timebase Energy Delivery, Predictable Outcome)



40kWh solar self-consumption system



60kWh Battery Array for Peak Shaving

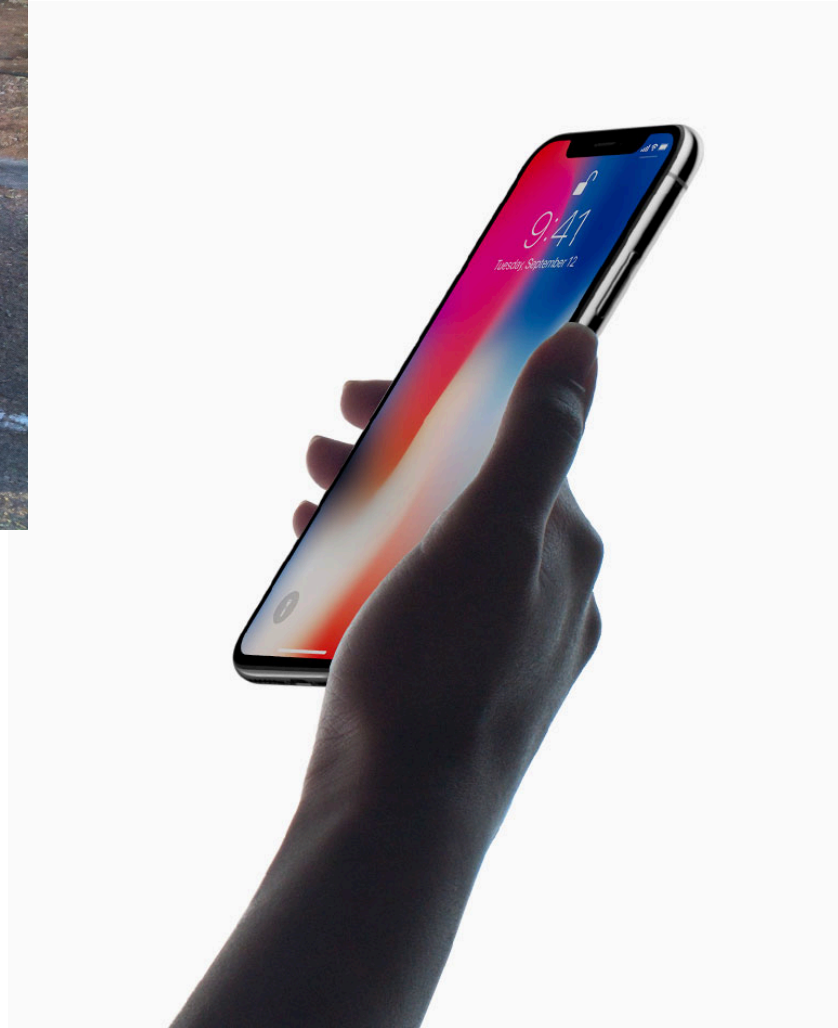
450kWh Battery / 100kWp Solar for solar self-consumption & backup

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BUT WHY NOT JUST USE
CONVENTIONAL BATTERIES
(LITHIUM-ION ETC)?

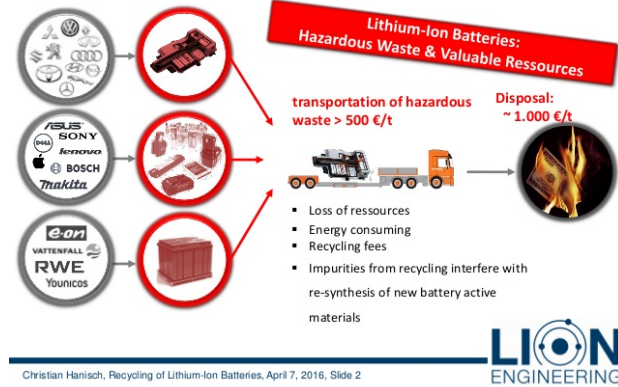


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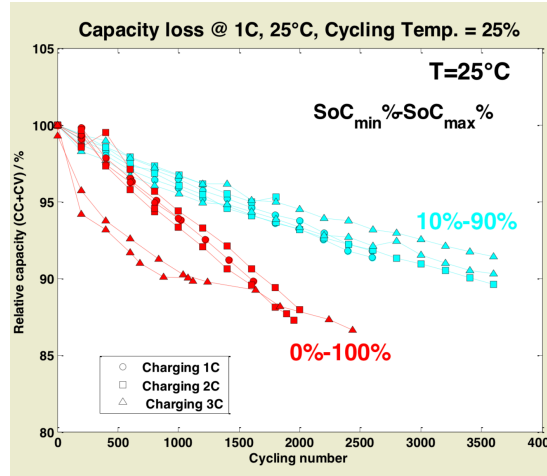
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SIGNIFICANT CHALLENGES WITH CONVENTIONAL BATTERIES

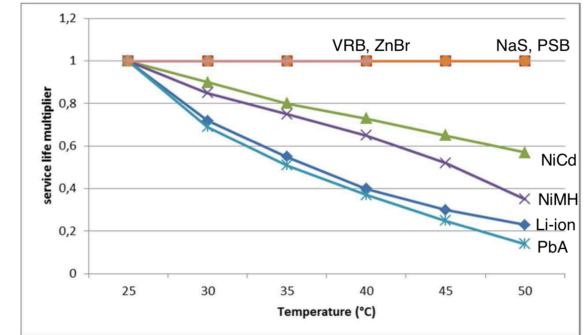
Recycling of Lithium-Ion Batteries - Problems



Deep Cycling Capacity Loss



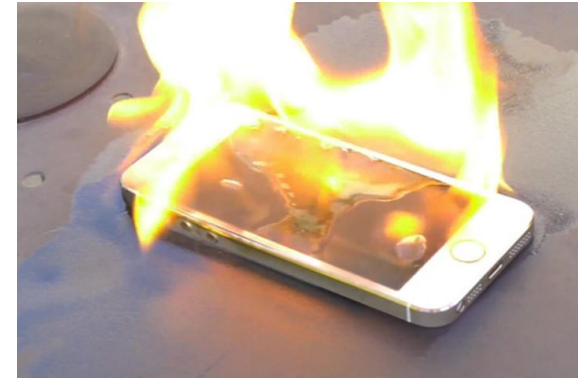
High Temperature Life Reduction



Data from Rydh & Sanden, 2005

Thermal Runaway After Physical Damage or Fire

Disposal Challenges



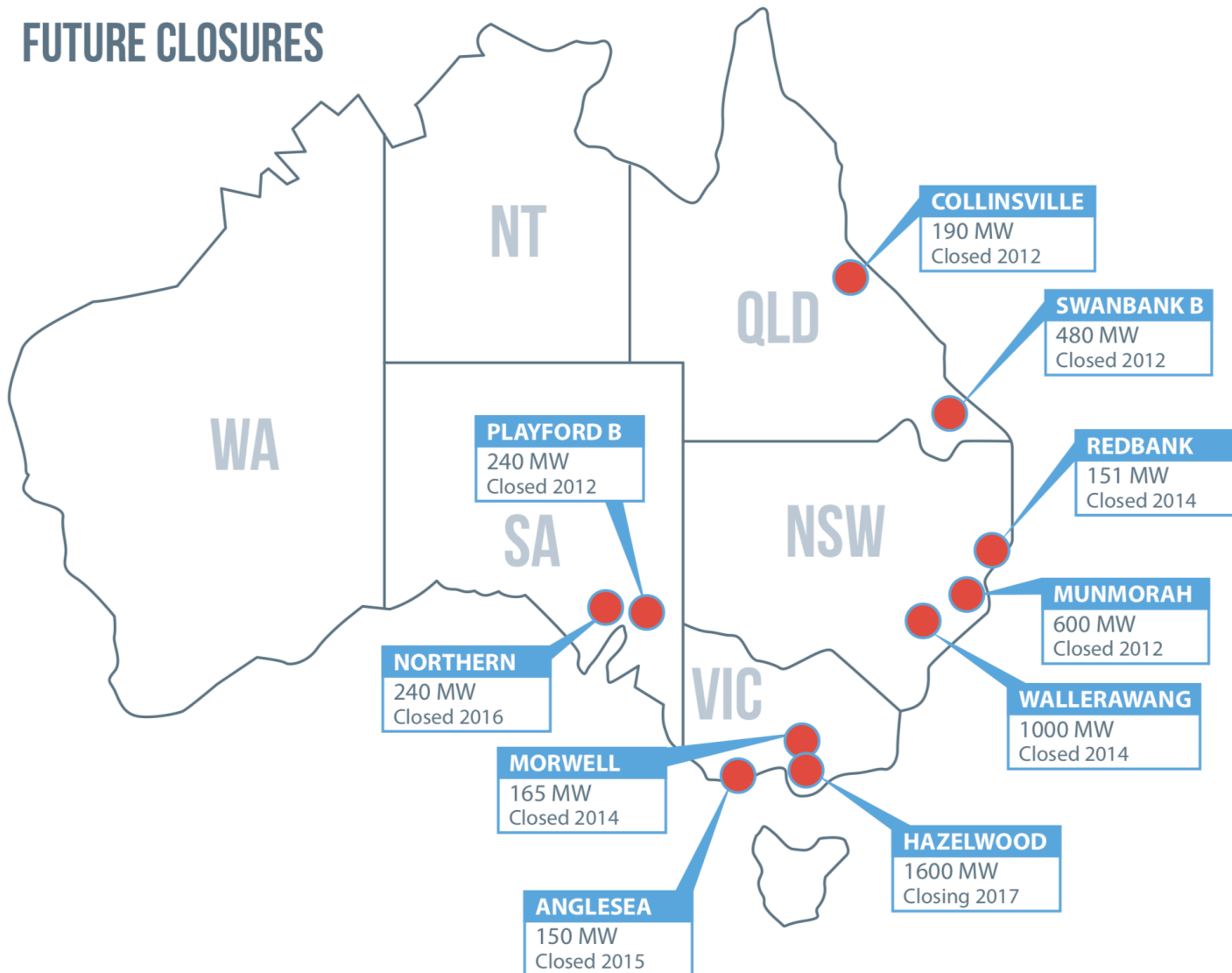
SIGNIFICANT CHALLENGES WITH CONVENTIONAL BASELOAD



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CLOSURE OF COAL-FIRED POWER STATIONS AND FUTURE CLOSURES



Source: http://ourenergyplan.sa.gov.au/sites/default/files/public/basic_page_attachments/4/24/441088034/our-energy-plan-sa-web.pdf



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Mar 13 · 5 min read

Economics, not Regulations, are Killing Coal Plants

Despite government efforts to boost coal plants, a new UT study finds they're on their way out, and the U.S. is on track to meet climate targets for its electricity sector. Part 2 of a Q&A.

By Steve Brooks

Apr 3 2018 at 6:17 PM
Updated Apr 3 2018 at 6:17 PM

Power industry says 'No' to new coal plant - again



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Texas at Austin. www
Mar 13 · 5 min re



Economist Coal

by Ben Potter

But the company backs the same mix of solar, wind and gas power, demand response, pumped hydro and battery storage that AGL Energy plans to replace its Liddell coal plant in the NSW Hunter Valley with by 2022.

EA closed the Wallerawang coal plant in NSW in 2014 while Yallourn has coal reserves to 2032 and Mount Piper is scheduled to close in 2042.

Energy Australia, "proud owner" of Victoria's Yallourn brown coal power station and Mount Piper black coal plant in NSW, says it "struggle[s] to make an economic case for new coal-fired technology in Australia".

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Scott Morrison: new coal-fired power station not the answer

The treasurer has pushed back against backbenchers arguing for a return to coal saying 'the days of subsidies in energy are over'



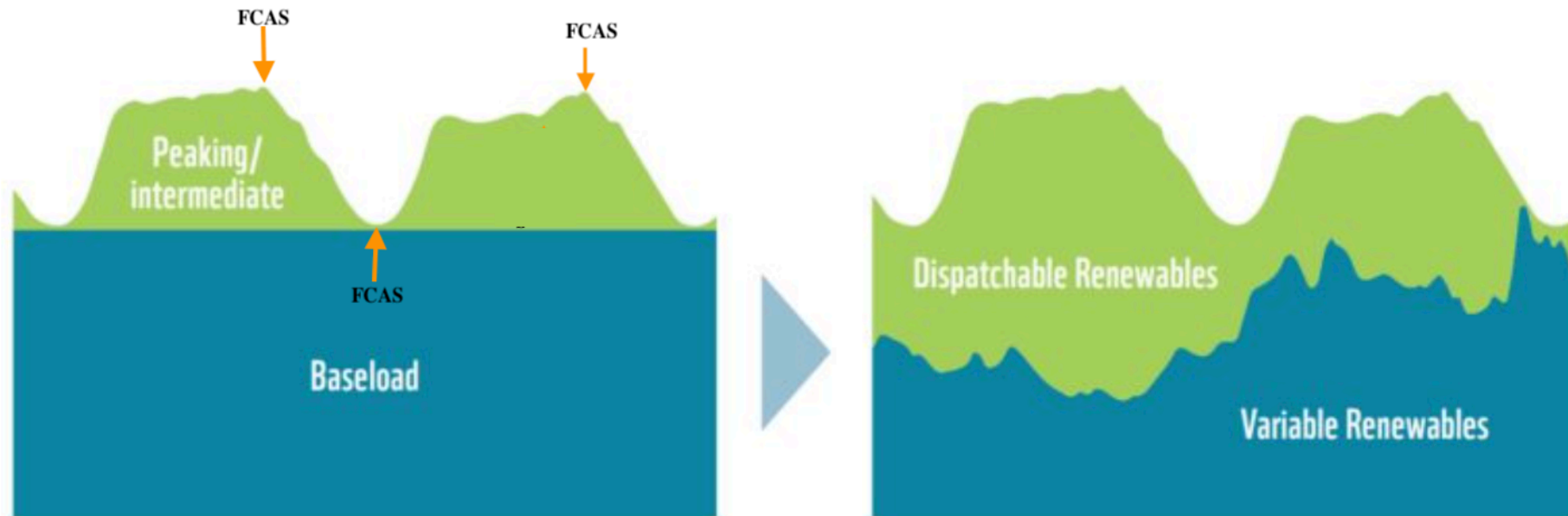
▲ Treasurer Scott Morrison says the idea that a new coal plant would produce cheaper energy is 'not an economic fact'. Photograph: Mike Bowers for the Guardian

The treasurer, Scott Morrison, has smacked down a backbench push for the Turnbull government to back a new coal plant, arguing that high-efficiency coal does not mean cheap energy, and taxpayers would also be left on the hook.

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IS BASELOAD GENERATION ESSENTIAL? CAN WE COPE WITH IT FALLING AWAY OVER TIME?

Our current baseload (left) system and the modern variable and dispatch model (right)

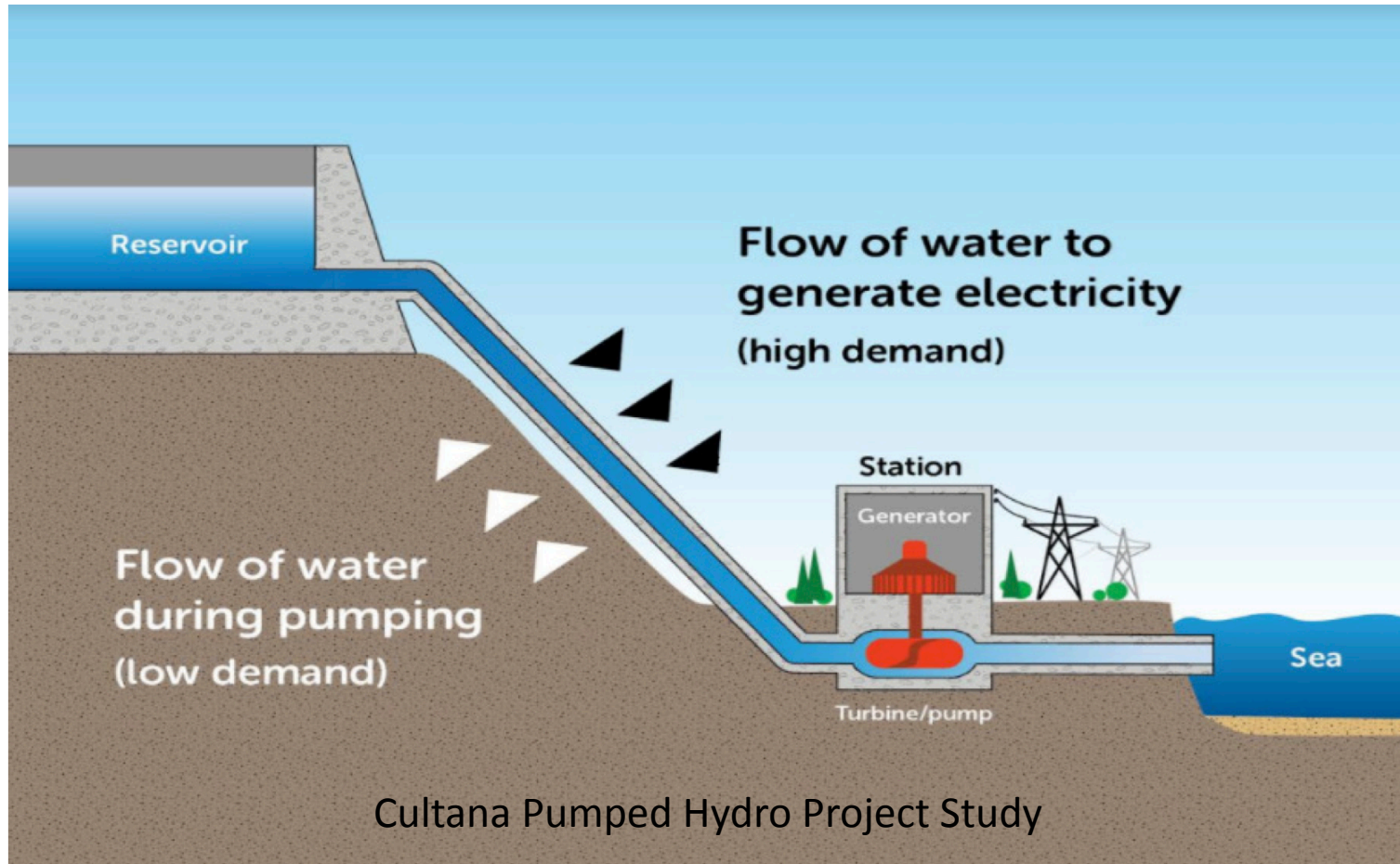


Riesz, J., Elliston, B., Vithayasrichareon, P., and MacGill, I. (2016). 100% Renewable Australia: A Research Summary. For the Centre for Energy and Environmental Markets (CEEM) and Getup and Solar Citizens (2016)

WILL DISPATCHABLE RENEWABLES BE DOMINATED BY LITHIUM-ION BATTERY STORAGE?



THERE ARE OTHER DISPATCHABLE RENEWABLE CHOICES



Source: <https://www.energyaustralia.com.au/sites/default/files/2017-08/Cultana%20Pumped%20Hydro%20Project%20Fact%20Sheet%20-%20August%202017.pdf>

SNOWY HYDRO 2.0



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PUMPED HYDRO REQUIRES SUITABLE GEOGRAPHY AND CAN HAVE SUBSTANTIAL ENVIRONMENTAL IMPACTS

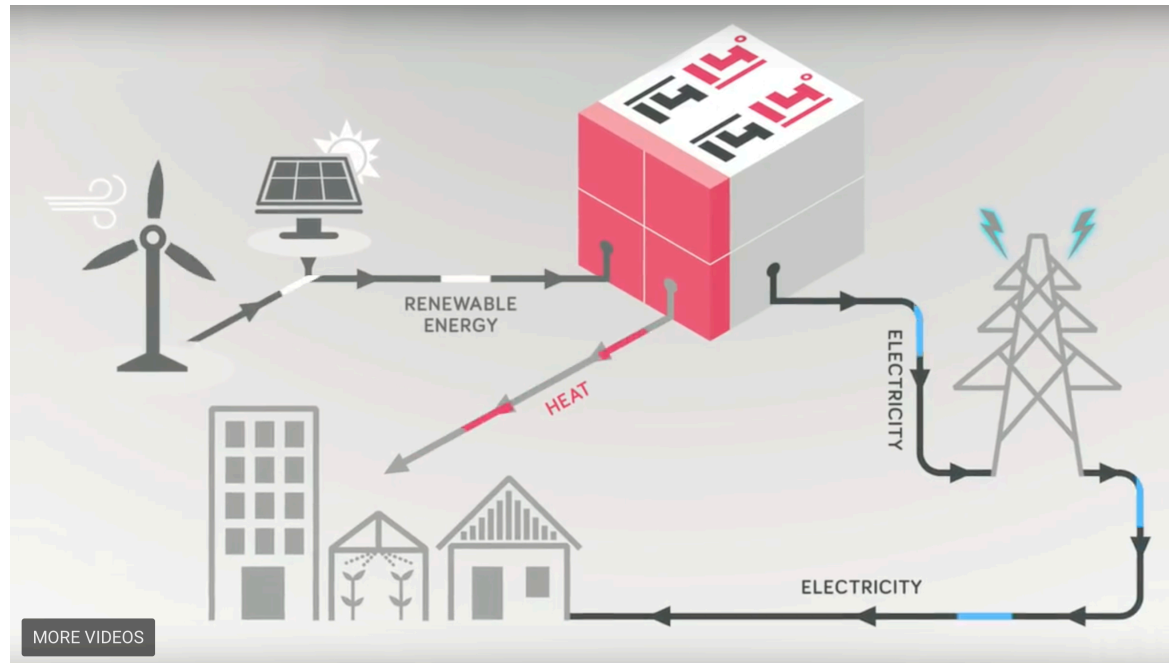


Lake Pedder, ca 1970 By Stefan Karpiniec - <https://www.flickr.com/photos/29585346@N07/4430526866/>

GRID SCALABLE THERMAL STORAGE

- GOOD FIT WHERE INDUSTRIAL PROCESSES REQUIRE HEAT + POWER

> TESS COMMERCIAL
DEMONSTRATOR MODEL

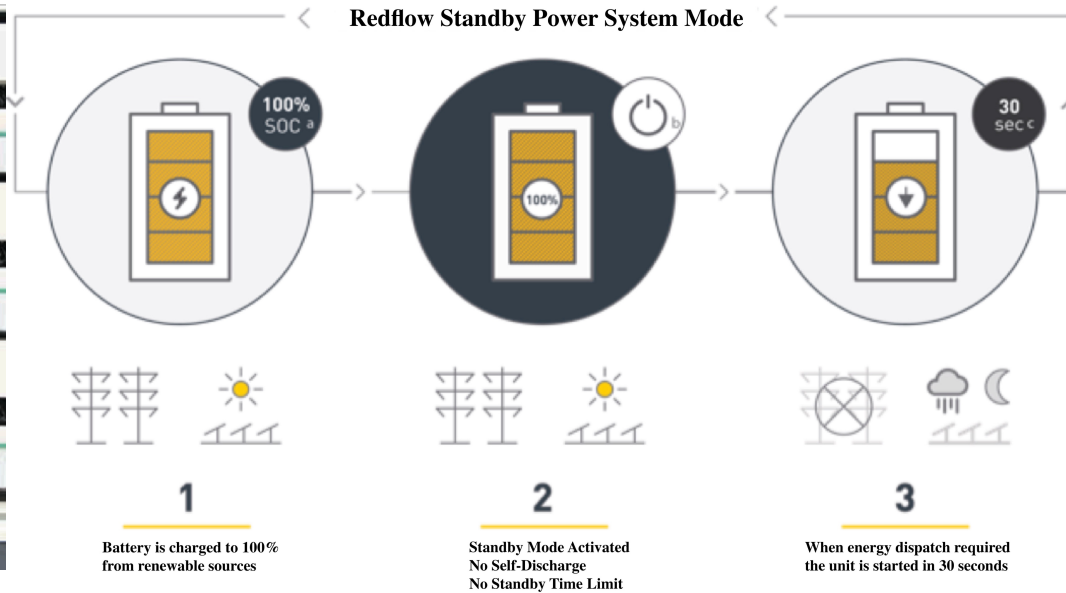


Source: 1414 Degrees Web Site

GRID SCALABLE FLOW BATTERIES



ANOTHER WAY TO ADDRESS THE CHALLENGES OF CONVENTIONAL BATTERIES



“PUMPED HYDRO” OPERATING CYCLE

UNLIMITED STANDBY TIME WITHOUT ENERGY LOSS

100% DISCHARGE DEPTH ENERGY WHEN DELIVERED

AVOID CAPACITY LOSS WITH AGE

NOT AT RISK OF THERMAL RUNAWAY

STRONG RECYCLING STORY

GRID SCALABLE FLOW BATTERIES



Auckland-based Hi-Tech Solutions is deploying Redflow's ZBM2 batteries to build advanced hybrid energy storage systems that will deliver reliable power to multiple remote sites in a Pacific Island nation.

Hi-Tech Chief Technology Officer Derek Gaeth said:

Lead acid has too short a service life in this application. Lithium performance degrades over time and would struggle with the heat and our desire to run batteries without any cooling. Redflow batteries also present no fire risk through 'thermal runaway'.

We believe there are still questions about the safe disposal and recycling of lithium batteries at their end of life, which could be a particular issue in the Pacific Islands where recycling costs can be very high. Redflow batteries are made of components that are easily recycled or re-used, which means this is not a problem.

CONCLUSION: DISPATCHABLE RENEWABLES AT GRID SCALE

WE CAN THRIVE IN A WORLD WITH A DIMINISHING FLEET OF CONVENTIONAL BASELOAD FOSSIL FUEL GENERATORS

THE FUTURE ENERGY GRIDS OF THE WORLD WILL BE FLEXIBLE, SOFTWARE-DRIVEN MARKETPLACES, ENABLED BY A DIVERSE ARRAY OF DISPATCHABLE RENEWABLE MECHANISMS.

THERE IS NO PERFECT ANSWER FOR ALL SITUATIONS.

THE ULTIMATE SCALE INVOLVED IS *MASSIVE*.

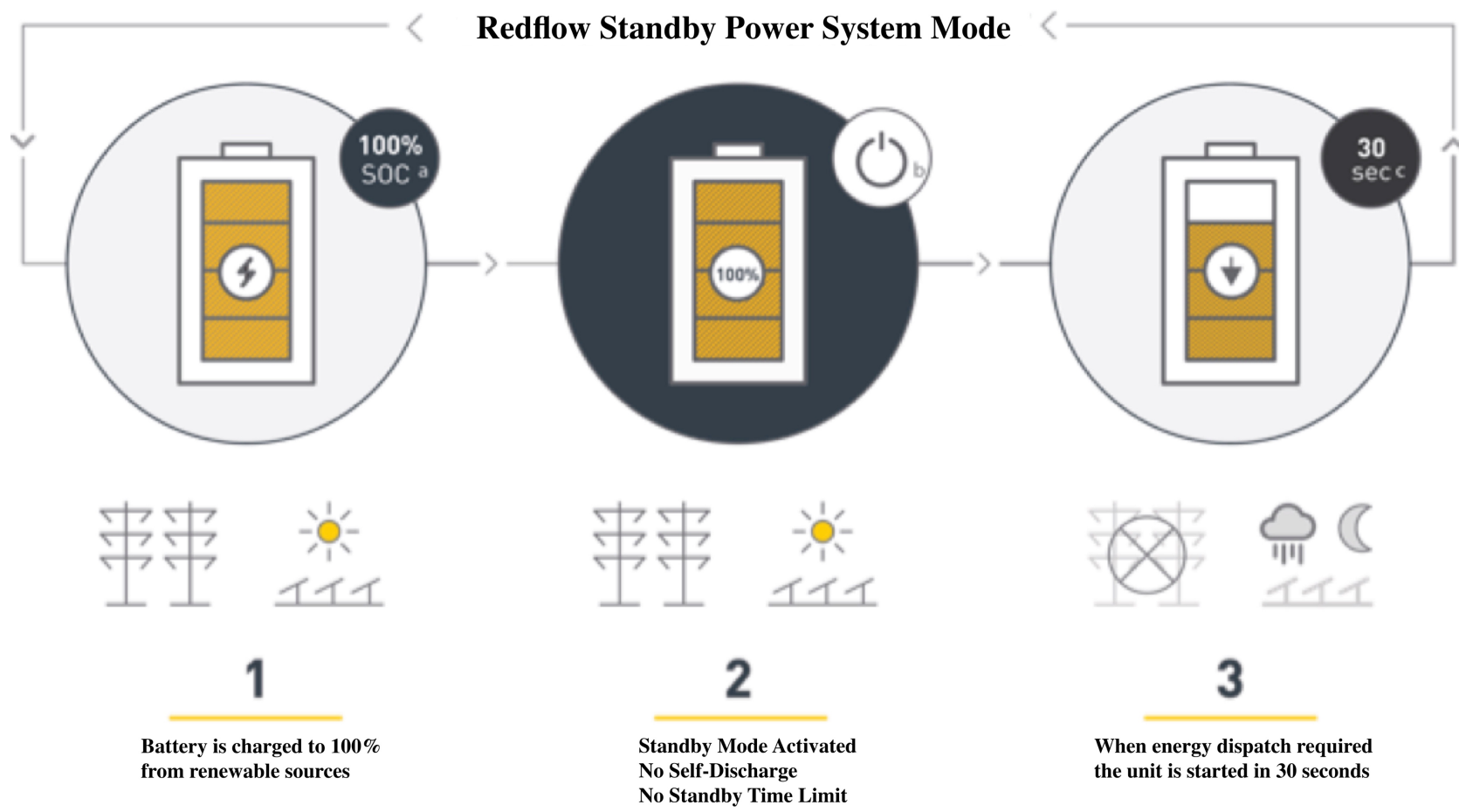
IT'S A GREAT CHALLENGE – AND A GREAT OPPORTUNITY – FOR US ALL.



THANK YOU

SUPPORT MATERIALS

REDFLOW STANDBY POWER SYSTEM MODE



REDFLOW ZBM2

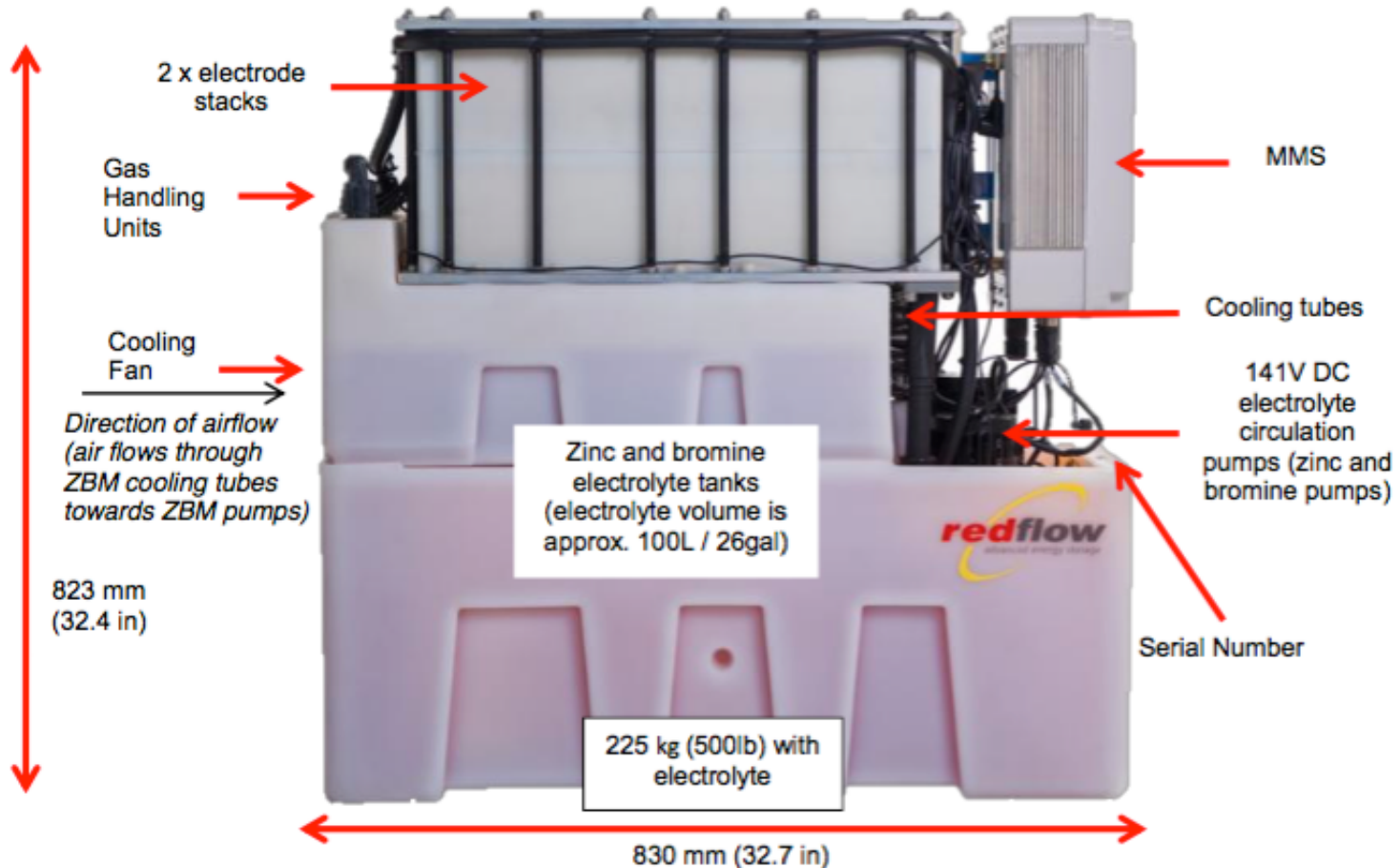


Figure 3.1: Gen 2.8 ZBM Zinc Bromine Battery Module

A ZINC ELECTROPLATING MACHINE
MADE OF RECYCLABLE PLASTIC

At Discharge

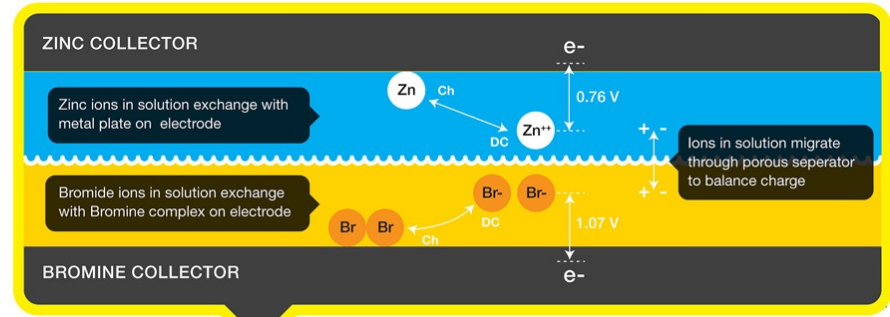
Neg Electrode: $Zn \rightleftharpoons Zn^{2+} + 2e^-$ (Zn ions in both electrolytes)

Pos Electrode: $Br_2(aq) + 2e^- \rightleftharpoons 2Br^-$ (Br ions dissolved in both electrolytes)

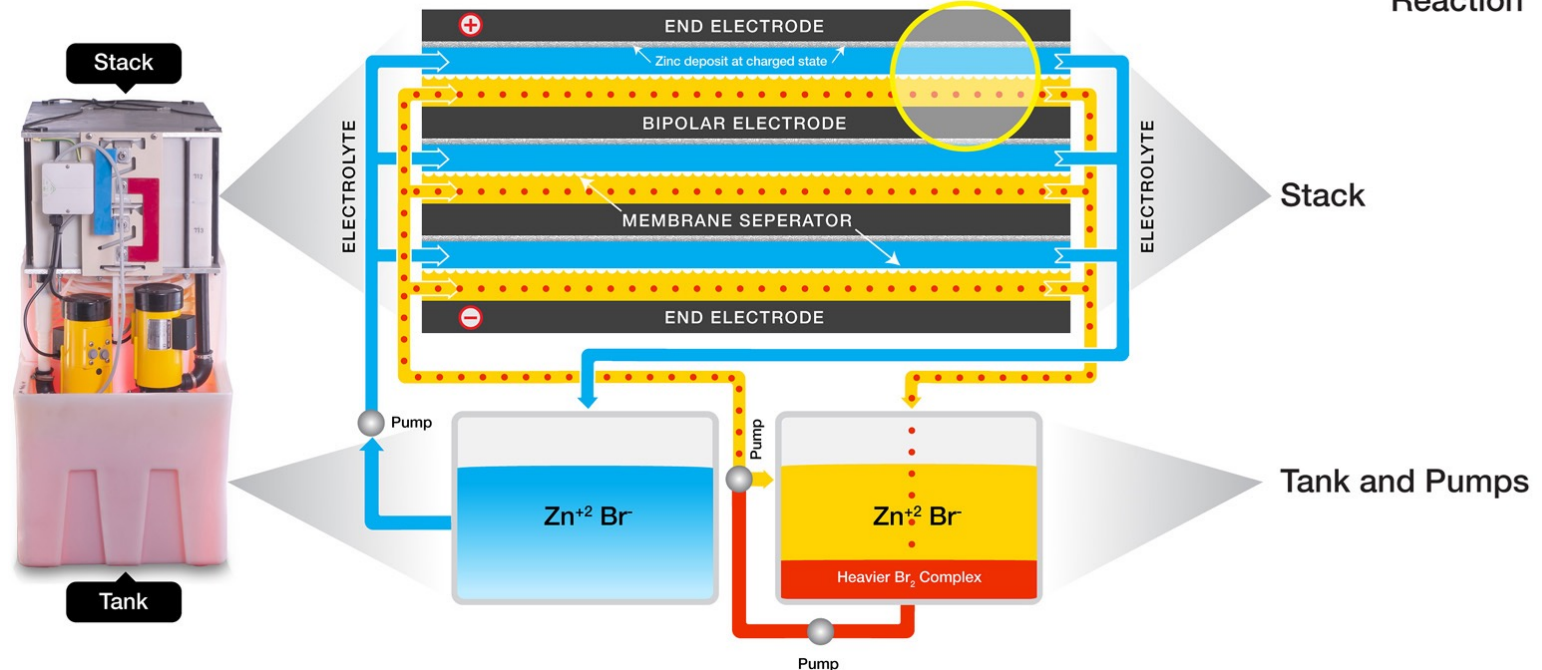
At Charge

Neg Electrode: $Zn^{2+} + 2e^- \rightleftharpoons Zn$ (Zn on electrode)

Pos Electrode: $2Br^- \rightleftharpoons Br_2(aq) + 2e^-$ (Br_2 complexed into thick sludge)



Reaction



ZBM2 Technical Specifications

Voltage	48 Volt DC nominal batteries (typical operating range 40-60V)
Capacity	Maximum 10kWh energy output per daily cycle No reserved battery capacity requirement – full 10kWh cycle depth available
Dimensions	845 L x 823 H x 400 W (mm) 33 L x 32 H x 16 W (in)
Weight	240 kg (530 lb) with electrolyte 90 kg (198 lb) without electrolyte
Electrolyte volume	100 L (26Gal)
Net energy efficiency	80% DC-DC Max
Internal (electrolyte) operating temperature	Operating electrolyte temperature range of 15°C to 50°C (59°F to 122°F), ZBM2 can typically operate at ambient temperatures outside this range for extended periods
Communication	MODBUS RS485
Safety data sheet	DG Class 8 for electrolyte
Power rating	3kW (5kW peak) 3kW continuous: current up to 75A (40V disconnection point) *1 5kW duration depending on the State of Charge (SOC): current up to 125A (40V disconnection point) *1, 2
Regulatory compliance marks	CE and RCM
Warranty	36,500 kWh of energy delivered or 10 years (whichever comes first) *3 No cycle depth limitations – battery performance and lifetime is not sensitive to cycle depth




* 1 Values reported for ZBM2 at 100% state of health (SOH) and room temperature

* 2 Redflow internal testing shows a 5kW supply for approximately 45 minutes before disconnection, for a ZBM2 starting at 100% state of charge (SOC)

* 3 See full warranty document for details, Terms and Conditions apply