NZWEA Energy Resilience Workshop: Lessons from South Australia blackout: Improving Resilience with Synchronous Wind Power

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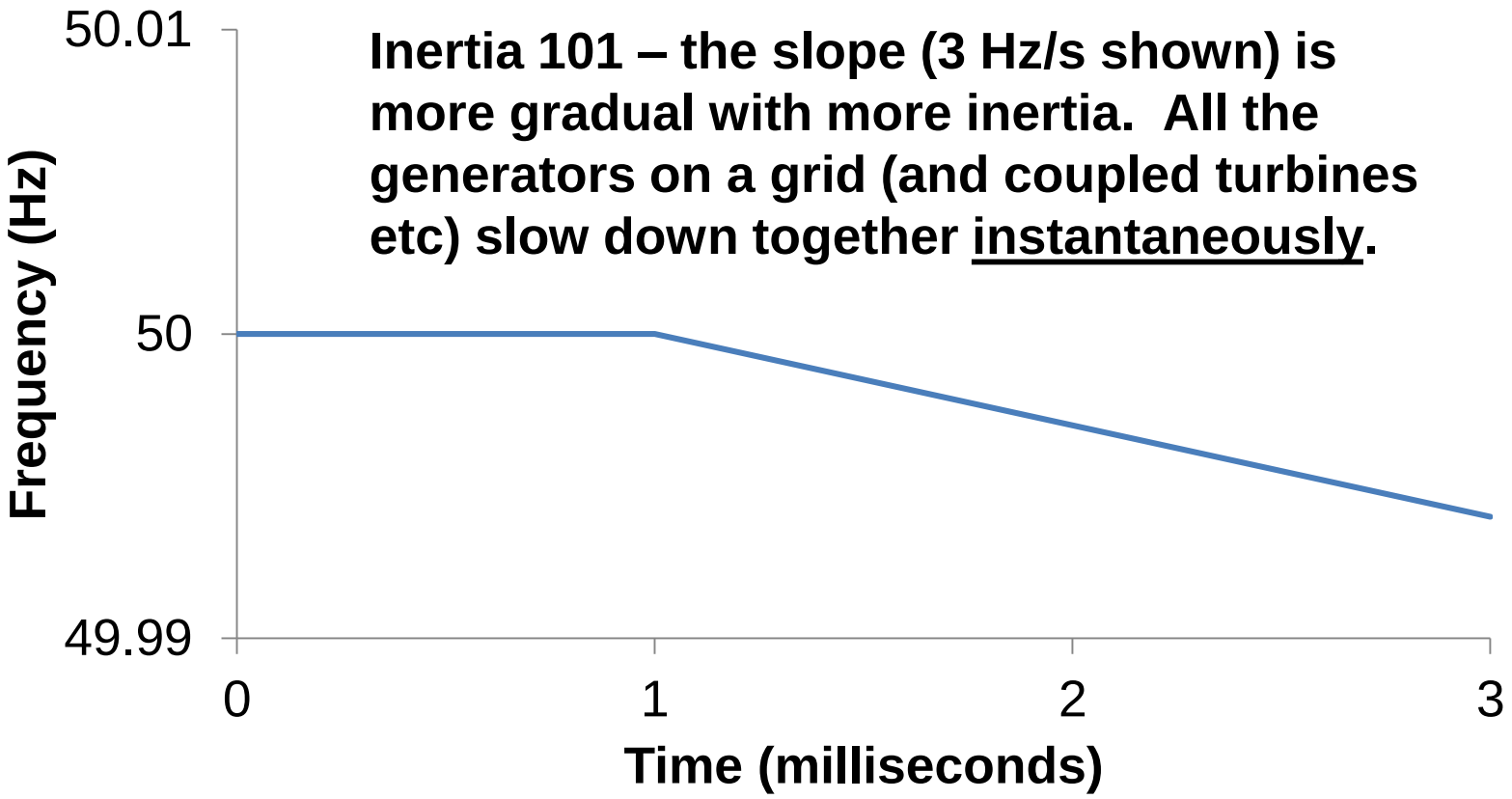
NZ's 21st Century Problem

- As solar PV and other renewables that have power electronics increase their penetration, system inertia falls, along with other attributes of synchronous generators like fault current/system strength and inherently helpful reactive power export/import
- Not a problem right now for NZ (with so much hydro)
- But what if population/power demand doubles and growth comes from wind and solar?
- South Australia already hitting up against stability limits
- Windflow's answer: synchronous wind power is possible, proven and cost-effective
- An inertia-less grid is not the answer

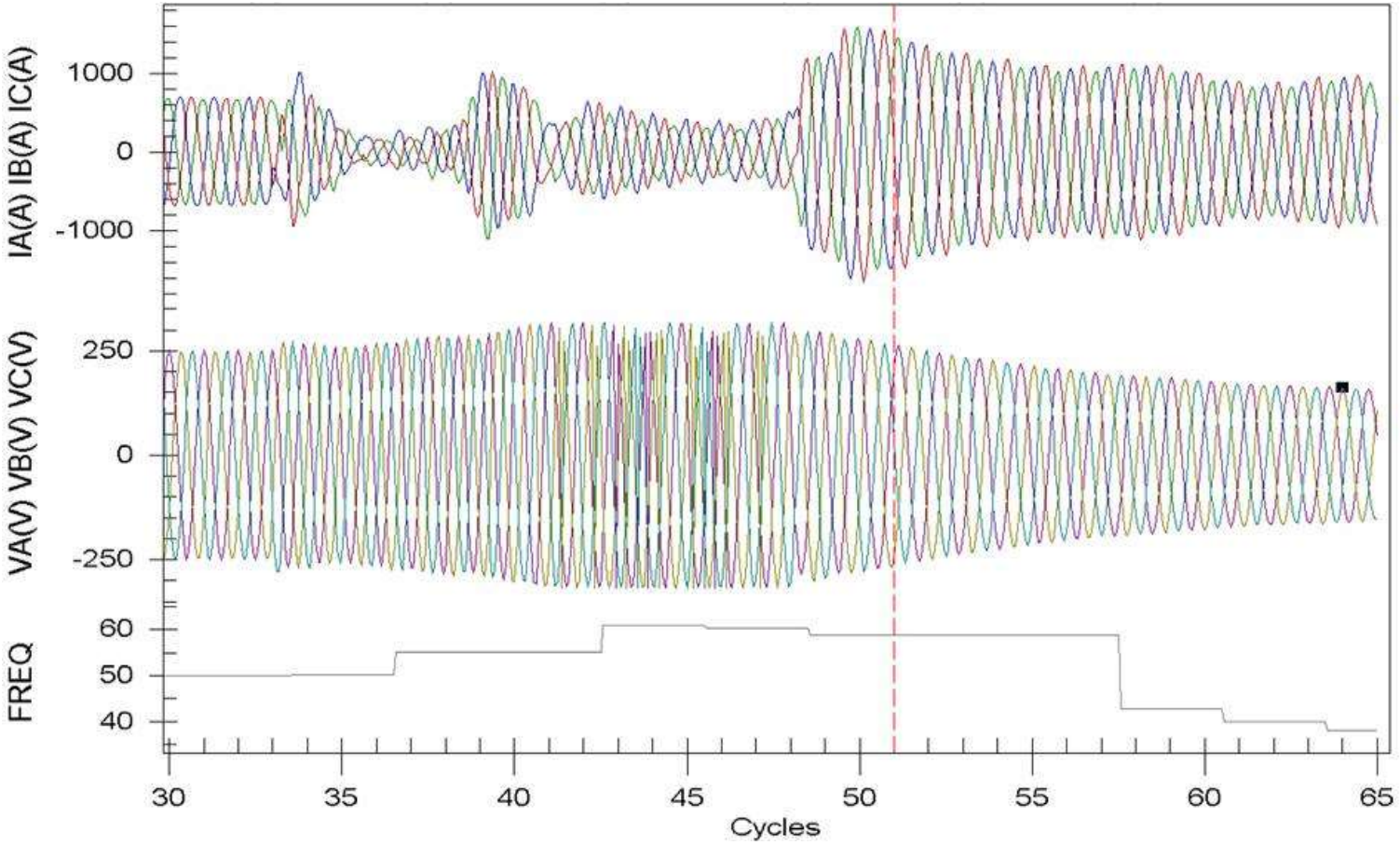
Inertia-less Grid Not the Answer: more an Oxymoron?



Inertia 101 – the slope (3 Hz/s shown) is more gradual with more inertia. All the generators on a grid (and coupled turbines etc) slow down together instantaneously.

An inertia-less grid? Imagine the slope of this ramp being vertical. System has no time to respond. "FFR" (aka "synthetic inertia") providers will always need some inertia on the grid to slow things down for them.

Inertia-less Islanding – an example from Orkney



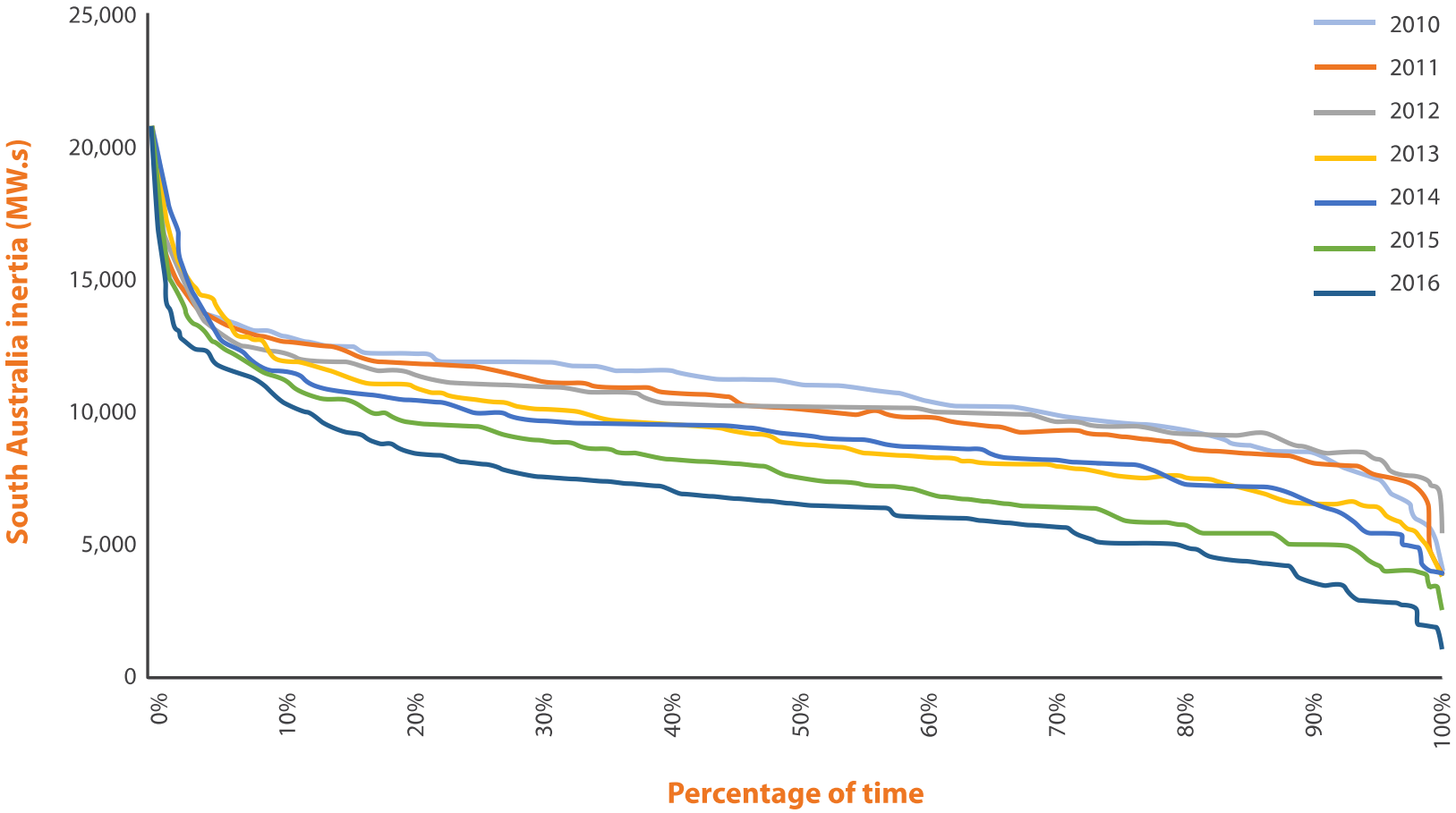
Prelude to a brief blackout in Orkney, January 2017. Note the step changes in frequency and the rough voltage due to power electronics on the local network

The South Australia Blackout

- 28 September 2016 - 88 second sequence
- Five system faults, six voltage disturbances (the sixth leading to total blackout)
- “due to the lower levels of system strength, …. one fault north of Adelaide triggered the LVRT mode for wind turbines located near Mt Gambier” (500 km away)
- After fourth fault (final 6 seconds), 445 MW of wind farms (25% of load) tripped off, causing
- Victoria interconnect (30% of load) to trip, so…
- Last wind farms and thermal stations tripped
- 8 hour blackout has led to several federal/state inquiries
- Many calls for increased inertia/system strength/ synchronous generation.

South Australia Inertia Trend

Figure 4.1: Reducing system inertia in South Australia (as a percent of total operating time)

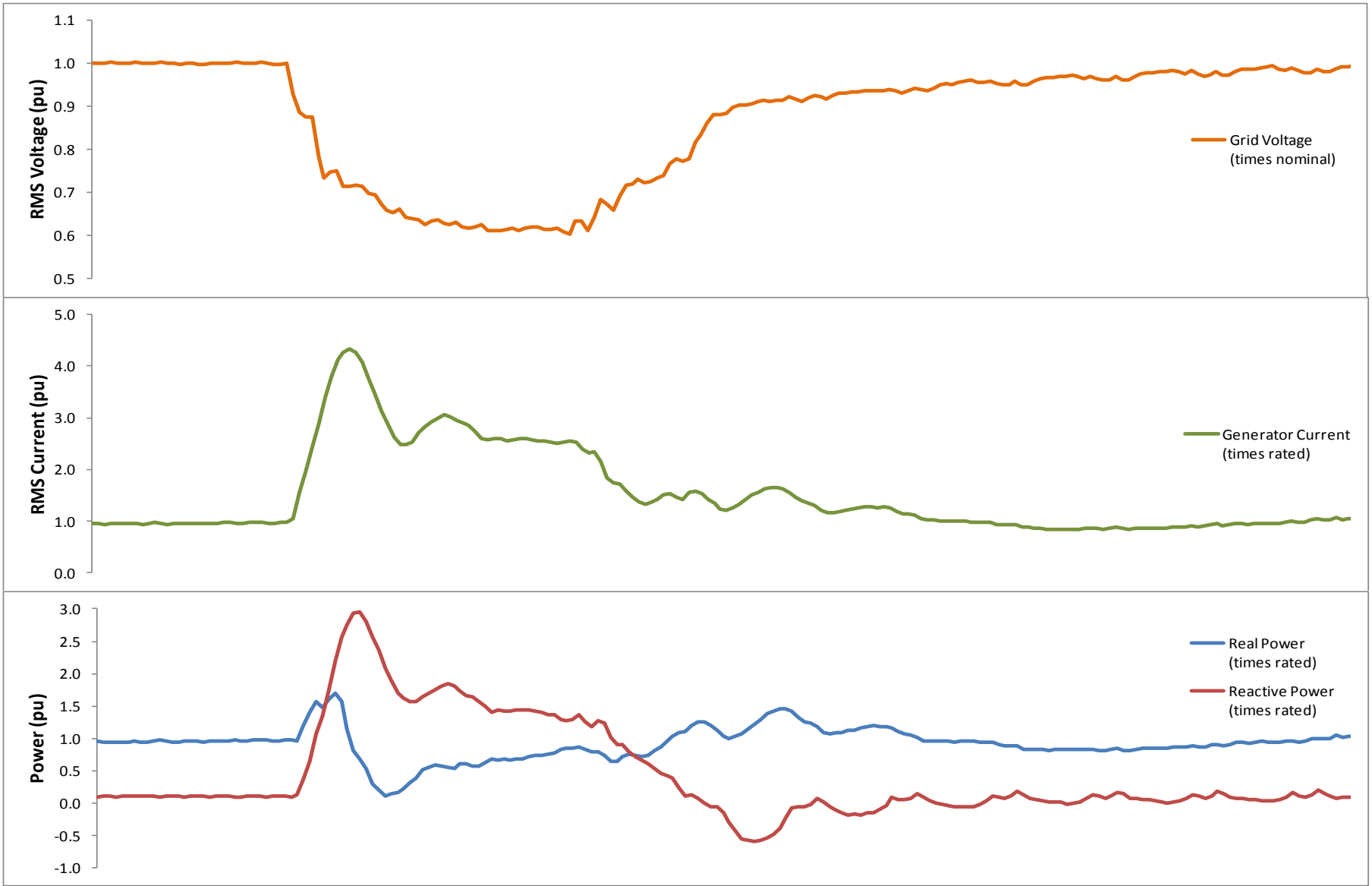


Source: Alan Finkel et al - *Independent Review into the Future Security of the National Electricity Market, Preliminary Report, December 2016*

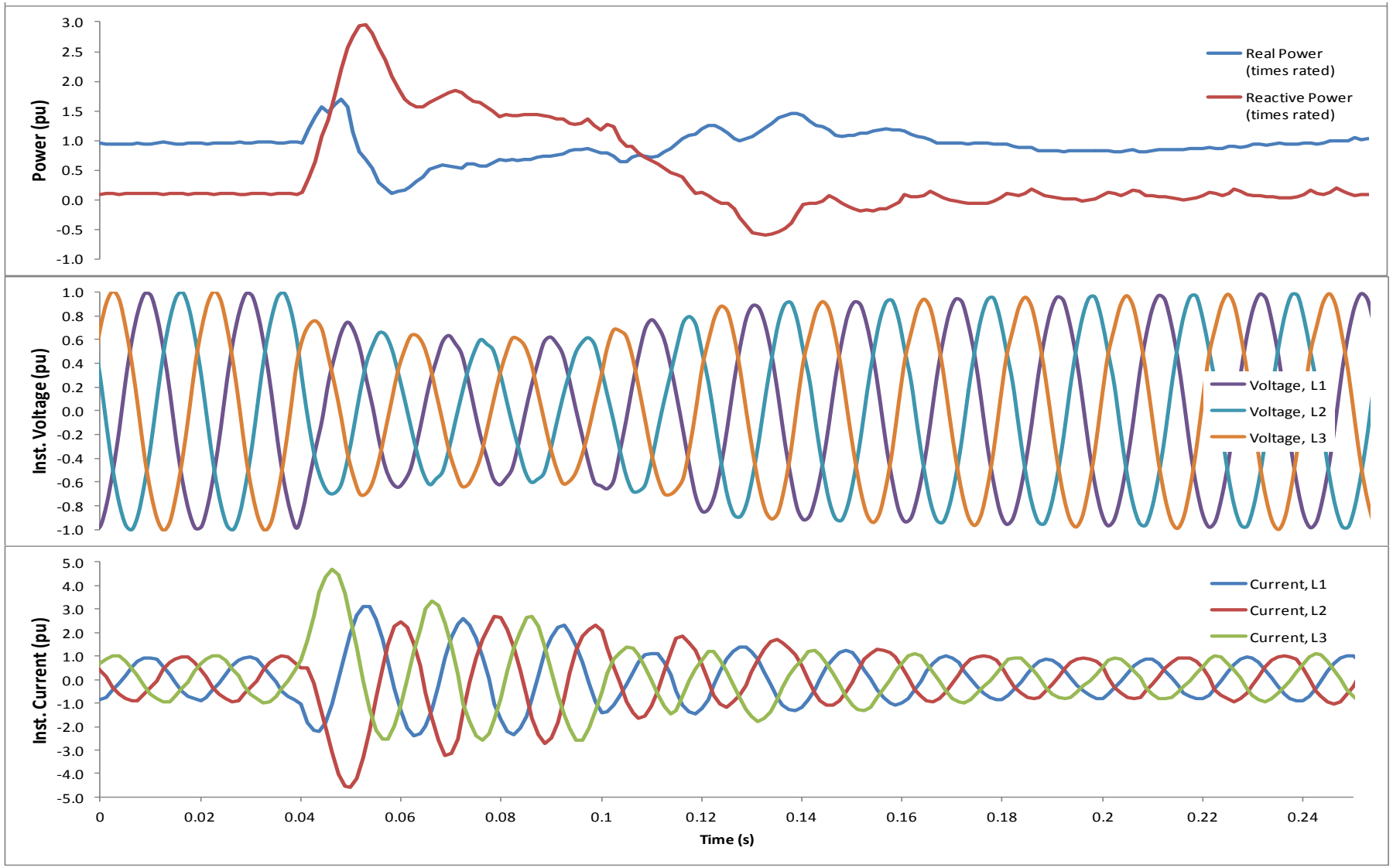
Synchronous Generation is Different – AEMO excerpts

- "System strength an intrinsic characteristic of the local power system, and primarily depends on the quantity of nearby on-line synchronous generators"
- *"Fault ride-through strategies for synchronous machines are fundamentally different to those for wind turbines and non-synchronous power electronic based devices."*
- "when SA is islanded with a moderately low level of synchronous generation, the system strength at a number of wind farms will fall below their minimum design level… wind turbines at these locations may not be able to ride through credible voltage disturbances, creating additional risks for islanded operation."

System Strength – a Windflow 500 Low Voltage Response 8/9/12



Windflow 500 Fault Current Response, not Mere Ride-through



Changes Coming – AEMO Exec Summary

- "following factors must be addressed to … avoid [another SA] Black System:
  - Sufficient inertia to slow down the rate of change of frequency
  - Sufficient frequency control services to stabilise frequency…
  - Sufficient system strength to control over voltages, ensure correct operation of grid protection systems, and ensure correct operation of inverter-connected facilities"
- Windflow's synchronous wind turbine technology provides an option, available for licensing to 2+ MW turbines
- Inertia per megawatt (MW) of installed wind turbines:
  - 20 kg.m^2 of generator rotor inertia at 1500 rpm (0.25 MW.s)
  - 176,000 kg.m^2 of wind turbine inertia at 49 rpm (2.25 MW.s)


Questions?