West Murray Technical Forum

10 February 2020

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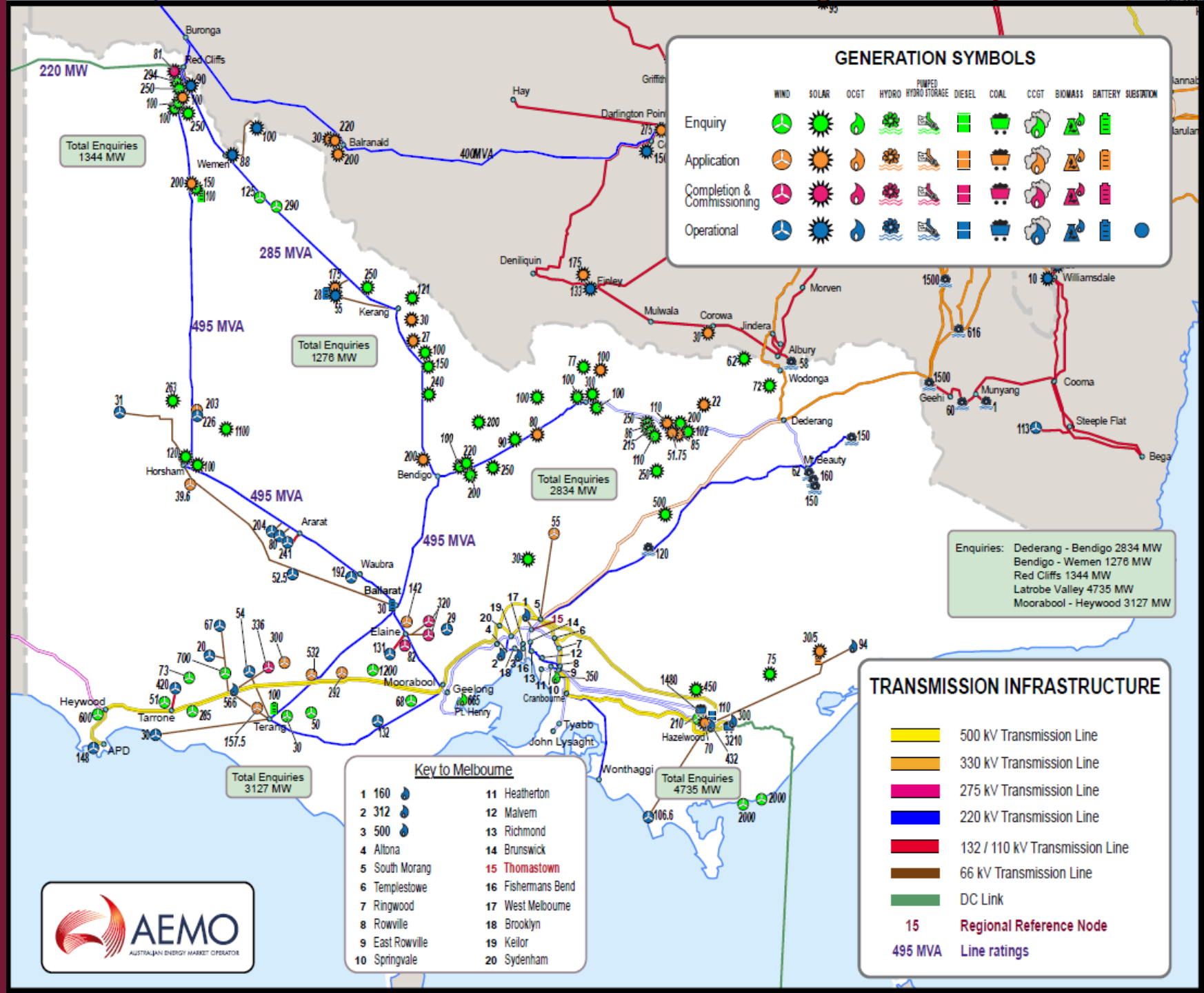

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What you need to know about this presentation

This slide deck summarises AEMO's presentation at a forum on 10 February 2020 in Melbourne about the technical issues impacting the operation and connection of generation in the 'West Murray' zone.

The information and analysis in this presentation is as available to AEMO at the date of the forum, and may change. It is general in nature and not to be relied on for any particular purpose or project. Opinions are AEMO's own unless otherwise stated.

AEMO has made every reasonable effort to ensure the quality of the information in this document, but does not represent it is accurate or complete.

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Agenda

- Welcome (Audrey Zibelman)
- Overview of the issue and proposed solution (Alex Wonhas)
- Technical presentations:
  - Technical issues causing instability and security concerns (Mark Gordon)
  - Application of system security management to West Murray (James Lindley)
  - Approach to lifting constraints, complete commissioning and connect additional generators (Mark Shilliday)
- Recap of next steps (Alex Wonhas)
- Q&A session (Tony Chappel)
- Feedback (Tony Chappel)
- Close (Alex Wonhas)

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Overview of the issue and proposed solution

Dr Alex Wonhas, AEMO Chief System Design & Engineering Officer

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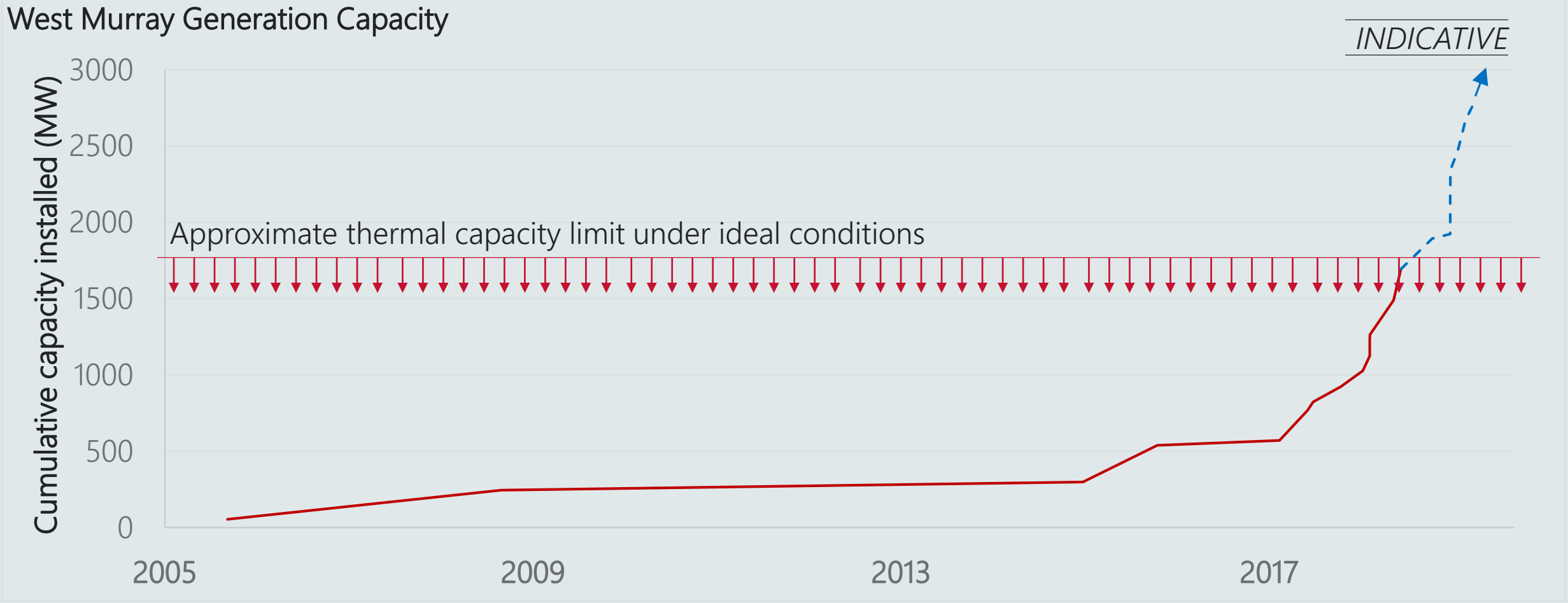
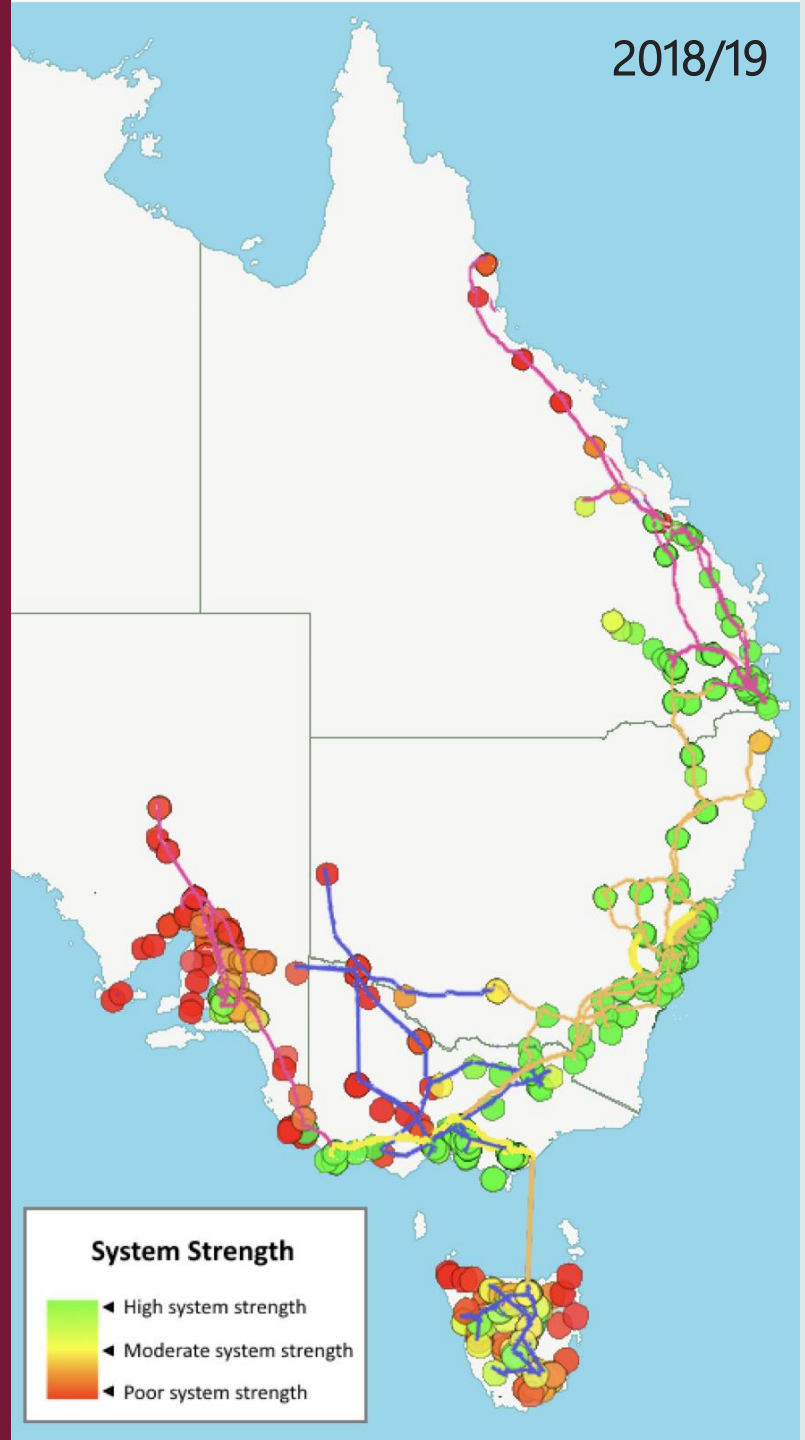
West Murray has reached its thermal capacity limit



Weak system strength in West Murray



Root cause of weak system strength:

- Low capacity (220 kV) transmission network
- Long distance (~500 km) from major load centre
- Long distance from conventional sources of system strength, e.g. synchronous generators
- High density of inverter-based generation

Source: 2018 ISP

System strength analogies: Marginally stable and unstable systems

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Other contributing factors

Key regulatory principles:

- Provide '**open access**' when it can be done securely
- Ensure new generators '**do no harm**'
- Maintain **confidentiality** of each generator's technical parameters and all power system model source codes

Complex multi-stakeholder process:

- AEMO
- Network Service Providers
- Original Equipment Manufacturer
- Consultants
- Investors
- Governments

Solutions

Short-term solutions

- Declared a system strength gap on 13 Dec 2019
- Beta testing a shareable PSCAD modelling platform
- Continue to encourage combined connections groups
- Restructure AEMO's connection teams
- Grow AEMO's account management capability
- Establish a well defined and transparent assessment sequence

Long-term solutions

- Develop novel technical solutions, e.g. via the Advanced System Integration Group
- Validate system model via measurements to enable operation closer to system capability
- Review 'do no harm' and potentially 'open access'
- Support and lead network augmentations via the current RIT-T processes and the Integrated System Plan

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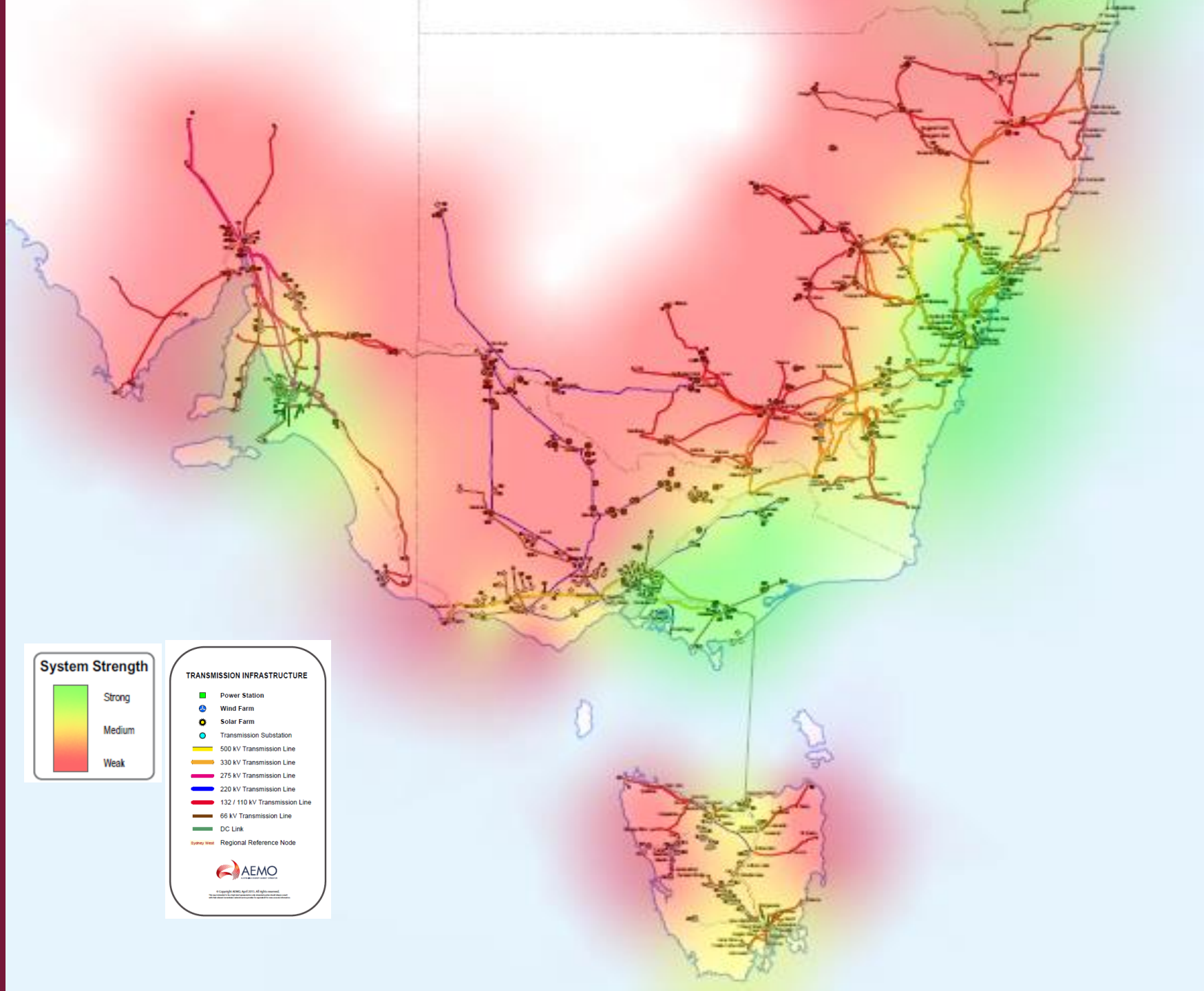
Technical issues causing instability and security concerns

Dr Mark Gordon, AEMO Specialist Engineer

System strength and implications for converter connected plants



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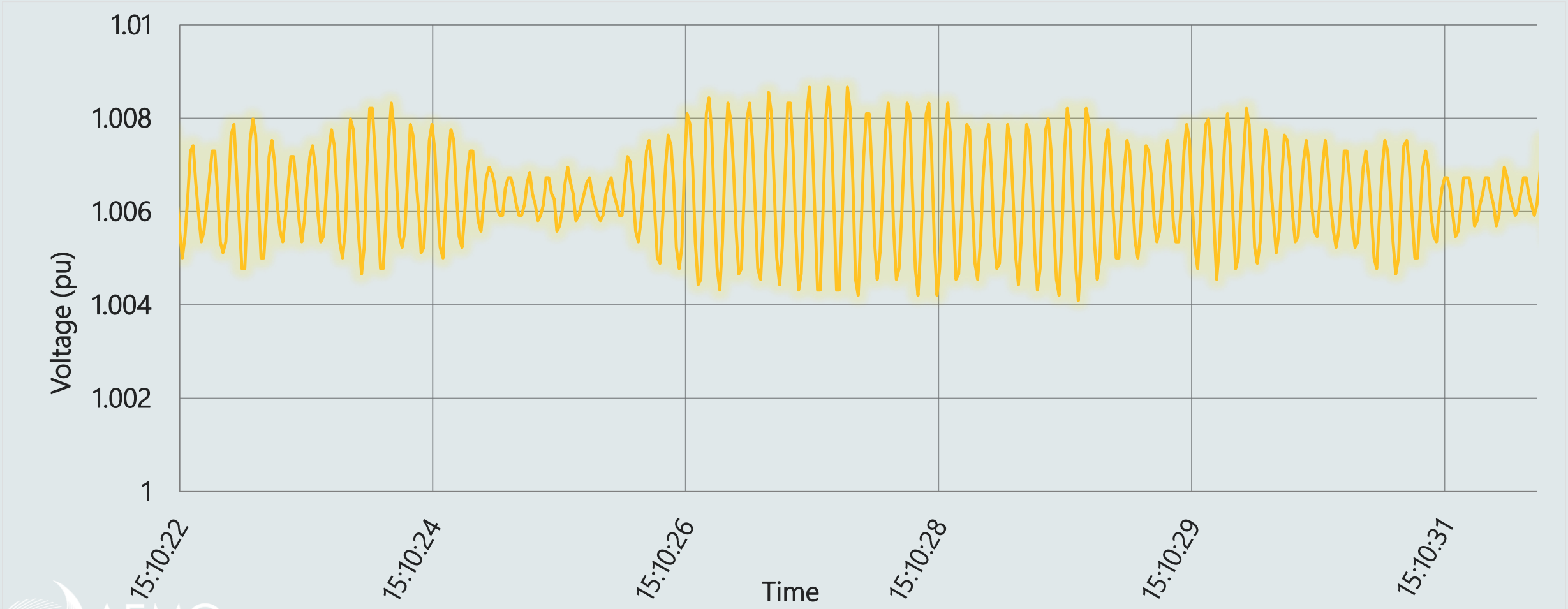
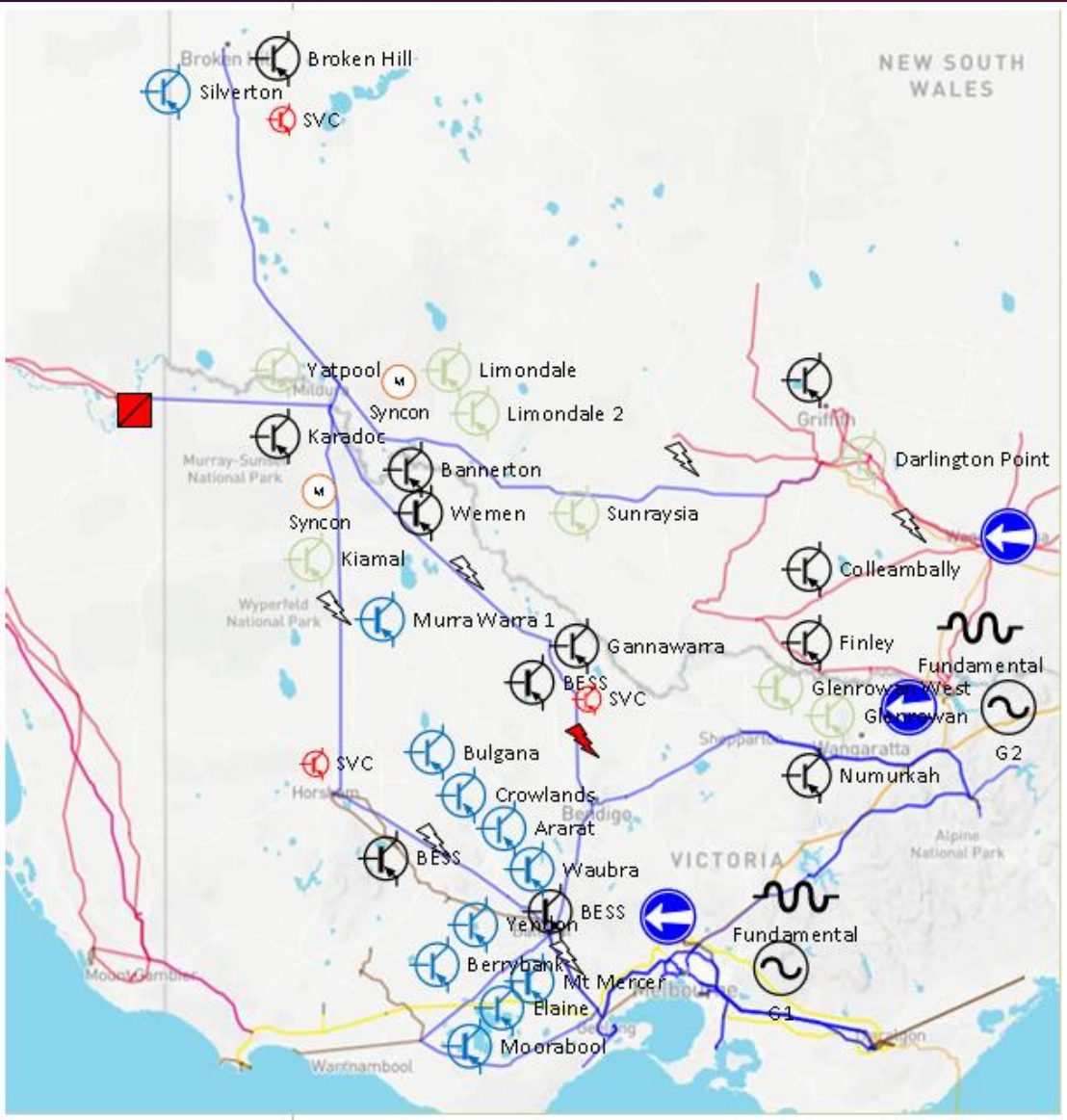
Converter oscillatory excitation – control test

Actual system test 220 kV 30 November in West Murray (50% constraints applied)



Technical issues



- Converter instability and its limitations
- Remediations and coordination
- Low short circuit levels for the region
- N-1 conditions, post-contingent stability
- Nodes for synchronous condenser locations
- Reliance on unvalidated plant performance (R1/R2)
- Voltage control and reactive power management
- Thermal limitations
- Fast Protection Schemes/ Voltage Collapse
- Review of Murraylink very fast run back

Concluding remarks

- The changing nature of generation highlights **the need for a coordinated approach** to planning and operation.
- The decrease in (available) system strength in WMZ requires NSPs and AEMO to **review operating system capability to enable integration of further generation**.
- The relatively **low short circuit system strength and thermal limitations** will likely result in additional **constraints and remedial/development works will be required** to ensure stable operation of generation.
- Critical aspects include the **converter/controller settings, balance of plant design** and overall coordination between PPC and the Converter controller, robustness and applicability for the network characteristics at the power system location in the NEM.

Application of system security management to West Murray

James Lindley, Group Manager, Systems Capability Operations

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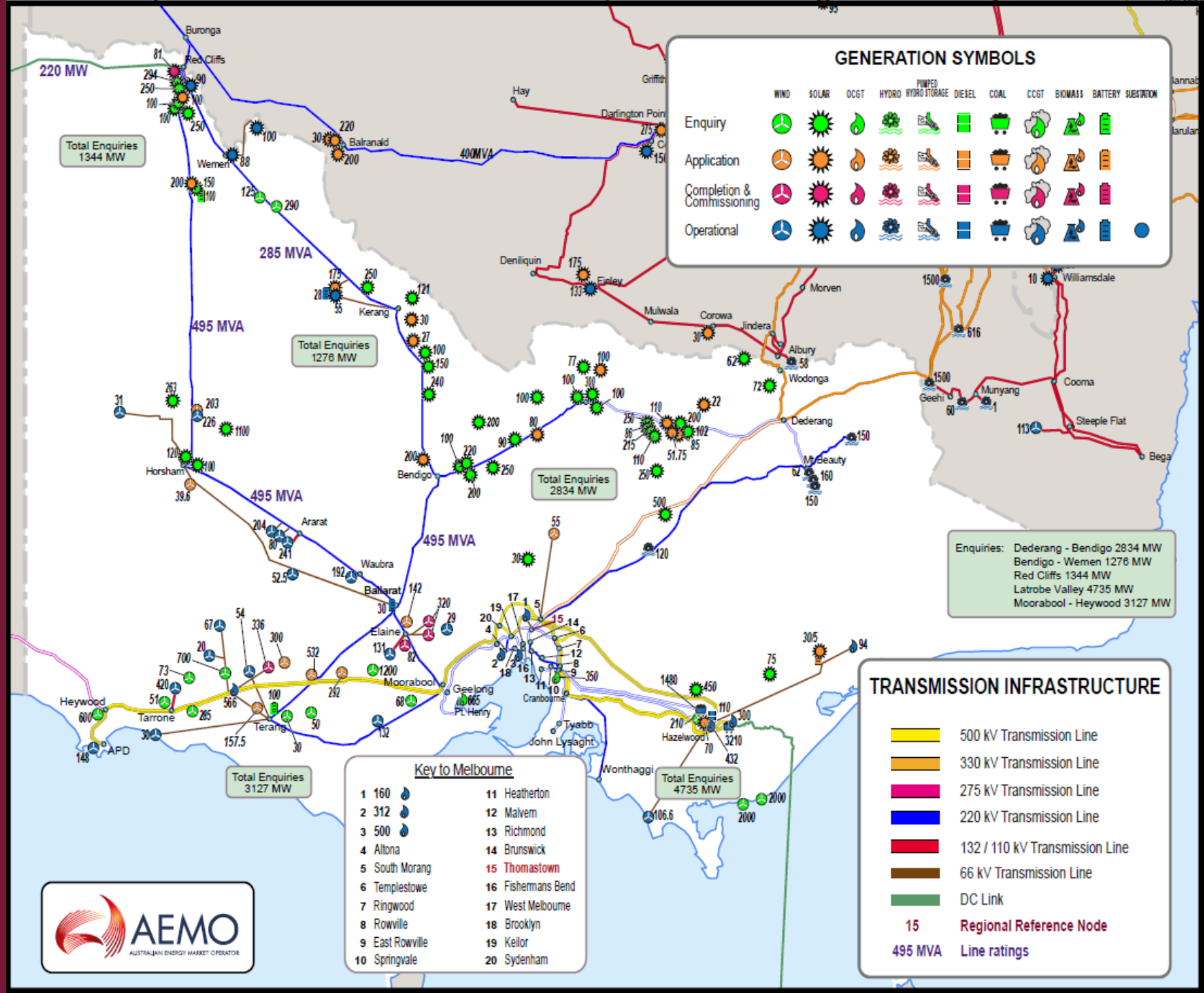
Operational overview



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Satisfactory operating state

Adequate damping of oscillations

Stable voltage control

Power system characteristics are within specified limits:

- Frequency
- Voltage
- Current flows on transmission lines
- Fault levels
- Stability (NER S5.1.8)
- Operating ratings of plant forming part or impacting on the power system

Secure operating state

- The power system is in a satisfactory operating state
- The power system will return to a satisfactory operating state following the occurrence of any credible contingency event in accordance with the power system security standards

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Credible contingency events

Contingency events which are considered reasonably possible in the surrounding circumstances.

Trip of 220 kV line in WMZ

Events which are considered to be ***credible contingency events*** at all times include but are not limited to the following:

The trip of any single generating unit

The trip of any single transmission line or cable

The trip of any single transformer

The trip of any single item of reactive plant including a capacitor, a reactor or any other plant providing reactive support to the network

System security summary

To maintain system security output of solar farms in the WMZ must be constrained:

- Both output and online inverters constrained
- Needed to maintain adequate oscillation damping and stable voltage control following a trip of a 220 kV circuit in WMZ

- Analysis based on modelling, confirmed by online testing

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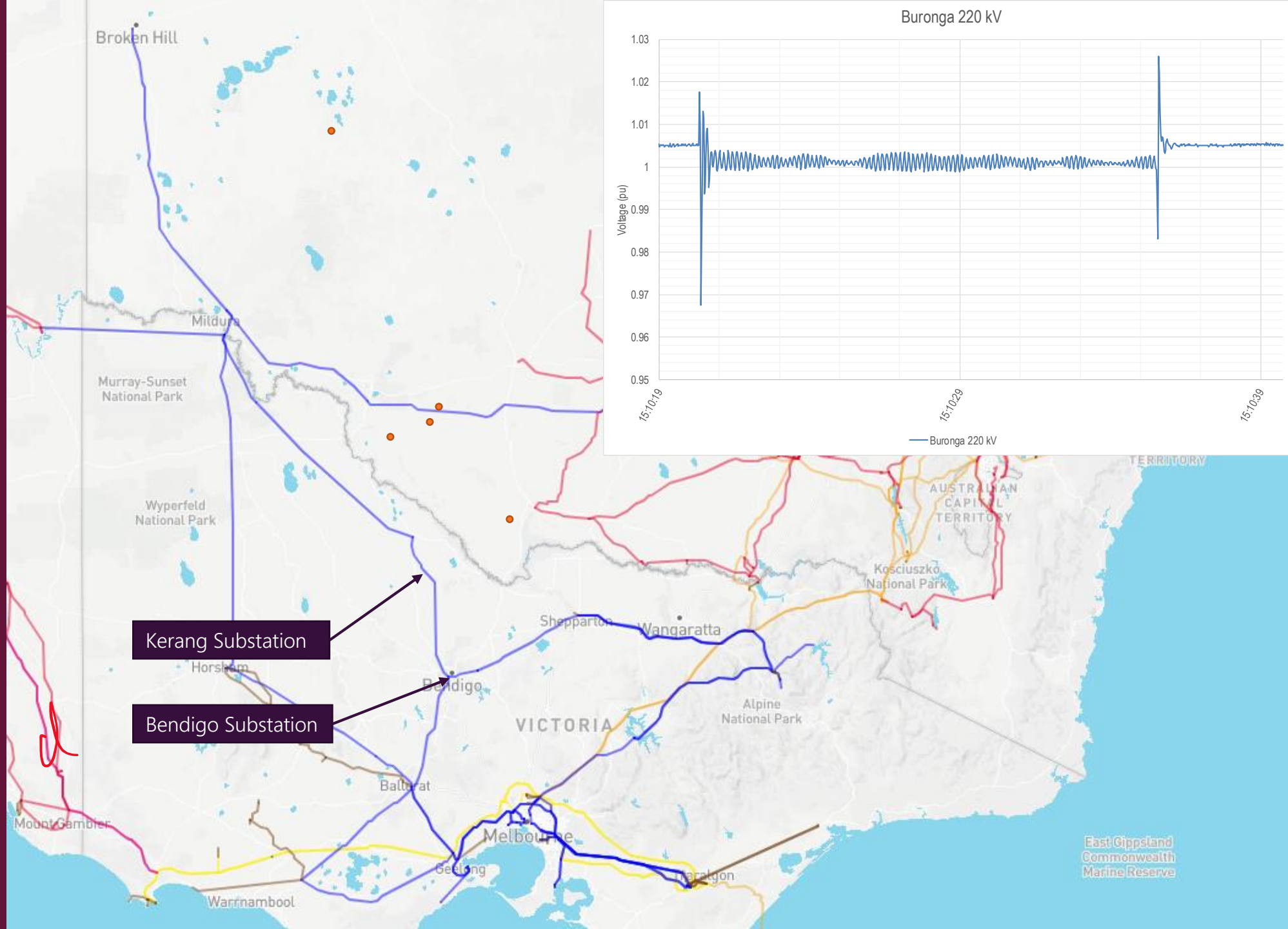
System testing



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Network limitations - thermal and voltage stability constraints

Network	Details
Ballarat to Waubra 220 kV line overload	• For trip of Murra Warra to Kiamal (V>V_NIL_6) or Kiamal to Red Cliffs (V>V_NIL_8) 220 kV lines.
Darlington Point 220/330 kV transformers (220 to 330 kV direction of flow) overload	• For trip of the parallel transformer (N>>N-NIL_DPTX_2). • Will bind during daylight hours on most days.
Buronga to Red Cliffs 220 kV line	• For no other line or generator trips (N>>V-NIL_0X1) • Will bind during daylight hours and at times of high wind.
Voltage stability for trip of the Ballarat – Ararat 220 kV line (V^V_NIL_ARWBBA)	• This also trips a number of generators. • Current cap of 600 MW on the generation.
Voltage stability for loss of the Darlington Point to Wagga Wagga (63) line	• Being investigated by TransGrid
Voltage oscillation limits under outage and system normal	

Outage information and links

- Network outages are submitted to AEMO into the NOS. Published here: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Network-Data/Network-Outage-Schedule

- North west VIC and south west NSW limitations: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Network_Connections/Power-System-Limitations-December.pdf

- Victorian Limits Advice: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Congestion-information/Limits-advice

- Generator maps: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Network-connections/NEM-generation-maps

Approach to lifting constraints, complete commissioning and connect additional generators

Mark Shilliday, AEMO Manager Network Development (NEM)

Topics

1. Wide area tuning to lift system security constraints

2. Proposed process for committed projects and generators seeking connection

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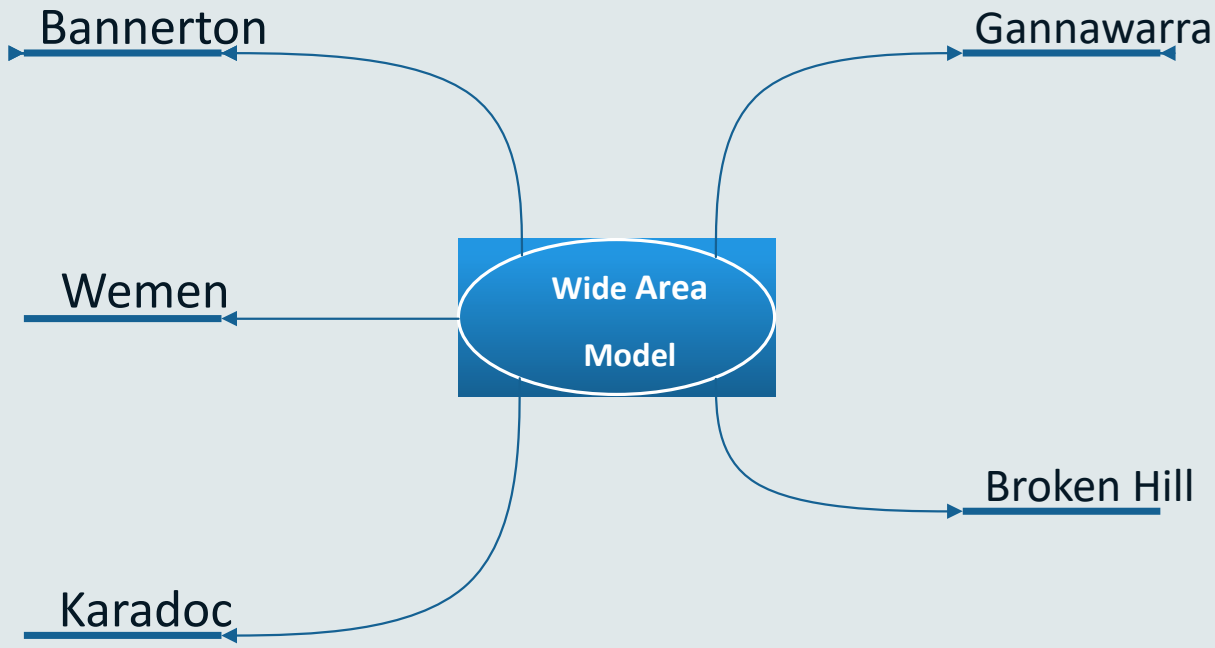
Wide area tuning - current system security constraints

Tuning of affected generators



AEMO engaged with SMA Germany (inverter manufacturer), NSPs and modelling experts to work with the inverter controls to find a combination of settings that would provide a suitable improvement in performance in the area.

Change process: NER 5.3.9

- To implement the changes, the generators had to follow clause 5.3.9 of the National Electricity Rules (NER).
- Generators must follow this procedure when materially altering their generating system, including firmware and hardware.
- AEMO and the NSPs have been working closely with the generators and OEM to obtain and assess the necessary data for the alterations to be approved, updated, tested and commissioned.

Key Challenges:

- Address the network security issue
- Ensure individual GPS compliance
- Commissioning, testing and validation

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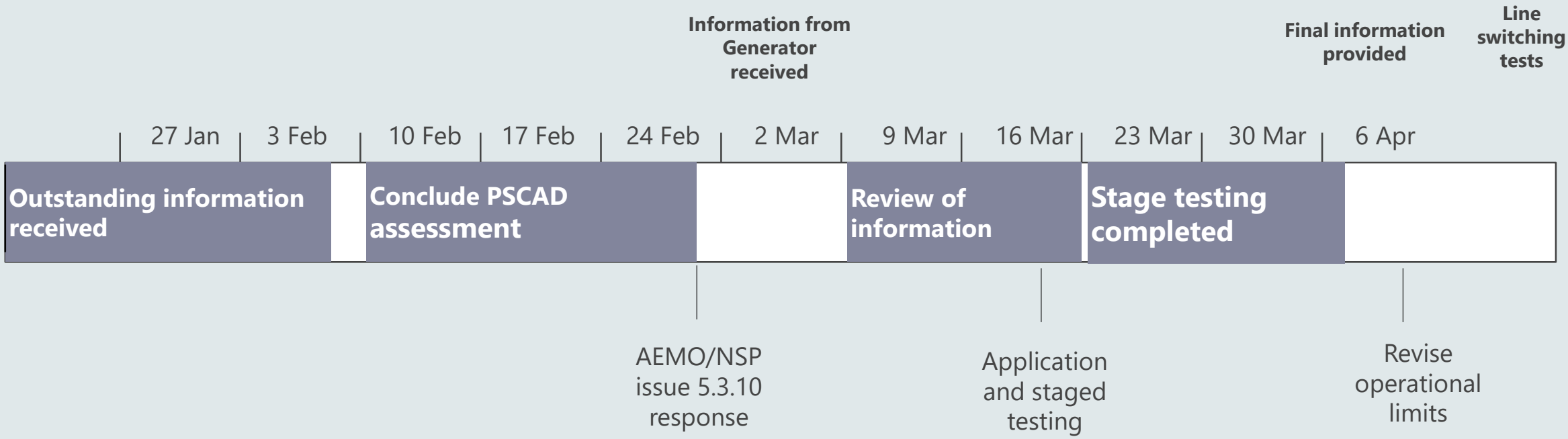
West Murray 5.3.9 process indicative timeline



Notes:

* Timeframe is intended as an overall / average timeframe for all 5 Solar Farm projects
* The duration of tasks is indicative, and timing will shift depending on provision of information

Proposed process for committed projects and generators seeking connection

High volume of connections requires a sequenced assessment approach

- 5 generators in operation – constrained
- 5 generators in commissioning – hold points
- 15 generators – committed
- 25 generators – application

Need to sequence project assessments

We would like your input on how to proceed with the assessment of projects

Current process

- Issue a new model when a new generator is connected to the system and require all connecting parties to re-assess

Proposed new approach: Sequenced assessment

1. **Constrained – operational**
   Currently being assessed in parallel
2. **Constrained – commissioning**
   Sequence based on date of registration or hold point assessment report, whichever is the latest
3. **Registered**
   Sequence based on date of registration
4. **Committed**
   Sequence based on date of grid connection agreement, 5.3.4 A, or 5.3.4 B letter, whichever is the latest

Note: No assessment can proceed unless all data and information pre-requisites are met, irrespective of date. Exceptions may apply.

Feedback welcome on the proposed approach (e.g. issues to be considered, alternatives) **by 21 February**

Email to:

stakeholderrelations@aemo.com.au

Overview of indicative WMZ project sequence

Committed projects only

	Timing	Projects to be assessed
Phase 1	Q4 2019 - Q1 2020	Generators, operational but currently constrained
Phase 2	Q2 2020	Projects in commissioning
Phase 3	Q3-Q4 2020	Projects awaiting registration
Phase 4	2021 onwards	Uncommitted generation

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Recap of next steps

Dr Alex Wonhas, AEMO Chief System Design & Engineering Officer

Solutions

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Questions

Tony Chappel, Chief External Affairs Officer

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Feedback