ESCRI-SA
Battery storage to improve transmission network resilience

Energy Storage in South Australia: Past Experience & Future Opportunities

National Wine Centre, 21 May 2018

In partnership with:

ARENA
Australian Government
Australian Renewable Energy Agency

Advisian
WorleyParsons Group

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Presentation outline

> South Australian power system context

> ESCRI-SA project background

> Battery storage to improve transmission network resilience

> Largest autonomous regional micro-grid

- Islanding detection
- Transitioning
- Islanded operation

> ESCRI-SA project update

About ElectraNet

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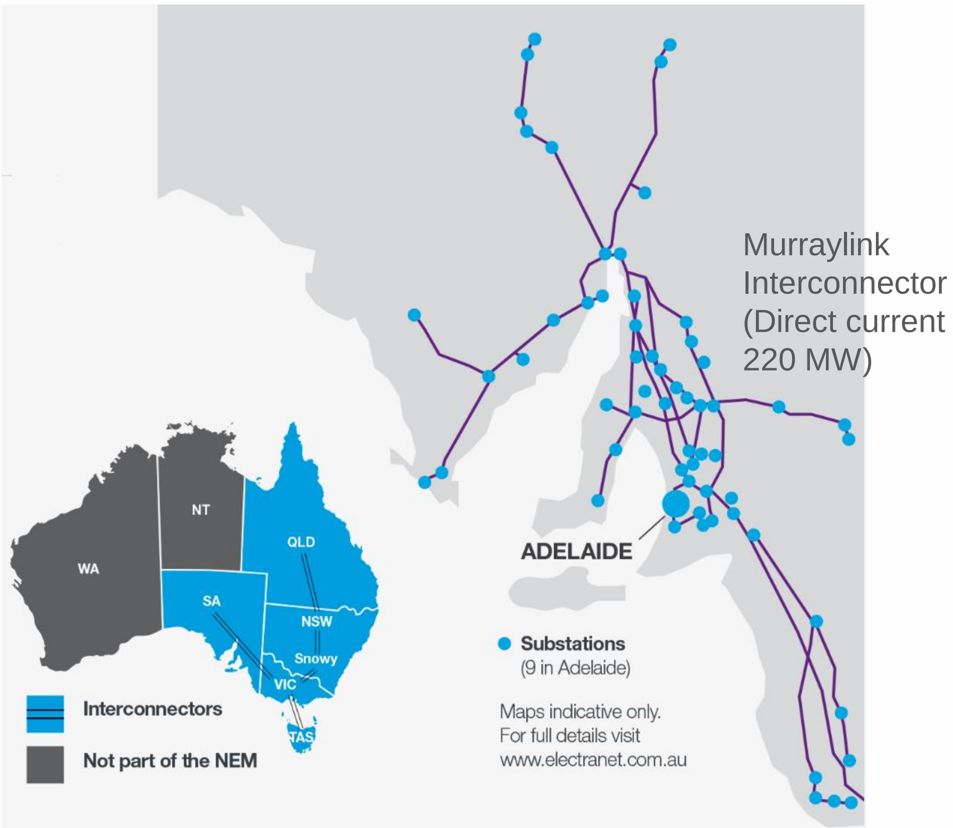
Owner and operator of South Australia's transmission network



Heywood Interconnector (currently 600 MW)

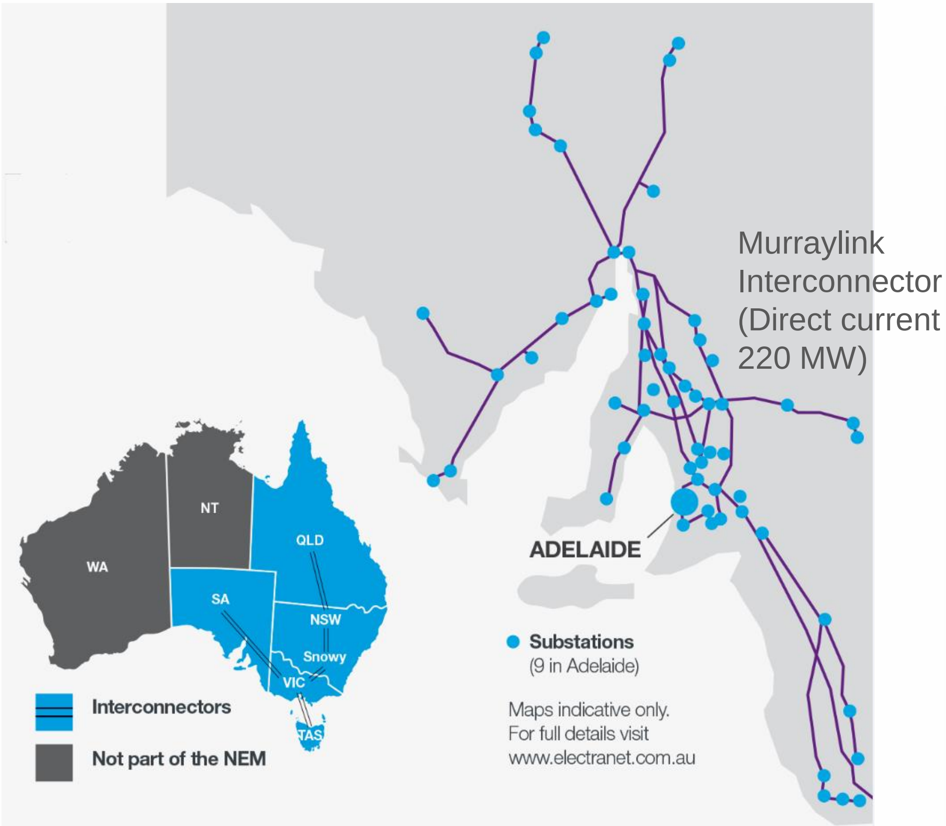
NEM – National Electricity Market
AEMO – Australian Energy Market Operator

- Connecting customers and moving power over long distances
- Private company with 3 major shareholders (State Grid Corporation of China, YTL Power and Hastings Funds Management)
- Total regulated assets of $2.5 billion
- Network covers area of over 200,000 square kilometers
- 91 high voltage substations
- 5,600 circuit km of high voltage transmission lines and cables
- 13,700 transmission towers

South Australian power system context

South Australian system overview

South Australia (SA) is at the forefront of energy transformation



Heywood Interconnector (currently 600 MW)

NEM – National Electricity Market
AEMO – Australian Energy Market Operator

> Abundant high quality renewable energy resources with leading wind and solar penetration levels compared to demand

> Last coal fired power station closed 2016

> Reliance on gas generation and impact of higher gas prices

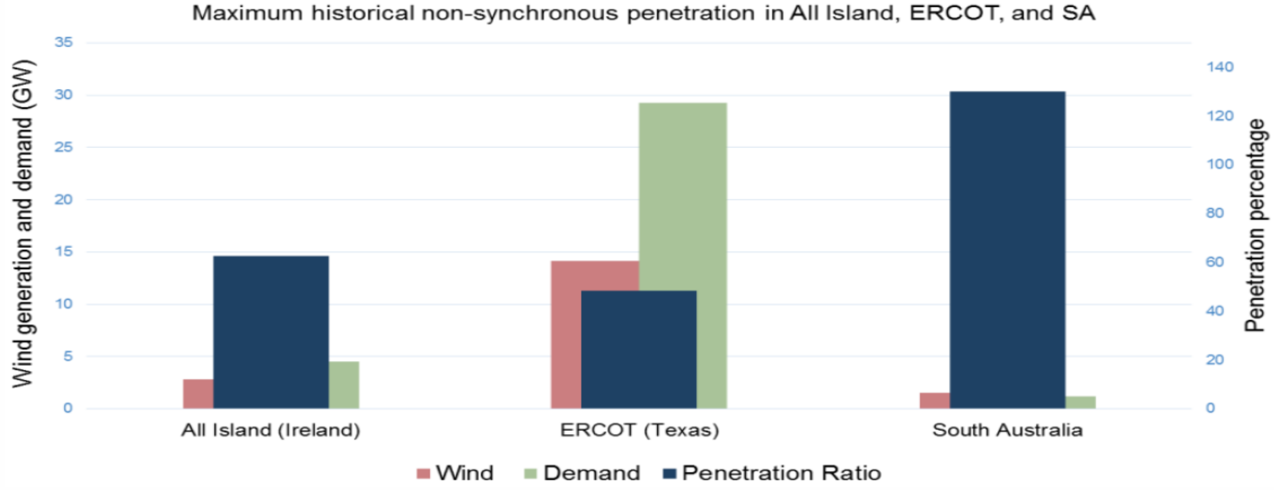
> Recent SA separation and load shedding events have led to heightened concerns about power system security

> New measures have been introduced by AEMO and the SA Government to manage power system security

> Ongoing policy drivers to lower carbon emissions, new technology and customer choice are driving energy transformation

SA renewable energy integration

> The challenges seen in SA in relation to minimum levels of synchronous generation are a first in any large scale power system in the world…



Source: AEMO, South Australian System Strength Assessment, September 2017

> SA is unique compared with other major systems with high levels of wind:

Denmark – has many interconnections with neighbouring countries

Ireland – restricts non-synchronous generation to 55% penetration levels

Germany – has many interconnections with neighbouring countries

Texas – has low levels of wind relative to system demand

Role for energy storage

- As existing synchronous generators operate less or are retired, new system security ancillary services are required to maintain stability of the power system
- Grid scale battery storage can help provide…
  - Power system security (resilient to disturbances)
  - Energy security (to supply customer demand)
- Neoen/ Telsa 100 MW 129 MWh battery has been operating in the market since late 2017
- ESCRI-SA 30 MW battery is next major battery project in SA
- Others have recently been announced paired with renewables projects

Energy batteries and power batteries

Batteries alone unlikely to provide required energy security

> Energy providers for energy security:
- Energy batteries (limited)
- Fast start synchronous generators (with sufficient fuel source)
- Solar thermal energy storage
- Pumped hydro energy storage
- Transmission interconnectors

> Grid scale batteries are well suited to assist with system security:
- Part of a System Integrity Protection Scheme (SIPS)
- Fast Frequency Response (FFR)
- Frequency Control Ancillary Services (FCAS)
- Voltage control

ESCRI-SA project background

Energy Storage for Commercial Renewable Integration – South Australia

Project scope and objectives

Scope: Nominal 30 MW, 8 MWh lithium-ion battery

1. Demonstrate that grid scale battery storage can effectively provide network reliability and security services alongside competitive energy market services

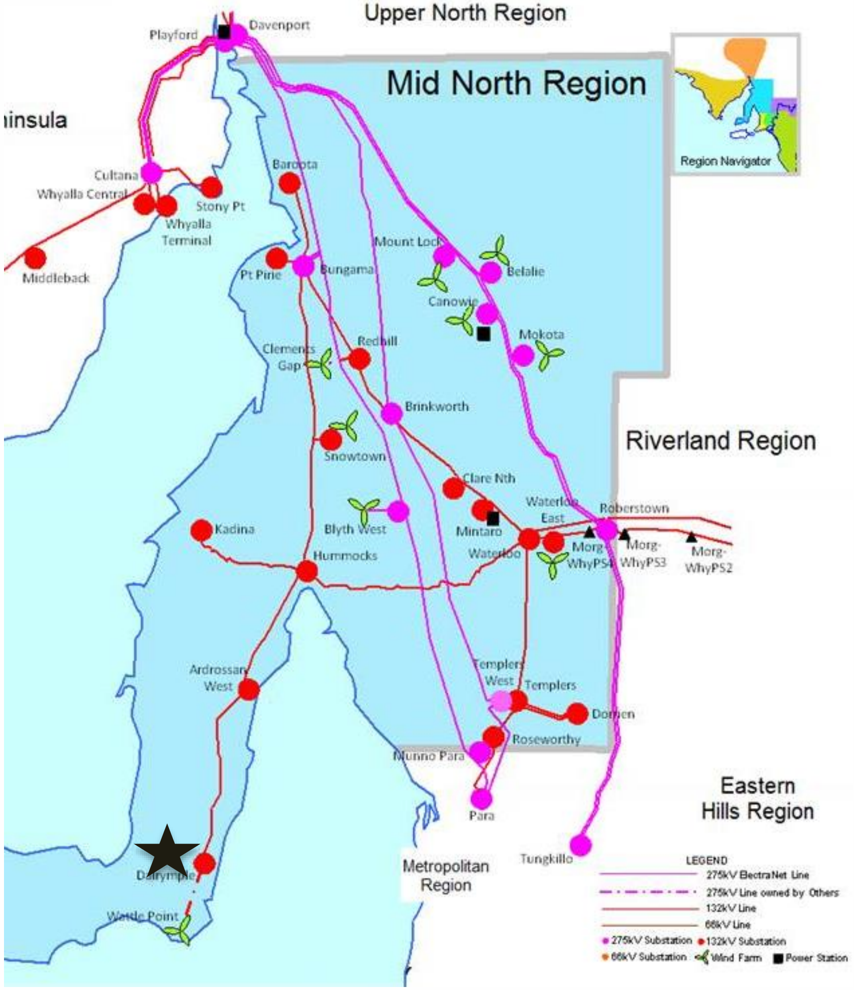
2. Demonstrate network ownership of battery storage and appropriate commercial separation of the provision of regulated services and competitive market services

3. Demonstrate islanded operation with 100% renewable generation following transmission outages

Location

Site selected to maximise value from BESS

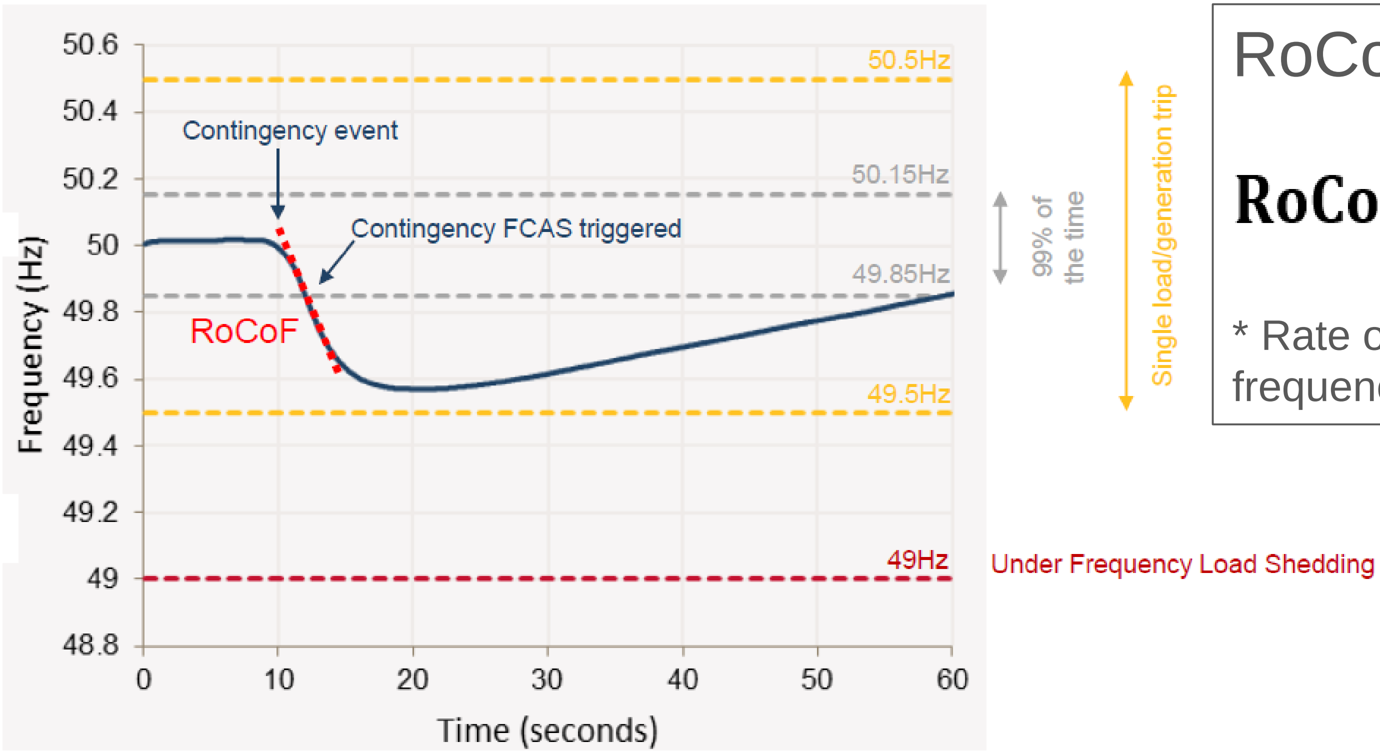
- Connection at 33 kV at Dalrymple substation on Yorke Peninsula
- Opportunity to reduce expected unserved energy under islanding conditions (max demand is about 8 MW but on average need about 3 MW for 2 hours)
- Site is close to the 91 MW Wattle Point Wind Farm – provides opportunity for battery to support islanded operation with the wind farm and 2 MW of local rooftop solar, following network outages



BESS – Battery Energy Storage System

Battery storage to improve transmission network resilience

Significant frequency event



RoCoF*

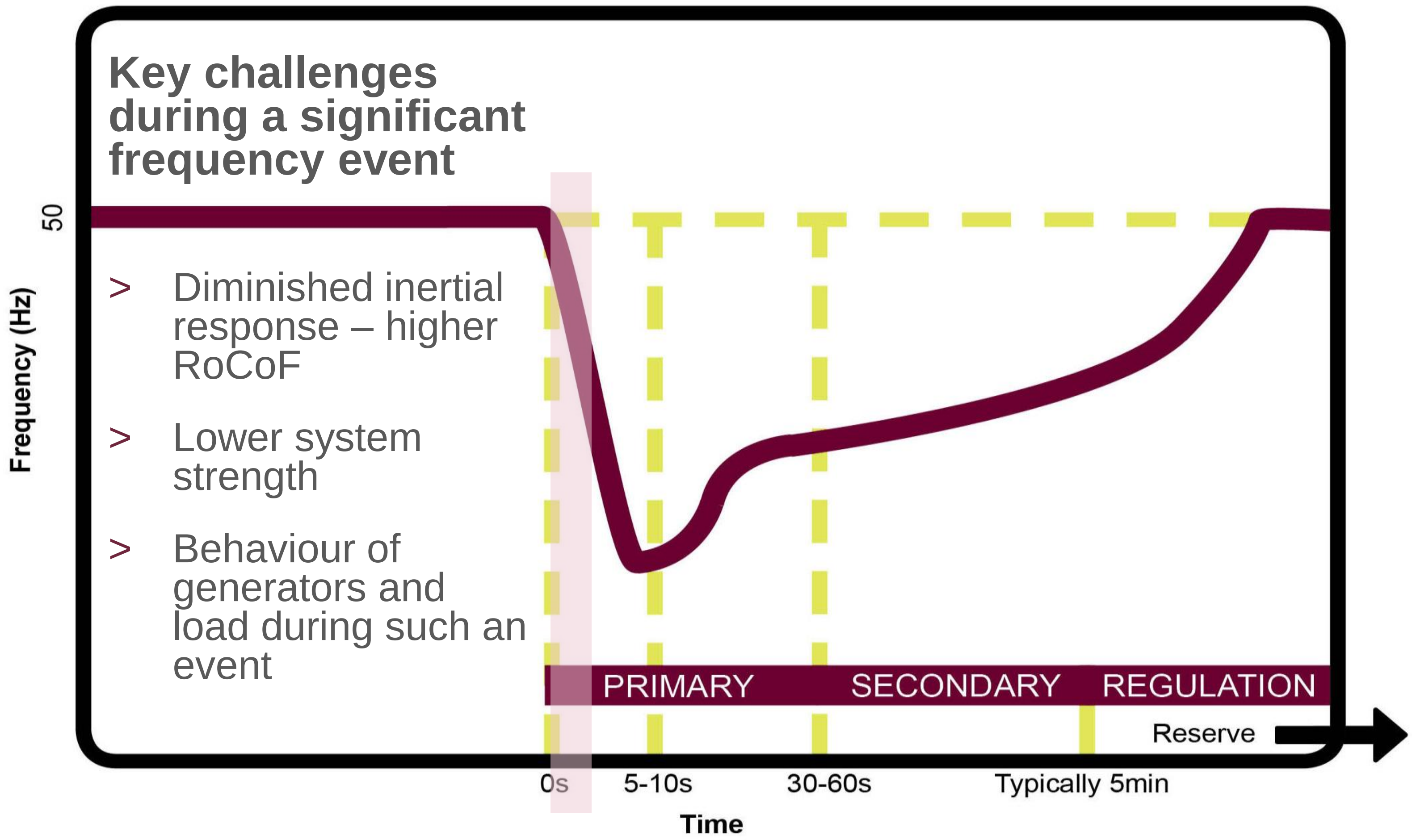
$$\mathbf{RoCoF} = 25\frac{\Delta \mathbf{P}}{\mathbf{H}}$$

* Rate of change of frequency

- Following an unexpected loss of generation / load the resulting imbalance of supply and demand causes system frequency to fall / rise
- If RoCoF is too high it could result in cascading trips of load or generation and emergency control schemes may not prevent system collapse
- Battery can provide fast injection of power to limit RoCoF

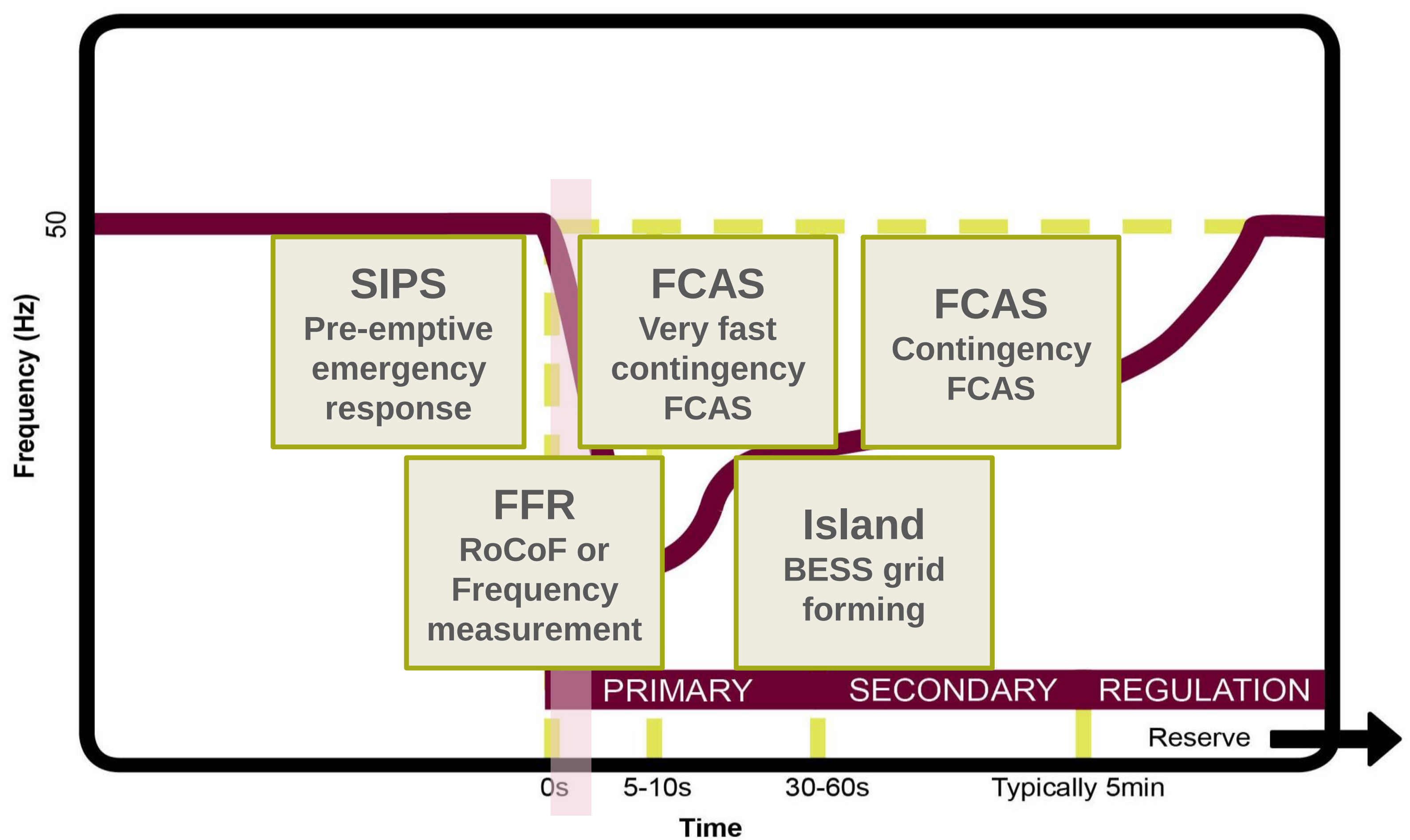
The first second is important

System security depends heavily on what happens straight after a frequency event



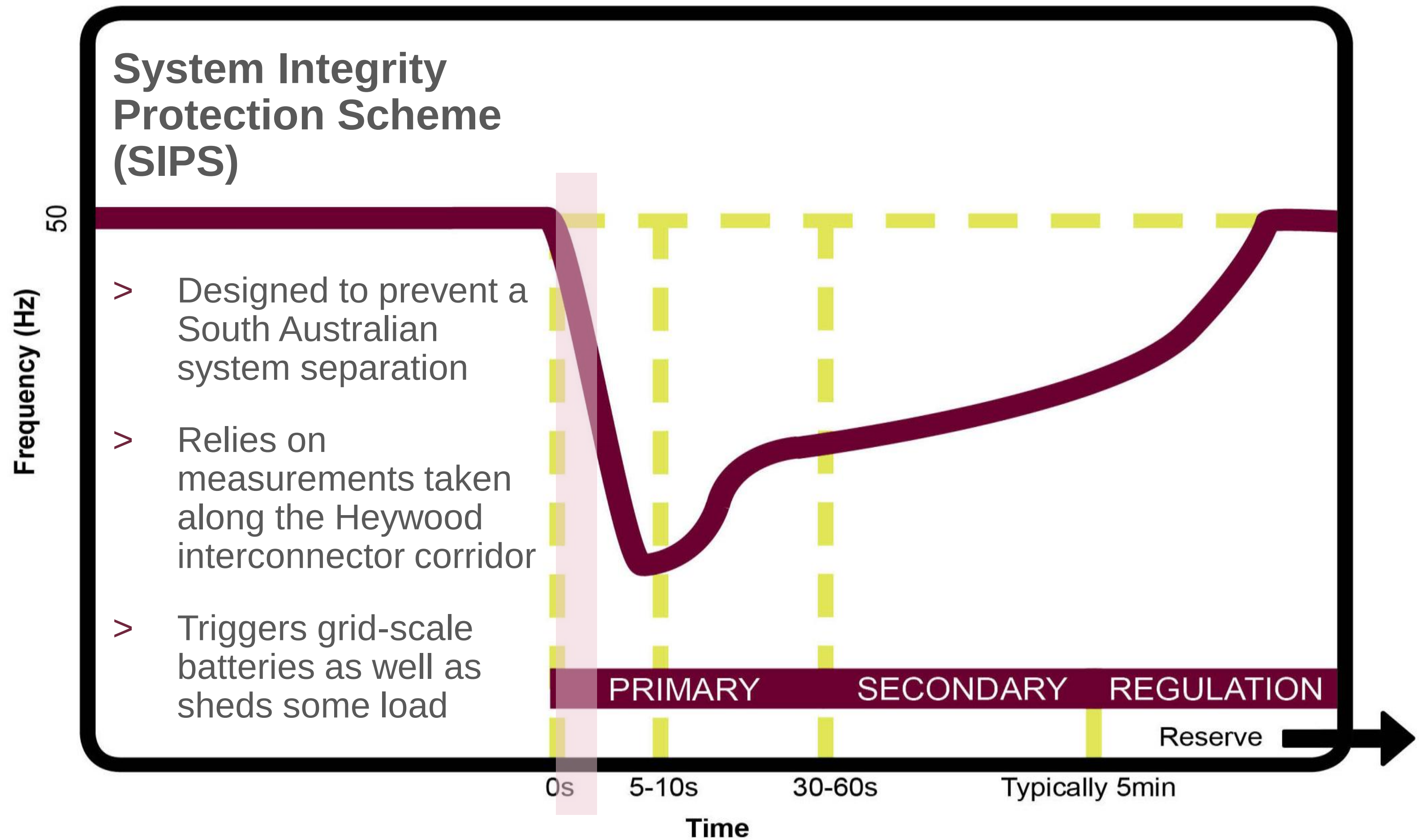
How can batteries help?

Battery storage can assist transmission network resilience in a number of ways



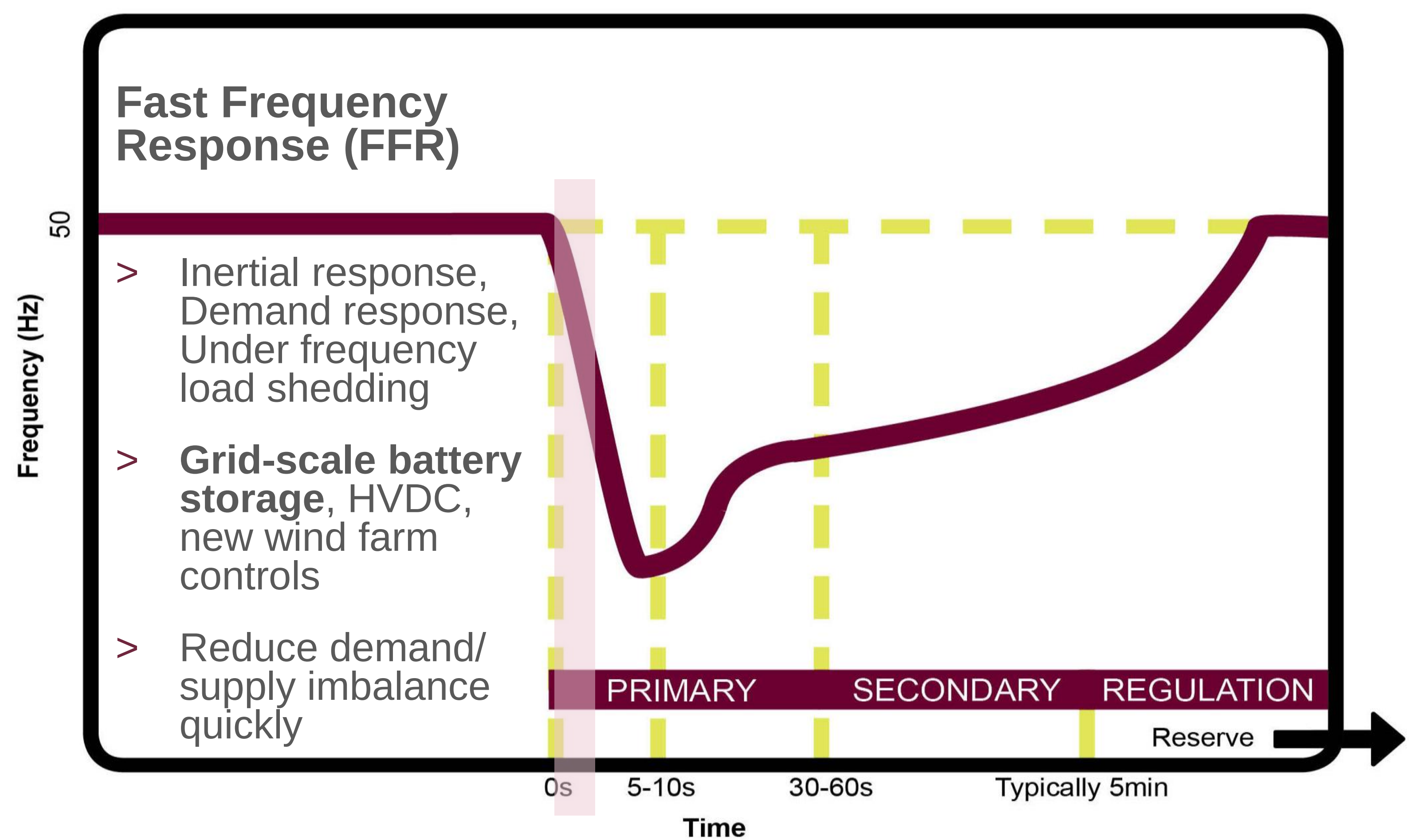
Pre-emptive emergency response

Act on an external signal BEFORE a frequency event occurs



Fast Frequency Response (FFR)

Act on local RoCoF or frequency measurement



Various battery applications

Batteries can help over various time frames

Service provided by:	Pre-emptive emergency response	Fast frequency response	Very fast contingency FCAS	Contingency FCAS
	External signal triggers SIPS	Local measure-ment of either RoCoF or frequency	Within 1-2 seconds	Normal 6 second market
Grid-scale BESS	✓	✓	✓	✓
Virtual Power Plant		✓	?	✓
Distributed Energy Resource		✓		
		Co-ordination?		

Largest autonomous regional micro-grid

Outline

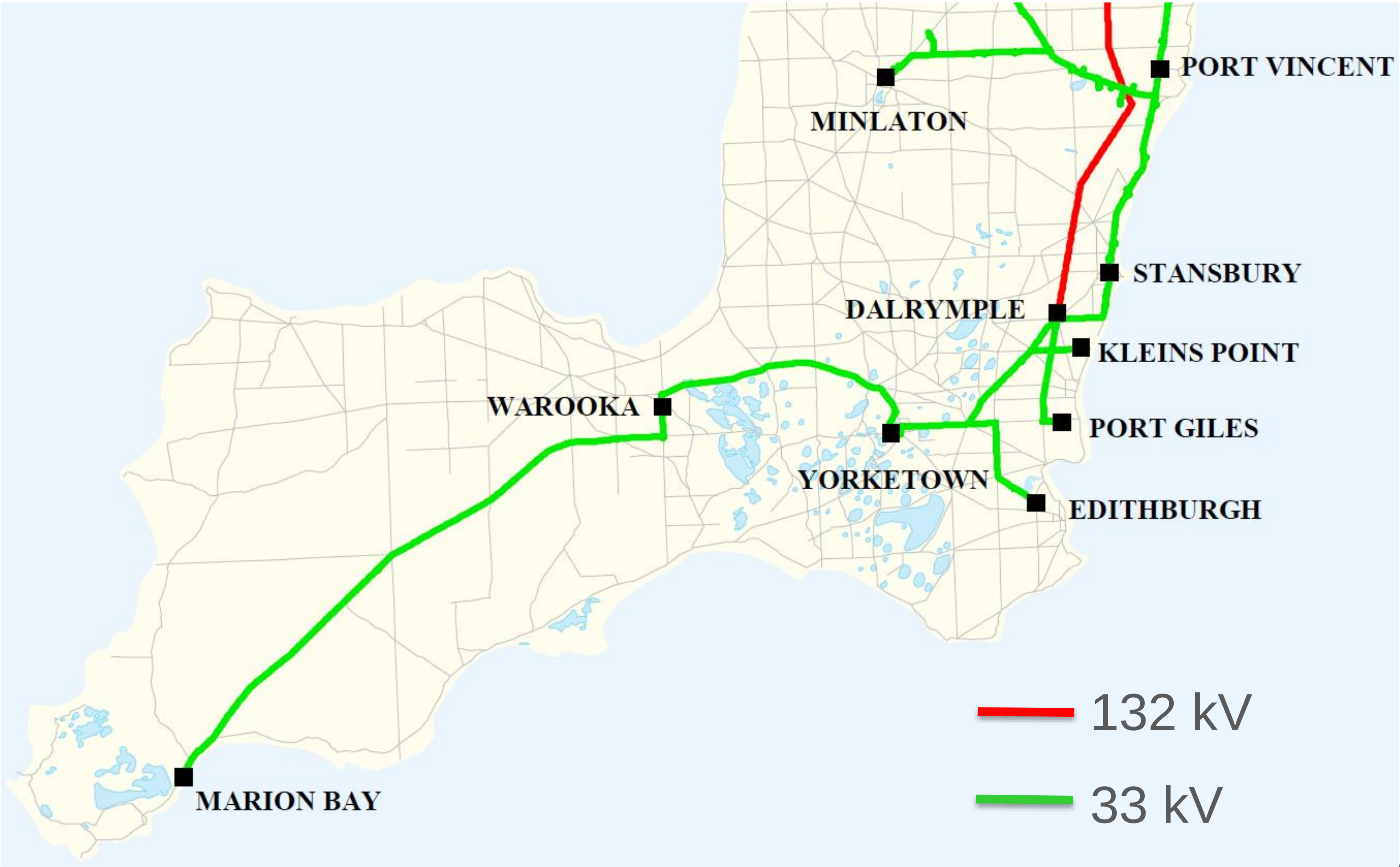
- > Industry innovation
- > 33 kV distribution network
- > Islanding detection
- > Transitioning to an island
- > Islanded operation
- > Challenges

Industry innovation

A number of firsts

- Largest (30 MW BESS) indoor and climate-controlled BESS installation in Australia
- Largest autonomous regional micro-grid development to-date. All-in-one control design co-optimised for both grid-connect and islanded operation, allowing seamless transition between the two operating modes
- Grid-forming capability implies ability to operate conceptually at very low Short Circuit Ratios (<<1.5)
- Islanded grid master control including WF generation MW dispatch / curtailment
- Black-start capability for 8 MW island
- Topology-based Islanding Detection Scheme (IDS)

Geographical supply area



Distribution Network

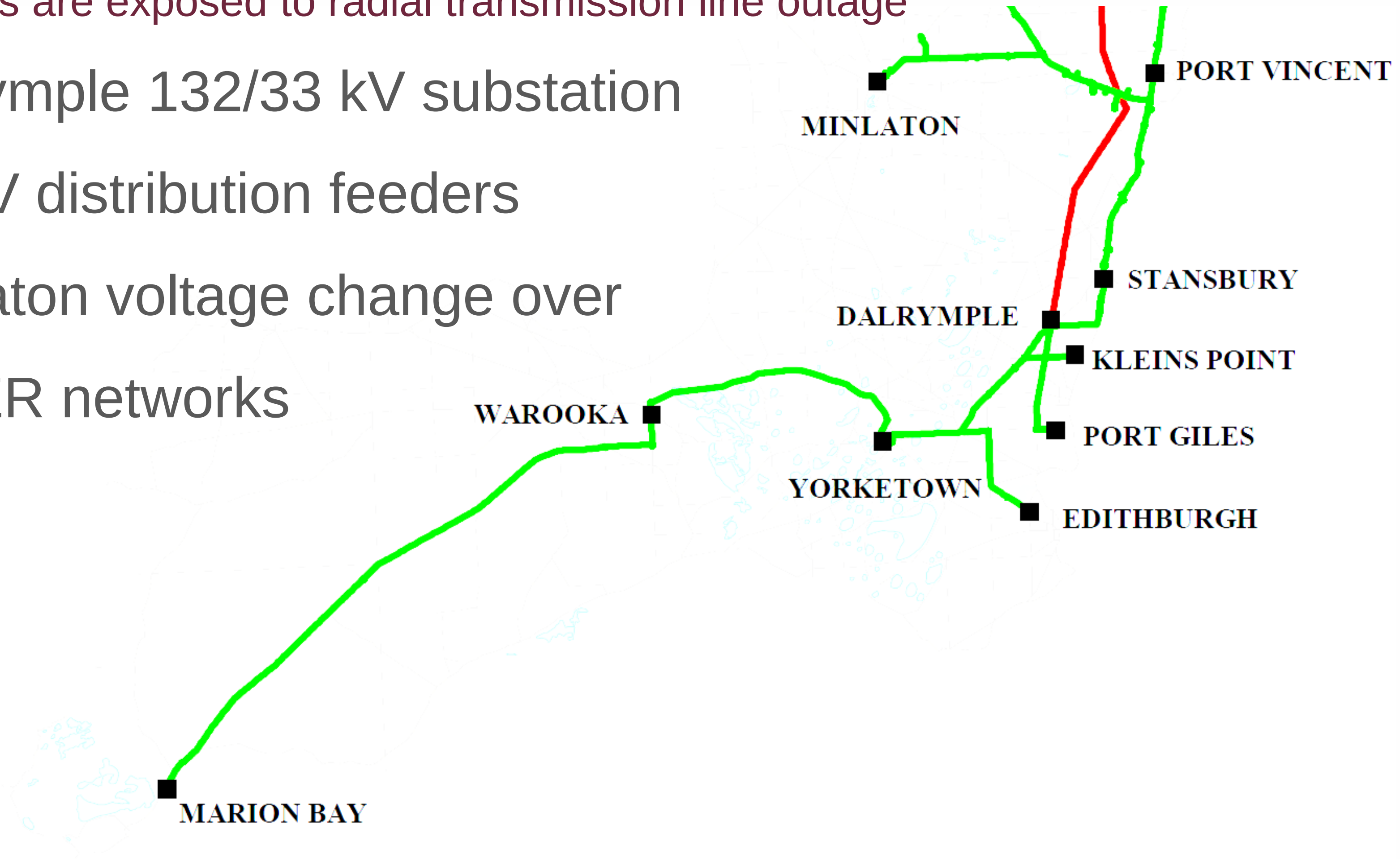
Customers are exposed to radial transmission line outage

> Dalrymple 132/33 kV substation

> 33 kV distribution feeders

> Minlaton voltage change over

> SWER networks



Key requirements for islanding

No local customer to be worse off

- No degradation of SA Power Networks service reliability and quality
- Dependable distribution protection
- BESS anti-islanding protection to disconnect BESS under certain conditions

Islanding detection

Important that an islanding condition is reliably detected

> Topology-based islanding system:

- Monitor status of circuit breakers (CBs) / disconnectors at various substations (via auxiliary contacts) ⬄ planned outages
- Monitor protection relays - i.e. CB imminent tripping under fault conditions detected via protection relays (even before the CBs would open) and transmitting trip signals via telecommunication system ⬄ unplanned outages

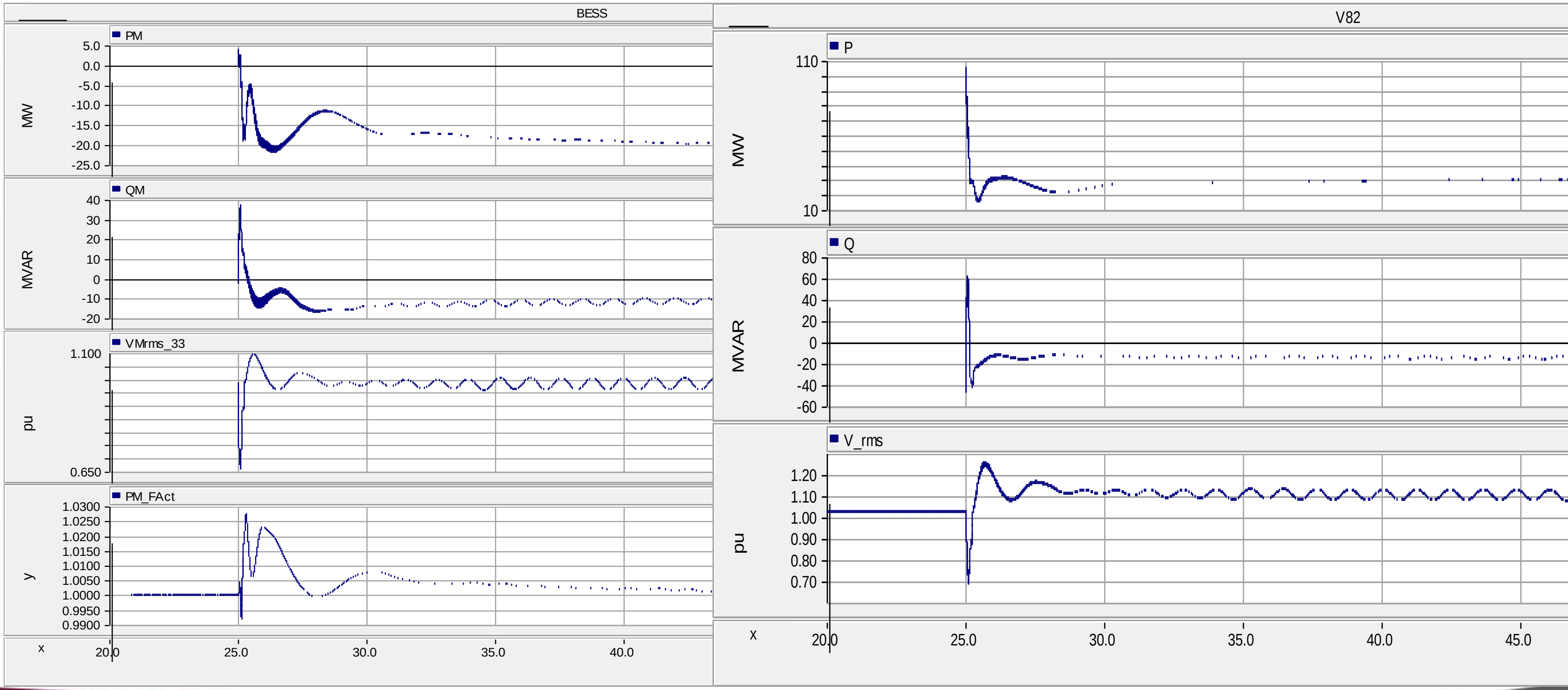
> BESS anti-islanding activation for:

- Insufficient number of batteries / inverters online (insufficient fault current contribution under islanded condition)
- Islanding detection system in-operational

Transitioning to an island

Draft results from transient studies

- > Disconnect 80% of wind farm
- > BESS grid master control transitions to islanded mode



Islanded operation

ESCRI-SA BESS controls the island

> BESS as island grid master control:
  - Voltage and frequency reference
  - Wind farm generation MW dispatch – to manage BESS charge level
  - Fault current provision

> Distribution protection

> Black start (if required)

Challenges

A number of challenges still to be fully addressed

- Transformer inrush current
- Wind farm integration
- Sub-synchronous resonance?
- PV backfeed
- Minlaton Voltage Change Over

ESCRI-SA project update

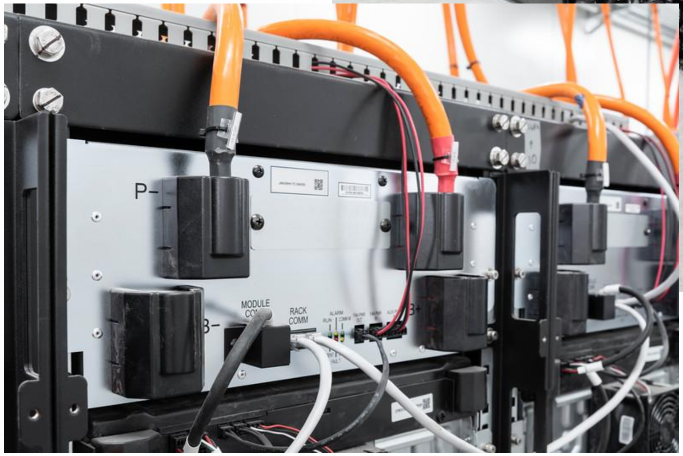
Project status

> The ESCRI-SA BESS project achieved Milestone 2, energisation, on 30 April 2018. This means construction has been completed and the facility has been energised

> We are now working through the next stage of the project, which is completing the registration process followed by commissioning

Dalrymple North – Completed BESS

Batteries



Inverters


ABB
PCS100 ESS Energy Storage System
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Transformers

Questions?

www.escri-sa.com.au

Thank you

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