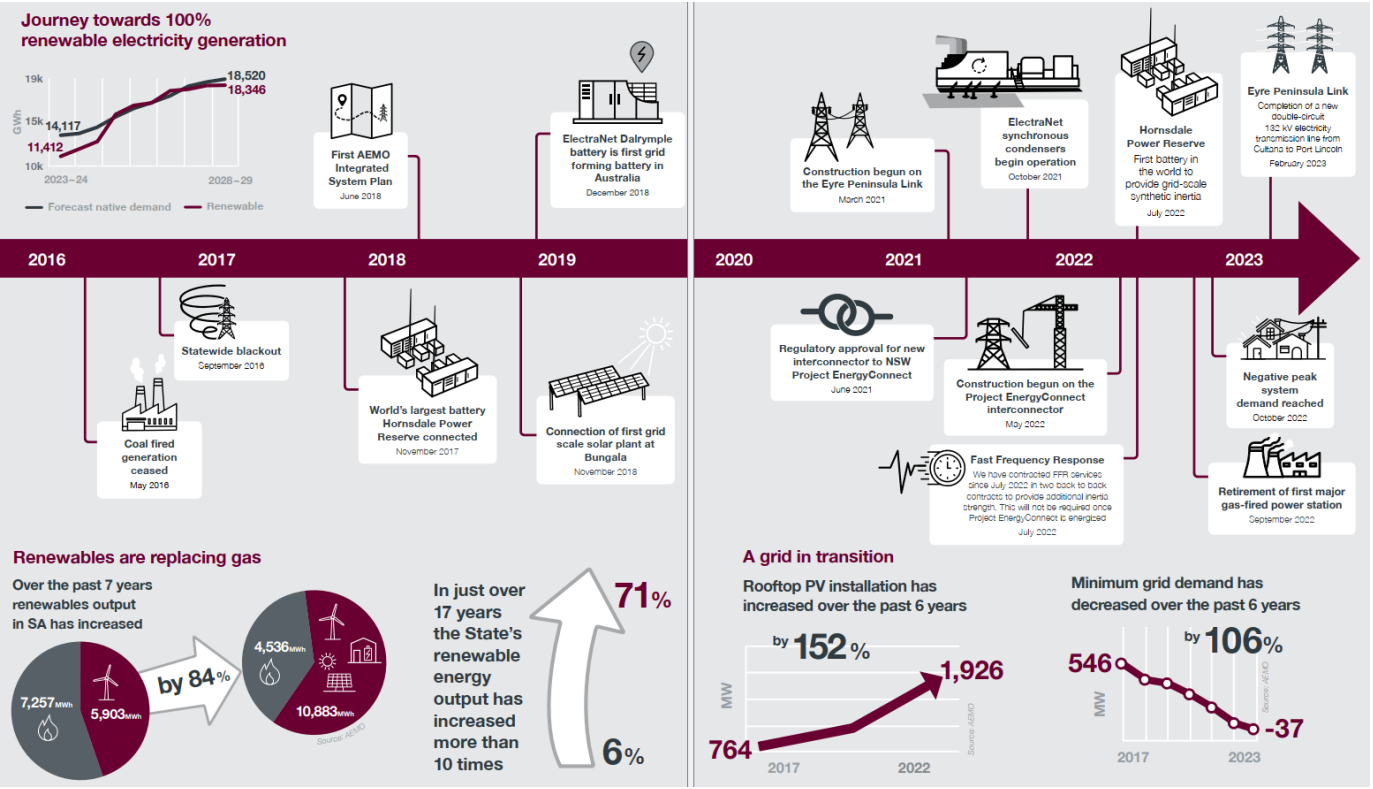
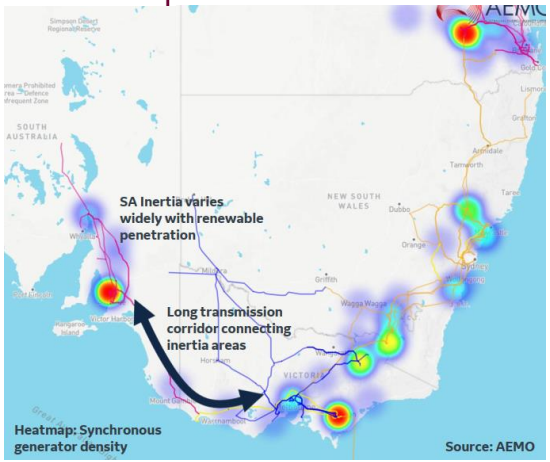
South Australia Wide Area Protection Scheme

Authors:
Filip Ivanovski (CSE)
Devinda Perera (ElectraNet)
Sean Norris (GE)

The 4th International Conference on Smart Grid Synchronized Measurements and Analytics (SGSMA 2024)
May 20-23, 2024, Washington DC, USA

Transforming South Australian Power System

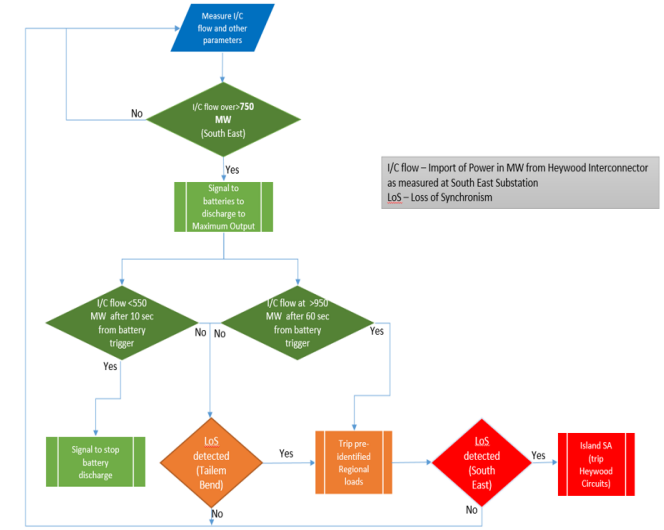


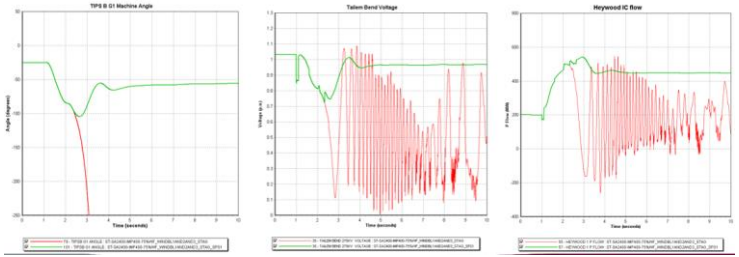


- Good dynamic data is critical to understand and improve the resilience of South Australia's system!

Background & Motivation

- Following the SA system blackout in 2016, Australian Energy Market Operator (AEMO) recommended the investigation of a special protection scheme (SPS) to detect multiple generation loss in SA and triggering suitable timely action to prevent separation of SA system from the NEM
- System Impedance measurement based; System Integrity Protection Scheme (SIPS) was developed in 2017
- SIPS incorporates three discrete progressive stages.
  - Stage 1 – Fast response trigger to inject energy from battery energy storage systems (BESS)
  - Stage 2 – Load shedding trigger to shed approximately 200 MW of South Australian loads
  - Stage 3 – Out-of-step trip scheme (islanding South Australia)





Background & Motivation

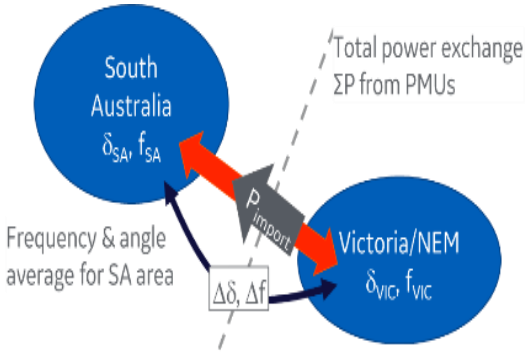
- In 2019, ElectraNet commenced an investigation into improving the design of the SIPS
- The new scheme needed to be based on time synchronised, high-speed measurements using synchrophasor technology
- Identified areas of improvement:
  - Detection and timely/early trigger
  - Real time response measurement
  - Proportional response
  - Operation of the scheme under system normal and prior outage conditions
- The new scheme, called Wide Area Protection Scheme (WAPS), replaced Stage 1 and Stage 2 of the SIPS
- The new scheme was placed into service in December 2023

Implementation of Wide Area Protection Scheme

WAPS utilizes a three-pronged approach. Triggers for different types of grid stress behaviour, including:

1. **Network Stress:** angle and frequency difference for emerging angle stability event
2. **Power Imbalance:** Level and change of power balance in SA. Measure of region power balance change
3. **System Event:** Large & fast frequency and ROCOF drop with external NEM event blocking. Fast detection in low inertia state

Required system response is determined using the Power Imbalance minus Power Target. Proportionate to event and adapt to network state



$$Pex = PImbal - HsaROCOFsa$$

where

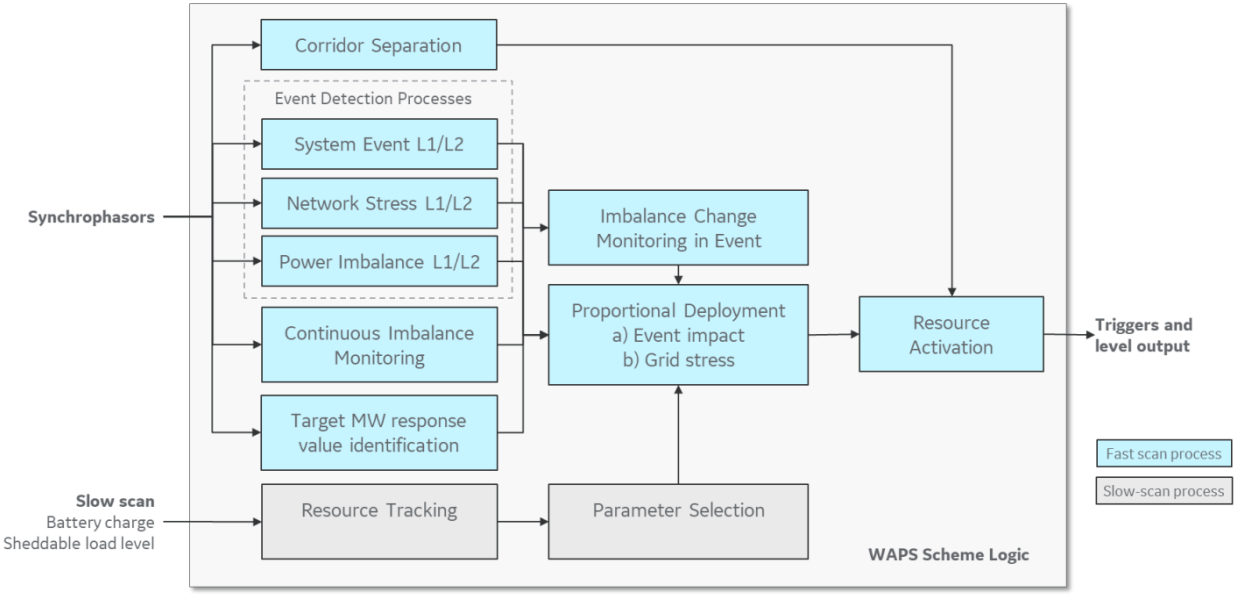
Pex is Instantaneous Power export from SA (measured)

PImbal is the Total Power Imbalance to be identified

Hsa is the effective inertia of South Australia

ROCOFsa is the ROCOF of the SA centre of inertia

Implementation – Functional Block Diagram



Response determined by:

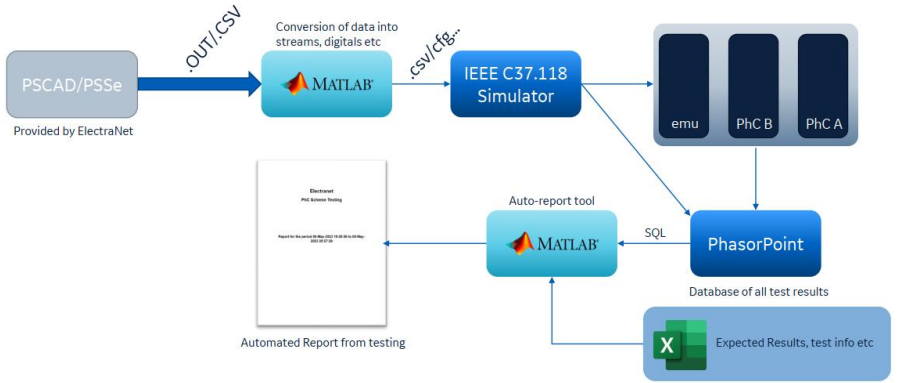
Level L1 BESS only or **L2** load shed response justified

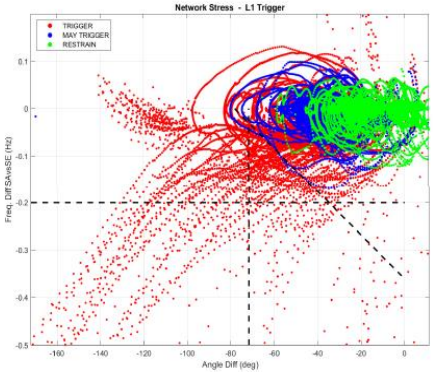
Power imbalance MW level reached due to event

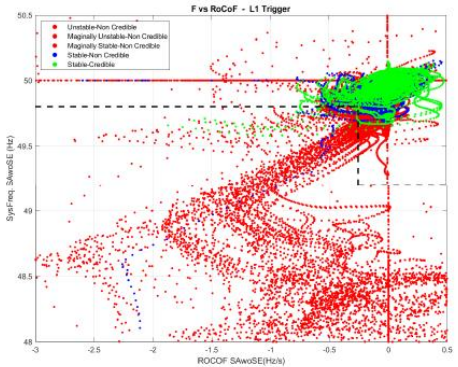
Corridor strength determining power target MW value

Initial Design – Testing & Tuning

- Complex multi-event simulations used as case library to test and tune scheme
- Open-loop testing by playing back simulation results to determine the trigger accuracy and parameters

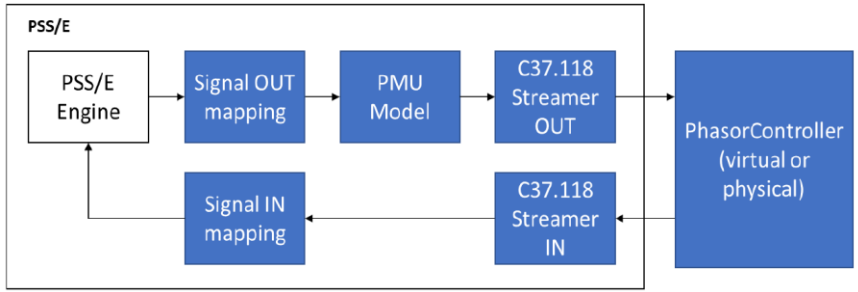






Real Code Models of the Controller

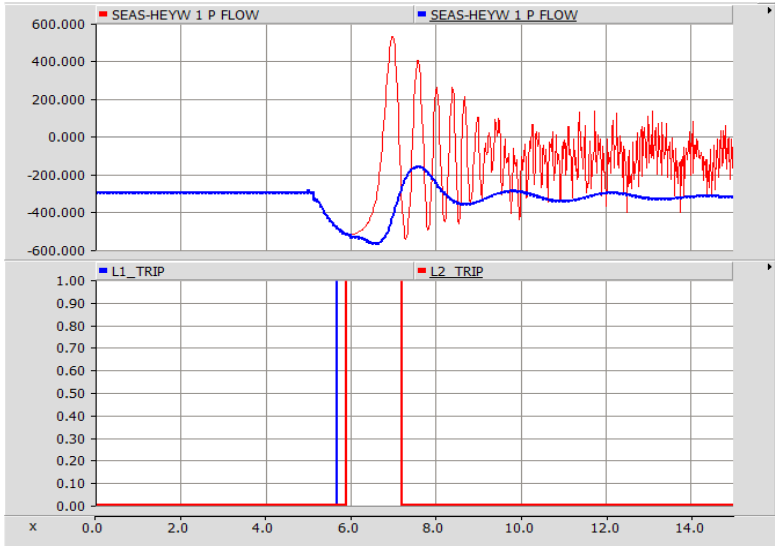
- Significant effort was spent on developing an accurate model of the controller and logic to be used in Power System Studies
- Two different Models
  - Blackbox Dynamic Link Library model for distribution to the Market Operator
  - Virtual hardware-based model with open logic for ElectraNet, for maintaining the scheme in the future

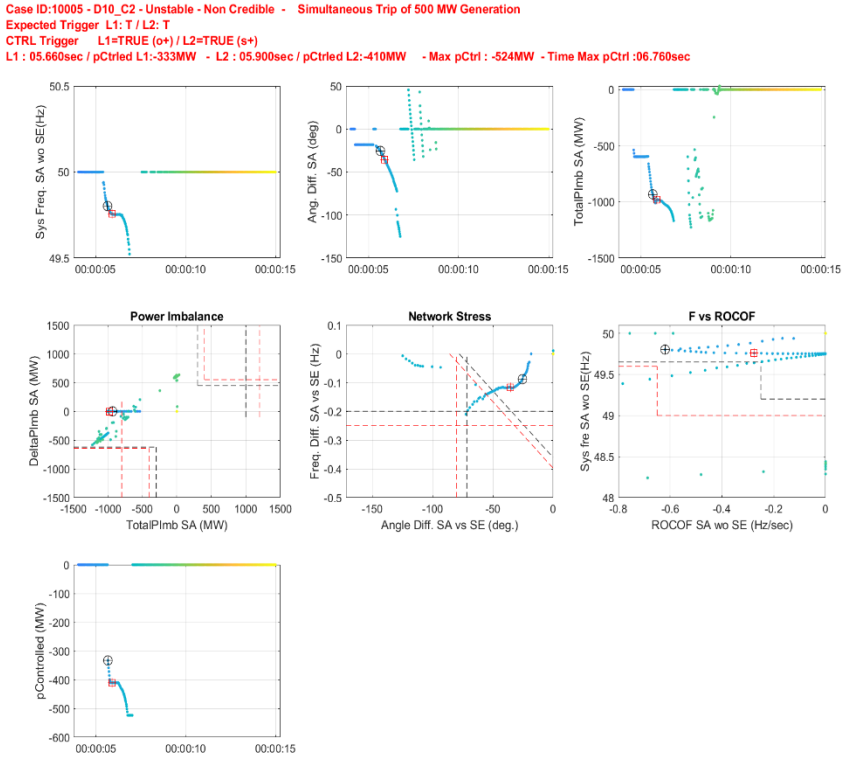


- DLL followed IEEE/CIGRE DLL Interface Standard and compatible with both PSSE and PSCAD software
- Controller model was extensively tested to ensure the models align with actual hardware
- Model was integrated to wide area PSSE and PSCAD model for final tuning of the setting

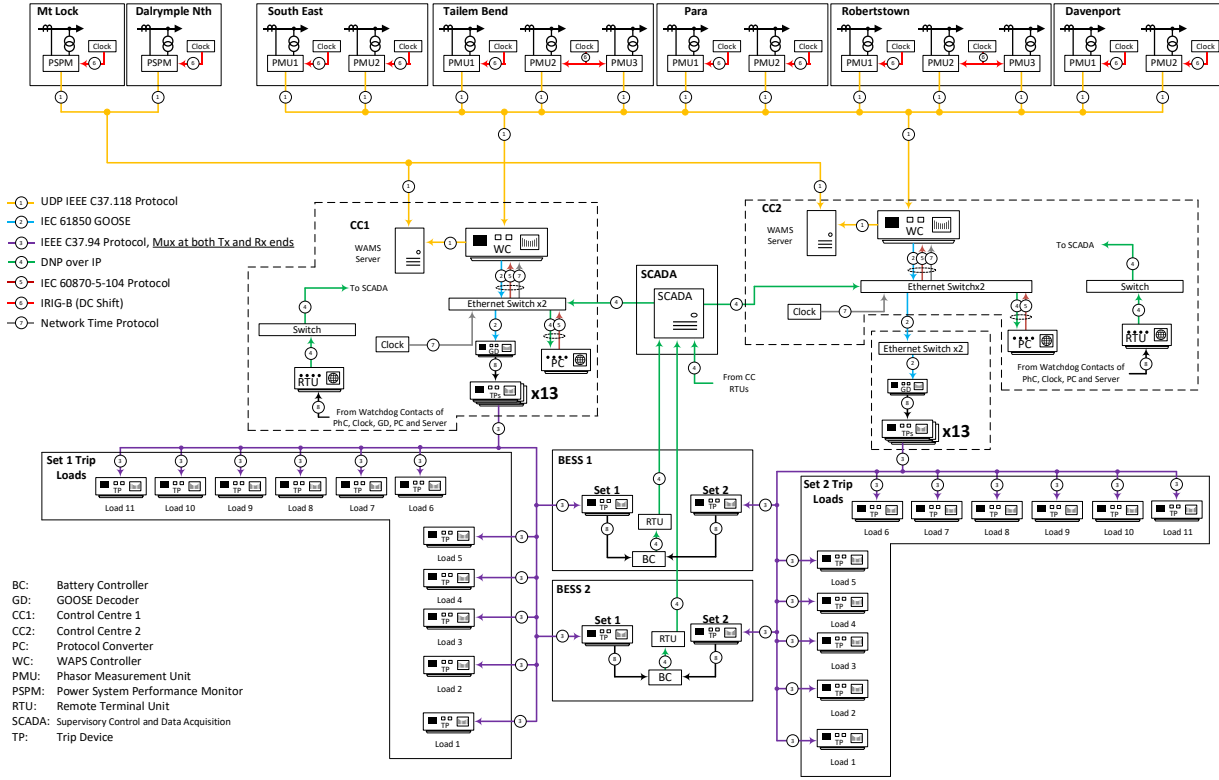
Closed Loop Simulation

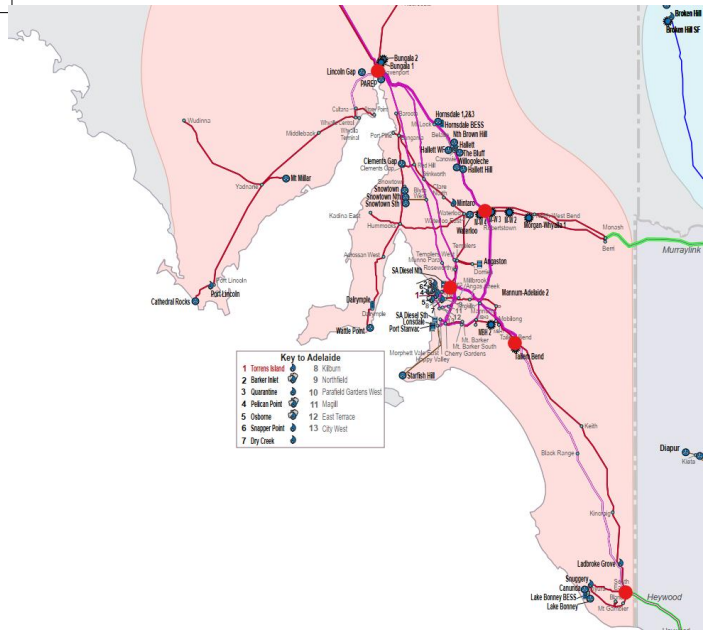
- Scheme response to a simultaneous loss of 500 MW generation





Architecture of the Scheme



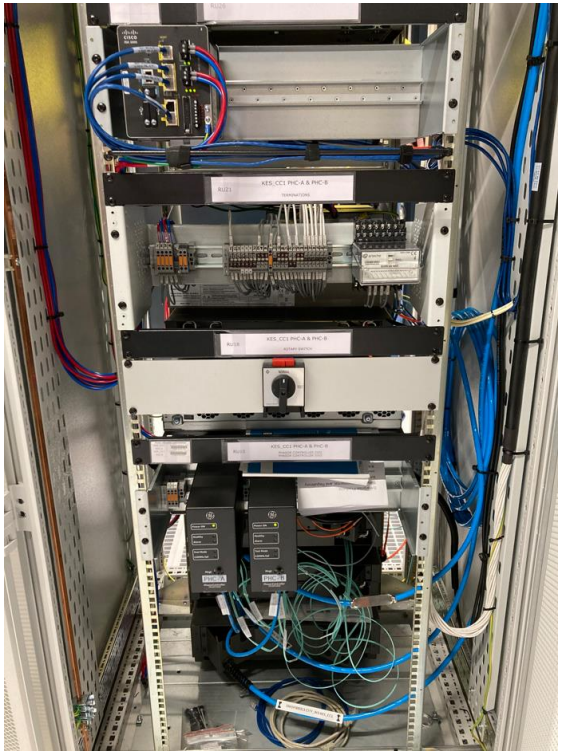


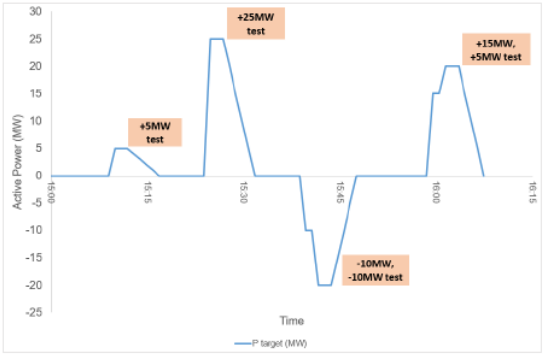
Commissioning of the Scheme

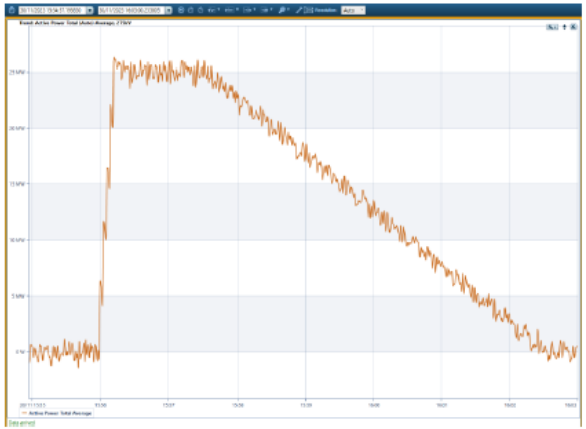
- Level 1 Factory Acceptance Testing
✓ Power-up each device, upload device settings and validate the local area communication networks

- Level 2 Factory Acceptance Testing
✓ Element Functionality
✓ Panel Functionality
✓ Design Logic Functionality

- Site Acceptance Testing (SAT)
✓ Design Scheme Functionality
✓ Off-load Commissioning Tests
✓ On-load Commissioning Tests



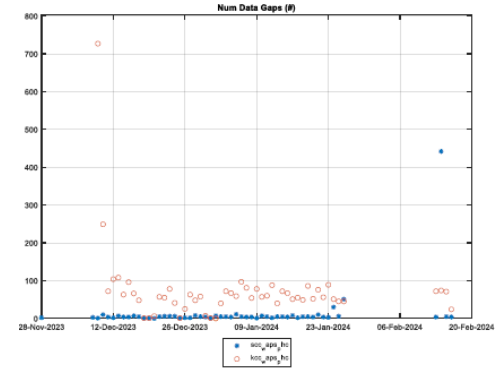




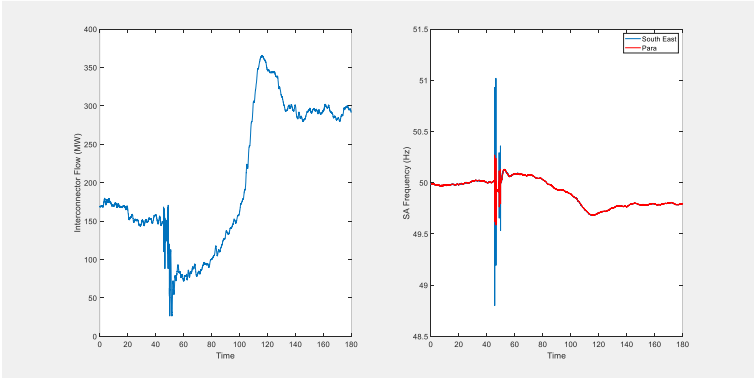
Operational Experience So Far

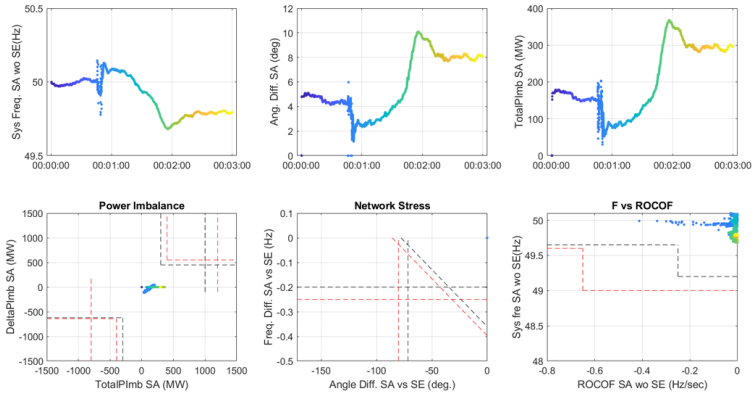
- Some issues observed during the operational period:
  - Data validity from EMS
  - PMU data validity

Date	PMUs Connected (min) %	PMUs Connected (max) %	PMUs Connected (mean) %	validPMU (min) %	validPMU (max) %	validPMU (mean) %	WAPS Data Available on WAMS (%)
28 Nov 2023	100	100	100	0	100	98.382	100
08 Dec 2023	91.304	100	99.649	0	100	99.715	73.964
09 Dec 2023	100	100	100	0	100	99.99	100
10 Dec 2023	100	100	100	0	100	99.876	100



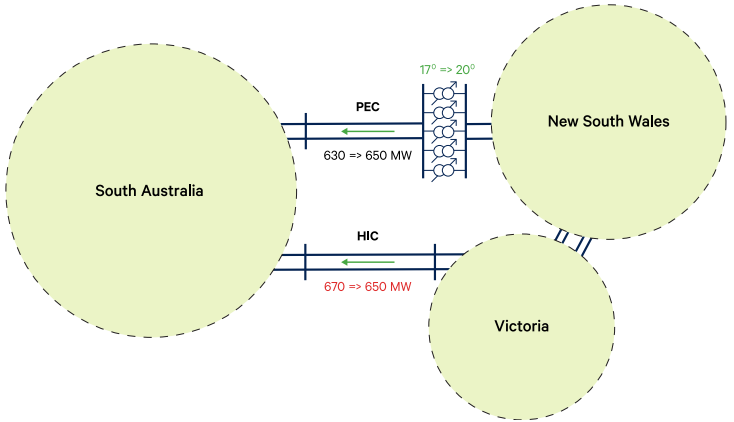
- The scheme was placed into service in December 2023
- No event occurred during this period which called on the scheme to operate
- The scheme rode through a major grid disturbance without any mal-operation
  - 500 kV double circuit line trip and loss of 2.4 GW of generation in Victoria on 13 February 2024





Future Steps

- ElectraNet together with Transgrid are constructing Project EnergyConnect (PEC), which will provide a geographically diverse second AC connection into South Australia, in addition to the existing Heywood Interconnector (HIC)
- SPS will be required to detect the non-credible loss of either HIC or PEC, and to take control action to prevent the tripping of the remaining interconnector due to transient instability
- A hybrid scheme which uses an event-driven approach (i.e. topology based) and synchrophasor based response-driven approach is required
    - **event-driven** component: initial fast response
    - **response-driven** component: complex events, DER trip, limit the need for over-compensation by the event-driven component (i.e. only operate if additional response is required)



South Australia Interconnector Trip Remedial Action Scheme (SAIT RAS)