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ENERGY SYSTEMS

HOMER MICROGRID & HYBRID POWER INTERNATIONAL, 2021

HOMER MICROGRID AND HYBRID POWER | 9TH ANNUAL INTERNATIONAL

Agenda

1 Brief background on flow battery technology

2 A look at a large-scale system in Southern Australia

3 Practical tips for modelling flow battery-enabled installations in HOMER

Invinity Merger Completed: April 2020

AVALON BATTERY

- Founded in 2013
- Based in North America
- Strong engineering focus

redT energy storage

- Founded in 1989
- Based in the UK
- Strong sales focus

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Corporate Overview

ESTABLISHED

2020

Merger of redT Energy and Avalon Battery

14

YEARS OF R&D INVESTMENT

Deploying our third generation of proven technology

73

PATENTS

Granted or pending, plus trade secrets and know how

50

PROJECTS

Over 25 MWh installed or signed on five continents

120

EMPLOYEES

We believe to be the most experienced team in flow batteries

WORLDWIDE PRESEN

Canada (Technology/NA hub)
UK (Technology/Sales)
US (Sales)
China (Manufacturing)

Invinity's Global Presence

FAIRFIELD/IOWA
Solar + storage BTM
1 MWh, 32 VFBs
Commercial operation 2018

SAN JACINTO/CALIFORNIA
CEC-funded project
0.5 MWh system
Powering critical infrastructure

ENERGY SUPERHUB OXFORD/UK
UK's largest flow battery
2 MW/5 MWh
Multiple grid services

HUANGHE HYDRO/CHINA
Utility solar + storage array
2 MWh, 64 VFBs
Commissioned 2018

YADLAMALKA/AUSTRALIA
World's largest solar-powered VFB
8 MWh + 6 MWp Solar
Dispatchable solar generation

Evolution

2015

SMALL SCALE C&I

2018

SMALL SCALE C&I
SOLAR + STORAGE

2020

DISTRIBUTED GRID ASSETS

2023

CENTRALISED
GRID ASSETS / 50 MW+

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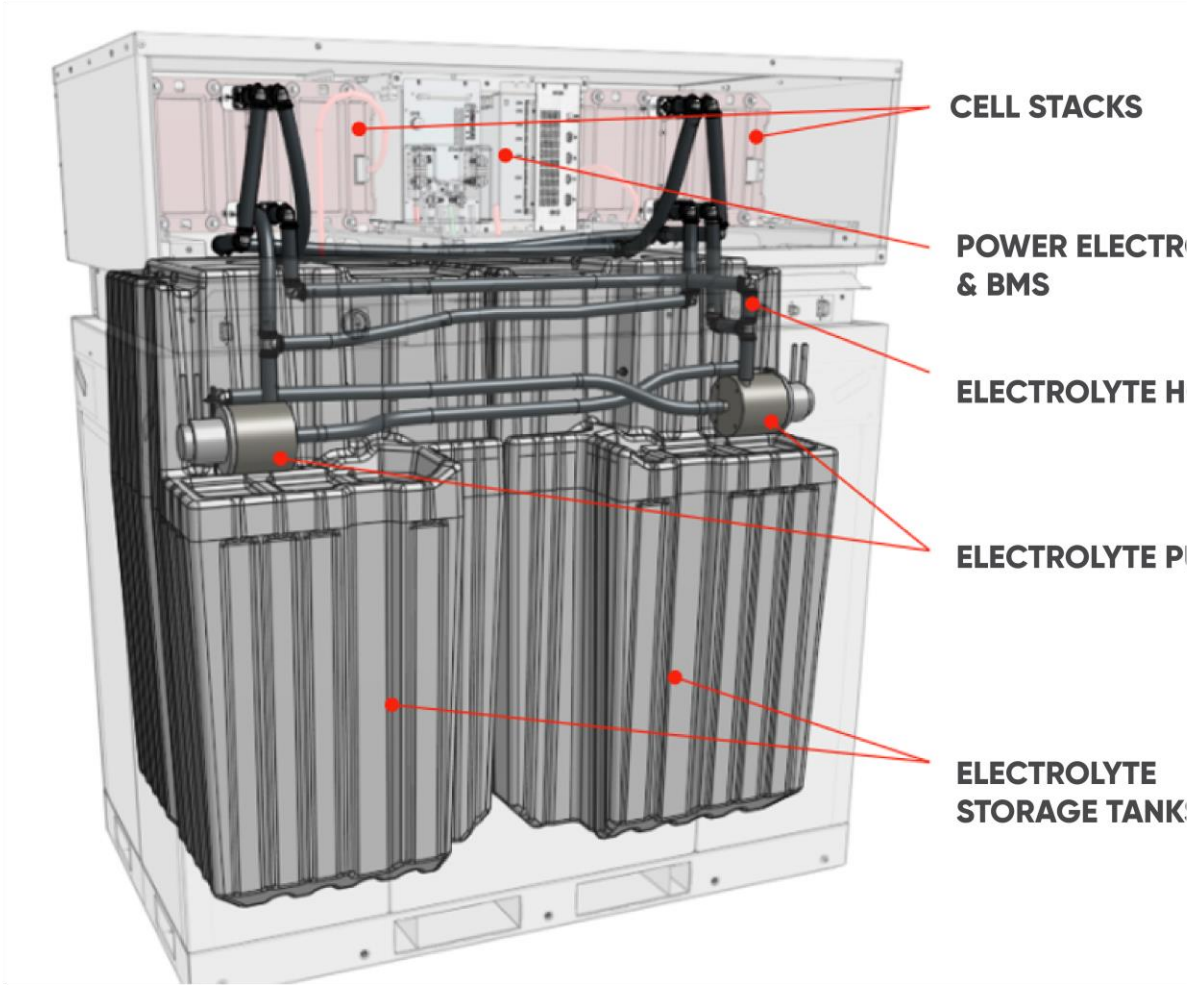
TECHNOLOGY OVERVIEW

Inside a VFB

Durable/Reliable/Economical/Proven



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FAIRFIELD/IOWA
1 MWh, 32 VFBs

HUANGHE/CHINA
2 MWh, 64 VFBs

VANADIUM

AVAILABLE

Element 23, readily available and more abundant in the Earth's crust than copper. Accessible reserves in Australia, South Africa, United States, Canada, Russia

REUSABLE

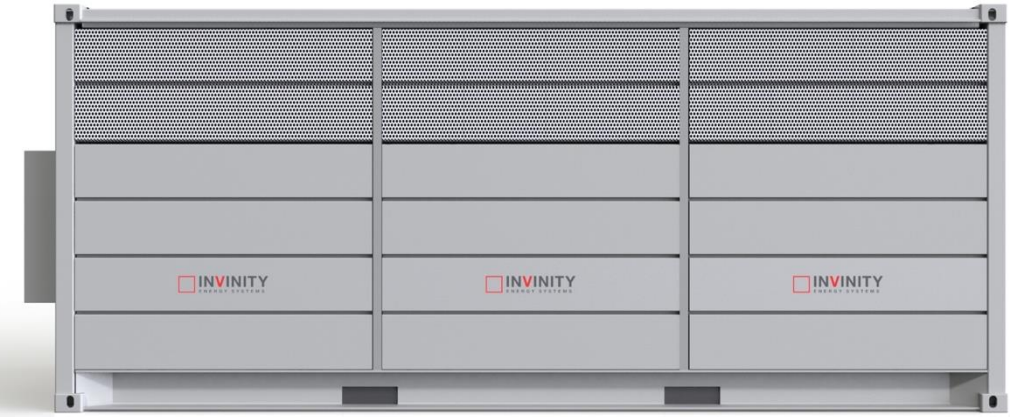
Virtually unlimited working life. 97% proven recovery rate from used electrolyte

SAFE

Electrolyte is ~70% water, non-flammable with no risk of thermal runaway

Invinity VS3-022

Safe. Dependable.
Economical.



ENERGY SUPERHUB
OXFORD/UK
2 MW/5 MWh

YADLAMALKA/
AUSTRALIA
8 MWh + 6 MWp Solar

RATED POWER: CONTINUOUS	ENERGY STORAGE: NOMINAL	ENERGY STORAGE: DURATION
78 kW	220 kWh	2-12 HOURS

LIFETIME:	RECOMMENDED DEPTH OF DISCHARGE:	CYCLE LIFE:
25 YEARS	100%	UNLIMITED

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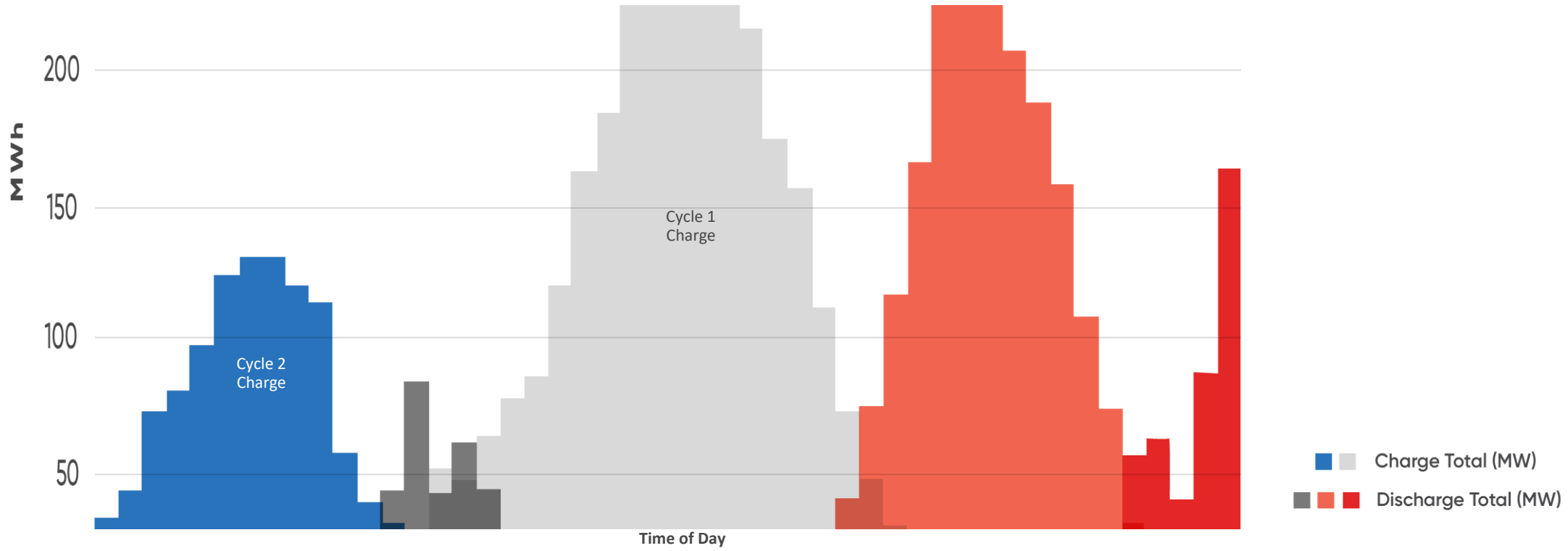
‘Stacking’ Cycles for Maximum Benefit

GRID-CONNECTED SOLAR-PLUS-STORAGE: 2+ CYCLES PER DAY, 24/7 BATTERY UTILIZATION

Cycle 1: Charge from low-cost excess solar during day. Discharge into evening peak

Cycle 2: Charge from low-cost overnight power. Discharge into morning peak

Cycle 2+ Performing ancillary services

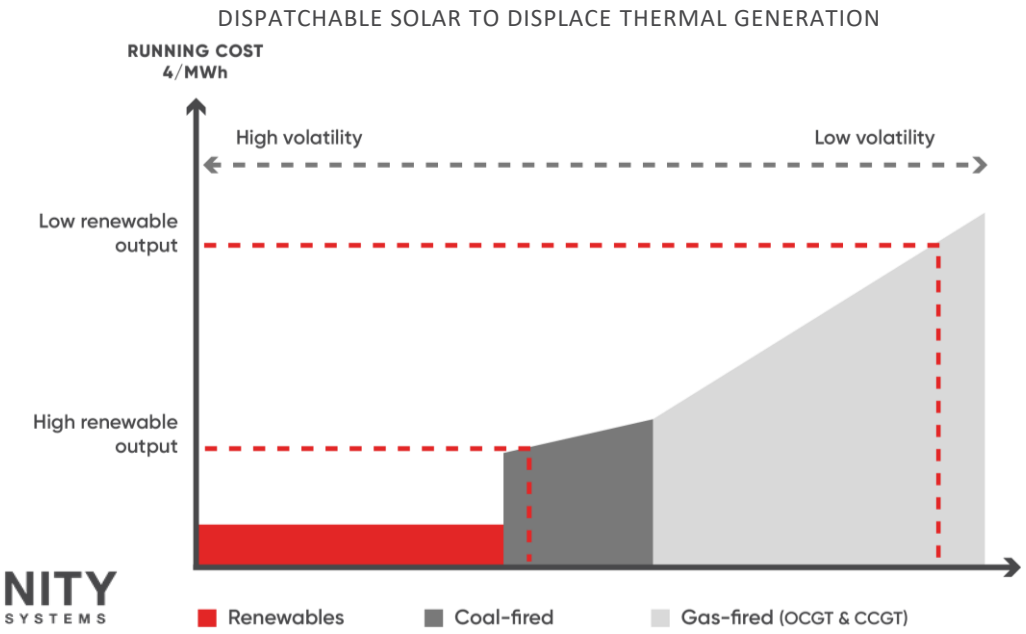


CASE STUDY: YADLAMALKA

Yadlamalka Solar + Storage

REGIONAL MARKET: SOUTHERN AUSTRALIA

- Increasing penetration of renewables on the grid led to frequency regulation issues, addressed with short-duration lithium ESS
- As renewables proliferate, longer duration, high-cycling ESS increasingly needed for shifting & firming renewables
- A new pumped hydro project (Snowy Hydro 2.0) won‘t be online until 2024
- Vanadium flow batteries fit the need; effectively “pumped hydro in a box”



Yadlamalka: Overview

WORLD'S LARGEST SOLAR-POWERED VFB

- 8 MWh Invinity Battery System + 6 MWp Solar PV
- Australia's largest flow battery
- Manufacturing starting H1 2021
- Delivery H2 2021

REVENUE STACK

- First two years:
  - Wholesale Energy Trading
  - Ancillary Services (FCAS market)
- Thereafter
  - Network and capacity services (e.g. covering shortfall from unplanned coal plant outage)
  - Long duration time shifting and off-take agreements with SA C&I businesses
  - Grid capacity services ~4 hours

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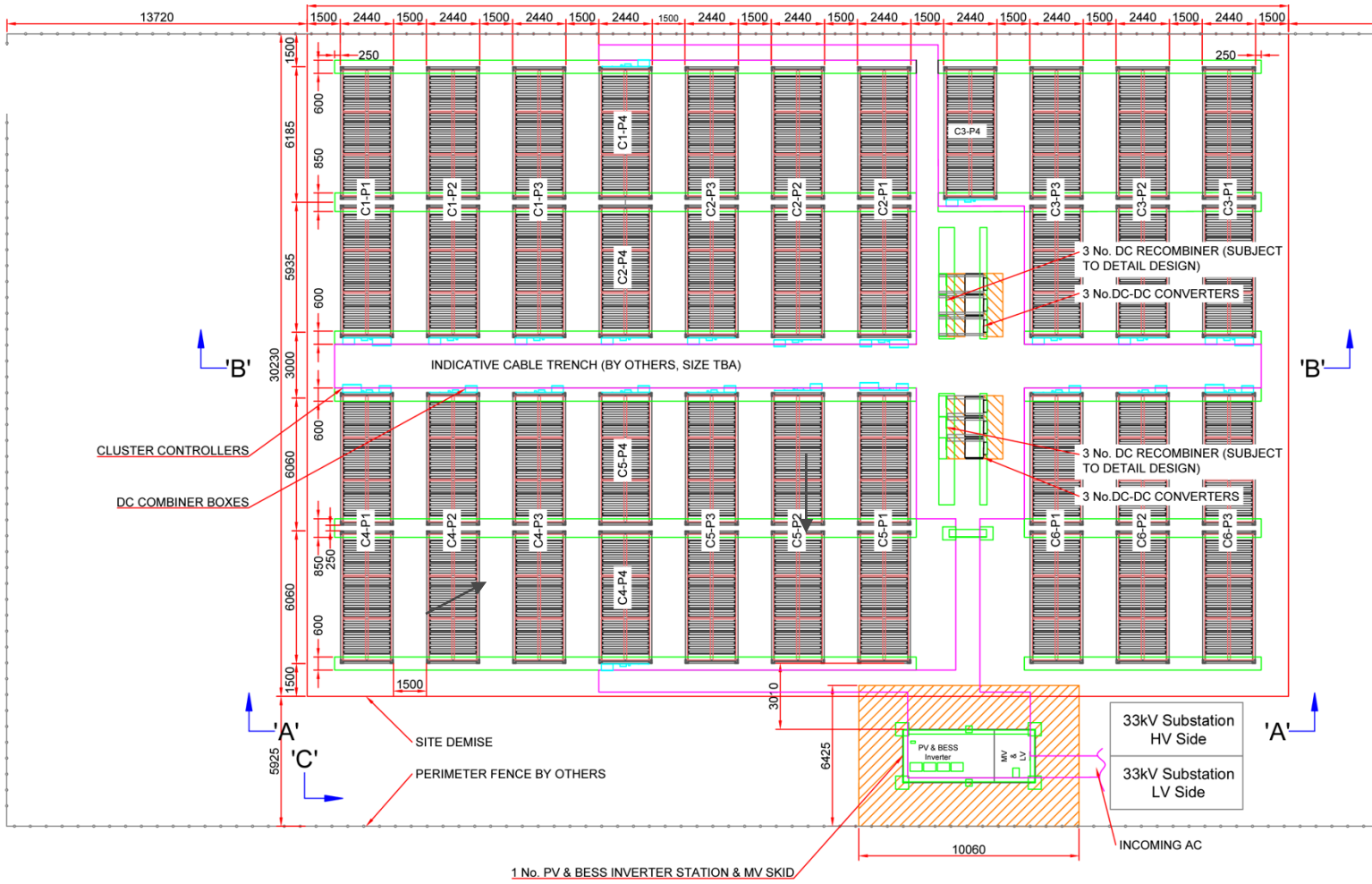
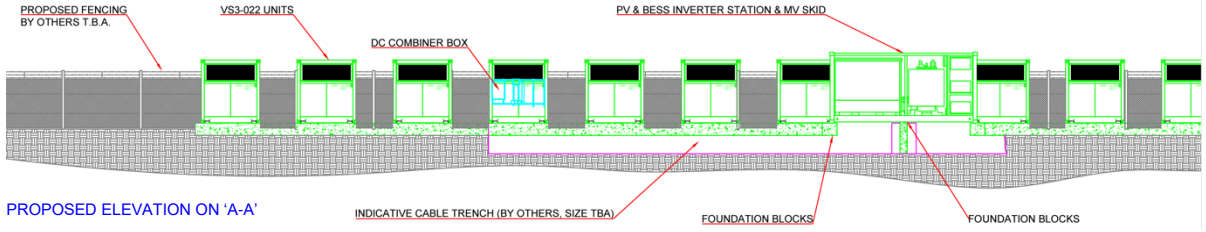
Yadlamalka: Technology

SYSTEM CHARACTERISTICS

- 41 Invinity VS3s (2 MW, 8 MWh)
- 6 MWp Solar PV (DC-coupled) behind a 4MWac connection
- Custom-built central PCS (Danfoss)
  - Allows fluctuating voltage (flow batteries can charge from zero voltage)
  - designed to operate with less energy management restrictions (vanadium flow cycling is not overly restricted due to heat and degradation considerations)





PRACTICAL ADVICE FOR MODELING FLOW BATTERY-ENABLED INSTALLATIONS IN HOMER

Modeling Tips for VFBs in HOMER

- Ask your VFB OEM for a HOMER library object
  - VFBs behave differently than lithium or lead acid
  - These differences add up to significantly influence project economics
  - Contact the OEM for a properly configured, HOMER library object
- Thorough costing is crucial
  - Get a full quote from the manufacturer
  - For any PV-coupled system, include the cost of 20-year O&M contracts, so that the battery matches the life of the PV system
  - For flammable battery technologies (e.g. lithium) include fire prevention, and suppression systems as well as increases in insurance premiums

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Safe/Durable/Economical/Proven Energy Storage

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