Redflow

International Flow Battery Forum Web Conference
June 2020

redflow
sustainable energy storage

Company Overview

Headquartered
In Brisbane, Australia

Company owned manufacturing facility in Thailand

Redflow designs and manufactures zinc-bromine flow batteries

Major Target Markets
Telco
Commercial, Industrial & Utility
Remote Area Power Systems
High end Residential

Key Geographies
Southern Africa
Australia
New Zealand
China and Selected Asia

~90 current deployments across multiple countries*

vodacom vodafone MOROPA TELECOMMUNICATIONS Rural Connectivity Group OPTUS yes ZbestPower 百能汇通 Knox City Council

Redflow is redefining energy storage in our target markets

redflow sustainable energy storage

* Deployments with Redflow batteries operational as of 25th May 2020 or active in the last 90 days

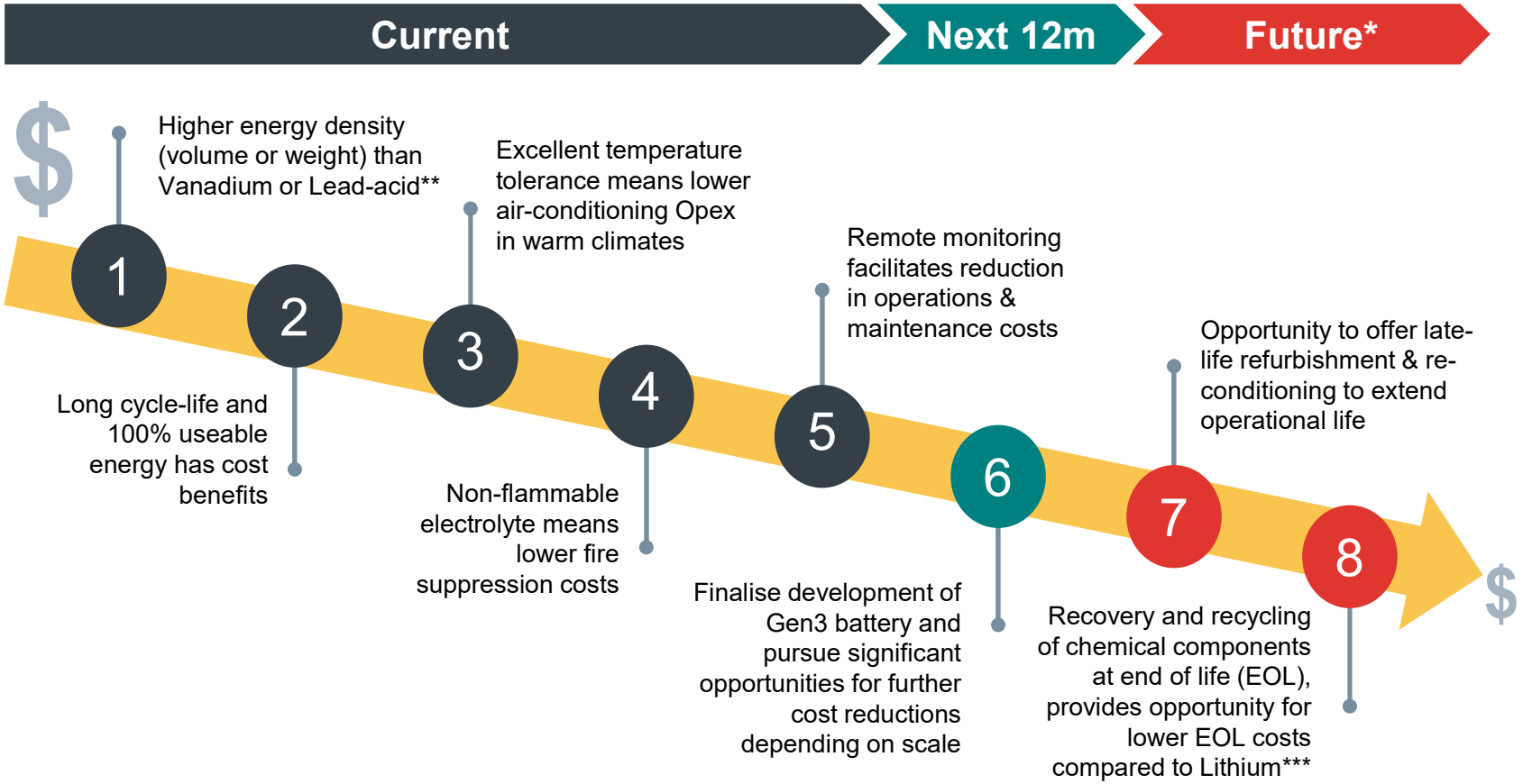
ZBM2 Technical Specs

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
Performance	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)

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

Decreasing life-time cost proposition



Target future customer benefits in development	• Increase in core battery capacity currently undergoing testing (customer $/kWh benefits) • Additional software based functionality to increase application specific performance

* Timing will be dependent on customer demand for service
** See CSIRO Report *Electrical Energy Storage: Technology Overview and Applications*, July 2015
*** Referenced from Renew Economy, '*Battery recycling could generate billion-dollar industry for Australia, push down prices.*'

Redflow Battery Performance

Independent Australian government funded testing show sustained performance

- Redflow is part of a Australian federal government funded testing of multiple batteries through the Canberra Institute of Technology. Managed by ITP Renewables
- After some earlier challenges with battery manufacturing faults, Thailand manufactured Redflow battery has been on test since Feb 2019
- The battery is cycled twice per day close to 100% Depth of Discharge charging at approximately 2.7kW and discharging at approximately 2.0kW.
- April 2020 report shows a State of Health of 100% after ~600 cycles. See report here
- Latest Redflow internal analysis of battery on ITP test bay shows no changes in the capacity, performance and behaviour of the battery can be determined after more than 700 equivalent cycles (>7000 kWh out). Analysis conducted 23rd May 2020.

Redflow Battery Test – Delivered Energy

Figure 8: Estimated full charge capacity per cycle by the Redflow battery pack

Graph extract from ITP *Public Report 8 Lithium-ion Battery Testing*, April 2020 which shows energy discharged from the battery during testing cycles. See report here.

Market Strategy

Redflow Customer Applications

Off-grid – Diesel Reduction

Weak-grid Resilience & Productivity

Battery Theft Avoidance

On & Off grid Renewable integration

Optimised minigrid operation

On-grid Power Consumption Reduction

Major target markets

Our sweet spots include…

Energy-focussed applications	Frequent cycling	Warm climates that rapidly degrade other batteries

Present Focus

Telco

- >4m mobile towers globally
- Power costs a major factor
- Load shedding / weak grids increase demand for long duration batteries
- Increase in infrastructure sharing and tower companies
- Battery theft plus commercial and environmental concerns over diesel use

Provide technical and commercial value proposition across off-grid, weak-grid and back-up power supply applications

Remote Area Power Systems (RAPS)

- Battery Energy Storage System crucial to RAPS with renewable energy sources and can improve efficiency of fossil fuel generation.
- Needs high temperature tolerance, and frequent deep cycling. Minimal capacity decline, like ZBM, highly desirable to maintain optimum operation over life.

Redflow technology is well suited to these applications and offers an attractive commercial proposition

Commercial, Industrial & Utility

- Multiple industries where stable and cost efficient power is critical
- Key issues include intermittent power, high peak demand tariffs and maximising renewable use
- Address solar curtailment
- Sub-station support as demands on grid increase.

Reduce energy costs by replacing / supplementing grid power and avoiding demand tariffs through storing off peak energy

Near term target market – Telco sector

4 million
telco base stations globally with 4.6% CAGR growth 2019-2024[1]

120,000
new base stations are deployed yearly – mostly in countries with poor grid infrastructure[2]

1 million +
off-grid and bad-grid towers by 2020 with over 90% using diesel as main power source[2]

- **Major growth in markets and geographies with no or weak grid environments plus resiliency programs in developed markets such as Australia**
  - Growth expected in areas of poor or limited grid connection and concentrated in Africa & Asia[2]
  - Government sponsored initiatives to improve telco resiliency/back up[3]
- **Base stations energy use are a major cost component for Telcos**
  - 160,000[4] base stations in Africa. Existing engagements cover ~37k towers
  - 21,000[4] base stations in ANZ & Pacific. Existing engagements cover ~16k towers
  - 407,000[4] in Asia (excl China, India & Japan). Existing engagements cover ~18k towers
  - Expected increase in power consumption due to 5G. Widespread upgrades of mobile base station power systems is anticipated
- **Growth of tower companies and infrastructure services**
  - Focus on efficient energy management and emergence of energy as a service models
- **Renewable Energy Commitments**
  - Global telco operators have clear and ambitious renewable energy goals e.g. replace use of diesel[5]
  - Government driven and funded initiatives to reduce blackspots in key countries
  - Government programmes to fund, subsidise or mandate build out of towers in rural or remote locations

1. Mordor Intelligence, *Telecom Towers Market, Growth, Trends and Forecast (2019 - 2024)*
2. GSMA Report, *Green Power for Mobile*, December 2014
3. For example, Australian government AUD$37m Telecommunications Emergency Resilience Package to improve the resilience of communications networks, 2020
4. TowerXchange 2019 Market Reports (Africa and Asia)
5. Vodafone Group *Sustainability Report*, 2019

Case Study Deep Dive

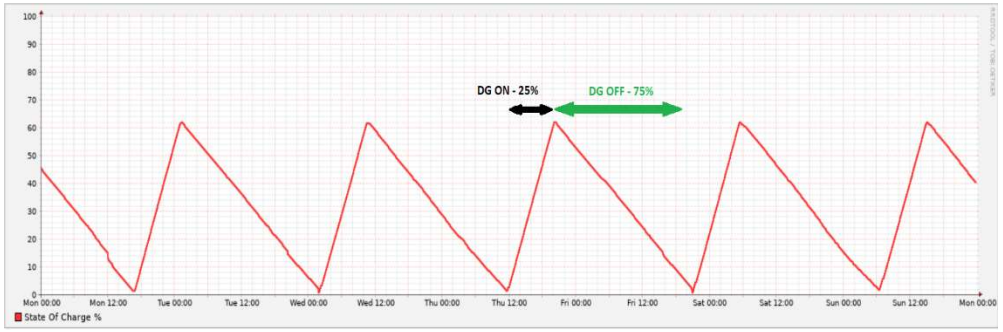
Optus Daintree Forest

Optus Daintree Forest Deployment

- Working with Optus, Australia's second-largest telecommunications carrier and sec ond-largest mobile operator.
- Target site mobile tower site in environmentally sensitive high temperature Daintree rainforest deployment in Queensland, Australia
- Site previously running 24 x 7 on diesel generators. No PV available due to restricted land and forest canopy
- Redflow selected due to sustained energy storage capacity, tolerance of warm temperatures, remote management capability and environmentally-friendly design

Optus Daintree Forest Deployment

- Utilises new Standby Power Supply feature to park batteries in reserve
- Deployed in April 2019. Commissioned May 2019.
- Total energy throughput since commissioning: 7.4MWh
- Achieved 70% diesel runtime reduction*
- Solution consisting of 60 kWh i.e. 6 x ZBM2 batteries and diesel generator (previously running 24 hours per day)
- Diesel generator powers site and charges battery.
- ZBM2 batteries on a simultaneous charge/sequential discharge cycle – managed through Redflow Battery Management System.



* Internal Redflow estimate of total energy output since commissioning to 2nd May 2020. Based on data received from Redflow Battery Management System

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