WEM Primary Frequency Response Case Study

This case study describes the standards and behaviour of generators supporting frequency control under connection arrangements in the Wholesale Electricity Market (WEM) in Western Australia. It looks at the impact of the WEM's mandatory requirements by examining a one-week snapshot spanning various conditions.

WEM primary frequency response (PFR) requirements

The mandatory PFR specifications for generators connected to the Western Power transmission network are described in the *Technical Rules*[1]. The key technical requirements are:

- All dispatchable generating units must operate continuously in a frequency responsive manner unless otherwise instructed. Non-dispatchable units need only provide a lower response.
- Maximum allowable droop is 4%.
- Maximum allowable deadband is 50 millihertz (mHz) (typically implemented symmetrically at 50±25 mHz).
- Applies up to 85% of maximum output, though some units apply response across their full range.
- Thermal units must sustain up to 10% raise and 30% lower services.
- Units must achieve 90% of their response in < 6 seconds (thermal), <30 seconds (hydro), or < 2 seconds (non-dispatchable). Active response must be sustained for ≥ 10 seconds.

System characteristics

The WEM is a smaller system than the National Electricity Market (NEM), with a peak 2018-19 load of 3,256 megawatts (MW)[2], compared to 3,244 MW in South Australia, and 13,861 MW in New South Wales. It has no interconnections.

However, there are various similarities with the NEM that can be highlighted. For example, the WEM has a very high penetration of distributed energy resources (DER). Output from rooftop photovoltaics (PV) reached 971 MW in 2019[3] and continues to grow. The WEM is also served by similar technologies as the NEM; a mixture of new and old thermal baseload generators, along with combined and open-cycle gas turbine units and many new solar and wind installations.

Case study

To show the behaviour of units in the system, and in particular how the mandatory PFR requirements impact their operation at a high level, this case study presents a recent week of operation. Figure 1 shows, over a 24-hour period:

1. System operational demand and ambient temperature (measured at Perth).
2. System frequency, total windfarm output and estimated total DER (rooftop PV) output.
3. Active power output (in p.u.) of various anonymised units that are all operating in accordance with the mandatory PFR requirements. The units are:
   a) GT1 – a large gas turbine that does much of the work of load following service (equivalent to Regulation frequency control ancillary services (FCAS) in the NEM).
   b) ST1 – a relatively new thermal coal unit.
   c) ST2 – a relatively old thermal coal unit.
   d) WF1 – a large wind farm (in the WEM context).
   e) GT2 – another gas turbine unit that supplements the GT1 at times for load following duty.

Charts spanning the full week of operation are provided as Figure 2.

[1] Available from the Western Power website, at https://westernpower.com.au/industry/manuals-guides-standards/technical-rules/.

[2] See https://www.aemo.com.au/-/media/Files/Electricity/WEM/Planning_and_Forecasting/ESOO/2019/2019-WEM-ESOO-report.pdf.

[3] See https://www.aemo.com.au/-/media/Files/Media_Centre/2019/QED-Q3-2019.pdf.

Observations

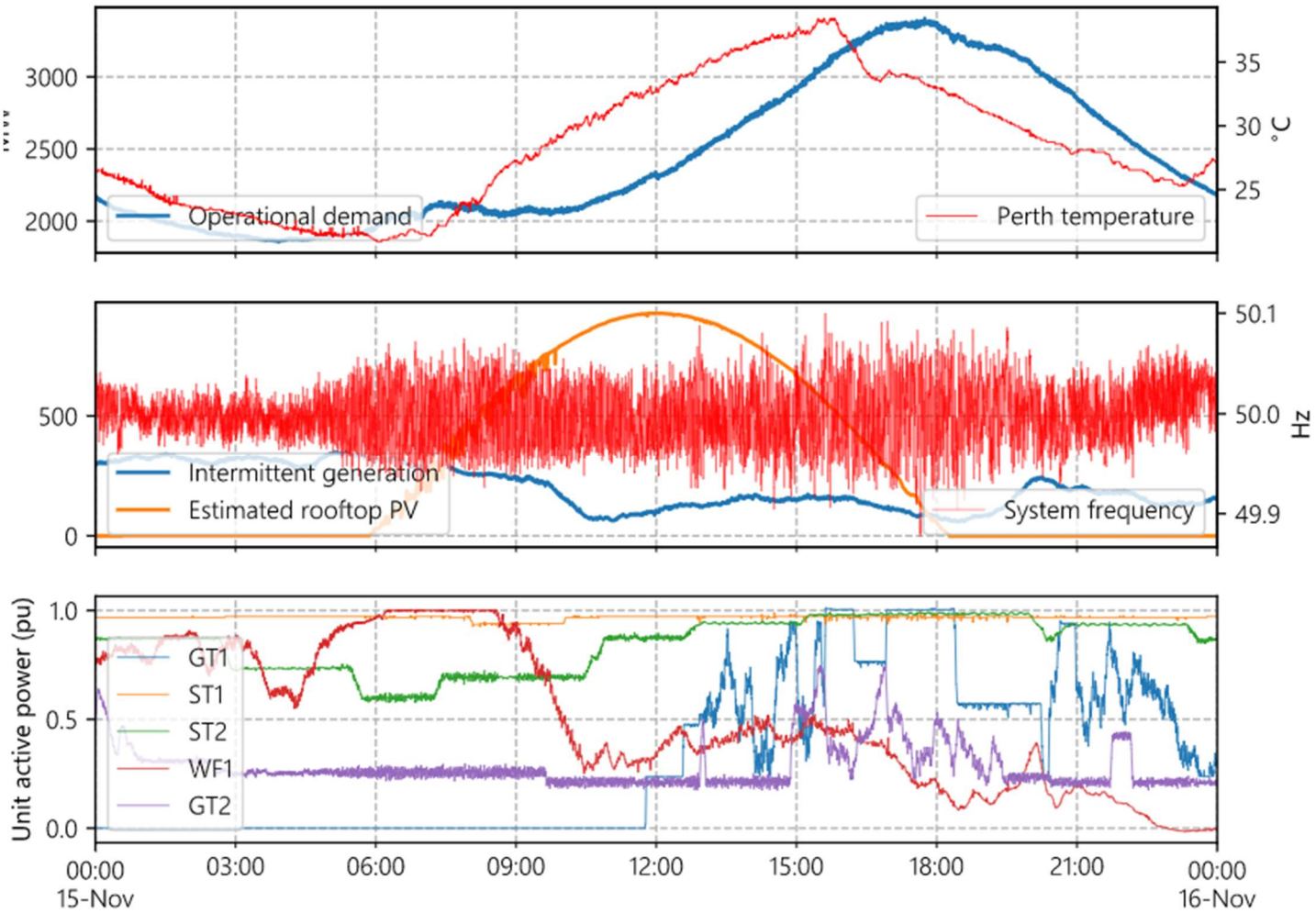
There are many interesting observations to be made over this period of operation. Some of these include:

- Under normal operation (>99% of time), frequency was held within +/-0.075 Hz.
- Frequency performance appears to generally be better at low load times and worse at high load times.

Examining the different units and how they provide PFR (and/or load following) shows that:

- Units providing only PFR (e.g. ST1 and ST2) generally do not move far from their basepoints, with variation only a very small fraction of output (typically ~1%[4]).
- Units providing load following service (GT1, GT2) are moved around considerably as they follow Automatic Generator Control (AGC) commands.
- The wind farm (WF1) demonstrates a downward PFR response while also varying in output considerably over the course of the week.

Figure 1 WEM system operation,15-16 November 2019



[4] Consider a 0.075 Hz frequency deviation with 4% droop and 25 mHz PFC settings. The maximum expected instantaneous basepoint correction is (0.075 - 0.025) / (0.04 * 50) = 2.5%.

Figure 2 WEM system operation, 13-19 November 2019