16 August 2017

ElectraNet

South Australia's electricity transmission specialist

What is a grid-scale battery energy storage system (BESS) best used for in SA?

Electric Energy Society of Australia

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ElectraNet

About ElectraNet

- Principal Transmission Network Service Provider (TNSP) for South Australia
- Owns and manages the SA regulated high-voltage electricity transmission network, and operates in Australia's National Electricity Market (NEM)
- 5,600 circuit kilometres of transmission line
- Where is the Yorke Peninsula?

Outline

- Context and background
- What is grid-scale BESS best used for in the South Australian Electricity System?
  - Not energy security
  - But rather system security
- Broad range of services & benefits (Market services, e.g. arbitrage or Caps, USE reduction, capital deferral, network support, etc.) with the business case being very application specific
- ESCRI case study
- Discussion / questions

South Australia renewable energy snapshot

SA has one of the highest interconnected system levels of intermittent renewable energy penetration in the world (about 41% of annual energy)

Maximum demand 3400 MW

Average demand 1500 MW

Minimum demand 800 MW and decreasing

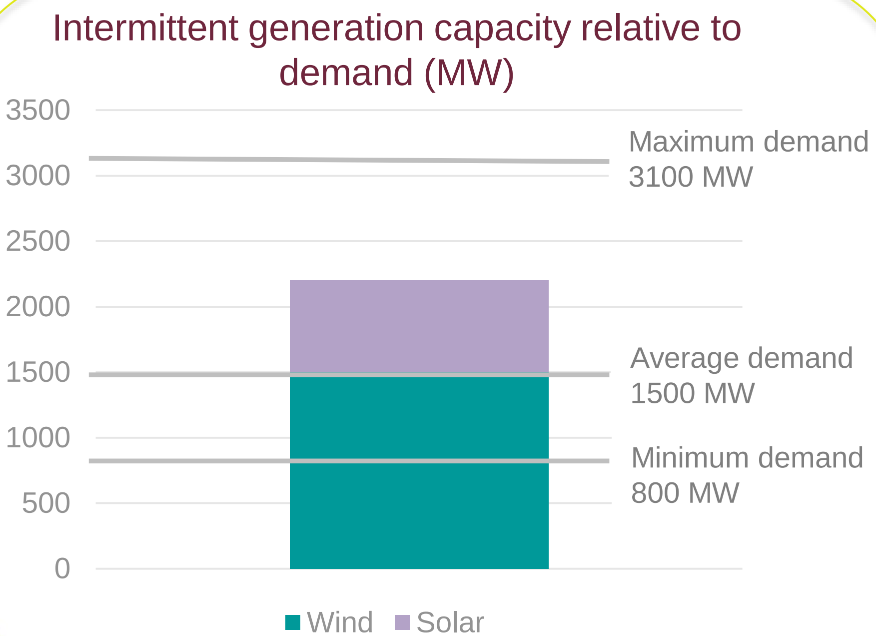
Wind capacity 1500 MW

Rooftop solar capacity 700 MW

No coal fired generation

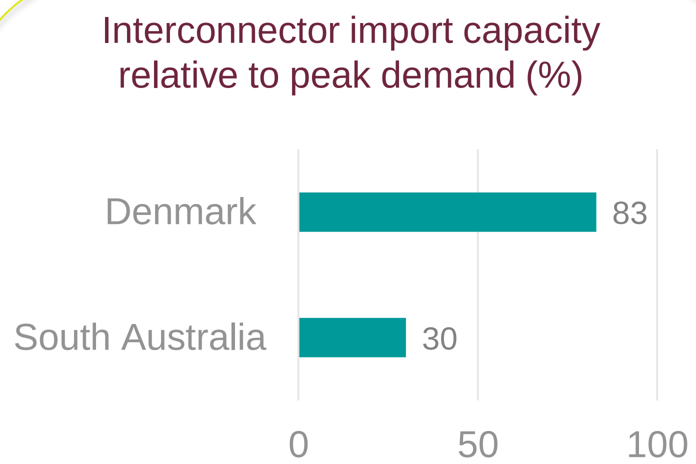
Renewable energy integration - intermittency

New challenges are emerging from the combination of high levels of intermittent generation and a relatively isolated and weakly interconnected system



Wind plus solar generation capacity is…

- 145% of average demand
- 275% of minimum demand

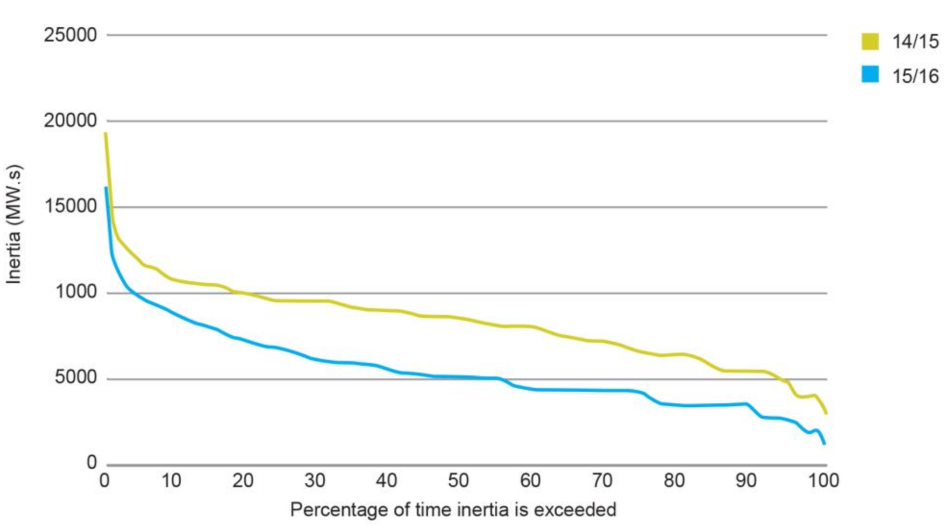


International experience shows that stronger interconnection is needed to support increasingly high levels of intermittent generation and to support energy transformation

System security implications - inertia

New measures are required to manage emerging system security challenges

Changes in South Australian system inertia



Source: AEMO

AEMC – Australian Energy Market Commission

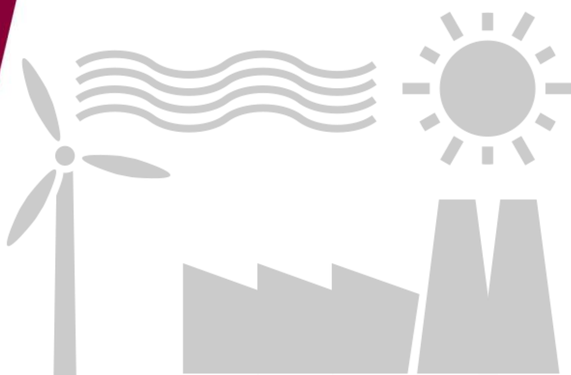
> In August 2016, AEMO reported growing SA exposure to high rate of change of frequency (RoCoF)

> On 12 October, the SA Government introduced a 3 Hz/s RoCoF limit to protect against the non-credible loss of the Heywood Interconnector
  – the resulting Heywood Interconnector limit has bound about 20% of the time

> Subsequently AEMO introduced new system strength measures for SA

> AEMC Future Power System Security work program is underway, including a number of Rule change proposals

Aspects of an energy only market



- Energy
  - Wholesale market
  - Cap trading and other instruments
- Ancillary Services
- The challenge of energy security

The challenge of intermittent generation

Wind and solar PV provide minimal support to SA for 15% of the time

Batteries and energy security

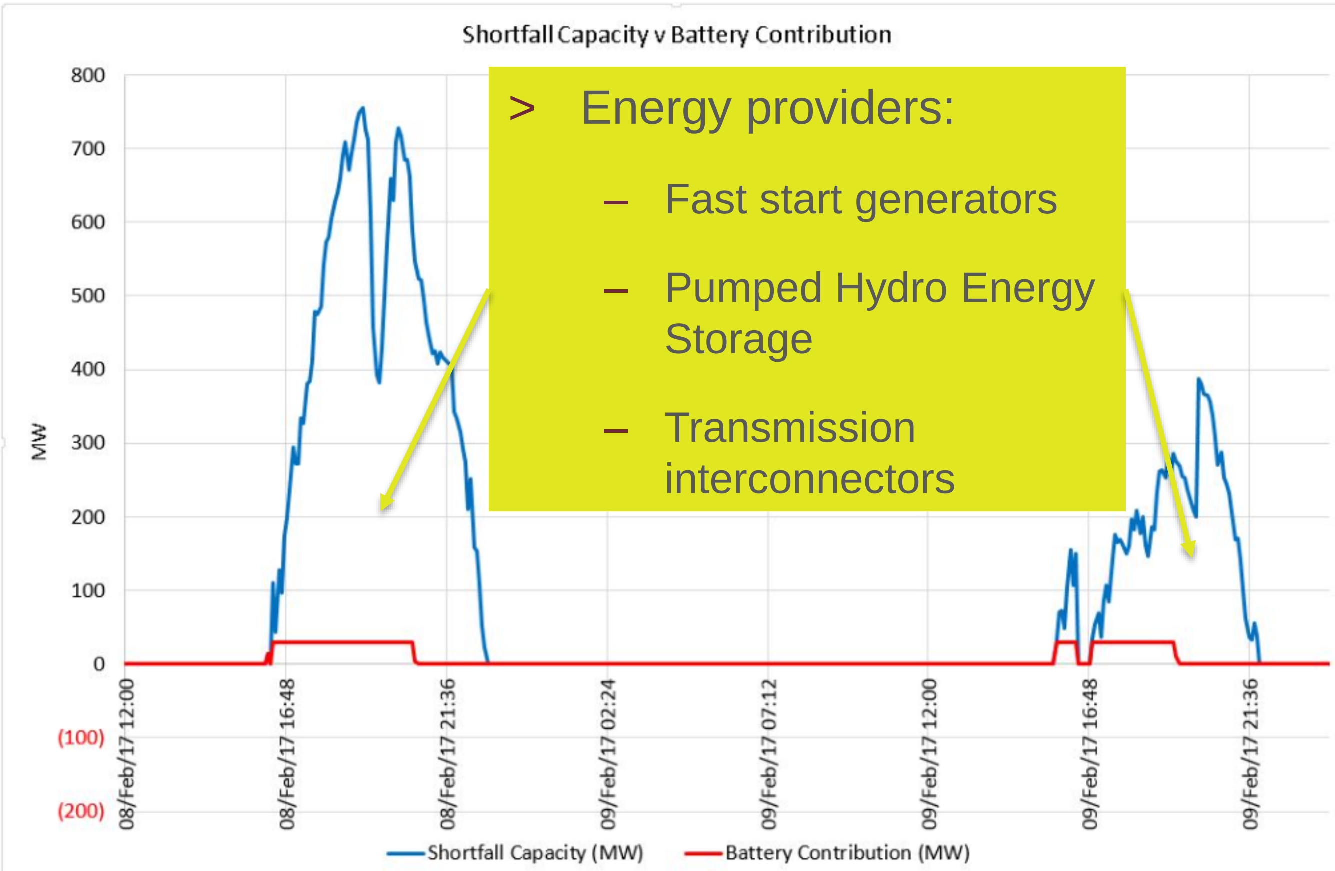
Many batteries required to provide energy security

- Assumptions:
  - Wind still night (12 hours)
  - Average state demand (1,500 MW)
  - Imports from Victoria at 650 MW
- Battery assumptions:
  - Batteries charged at 50% at start
  - SA Government battery – 129 MWh
  - Residential battery – 10 kWh
- How many batteries do we need?

Type of battery	Utility scale	Residential
Scenario 1	> 150	None
Scenario 2	> 80	500,000

Batteries and energy security

Batteries are limited in providing energy security, e.g. 8-9 Feb 2017



- Energy providers:
  - Fast start generators
  - Pumped Hydro Energy Storage
  - Transmission interconnectors

Source: AEC article by Duncan MacKinnon, 16 July 2017

Ancillary services needs

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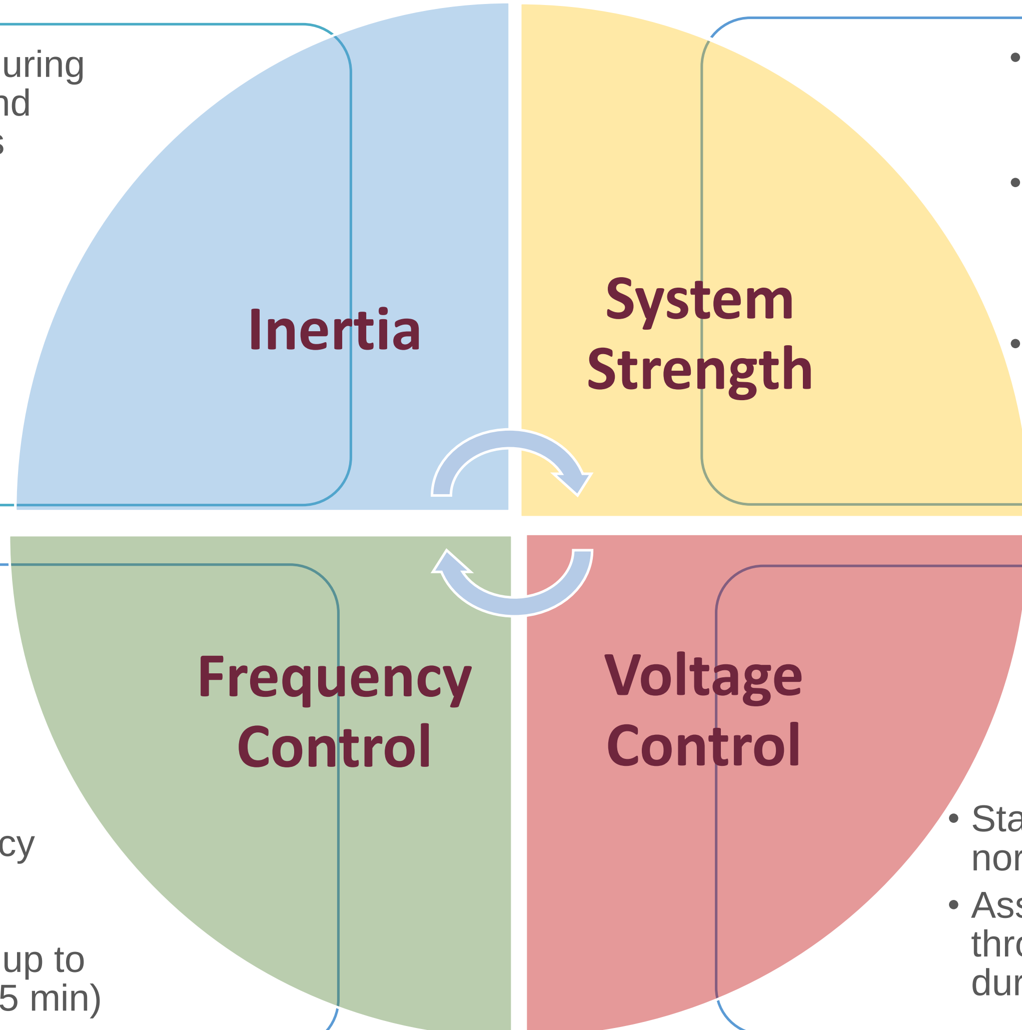
Ancillary services required in an "energy only" market for a viable electricity system

- Steady operation during normal operation and during disturbances
- Limits rapid rate of change of system frequency (RoCoF)

- Associated with fault levels and short circuit ratios
- To operate the system securely and ensure safe protection systems
- Required for fault ride through and recovery from faults



- Balancing load and generation
- Following a frequency disturbance, control required in different timescales (<1 sec, up to 60 sec,1 to 5 min, >5 min)

- Stable operation during normal conditions
- Assist in fault ride through and recovery during disturbances

Ancillary services provided by?

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Various technologies can participate in providing the range of required services

Inertia

- Synchronous generators
- Synchronous condensers
- Synthetic inertia sources (e.g. grid scale batteries, VSC HVDC links, new wind farms with controls)

System Strength

- Synchronous generators
- Synchronous condensers
- VSC HVDC / grid scale batteries (limited)

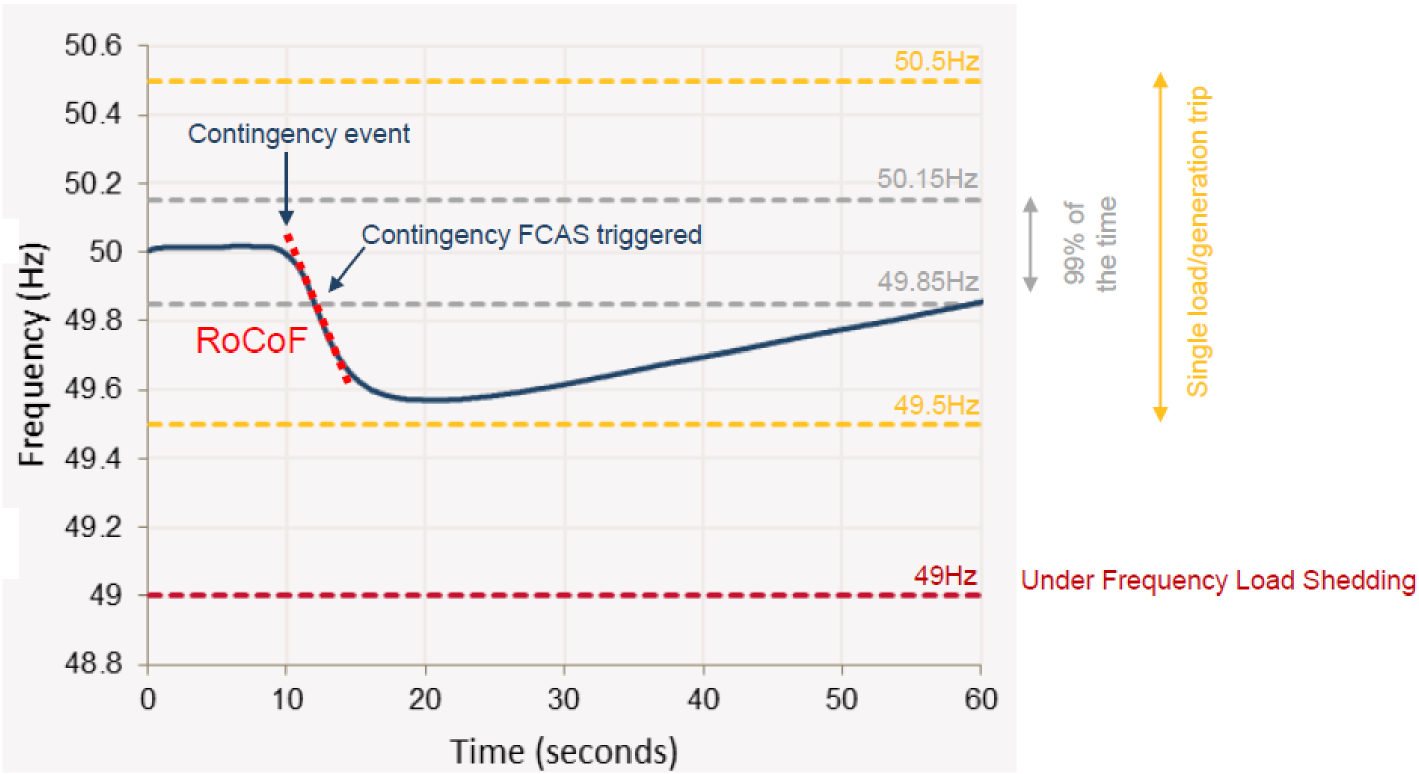
Frequency Control

- Inertial response: Synchronous generators & synchronous condensers (arrest RoCoF)
- Batteries and other storage
- HVDC links
- New wind farms with controls
- Load shedding

Voltage Control

- Generators
- Synchronous condensers
- SVCs/STATCONs
- Capacitors/reactors
- Batteries and storage
- Load shedding

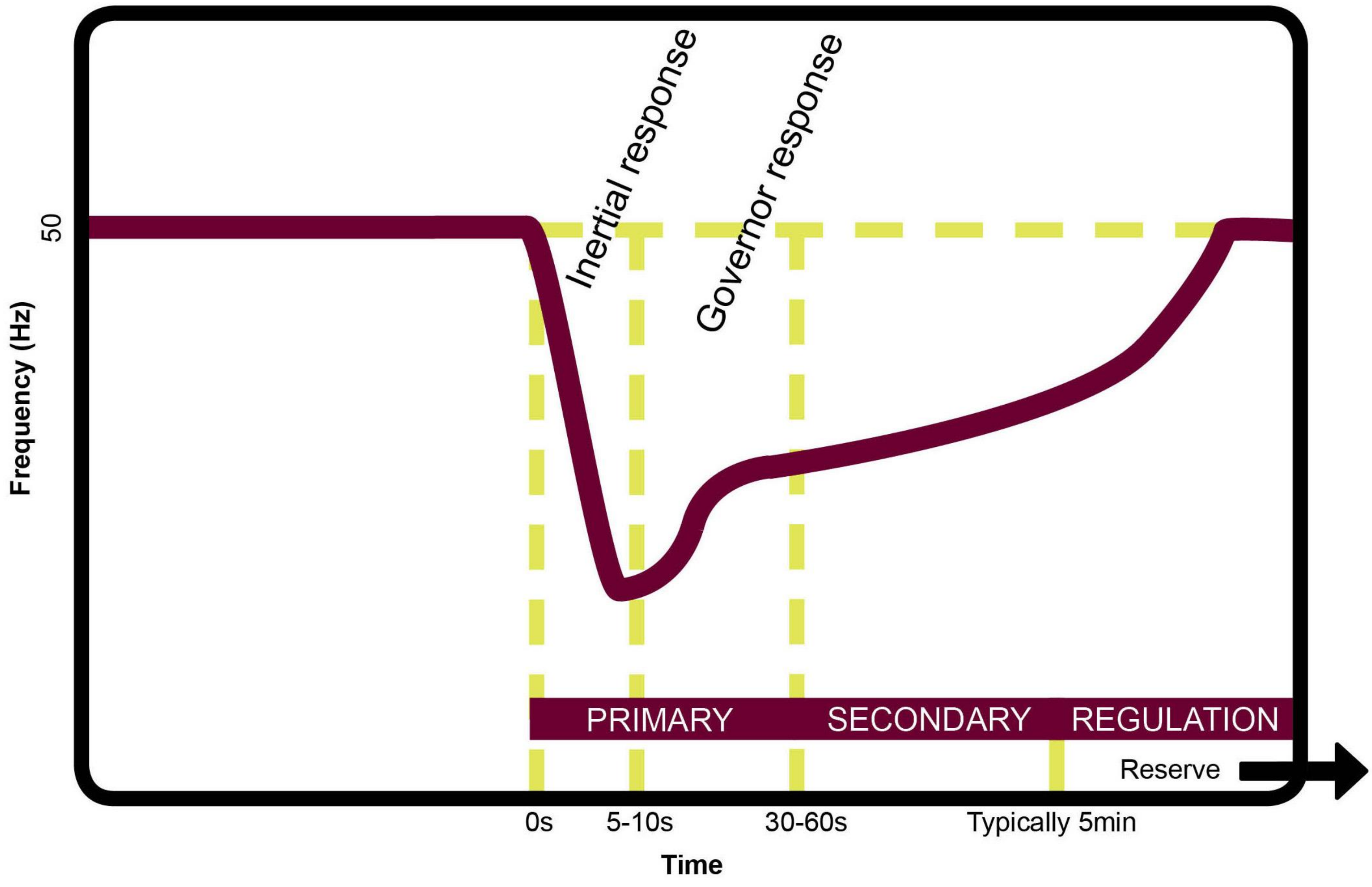
Rate of change of frequency (RoCoF)



- 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

Frequency - separation event

Typical frequency response: Arresting, stabilisation and recovery



Stabilisation and recovery

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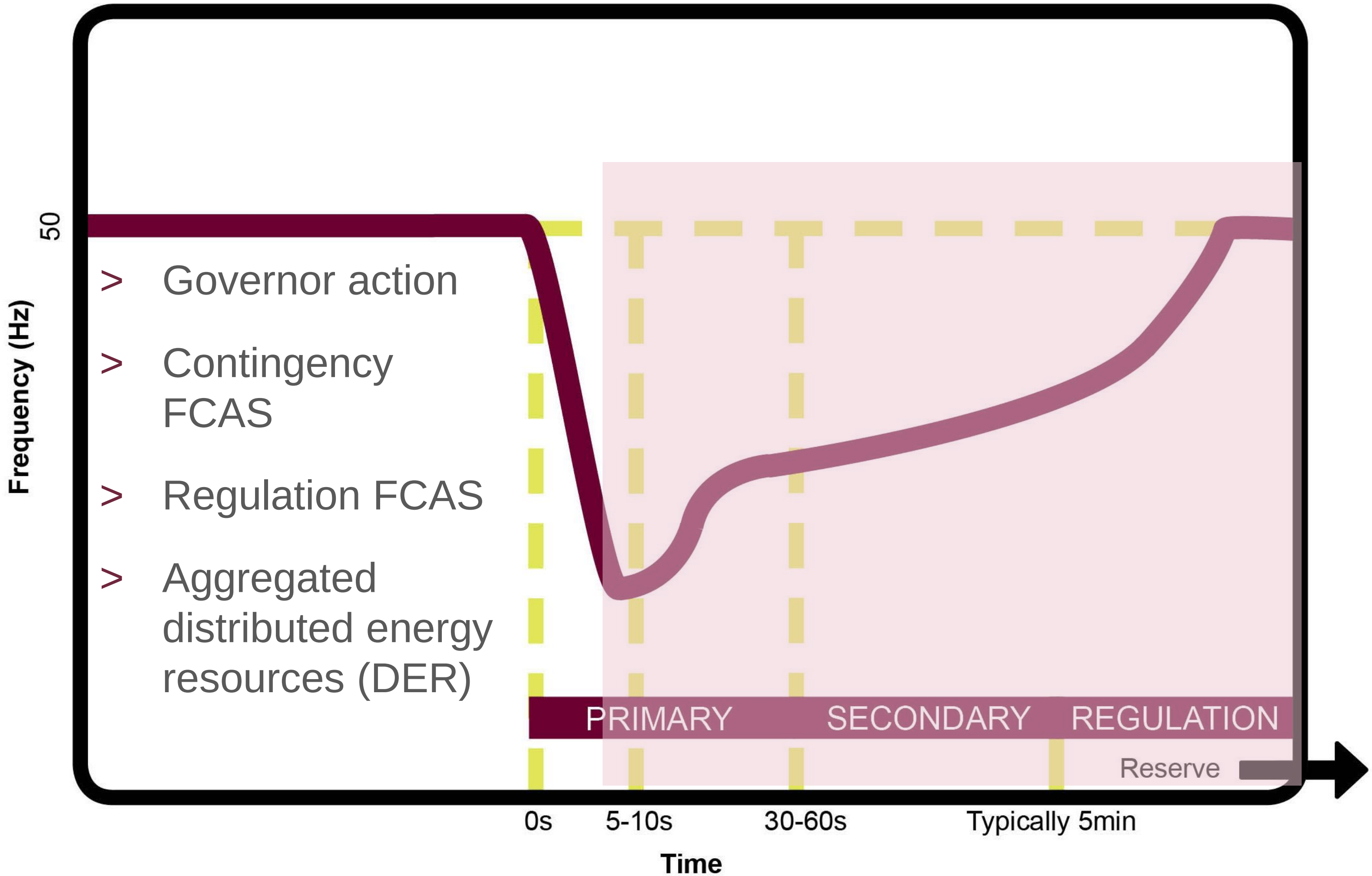
Existing arrangements (governor action and FCAS) can cater for most events

- Governor action
- Contingency FCAS
- Regulation FCAS
- Aggregated distributed energy resources (DER)



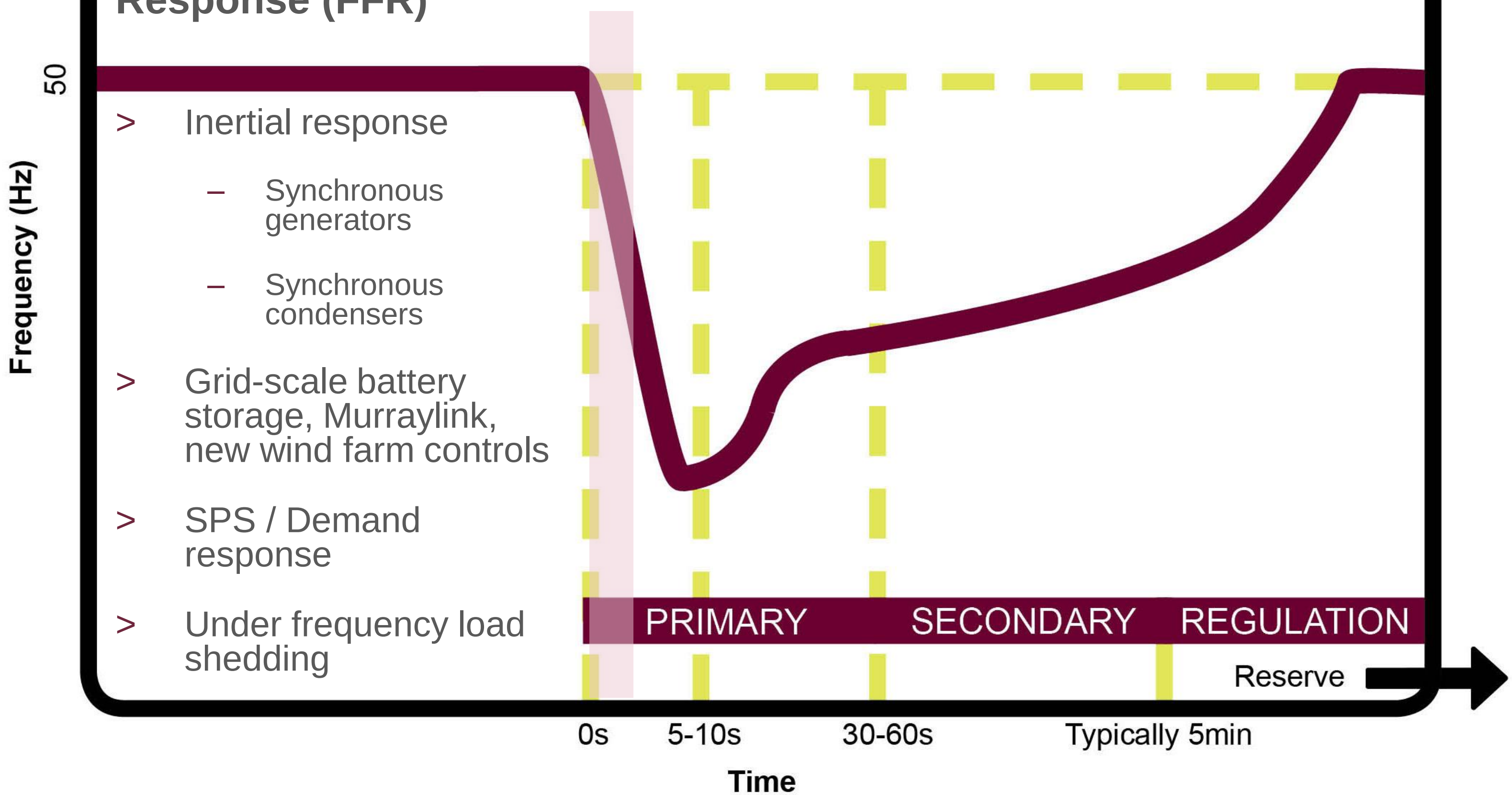
FCAS: Frequency control ancillary service

Arresting frequency

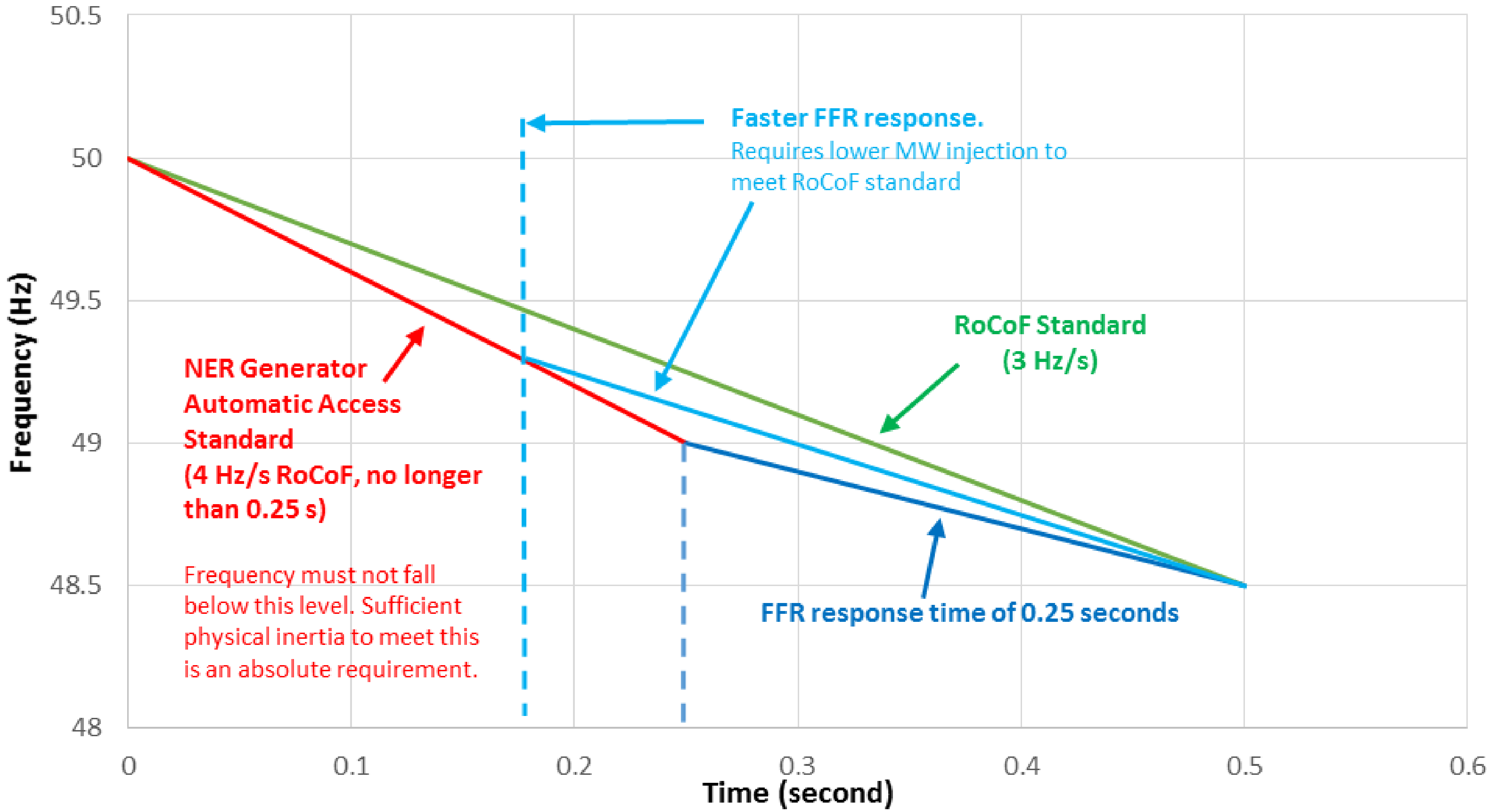
A combination of inertia and FFR providers will be required in future

Fast Frequency Response (FFR)

> Inertial response
  – Synchronous generators
  – Synchronous condensers
> Grid-scale battery storage, Murraylink, new wind farm controls
> SPS / Demand response
> Under frequency load shedding



Alternative Inertia and FFR characteristics to meet minimum 3 Hz/s RoCoF standard



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Trade-off between FFR MW and system inertia requirements for different FFR response times to meet minimum 3 Hz/s RoCoF requirement

	Example 1: 250 ms response	**Example 2: Faster response**	**Example 3: Slower response**	**Example 4: Inertia only**
FFR response Time (ms)	250	150	350	N/A
Inertia (MWs)	4,000 – 4,500	4,000 – 4,500	4,500 – 5,000	5,000 – 5,500
Inertia increase from example 1 (MWs)	N/A	0	500	1,000
FFR required (MW)	300 – 350	200 - 250	250 - 300	N/A
FFR reduction from example 1 (MW)	N/A	~100	~50	300 - 350

ESCRI case study

ESCRI – Phase 1

> Energy Storage for Commercial Renewable Integration in South Australia

> An Australian Renewable Energy Agency (ARENA) funded project that started out to investigate the business case for transmission grid-scale (5 – 30 MW) storage in South Australia

ARENA

Australian Government

Australian Renewable Energy Agency

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AGL

WorleyParsons resources & energy

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ESCRI

Phase 1 – Business Case

- Regulatory environment
- Initial siting
- Functional specification
- Capital estimating
- Technology selection
- Commercial framework
- Market impact & value

Phase 2 – Project Delivery

- Statutory approvals
- Formal procurement
- Finance raising
- Detailed design
- Construction
- Commercial contracts
- Operation of asset

ARENA
Australian Government
Australian Renewable Energy Agency

Phase 1 Basic Outcomes

Phase 1 – Business Case

- Regulatory environment
- Initial siting
- Functional specification
- Capital estimating
- Technology selection
- Commercial framework
- Market impact & value

No particular regulation impediment

Siting was an iterative task, considering multiple criteria. Screening methodology resulted in three sites initially

A mathematical model was built to assess the large arrange of options, and determine a functional algorithm to maximise revenue

A formal RFI was used with 42 national/international vendors responding – shortlisted to eight proponents. A wide range of technologies were assessed

Various commercial frameworks are possible
TNSP owned most effective in this case

Business case was eventually assessed for a 10 MW, 20 MWh Lithium-Ion battery based at Dalrymple on the Yorke Peninsula

Project development history

ESCRI-SA Phase 1 – Business Case exploration

November 2014 to December 2015	Examined regulatory, commercial, technology and technical issues and publicly reported results – Business case for a 10 MW, 20 MWh BESS was poor

ESCRI-SA Phase 2 – Expression of Interest for delivery phase

March to July 2016	30 MW, 8 MWh BESS targeting demonstration of FFR but unable to monetise – Benefits included increased Heywood Interconnector import capability, reduced unserved energy, and market price cap trading. Business case improved

ESCRI-SA Phase 2 – Full Application for delivery phase

January to March 2017	Same 30MW, 8MWh BESS but with FFR system security benefit monetised (reducing Heywood Interconnector import constraints) and ancillary services revenue (FCAS) added. ARENA grant funding of up to $12m

BESS – Battery Energy Storage System

Project scope and objectives

Scope: Nominal 30 MW, 8 MWh proof of concept battery storage project

Primary objective:

> Demonstrate that utility scale energy storage can be a key enabler of large scale intermittent renewable energy on an interconnected system, through the provision of FFR services alongside other parallel network and market services

Secondary objectives:

> Explore islanded operation with 100% renewable generation

> Build delivery capability for such assets

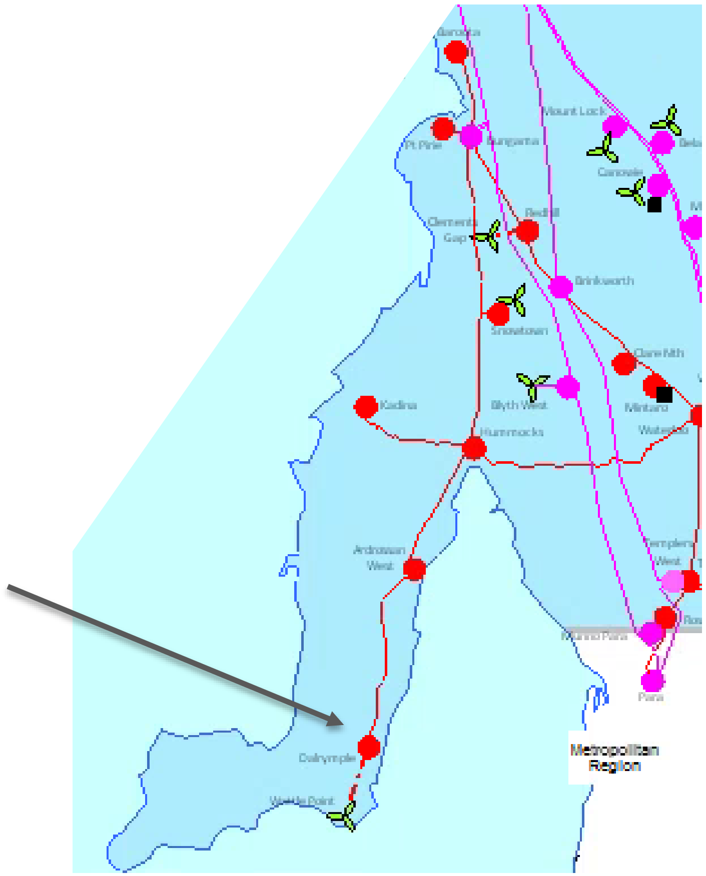
> Demonstrate commercial separation and provision of regulated services and energy market services

FFR – Fast frequency response

Why Dalrymple?

Site selected to maximise value and minimise ARENA ask

- Transmission level connection at 33 kV at Dalrymple substation on Yorke Peninsula – land available
- Has an opportunity to reduce Expected Unserved Energy under islanding conditions, with a maximum load of around 8 MW (more typically about 3 MW for 2 hours)
- The site is close to the 91 MW Wattle Point Wind Farm – and provides opportunity for the battery to support islanded operation with the wind farm and 2 MW of local rooftop solar, following outages of the 132 kV network



Potential BESS services

Component	Service / Benefit	BESS	Comment
Energy	Cap trading	✓	Long term energy: Fast start GTs, gas, PHES, DER, wind, PV, coal, diesels, transmission
	Energy time shifting	✓	
	Energy security		
Network reliability / support	USE reduction	✓	
	Capital deferral	✓	
	Voltage & reactive control	✓	
Frequency control	Short term spinning reserve	✓	
	FCAS	✓	Aggregated DER
	Fast Frequency Response	✓	SPS, UFLS
Safety	Fault level		Synchronous condensers
	Black start	✓	

Revenue streams

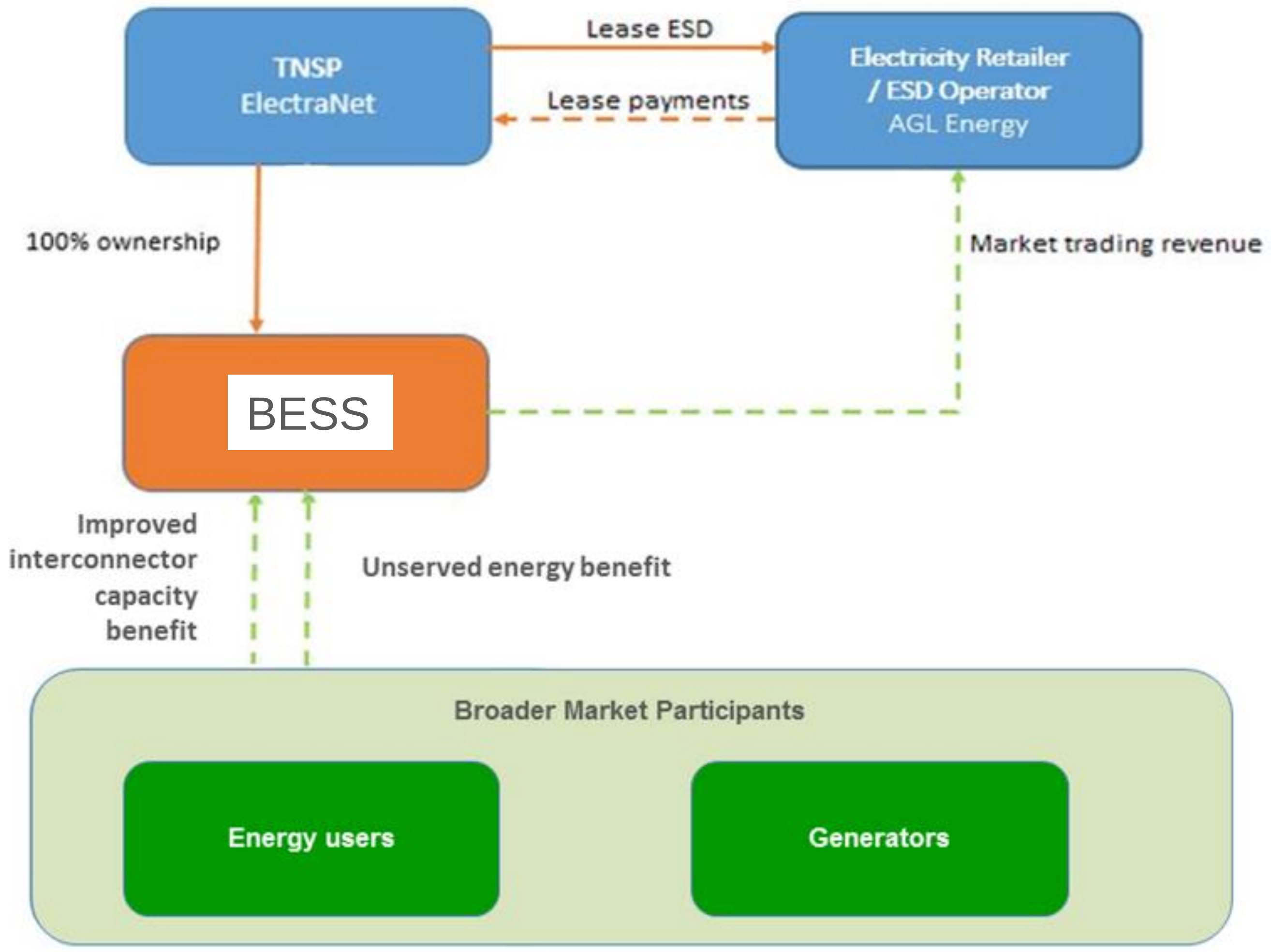
Battery will be leased to AGL to capture competitive market services

Regulated services	Competitive market services
Fast frequency response Heywood Interconnector benefit	Ancillary services revenue (FCAS)
Reduced unserved energy benefit	Market cap trading

Fast frequency response benefit arises from reducing Heywood Interconnector constraints that limit imports over the interconnector to manage high rates of change of frequency (the 3 Hz/s Rate of Change of Frequency (RoCoF) limit)

Commercial construct

Proposal complies with relevant regulatory rules and guidelines



ESCRI status update

- ARENA grant funding of up to $12m
- Re-engaged identified proponents via RFP & RFT
- Refined financial model and progressed internal approvals
- Engaged AGL:
  - BESS operating protocol (AGL to have operational control)
  - Lease payments, varied according to different MWh offerings
  - Various agreements
- EPC contract award shortly
- Energisation early 2018

Protecting regulated services

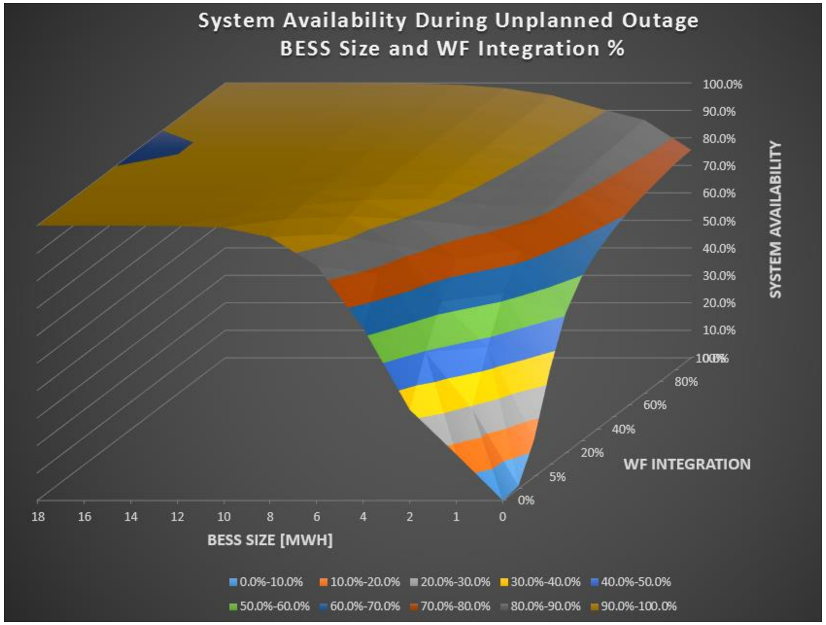
AGL / ElectraNet operating protocol to be setup to protect the regulated services

Initial approach:

- BESS mostly fully charged
- Once AGL has used the BESS, recharge within a few hours

Revised approach:

- With wind farm integrated:
  - BESS charge to remain within 10% and 90%
  - Allows AGL more flexibility, also FCAS lower opportunity
  - Improved BESS longevity
- Without wind farm integrated, BESS charge to remain above 60%



Thank you

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