10 July 2014

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South Australia's electricity transmission specialist

Renewables and Power System Security – lessons from South Australia

Future Grid Symposium 2014

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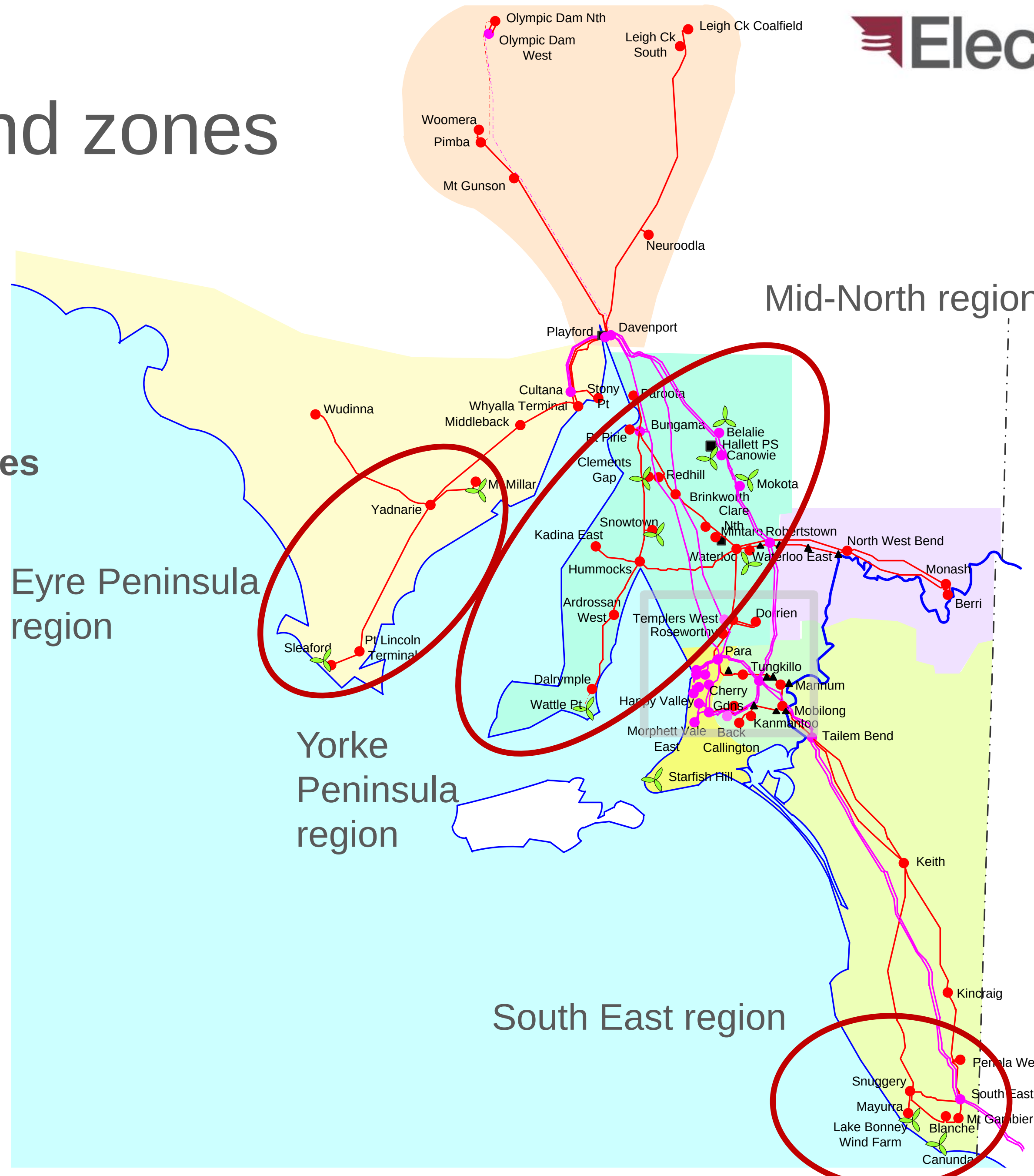
Presentation outline

> Provide context of high levels of wind energy penetration in South Australia and recent trends

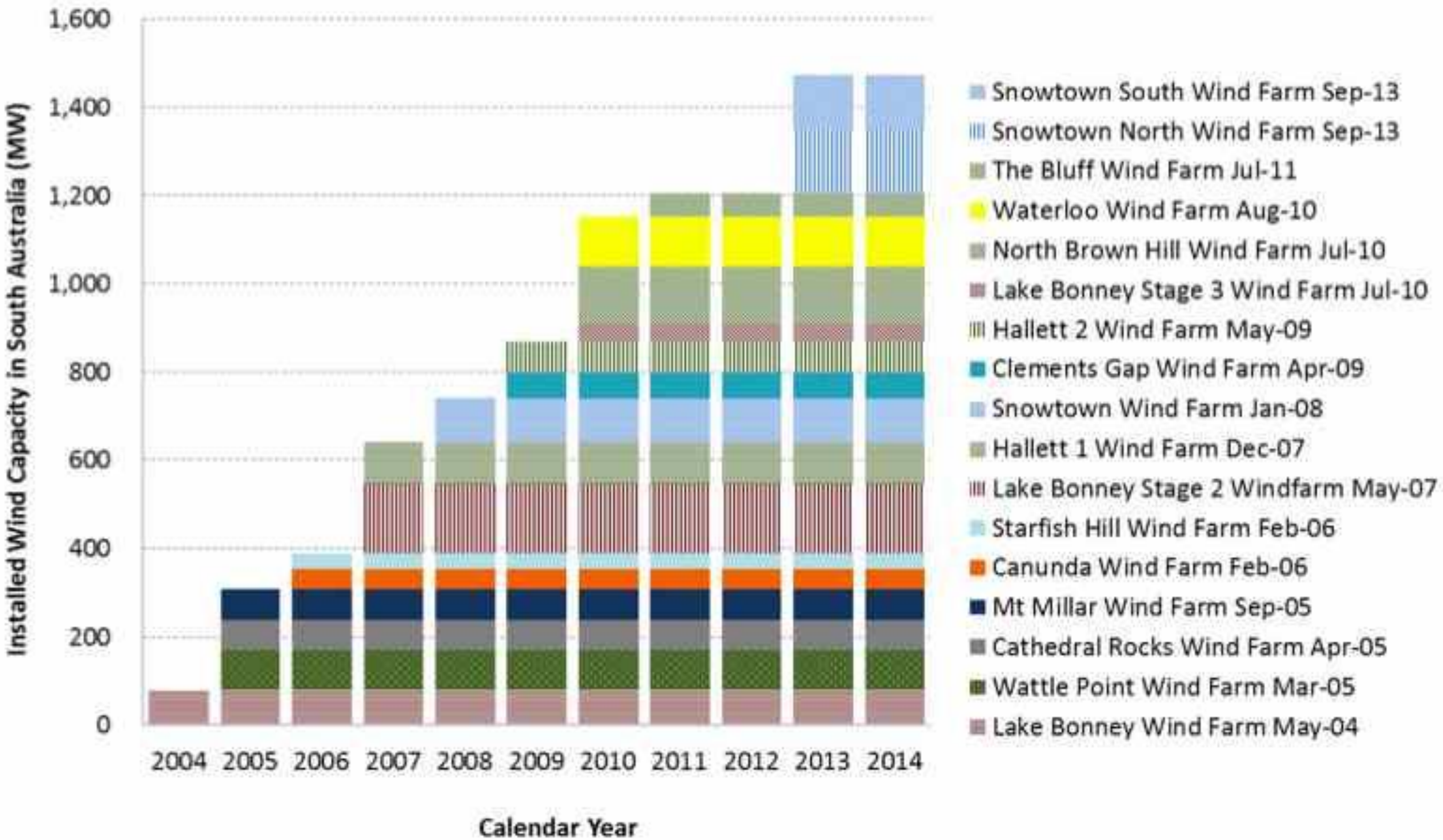
> Present early results of an ElectraNet and AEMO study which is investigating the system security implications of high levels of wind generation in South Australia

SA wind zones

Major wind zones



SA installed wind capacity



Source: Alinta Energy submission to RET review, 16 May 2014

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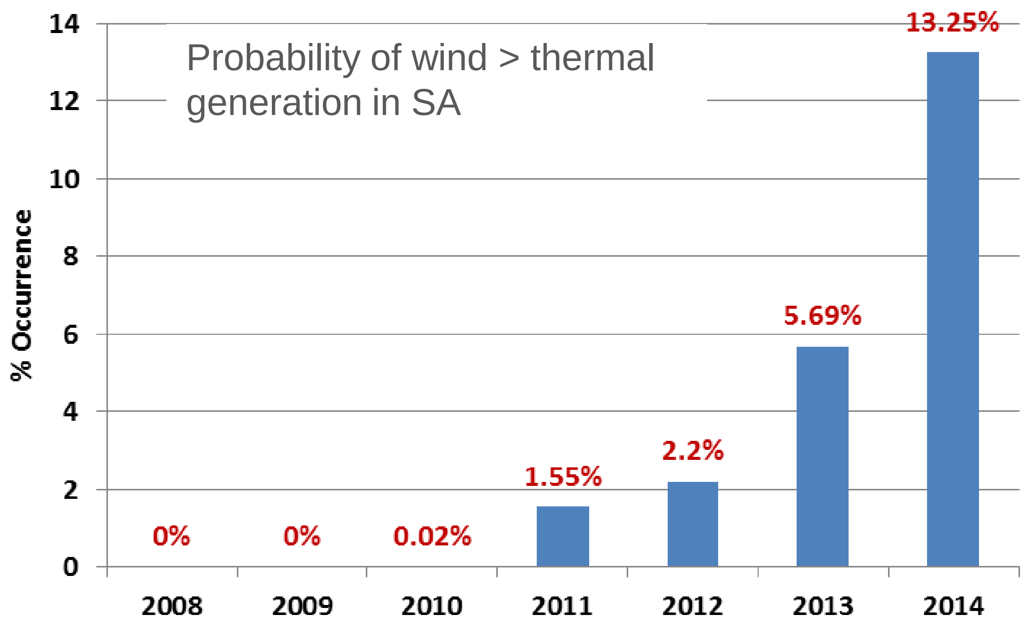
SA wind penetration metrics

Metric	Value for SA
Total installed wind generation capacity at 30 June 2014	1477 MW
Maximum instantaneous wind generation (3 July 2014 at 10pm)	1270 MW (86% of capacity)
Energy penetration – ratio of annual wind energy to annual total energy demand	> 25%
Maximum instantaneous penetration (excluding exports) – maximum observed ratio of wind energy to demand (Wind generation of 1138 MW, SA demand 1122 MW and SA export 487 MW on 27 June 2014 at 5am)	101%
Maximum possible instantaneous penetration – ratio of installed capacity to minimum demand (978 MW on 20 April 2014 at 5am)	151%
Average possible instantaneous penetration – ratio of installed capacity to average demand (1532 MW in 2013-14)	96%

Source: ElectraNet data

SA wind energy trends

- Increasing probability of wind-dominated generation scenarios (>50% of generation mix)
- Expected to increase in the future under favourable market and policy scenarios



Source: ElectraNet data

Wind integration study

Objective:

> Identify potential system security limitations arising from high levels of wind generation in South Australia

Study scope:

> Evaluate power system operation against the following criteria…

1. Minimum fault levels and short-circuit ratios
2. Frequency control and fault ride-through assessment
3. Reactive power support/ voltage control
4. Small-signal stability/ system damping
5. Transient stability

> Consider a range of system operating conditions with high levels of wind and low levels of conventional synchronous generation

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Power system security criteria

No	Criterion	What is it?	Why does it matter?
1	Minimum fault levels, short-circuit ratio	Measure of power system capability/ strength at various connection points	Load voltage regulation, protection co-ordination, fault ride-through capability
2	Frequency control (system inertia)	Maintain system frequency within prescribed limits (inertia helps by virtue of stored rotational energy)	Frequency recovery required to maintain system stability
3	Reactive power support	Required to support real power transfer and stable system voltages	Voltage stability (both steady-state and transient)
4	Small-signal stability	Adequate damping of small oscillations on electrical network	Mechanical integrity of connected generators and the power system
5	Transient stability	Ability to recover from large system disturbances	Maintain security of plant and power system

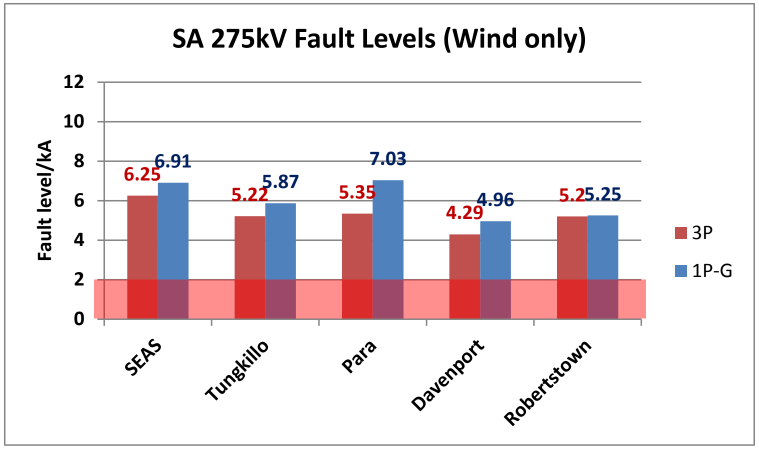
Operating conditions studied

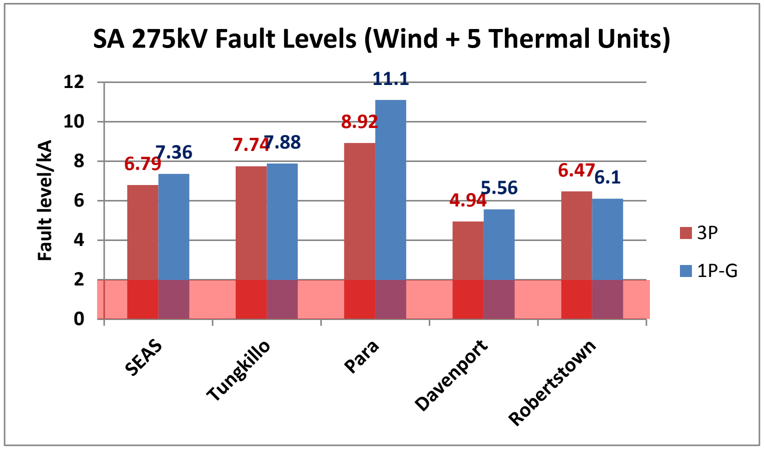
> Power system scenarios:
  - SA light demand (1100 MW to 1400 MW)
  - Low conventional/ synchronous generation (0-5 thermal units) online
  - High wind generation (up to 1500 MW)

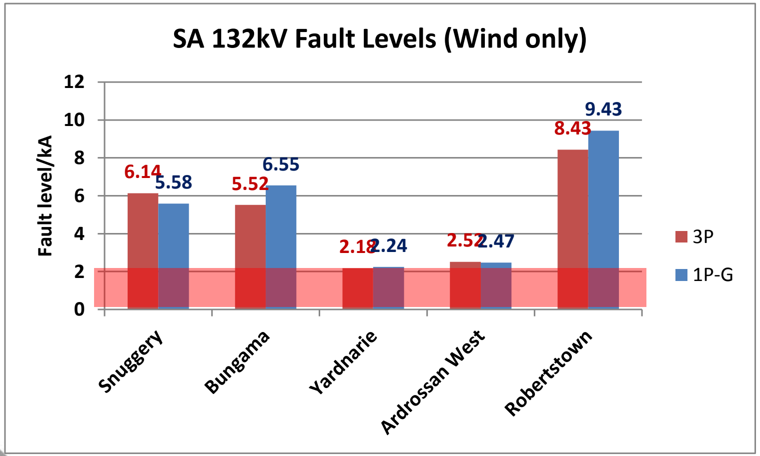
> Heywood Interconnector maximum import and export scenarios at current capacity (460 MW) and upgraded capacity (650 MW)

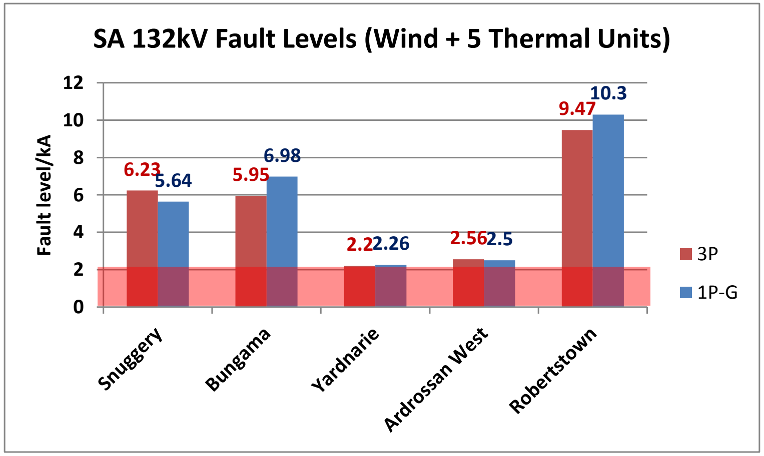
> Range of contingencies considered including loss of the Heywood Interconnector between SA and Victoria

Results – Fault levels









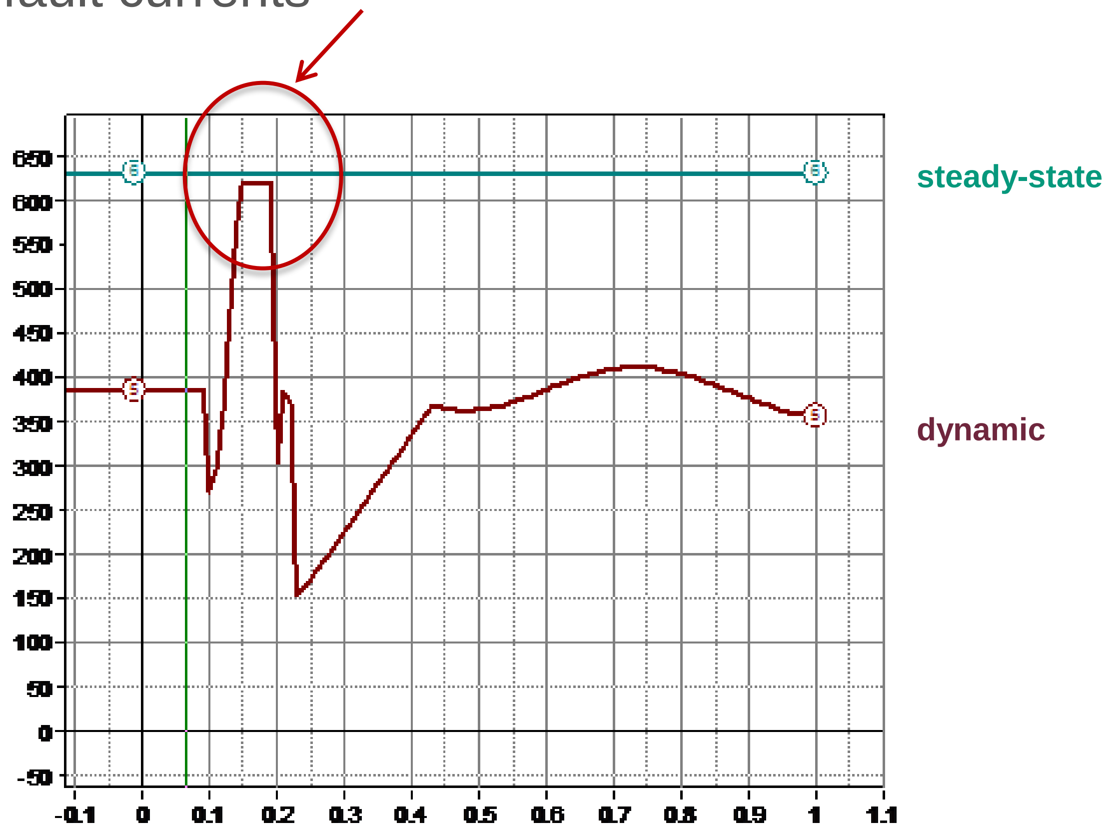
- All fault levels at or above the 2 kA minimum required for effective operation of protection systems even with no thermal units
- Adequate margins (>4 kA) on most 275/132kV buses, except on Eyre and York Peninsula.

Fault levels and short-circuit ratios

> All short circuit ratios were at the about 4 or above required for effective operation of protection and wind farm control systems

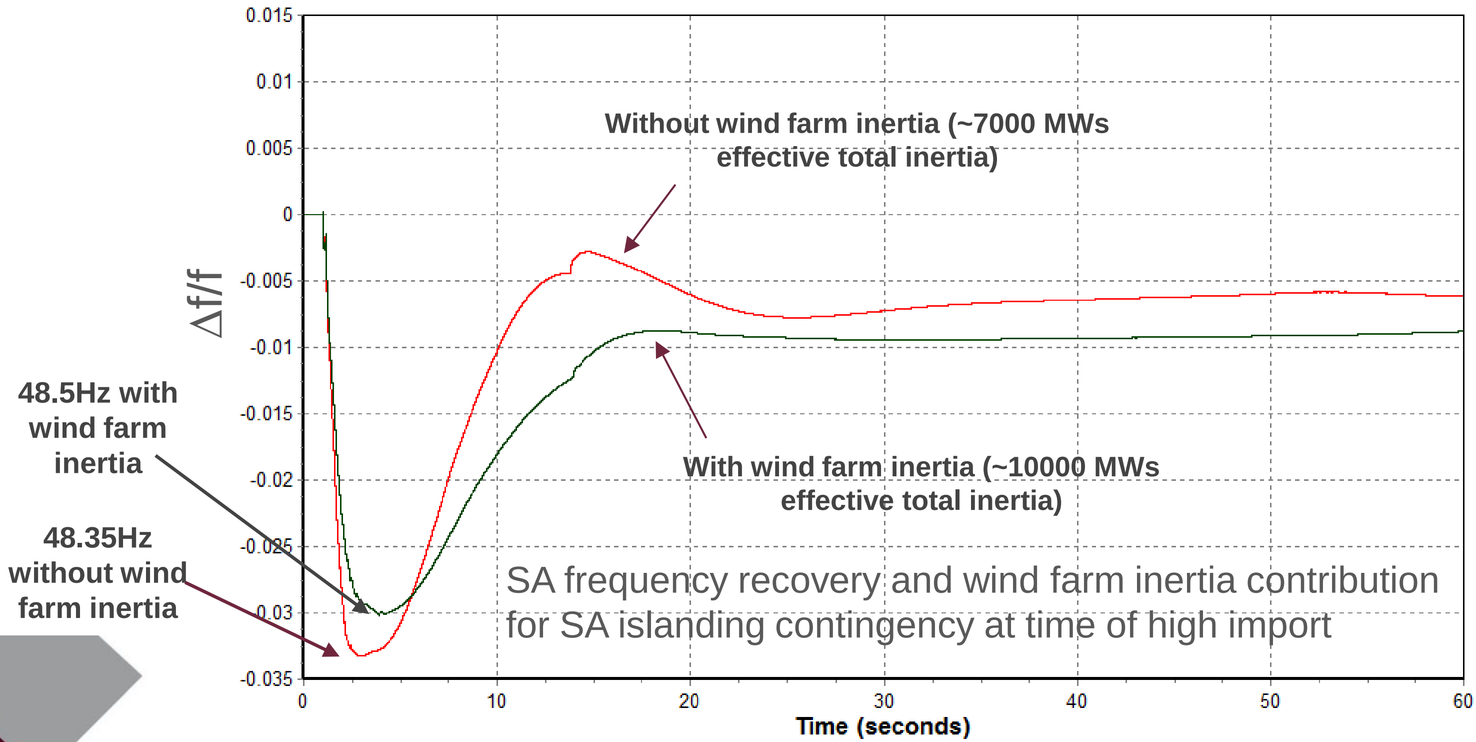
> Good correlation obtained between static (steady-state) and dynamic fault currents

Example comparison between steady-state and dynamic fault current calculations



System inertia and fault ride through

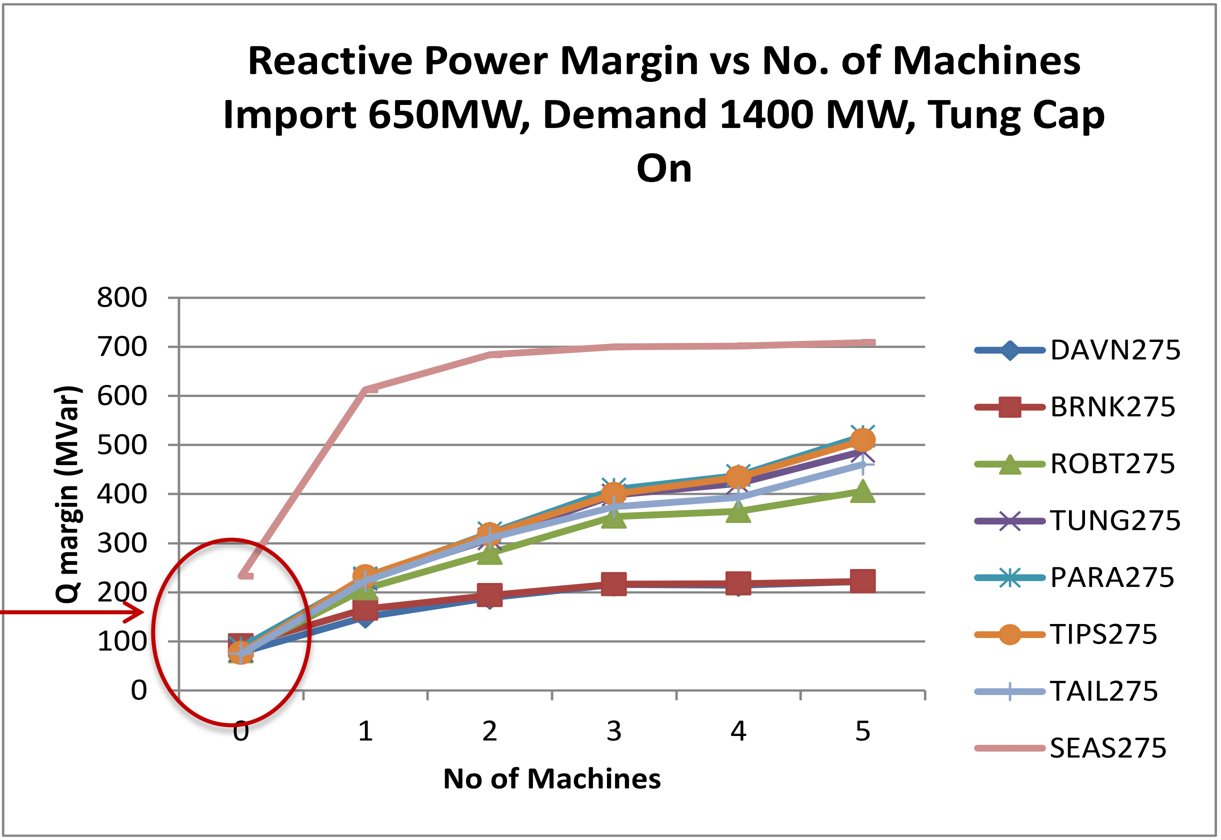
- At least one thermal unit is required on-line to control frequency
- SA is able to survive islanding under high import conditions with at least one thermal unit on-line (and under frequency load shedding);
- Inertia contribution from SA Type 1 & 2 wind farm models observed which limits rate of change as well as depth of frequency excursion



Reactive support/ voltage stability

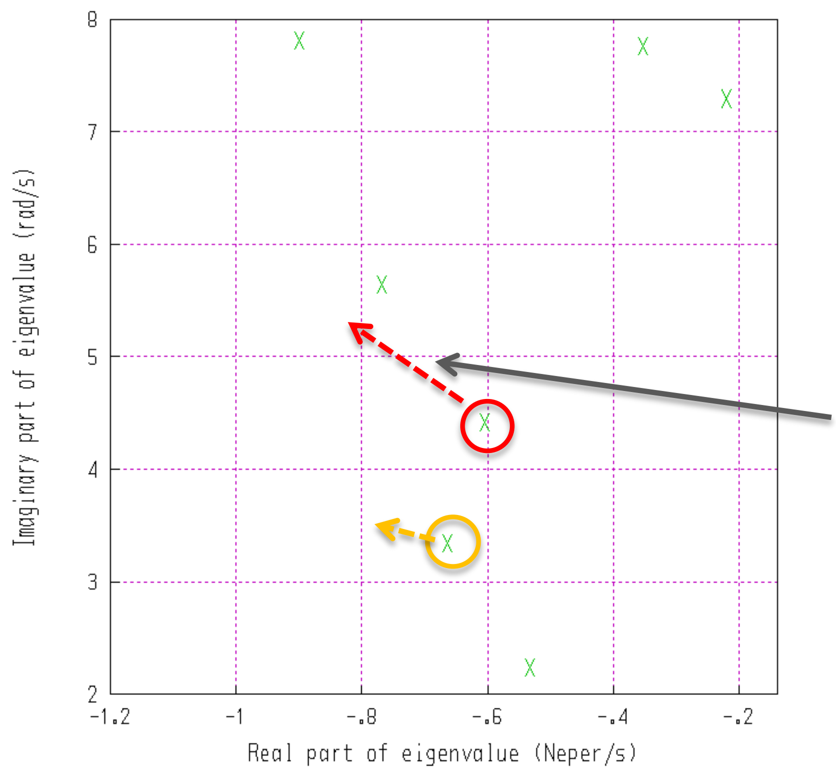
- No reactive support issues under high export conditions
- Worst case condition is high import conditions with no thermal units – additional reactive support needed to maintain voltage stability)

Additional 100MVAr reactive dispatched in limiting case with no thermal units to maintain positive Q-V margin



Small signal stability

- Sufficient system damping observed under maximum wind dispatch even with no thermal units – modes disappear with no thermal units
- Inter-regional modes to be investigated further



SA import conditions

Left shift in some intra-regional machine modes (improvement in damping) observed when reduce thermal units from 4 to 1

Further work to be undertaken to test and understand this outcome

Summary of findings

- Studies indicate that the South Australian power system can be operated securely at N-1 with high levels of wind generation
- Most system security criteria were satisfied even with no thermal generating units on-line except…
  - Frequency control requires at least one thermal unit
  - Voltage stability under high SA import conditions requires at least one thermal unit or additional reactive dispatched
  - Transient stability/ overvoltage and voltage recovery under islanded conditions
- No network and generation protection co-ordination issues were identified

Summary of findings (cont.)

- For credible contingencies, no issues with system frequency and voltage recovery post-fault (with at least one thermal unit)
- For non-credible contingency involving loss of Heywood Interconnector, local SA frequency controls allow SA system frequency recovery to within Frequency Operating Standards (with at least one thermal unit)
- Sufficient reactive support margins (when utilising all mitigation options including high voltage capacitor bank dispatch)
- Sufficient system damping under maximum wind dispatch

Next steps

> Current studies expected to be concluded within next months with recommendations for further work

> ElectraNet and AEMO to consider how results are communicated

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