AEMO Large Loads TWG #3

December 2025

Topics

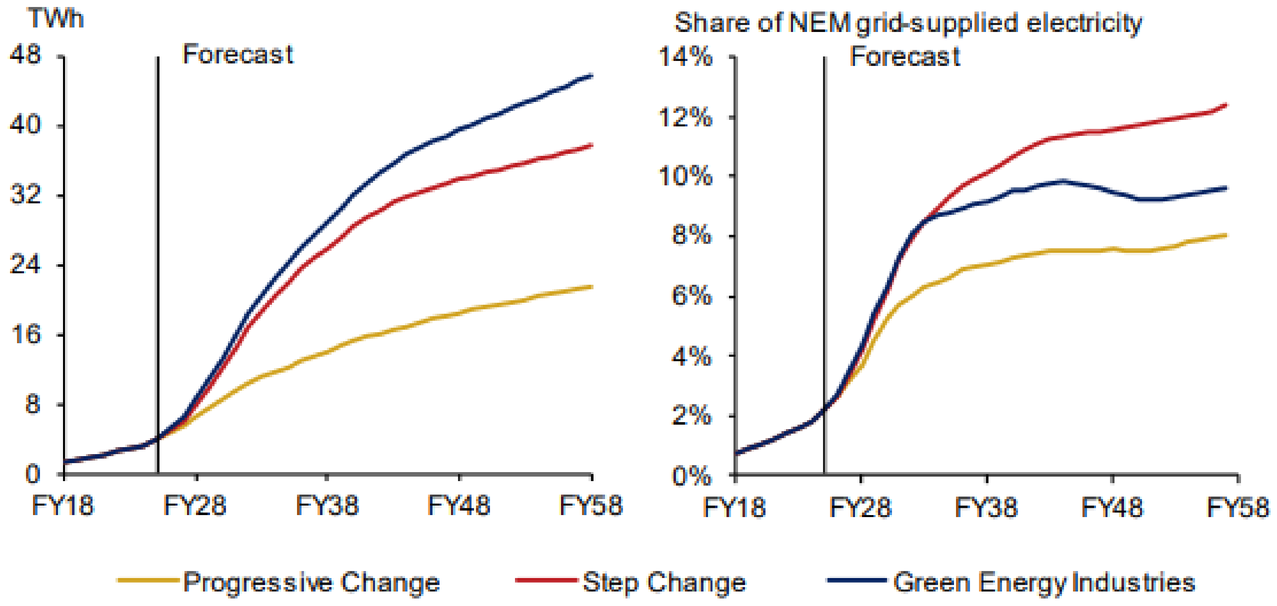
1. System security considerations
2. Plant capabilities and model maturity
3. Key take-aways

System security considerations

AEMO's Forecasted Demand Growth

Data centre consumption is forecast to reach 25 TWh by 2035.

Fig. 1. Data centre energy consumption in Australia (LHS) and NEM data centre energy consumption as a share of grid-supplied electricity (RHS) by scenario, Australia



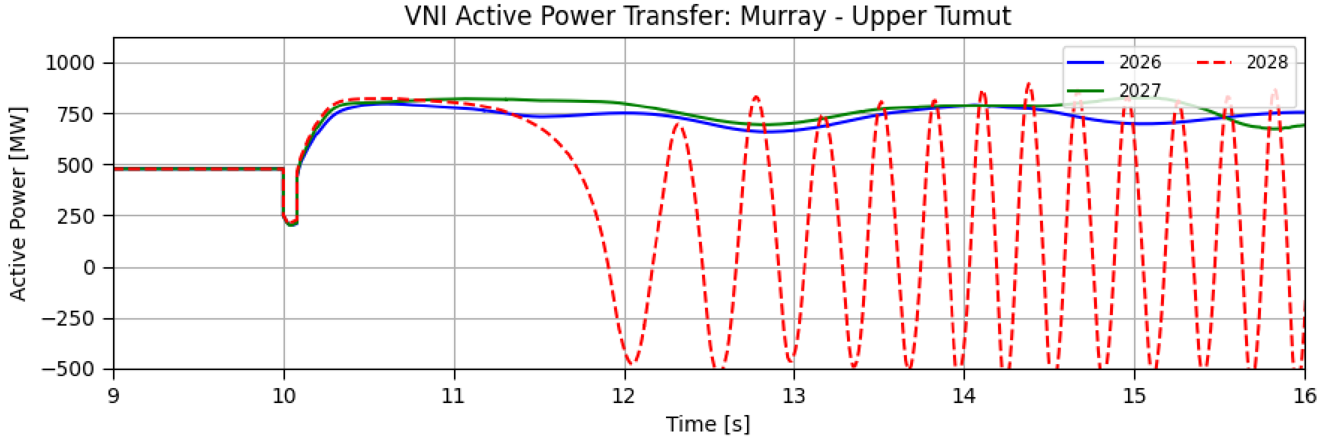
Source: Oxford Economics Australia based on AEMO data.
Note: The 'share of NEM grid-supplied electricity' is equal to OEA's estimates of 'NEM data centre energy consumption' as a share of 'NEM operational sent-out consumption' from the 2025 Electricity Statement of Opportunities.

Modelling inputs and assumptions

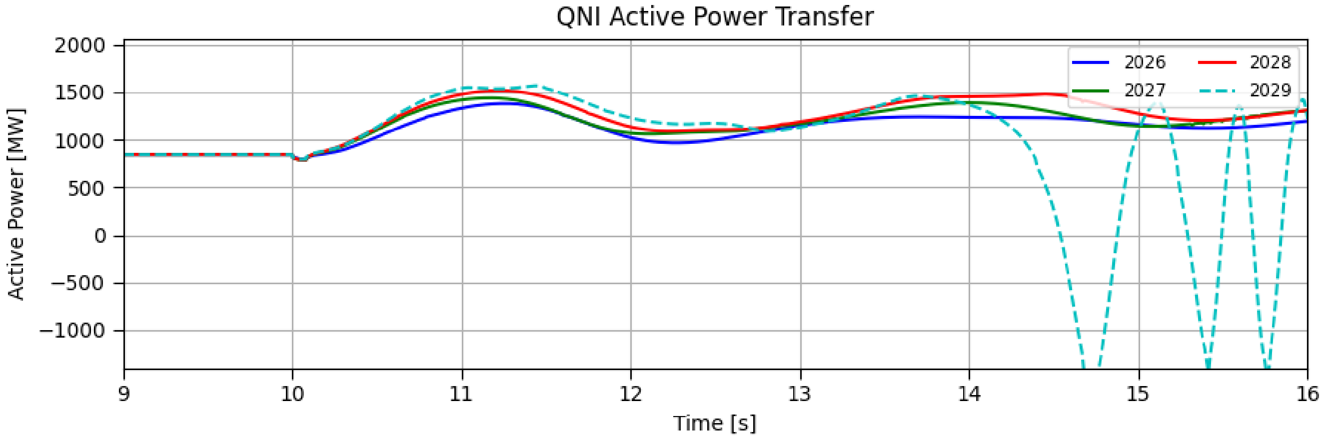
- AEMO has completed preliminary dynamic modelling for the forecasted data centre growth in Victoria and NSW to 2030.
- The following inputs and assumptions apply:
  - Sensitivities have been assessed both with and without committed future network augmentations, illustrating the potential impact of delayed upgrades.
  - Data centre fault ride-through performance has been modelled according to ITIC thresholds.
    - Tripping under 0.7 pu voltage if sustained for 20 ms.
  - A two-phase to ground fault was simulated and cleared according to NER maximum clearing time requirements.

Disconnection of large loads can exceed network limits

Without Network Augmentations



With Network Augmentations



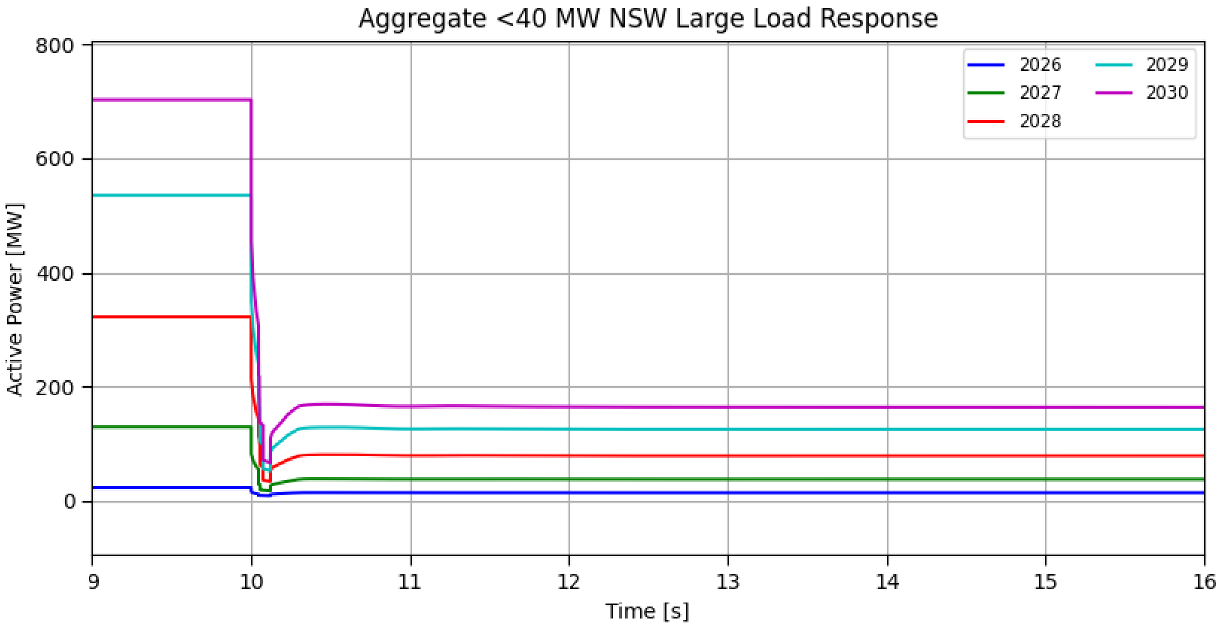
Results for a credible fault and load continency in Victoria

- Increasing credible load contingency sizes, driven by poor fault ride-through performance of large loads, could exceed current network limits.
- This would necessitate tighter constraints on network transfers and reduce overall network operability.
- Delays in network augmentation further increase this risk as loads connect.

Cumulative effect of smaller loads has an impact

- Impacts arise not only from the largest connections but also from the combined behaviour of smaller connections.
- An aggregated response can match or even exceed the severity of the response from larger individual connections.
- This impact increases beyond the 2026 – 2030 study horizon.

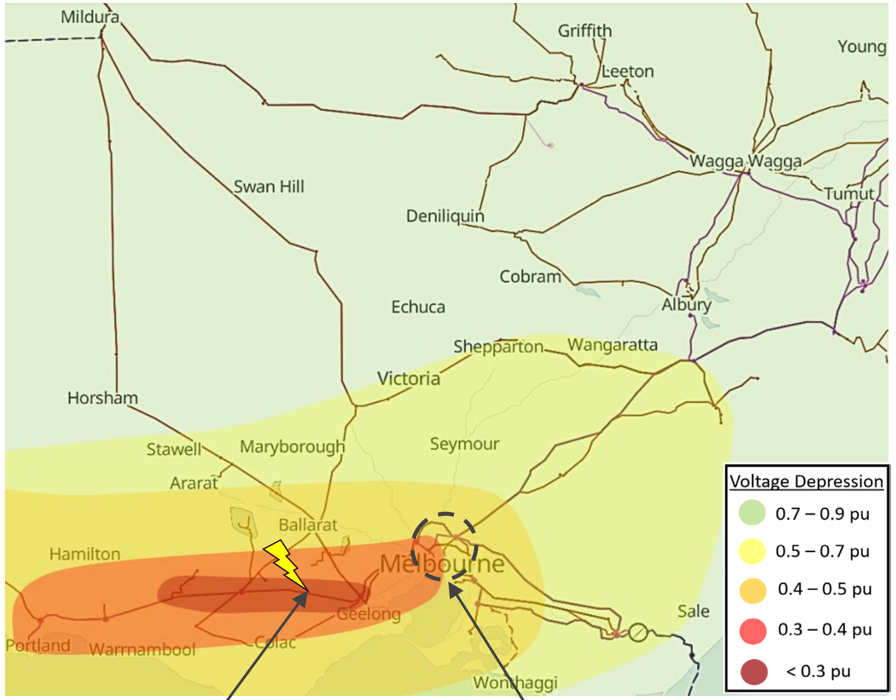
Results for a credible fault in NSW



Fault-induced undervoltage propagation is widespread

- Remote credible faults in Victoria can cause voltages to be depressed below 0.5 pu across the Greater Melbourne area.
- This impacts all forecast data centres in Victoria and can results in their disconnection from the grid.
- Less severe faults can also depress voltages below the 0.7 pu ITIC threshold.

South-west Victoria voltage dip propagation



Credible 2-phase to ground fault between Moorabool and Cressy

Victoria data centre zone

Plant capabilities and model maturity

Learnings from OEM engagement

Summary of Learnings from OEMs

Early feedback has been very positive:

- OEMs have typically only considered protecting the load side, rather than grid impact, but this is starting to shift.
- OEMs recognise international requirements are increasing (ERCOT, NERC, EirGrid, Energinet etc).
- Model maturity differs significantly across OEMs.
- Several jurisdictions across Australia are looking at imposing additional performance requirements including disturbance ride-through, but they are not consistent - making compliance difficult.
- Within Australia, TNSPs have developed their own views on performance requirements but these also vary across jurisdictions.

Performance Requirements

Performance varies between OEMs:

Fault ride-through – load does NOT disconnect

- Range from ride-through for voltage drops:
  - Some OEMs can stay connected to 0.5 pu or lower
  - Typically to 0.7pu
- Load reduction may occur for smaller volt drops – rectifier current limit
- Typical for rectifier to current-limit as voltage drops, requiring batteries to supplement load
- Deep voltage drops (say, <0.5) cause rectifier blocking – this is **disconnection**.
- Some unblock when voltage is restored and integrity of control system is confirmed.
  - This can be quick <1 s
  - Or slower – several seconds
- Many settings are selected for high reliability for the load, less emphasis on minimising grid impact

Load restoration – after disconnection

- Restoration can happen in less than 1 s
- Common to be in the order of seconds to unblock the rectifier followed by seconds to restore load
- Options to ramp load include:
  - Fixed time
  - Fixed rate, variable time
  - Few cycles
- Generally, rectifier and batteries share load
- During load restoration, diesels (etc) are typically isolated, but may also share load for a few seconds.

Model Maturity

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Models may be:

- ‘Real code’ type – based on actual firmware, compiled for EMT
- ‘Generic’ type – parameters fitted from factory tests – EMT and RMS
- Validated during Factory testing or HIL testing
- Very detailed – similar structure to IBR models

Available parameter list is very limited:

- Typically set at factory
- OEM may adjust some settings for site specific requirements – like SS

Application:

- Very important to represent ride-through and load restoration correctly
- Simulate critical [credible] contingencies to assess PS security
- Simulate to assess service requirements (eg FCAS, voltage control)
- Good models make it easier to connect larger loads

Other Learnings

- Voltage withstand: Most IBLs have wide frequency and rate of change of frequency withstand.
  - For IBRs, the requirement is:
    - High voltage 1.3 pu [ERCOT Texas >= 1.2 pu]
    - Low voltage 0.7 pu [ERCOT Texas <0.2 pu for 0.15s]
  - Typical IBLs are +/- 15%, sometimes with a better lower voltage range
    - Can probably be made to meet 0.7-1.3 pu
    - Require firmware and hardware changes
- Auxiliary loads: Cooling etc.
  - Can be as high as 20-30% of total datacentre load
  - Back up arrangements can differ from IT load
- Other topics:
  - Mostly controllers are pre-set – not common to change for specific sites – few, if any, user settable controls
  - Mostly the rectifier front end is configured not to inject into the grid
  - Use of PLLs indicates that sub-synchronous oscillations are probable/possible under some conditions

Key take-aways

Anatomy of a ride-through

- If voltage drops at IBL terminals – several things can happen:
  - V> Vmin: Rectifier current limit operates –
    - Depends on initial load
    - Battery makes up difference to meet load requirement
  - V< Vmin: Rectifier blocks – no load on grid
- Fault clears, voltage is restored:
  - If on current limit, load ramps up as voltage rises
  - If blocked – there is a delay as controller is checked, then load is restored
    - Some [hundreds] of milliseconds up to several seconds needed to confirm device integrity
    - Load restoration can then occur over some milliseconds to a settable duration of 1-100+ seconds
- A deep fault (V<Vmin) can cause many/most affected rectifiers to block
  - This is technically not ride-through
  - ERCOT, for example, consider it RT if load is restored in < 1 s

Market and consumer impacts

Absent ride-through requirements, under the Rules, AEMO would need to impose tighter constraints on network transfers reducing operability and procure more FCAS

The implications are cost increases, ultimately borne by consumers

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