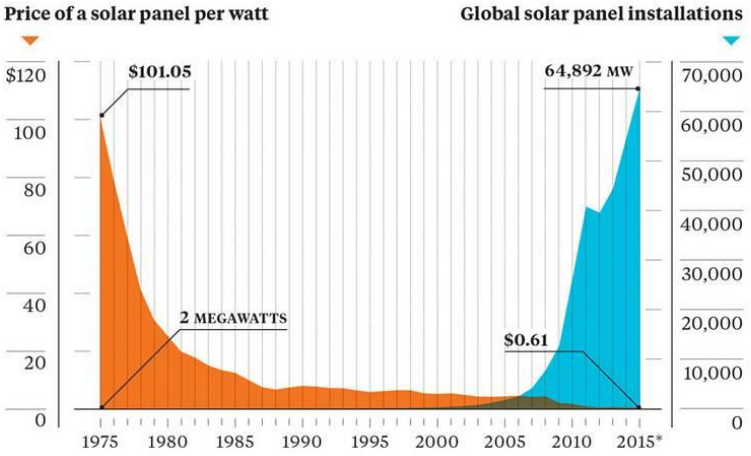
REDFLOW LIMITED JUNE 2018

The Future of Storage Technologies and the Role of Flow Batteries

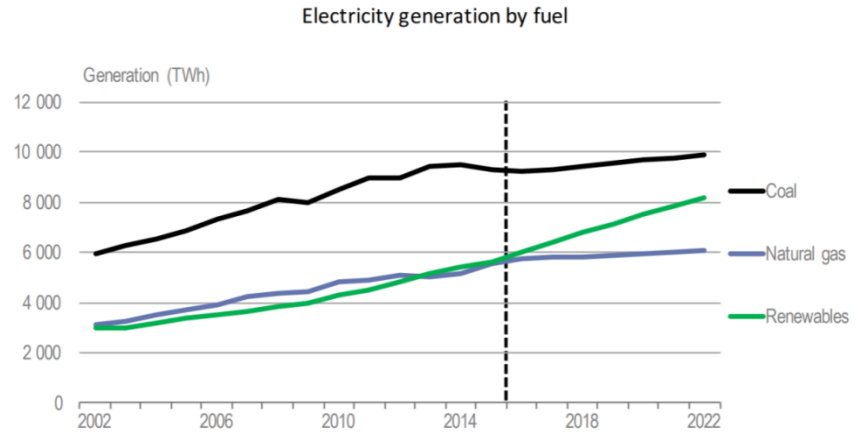
Singapore

Major inflection point - installed capacity grows as installation costs fall

- Renewable energy costs have fallen rapidly
- US$ 279.8 Billion invested in renewable power and fuels during 2017
- Most investment in solar PV & wind power. Investment in renewable power capacity in 2017 was three times higher than investment in new fossil fuel capacity
- 130 million off-grid solar systems sold cumulatively by end-2017, providing electricity access to about 360 million people worldwide. However ~1bn people still live without electricity
- Developed countries target large-scale emission and renewable projects
- Developing economies account for 63% of total renewable energy investment in 2018. China accounts for 45% of global spend
- EVs on the road passed the 3 million mark in 2017 but remain a very small proportion of the global market (1%)



Source: Earth Policy Institute/Bloomberg



Sourve: IEA Renewables 2017 Market Report

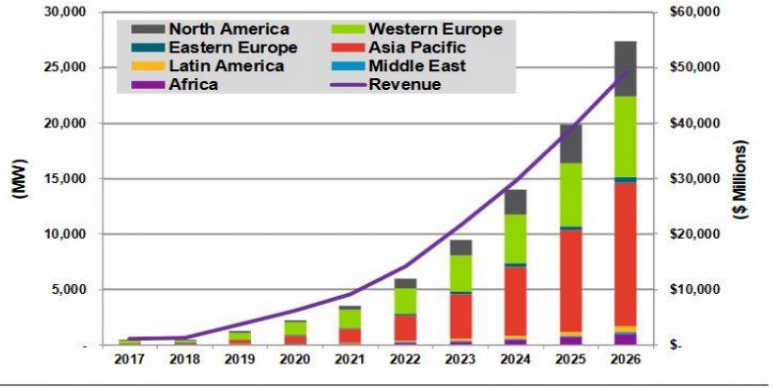
Sources: Renewables 2018 Global Status Report, IEA Renewables 2017 Market Report

ENERGY STORAGE
The missing link between renewable and dispatchable energy

- **Renewable energy brings massive disruption to traditional energy models**
  - In Australia, while renewable energy sources such as solar and wind power are dropping in cost, they introduce the problem of **intermittency**
  - China's 2016 national average **curtailment** ratio was 17% for wind and 10% for solar - 56.2TWh
  - Rapid EV uptake will offer **additional challenges** and require more flexible energy supply model
- **Sustainable energy storage is the lynchpin:**
  - Solves intermittency by time-shifting energy
  - 'Shaves' peaks during heavy demand periods
  - Creates on-demand Virtual Power Plants
  - Enables further increases in renewable energy production and consumption
  - Reliable energy for off grid/poor grid environments
- **Energy storage is a core requirement for an efficient, sustainable, flexible, predictable and resilient energy system in a decentralised generation world**

Major Advances in Storage in last 10 years

- Massive progression in performance and price across multiple technologies
- Battery storage makes renewable energy competitive with fossil fuelled energy sources
- Global energy storage market growth 15.9% in 2017/8.
- Global market forecast to be >$50Bn by 2026



Annual distributed and remote, off-grid solar PV-plus-energy storage power capacity and vendor revenue by region, world markets 2017-2026. Source: Navigant Research

Sources: *Global Energy Storage Market Outlook, 2018: Bloomberg* China's Renewable Curtailment and Coal Assets Risk Map, Oct 2017, Brisbane Times **Too much of a good thing: Solar power surge is flooding the grid**, *June 2018; The Conversation, Renewables will be cheaper than coal in the future. Here are the numbers, (September 17, 2017)*

THE ENERGY STORAGE LANDSCAPE
Existing and emerging battery solutions meet different needs

Energy storage systems empower the next generation electricity grid by making renewable energy sources available 24/7 and distributing energy generation and storage throughout the electricity network.

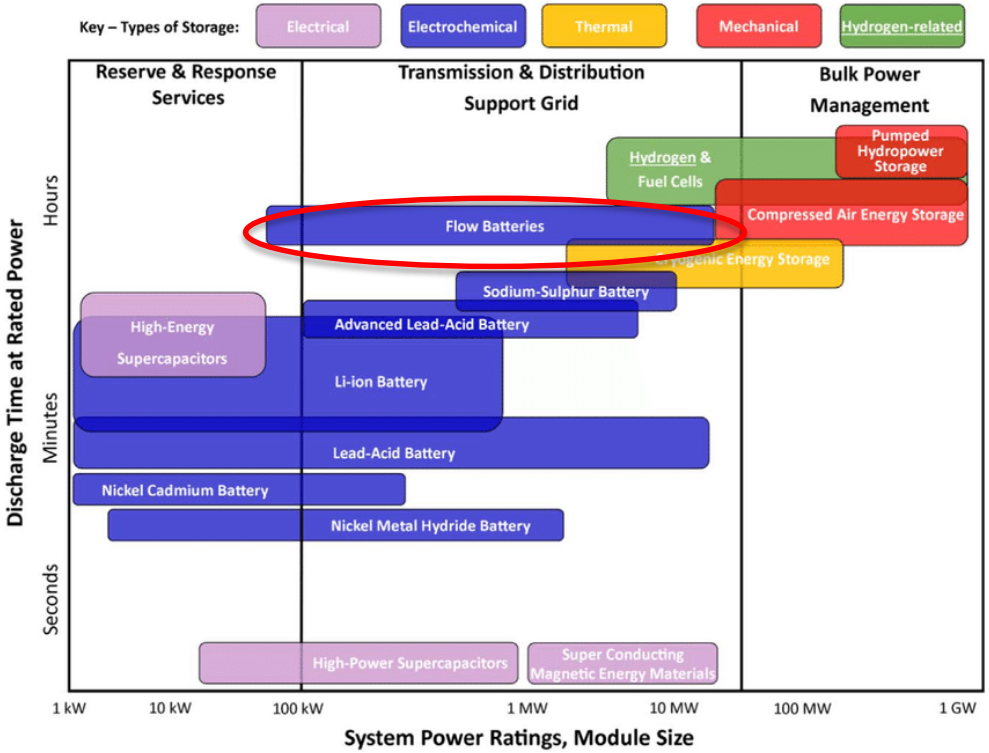
Available energy storage systems serve different applications.

1. **Pumped hydro** time-shift renewable energy at grid-scale
2. **Lithium batteries** deliver power "bursts" with occasional use e.g. electric vehicles, frequency stabilization
3. **Flow batteries** are energy storage "workhorses" that deliver 100% depth of discharge daily for a decade.

Practical considerations when choosing energy storage:

- Operating life
- Energy throughput
- Temperature tolerance
- Size and installation
- Safety e.g. "thermal runaway"
- Environmental concerns
- Total Cost of Ownership

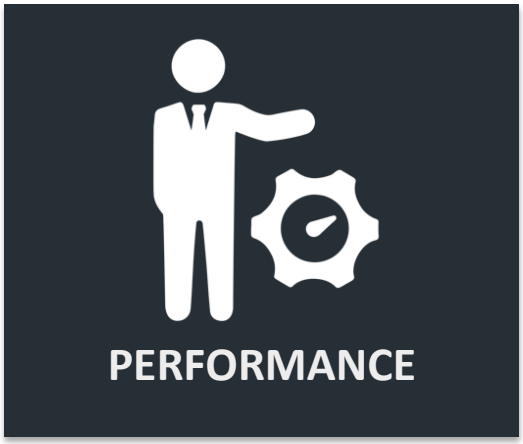
Multiple start up and investor activities around flow batteries but only Zinc Bromine, Sodium Sulphur and Vanadium have reached commercialisation stage



"A next-generation smart grid without energy storage is like a computer without a hard drive: severely limited."

Katie Fehrenbacher, Technology Analysis Firm GigaOm

ENERGY STORAGE CONSIDERATIONS



LITHIUM AS THE TOTAL SOLUTION?

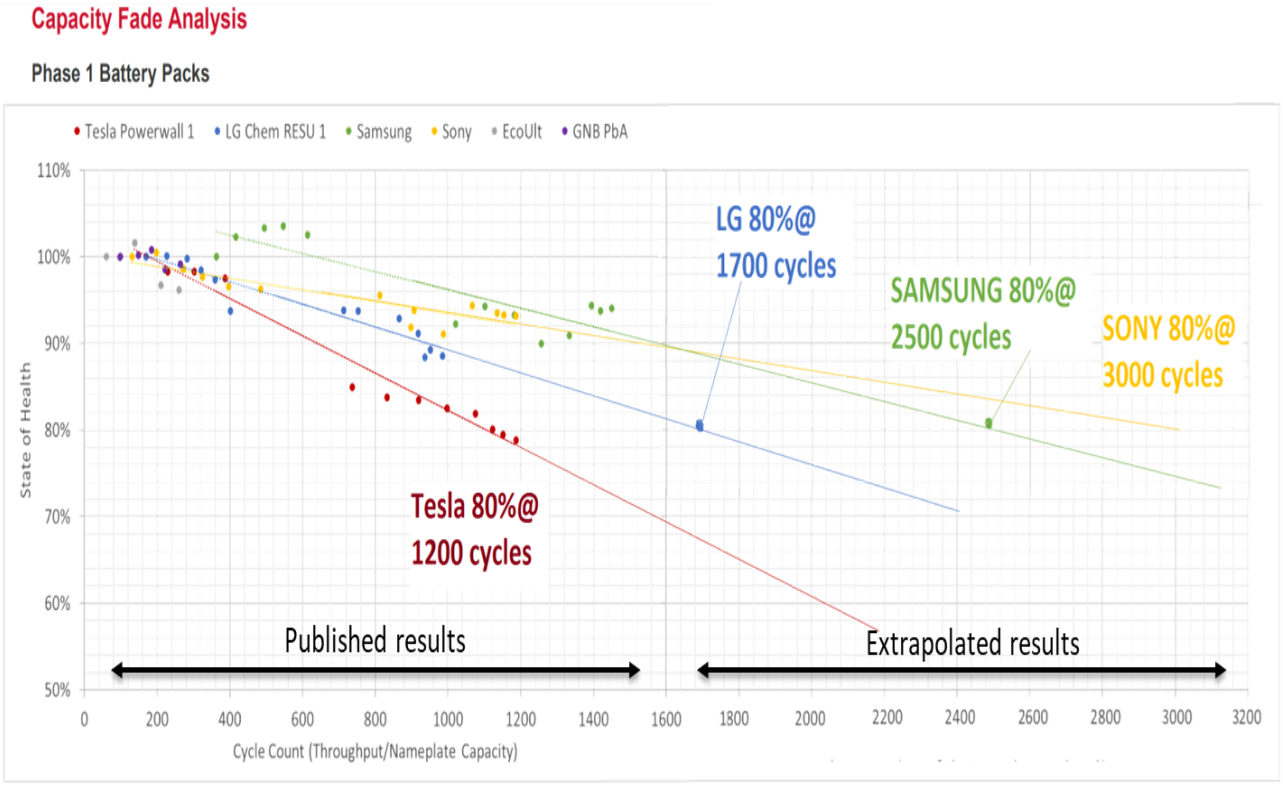


Figure 1. Capacity fade of Phase 1 battery packs

The above chart shows capacity fade for each of the Phase 1 battery packs over the life of the

Source: Arena funded independent Battery test report (Australia)

- The linear decay of the battery capacity is the most optimistic hypothesis
- It can be expected that below the 80% capacity the battery will experience a fast degradation
- The extrapolation has been conducted by extending the third party "best fit" lines

Source: Tesla goes up in flames in video captured by actor Mary McCormack, 17th June 2018, Guardian Website

REDFLOW TECHNOLOGY

Redflow has a unique product with a clear market differentiation

- **Small zinc-bromine flow battery** – can fit in sites that challenge other flow batteries
- Technology is protected by a **combination of patents in multiple countries and trade-secret technology**
- The Redflow battery is designed for **stationary electricity storage applications**
- **Optimised for applications** that require:
  - Constant energy delivery rates & daily deep cycling
  - Tolerance for high ambient temperatures without external cooling
  - Applications where remote or difficult access makes replacement costly
- **Output capacity** does not materially reduce with age or daily deep cycling
- **Scalable storage** - link units in parallel for high availability power system with energy delivery sequenced under software control
- **Redflow Battery Management System (BMS)** with Internet-based remote performance, monitoring, diagnostics and firmware updates
- **Recyclable HDPE plastic and re-usable electrolyte**
- **Smart** – built in battery self-protection features
- **10 years or 36,500 kWh delivered energy warranty**, subject to standard warranty conditions

Stationary Energy Storage Comparison

	ZBM2	Lithium-ion	Lead-acid
Competitive total cost of ownership	✓	✓	✓
No material loss of output capacity with age or exposure to high ambient temperatures	✓	✗	✗
Total battery discharge without damage	✓	✗	✗
Low risk of thermal runaway in a fire	✓	✗	✓

ZBM2 TECHNICAL SPECIFICATIONS

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)
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

Source: https://redflow.com/products/redlow-zbm2/

Field Deployment in Pacific Islands

In 2017, Auckland-based Hitech Solutions ordered 160 Redflow ZBM2 batteries to build an advanced hybrid energy storage system to deliver reliable power to multiple remote sites in a Pacific Island nation.

"We considered both lithium and lead-acid based batteries.

"Lead acid has too short a service life and was very bulky in the limited space we had. We saved 40 tonnes of battery weight by choosing Redflow.

"Lithium performance degrades over time and would struggle with the heat and our desire to run batteries without any cooling, even on days that are hotter than 30 degrees Celsius.

"Redflow batteries also present no fire risk through 'thermal runaway'. In addition, we believe there are still questions about the safe disposal and recycling of lithium batteries at their end of life. Redflow batteries are made of components that are easily recycled or re-used."

Hitech Chief Technology Officer Derek Gaeth