



# DEPLOYING THE WORLDS SMALLEST FLOW BATTERY AT GRID SCALE

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Simon Hackett

System Integration Architect, Redflow Limited

[simon.hackett@redflow.com](mailto:simon.hackett@redflow.com)



redflow

sustainable energy storage

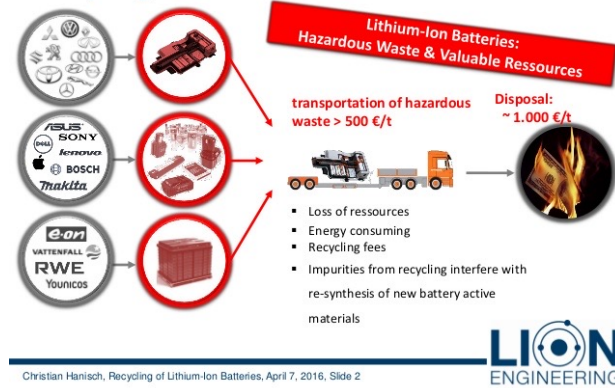
# AGENDA



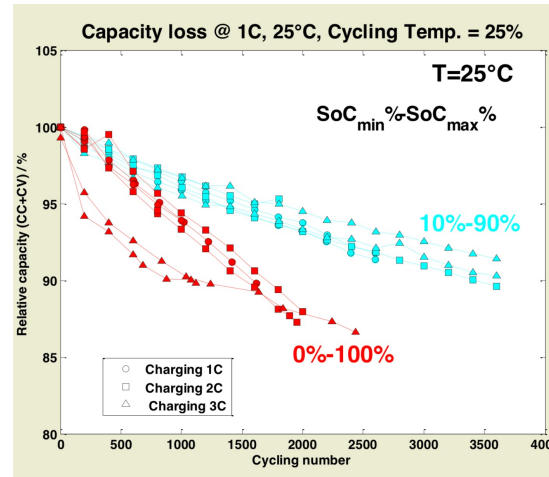
- The Redflow ZBM2 Zinc-Bromine Flow Battery
- Standby Power System (SPS) mode
- Redflow energy system deployments at Grid Scale

# SIGNIFICANT CHALLENGES WITH CONVENTIONAL BATTERIES

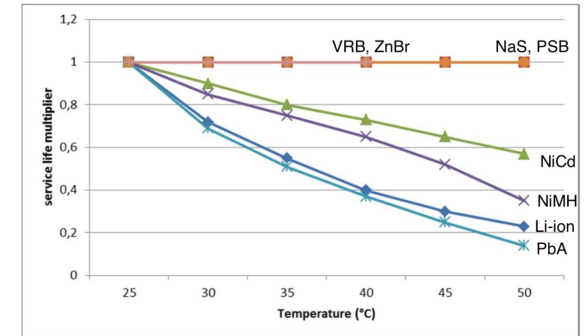
## Recycling of Lithium-Ion Batteries - Problems



## Deep Cycling Capacity Loss



## High Temperature Life Reduction

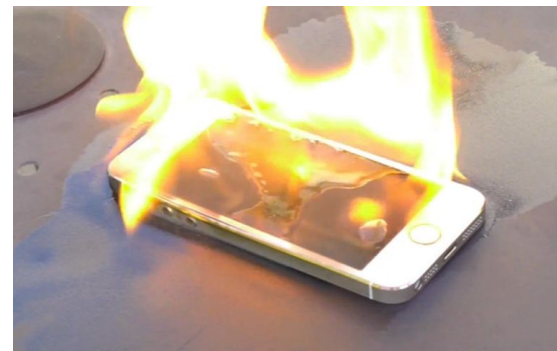


Data from Rydh & Sanden, 2005

## Disposal Challenges



## Thermal Runaway After Physical Damage or Fire



## LITHIUM FIRES AT GRID SCALE: NOT JUST THEORETICAL

- Tesla Megapack (300MW/450MWh) Module Fire

- 30 July 2021
- Victoria, Australia
- 3 days to extinguish
- Major Air Quality Alert





# REDFLOW ZBM2 ZINC BROMINE FLOW BATTERY

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



## Technology Comparison

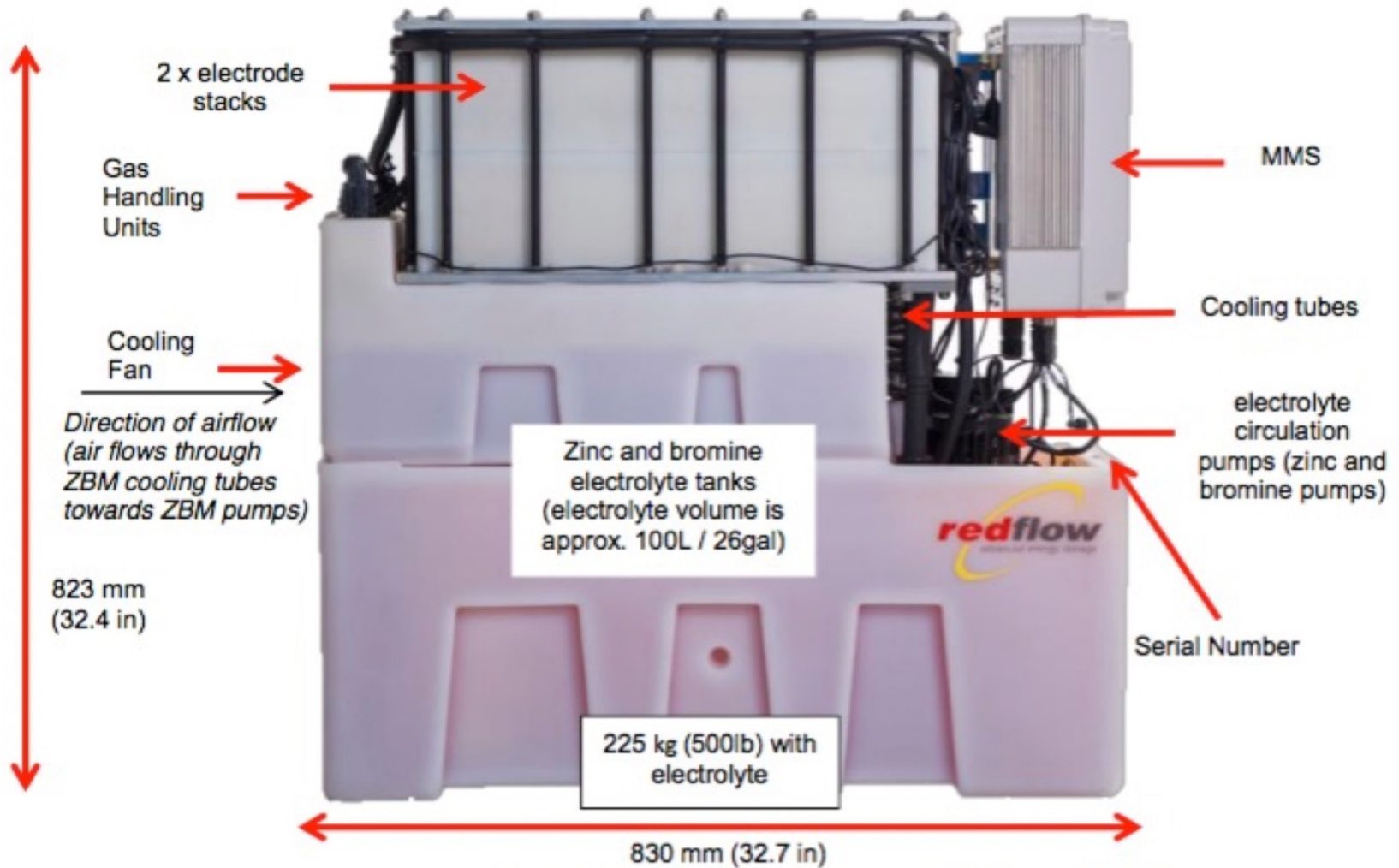
	ZBM2	Lithium-ion	Lead-acid
Competitive total cost of ownership	✓	✓	✓
No material loss of output capacity with age	✓	✗	✗
High ambient operating temperature does not reduce operating life	✓	✗	✗
Daily 100% discharge without damage or reduced operating life	✓	✗	✗
Low risk of thermal runaway in a fire	✓	✗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

## 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



# REDFLOW ZBM2



**Gen 2.8 ZBM Zinc Bromine Battery Module**

# A ZINC ELECTROPLATING MACHINE MADE OF RECYCLABLE PLASTIC

## At Discharge

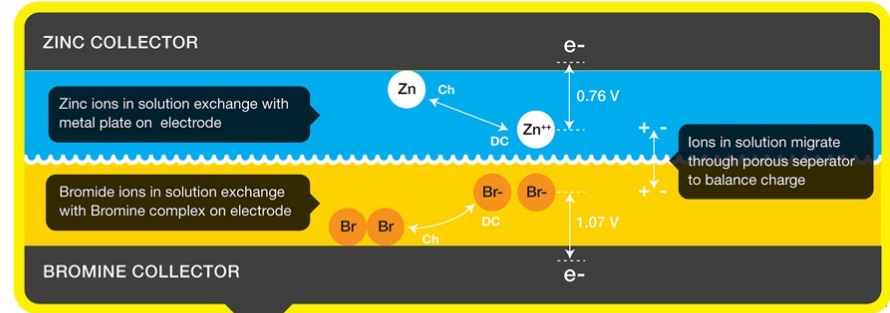
Neg Electrode:  $Zn \rightleftharpoons Zn^{2+} + 2e^-$  (Zn ions in both electrolytes)

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

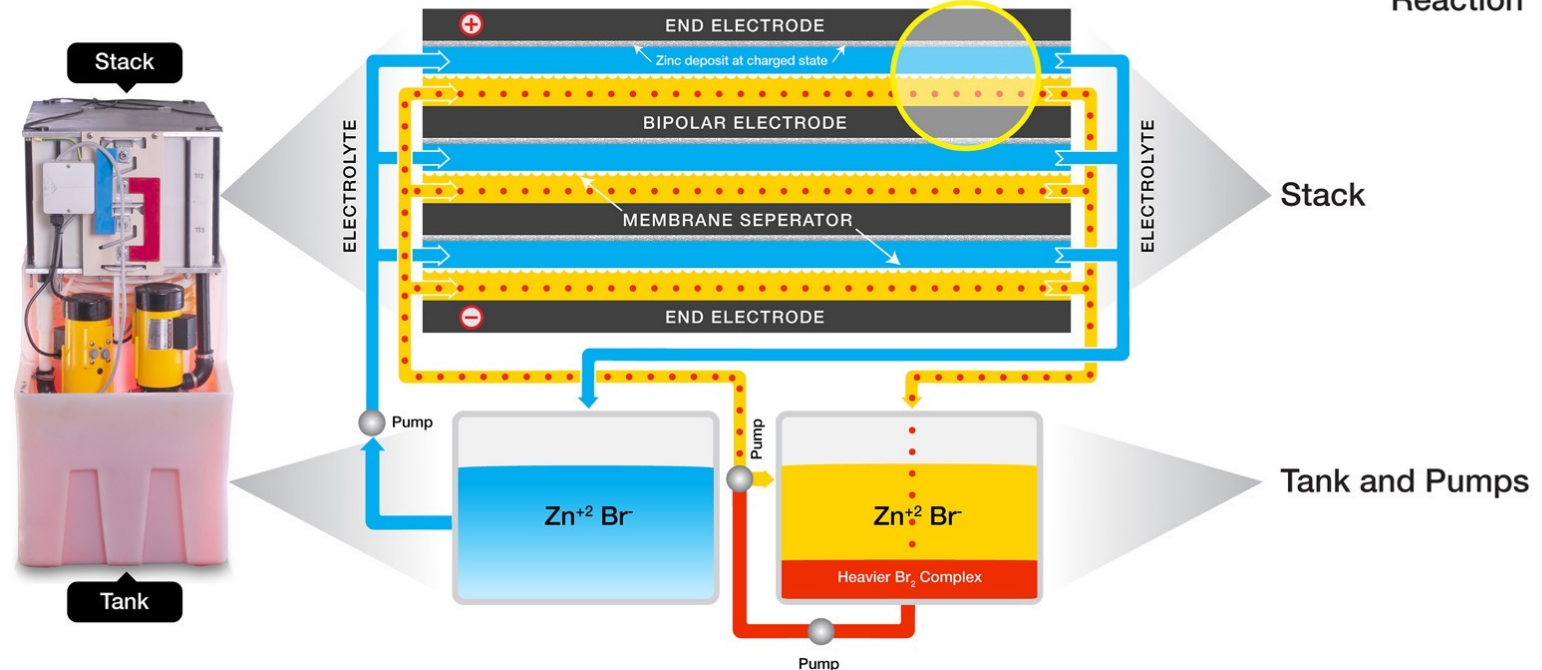
## At Charge

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

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

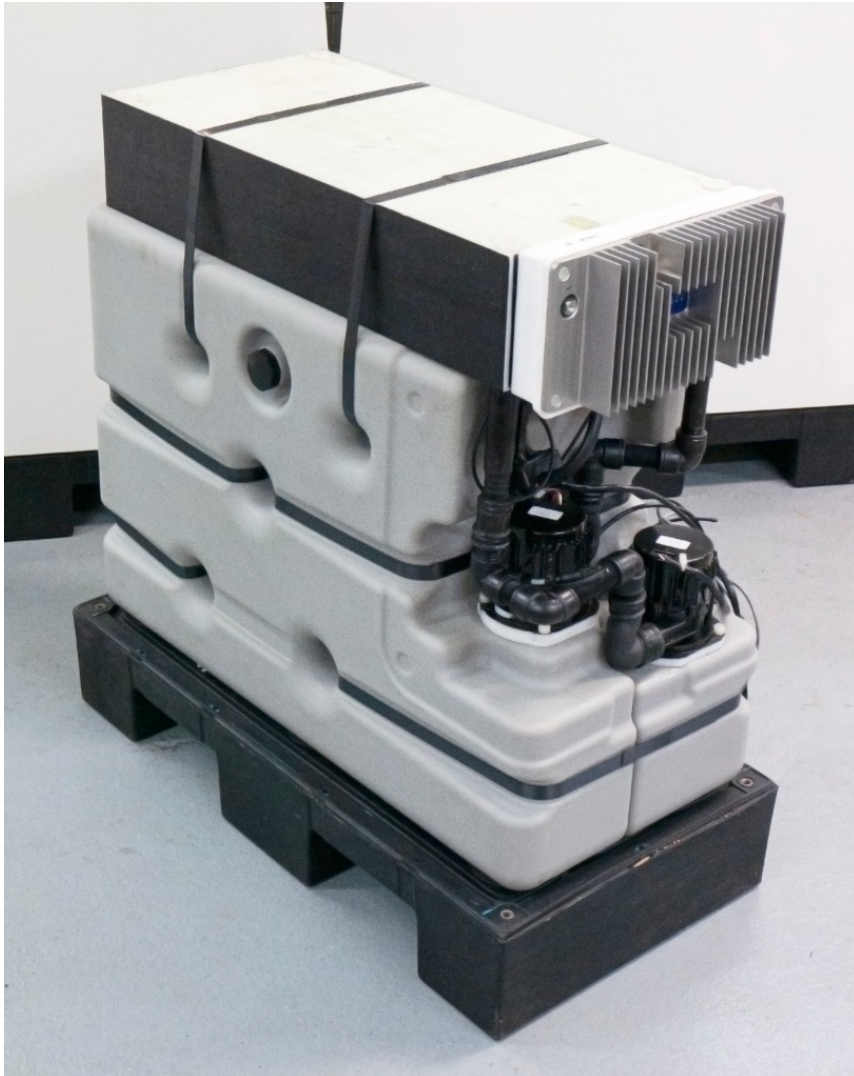


Reaction



# GENERATION 3 Zinc Bromine Module

In pre-release testing now



## Features

- New single stack replaces two stacks on Gen 2.5
- Improved tank design
- Redesigned electronics control module
- Designed for lower cost and scaled-up manufacture
- Baseline performance is the same, drops in to existing Redflow energy system designs with no change





Commercial solar and storage sites for local government in Victoria, Australia

- 36 Redflow batteries across two child care centres combined with 180 kw PV solar panels. Maximisation of PV use, back up & grid independence
- Architectural Design/Green Architecture category in the 2019 International Architectural MasterPrize Awards
- Total battery energy throughput since commissioning: 75.2MWh





## 50 kWh Remote Telecom New Zealand



- Located in remote valley with no grid power
- Business case on cost of delivered diesel, maximising use of renewables & lower opex and enhanced reliability





60 kWh storage for remote telecommunications tower in Queensland for Optus



- Consisting of 6 ZBM2 batteries and diesel generator (previously running 24 hours per day)
- Deployed in environmentally sensitive high temperature Daintree rainforest deployment in Queensland, Australia
- **Total Redflow estimated energy throughput since commissioning: 7.4MWh (70% diesel runtime reduction).**





- **Operates in a back-up power mode as lead-acid replacement.**
- Long 10-year life expectancy bolsters business case versus lead-acid
- Provides a solution in high-theft environment where there is significant black market for lead-acid and lithium batteries. No black market for Redflow ZBMs!

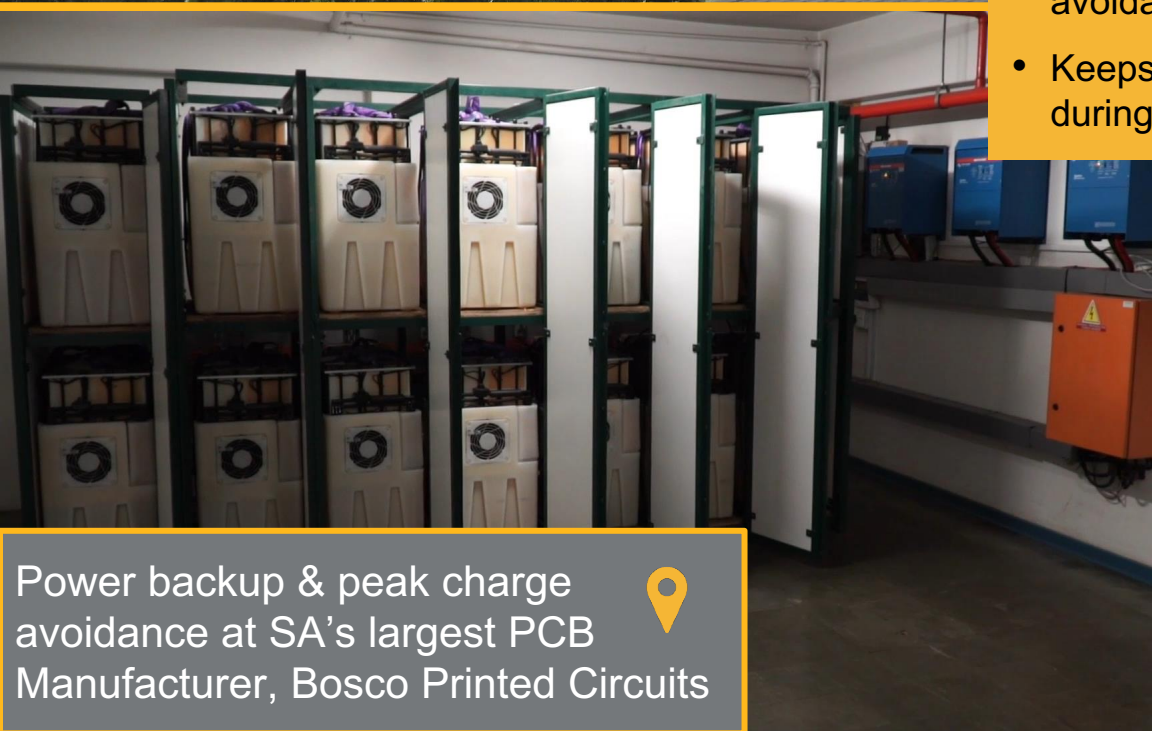
Mobile phone towers  
South Africa







- 140kWh of ZBM storage
- Provides security against power outages and avoidance of peak power prices
- Keeps the PCB manufacturing line operating during grid outages, avoiding heavy wastage

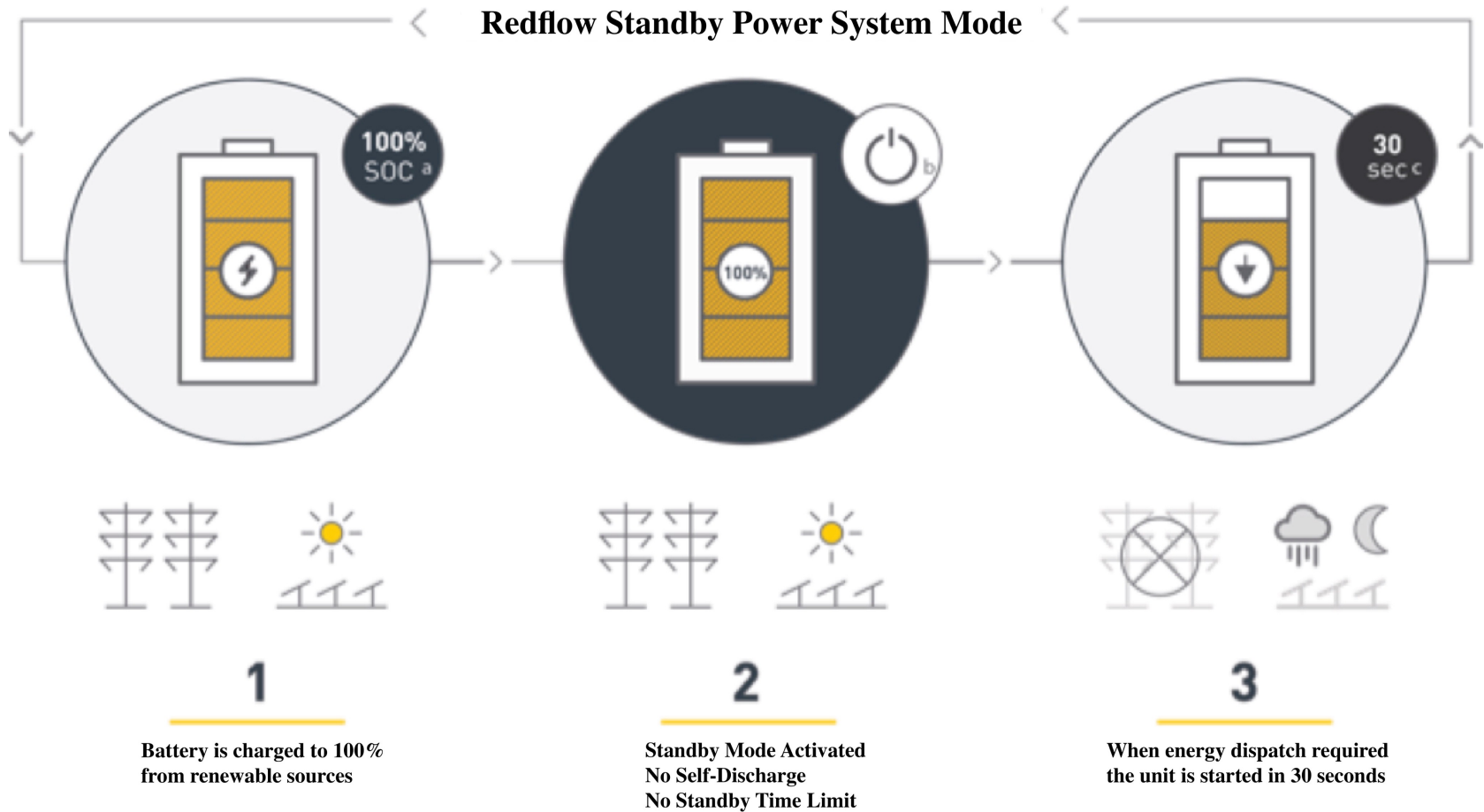


Power backup & peak charge avoidance at SA's largest PCB Manufacturer, Bosco Printed Circuits



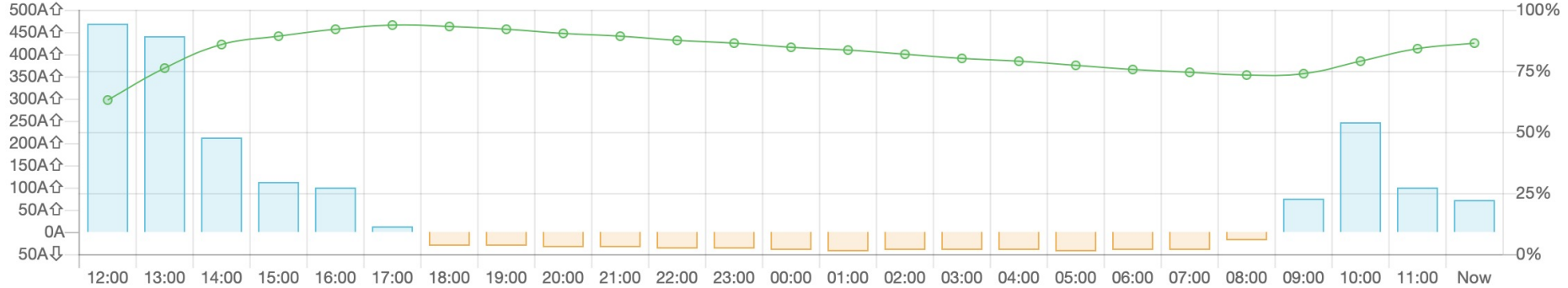
# REDFLOW STANDBY POWER SYSTEM MODE

The ZBM2 can hibernate (no self-discharge) – and wake up (much) later





# ORCHESTRATED BY THE REDFLOW BMS



**ID** **Serial** **Status** **SoC** **Contacts** **Amp Hours** **Volts** **Amps** **kW** **Temp** **Last Maint** **Time Limit** **Firmware** **Mode**

System	OK	86.5%	↑	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	2422.2 AH	56.1 V	-73.3 A	-4.1 kW	34.3 C				
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## RUN MODE

3	219060028	OK	48.3%	↗	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	96.7 AH	56.2 V	-36.6 A	-2.1 kW	34.3 C	3h56m	2d20h	32.19.00	Run (702)
5	219030057	OK	99.2%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	198.4 AH	53.2 V	0.0 A	0.0 kW	31.7 C	2d4h	19h36m	32.19.00	Run (702)
7	219060027	OK	99.2%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	198.3 AH	53.2 V	0.0 A	0.0 kW	33.7 C	2d4h	20h22m	32.19.00	Run (702)
8	219030052	OK	46.4%	↗	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	92.8 AH	56.1 V	-36.7 A	-2.1 kW	32.5 C	4h22m	2d20h	32.19.00	Run (702)
12	219060020	OK	99.3%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	198.5 AH	53.3 V	0.0 A	0.0 kW	34.3 C	1d8h	1d20h	32.19.00	Run (702)
13	219060018	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	198.3 AH	53.1 V	0.0 A	0.0 kW	33.7 C	1d7h	1d17h	32.19.00	Run (702)

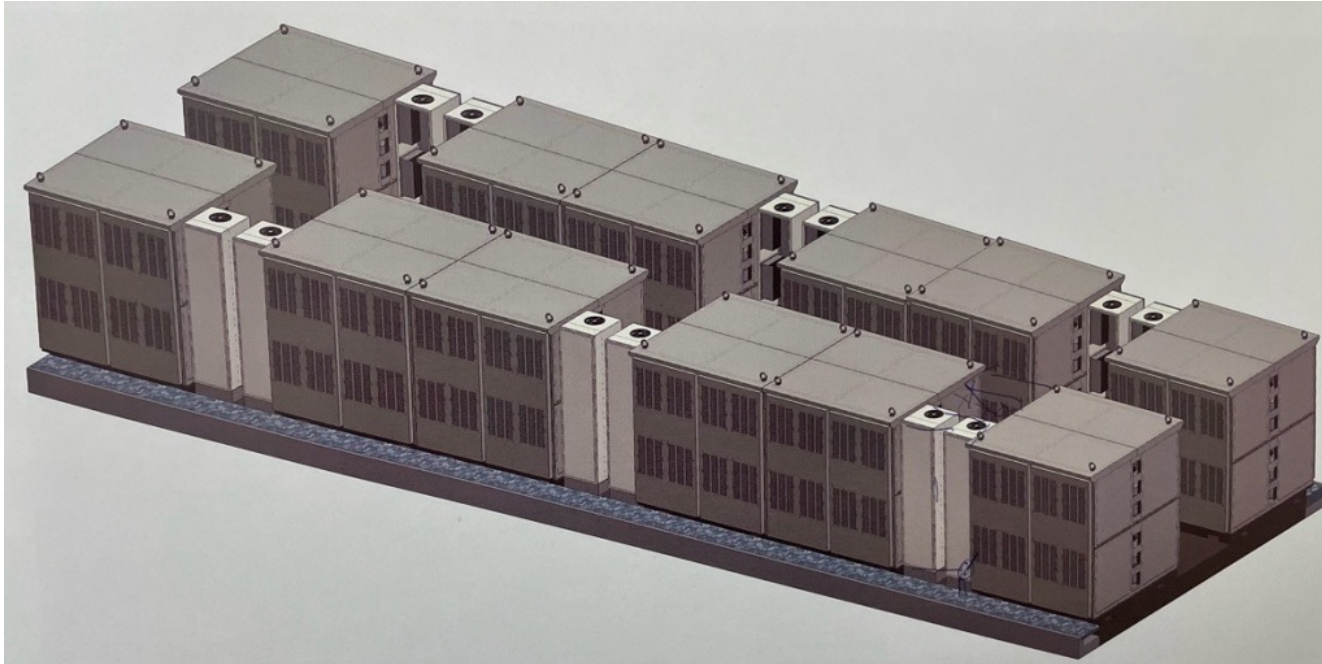
## STANDBY MODE

1	219030058	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	179.9 AH	50.8 V	0.0 A	0.0 kW	28.5 C	3d4h	17h36m	32.19.00	Sps (782)
2	219060031	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	179.9 AH	50.9 V	0.0 A	0.0 kW	30.1 C	3d3h	18h54m	32.19.00	Sps (782)
4	219030049	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	179.9 AH	51.0 V	0.0 A	0.0 kW	28.7 C	3d4h	18h3m	32.19.00	Sps (782)
6	219060023	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	179.9 AH	50.9 V	0.0 A	0.0 kW	29.8 C	3d3h	18h2m	32.19.00	Sps (782)
9	219030050	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	179.9 AH	50.8 V	0.0 A	0.0 kW	27.9 C	3d3h	18h47m	32.19.00	Sps (782)
10	219050036	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	179.9 AH	51.0 V	0.0 A	0.0 kW	29.2 C	3d3h	18h33m	32.19.00	Sps (782)
11	219030055	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	179.9 AH	50.9 V	0.0 A	0.0 kW	28.1 C	3d3h	19h1m	32.19.00	Sps (782)
14	219030047	OK	99.1%	—	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	179.9 AH	50.8 V	0.0 A	0.0 kW	28.1 C	3d3h	18h50m	32.19.00	Sps (782)

# POD-Z: MODULAR, GRID-SCALE REDFLOW DEPLOYMENTS



MODULAR DEPLOYMENT SYSTEM: 160kWh per POD  
HORIZONTALLY SCALEABLE WITHOUT FIXED UPPER LIMIT



Redflow 48V DC Batteries in a 16 node cluster with BMS (50kW / 160kWh per Pod)

Trumpf Hüttinger DCDC Conversion Module Cluster (48 V  $\leftrightarrow$  650-950V Bidirectional conversion)

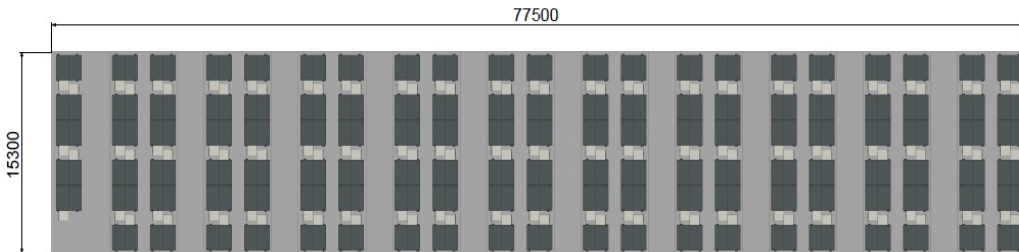
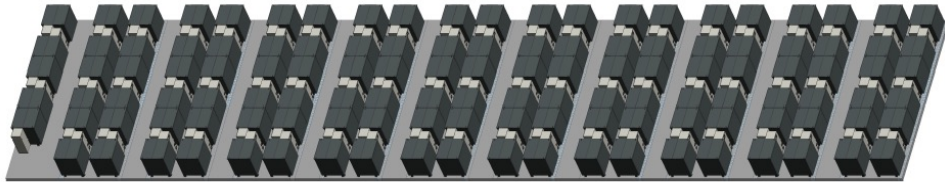
Direct HVDC output or optional internal Trumpf AC modules



# Energy Pod Z for Larger Systems

Example 20 MWh System

CONCEPT DRAWING



### Key Design Inputs

- Available footprint
- Application requirements
- Load profile
- Energy v power requirements
- AC or DC design – inverter and Energy Management System selection
- Auxiliary features



Micro Grid and Smart Grid

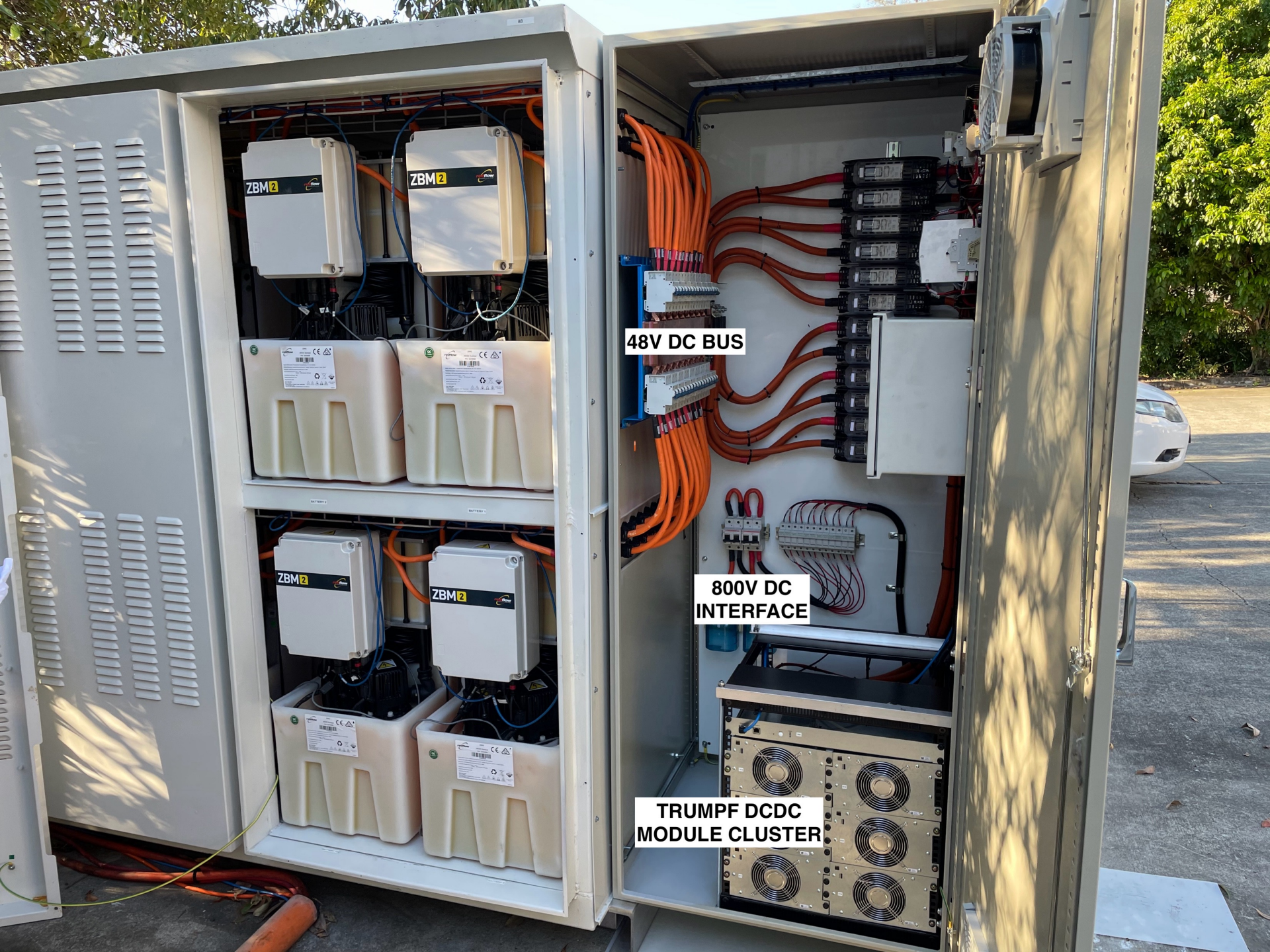


Transmission and Distribution Deferral









**48V DC BUS**

**800V DC  
INTERFACE**

**TRUMPF DCDC  
MODULE CLUSTER**



# POD-Z: MODULAR, GRID-SCALE REDFLOW DEPLOYMENTS



2MWh energy storage system for the Anaergia Rialto Bioenergy Facility in southern California

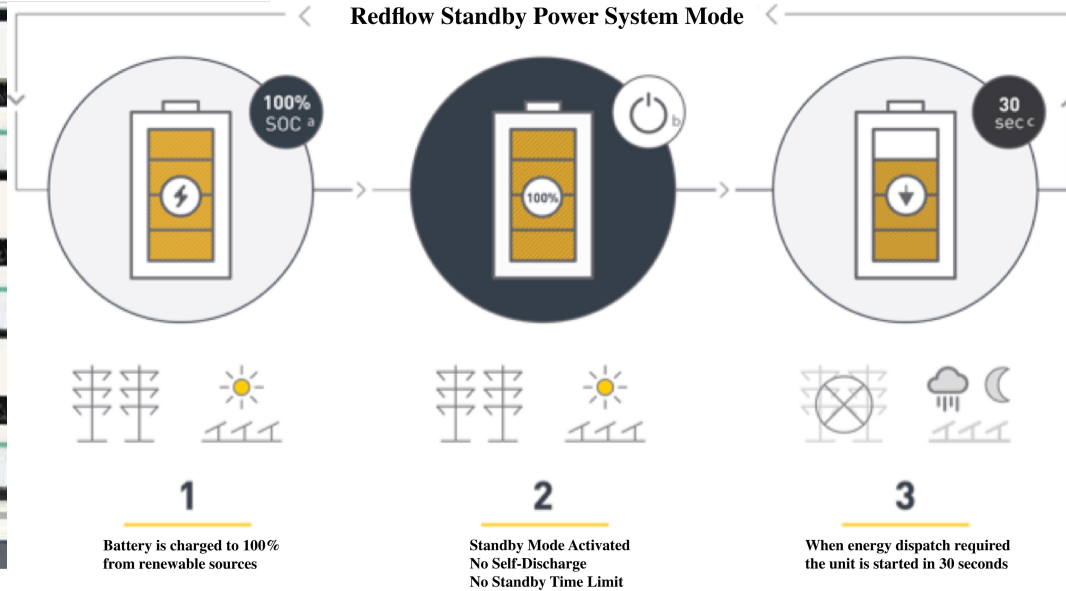
redflow

sustainable energy storage



# GRID SCALABLE FLOW BATTERIES

SUBSTANTIAL ROLE FOR LONG DURATION STORAGE USING FLOW BATTERIES  
CAN CREATE HYBRID OF LONG DURATION FLOW + HIGH IMPULSE POWER LITHIUM



“PUMPED HYDRO” OPERATING CYCLE

AVOID CAPACITY LOSS WITH AGE

UNLIMITED STANDBY TIME WITHOUT ENERGY LOSS

NOT AT RISK OF THERMAL RUNAWAY

100% DISCHARGE DEPTH ENERGY WHEN DELIVERED

STRONG RECYCLING STORY

THANK YOU