vsun energy

Understanding battery life – vanadium redox flow batteries

Vincent Algar, Managing Director, VSUN Energy

Australian Solar Council 2017 Solar Exhibition & Conference

Australian Vanadium Ltd

VSUN Energy is a 100% owned subsidiary of ASX listed AVL

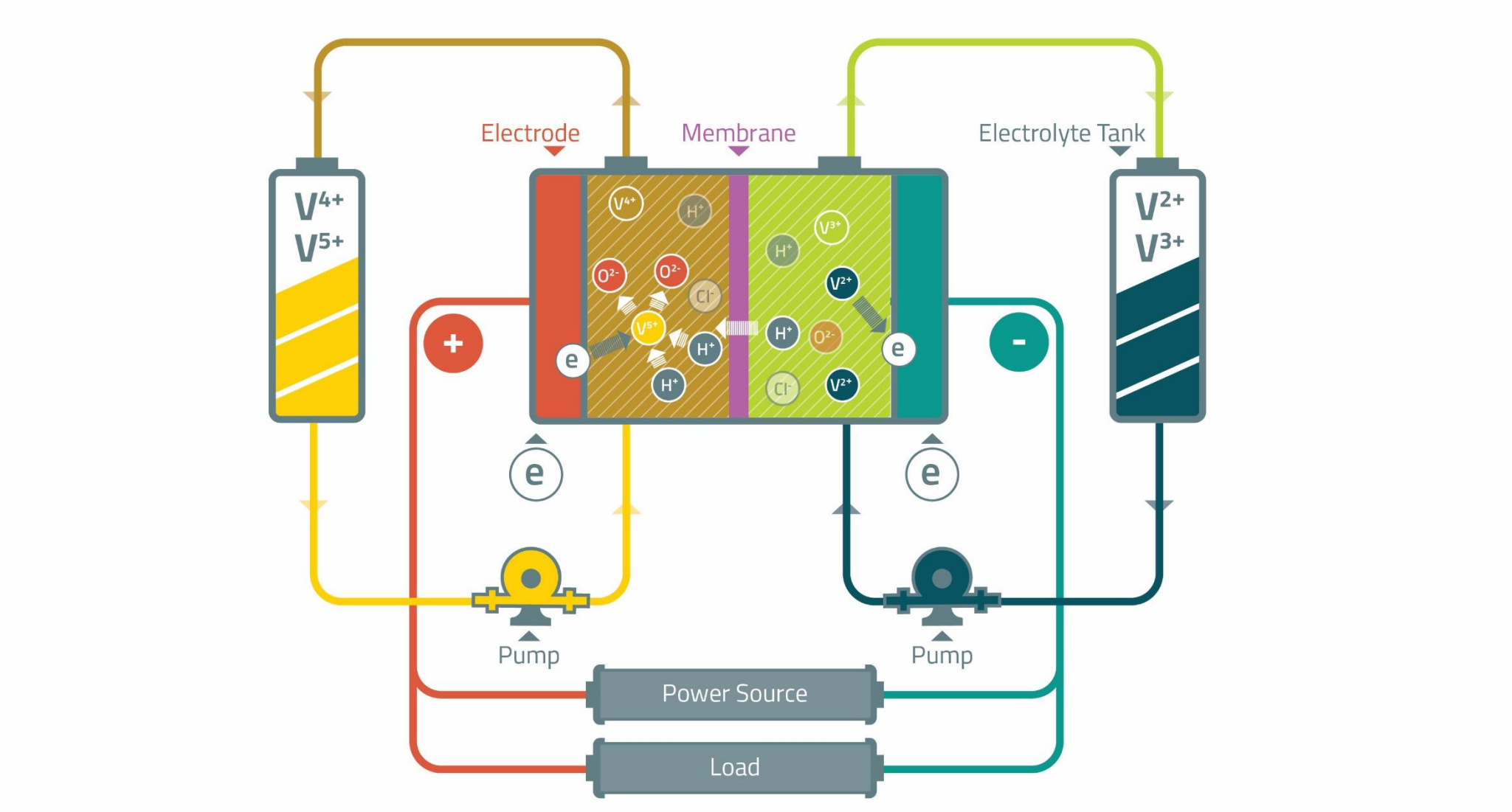
- AVL has been listed on ASX since 2007.
- VSUN Energy is focused on Australian vanadium redox flow battery (VRB) market development.
- Distribution Agreement (non exclusive) with commercial VRB manufacturer GILDEMEISTER.
- Active relationships with multiple renewable installers, consultants, integrators (eg Sun Connect, EPC Technologies).
- Finance options available (including New Direction Finance and Megawatt Capital).
- Dual income streams from VRB sales and vanadium electrolyte sales (both local and export).
- Vanadium electrolyte commercialisation study underway.

VSUN Energy Installation of 10kw/100kw Cellcube

Islanded Busselton Battery operating continuously since early October 2016

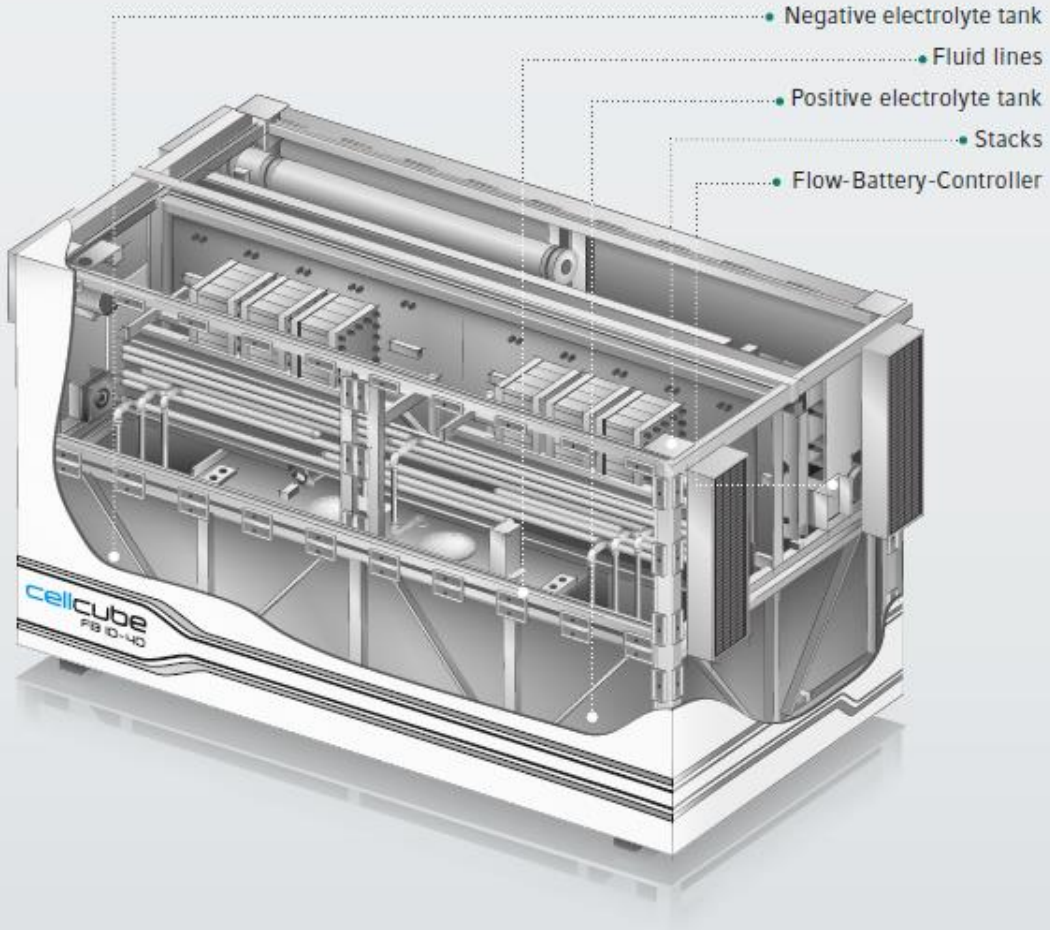
The Vanadium Redox Flow Battery

How it works



The Vanadium Redox Flow Battery

How it works

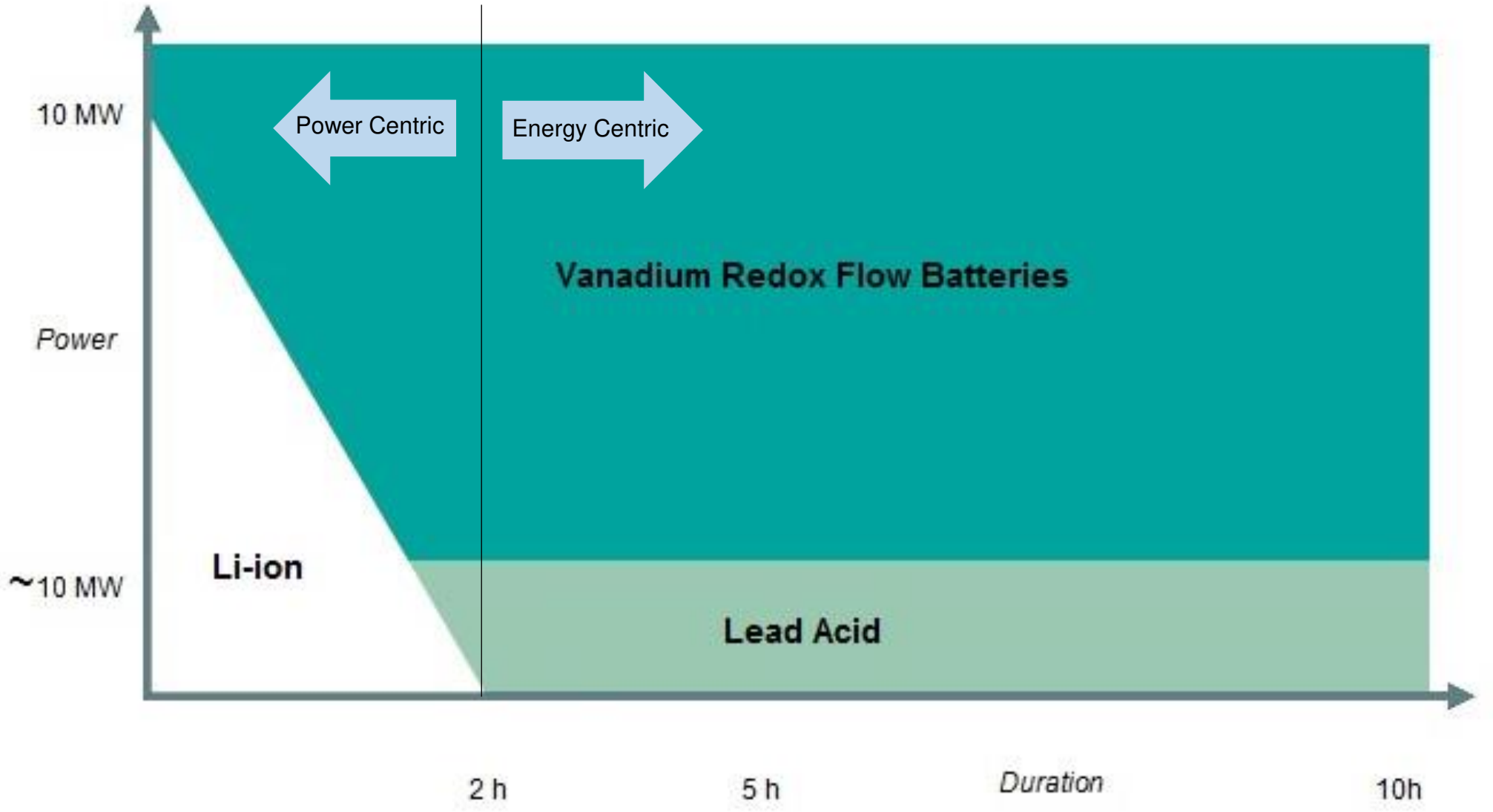


Vanadium

Vanadium redox flow is the most sustainable and durable energy storage technology available today. The vanadium storage system exclusively uses fluid energy sources with dissolved vanadium salts. They are not subject to cycle degradation and can be used without limitation. Conventional batteries are subject to wear and tear through loss of reactive materials. Vanadium flow energy storage systems do not contain any deleterious materials such as lead, cadmium or mercury and are neither flammable nor explosive.

Technology Introduction

Battery technology mapping – Defining the space for flow battery technology



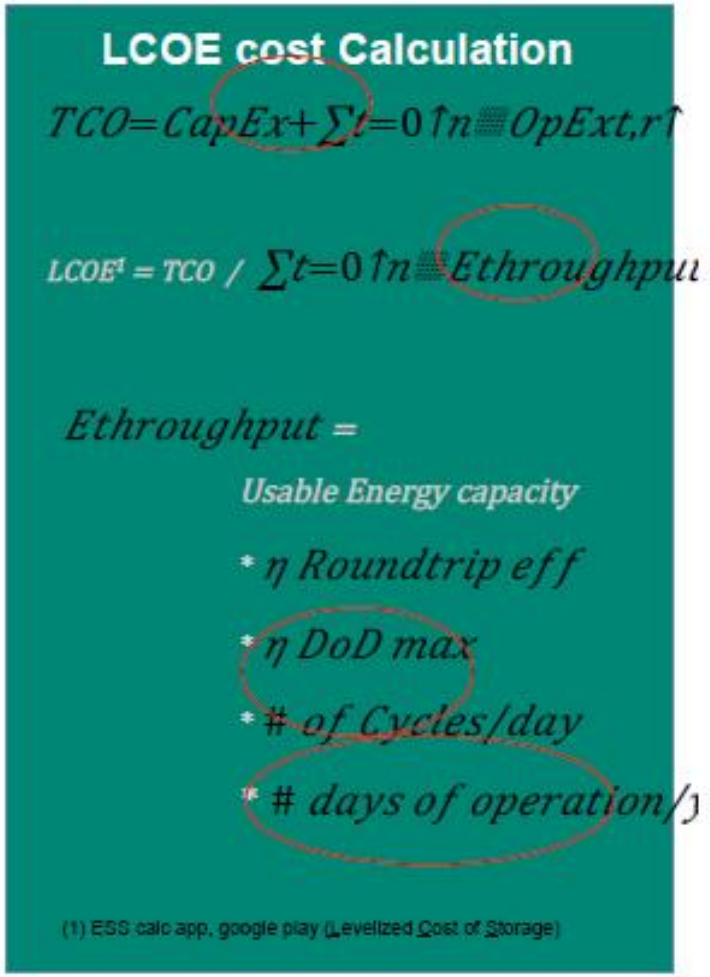
Vanadium vs Lithium

Key Comparisons

Vanadium Flow Battery	Lithium (Li-ion)
Energy Battery – Store large amounts of energy for later use	Power Battery – ideal for shorter term high power application
Energy stored in Electrolyte Tanks	All energy stored in cell
Stable – non-flammable	Flammable (prone to thermal runaway)
Round Trip efficiency 70%	Round trip efficiency 80%-90%
Long lifespan (20 years) due to very high cycle life. No degradation during cycling (20,000 cycles)	Short lifespan (5-10 years) due to physical changes induced in charge discharge cycle (6000 cycles)
Vanadium Electrolyte can be re-used, does not degrade (30% residual value)	Recycling difficult due to multiple components (no residual value)
Scalability – as modules or by introduction of larger tanks – fewer control systems	Multiple small batteries required – Complexity of control increases
100% depth of discharge with no lifetime capacity loss	Limited to 80% depth but with increasing capacity loss in high cycle environment

Working out LCOE

Levelised cost of energy (LCOE)



- TCO – Total cost of ownership is the upfront capex and the sum of the operating costs over the life of the battery
- If that life turns out shorter than expected, that means a new capex will need to be added.
- So.. TCO depends on Battery Life

- Energy Throughput is the Useable Energy Capacity
- It depends on ;
  - The roundtrip efficiency
  - The true Depth of Discharge Range
  - The number of useable cycles per day
  - The number of days of operation

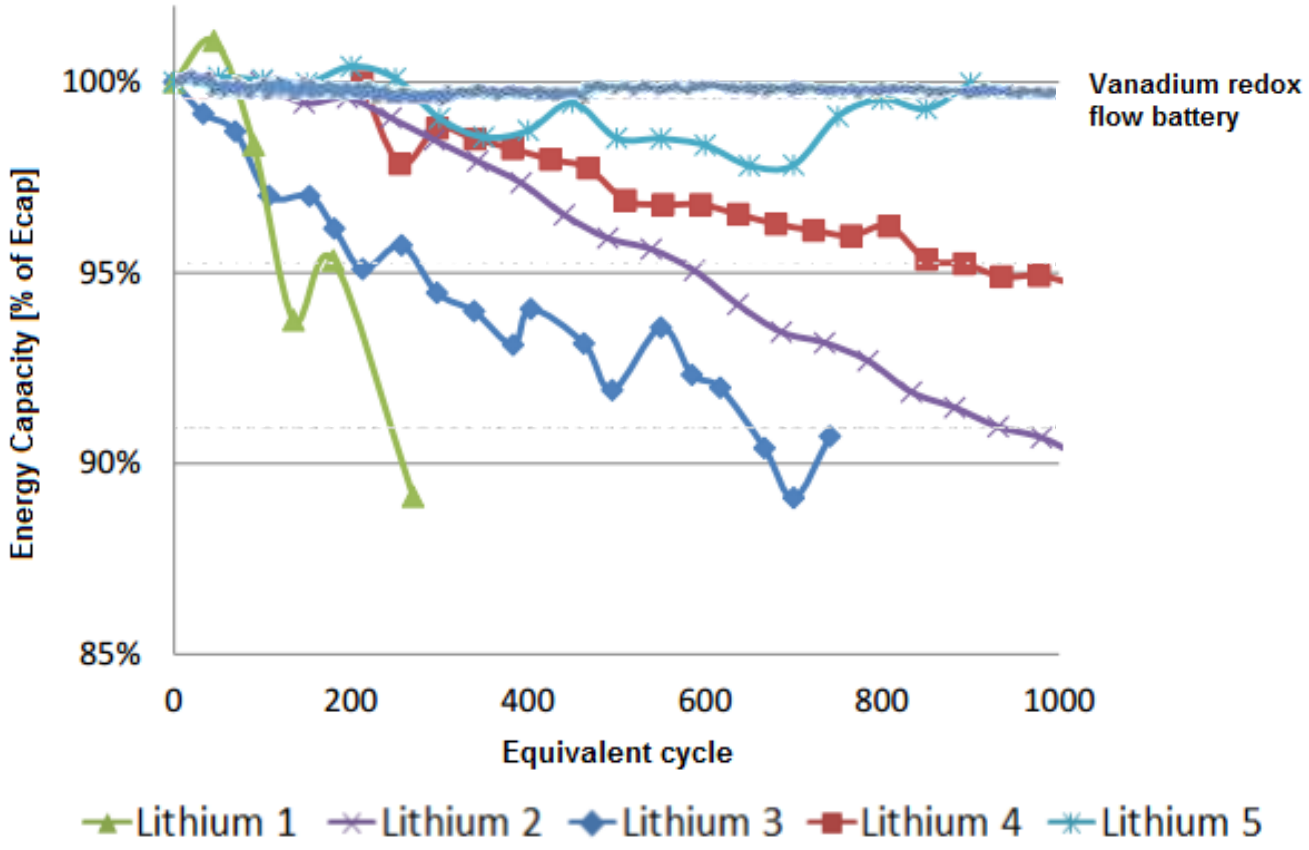
- The LCOE is important (even for domestic users)

- Vanadium Flow battery features add up to a comparable LCOE for a number of load and location situations and are worth consideration

Battery life - factors to compare

Vanadium flow design and operation mean no degradation in energy capacity over time.

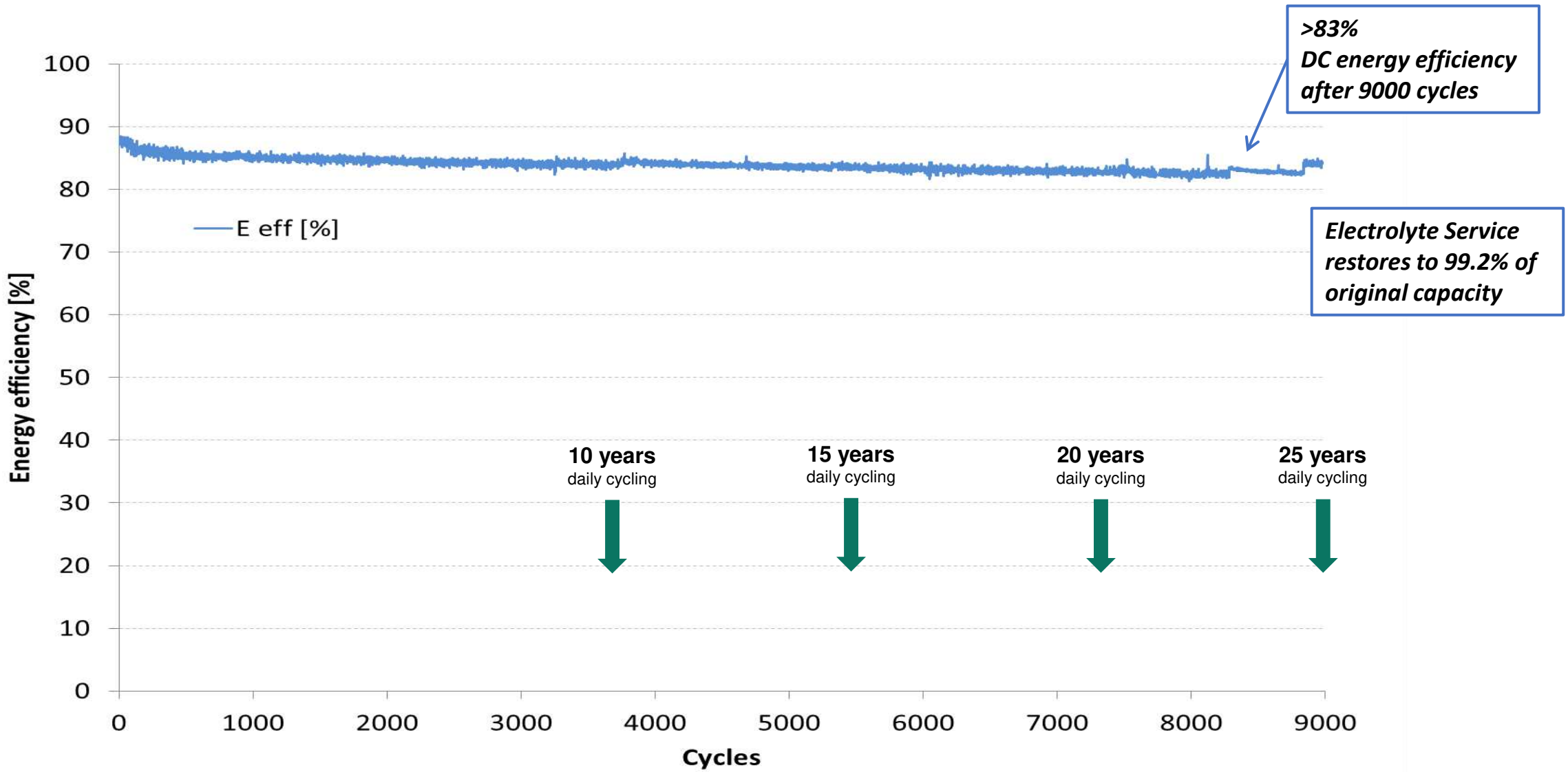
- Fluid Battery with one chemistry (Vanadium).
- Flow means no heat and no destruction of cell over time.
- An engine.. With fluid pumps and pipes , very responsive and very easy to maintain.
- Zero % performance degrade over two years using one daily cycle. Very low over 20 years (ability to reset electrolyte easily)
- System can cycle twice per day (faster payback)
- Ability to cycle to 100% DOD. Able to maintain very high DOD range with no damage
- No efficiency losses in -15 to 45 degree C conditions with no cooling. Assisted by high thermal inertia of electrolyte tanks
- Excellent end-of –life characteristics (20 year life)
- Rapid response times (40ms charge/discharge) ideal for benefit stacking opportunities
- Likes to work hard ! Ideal for replacing diesel – Solar +VRB



Li-ion results from Terna tests 2016

VRB battery life

Over very long operational lives – ideal for long term and grid applications



Battery life

What do we all expect from a battery ?

- All 21st Century humans inherently understand batteries and what they do (even from very young)
- We expect them to perform at their full capacity forever (and are always disappointed when they don't)
- Our expectation of residential, commercial and grid batteries will be no different (maybe we should call them ESS now to avoid the)
- Different storage technologies are going to offer different experiences. Providers should provide realistic data about their positive and negative features with realistic studies and comparisons
- Comparative data is hard to come by ..only time will tell..
- ESS are not all about Li-Ion , Australian inventions such as the VRB will have a role… as will many new inventions over the next few exciting years.

- Finally , investigate everything and match your system to your ongoing expectation and your power situation.

Thank you for your attention

Vincent Algar
Managing Director

VSUN Energy Pty Ltd
Level 1, 85 Havelock Street
Perth WA 6005

Phone: +61 8 9321 5594
vincent@vsun.com.au
vsunenergy.com.au