

# AEMO review of technical requirements for connection

Draft Report stakeholder forum  
12 April 2023



# Forum recording

- This stakeholder forum will be recorded by AEMO and may be accessed and available for use by AEMO stakeholders who have not been able to attend the session live.
- By attending the meeting, you consent to AEMO recording the meeting and using the record for this purpose.
- No other recording of the meeting is permitted.

# Agenda

1. Introduction & context (15 mins)
  - i. Forum objectives & participation
  - ii. Regulatory context & current status
  - iii. Stakeholder engagement
2. Draft Recommendations (including Q & A)
  - i. NER Sch. 5.2 - Conditions for connection of Generators (65 mins)
  - ii. NER Sch. 5.3 - Conditions for connection of Customers (25 mins)
  - iii. NER Sch. 5.3a - Conditions for connection of Market Network Services (10 mins)
3. Next steps (5 mins)

# Forum purpose & participation

## Stakeholder forum objectives

To provide:

1. **Context:** background, approach and current status of the Review
2. **Recommendations:** overview of recommendations made by the draft report and addendum
3. **Q&A:** opportunity for stakeholders to raise questions or issues regarding the draft recommendations.

**[contact.connections@aemo.com.au](mailto:contact.connections@aemo.com.au)**

Get in touch with the Project Team throughout the Review via AEMO's Contact Connections email address.

## Participation and engagement today

- AEMO welcomes questions on the issues presented
- Questions and issues can be raised in the Q&A window
- Attendees are encouraged to “Like” other participant’s questions
  - Questions and issues will be prioritised on this basis
- Discussion today will be focussed on higher level issues rather than detailed technical discussion, please get in touch if you would like to get involved
- We may not be able to address all queries or issues today. In this event we:
  - Encourage you to raise issues with our recommendations via the formal stakeholder engagement process
  - Get in touch with the Project Team with any questions that you need resolved in order to make your submission

# Regulatory context

- Under NER 5.2.6A, AEMO must:
  - at least once every 5 years, review some or all technical requirements for connection in NER Schedules 5.2 (Generators), 5.3 (Loads) and 5.3a (Market Network Service Providers)
  - consult with affected parties including the Reliability Panel
  - assess whether the said requirements should be amended, having regard to:
    - (1) the National Electricity Objective
    - (2) the need to achieve and maintain power system security;
    - (3) changes in power system conditions
    - (4) changes in technology and capabilities of facilities and plant.
- As part of the review process, AEMO must also publish:
  1. an Approach Paper
  2. a Draft Report setting out recommended amendments with reasons, and seek submissions
  3. a Final Report, and submit any Rule Change request to the AEMC thereafter.

# Current status

- 1st phase:
  - **Approach Paper** published in October 2022
- 2nd phase:
  - **Draft Report** published in March 2023 – sets out recommendations for amendments to:
    - NER Schedule 5.2 (conditions for connection of Generators and Integrated Resource Providers)
    - NER Schedule 5.3a (conditions for connection of Market Network Service Providers)
  - **Addendum** to Draft Report published in April 2023 – sets out recommendations for amendments to:
    - NER Schedule 5.3 (conditions for connection of Customers)
  - **Draft Rules** arising from Draft Report and Addendum during Q2 – Q3 2023

## Related consultation steps:

- Forum today, 12 April 2023
- Submissions on Draft Report closing 20 April 2023
- Submissions on Addendum closing 23 May 2023
- Submissions on Draft Rules closing Q3 2023

# Stakeholder engagement



Reliability Panel (meetings every 2 months) & AEMC (bilateral meetings as required and workshop observation)

## Preliminary consultation & perspectives

AEMO connections and operations teams

Project consultants, Digsilent Pacific

Network service providers (NSPs)

Connections Reform Initiative (CRI) discussions

Central West Orana REZ access standards consultation

Individual stakeholders to AEMO

## Approach Paper

- Scope of review
- Nature and extent of issues to be reviewed
- Technical requirements to be consulted on

## Industry & technical consultation

### Industry association briefing

- Overview of proposed scope
- Invitation to provide feedback

### TFG Prioritisation workshops

- Understand views on the criticality of addressing each identified issue,
- obtain feedback to refine or amend issues

### TFG Options Assessment workshops

- issues involving greater complexity or with lower levels of consensus
- identifying potential options to address the issues

## Draft Report

- Recommendations for amendments to NER technical requirements (S5.2, S5.3, S5.3a)

## Draft Recommendation consultation

### Draft Report Stakeholder forum

- Summarise report
- Address stakeholder Q&A

### Formal submissions

- Written feedback on draft report recommendations

### Follow-up consultation

- Follow up consultation with targeted stakeholders (as indicated by stakeholder feedback)

## Rules drafting

- Proposed drafting for Rules amendments

## Final report

- Final recommendations and proposed Rule drafting










## Technical Focus Groups (TFG)

- 4 Technical Focus Groups established to provide input to the Review.
- Representatives with direct experience of technical requirements from NSPs, Generators, Loads, developers and OEMs.

# Draft recommendations at a glance

Schedule and clause	Issues
<b>Schedule 5.2 Conditions for Connection of Generators</b>	<b>34</b>
S5.2.1 – Outline of requirements	1
S5.2.5.1 – Reactive power capability	3
S5.2.5.1, S5.2.5.5, S5.2.5.7, S5.2.5.8	1
S5.2.5.2 – Quality of electricity generated	1
S5.2.5.4 – Generating system response to voltage disturbances	3
S5.2.5.5 – Generating system response to disturbances following contingency events	12
S5.2.5.7 – Partial load rejection	2
S5.2.5.8 – Protection of generating systems from power system disturbances	3
S5.2.5.10 – Protection to trip plant for unstable operation	1
S5.2.5.13 – Voltage and reactive power control	6
Ch 10 definition – CUO	1
<b>Schedule 5.3 Conditions for Connection of Customers</b>	<b>9</b>
New clause – Operation of large loads during frequency disturbances	1
New clause – Operation of large loads during contingency events	2
New clause – Operation of large loads during voltage disturbances	1
New clause – Stability of IBL – monitoring, protection and performance	1
S5.3.3 – Link to ‘ride through’ requirements and maximising protection	3
S5.3.10 – Emergency under-frequency ramp down of large loads	1
<b>Schedule 5.3a Conditions for connection of Market Network Services</b>	<b>8</b>
S5.3a.1a – Introduction to the schedule	1
S5.3a.4 – Monitoring and control requirements	1
S5.3a.8 – Reactive power capability	1
S5.3a.13 – Market network service response to disturbances in the power system	3
New clause	2
<b>Multiple schedules</b>	<b>2</b>
S5.2.5.2, S5.2.5.6, S5.2.5.10, S5.3.7, S5.1.5	1
S5.2.5.2, S5.2.5.6, S5.3.8, S5.3a.11, S5.1.6	1
<b>Total issues with recommendations</b>	<b>53</b>

## High level objectives

-  **Align with best power system performance.**
-  **Improve power system resilience.**
-  **Support efficient investment and operation.**
-  **Streamline the connection process.**
-  **Remove inadvertent impediments to the connection of grid-forming inverters.**
-  **Broaden application of technical requirements to synchronous condenser connections.**
-  **Incorporate the impact and capability of large loads into technical requirements**
-  **Broaden the application of technical requirements to all HVDC system connections**
-  **Incorporate and expand technical requirements to account for impact and capability of HVDC**

Schedule 5.2 recommendations

Schedule 5.3 recommendations

Schedule 5.3a recommendations



# NER Schedule 5.2 recommendations


## Conditions for Connection of Generators

Please enter your questions in the webinar Q&A.

Please “Like” other stakeholder’s questions to prioritise issues addressed in the Q&A

# NER S5.2 (Generator) recommendations

Recommendations for amendments to the NER Schedule 5.2 sought to achieve six high-level objectives. Select examples follow.



## Align with best power system performance.

Draft recommendations include:

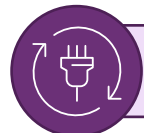
- Amend S5.2.5.1 voltage range for reactive power
- Amend S5.2.5.5 to target minimising voltage deviation from pre-fault conditions



## Streamline the connection process.

Draft recommendations include:


- Amend S5.2.5.8 to add flexibility in over-frequency ramp-down requirements
- Amend S5.2.5.1 to clarify reactive power requirements with temperature



## Remove inadvertent impediments to the connection of grid-forming inverters.

Draft recommendations include:


- Amend continuous uninterrupted operation definition or clauses to allow for phase angle jump response and inertial response
- Amend S5.2.5.13 to remove impediments to unit-level voltage control



## Support efficient investment and operation.

Draft recommendations include:


- Amend S5.2.5.13 to consider primary and secondary operation modes, with lower requirements for secondary modes
- Amend S5.2.5.4 to clarify the application of continuous uninterrupted operation



## Improve power system resilience.

Draft recommendations include:

- Amend S5.2.5.13 to focus on stability at low system strength conditions rather than speed of response
- Amend S5.2.5.5 multiple fault ride through for disclosure of conditions under which MFRT is not achievable



## Broaden application of technical requirements to synchronous condenser connections.

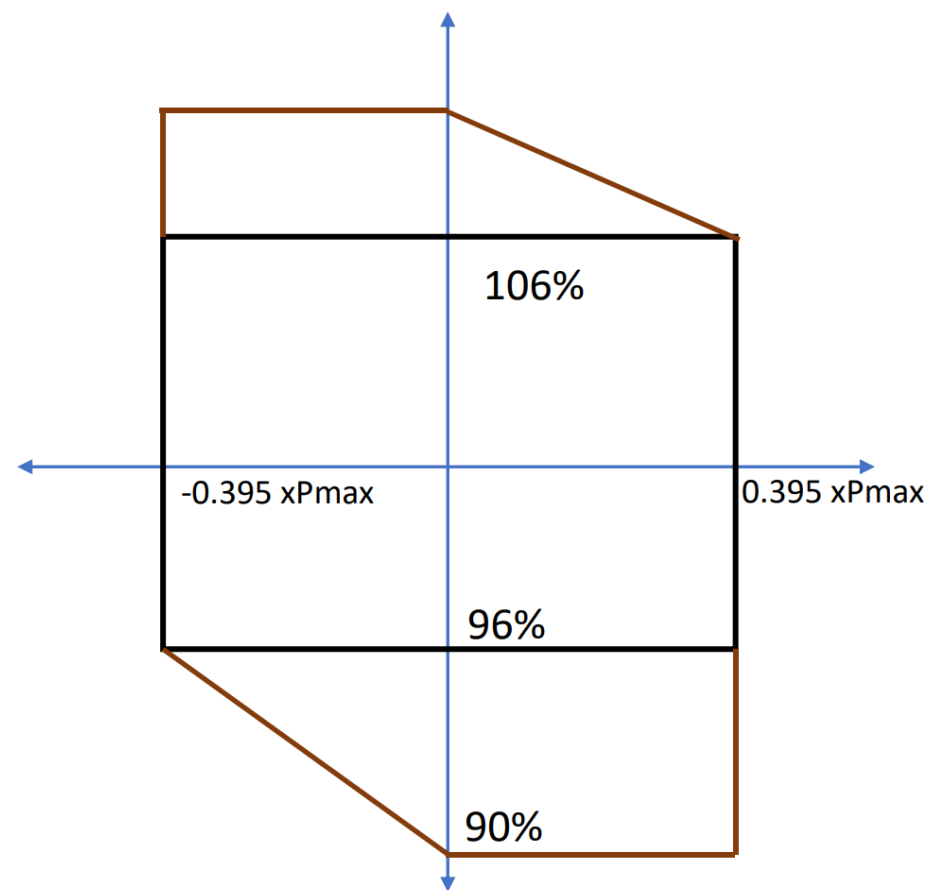
Draft recommendations include:

- Amend S5.2.1 to align the schedule with plant rather than registration category
- Identify specific clauses that apply to synchronous condensers



## S5.2.5.1 Reactive power requirement as a function of voltage (AAS)

- 10% range for full reactive requirement – mid point can be specified by NSP to suit connection
- Reduced injection requirement above upper threshold
- Reduced absorption below lower threshold





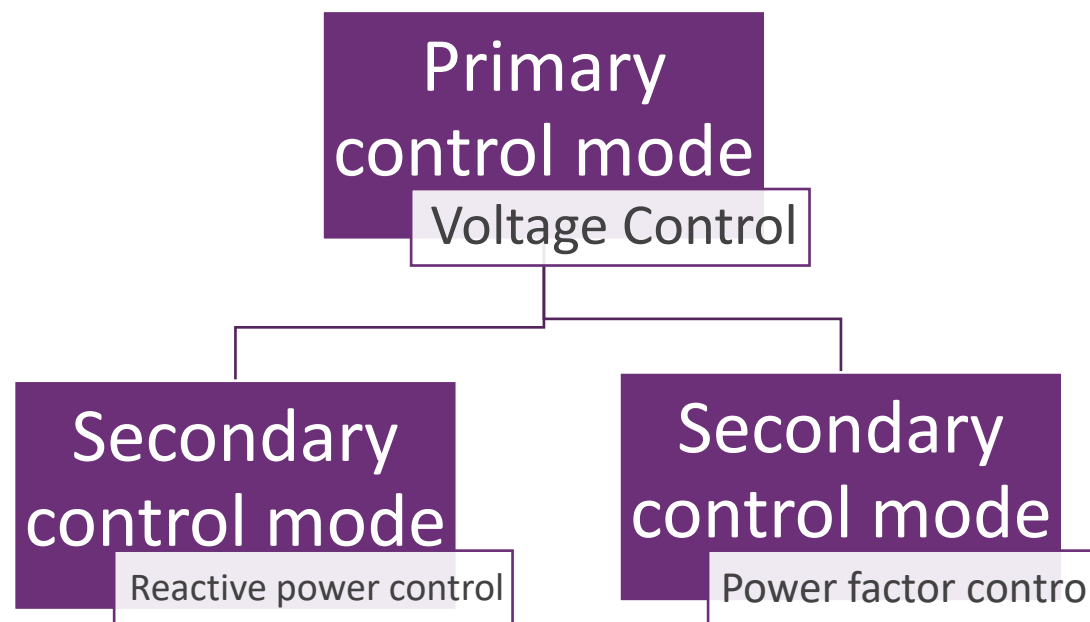
## S5.2.5.5 reactive current contribution to target minimising voltage deviation on each phase from pre-fault conditions

- Seeks to provide guidance for tuning under S5.2.5.5
- Unbalanced faults are more common than balanced
- Need to consider over-voltages on unfaulted phases
- Also consider immediate post-fault conditions
- Tuning needs to consider positive sequence and negative sequence injection wholistically to optimise overall response
- Should provide an optimisation criterion that can be demonstrated through studies.



## S5.2.5.13 to consider primary and secondary operation modes, with lower requirements for secondary modes

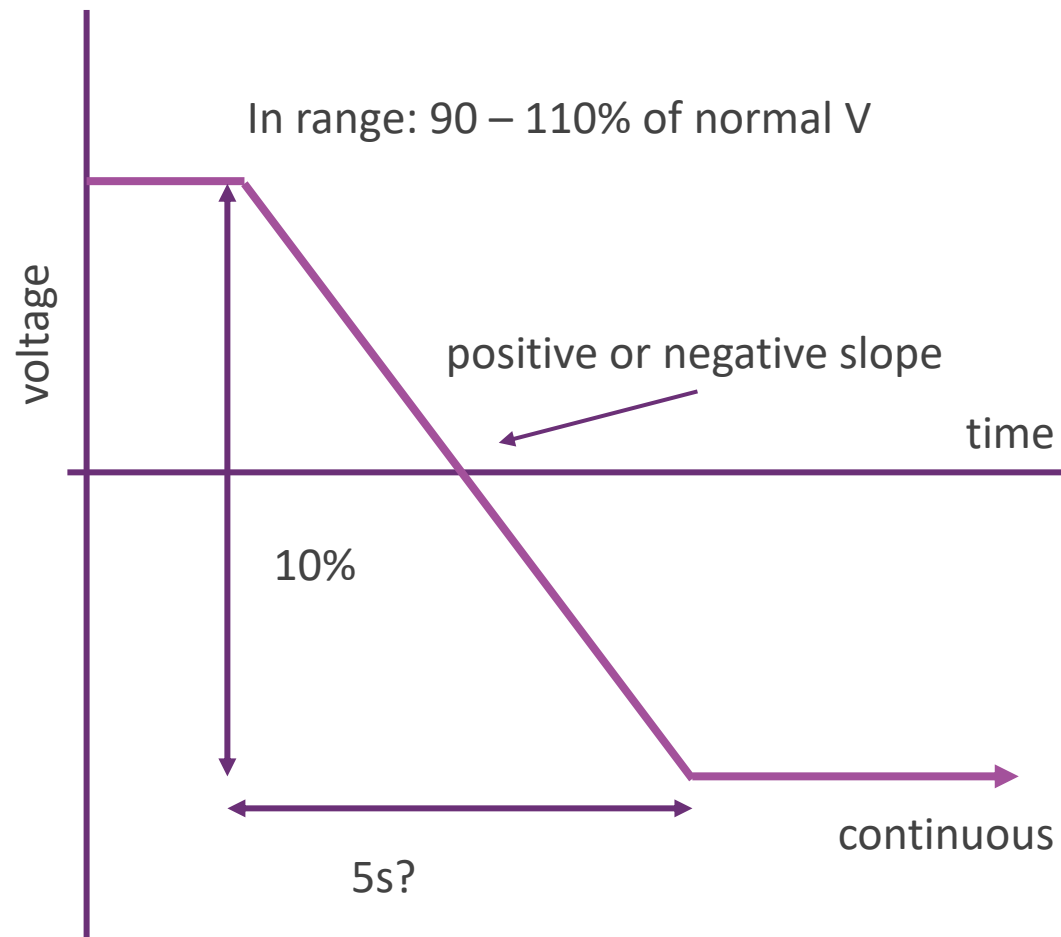
- AAS – plant to be tuned and assessed for compliance for a primary and secondary mode of operation, with ability to switch between them
- Primary mode – voltage
- Secondary mode either PF or reactive
- Reduced requirements in secondary mode
  - Do not require settling time calculation for setpoint change of PF or reactive power
  - Retain requirement for settling time assessment to a voltage change when in PF or reactive power mode)
  - If PF mode is primary mode, setpoint step response requirement remains
- Should reduce compliance assessment and testing at connection and on-going compliance assessment costs.

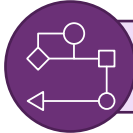




## S5.2.5.4 to clarify the application of continuous uninterrupted operation

- Requirement is for CUO continuously in the range 90-110%
  - Links to S5.2.5.1 and 13
- Lack of clarity leads to different approaches applied across the NEM
  - Has material impact on capital costs, especially for IBR plant
  - Can affect cost and duration of connection time





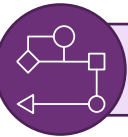
## S5.2.5.8 to add flexibility in over-frequency ramp-down requirements

### Issue

- Some plants e.g. hydro can't [always] meet the MAS for fast ramp down or proportional ramp down within 3s of frequency achieving 52 Hz
  - Only option to meet clause is tripping
    - ↓ inertia, ↑RoCoF (resilience impact)
    - Preferable that plants stay connected
- Clause reference upper limit of extreme frequency tolerance band – but plant is permitted to trip then
- Many plants now enabled for PFR
- Applies to 30 MW plant, except batteries at 5 MW

### Proposed solution

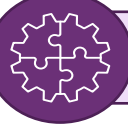
- Record best capability considering physical attributes of plant
- Allow ramp down to commence earlier than 51 Hz
- Refer to 0.5 Hz less than upper limit...
- [Set protection to trip at higher than 52 Hz where safe to do so with modest safety margin]
- Make the requirement only for plant not providing PFR
- Make consistent at 30 MW



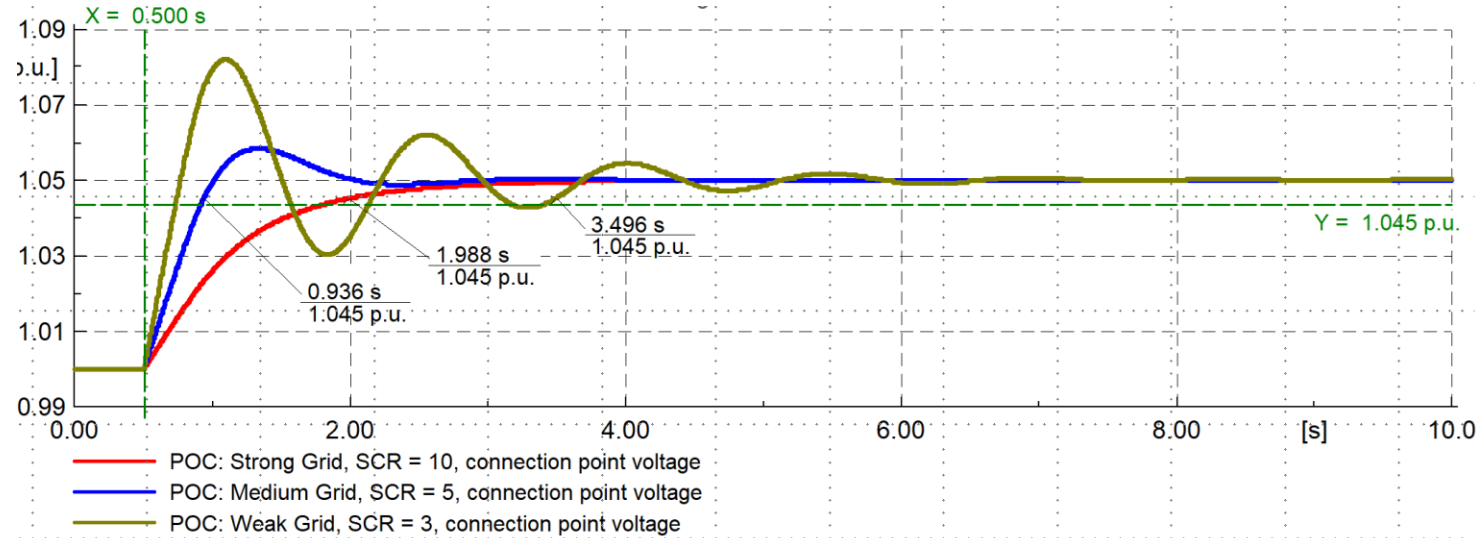
## S5.2.5.1 to clarify reactive power requirements with temperature

- Many plants derate with temperature
  - Trade off between active and reactive power capability (capital cost/ yield implications)
- NER is silent on how reactive power requirement is determined for temperature derating
  - Not consistently applied across the NEM
- Propose that AAS requirement is  $\pm 0.395 \times P_{\max} (T)$ 
  - For a bidirectional unit absorbing active power  $\pm 0.395 \times P_{\min} (T)$

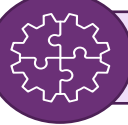




## S5.2.5.13 to focus on stability at low system strength conditions rather than speed of response

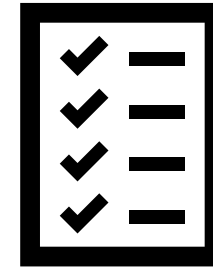


- Stability reduces with increased impedance (reduced fault level)
  - Consider the range of system impedance [site specific]
- Voltage response most critical when system is stressed
- Refocus on stability at low system strength, rather than speed of response
- AAS 2 s rise time at highest system impedance level
- If AAS settling time cannot be met at low and high impedance, prioritise high system impedance response (not so important if low impedance settling time is overdamped, and slower)
- Record range of impedances – for tracking & possible future retuning



## S5.2.5.5 multiple fault ride through - disclosure of conditions under which MFRT is not achievable

- Current NER has rules for MFRT, but perversely incentivises proponents not to check all possible combinations of faults
  - Technically challenging to select most critical combinations
  - Costly and time consuming
  - Risky because one combination of faults not ridden through is a fail
  - Inconclusive – can't prove compliance, only non-compliance
- More beneficial to incentivise disclosure of limitations on MFRT
  - Operations can work with known limitations (envelop of secure operation)
- Proposal includes:
  - Assessment against a suite of tests (power system conditions adjusted to connection point conditions – range of fault level/system impedance)
  - Declaration of limitations – effectively exemptions on MFRT
  - Supporting evidence/documentation to be provided



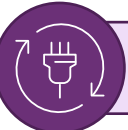
Test Suite



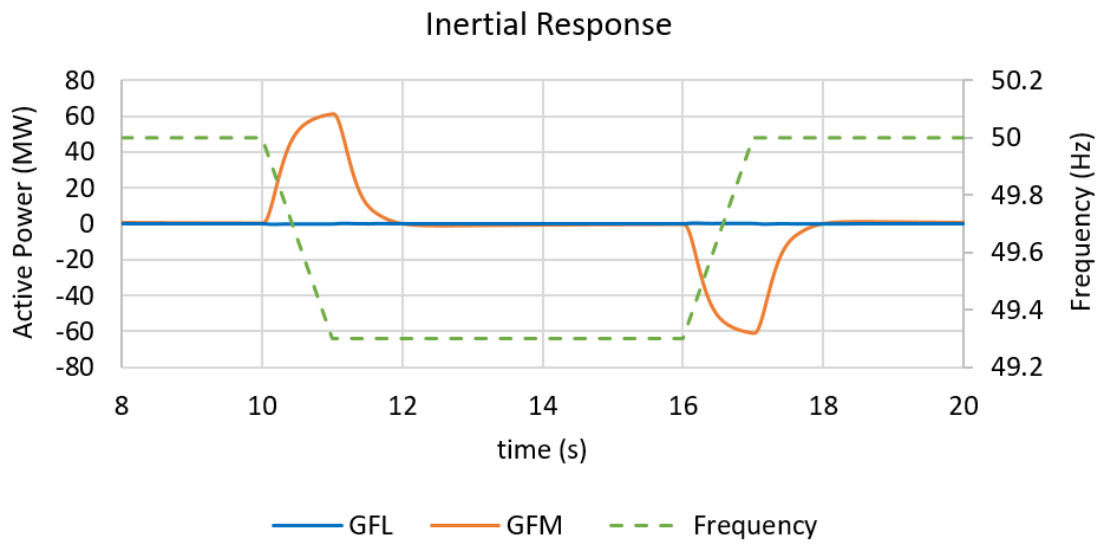
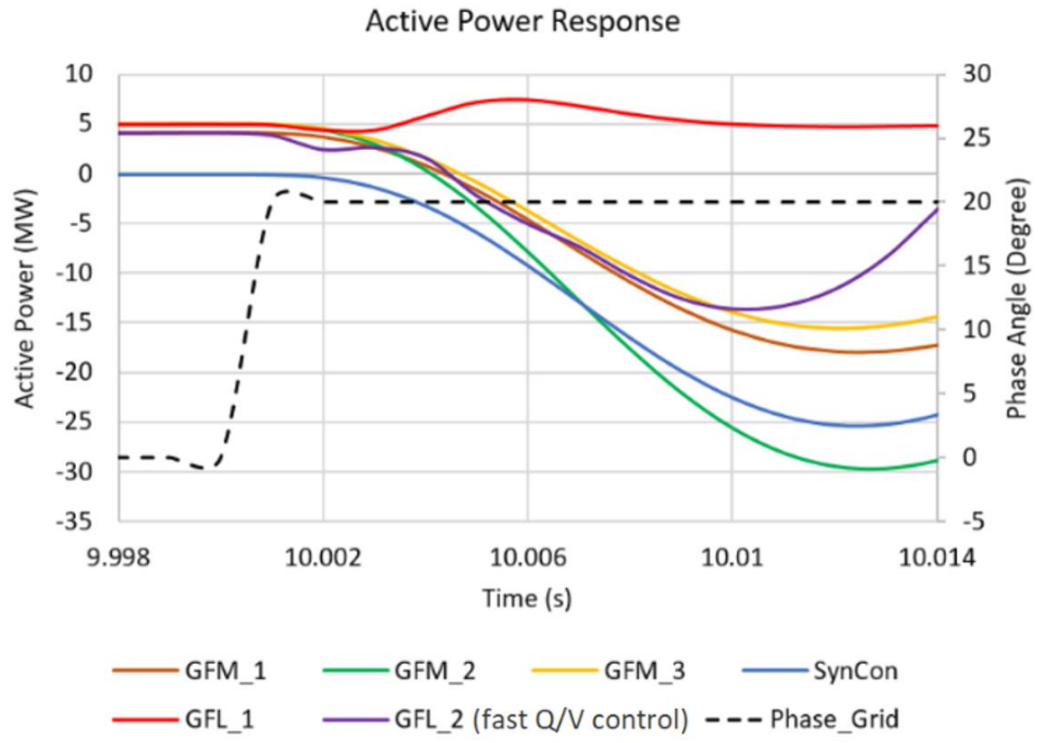
Declaration of limitations

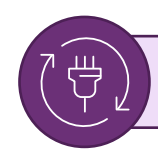


Document assessment conditions



# Amend continuous uninterrupted operation definition or clauses to allow for phase angle jump response and inertial response





## S5.2.5.13 - remove impediments to unit-level voltage control

- GFM inverters are most useful for low system strength situations
- Under these situations the dual ppc-inverter voltage control is not ideal
  - Lags from communications between PPC and inverter levels
  - Sample and hold ppc controls typically 100 ms sample rate
    - Unit level control will be beneficial at low system strength
- Clarify that voltage, reactive and pf control may be implemented at unit level for both synchronous
- Allow rate limited setpoint changes under normal operations
- Bypass rate limiting for testing purposes



## S5.2.1 to align the schedule with plant rather than registration category

- At present Schedule 5.2 is relevant to Generators and IRP
  - Synchronous condensers are covered to the extent they are registered by Generators or IRP
  - A standalone synchronous condenser cannot register as a Generator.
  - No performance standards apply for standalone synchronous condensers at present
  - In future there may be many standalone synchronous condensers
- Intend to reformulate so that the schedule applies to the plant rather than the registration category



## Identify specific clauses that apply to synchronous condensers

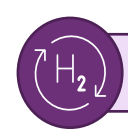
- Synchronous condensers – apply synchronous generating unit/system clauses, other than active power

# NER Schedule 5.3 recommendations

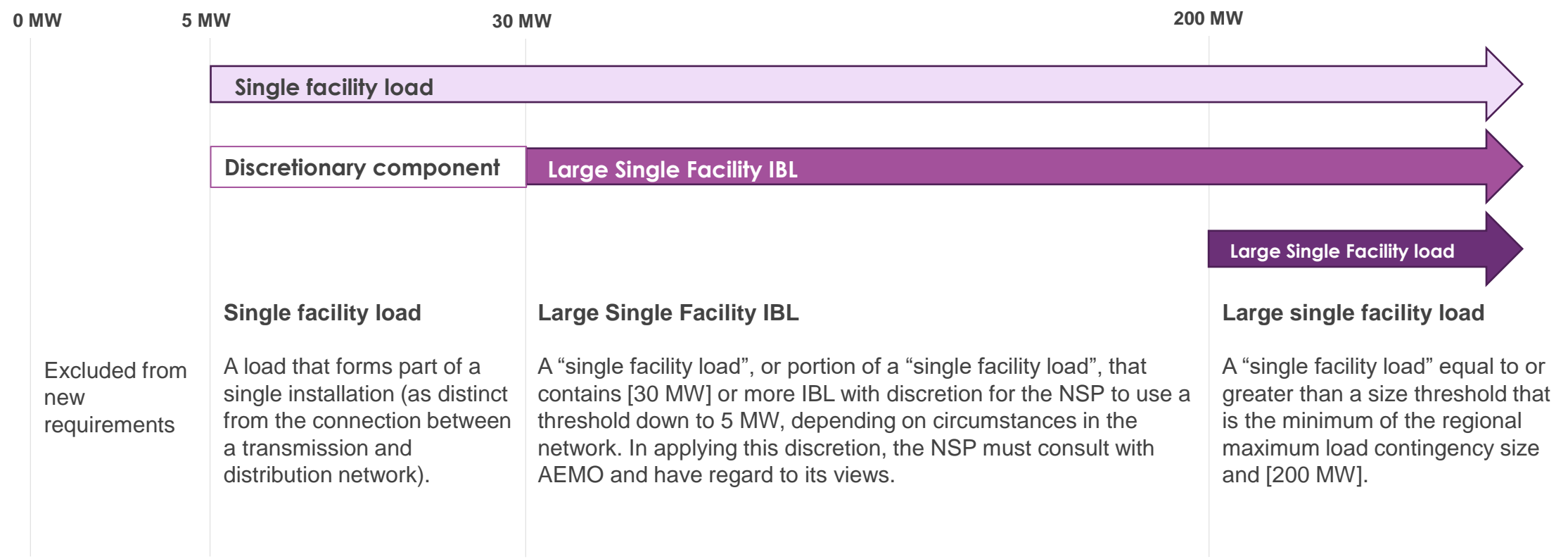
## Conditions for Connection of Customers

Please enter your questions in the webinar Q&A.

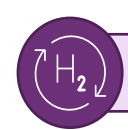
Please “Like” other stakeholder’s questions to prioritise issues addressed in the Q&A



# Recommendations – Definitions

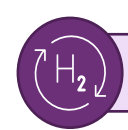






# Recommendations – Policy positions

Issue	Recommendation
<b>Recognition of different load technologies</b>	Consider IBL ride through requirements and general requirements for load separately.
<b>Thresholds for requiring loads to have ride through capability</b>	Apply different thresholds for traditional loads and IBL: <ul style="list-style-type: none"> <li>• Require ride through performance standards for:               <ul style="list-style-type: none"> <li>• traditional loads above a high threshold (see New Definition of <i>large single facility load</i>)</li> <li>• IBL above a lower threshold (see New Definition of <i>large single facility IBL</i>)</li> </ul> </li> <li>• Require a MAS for all single facility loads of 5 megawatts (MW) or more to have protection systems that do not disconnect the plant for voltage, frequency and rate of change of frequency (RoCoF) disturbances within the inherent technical capability of the plant, allowing for modest safety margins.</li> </ul>
<b>Treatment of different load technologies within a load facility</b>	Apply thresholds based on the portions of load with and without ride through capability, with the agreement of the NSP and AEMO.
<b>Continuous uninterrupted operation (CUO)</b>	Apply a light-handed CUO which requires a large load not to: <ul style="list-style-type: none"> <li>• disconnect for the specified conditions.</li> <li>• change its active power by more than [20%] following the disturbance, or as agreed with the NSP and AEMO, except where it is required to participate in load-shedding or frequency response.</li> <li>• materially exacerbate or prolong the disturbance or cause a subsequent disturbance for other connected plant</li> </ul>
<b>Treatment of loads with UPS</b>	Treat a large load with a UPS consistent with any other load, either as a traditional load or an IBL depending on the technology used for the UPS. The same thresholds as other loads would apply for determining what ride through requirements would be required.
<b>AEMO advisory matters</b>	Prescribe load access standards that relate to AEMO’s system security functions under the National Electricity Law (NEL) to be AEMO advisory matters.



# Recommendations – Technical requirements

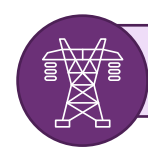
New/amended clauses for ride-through requirements			
	AAS	MAS	AAS & MAS
<p>3a. Operation of large loads during frequency disturbances</p> <p>AEMO advisory matter</p>	<p>For a large single facility load and for a large single facility IBL, apply an AAS consistent with the S5.2.5.3 AAS requirements. This would also include a RoCoF requirement, consistent with NER S5.2.5.3.</p>	<ul style="list-style-type: none"> <li>For large single facility IBL, apply a MAS consistent with NER S5.2.5.3 MAS, including RoCoF.</li> <li>For large single facility loads (other than large single facility IBL), apply a MAS consistent with a single credible contingency event, and RoCoF in accordance with the NER S5.2.5.3 MAS.</li> </ul>	<p>Apply light-handed CUO requirements.</p>
<p>3b. Operation of large loads during contingency events</p> <p>AEMO advisory matter</p>	<p>For large single facility IBL, for the (IBL component), apply a AAS consistent with the AAS of S5.2.5.5 for faults, credible contingency events, and multiple disturbance ride through.</p>	<ul style="list-style-type: none"> <li>For large single facility IBL, apply a MAS consistent with the MAS of S5.2.5.5 for faults, credible contingency events, and multiple disturbance ride through.</li> <li>For large single facility loads (other than large single facility IBL), apply a MAS consistent with a single credible contingency event.</li> </ul>	<p>Apply a light-handed CUO requirements.</p>
<p>3c. Operation of large loads during voltage disturbances</p> <p>AEMO advisory matter</p>	<p>For large single facility loads and large single facility IBL, apply an AAS consistent with the AAS levels of S5.2.5.4.</p>	<ul style="list-style-type: none"> <li>For large single facility IBL, apply a MAS consistent with the MAS level of S5.2.5.4.</li> <li>For large single facility loads (other than large single facility IBL), the MAS is that no capability is required.</li> </ul>	<p>Apply a light-handed CUO requirement.</p>
NER S5.3.3 – protection systems and settings			
<p>3d. Link to 'ride through' requirements and maximising protection</p> <p>Not an AEMO advisory matter</p>	<p>Set a MAS requirement that protection be set to maximise capability to ride through voltage and frequency disturbances including RoCoF subject to the technical capabilities of the plant and safe operation, and modest safety margins.</p>		
NER S5.3.10 – Load shedding facilities			
<p>3e. Emergency Under-frequency ramp down of large loads</p> <p>AEMO advisory matter</p>	<p>Explicitly include options of ramp down proportional to frequency, rapid ramp down, when frequency drops below a threshold, and load shedding in one or more blocks and combinations of these, as acceptable ways of meeting the under-frequency load shedding requirements, with settings to be provided by the NSP.</p>		
New clause for instability monitoring and prevention			
<p>3f. Stability of IBL – monitoring, protection and performance</p> <p>AEMO advisory matter</p>	<ul style="list-style-type: none"> <li>Require monitoring for single facility loads with IBL components <math>\geq [5]</math> MW</li> <li>Require protection for instability for single facility loads with IBL components <math>\geq [20]</math> MW</li> <li>In the AAS, require detection devices that can determine the contribution to an instability.</li> <li>In the AAS, permit alternative actions to tripping (to reduce instability).</li> <li>Require single facility loads to not to cause an oscillation that isn't adequately damped and does not amplify any oscillation. (Amend NER S5.3.11 MAS)</li> </ul>		

# NER Schedule 5.3a recommendations

## Conditions for Connection of Market Network Services

Please enter your questions in the webinar Q&A.

Please “Like” other stakeholder’s questions to prioritise issues addressed in the Q&A



Broaden the application of technical requirements to all HVDC system connections



Incorporate and expand technical requirements to appropriately account for the impact and capability of HVDC

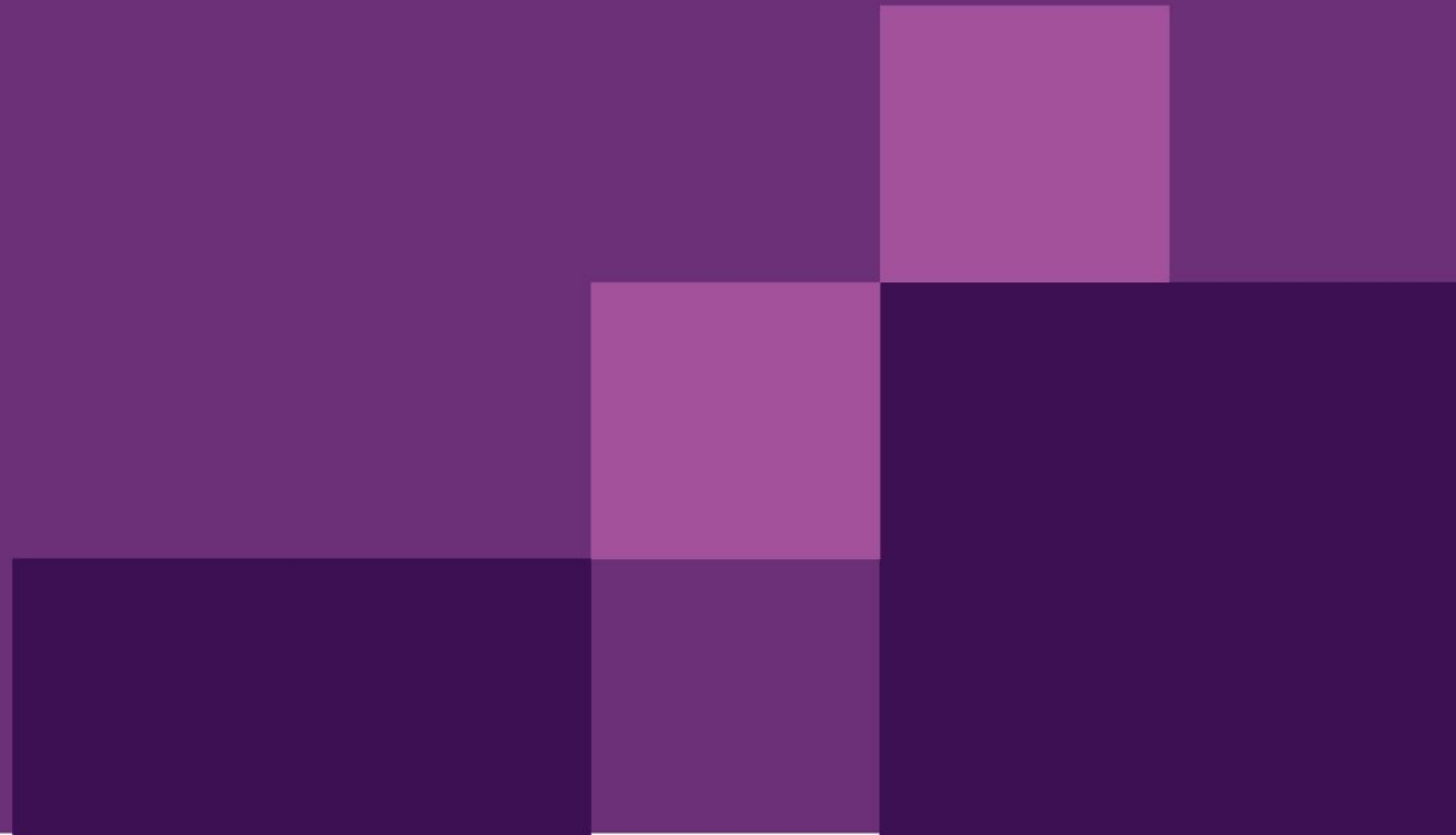


# NER S5.3a (Market Networks Services) recommendations

Schedule and clause	Issues
Schedule 5.3a	8
S5.3a.1a Introduction to the schedule	1
S5.3a.4 Align remote inverter stability monitoring and protection	1
S5.3a.8 Reactive power capability with S5.2.5.1	1
S5.3a.13 Align frequency disturbance capability with NER S5.2.5.3	1
S5.3a.13 Align voltage disturbance capability with NER S5.2.5.4	1
S5.3a.13 Align multiple fault ride through capability with NER S5.2.5.5	1
New clause: Align voltage control with NER S5.2.5.13 for generators	1
New clause: Align active power control NER S5.2.5.14 for generators	1

Recommendation to amend S5.3a.1a such that it apply to all HVDC system connections (not just to Market Network Services category)

# Next steps



# Next steps



**12 Oct 2022**

Approach Paper publication



**3 Mar & 4 Apr 2023**

Draft Report publication



**Jun-Aug 2023**

Draft Rules release



**Oct 2023**

Final Report publication



**~Nov 2023**

Rule change proposal

**20 Apr & 23 May 2023**  
Consultation closure

**Jul – Aug 2023**  
Consultation closure

*Refine scope and preferred solutions in consultation with stakeholders*

*Review feedback, refine recommendations & draft Rules*

*Review feedback, refine recommendations & finalise Rules*

*Participate in Technical Focus Groups*

*Review Draft Report*

*Participate in stakeholder consultation as required*

*Review Draft Rules*

*Participate in stakeholder consultation as required*

**12 April 2023**  
Stakeholder Forum



Activity	Timing
Approach Paper released	12 October 2022
Draft Report (Part 1) published	3 March 2023
Draft Report (Part 2) addendum published	4 April 2023
Draft Report (Part 1) consultation closes	20 April 2023
Draft Report (Part 2) consultation closes	23 May 2023
Draft Rules consultation commences	June - August 2023
Final Report released	October 2023
AEMC formally notified of outcomes	Early November 2023 (indicative)



For more information visit

[aemo.com.au](http://aemo.com.au)