Reliability of Supply, Security of Supply & the SA Black System Event - Lessons from Australia

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Background to Australia's National Electricity Market (NEM)

- Formed in 1998. Covers eastern seaboard of Australia (QLD, NSW, VIC, SA, TAS, ACT)
- Max Demand 34,000 MW (Sum of the Regions = 38,400 MW)
- Energy Demand 204,000 GWh (incl. 9,170GWh rooftop PV)
- 8.9 million residential connections + 1 million business connections
    - 1.9 million NEM households have a rooftop solar PV system (10,000+ MW)
- Installed Capacity* 47,500 MW - Coal 71%, Gas 8%, Renewables 21% of which 13.8% is VRE
        - SA = 51% renewables (29% wind + 4% solar + 16% rooftop solar), 46% gas, 2% BESS
- New entry 2018-2020: 9,034 MW across 77 Projects commissioned or under construction
    - 46 x Solar PV Projects (4,771 MW) and 23 x Wind Projects (3,907 MW)

*Excludes rooftop PV and non-scheduled generators

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NEM Market Design

- Real-time, gross-pool energy-only market. Self commitment. Single platform. 5 regions, zonal prices.
  - $19.4 billion turnover in 2018-19
  - Forward market liquidity ~350% of physical in 2018-19
  - One of the longest interconnected grids in the world (40,000km Trans.)
- 4 co-optimised Frequency Control Ancillary Services (8 spot markets)
  - FCAS Regulation (~250-300MW raise/lower, up from 130MW)
  - FCAS 6 Second Contingency
  - FCAS 60 Second Contingency
  - FCAS 5 Minute Contingency

  } Largest Credible Contingency (i.e. ~750MW unit)
- Normal Operating Frequency Band 50Hz +/- 0.15Hz ≥ 99%

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Reliability of Supply vs Security of Supply

- Reliability of Supply (Resource Adequacy) is different to Security of Supply
- Reliability of Supply: does the power system have sufficient supply-side (and DR) resources given expected (PoE10) Maximum Demand
  - NEM Reliability Criteria: *no more than 0.002% lost load*
  - In energy-only markets, essential that Market Price Cap has tight nexus with Reliability Criteria
- Security of Supply: can the power system withstand the sudden loss of the largest generation or transmission element (i.e. a credible contingency)
- AEMO is responsible for Security
- 'The Market' is responsible for Reliability

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On Reliability of Supply

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Market Design & Markets in Transition

- The NEM's energy-only spot and forward markets have delivered Resource Adequacy and met the Reliability criteria very few exceptions over the last 20 years (5 regions)
- This has happened under a wide range of economic and technical conditions. Going forward, I have no reason to believe this will not continue
  - Rising VRE is not a reason to change market design – the supply curve remains upward-sloping and therefore the market remains tractable (at least through to 50% VRE – see South Australian NEM region, also see Simshauser 2018, Marshman et al. 2019)
  - But with rising VRE, maintaining system security is becoming increasingly challenging and this is a problem that needs addressing - 'missing markets' (not to mention our 'missing policy')
- Market design changes require problems to be identified with 'surgical precision', and solutions rolled out quickly to minimise disruption to the flow of funds

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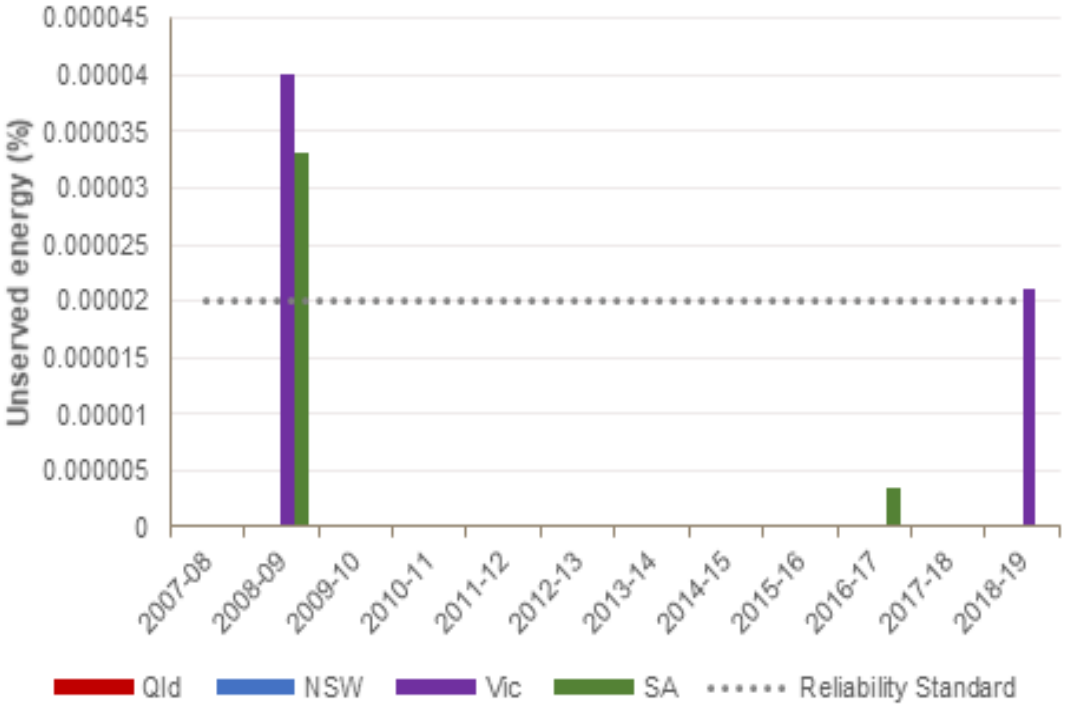
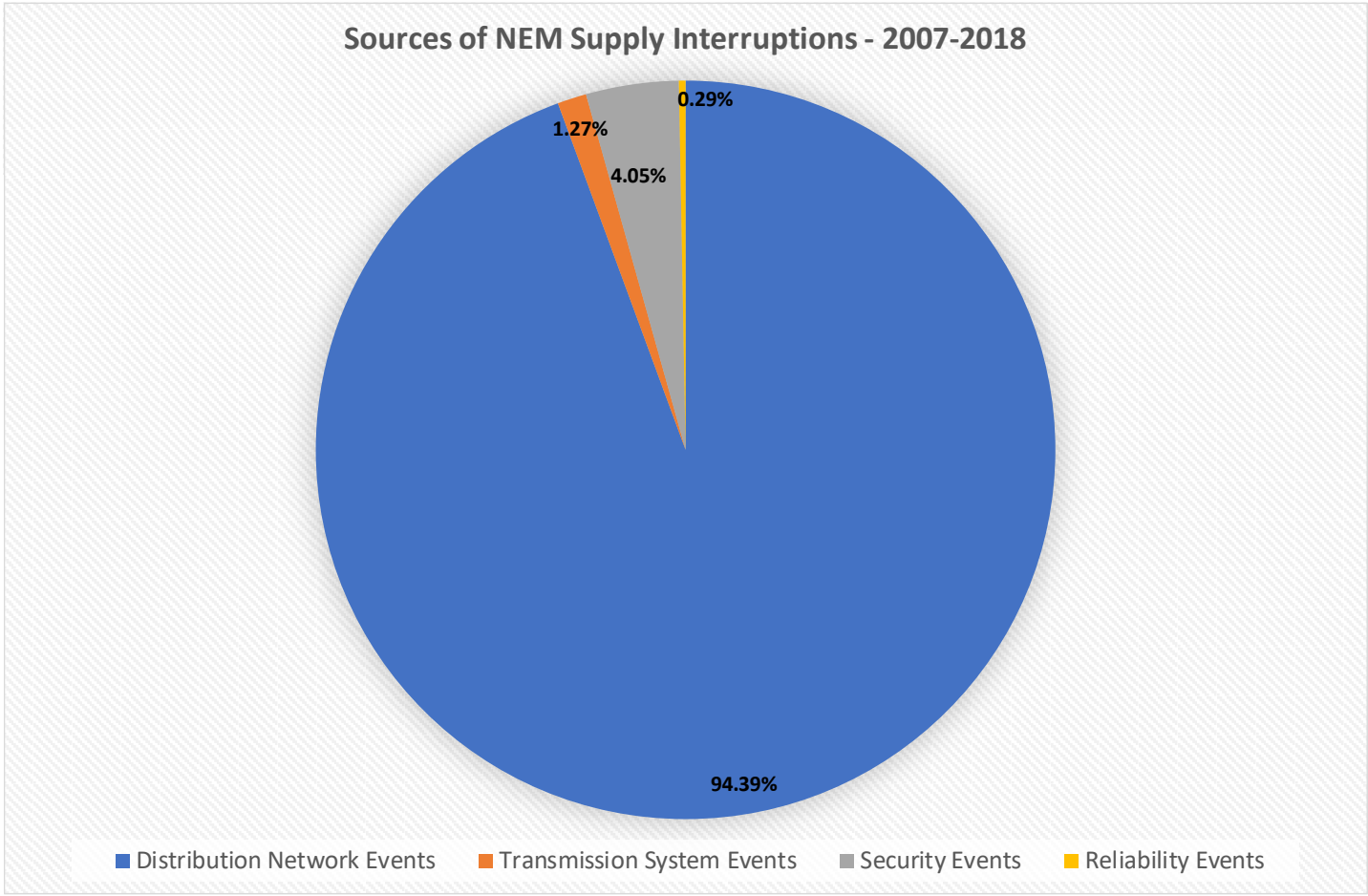
Reliability of Supply: met with few exceptions





Source: AEMC

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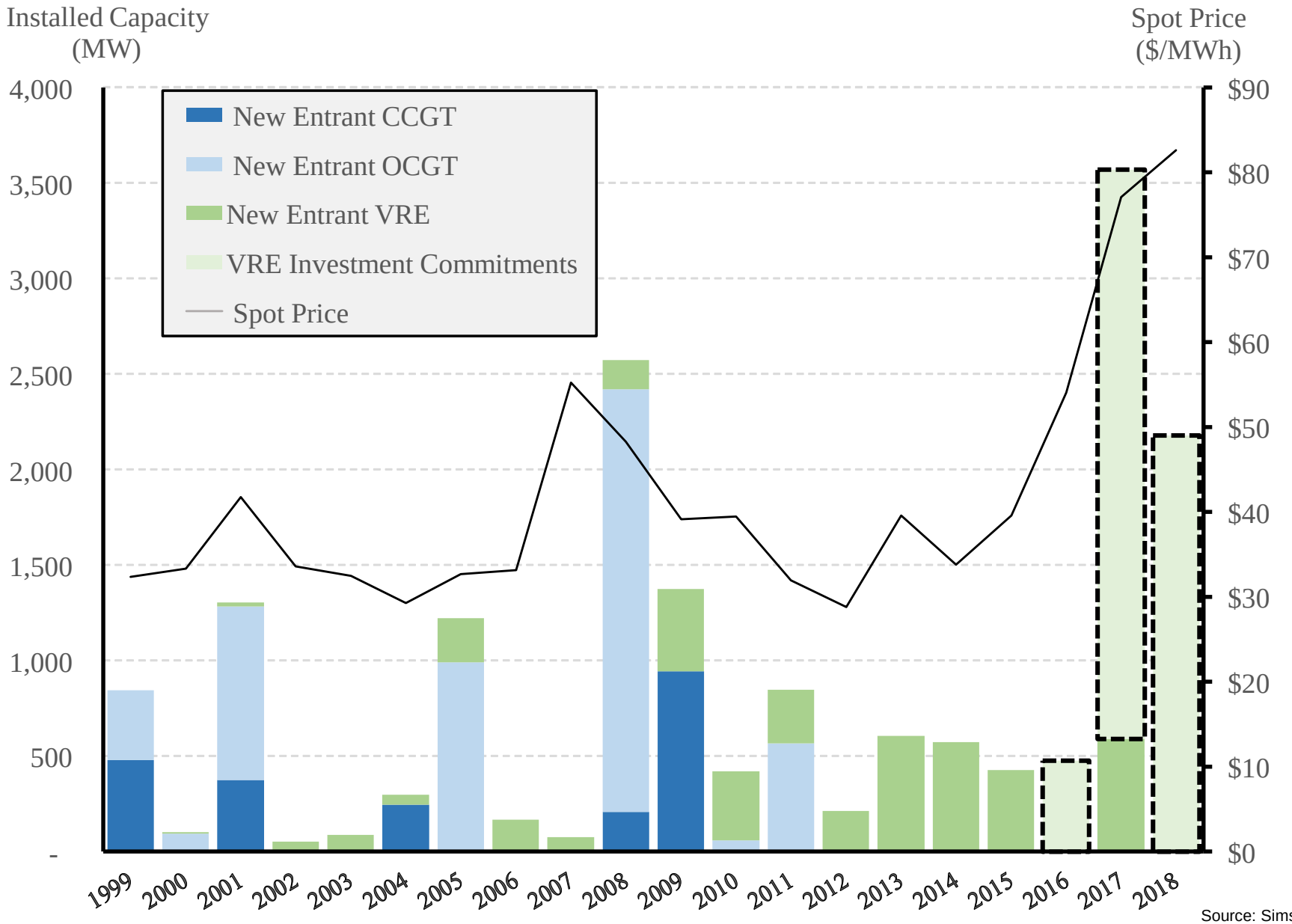
Spot and forward markets: investment occurs when required



Source: Simshauser (2019)

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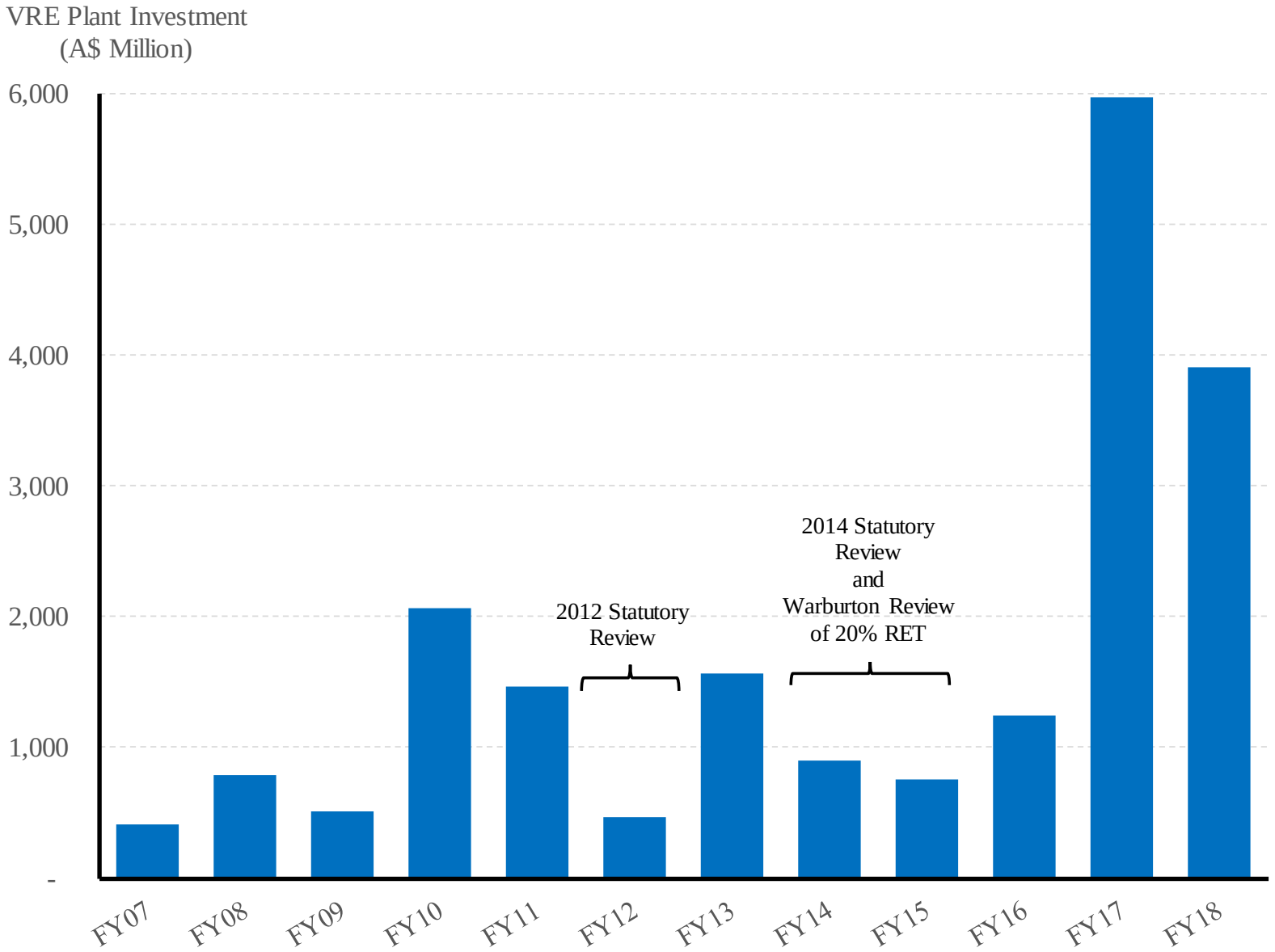
Changes to market requires surgical precision. Uncertainty can lead to an investment freeze while we decide.



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On Security of Supply

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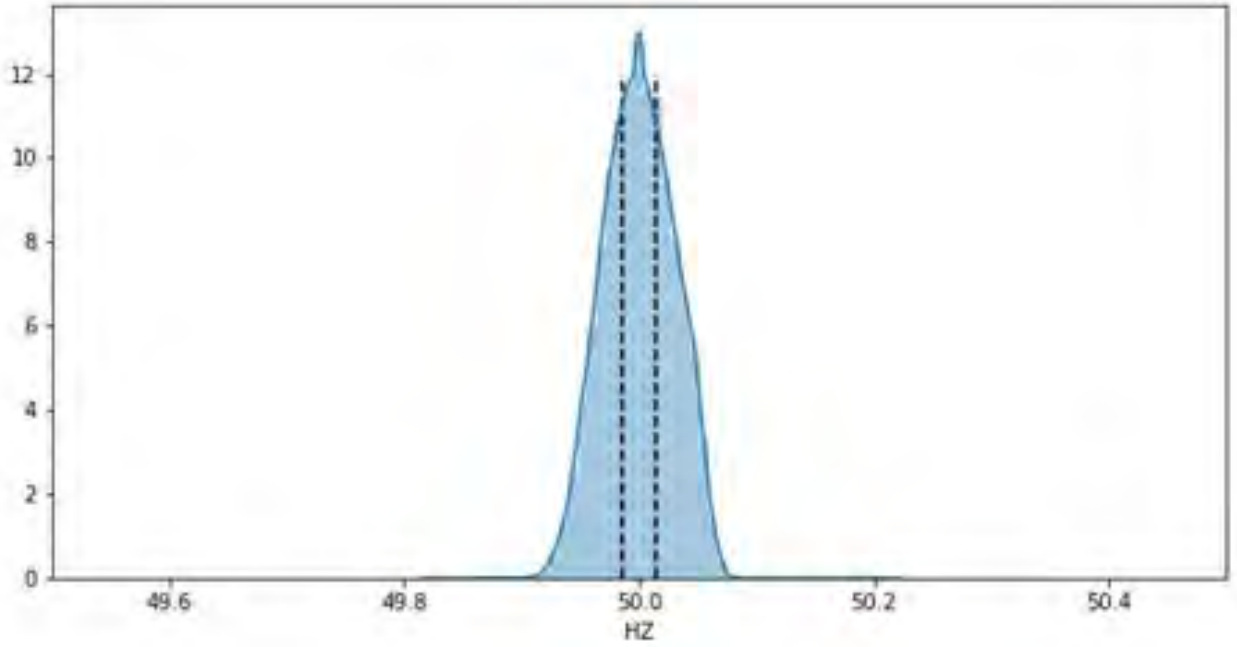
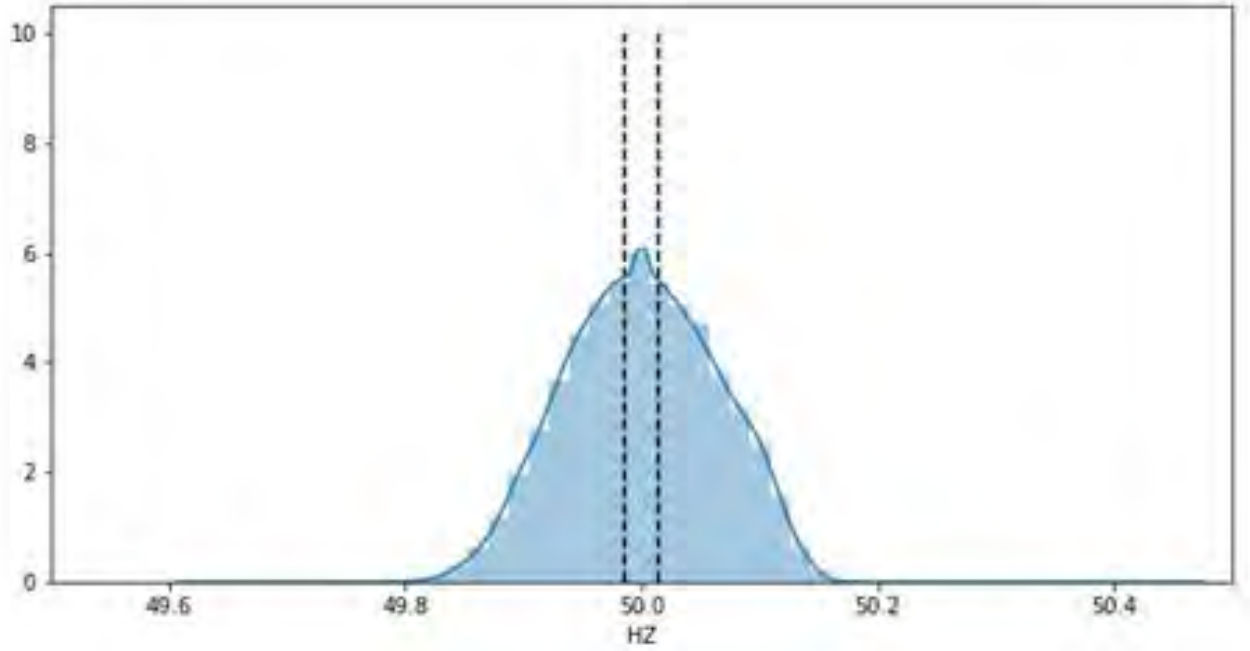
Security of supply - increasingly challenging.

System Frequency 2005



System Frequency 2019



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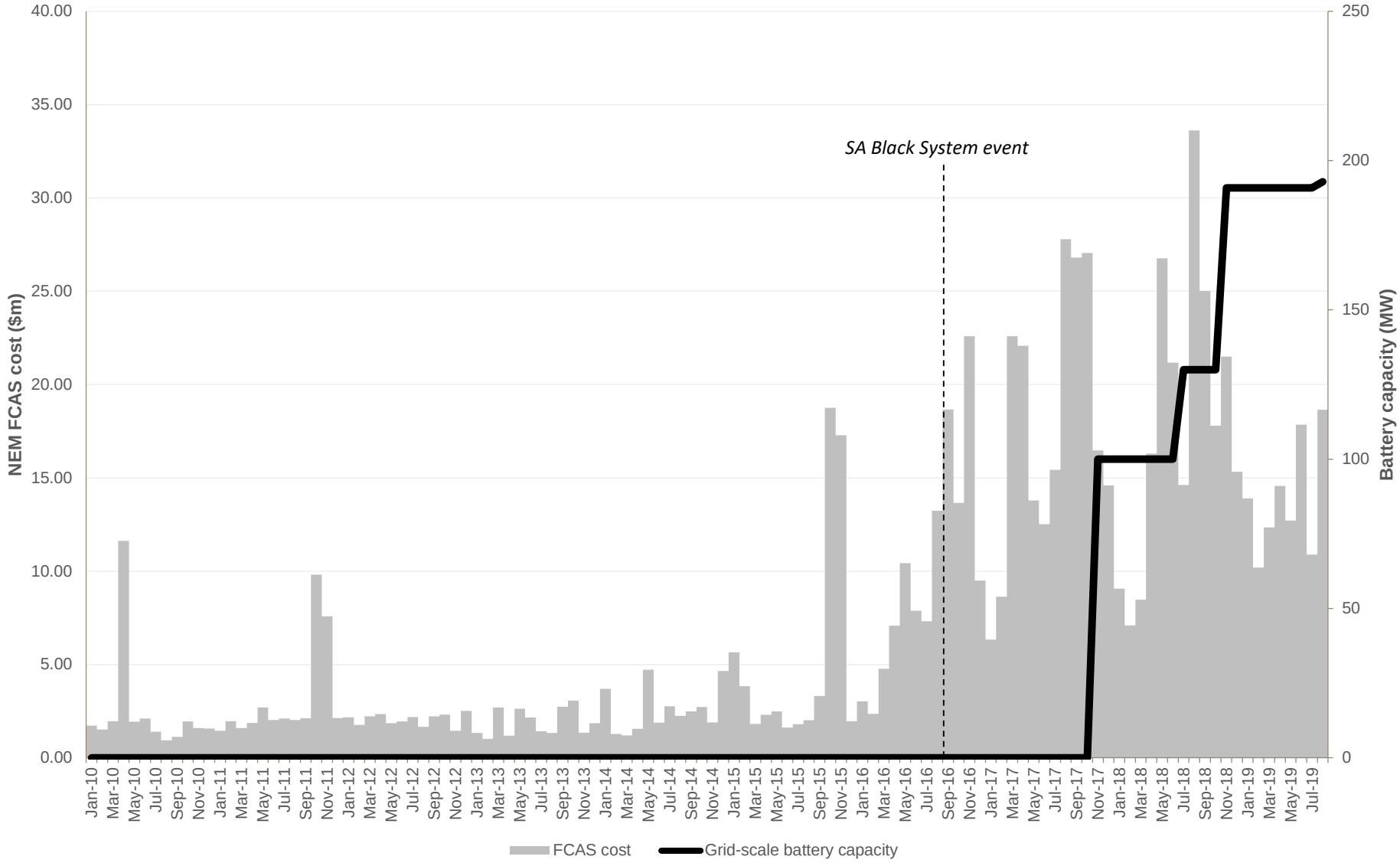
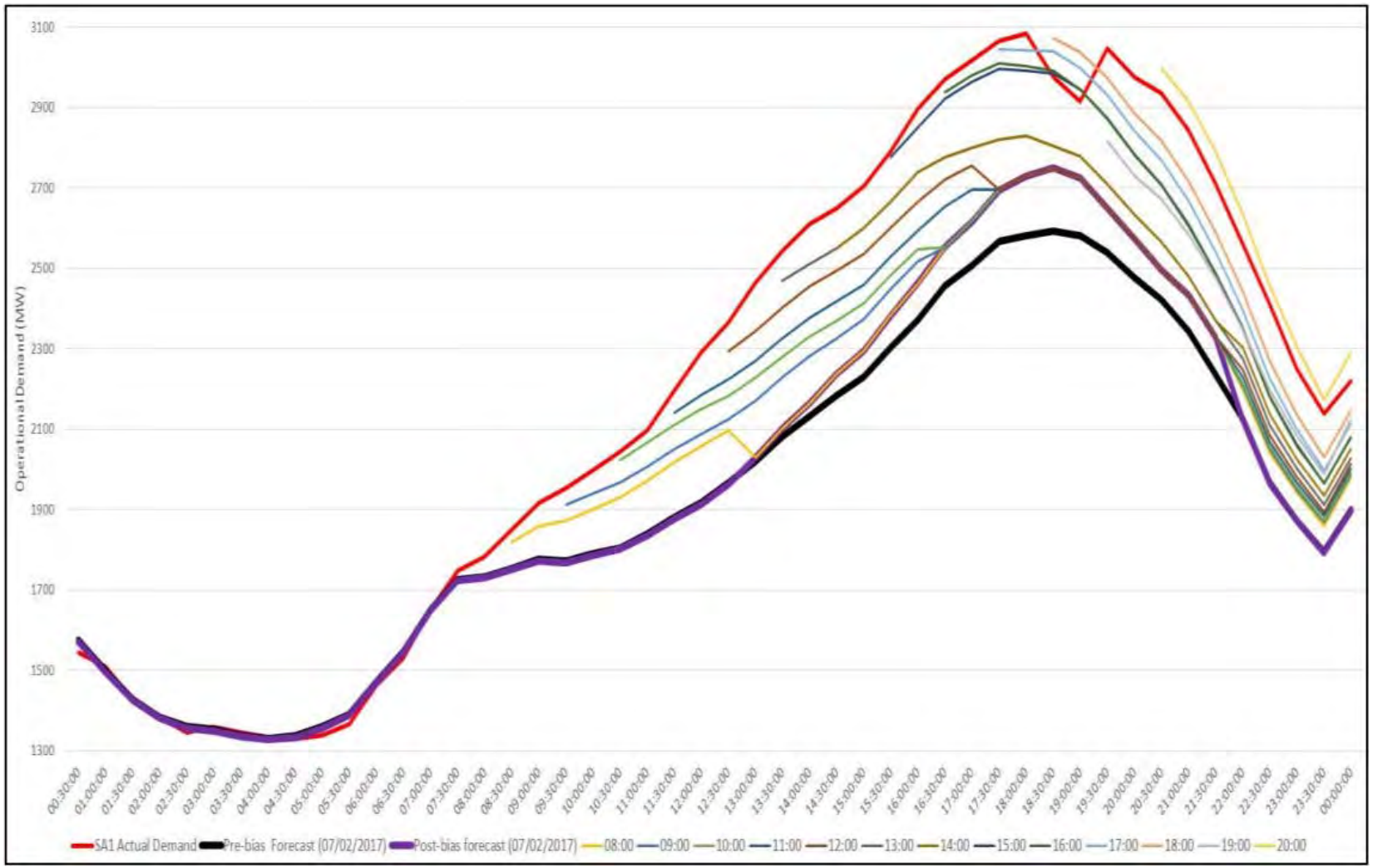
NEM FCAS Costs 2010-2019 – rising sharply



Source: Simshauser & Gilmore, IFN Submission to ESB (2019)

Forecast Uncertainty…



SA, 8 Feb 2017

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On the SA Black System Event

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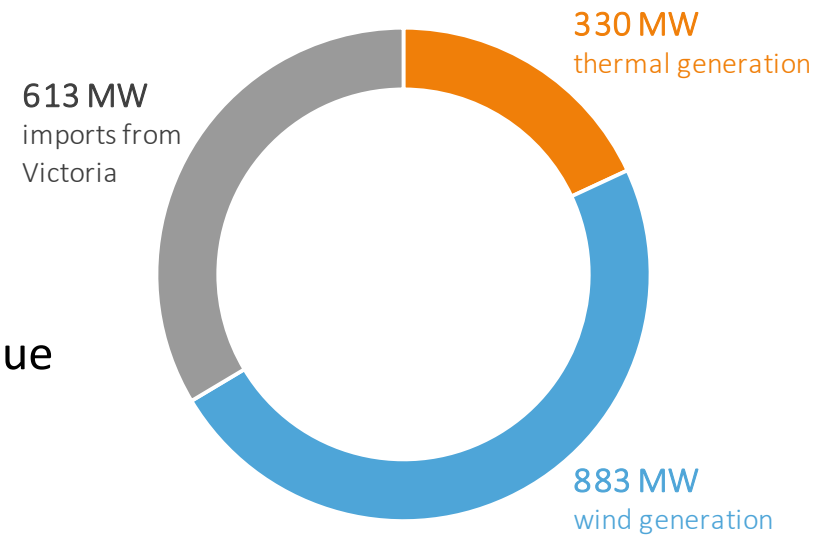
Background to Black System Event

- On 28 Sept 2016, the SA power system collapsed
- First black system event in Aust since 1964
- Severe storm cell moved through the state, transmission lines damaged causing a series of voltage dips over a 2 minute window
- System Configuration at t-7 seconds:
  - 883MW Wind
  - 330MW Gas
  - 613MW Vic-SA Interconnector (~fully loaded)
- 4 wind farms (456MW) disconnect – an unknown fault ride-through issue
- Interconnector surges to 890MW (260MW > overload capacity)
- Interconnector opens, SA system is 'islanded'.
- RoCoF was at least 6.25Hz/s – lack of inertia…
- FCAS Regulation + UFLS can arrest RoCoF of ~3.5Hz/s



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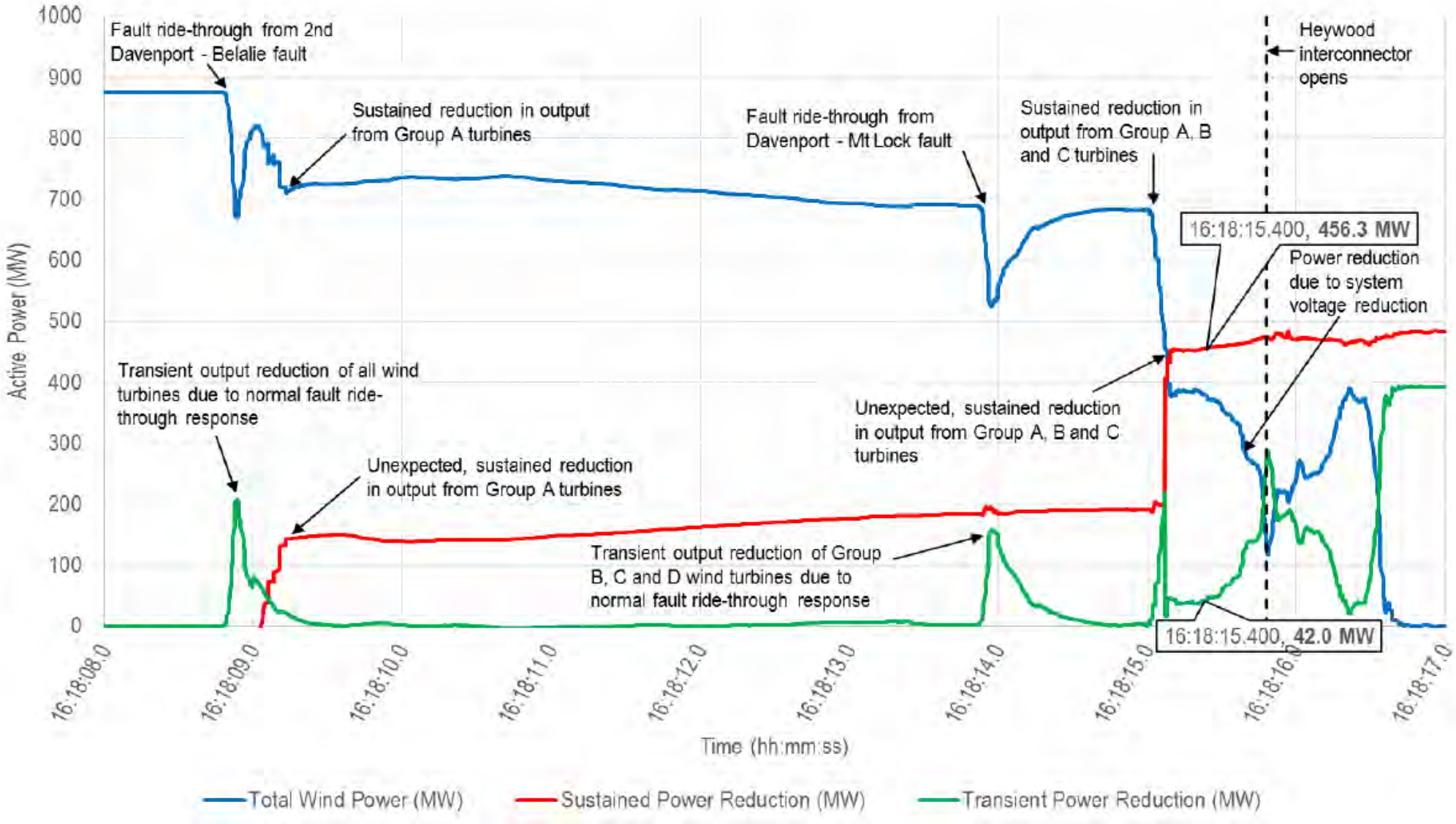
Wind Farms Disconnect over a 7-second period



456MW of wind disconnected over a 7 second period

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SA System Frequency (Blue) vs VIC System Frequency (Red)

2.5 second time lapse

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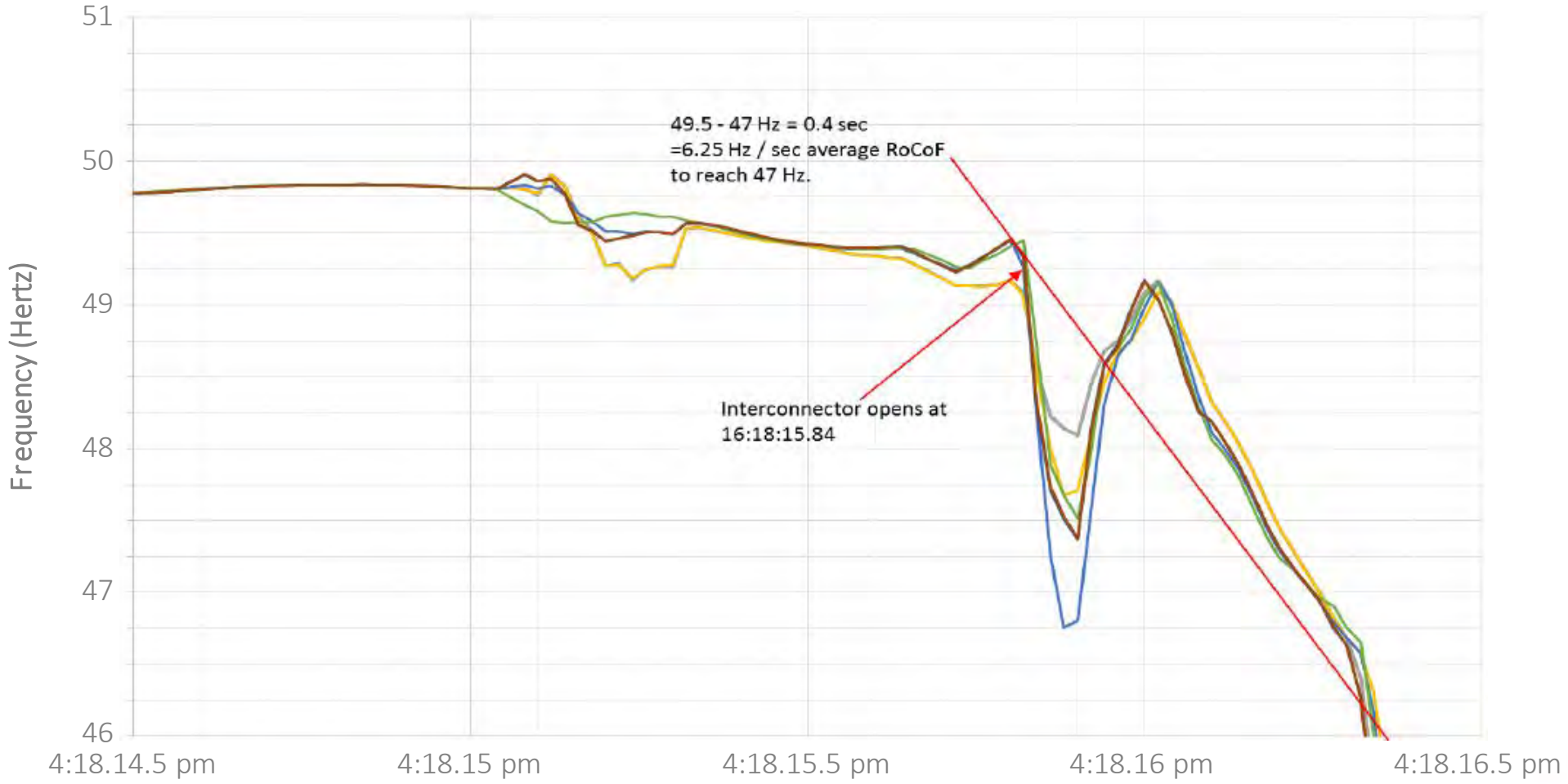
Rate of Change of Frequency – various SA nodes



2.5 second time lapse

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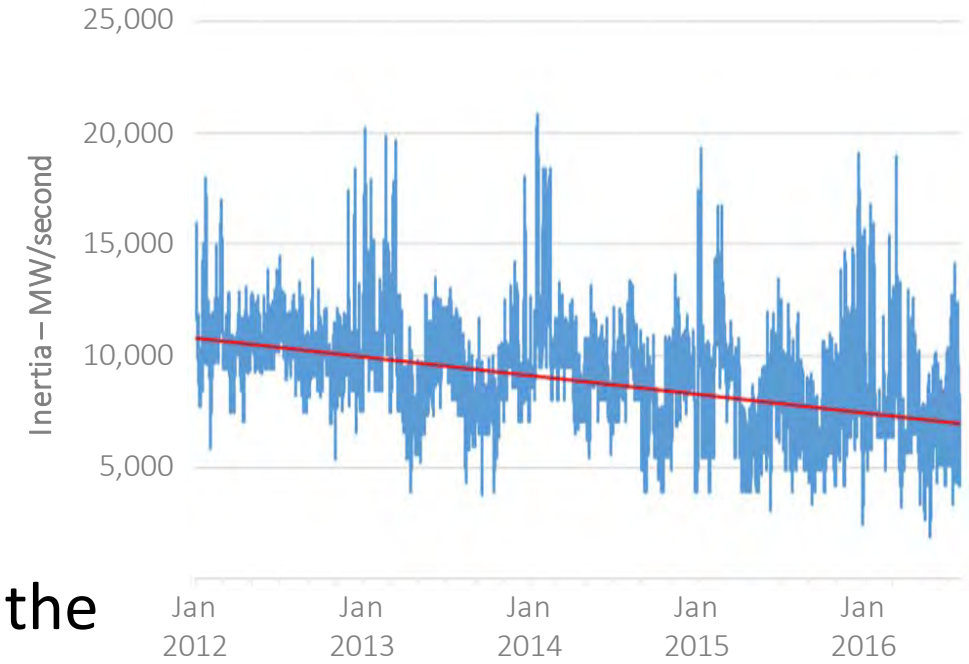
Security of Supply

- With rising VRE, system conditions become more volatile
- As coal plant exits – Inertia (MW/s) declines
- It also deducts from the supply of Primary Frequency Response
- FCAS quantities procured need to rise
  - FCAS Regulation incr. so far: 130 - 300MW
  - Forecast Uncertainty will eventually become the largest credible contingency, and FCAS Contingency needs to rise accordingly
- Inertia (SynCons), Fast Frequency Response (BESS) and Operating Reserve Markets are now required



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Summary

- Australia's NEM has met the Reliability Criteria with very few exceptions under a wide array of technical & economic conditions
  - A tight nexus exists between the Market Price Cap and Reliability Criteria (at $14,700/MWh – it is among the highest in the world)
- Where the NEM has struggled is Security of Supply - repeatedly caught flat-footed from ~May 2016:
  - FCAS Regulation quantities should have been raised *much* earlier
  - The loss of coal plants should have brought on markets for Inertia and Fast Frequency Response earlier (i.e. SynCons, <2 second response etc)
  - FCAS Contingency also needs to be expanded to incorporate additional Operating Reserves to deal with rising Forecast Uncertainty (which in our market, is routinely measured and monitored by AEMO)
  - nb. I have a Rule Change being drafted on FFR & Op. Reserves!

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