



World-leading energy
storage solutions

ZBM2



Investor Presentation

July 2017

redflow.com

sustainable energy storage

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3. The Redflow opportunity

Unique technology, commercially available

Redflow Limited (ASX: RFX) was founded in 2005. Over more than a decade Redflow has designed, developed and commercialised the world's smallest zinc-bromide flow battery, the 10kWh Redflow ZBM2. The small size of the ZBM2 allows it to access telecommunications, commercial and residential market opportunities that are physically unavailable to any other flow battery.

Disrupting established markets with growing battery demand

The ZBM2 has a variety of key attributes that set it apart from conventional batteries and increase its commercial attractiveness in its target markets. It is warranted for long term performance in environments that can wear out or destroy lead-acid batteries in 18-36 months.

Strategic opportunity with a clear path to scalable manufacture

Redflow is relocating ZBM2 manufacturing closer to established markets in Oceania and South Africa. Redflow is driving down production costs to improve product profit margins and configure the company for future growth.



4. Energy storage market

1. Off-grid, weak-grid and remote location markets have deployed energy storage systems extensively for many years
2. New applications for energy storage emerge as battery acceptance increases and battery costs reduce
3. Most energy storage applications are based on conventional battery chemistries – typically lead-acid or lithium-derived
4. Conventional battery technologies suffer many endemic shortcomings, risks, and complications
5. Large key market segments are ripe for disruption by a new energy storage technology that overcomes these limitations.

Lead-acid



Lithium-ion

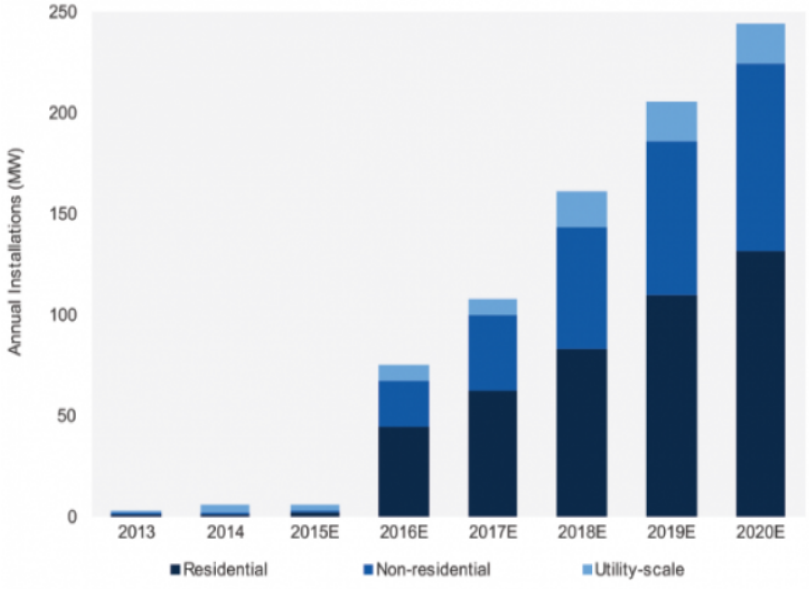


Zinc Bromide



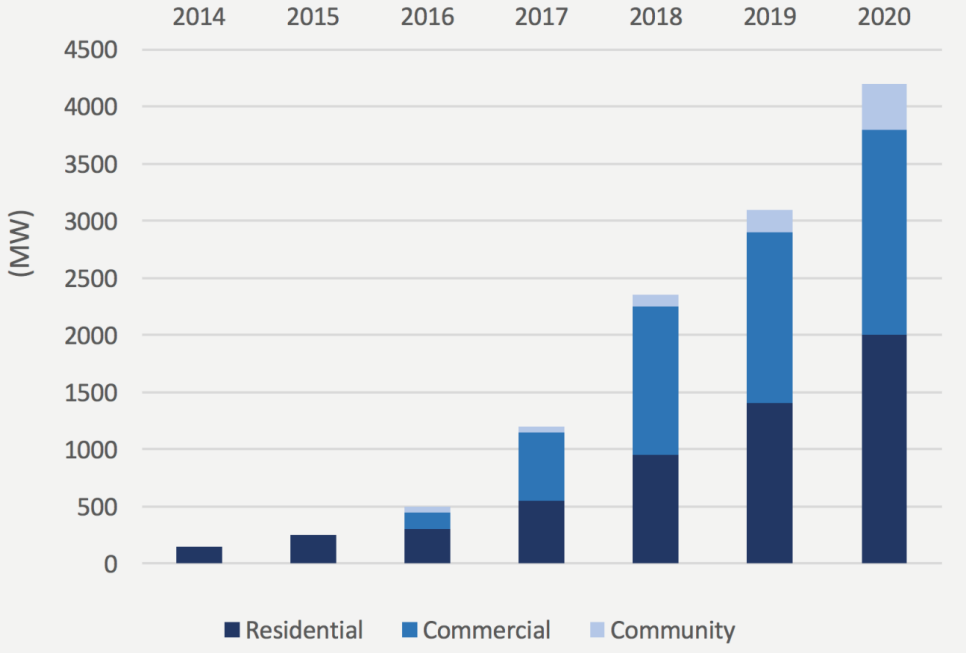
Growing Australian and global markets

FIGURE: Australia Energy Storage Forecast by Segment, 2013-2020E



Source: GTM Research's The Australian Energy Storage Market

Installed Distributed Energy Storage System Power Capacity By Application World Markets 2014-20 (source: Navigant Research)



Redflow ZBM2 redefines the battery

Typical characteristics of most conventional batteries (lead-acid and lithium)	Disruption – Redflow ZBM2 flow battery
Depth of discharge limited (40-60% typical) to avoid damage	ZBM2 supports 100% cycle depth daily with no loss of storage capacity.
Battery energy storage capacity diminishes with age	ZBM2 retains full energy storage capability over its lifetime.
Battery lifetime typically shortened the more frequently it is cycled	ZBM2 lifetime is not affected by cycle depth or daily use.
Battery damage occurs if battery is allowed to be completely discharged	ZBM2 is unaffected by complete discharge for arbitrary periods.
High battery temperature shortens battery lifetime	ZBM2 operates at up to 50 degrees Celsius without external cooling.
Some batteries are at risk of causing 'thermal runaway' (fire)	ZBM2 is not prone to thermal runaway or fire.
Lead-acid systems wired in series strings with single points of failure	ZBM2 batteries are natively 48 volt and wired in parallel.
Lead-Acid batteries are a simple 'box of chemicals' with no self-protection	ZBM2 is smart - active control, monitoring and self-protection systems.
Recycling can be challenging – especially if batteries are replaced frequently	ZBM2 tanks made of recyclable HDPE that contain re-useable electrolyte.

Sustainable Intellectual Property Advantage

Redflow's development path: A hard act to follow

The 10kWh ZBM2 is **the world's smallest zinc-bromide flow battery(*)**.

It displaces the use of conventional batteries in key energy storage market segments where other flow batteries are simply too large to be contenders.

Redflow's technology is **protected** by a combination of **patents** in multiple countries and **trade-secret technology** in the core electrode stack.

It features enhanced reliability due to all electrode fluid flow paths being internal to, and sealed within, the ZBM2 electrode stack during the manufacturing process.

Redflow has undertaken a long and complex journey to reach **reliable commercial manufacture** - reflecting a correspondingly high level of difficulty in terms of independently copying/cloning the product.



(*) The Primus Power EnergyPod 2 Zn/Br flow battery product is a 125kWh unit. The EnSync Agile Zn/Br flow battery product range starts at 55kWh.

5. Strategic direction

Redflow has completed a comprehensive assessment of its strategic direction in the current market, including an independent strategic review of its operations, to identify the optimal path to sustainable economic success.

Redflow's key focus is to disrupt the existing lead-acid replacement market, replacing short-lifetime lead-acid batteries with long-life flow battery deployments in the off-grid, telecom, commercial and industrial sectors.

Strategic directions arising from the review:

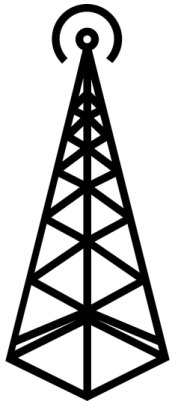
1. Target sales focus to deliver results in proven demand areas
2. Relocate manufacturing closer to priority markets
3. Implement cost-down projects to create sustainable gross operating margin

Redflow sales strategy

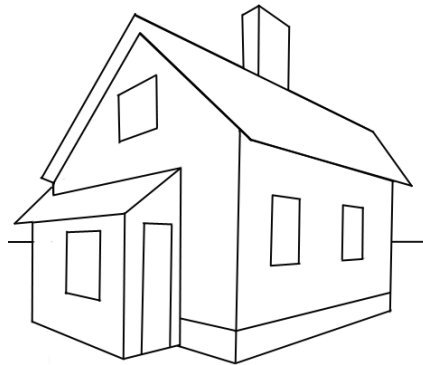


Target sales focus to deliver results in proven demand areas

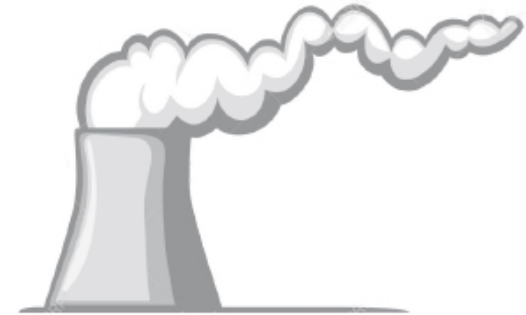
1. **Target sectors where ZBM2 has a competitive advantage**, replacing conventional batteries - especially lead-acid - where ZBM2 attributes deliver superior economic and technical outcomes
2. **Prioritise market development and sales to mature segments with a large, proven and ongoing demand for energy storage** - telecommunications / industrial / commercial / remote / off-grid power / 'weak-grid' - that fit the "sweet spot" of Redflow's unique value proposition.



**Telecommunications
and Network Power**
Weak-grid and off-grid focus



Residential
On-Grid and Off-Grid



**Commercial & Industrial / Mining
/ Micro-Grid / Remote Power**
*Diesel run-time reduction,
renewable energy integration*

Geographic sales focus areas

Immediate focus:

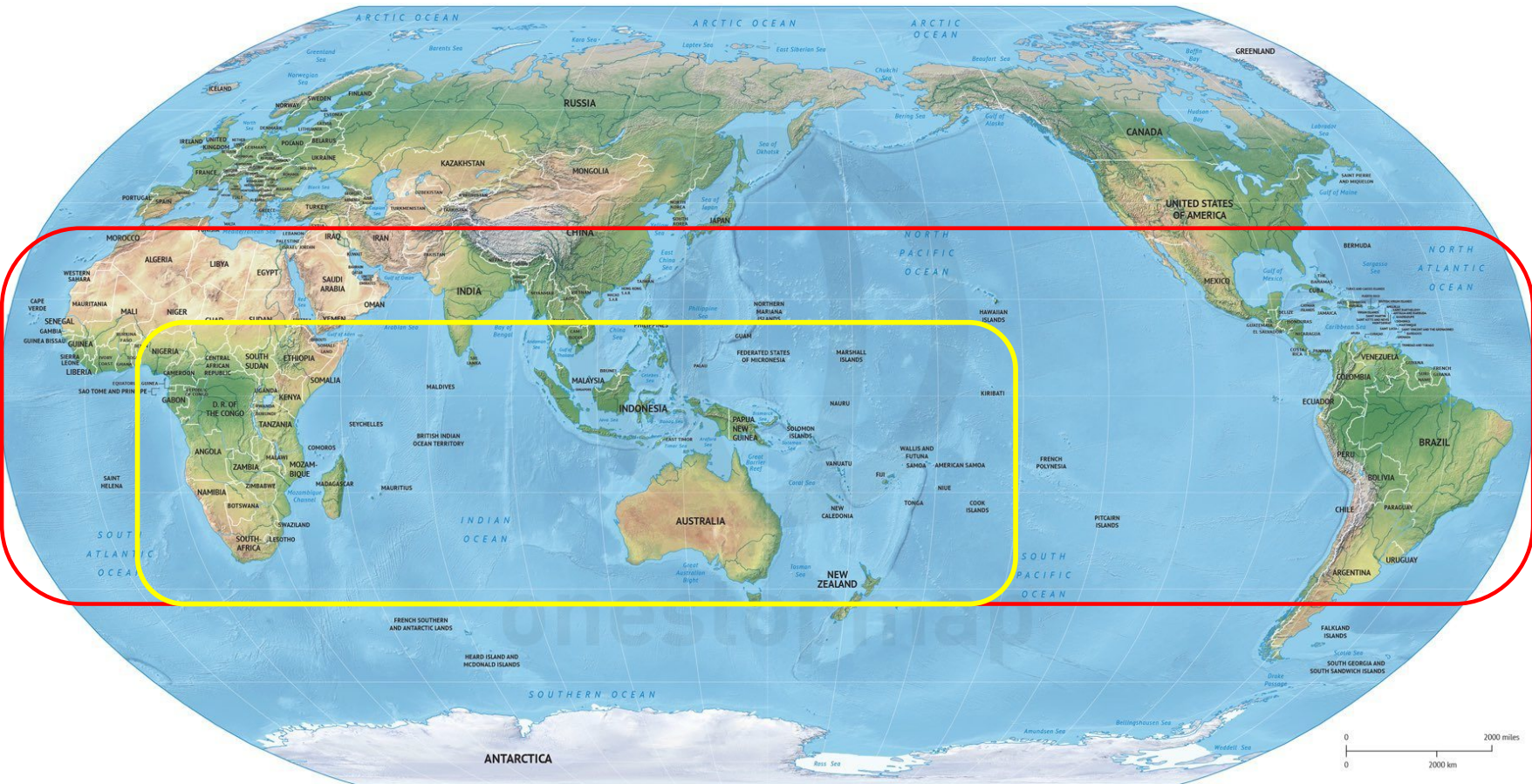
Oceania and South Africa

Medium term focus:

Tropical zone with populous countries and fast-growing economies.

ZBM2 strengths:

- High ambient temperature
- Unreliable or unavailable energy grid
- High cycle-rate applications



Lead-acid world market

Established, large and growing worldwide – ripe for disruption

The global lead-acid battery market is expected to grow from US\$53.32 billion in 2016 to reach US\$81.25 billion by 2022 with a CAGR of 7.2%. *

Stationary energy storage segment is anticipated to command the market with a higher CAGR.

Asia Pacific dominates the global market over the forecast period.

* Statistics MRC from: <http://www.strategymrc.com/report/lead-acid-battery-market>



Disrupting the lead-acid battery market

Compelling alternative to lead-acid in stationary energy storage

Well-established and large market segment with 18-36 month refresh cycle

Lead-acid batteries dominate global stationary energy storage markets.

Frequent battery replacement is the status quo for high cycle intensity (cycle depth and/or cycle frequency) applications and in high ambient temperatures.

ZBM2 life not shortened by high cycle intensity or high ambient temperature.

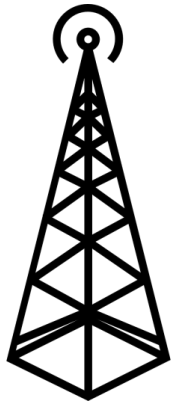
Redflow's core business case is to replace short lifetime (typically 18-36 month) lead-acid deployments with deployments of the long-lifetime (10 year warranty) ZBM2 flow battery.

ZBM2 has proved its appeal to this sector through sales and deployment success

Redflow has demonstrated the appeal of ZBM2 batteries over incumbent lead-acid batteries with commercial sales and deployment success in Oceania and South Africa.



Redflow sales strategy



**Telecommunications
and Network Power**



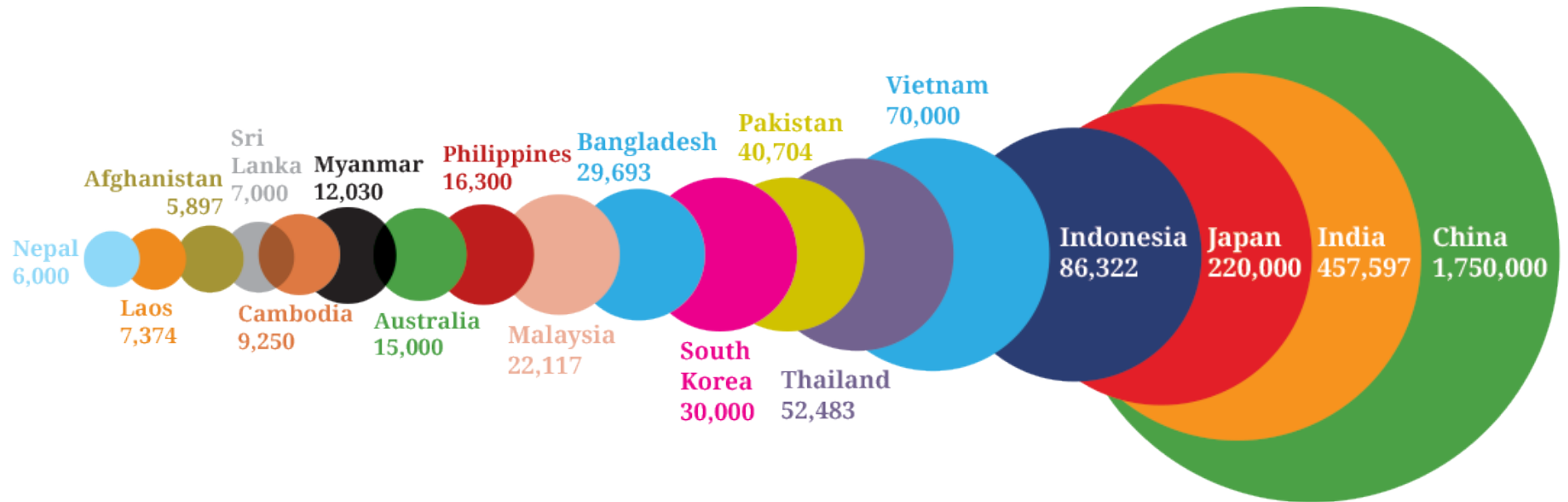
Residential / SOHO



Commercial & Industrial / Mining
/ Micro-Grid / Remote Power

Telecommunications markets – ZBM2

Telecommunications tower sites using DC power (weak grid or off-grid)



- Millions of telco sites globally – including but not limited to communications network tower sites
- Asia alone has more than 2.7 million telecommunications tower sites
- Large proportion, especially in developing countries, are off-grid or in weak-grid environments
- An entry-level telecommunications site deployment typically uses 2-4 ZBMs to replace a lead-acid battery system.

Telecommunication success – ZBM2

Installation Example

Project: Off-Grid 48V DC hybrid energy system for Mobile Network Operator (MNO) in New Zealand

Integrator: Vertiv (formerly Emerson Network Power)

System Setup for Base Station Transceiver (BTS):

- 12 kWp solar array and 2 Wind Turbines
- 5 x ZBM2 (40kWh) energy storage + Redundancy
- 12 kW Diesel Generator
- Emerson Network Power energy system controller

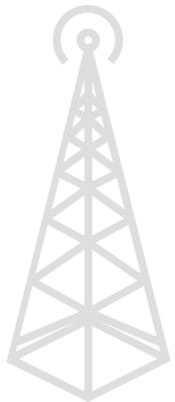


New telecommunication sector sale

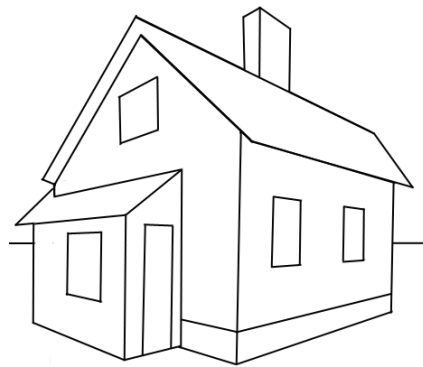
In May 2017, Redflow announced its largest single sale to date of ZBM2 zinc-bromine flow batteries, worth about US\$600,000 (A\$800,000), for multiple sites in the Pacific Islands. New Zealand-based Hitech Solutions is building advanced hybrid energy storage systems to provide reliable, remote power to multiple sites in a Pacific Island nation.

Follow-on orders are considered likely once this order has been successfully deployed.

Redflow sales strategy



Telecommunications
and Network Power



Residential / SOHO



Commercial & Industrial / Mining
/ Micro-Grid / Remote Power

Residential / SOHO Markets

On-Grid



Deployments of battery storage to augment on-site renewables (typically solar) have expanded rapidly in residential / SOHO over the last 18 months and deployments are expected to further accelerate.

Redflow launched its ZCell on-grid residential / SOHO market sales strategy in 2016, targeting early adopters and tech-savvy customers, to provide the broader market with a third party endorsement of its zinc-bromide technology. ZCell is now a recognised brand in the Australian energy storage market.

Redflow's ZCell installer channel is successfully selling and deploying ZCell batteries to high-value customers who are sensitive to the inherent technical, lifetime and safety advantages of this product.

Redflow expects its new manufacturing location and cost-down initiatives to advantage ZCell penetration into this market in the future.



Residential / SOHO Markets

Off-Grid



Off-grid deployments typically occur where the grid is not available or where the cost to install a grid connection is in excess of the cost of creating an off-grid energy system.

Redflow's ZCell value proposition and technical advantages have proven well suited to meeting the needs of **off-grid** and **weak-grid** energy storage customers – including at fringe, rural and remote locations.

Redflow continues to deploy ZCell into this market around Australia, with typical installations ranging from 2 x ZCell to 6 x ZCell systems.

Redflow considers the global off-grid lead-acid replacement market holds similar opportunities to the telecommunications sector.



*6 x ZCell Offgrid System with 20kWp solar array
Regional Queensland Off-Grid House
Installed in June 2017 by Offgrid Energy Australia*

Off-grid ZCell installation



Google ANZ Engineering Director Alan Noble

Project: Alan Noble rural property
Location: Willunga, South Australia
Integrator: Off-Grid Energy Australia

System Setup:

- 6kW Solar Array with DC MPPT
- 2 x 10kWh ZCells
- Victron MultiPlus 48/5000



Outcomes:

- System cost was less than connection fee to access rural energy grid
- No grid energy bills – ever
- Guaranteed power availability for pumps during high risk fire days

Off-grid ZCell installation



Project: Off-Grid House
Location: Regional Queensland
Integrator: Off-Grid Energy Australia



System Setup:

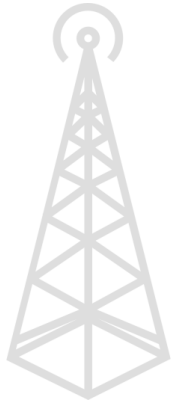
- 20kWp DC Coupled Tindo Solar Array
- 6 x 10kWh ZCells (60kWh total)
- 2 x Victron Quattro 10kVA (8kW) inverters (16kWp total)
- 20kVA diesel backup generator



Outcomes:

- No grid energy bills – ever
- High availability, high capacity renewable energy system
- Genset available as backup but system sized to avoid needing it
- Designed to be expandable to 12 x ZCell (120kWh)

Redflow sales strategy



Telecommunications
and Network Power



Residential / SOHO



**Commercial & Industrial / Mining
/ Micro-Grid / Remote Power**

Commercial & industrial / mining / micro-grid / remote power markets

Factors driving energy storage uptake in this large market – in Australia and globally – include:

- The high cost of electricity consumption, including punitive peak-time / demand charges
- The high cost of connecting to the electricity grid when supply is required
- Unreliable energy supply, e.g. power cuts interrupting business operations
- Increasing affordability of solar PV energy generation to offset grid supply costs.
- Increasing deployment of self-contained/micro-grid energy systems to communities with no access to a conventional energy grid, such as developing nation electrification, remote mining facilities, offshore platforms, etc

These are applications where the economic and technical advantages of the ZBM2 compared to lead-acid – and the potential to displace it – are just as strong as they are in the telecommunications and network power market sectors.

ZBM2 at large commercial site



Commercial deployment

Project: Bosco Printed Circuits, South Africa

System setup:

- 12 x ZBM2 (120kWh) energy storage
- 51 kW solar array
- 48kW three phase Victron Inverter cluster.

Integrator: Specialized Solar Systems

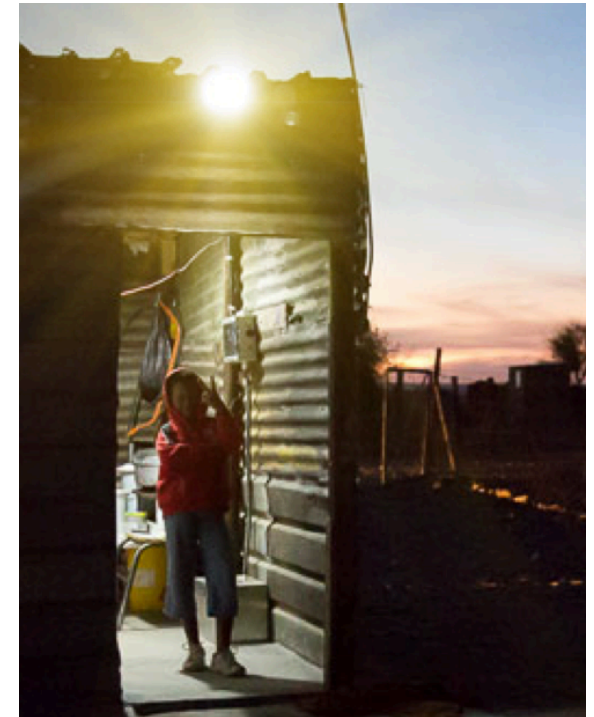
Deployment benefits:

- Continuous power supply in a weak grid area
- Time-shifts solar power to avoid demand charges
- Stores solar power to avoid grid power charges.

ZBM2 sales opportunity: South Africa



- Redflow's integrator in South Africa, Specialized Solar Systems (SSS) has deployed a DC energy utility service, using lead-acid based micro-grids, to 25,000 dwellings in South Africa.
- SSS plans to expand the rollout to a further 300,000 dwellings over the next five years.
- SSS is undertaking a project with Redflow evaluating use of the ZBM2 to replace large Lead-Acid battery banks in this rollout.
- Technical verification of the solution is underway with trials planned for this calendar year ahead of field deployments from early 2018.



6. Manufacturing optimisation

Relocate manufacturing closer to priority markets

Redflow is moving its battery production facility closer to its target markets to deliver immediate production cost savings and reduce supply chain length / cost / delivery time. After careful evaluation, Redflow selected MPTS as its new manufacturing partner. Redflow has an existing relationship with MPTS as a long-term supplier of a core component of its battery stack.

Current Status:

- MOU executed, detailed commercial contract under negotiation
- Production plan for stack and for full ZBM2 completed
- Initial manufacturing cost agreed.
- Agreement is non-exclusive to ensure appropriate commercial tension.

MPTS will deliver a **10% reduction** in per-unit manufacturing and delivery cost as soon as their production commences, ahead of further planned engineering cost-downs

MPTS satisfies all key attributes Redflow required in a manufacturing partner:

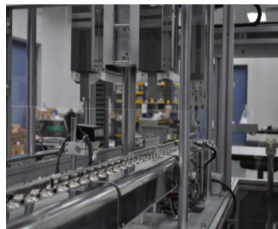
- ✓ Successful track record of manufacturing similar componentry
- ✓ Immediate build cost savings from a lower cost, high competency labour pool
- ✓ Capability in design-for-manufacture and collaborative cost-down work
- ✓ Strong skills in precision manufacturing
- ✓ In-house resources in factory automation, equipment design and build
- ✓ Physical location closer central to existing successful markets for product.

New manufacturing partner: MPTS

MQ Technology: Commenced operations in Malaysia in 1996 – over 20 years of experience in the precision tooling industries. **Subsidiaries:** MPT Solutions Co., Ltd. ; Microlead Precision Technology

Key manufacturing proficiencies

- High precision machining of complex tooling elements
- CNC Milling; Wire EDM; Sinker EDM; Surface Grinding
- Precision tooling assembly
- Progressive stamping tools
- Jigs and fixtures tooling design



Automation system design capabilities

- Electro-mechanical motion systems
- Pneumatic/hydraulic systems
- Conveyor systems (chain, belt, roller & other specialty equipment)
- Robotic systems
- High speed precision sorting, turning, pick & place for small components

System control & electro-mechanical assembly

- PLC & PC-based software development
- Electrical control design
- PCB design & PCBA electronic control
- Technical team for electrical wiring, wire harness & mechanical assembly

High profile clients



7. Cost downs

Implement cost-down projects to create sustainable gross operating margin

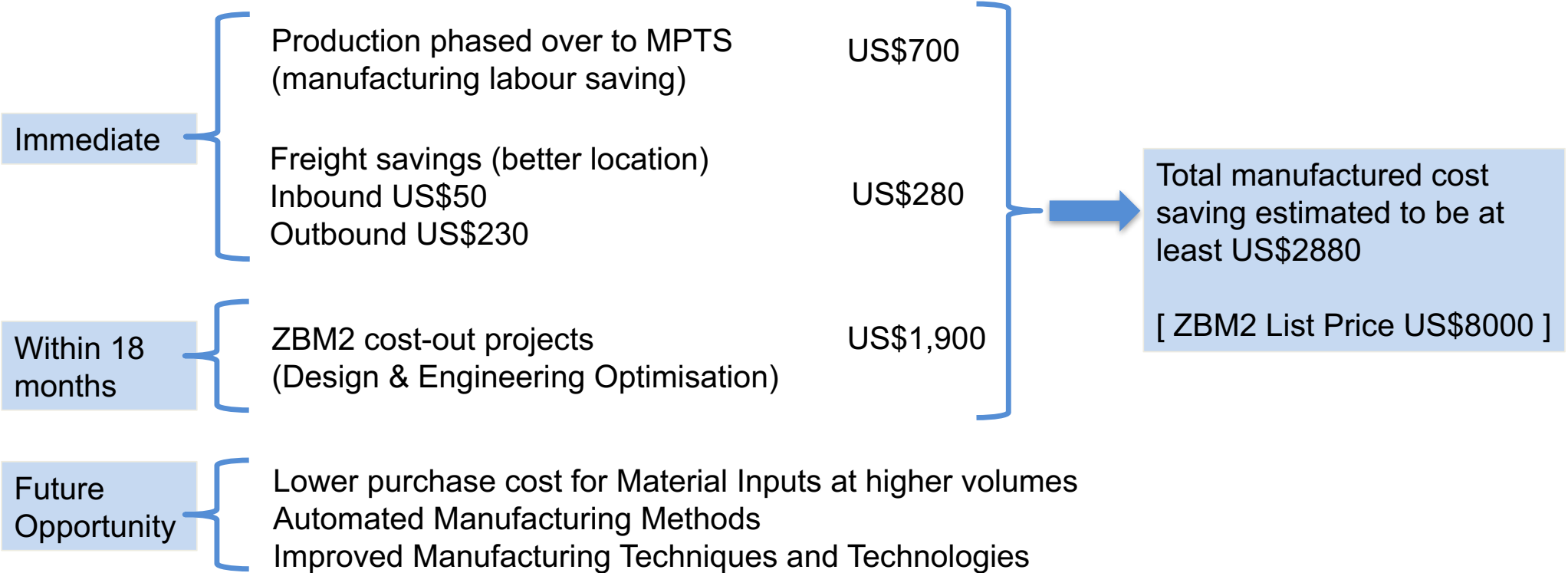
Redflow is undertaking a detailed program of manufacturing cost-downs to increase the operating margins from sales of its product as a key driver to achieving cashflow-positive and economically sustainable company operations.

Redflow will achieve significant cost-downs immediately by moving to an optimal manufacturing location, followed by substantial product cost-down projects implemented by Redflow engineering staff in concert with our manufacturing partner.

Redflow cost-down objectives:

- Reduce delivered product manufacturing unit cost by at least 30% over the next 18 months;
- Target concurrent operating overhead cost reductions of 10-15%; and
- Target sustainable cashflow-positive operations by the end of calendar year 2018.

Product cost-down projects and new manufacturing site drive overall manufacturing unit cost reduction target at least 30% @ 90/month production rates.



8. Transition and beyond

Transitional delivery arrangements

Existing Redflow-owned manufacturing equipment is currently being relocated to MPTS.

Redflow will continue to supply key markets during the transition period from stock on hand, stock in transit, and completion of existing battery subassemblies, ahead of production commencement in the new manufacturing site.

Stable MPTS production using Redflow manufacturing equipment is projected for December 2017. Production ramp-up planned from July 2018.

Second-source manufacturing path to enable further scale and distributed manufacture is being explored.

High-level three-year objectives



9. Management

Redflow executive management

Simon Hackett: CEO, Executive Chairman, Largest Shareholder

- Experienced and successful technology industry entrepreneur, with a track record in technology and commercialisation
- Battery Management System and energy system interface design and deployment lead

Richard Aird, COO

- Track record in successful business, project and team management in engineering-focused companies
- Experienced and involved with Redflow operations and management since IPO
- Driving the core manufacturing and cost-down transition roadmap

Dr. Alex Winter, Chief Engineer

- Co-designer of the ZBM2 product
- Chemical and Mechanical engineering design lead

Dr. Michele Giulianini, Chief Technology Officer

- Electrical and electronic design lead
- Key customer engineering support authority
- Battery System on-board-controller design and evolution

Appropriate senior management & staff recruitment under consideration for 2017 including

- CFO/Company Secretary; CIO
- Logistics, supply-chain management, engineering project management & manufacturing industry expertise

Management

Redflow board

Current Board

- Simon Hackett: CEO, Executive Chairman, Largest Shareholder
- Richard Aird, COO, Executive Director
- David Knox, Non-Executive Director
- Patrick Tapper, Non-Executive Director
- Howard Stack, Deputy Chairman, Non-Executive Director
- Bruce Brown, Non-Executive Director

Board skills assessment and refresh process underway

- Increase skills mix and diversity
- Separate roles of CEO and Chairman

10. Equity Raising

Redflow Limited has achieved many key milestones related to its unique product since its inception in 2005. Recent sales success shows that market demand exists and that the product can satisfy it.

Market experience with ‘real world’ deployments in the last 18 months have given Redflow the experience and information necessary to optimise our unique product, control systems and software to work seamlessly in place of conventional batteries in a variety of settings.

Redflow is now preparing our core product for sales in volume by undertaking an organised program of build-cost reduction and manufacturing optimisation in readiness for a planned scale-up of production, delivery and sales from mid-2018.

The best path for Redflow to achieve economic sustainability is clearly defined, with the necessary actions to achieve that outcome already underway.

Redflow is undertaking a new placement of equity to sophisticated and institutional investors in support of our continued progress toward this outcome.

This equity injection will enable Redflow to complete the relocation of manufacturing to a more appropriate location and deliver key cost-downs to prepare for optimised and sustainable manufacture at scale.

Use of funds

Transfer of manufacturing to new location in South-East Asia	\$1.6m
Purchase and transfer of raw material inventory	\$1.8m
Development investments (product cost-down engineering, quality, sales and logistics)	\$2.5m
Recruitment and restructuring costs for senior management and board	\$0.4m
Capital raising costs	\$0.5m
Ongoing operating costs	\$7.7m
Total	\$14.5m

This is a statement of present intention only. The Company reserves the right to change the way and the amount in which funds are applied.

A total of \$4m of has already been received by Redflow via the existing Convertible Note. The new placement tranches will raise \$10.5m of new cash before offer costs.

Funds converted to equity from proceeds of the existing Convertible Note will convert on an equal footing to other investors.

Capital Raising Details

PLACEMENT

Capital raising price	\$0.10 per share
Gross proceeds target	\$14.5 million, comprised of: <ul style="list-style-type: none"> • ~\$5.82 million tranche one • ~\$4.68 million tranche two, settling shortly after shareholder approval granted • \$4 million existing note held by Simon Hackett (largest existing shareholder) converted on same terms as placement at same time as tranche two

PRO FORMA CAPITAL STRUCTURE

Current issued capital	394,795,214 shares
Shares to be issued under tranche one	58,161,846 shares
*Shares to be issued under tranche two	46,838,154 shares
*Conversion shares	40,000,000 shares
Post Raising capital structure	539,795,214 shares

DISCOUNT METRICS

Last closing price of \$0.1550 on Wednesday, 12 July	35.48% discount
5 Day VWAP of \$0.1592	37.18% discount

* Subject to shareholder approval

Indicative Timetable

EVENT	DATE
Trading halt	Thursday, 13 July 2017
Announcement and recommencement of trading	Pre-market Friday, 14 July 2017
Expected allotment of new shares (tranche one)	Thursday, 20 July 2017
Extraordinary General Meeting of Shareholders	Friday, 25 August 2017
Expected allotment of new shares (tranche two and conversion shares), subject to shareholder approval	Wednesday, 30 August 2017

Indicative timetable only and subject to change without notice

11. Key Risks

General:

An investment in Redflow is speculative and should be considered to be high risk. Investment returns are not guaranteed.

Key Risks:

- Manufacturing transition executed to plan (time and budget)
- Supply chain quality and quantity control appropriate and adequate
- Sufficient capital obtained as needed
- Continued sales achieved in line with expectations
- Market development, sales and deliveries in transitional period consistent with forecast
- Product quality, performance and reliability consistent with expectations

12. Summary

Achievements, Actions and Aims

Achievements:

- Redflow has delivered a patent-protected energy storage product solving problems with conventional batteries
- Redflow has commercially manufactured its ZBM2 zinc-bromide flow battery, launched its ZCell residential battery brand and delivered its products into target markets through experienced installation/integration channel partners.

Actions:

- Redflow has identified and verified the energy storage market segments that it is uniquely equipped to disrupt
- Redflow is moving manufacturing closer to these markets and implementing cost-down projects to improve margins.

Aims:

Redflow will support the next stages of its development using the capital raised.

Redflow will also strengthen its executive and board skillset to manage and monitor growth, product quality and innovation.



Appendix A – ZBM2 advantages in detail



Hybrid Zinc-bromide Flow Battery

100% reversible zinc deposition system made of recyclable plastic

At Discharge

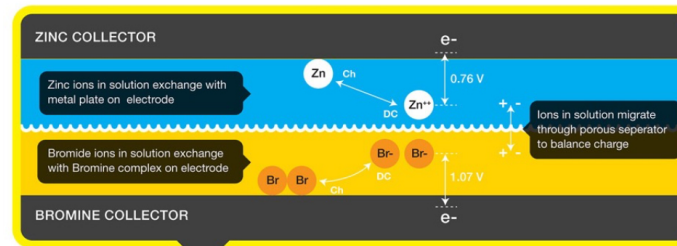
Neg Electrode: $Zn \rightarrow Zn^{2+} + 2e^-$ (Zn ions in both electrolytes)

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

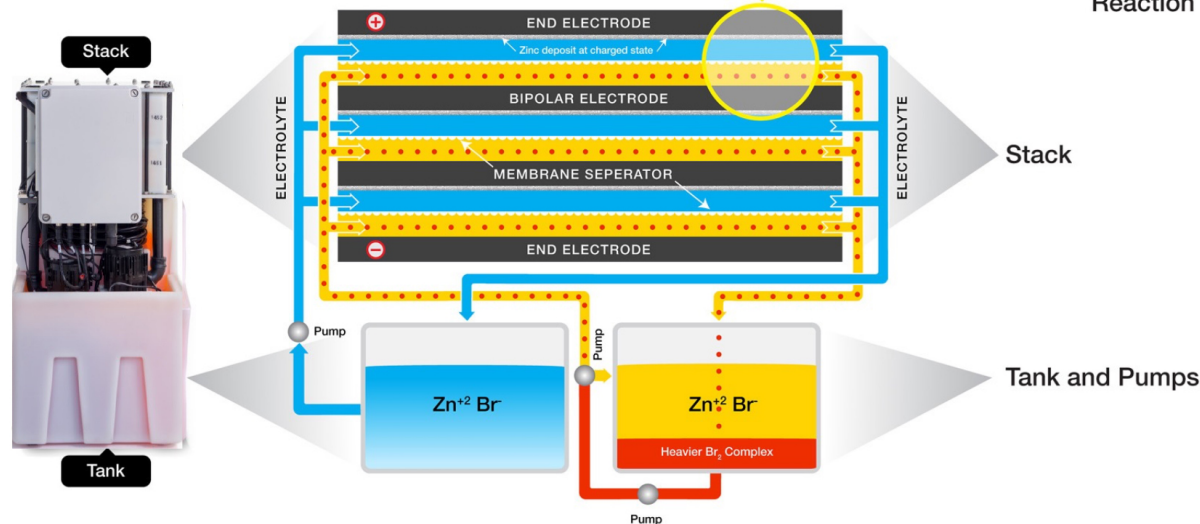
At Charge

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

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



Reaction



ZBM2: Sustainable energy storage

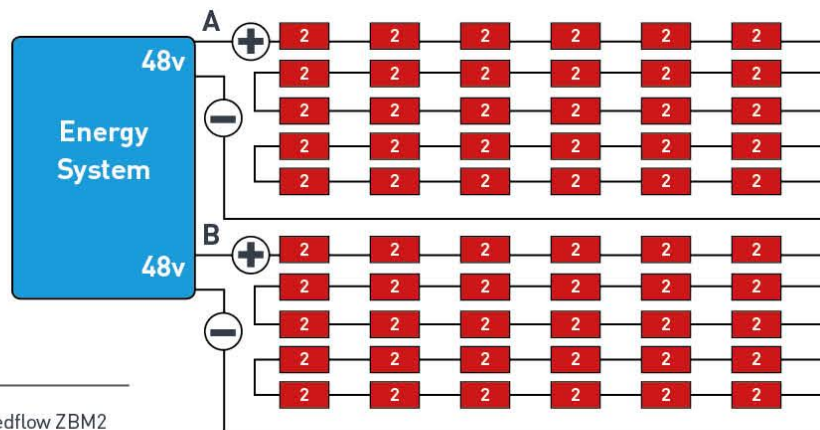
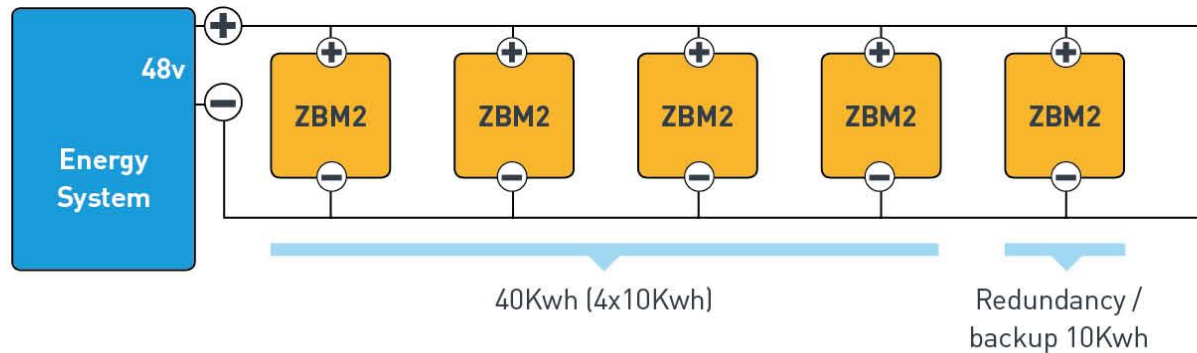
Sustainability Aspect	Outcomes Delivered - Detail
Commercial Sustainability	<p>World's smallest commercially sold zinc-bromide flow battery – serve applications where other flow batteries are too large to compete</p> <p>Business case based on replacing serial strings of short-lifetime Lead-Acid batteries with fault-tolerant clusters of ZBM2 48V modules</p> <p>Use multiple 10kWh ZBM2 modules in parallel to build a 48V energy system of any required size using N+1 for redundancy instead of needing up to Nx2</p>
Sustainable Operating Envelope	<p>Thrives on high intensity, constant usage, deep-cycling applications that reduce operating lifetime and may damage or destroy other batteries</p> <p>Tolerates high ambient operating temperatures (up to 50C ambient) without lifetime reduction</p> <p>Can be left fully discharged or completely shut down at any state of charge for an arbitrary period with no damage and no self-discharge.</p>
Environmental Sustainability	<p>Core components made of commonly available materials with no rare-earth metals</p> <p>Electrode stack and tanks of recyclable plastic.</p> <p>Electrolyte fluid can be cleaned and re-used at end of life.</p>
Energy Delivery Sustainability	<p>Sustains its full 10kWh energy discharge capacity, with no loss of energy output capacity regardless of cycle depth or cycle frequency</p> <p>Delivers 100% of rated output during discharge – no 'reserved' capacity required</p> <p>"Right Size" the system up front - conventional batteries require substantial over-sizing of installed capacity for both of these reasons.</p> <p>Near-linear charge and discharge rates available from empty->full->empty for predictable and tractable energy storage and delivery</p>

ZBM2: Sustainable energy storage

Sustainability Aspect	Outcomes Delivered - Detail
Technical Sustainability	<p>Remote and secure Internet based monitoring and control of ZBM2 energy clusters using the Redflow BMS</p> <p>New operating features and improved operation over time via remote over-the-air software updates.</p> <p>Easy drop-in replacement of Lead-Acid batteries in most 48V DC systems, using standard interface protocols including CANBus and MODBUS</p> <p>Parallel-wired 48V modules are fault tolerant. Serial-wired Lead-Acid strings fail entirely if any battery in the string fails</p> <p>Multiple batteries in a cluster can operate at different states of charge with software controlled energy delivery sequencing/optimisation</p>
Sustainable Maintenance	<p>Extended lifetime in appropriate markets and applications compared to incumbent batteries</p> <p>Low maintenance overhead – sealed system, minimal physical maintenance and inspection requirements</p>
Sustainable Safety	<p>Intrinsically fire retardant electrolyte.</p> <p>Energy density sufficient for high performance but not high enough to create risk of thermal runaway or fire.</p> <p>Self-protects automatically if any environmental or operating limit for the device is exceeded. Automatic self-recovery.</p>

Benefits of parallel vs serial wiring

ZBM2 parallel wiring is easier, simpler and more fault-tolerant



two complete serial battery strings for redundancy against single points of failure



- KEY
- = 48 Volt DC Redflow ZBM2
 - = 2 Volt DC Lead Acid Battery

Appendix B – Business Case Support



Lead-acid battery performance / life in telecom environment

12V AGM Telecom battery	115Ah	165Ah	200Ah
Capacity 1 / 3 / 5 / 10 / 20 hours (% of nominal)	60 / 75 / 82 / 91 / 100 (@ 70°F/25°C, end of discharge 10,5V)		
Capacity 10 / 20 / 30 / 40 minutes (% of nominal)	33 / 44 / 53 / 57 (@ 70°F/25°C, end of discharge 9,6V)		
Nominal capacity (77°F/25°C, 10,5V)	115Ah	165Ah	200Ah
Cold Cranking Amps @ 0°F/-18°C	1000	1500	1800
DIN cold start current (A) @ 0°F/-18°C	600	900	1000
Short Circuit Current (A)	3500	5000	6000
Reserve Capacity (minutes)	200	320	400
Shelf life @ 70°F/20°C	1 year		
Absorption voltage (V) @ 70°F/20°C	14,4 – 14,7		
Float voltage (V) @ 70°F/20°C	13,6 – 13,8		
Storage voltage (V) @ 70°F/20°C	13,2		
Float design life @ 70°F/20°C	12 years		
Cycle design life @ 80% discharge	500		
Cycle design life @ 50% discharge	750		
Cycle design life @ 30% discharge	1800		
Dimensions (l x w x h, mm)	395 x 110 x 293mm	548 x 105 x 316mm	546 x 125 x 323mm
Dimensions (l x w x h, inches)	15.37 x 4.33 x 11.53	21.57 x 4.13 x 12.44	21.49 x 4.92 x 12.71
Weight (kg/pounds)	35kg/77lbs	49kg/88lbs	60kg/132lbs

Table Source - Victron Energy Telecom lead-acid battery:
<https://www.victronenergy.com/upload/documents/Datasheet-Telecom-batteries-EN.pdf>

This is an exemplar of a lead acid battery designed for Telecom applications.

Multiple factors act to require the installation of additional 'raw' battery capacity to obtain sufficient and sustained application energy output over a ten year period.

For a 750 cycle design life (2 years of daily cycles) – as shown in the table – the depth of discharge must be limited to 50%. Hence twice the raw capacity must be purchased.

Discharge capacity is reduced based on how rapidly energy is discharged. The example highlighted in the table is for 3 hour discharge, yielding 75% of the rated discharge output capacity. Further capacity must be purchased if this is to be offset.

Output capacity also diminishes with age. Industry definition of 'end of life' for Lead-acid is at 80% of original discharge capacity. Further capacity must be purchased if this is to be offset.

These factors are multiplicative, yielding only 50% x 75% x 80% = 30% of the 'raw' energy capacity purchased. For example, 10 kWh of minimum output capacity on a daily full-cycle basis would require the purchase of 10kWh / 30% = 33kWh of raw battery capacity based on the factors noted above.

Over a ten year period of daily full discharge cycles this system must also be replaced 5 times, requiring a total of 5 x 33kWh = 165 kWh of raw capacity in aggregate over that period. Physical transport and installation costs occur for each repeated replacement.

Operation in higher ambient temperatures acts to shorten lead acid battery life in addition to the factors noted above (see following slide)

ZBM2 Comparison:

A 10kWh ZBM2 is warranted to deliver a sustained 10kWh of output on a daily full cycle basis under similar circumstances for 10 years (or 36500 kWh, whichever comes first). None of the scaling factors above need be applied to the ZBM2 capacity.

Lead-acid battery lifetime: Relationship with ambient temperature

Typical Temperature vs Lifetime for lead acid batteries

Operating Temperature (degrees C)	Typical Operating Life Lead Acid (Years)	Operating Life Redflow ZBM2 (Years)
25	10	10
33	5	10
42	1	10

ZBM2 lifetime is not adversely impacted by high ambient operating temperatures and operates at up to 50 degrees C (electrolyte temperature).

High thermal mass means the peak ambient environmental temperature can rise above 50°C without the electrolyte temperature exceeding 50°C.

ZBM2 self-protects under very extreme temperature conditions (electrolyte temperature exceeding 50°C) with automatic self-recovery.

The optimum operating temperature for the lead-acid battery is 25°C (77°F). As a guideline, every 8°C (15°F) rise in temperature will cut the battery life in half. VRLA, which would last for 10 years at 25°C (77°F), will only be good for 5 years if operated at 33°C (95°F). Theoretically the same battery would endure a little more than one year at a desert temperature of 42°C (107°F).

Source: Sandia Report, a Lockheed Martin Company for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL 85000

Lithium batteries

Not well suited to our core market segments

- The technical strengths of Lithium batteries (high impulse power output and high energy density) are not required and offer no advantage in these markets.
- The perceived risk in terms of thermal runaway or fire is unacceptable to some customers and can add substantial cost (fire safety protection, barriers to installation approval from councils and safety agencies).
- The consequential economic loss risks inherent in the destruction of a major telecommunications or network power site are substantial. The potential for damage due to fire originating within the energy system is a common concern in this marketplace.
- Redflow target markets for energy storage and delivery are those that need a long-life, daily-deep-cycle “*marathon runner*”.
- Lithium based technology is best suited for applications that require a “*sprinter*”, with a focus on the delivery of very high power energy discharges of relatively short duration (e.g. electric vehicles, grid frequency and voltage stabilisation) or that require very high energy density for portability (e.g. consumer electronics).



Appendix C

South Africa micro-grid opportunity



The following slides are an extract from the Specialised Solar Systems business plan for their intended micro-grid energy services rollout in South Africa (DC GO is the project name for the rollout).

They illustrate the size of the addressable market for DC micro-grid service provision in geographic regions that do not have an existing energy grid.

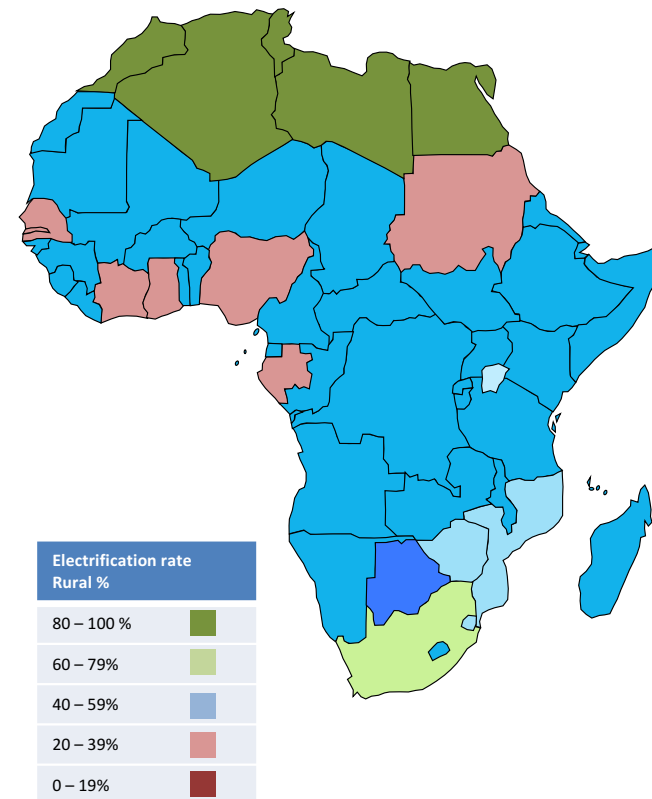
The African electrification market

Estimated spend of **\$27 billion** per annum on lighting solutions such as kerosene, candles, battery torches and other fossil-fuels

The rate of electrification in sub-Saharan Africa has not kept pace with population growth. Nearly **1 in 5** people in the Africa live without access to electricity, amounting to **634 million** people in sub-Saharan Africa. Many of these people living in locations that are beyond the reach of the current grid system. In South Africa, the majority of un-electrified settlements will not receive grid power for the next **20 years**.

Source: International Energy Agency (IEA)

SADC region electrification rate, IEA World Energy Outlook 2015		
	National	Rural
Botswana	66%	54%
Lesotho	17%	8%
Malawi	9%	4%
Mozambique	39%	26%
Namibia	32%	17%
South Africa	85%	77%
Swaziland	27%	23%
Zambia	26%	14%
Zimbabwe	40%	21%



- A solar electrification business on a utility scale



The off-grid industry & trade segment

Investment in the market segment has increased in recent years; 41% increase between 2015 and 2016.

The Off-grid Market Segment

Private equity invested **>USD 60 million** in Mobisol and Lumos in 2016

USD 142 million branded off-grid solar lighting kits sold in H1 2016

USD 223 million invested in PAYG solar companies in 2016

USD 158 million invested in PAYG solar companies in 2015

Fluidic raised **USD 20 million** in 2016

Traditional Trade* Market

Sales through traditional trade account for **ZAR 46 billion** in South Africa

There are **134,000** traditional trade stores across South Africa; representing **95%** of retail outlets in the country

77% of South African households shop in traditional trade stores (e.g. spaza shop)

One of key areas of growth with the traditional trade sector emanates from the **evolution** of spaza shops that have become more organized, increasing the range and variety of brands and categories on offer

48% of shoppers have visited a spaza outlet in the last seven days

** South Africa Traditional Trade Report 2016 - The Nielsen Company*



DC Go's market positioning

Targeting the massive emerging African electrification markets where energy demand is being suppressed with none or little foreseeable grid electrical solutions in the near future

Key market differentiators

Local and African expertise

DC Go has an understanding of the African market; with extensive experience of doing business within these markets. Competitors are largely foreign entities with a focus on east Africa. **DC Go** will strategically expand into Africa from a firm base in South Africa.

Intellectual Property

Proprietary *ePower* system: a remote and cloud-based utility management system that provides the necessary tools for sustainable remote solar energy and client management

Sophisticated installation

Integration into the household including reticulation and a smart DB box that includes tamper detection.

Scale-ability

incredible degree of design flexibility and threshold settings that can be adapted to the needs of any dwelling; or large scale project. Information is always available through the proprietary online management platform facilitating quick and informed decision making based on accurate data.

Monitoring and security

Proprietary online management platform offers secure remote system monitoring, client billing, vendor management and automated system switching from national operations centre.



Proven technology and track record: Technology in action

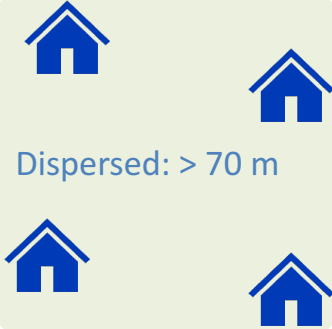



*Proven systems that are easy to install, safe to use (no open flames), of the highest safety and design specifications, and remotely managed.
Empowering rural and peri-urban communities with renewable clean energy as a catalyst for equality acceleration and socio-economic transformation.
Sustainable solar energy implementation in developing countries is a worthy opportunity:*



A solar electrification business on a utility scale

Modular Solar Power Delivery Systems

The future of energy access, having the potential to fill gaps in grid infrastructure smarter and faster. Solar power systems that generate energy, offer energy metering and remote communication with switching options; providing power to efficient DC appliances

Housing Density	System	Solar generation offering
 <p>Dispersed: > 70 m</p>	<p>De-centralised</p> 	<p>De-centralised solar energy supply</p> <p>The de-centralised system is ideal for scattered, rural environments where the distance between installations is large and the demographics sparse. The unit is installed at an individual's premises where the energy is produced and used.</p>
<p>Close proximity: 40 – 70 m radius</p> 	<p>Sub-centralised</p> 	<p>Sub-centralised solar energy supply</p> <p>The sub-centralised system is ideal for supplying energy to multiple dwellings from a central location and has many applications, options and configurations. It is ideal for per-urban congested environments.</p>



Off-Grid Remote
Power and Telcos



Renewable Energy
Integration



Transmission and
Distribution Deferral



Smart
Grid