AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Overview of rule change proposals to improve NEM access standards

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New South Wales | Queensland | South Australia | Victoria | Australian Capital Territory | Tasmania | Western Australia

Australian Energy Market Operator Ltd ABN 94 072 010 327

Purpose

This document describes AEMO's rule change proposals to improve the technical requirements for connection (access standards) in Chapter 5 of the National Electricity Rules, and associated provisions.

AEMO acknowledges the Traditional Owners of country throughout Australia and recognises their continuing connection to land, waters and culture. We pay respect to Elders past and present.

Contents

1 Summary

The Australian Energy Market Operator (AEMO) is submitting two rule requests containing proposals to improve the technical requirements for connection (access standards) for the National Electricity Market (NEM) in the National Electricity Rules (NER or rules). The current access standards[1] cover the connection of generators and integrated resource providers (IRPs), customers (loads) and market network service providers (MNSPs).

This document sets out the nature and objectives of the rule change proposals and how they advance the national electricity objective (NEO). AEMO considers the proposed rule changes will:

- Streamline the connection process – accelerating the connection of new generation necessary to deliver on targets to reduce Australia's greenhouse gas emissions and bringing forward the benefits of new connections for electricity consumers.
- Improve the resilience of the NEM – reducing the risk of interruptions to electricity supply.
- Support efficient investment in and operation of the NEM – reducing the cost of electricity.
- Better accommodate new and evolving technologies – allowing the NEM to realise the benefits of these technologies.

These proposals give effect to the final recommendations of AEMO's Access Standards Review (the Review).[2] Over the course of the Review, AEMO developed the proposed rule changes through iterative and detailed public consultation. This included targeted engagement with particularly affected stakeholder groups such as network service providers (NSPs), generators, developers, original equipment manufacturers (OEMs) and large customer representatives. The reports, submissions and other documents produced at each stage of the Review are available on AEMO's website.[3]

The Review allowed AEMO to identify and consider a comprehensive number of existing and emerging issues relating to the access standards for connection to the NEM. The constructive participation of a broad range of stakeholders in the Review provides assurance that the proposed rule changes represent robust and well-informed solutions to the identified issues.

AEMO notes that a comprehensive consultation does not guarantee unanimous support for the proposed changes. The interests of different groups of stakeholders may not align on aspects of the access standards for NEM connection, because those standards allocate risks and costs across different industry participants. AEMO's primary objective has been to develop rules that best advance the NEO, not necessarily to achieve consensus on all proposals.

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1 As will be amended from 3 June 2024 by the *National Electricity Amendment (Integrating energy storage systems into the NEM) Rule 2021* to include access standards for integrated resource systems*.*

2 For further information on this review please see: https://aemo.com.au/en/consultations/current-and-closed-consultations/aemo-review-of-technical-requirements-for-connection. The final recommendations are set out in the final report: AEMO, *Review of technical requirements for connection - National Electricity Rules Schedules 5.2, 5.3 and 5.3a: final report*, December 2023.

3 https://aemo.com.au/en/consultations/current-and-closed-consultations/aemo-review-of-technical-requirements-for-connection

1.1 Two rule requests

AEMO is requesting the Australian Energy Market Commission (AEMC) to make a 'fast track' rule to implement the majority of the Review's recommendations. Under the 'fast track' process in the National Electricity Law (NEL), the AEMC may publish a draft rule without needing to first seek submissions on the rule request. This process allows for a streamlined consultation process for greater efficiency where a market body has conducted adequate consultation before submitting the request. AEMO's request for a fast track rule is supported by the extensive public consultation it undertook in developing the proposed rule changes – which included an opportunity to comment on a preliminary draft of the rule changes now being requested. This public consultation is detailed in section 2.3 of this Overview.

AEMO is also submitting a request for the AEMC to make a rule under its standard rule change process in the NEL. The standard rule request contains a comparatively small number of amendments. These relate to issues or solutions that may not have been fully canvassed in the Review and are likely to benefit from an additional stage of consultation by the AEMC.

This Overview explains the rule change proposals covered by both requests, which are best understood as a package. They share the same objectives and address similar issues. Taken together, they deliver on AEMO's final recommendations from the Review. Further, while the proposed changes in the fast track request stand alone, the standard request builds on some of the proposed fast track changes.

This Overview does not explicitly highlight the proposed fast track rules, as they make up the majority of the proposed amendments. However, amendments requested under the standard rule change process are flagged.

The proposals include detailed drafting of suggested NER amendments. AEMO has prepared a marked-up version of the relevant NER extracts showing proposed amendments under both rule requests.

1.2 Rule change proposal documentation

To present and explain the rule change proposals AEMO has prepared four documents – this Overview and three attachments. This Overview explains the rule change proposals from a top down-perspective. The attachments are as follows:

- Attachment A is AEMO's request to make a rule using the fast track process in section 96A of the NEL.
- Attachment B is AEMO's request to make a rule under the standard NEL rule change consultation process.
- Attachment C is a mark-up of rule extracts with proposed drafting for AEMO's proposed amendments under both rule requests. These amendments are presented together for convenience as they share the same objectives and many amendments proposed under the standard request build on those in the fast track request.

  The proposed amendments are colour coded to distinguish between fast track and standard requests. The mark-up also contains drafting notes to explain amendments and corrections that may not be specifically noted in this Overview.

The remainder of this Overview is structured as follows:

Section 2 *Background* provides context for the rule change proposals. This includes the purpose and function of the access standards, the key drivers for change and a high-level description of the Review and the consultation AEMO undertook over the course of the Review.

Section 3 *Delivering on the national electricity objective* lists the objectives that underpin the Review and the rule change proposals. This section also sets out the issues each objective addresses and how each objective contributes to the advancement of the NEO.

Section 4 *Changes to the access standards application framework* describes AEMO's proposed rule changes to support the application of the access standards based on the nature and impact of connected plant, rather than the category or registration status of the person who owns, operates or controls the plant.

Section 5 *Access standards for generation, integrated resource systems and synchronous condensers* outlines AEMO's proposed NER amendments (primarily in schedule 5.2) to improve the access standards for generation, IRS and synchronous condensers.

Section 6 *Access standards for HVDC links* outlines AEMO's proposed NER amendments (primarily in schedule 5.3a) to improve the access standards for HVDC links.

Section 7 *Access standards for loads [Standard – non fast track – amendment]* This section outlines AEMO's proposed NER amendments (primarily in schedule 5.3) to improve the access standards for loads.

Section 8 *Other NER amendments* describes other proposed amendments intended to either align the function of specific rules with their intent, reduce ambiguity, or improve outcomes consistent with the NEO.

1.3 Proposed draft rules and transitional arrangements

Sections 4 to 8 of this Overview do not detail every NER amendment that AEMO is proposing. Additional amendments are included in the mark-up of rule extracts in Attachment C, with explanatory drafting notes where the reasons for change may not be clear. These include consequential amendments flowing from changes discussed in this document, amendments to correct omissions or errors, and amendments for clarification purposes or to streamline the rule drafting.

AEMO has not attempted to draft transitional rules for these proposals. AEMO expects that amendments to the access standards would generally take effect for plant under connection applications (and alteration submissions) made after the effective date of the relevant rule change. AEMO is happy to discuss transitional issues with the AEMC and relevant stakeholders with a view to achieving an appropriate and consistent transition that allows benefits to be realised for all involved in the connection process at the earliest opportunity.

2 Background

The energy transition is well underway, and the NEM needs to grow and change to continue delivering secure, reliable and affordable electricity to millions of Australians whilst achieving emissions reduction targets. AEMO's draft 2024 Integrated System Plan (ISP) projects that on the optimal development path, grid-scale variable renewable energy would triple by 2030 and increase by seven-fold by 2050.[4]

Competing objectives need to be balanced to best deliver the transition in accordance with the NEO. The NEM must operate safely and reliably today while being refitted for tomorrow. It must integrate new technologies piece by piece while keeping the whole system stable to continue to deliver reliable and affordable electricity throughout the transition. These tensions were front-of-mind when conducting the Review.

2.1 Requirement for the Review

The requirement for a regular review of the access standards was initially proposed in the Independent Review into The Future Security of the National Electricity Market (Finkel review).[5] This review noted the importance of connection standards being fit for purpose in a modern and rapidly transforming power system. It recommended, given the ongoing technological change facing the NEM, a regular comprehensive review of the connection standards.[6]

The AEMC introduced clause 5.2.6A into the NER in response to this recommendation, together with the major revisions to the access standards that were implemented in 2018.[7] NER 5.2.6A requires AEMO conduct a review of some or all of the technical requirements in NER schedules 5.2, 5.3 and 5.3a at least once in every five year period. In making NER 5.2.6A, the AEMC considered that AEMO should be able to exercise its discretion to set the scope of the Reviews to address the most pressing needs of the power system.[8]

Each of the schedules is currently drafted to apply to different connecting participants, as follows:

- Schedule 5.2 – requirements to be met by registered (and some exempt) generators and integrated resource providers[9] as a condition of connecting a generating system or integrated resource system to the power system.
- Schedule 5.3 – requirements to be met by market customers for their market connection points, and registered or potentially unregistered customers connecting load facilities to a network, and distribution network service providers (DNSPs) connecting to other networks.

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4 AEMO, *Draft 2024 Integrated System Plan for the National Electricity Market, A roadmap for the energy transition*, 15 December 2023, pp, 10, 48

5 Dr Alan Finkel AO, Chief Scientist, Chair of the Expert Panel | Ms Karen Moses FAICD | Ms Chloe Munro | Mr Terry Effeney | Professor Mary O'Kane AC, *Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future*, June 2017.

6 Ibid. p. 54.

7 *National Electricity Amendment (Generator Technical Performance Standards) Rule 2018*.

8 AEMC, *Rule Determination: National Electricity Amendment (Generator Technical Performance Standards) Rule 2018*, September 2018, p. 245.

9 Integrated resource providers to be added as a category of registered participant for 'integrated resource systems' from 3 June 2024. The Review considered improvements to the access standards as if these changes were already in the NER.

- Schedule 5.3a – requirements to be met by market network service providers connecting to a transmission or distribution network.

The 2022-23 Review was the first undertaken by AEMO under NER 5.2.6A.

2.2 Role of access standards in the connection process

To establish a new connection under NER Chapter 5 (following the process in rule 5.3 or 5.3A), a connection applicant and the connecting NSP must agree a set of performance standards for the connecting plant within the parameters set by the access standards in the applicable schedule.

The current format of the access standards was established after a 2001 review by the then National Electricity Code Administrator (NECA), which found that mandatory fixed access standards were inefficient. NECA noted that the cost of meeting those standards will vary dramatically for different types of plant. Some could significantly overachieve against a mandatory standard at low cost, while others may only be able to achieve that standard at prohibitive cost.[10] In addition, the need for plant to meet a mandatory level of technical performance was likely to vary between different locations within the NEM. NECA introduced flexibility in access standards by specifying a negotiating range, subject to a mandated minimum.

Each access standard relates to a technical requirement for the performance of a connected plant, regarding its impact on the broader power system. Most (but not all) access standards have two components:

- An automatic access standard (AAS), meaning connection cannot be refused if the plant meets that standard.
- A minimum access standard (MAS), meaning that connection must be refused if the plant does not meet that standard.

The negotiation framework in the NER requires a connection applicant to propose standards that are as close as practicable to the AAS. A proposed standard below the AAS, down to and including the MAS, is a negotiated access standard (NAS). AEMO reviews and provides advice to NSPs on negotiated access standards for several technical requirements[11], where there is potential to impact power system operation. These are referred to as 'AEMO advisory matters'.

Once the proposed access standards are agreed (with AEMO approval where required), they become the performance standards for the relevant plant, and are included in the binding connection agreement between the connection applicant and the NSP. Where applicants are (or will be) registered participants, the performance standards must be registered with AEMO and an ongoing compliance regime will apply under NER 4.15.

[10] National Electricity Code Administrator, *Review of technical standards final report*, December 2001.
[11] Listed in the NER glossary term "AEMO advisory matter"

Each plant's performance standards should be consistent with achieving the network performance requirements of the NSP[12]. In turn, they must also be consistent with overall system standards for the NEM.[13]

2.3 AEMO's consultation on the Review

AEMO adopted a systematic and detailed approach to the Review. With extensive stakeholder input, and the experience of its own specialist teams across broad system design and operational areas, AEMO identified a large number of issues that frequently arise in respect of individual access standards, and considered improvements to the broader application of relevant standards to existing and emerging technologies in the NEM.

Formal consultation on the Review commenced in October 2022 with the publication of an approach paper, itself developed after an initial scoping exercise canvassing multiple stakeholder groups and forums. The consultation followed a more extensive process than that required by the NER, including two further stages of public reporting and written submissions: on draft recommendations (March and April 2023), and on updated draft recommendations and draft rule amendments (July 2023). At each stage, and in the lead-up to the final report in December 2023, AEMO held multiple technical industry workshops and meetings with interested stakeholders, and responded in detail to all public submissions.

Table 1 sets out the consultation AEMO undertook over the course of the Review.

Table 1 Summary of public stakeholder consultation steps

Review stage	Stakeholders involved
Issues scoping and preparation of approach paper	
Scoping across multiple stakeholder groups to identify issues for consideration under the Review.	Network service providers, Connections Reform Initiative workshop attendees, Central West Orana Renewable Energy Zone access standards stakeholders, the Clean Energy Council, Energy Users Association, Australian (EUAA), Energy Council, Energy Networks Association, and the AEMC Reliability Panel.
Preparation of draft report	
Key stakeholder group briefings Briefings on the on the proposed scope set out in the Approach Paper and invited feedback on the scope of the Review.	Clean Energy Council, Energy Users Association of Australia, Australian Energy Council, Energy Networks Association, and the AEMC Reliability Panel.
Prioritisation workshops Four prioritisation workshops for each of the four technical focus groups to understand views on the criticality of addressing each identified issue, and obtain feedback to refine or amend issue statements. Workshop discussions informed AEMO's determination of issues to pursue through this Review.	AEMO established four technical focus groups comprising representatives with technical expertise and direct experience with access standards from NSPs, market participants (generators and large loads), developers and OEMs. The four technical groups covered: • General standards • Grid-forming inverter standards • Large load standards • HVDC link standards The AEMC also observed these workshops.

[12] As per NER Schedule 5.1.
[13] As per NER Schedule 5.1a.

<table>
<tr><th>Review stage</th><th>Stakeholders involved</th></tr>
<tr><td>Options assessment workshops
13 options assessment workshops on 28 issues involving greater complexity or with lower levels of consensus around their impact, interpretation or potential resolution.</td><td>Representatives of each of the relevant technical focus groups (noted above) attended these workshops, with 100 individuals attending one or more workshops.
The AEMC also observed these workshops.</td></tr>
<tr><td colspan="2">Preparation of update report and draft NER amendments</td></tr>
<tr><td>Draft report stakeholder forum - AEMO review of technical requirements for connection
This forum was facilitated to provide:
• background, approach and current status of the Review
• overview of recommendations made by the draft report and addendum
• opportunity for stakeholders to raise questions or issues regarding the draft recommendations.</td><td>Over 100 interested parties attended the webinar (invitations to register were issued via the AEMO newsletter and website and communications targeted at technical focus groups).</td></tr>
<tr><td>Formal written submissions
Submissions on draft report.</td><td>18 respondents made submissions in response to the draft report on recommendations for NER Schedules 5.2 and 5.3a.</td></tr>
<tr><td>Ad hoc meetings
Meetings to:
• clarify understanding of issues raised and discuss proposed positions
• discuss feedback with small number of High voltage direct current (HVDC) link stakeholders
• discuss draft recommendations with NSPs that had not made a formal written submission.</td><td>A range of stakeholders submitting formal feedback, as well as NSPs which had not been able to provide feedback.</td></tr>
<tr><td>Drafting discussion
Discussion of key drafting and structural issues.</td><td>NSP legal and technical representatives</td></tr>
<tr><td colspan="2">Preparation of final report</td></tr>
<tr><td>Update report stakeholder forum - revised recommendations
The forum was facilitated to provide:
• Current status of the Review and consultation
• Overview of revised recommendations made by the update report
• Opportunity for stakeholders to raise questions or issues regarding the revised recommendations.</td><td>130 interested parties attended the webinar – invitations to register were issued via the AEMO newsletter and website and communications targeted at technical focus groups.</td></tr>
<tr><td>Formal written submissions
Submissions on addendum to draft report.</td><td>11 respondents made submissions in response to the draft report on recommendations for NER Schedules 5.3 which were then addressed in final recommendations set out in this report (an update report was not issued in respect of loads).</td></tr>
<tr><td>EUAA workshops
Follow-up workshops with the EUAA to discuss recommendations for load connections made in the draft report addendum, specifically to:
• Discuss AEMO's recommendations and underlying rationale;
• Understand EUAA member concerns as raised in its written submission
• Discuss potential solutions and alternatives.</td><td>EUAA membership group.</td></tr>
</table>

Review stage	Stakeholders involved
Formal written submissions Submissions on update report and NER drafting.	23 respondents made submissions in response to the update report on recommendations for NER Schedules 5.2 and 5.3a and the accompanying draft NER to give effect to those recommendations.
Large load connections fundamental concepts webinar The webinar was facilitated in response to stakeholder feedback that foundational detail would assist those stakeholders to better understand and discuss issues. The webinar provided: • an overview of fundamental technical, engineering and regulatory concepts underpinning AEMO's recommendations • opportunity for stakeholders to raise questions on, or clarify, fundamental concepts.	Approximately 60 attendees, largely representing large load connections, developers, and original equipment manufacturers (OEMs) – including hydrogen, battery energy storage systems, manufacturing and mining industries.
Large load connections policy framework options assessment workshop • The workshop sought to: • Shared the project team's revised thinking on the policy framework that supports the application of access standards to large loads. • invited stakeholder positions on the more substantial changes to the draft recommendations being proposed. • Identified whether there are solutions which result in broad consensus.	Approximately 70 attendees, largely representing large load connections, developers and OEMS, and NSPs.
One-on-one technical discussions Discussions to understand the technical capability and limitations of technology associated with hydrogen production facilities.	One-on-one discussions with hydrogen OEMs and potential developers.
Targeted meetings Meetings to clarify understanding of issues raised and discuss proposed positions.	Stakeholders which made submission which sought further discussion with AEMO, or where further discussion was requested by AEMO.
Recommendations finalisation discussions Three separate discussions with NSP, OEM and developer representatives, respectively, to discuss proposed final positions, specifically to: • provide an update on key proposed final recommendations (issues of key interest and impact to specific groups). • Provide the opportunity to comment on proposed recommendations.	Approximately 100 individuals across NSP, OEM and developer stakeholder groups (invited from technical focus group member pool, stakeholders which made submissions and peak bodies).

2.3.1 Consultation documents

Before submitting these rule change proposals, AEMO published the following key documents as part of the Review:

- An approach paper describing the matters AEMO proposed to include in the Review.[14]

[14] AEMO Review of technical requirements for connection - Approach Paper, 12 October 2022, refer to: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/aemo-review-of-technical-requirements-for-connection-ner-clause-526a/aemo-review-of-ner-technical-requirements-for-connection.pdf?la=en

- A draft report with AEMO's draft recommendations for amendments to the access standards in NER Schedules 5.2 and 5.3a, with accompanying reasons.[15]
- An addendum to the draft report setting out its draft recommendations for amendments to the access standards in NER Schedule 5.3, with accompanying reasons.[16]
- An update report setting out revised recommendations for amendments to the access standards in NER Schedules 5.2 and 5.3a in response to feedback on the draft report, and initial drafting of potential NER amendments that could give effect to the revised recommendations.[17]
- A final report setting out final recommendations for amendments to the access standards in Schedules 5.2, 5.3 and 5.3a, with reasons and responses to stakeholder feedback on the update report and addendum.[18]

2.3.2 Technical focus groups

AEMO established four technical focus groups to provide input to the Review, focused on the following groups of issues:

- General standards.
- Grid-forming inverter standards.
- Large load standards.
- HVDC link standards.

The technical focus groups comprised representatives with technical expertise and direct experience with access standards from NSPs, market participants (generators and large loads), developers and OEMs.

2.3.3 Prioritisation workshops

To develop its draft report, AEMO ran a prioritisation workshop for each of the four technical focus groups to understand views on the criticality of addressing each identified issue, and to obtain feedback to refine or amend these issues. Workshop discussions were used to inform AEMO's determination of issues to pursue through the Review, to prioritise those identified issues and to identify those needing further discussion via options assessment workshops.

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[15] AEMO Review of technical requirements for connection - draft report, 3 March 2023, refer to: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/aemo-review-of-technical-requirements-for-connection-ner-clause-526a/2023-03-03_technical-requirements-review_draft-report_final.pdf?la=en

[16] AEMO Review of technical requirements for connection – Addendum to draft report, 4 April 2023, refer to: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/aemo-review-of-technical-requirements-for-connection-ner-clause-526a/2023-04-04_technical-requirements-review_draft-report_s53-addendum_final.pdf?la=en

[17] AEMO review of technical requirements for connection Draft Recommendations Update Report (Part 1) – Schedules 5.2 & 5.3a of the National Electricity Rules, 26 July 2023, refer to: draft-recommendations-update-reportpart-1-ner-Schedules-52--53a.pdf (aemo.com.au)

[18] AEMO, *Review of technical requirements for connection - National Electricity Rules Schedules 5.2, 5.3 and 5.3a: final report*, December 2023. Refer to: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/aemo-review-of-technical-requirements-for-connection-ner-clause-526a/final-report_access-standards-review_final_.pdf?la=en

2.3.4 Options assessment workshops

AEMO ran a follow-up round of options assessment workshops on issues involving greater complexity or with lower levels of consensus regarding their impact, interpretation, or potential resolution. These workshops explored the issues in more detail, with the objective of seeking validation or refinement of the issues, determining the principles that should underpin any recommendation; and identifying potential options to address the issues. The workshop discussions were highly valuable to AEMO, and the perspectives expressed by various stakeholder groups were key to optimising recommendations that appropriately balance the needs of various stakeholder groups and the present and emerging needs of the power system, where possible.

2.4 Broader development of the rules

AEMO has an obligation to review the access standards at least once every five years, and may do so more frequently where pressing needs are identified. Future access standard reviews will consider the suitability of access standards given the evolution of the technologies and the circumstances of the NEM.[19] AEMO has already indicated its intention to conduct further in-depth reviews of the access standards for loads and grid-forming (GFM) technology.

AEMO and other market bodies are also working to address issues that may impede the delivery of secure, reliable and affordable electricity over the course of the energy transition. This requires consideration of many aspects of the rules, including:

- The changing characteristics of reliability as the national electricity market (NEM) transitions to net zero.
- The rules and standards necessary to ensuring appropriate levels of system strength across the NEM.
- Approaches to improve the framework for renegotiating connection agreements to unlock the benefits of new technologies and approaches to maintaining reliability and security of supply.

[19] For example, in the next access standards review AEMO might consider the appropriateness of the short circuit ratio minimum access standard of 3 considering any changes in the power system's ability to manage increases in asynchronous generation.

3 Delivering on the national electricity objective

AEMO's has developed the rule change proposals to advance the NEO in section 7 of the NEL, being:

> *To promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:*
>
> *a. price, quality, safety, reliability and security of supply of electricity; and*
> *b. the reliability, safety and security of the national electricity system; and*
> *c. the achievement of targets set by a participating jurisdiction—*
> *i. for reducing Australia's greenhouse gas emissions; or*
> *ii. that are likely to contribute to reducing Australia's greenhouse gas emissions.*

The emissions reduction component was added to the NEO shortly before the Review concluded. Although, under the transitional arrangements in the NEL, AEMO did not need to have regard to the amended NEO in relation to the Review, AEMO's approach has been to design outcomes that will clarify, simplify, and add flexibility to the connection requirements of low and no emission generation and storage technologies in the NEM. AEMO therefore considers that the rule change proposals contribute to the delivery of the updated NEO.

With stakeholder input, AEMO developed a set of nine high-level objectives for the Review (and consequential rule changes), aligned with the four mandatory considerations for the Review in NER 5.2.6A(a), namely:

- the NEO,
- the need to achieve and maintain power system security,
- changes in power system conditions, and
- changes in technology and capabilities of facilities and plant.

The nine objectives were applied in the Review to develop options and preferred solutions to identified issues relating to the access standards. The remainder of this section explains each objective and describes the issues it addresses and how it contributes to the NEO.

3.1 Align with best system performance

Achieving the AAS for any given technical requirement should produce better outcomes for power system performance, compared with a NAS. The AAS for some access standards does not consistently align with achieving an appropriate level of power system performance to meet the network performance requirements and, in turn, the system standards for the benefit of all network users. There is scope for improved access standards where:

- The AAS is set at a level where the power system cannot make use of the full performance range required, but there is a capital cost associated with the requirement – leading to inefficient investment.
- The AAS does not necessarily achieve the best outcomes for the power system's operation and performance. Making the AAS less onerous would sometimes lead to better outcomes at reduced or no additional cost.

- Improved power system security outcomes can be achieved by redefining AAS requirements and improving guidance on negotiating access standards, for better alignment with power system needs, at minimal or no additional cost.

This objective aligns with the NEO by promoting:

- a general reduction in the cost of connections, without compromising the security of the electricity system – thus encouraging the efficient connection of generation required to maintain secure operations, meet long-term demand for electricity and meet government commitments to reduce carbon emissions; and
- improvements in the ability of the access standards to deliver their intended power system outcomes across the NEM, resulting in more efficient operation and maintenance of the power system with respect to its security and the quality of electricity supply.

3.2 Improve power system resilience

The power system is operated to manage individual credible contingencies (where a single element of the electricity system becomes inoperable) as a matter of course. A prudent level of investment is also necessary to manage the impact of multiple contingency events depending on their likelihood and consequences. While the probability of multiple simultaneous contingency events is lower, the security of supply and longer term economic consequences for electricity consumers can be much worse.

The Review identified opportunities to amend the access standards to improve resilience at low cost, including for access standards where:

- There is scope to better utilise already available performance capability to make the power system more resilient to contingency events, without material additional cost.
- The AAS is not practically achievable or may place an unmanageable risk on the participant, including by compromising their ability to achieve other access standards. Such risks detract from achievement of a resilient power system and may deter or delay the connection of assets necessary for an effective energy transition. They may also disincentivise network investment that would more efficiently manage the risk.

AEMO has taken the approach that, where possible, responsibility for managing risk should be borne by the party best placed to manage the risk. Where investment is required, the NER should promote actions consistent with good engineering practice, balancing mitigation costs against risk, to achieve an efficient level of power system resilience.

This objective aligns with the NEO by promoting efficient investment and efficient operation of the electricity system with respect to security of supply.

3.3 Streamline the connection process

Some viable connection projects have experienced delays in the access standard negotiation or verification process due to unclear or unsuitable access standards. Updating these access standards to minimise ambiguity and clarify their application to different technologies should speed up the connection process without compromising system security or supply reliability. Reducing unnecessary delays will support the efficient connection of generation, interconnection and network support facilities required to meet and manage expected future demand.

This objective aligns with the NEO by accelerating the connection process to bring forward the benefits of connecting plant: reducing future electricity costs, improving reliability and supporting the delivery of Government commitments to reduce carbon emissions.

3.4 Support efficient investment and operation

The application of some access standards to different connecting plant in different circumstances can result in inefficient outcomes, for example by requiring:

- Capital or operating expenditure that is disproportionately costly relative to its benefits.
- Performance beyond that which is useful or usable.
- Investment in capability that could be better delivered by a more cost-effective alternative.

The Review identified opportunities to improve efficiency by allowing access standards to be better tailored to power system performance requirements and/or broadening the options available for connection proponents.

This objective promotes efficient investment in, and utilisation and operation of, electricity infrastructure in the NEM, which can be expected to result in longer-term benefits to consumers in line with the NEO.

3.5 Remove impediments for the connection of grid-forming inverters

Existing access standards were formulated for older technologies and have been adapted in successive rule changes for asynchronous technologies, which to date have been mainly grid-following (GFL). As a result, the drafting of some standards can inadvertently present unnecessary barriers for GFM inverter connections, including:

- The access standards do not account for some beneficial GFM behaviours such as response to phase angle jumps and inertial response, and in some cases effectively discourage proponents from programming them in GFM inverters.
- Some technology-specific technical requirements may encourage development of GFM inverters in a direction that is not well aligned to best power system performance.

The Review addressed several issues that may facilitate the connection and operation of GFM inverters, including at the AAS, in a way that best utilises their capabilities for the benefit of the power system overall.

This objective will remove unnecessary technology-related restrictions and aligns with the NEO by supporting the delivery of an overall lower cost and lower emissions generation fleet, while maintaining power system security and reliability as traditional forms of synchronous generation retire.

3.6 Broaden application to synchronous condenser connections

Synchronous condensers can efficiently provide system security services (e.g. system strength and inertia) to support the energy transition. They have analogous characteristics and impacts to synchronous generation, but there are no corresponding access standards applicable to stand-alone synchronous condensers (including generation permanently converted to operate as a synchronous condenser, or those operated as part of an NSP's network).

Applying appropriate access standards to synchronous condensers that are not part of a generating or integrated resource system will deliver clear and consistent regulation of their performance on matters relevant to their capabilities and power system impacts. The technical requirements for synchronous condensers therefore need to apply irrespective of the registration status or category of the person who owns, operates, or controls them.

NER amendments to apply appropriate and consistent regulation to synchronous condensers across the NEM will align with the NEO by enhancing power system security and the reliability of electricity supply that depends on regular or continuous support from synchronous condenser operation.

3.7 Broaden the application of technical requirements to all HVDC links

The requirements of NER schedule 5.3a are currently limited to 'independently controllable two-terminal links' operated as market network service facilities by an MNSP. The last remaining market network service facility, Basslink, is in the process of conversion to a regulated network[20] and it may be unlikely that any future HVDC links will be operated on a market basis. This leaves future regulated HVDC interconnectors and intraconnectors, and links to offshore generation zones, without comparable technical standards within the NER. This creates a gap that may disincentivise future efficient investment in HVDC links, and presents a risk that individually negotiated connection arrangements may be inefficient or inconsistent across the NEM.

Broadening the application of schedule 5.3a to all future HVDC links will support the NEO by promoting certainty for investment in HVDC systems that can effectively and efficiently support the reliability of supply in a coordinated manner.

3.8 Incorporate impact and capability of HVDC links into technical requirements

HVDC links can have a significant impact on the operation of the power system, similar to bidirectional systems of comparable size. Effective performance of HVDC links is therefore important for the efficient operation of the NEM, yet the existing requirements in schedule 5.3a are not as comprehensive as those for generators and integrated resource providers.

HVDC links are typically bespoke and have high capital cost. Inadequate performance of HVDC links would need to be compensated for by restrictions on the operation of the power system and the market,

[20] Information about the Basslink conversion proposal is available on the Australian Energy Regulator website at: https://www.aer.gov.au/industry/registers/determinations/basslink-determination-2025-30

at potentially high cost to electricity consumers. At the same time, the existing MNSP access standards requirements do not capture the benefits of improved capabilities of modern HVDC links, which could be achieved at minimal additional cost. Clear AAS and MAS will provide clarity for the design of HVDC links, coordinated with network planning, to achieve overall efficient investment and power system operation.

Appropriate and consistent access standards for all HVDC links can be expected to deliver better coordinated performance, improving power system security for the benefit of electricity consumers in accordance with the NEO.

3.9 Incorporate impact and capability of large loads into technical requirements

The existing customer access standards in NER schedule 5.3 are not adequate to address the impacts of the anticipated growth in large converter-based loads, such as large hydrogen hubs. Without sufficient stability measures and an appropriate level of ride-through capability for power system disturbances, the power system may need to be significantly constrained to maintain power system security for the risk of such large plants disconnecting. In some conditions, such constraints could significantly reduce the capacity of the power system to meet electricity demand.

Some large load technologies may also have capabilities that could support power system operation during disturbances, equivalent to voltage and frequency response provided by generators and synchronous condensers. Appropriate access standards could provide additional options for efficient provision of those services.

This objective will facilitate the planning and design of large loads in a way that will support their operation and mitigate any adverse power system impacts, as well as facilitating the provision of system security services at lower cost as part of the energy transition. This aligns with the NEO by promoting secure system operation and efficient service provision in the long term interests of electricity consumers.

Consultation with industry revealed that the technology of large converter-based load technologies is rapidly evolving. The sector's understanding of vulnerabilities of this technology to network disturbances and the capabilities of this technology to support the network is developing. Hence, these rule change proposals only incorporate initial measures as a first step towards establishing appropriate detailed access standards for large load ride-through capabilities. AEMO plans to undertake a further targeted review and consultation to further improve schedule 5.3 access standards.

4 Changes to the access standards application framework

The effective implementation of many Review recommendations depends on expanding and clarifying the NER provisions through which plant performance standards are established. For future system security and reliability, it is critical that the schedule 5.2, 5.3 or 5.3a access standards apply to all connections with plant characteristics making them appropriate for technical regulation under one of those schedules - irrespective of who owns, operates or controls the plant.

To achieve this, AEMO is proposing extensive NER amendments both within and beyond the access standard schedules themselves, as described in this section.

4.1 Issues

The access standards in schedules 5.2 and 5.3a, and to some extent schedule 5.3, are currently[21] expressed as obligations on specified types of registered participant, for the type of plant to which that registration applies:

- Schedule 5.2 applies to registered generators and IRPs for their generating systems and integrated resource systems (IRS) respectively. Although not expressed in terms that include exempt generators, there is an apparent intent that schedule 5.2 could be applied to them in some circumstances.[22]
- Schedule 5.3 applies to market customers in respect of their market connection points (although the extent to which the access standards are expected to apply to retailer market participants is unclear), non-registered customers in respect of their connections (at least where they seek connection to a transmission network under NER 5.3.2), and DNSPs in respect of their networks.
- Schedule 5.3a only applies to MNSPs in respect of their market network service facilities.

This means that technologies connecting to the grid with fundamentally equivalent capabilities and power system impacts are not captured by the NER access standards if they do not fit the plant descriptions in the schedules, or if the same or similar plant is connected by other industry participants, whether registered in a different category or not required to register at all. In these cases, performance requirements are a matter for negotiation in the connection agreement (if there is one) without AEMO advice, risking material gaps and inconsistencies. Examples include:

- Synchronous condensers not forming part of a generating system or integrated resource system. These may be operated as part of an NSP's network, or by a market customer or an unregistered participant to provide system security services to a generator or NSP. Apart from the production of active power, the potential risks and benefits of synchronous condenser operation are very similar to synchronous generation. The Review concluded, with broad support, that all relevant schedule

[21] All references to the current NER should be read as including the amendments to be made by the *National Electricity Amendment (Integrating energy storage systems into the NEM) Rule 2021*, effective from 3 June 2024.

[22] NER S5.2.1(b)

5.2 access standards should extend to stand-alone synchronous condensers.[23] It is likely that many more synchronous connectors will be connected to the NEM in the near future, and existing synchronous generators could be permanently repurposed as synchronous condensers[24] (not requiring ongoing registration under the current NER).

- HVDC links operated as a regulated network asset Registered NSPs are required to operate a regulated HVDC link consistently with NER schedule 5.1, but those requirements are directed principally at AC networks. They do not adequately address the different behaviours of HVDC links.
- HVDC links operated as an exempt network (including potential future links connecting to offshore wind facilities). For exempt networks, the application of access standards would currently depend on the exemption conditions specified by the AER.

The application of access standards to defined plant types without regard to registration category or status is necessary to ensure the impacts and capabilities of these new connections are visible to the market operator, and consistently assessed and managed. Restructuring the application of access standards in this way should also facilitate any future rule changes to accommodate new or evolving technologies. These proposed amendments align with the following Review objectives.

Objectives

Align with best power system performance	Improving power system resilience
Streamline the connection process	Support efficient investment and operation
Remove impediments for connection of GFM inverters	Broaden application to synchronous condenser connections
Broaden the application to all HVDC link connections	Incorporate impact and capability of HVDC systems
Incorporate impact and capability of large loads	

4.2 Proposed amendments

AEMO's proposed amendments to implement these structural changes supporting the Review recommendations are summarised in three tables below, categorised as:

- Defining plant types for application of access standards.
- Defining the persons to which the access standards apply.
- Consequential amendments.

[23] There is currently no registration requirement for stand-alone synchronous condensers. Consideration of registration was outside the scope of the Review, but the absence of a registration category may become an issue for future NEM development.

[24] For example, as contemplated in the *Queensland SuperGrid Infrastructure Blueprint, Optimal infrastructure pathway for the Queensland Energy and Jobs Plan*, Queensland Government, September 2022.

Table 2 Amendments to define plant for application of access standards

Amendment summary	Reasons
Amend the application provisions in schedules 5.2, 5.3 and 5.3a to define the plant they can apply to (subject to the criteria described in section 4.3 for a person to be subject to the relevant schedule in respect of the plant), without reliance on registration categories: • Amend S5.2.1 to define "schedule 5.2 plant" as a production system or synchronous condenser system, with new Chapter 10 definitions as noted below. Clarify that, for IRS, the definition of production system includes only its production units and synchronous condensers, and relevant auxiliary or reactive plant. Any other source of load that is part of an IRS may be a schedule 5.3 plant, depending on its characteristics. • Amend S5.3.1a to define "schedule 5.3 plant" as plant that consumes electricity from a network, including a distribution network or a source of load in an integrated resource system, but excluding schedule 5.2 plant and schedule 5.3a plant "schedule 5.3a plant". • Amend S5.3a.1a to apply by reference to a new Chapter 10 definition of "schedule 5.3a plant", being a system comprising high voltage direct current technology used to transfer electricity to, from or between one or more alternating current networks (or parts of an alternating current network) operated by an NSP. A 5 MW power transfer capability threshold is added for consistency with schedule 5.2.	Aligns the access standards with the plant to which they apply, and breaks the existing fixed link with registered participant categories. This allows consistent technical access standards to be applied to plant with similar impact risks and capabilities. Broadens the application of schedule 5.2 to synchronous condensers, including standalone synchronous condenser systems. Broadens the application of schedule 5.3a to all HVDC links, allowing for a range of different physical and regulatory arrangements that could apply (one or more poles, one or more connection points and one or more connected AC networks).
Include an explanatory paragraph in S5.2.1 to confirm the application of some requirements in S5.2.5 and S5.2.6 to synchronous condensers has been excluded or modified. Where exclusions or modifications apply, they are noted in the first paragraph of the relevant sub-clauses. At the beginning of each access standard clause that requires modification for synchronous condenser application, include a paragraph identifying which paragraphs do not apply, or apply with modifications.	Recognises that some aspects of the access standards cannot apply to synchronous condensers as they depend on active power, or must be modified to reflect the capability of synchronous condensers
Define new system terms: • New definitions of a 'production system' (confined to use for the purposes of schedule 5.2 and covering generating systems and IRS, for convenience of drafting), and a 'synchronous condenser system' (being a standalone system not behind the connection point of a generating system or IRS). • For the purpose of the production system definition, confirm that an IRS includes only its production units and synchronous condensers, and relevant auxiliary or reactive plant. Any other source of load that is part of an integrated resource system may be a schedule 5.3 plant, depending on its characteristics.	To better reflect and clarify the plant subject to schedule 5.2, including standalone synchronous condensers. Facilitates drafting convenience to avoid the need to specify in multiple access standards a generating system and an integrated resource system, to the extent of its production units.
Change definitions of: • 'plant' to ensure it covers equipment such as synchronous condensers that are not necessarily 'involved in' generating, consuming or transmitting energy, but support it. Broaden 'transmitting' to 'conveyance' to reduce risk of conflating with transmission (only). • 'synchronous condenser' to describe its function/operation and distinguish more clearly from synchronous generation • 'nameplate rating' to provide for synchronous condenser ratings in megavolt-amperes (MVA).	Necessary to broaden the application of the access standards to synchronous condensers and more clearly describe their characteristics.

Table 3 Amendments to define persons to which access standards apply

<table>
<tr><th>Amendment summary</th><th>Reasons</th></tr>
<tr><td>
Define the persons to which schedules 5.2, 5.3 and 5.3a apply with reference to the plant they are seeking to connect. New definitions as follows:

Schedule 5.2 Participant – defined by reference to S5.2.1(b) as :

a Connection Applicant in respect of a schedule 5.2 plant, who is, or intends to be, the Registered Participant for that plant, or has appointed or intends to appoint an intermediary;
a Connection Applicant for a production system who will be exempt from registration, but only to the extent that the NSP considers the application of the access standards necessary to minimise any adverse effect on the quality or security of network service;
a Connection Applicant for a synchronous condenser system of 5 MVA or more that is neither part of a production system nor part of the network to which it is or will be connected, and a smaller synchronous condenser system only to the extent of the requirements the NSP considers necessary to minimise any adverse effect on the quality or security of network service;
an NSP whose network incorporates a schedule 5.2 plant of 5 megawatts (MW) / 5MVA or more, and not operated under a connection agreement with a third party.

Schedule 5.3 Participant – defined by reference to S5.3.1a(a1) as:

a Connection Applicant for a schedule 5.3 plant, who is, or intends to be, the Registered Participant for that plant, or has appointed or intends to appoint an intermediary;
a Connection Applicant seeking connection of a schedule 5.3 plant to a transmission network;
any other Connection Applicant for a schedule 5.3 plant, but only to the extent that the NSP considers the connection or operation of the schedule 5.3 plant would otherwise (i.e. if access standards were not applied) adversely affect quality or security of network service.

Schedule 5.3a Participant – defined by reference to S5.3a.1a(b) as:

the registered MNSP or intending MNSP for a schedule 5.3a plant;
any other NSP, or a person exempted under clause 2.5.1(d) from the requirement to register as an NSP, for a schedule 5.3a plant to be connected to the alternating current network of a registered NSP, or interfaced only with alternating current sections of the person's own network.

Schedule 5 Participant – collective term for all or any of the above.

</td><td>
Recognises that a range of participants (whether registered or not, or registered in different categories), may connect plant for which NER access standards should apply. Facilitates the use of clear and consistent terminology to describe relevant groups of participants.
Maintains application of the access standards to relevant plant connected by registered participants, but otherwise refines the definition of schedule 5.2, 5.3 or 5.3a plant by reference to the characteristics of the connection.
For an applicant that will not be a registered participant or a transmission network user, preserves, extends and clarifies existing discretion in S5.2.1 for the NSP to apply the relevant schedule only where the plant is considered significant enough to have adverse system impacts, with further discretion to limit applicable access standards only to those needed to address those impacts – not necessarily the entire schedule.
Recognises that access standard rights and obligations must sit with the person who will enter into the connection agreement, who may not be the same as the registered participant for the plant (if any). For schedule 5.3, in most cases the market customer for the connection point will not be the person entering into the connection agreement.
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<tr><td>
Add qualifying provisions and additional requirements in S5.2.1 and S5.3a.1a, together with a new clause 5.2.3(c1) and consequential amendments to 5.2.3, to address circumstances where the Schedule 5.2/5.3a Participant is the NSP, and will not be negotiating a connection agreement with itself.
For the purpose of applying the access standards to the NSP in its capacity as a Schedule 5 Participant, deem the connection point(s) to be the interface(s) between the schedule 5.2/5.3a plant with other elements of the NSP's network.
For HVDC links interfacing with AC networks, add a provision in S5.3a.1a to clarify that references to the NSP in the substantive access standards are to the operator(s) of the AC network(s).
Confirm in a new clause S5.1.1(h) that the access standards in the relevant schedule apply in place of schedule 5.1 for relevant network elements operated by the NSP.
</td><td>
Recognises there is no negotiation or connection agreement under rule 5.3/5.3A for schedule 5.2/5.3a plant operated as part of the NSP's own network. Provides an alternate mechanism to establish, document and apply performance standards for that plant.
Incorporates requirements for AEMO advice where applicable.
Clarifies the performance standards that apply to schedule 5.2/5.3a plant within a network, removing any potential conflict with schedule 5.1
</td></tr>
</table>

Amendment summary	Reasons
In the schedules, replace references to terms including *Connection Applicant, Generator*, *Integrated Resource Provider*, *Customer*, *Market Network Service Provider,* and *Network User* with references to *Schedule 5.2 Participant, Schedule 5.3 Participant* or *Schedule 5.3a Participant*.	Consistent and concise terminology to capture the different types of participant responsible for the plant to be covered by the schedule 5.2, 5.3 and 5.3a access standards.
Amend Parts A and B of Chapter 5, in particular rules 5.1, 5.1A, 5.2, 5.3 and 5.3A, to clarify application of the access standards to the full range of connection applicants seeking to connect schedule 5.2/5.3/5.3a plant to a transmission or distribution network, including: • Replacing the table in 5.1.2 and modifying 5.3.1 and 5.3.1A to more comprehensively and clearly capture types of plant and associated applicants that may be Schedule 5.2/5.3/5.3A Participants, including those that may use the NER Chapter 5A connection framework. • To cover a broader range of connection applicants, replacing references to Registered Participants with *Connection Applicant*, or removing references to multiple registration categories where possible without making the right or obligation less effective. • Using references to schedule 5.2, 5.3 or 5.3a plant where possible and appropriate, instead of the individual plant types within the category. • Amending 'performance standard' definition to capture Schedule 5 Participants not subject to the access standard negotiation process in NER 5.3.4A, i.e. NSPs for relevant plant in their own networks, and applicants not required to follow the Chapter 5 process but still subject to one or more schedule standards at NSP discretion.	Aligns the NER requirements and processes for network connection with the intended application of the access standards to all relevant plant. Clarifies some existing ambiguities or inconsistencies relating to the application of the alternative connection frameworks to some plant, including inverter-based load and exempt generation. Incorporates NSPs for relevant plant within their networks where there is no 'connection' as defined in the NER.

Table 4 Consequential amendments

Amendment summary	Reasons
Amend rule 5.2 to streamline obligations of registered participants, including with regard to compliance with connection agreements, remove unnecessary provisions consequential on the amendments described in the sections above.	Streamlines NER by reducing unnecessary repetition of requirements applicable to all registered participants
Revise and combine existing separate NER clauses where they apply the same right or obligation to generators/generating systems and IRP/IRS, in circumstances where new terminology can be used (schedule 5.2 plant or Schedule 5.2 Participant).	Streamlines NER by reducing unnecessary repetition of requirements applicable to different registered participant types for the same category of plant.
Amend 5.3.7, 5.3.8, 5.3.9 and 5.3.12 to confirm extension of requirements for establishing and changing performance standards and notification to AEMO where the applicant is not a registered participant, if they include AEMO advisory matters. Registration of performance standards – under the amended rules AEMO will only register performance standards (for compliance purposes) for registered participants (including NSPs). Minor drafting amendments to rule 4.14 and throughout chapter 5 for clarity and consistency with the process and terminology of negotiating proposed access standards leading to the establishment of performance standards and their inclusion in a connection agreement, including AEMO's advisory role.	Provides a process for notifying AEMO of performance standards for schedule 5.2, 5.3 and 5.3a plant, where the access standards include matters affecting power system operation or security. Maintains the regulatory performance compliance monitoring and enforcement regime for registered participants only (other schedule 5.2/5.3/5.3a plant performance standards are still enforceable by the NSP through the connection agreement). Adopts consistent terminology to describe the access standards in the schedules and the process by which they become performance standards and are recorded in a connection agreement (or documented for NSP's relevant plant).
Amend S5.2.4, S5.3.1 and S5.3a.1 to extend confidentiality obligations (rule 8.6) to non-registered schedule 5.2, 5.3 and 5.3a participants in respect of the information they require from the NSP to propose and negotiate performance standards.	Connection applicants (who may not all be registered participants) may require some confidential information to prepare their connection application and negotiate proposed access standards. Confidentiality obligations in the NER only apply to registered participants unless otherwise provided.

Amendment summary	Reasons
[Standard – non fast track – amendment]	
Amend 5.7.2 to extend mutual rights to request testing to non-registered Schedule 5 Participants, and require them to comply with a request for testing on plant. Extend 5.7.3 to any category of registered participants. Amend 5.7.3(d) to (f) permitting AEMO to request testing of compliance with AEMO advisory performance standards for both registered and non-registered schedule 5 participants, on the same conditions.	Because schedule 5.2/5.3/5.3a plant can, by nature, adversely impact the operation of other power system equipment, interconnected participants and AEMO may need rights to require or observe testing, including as part of commissioning. The proposed extension of regulatory obligations to non-registered participants should not be excessive - limited to matters that may not be adequately or consistently addressed or enforced through a connection agreement. These changes do not apply the formal compliance testing program to non-registered participants.
Extend the commissioning requirements of 5.8.2, 5.8.4 and 5.8.5 to Schedule 5 Participants that are not registered participants, by the addition of a new clause 5.8.1A.	

5 Access standards for generation, integrated resource systems and synchronous condensers

This section outlines AEMO's proposed NER amendments (primarily in schedule 5.2) to improve the access standards for generation, IRS and synchronous condensers, based on Review recommendations with the objectives described in section 3.

5.1 NER S5.2.5.1 – Reactive power capability

Reactive power capability is critical to prevent voltage fluctuations from causing system failures and asset damage. Production systems and synchronous condensers help to meet the system standards by supplying or absorbing reactive power at their connection point within a defined voltage range (reactive power capability).

5.1.1 Voltage range for full reactive power requirement

Objectives

- Align with best power system performance
- Streamline the connection process
- Support efficient investment and operation

Issues

The AAS for reactive power capability is a function of the generating system's active power capability. To meet the current AAS, a generator must have the ability to supply and absorb continuously at its connection point an amount of reactive power of at least the amount equal to the product of the rated active power of the generating system and 0.395 over the voltage range 90% to 110% of normal voltage at the connection point.

Supplying reactive power at high voltages and absorbing reactive power at low voltages are both undesirable for power system operation, as these actions will exacerbate high or low voltages. Removing these unnecessary requirements and allowing for flexibility to set voltage ranges for reactive power capability based on power system needs at the connection location will materially reduce the existing costs of meeting the AAS for many connection projects, without adverse impacts on the reliability and security of the NEM.

Proposed amendments

Figure 1 illustrates the difference between the current and proposed AAS.

Figure 1 Proposed AAS and current voltage range for full reactive power requirement

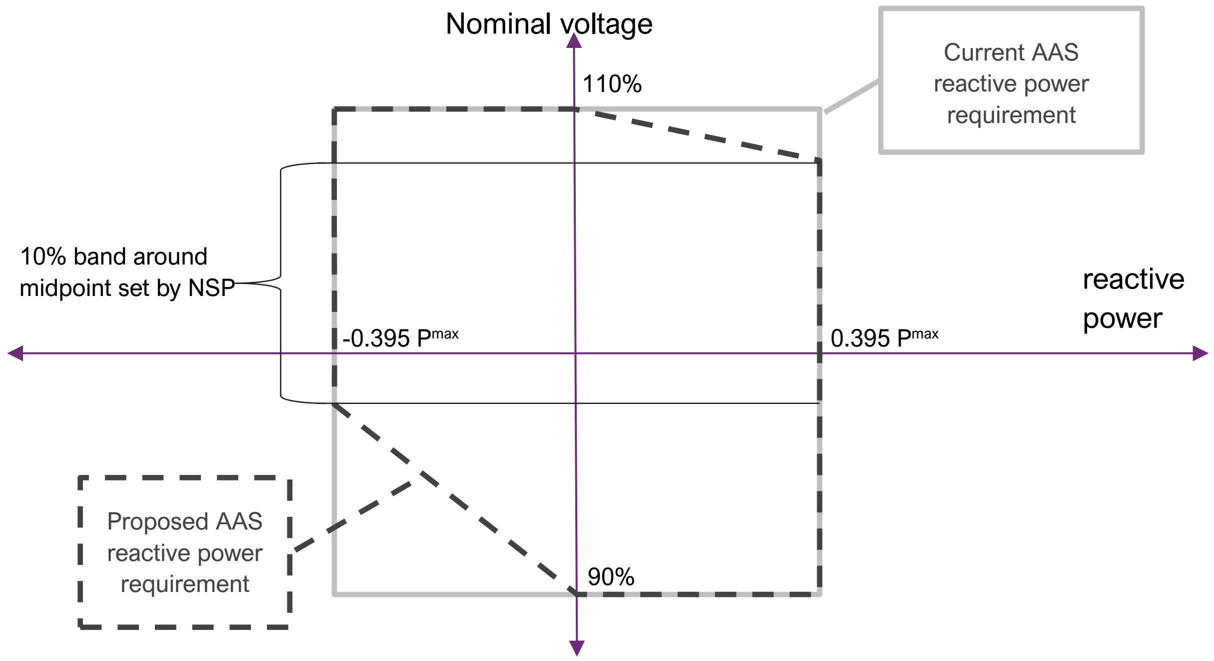

Table 5 Amendments for reactive power capability voltage range

Amendment summary	Reasons
Amend S5.2.5.1 to: • Limit the AAS requirement for full reactive power capability to a 10% voltage band around a centre point. The centre point voltage is nominated by the NSP in the range 95% to 105% of the connection point nominal voltage. • For voltages within the 10% voltage band, require at least 0.395 x maximum active power (Pmax) reactive injection and absorption. • For voltages below the 10% voltage band down to 90%, require at least 0.395 x Pmax reactive injection. • For voltages above the 10% voltage band up to 110% require at least 0.395 x Pmax reactive absorption. • For voltage from the lower limit of the 10% voltage band to 90%, the requirement for reactive absorption decreases linearly with decrease in voltage from -0.395 x Pmax to 0 megavolt-ampere reactive (MVAr). • For voltages above the 10% voltage band up to 110%, the requirement for reactive injection reduces linearly from 0.395 x Pmax to 0 MVAr. • Define Pmax using an amended definition of 'active power capability' instead of rated active power (see definitional changes described in section 8 of this document), as well as maximum demand for IRS. • Provide, in the general requirements, for the basis on which maximum active power and reactive power capability may be reduced with fewer than all production units in service.	A 10% voltage band with full reactive absorption and injection aligns with normal power system operation. Allowing the NSP to set the centre point allows for alignment with the requirements of system at the point of connection. The requirements within 20% band cover unusually high or low voltage conditions, and specify separate requirements for reactive power injection and absorption. This reflects actual power system needs for high and low voltages respectively, lowering the cost of compliance by removing unnecessary response capabilities. Using redefined active power definitions, and flexibility for appropriate changes in reactive power capability based on plant topology with fewer than all units in service, better aligns the access standards with what a connected asset may realistically be able to provide.

5.1.2 Treatment of reactive power capability considering temperature derating

Objectives

- Align with best power system performance
- Streamline the connection process
- Support efficient investment and operation

Issues

The reactive power capability of plant may differ depending on temperature (as per the plant's temperature derating). At present, NER S5.2.5.1 expresses the requirement for reactive power as a function of active power but is silent on temperature derating, which has led to differing interpretations of this requirement. If the apparent power is derated with temperature, it is unclear what value of active power should be recorded under NER S5.2.5.1(f) and hence be used to define the reactive power requirements.

If a plant is required to maintain both its active and reactive power over a wide range and the plant naturally derates with temperature, this will lead to restricted production over the whole of the plant's operation. However, there are some technologies (e.g. inverter systems with water cooling) that can operate without derating across a wide range of ambient temperatures. There is almost always a maximum operating temperature above which plant will not be able to operate continuously.

If a plant that is naturally temperature derated must maintain its reactive power over a wide temperature range at the expense of active power, this will lead to higher cost per MW of production over the life of the plant. If the same plant was required to maintain both active and reactive power at the same level, the cost per MW of production would be even higher, because it would need to be permanently derated to the MW value it could achieve with full reactive power at the highest temperature required. This would be very inefficient, as the ambient temperature is only close to maximum for a small percentage of the time.

Nevertheless, some inverter-based systems have in-built cooling systems that can operate without derating over a wide range of ambient temperatures, which is advantageous for both the plant and the power system.

A broadly-applied requirement to prioritise reactive power over active power could impact supply reliability on hot days. On the other hand, if active power is maintained at the expense of reactive power, the power system may experience reductions in voltage control capability, which may result in network constraints on hot days or a need for increased capital expenditure on network reactive plant in some network locations (noting that capacitors are generally cheaper sources of reactive power than inverters).

Dialogue to resolve the uncertainty on how to reflect temperature derating in the performance standard adds cost and time to the connection process, in addition to the material impact on cost of the connection.

Proposed amendments

Table 6 Amendments for temperature derating

Amendment summary	Reasons
Amend S5.2.5.1 to: • Add a definition of 'temperature derating' where plant capacity is materially affected by ambient temperature. Any derating calculation reduces active power capability (or reactive power capability for a synchronous condenser) • Provide for an AAS to be achieved with no temperature derating below 50°C. • Allow for a NAS to include a temperature derating. Unless the NSP agree otherwise, this must represent a proportional derating of active power and reactive power at equipment level, projected to the connection point. • Require the performance standard to document the maximum operating temperature, and any derating for a NAS.	The AAS is set with no derating (for temperatures up to 50°C), reflecting that this makes the power system easier to operate and minimises the need for additional investment to provide reactive power. Explicitly recognises temperature derating representing reduced active power (and consequently reactive power) capability as part of a NAS, with a preference for proportional active and reactive power derating but allowing flexibility in appropriate circumstances (e.g. to account for losses between unit terminals and the connection point. Records the maximum operating temperature and any applicable derating below 50°C for visibility and certainty.

5.1.3 Compensation of reactive power when units are out of service

Objectives

Streamline the connection process | Support efficient investment and operation

Issues

When a generating system or IRS is not in service there is typically some net energy consumption to support the system's auxiliary load. This may be insignificant compared to the rating of the system, but may also have a leading power factor due to unloaded cables and lines, and from capacitors used for harmonic filters or reactive power contribution. Auxiliary load for thermal synchronous machines may have a low lagging power factor.

NER S5.2.5.1 currently provides that a performance standard for the auxiliary load of a generating system or IRS when not in service should be established under NER S5.3.5. That clause specifies the reactive power requirements in terms of a minimum lagging power factor and excluding leading power factors, with a lower power factor permitted by the MAS if AEMO advises the NSP that it will not detrimentally affect power system security or reduce power transfer capability.

The intent of this standard is to manage the impact of auxiliary load on power system voltage at the connection point, as opposed to fully disconnecting the connected plant from the power system. Correcting the power factor when units are not producing active power involves operating one or more units in a mode than can compensate for the reactive power injection or absorption of the auxiliary load. Whether there is net benefit to the power system in correcting the power factor in this way will depend on the size and direction of the voltage impact, and the cost of providing this corrective response.

In addition, an NSP may require some production units to be kept in service to provide dynamic reactive power capability in voltage control mode. If a small proportion of units is kept in service specifically for power factor correction, less arduous compliance requirements can be contemplated, considering that the impact on the power system will be small, to achieve efficient investment and operation of electricity services.

Proposed amendments

Table 7 Amendments for compensating reactive power for auxiliary load

Amendment summary	Reasons
Replace S5.2.5.1(g) (requiring a performance standard for auxiliary load under S5.3.5) with a new AAS and MAS for schedule 5.2 plant that is electrically connected but not otherwise in service, as follows: • An AAS requirement that there is no impact on voltage compared with the plant being fully disconnected. • An MAS requirement that any voltage impact is limited to 1%, unless a higher percentage agreed with the NSP. • Voltage impact to be assessed in steady state conditions and for the highest system impedance value nominated by the NSP under S5.2.5.13 This is based on the equivalent impedance for the minimum three phase fault level declared at the electrically closest system strength node, in combination with the network outage that would cause the greatest reduction in the three phase fault level at the connection point.	Establishes an access standard within schedule 5.2 with a clear outcome-based requirement targeting the network impact of the plant consuming auxiliary load only. This allows the connection applicant to meet the standard using options that are most appropriate for their plant. The MAS allows flexibility for connection applicants and NSPs to negotiate an alternative requirement taking into account the specific circumstances of the connection. Provides clear guidance on the method of assessing the voltage impact, including a published reference point at the electrically closest system strength node.
In the general requirements for S5.2.5.1: • Require the performance standards to record the level or range of reactive power to meet the compensation requirement (in MVAr), and any associated operational arrangements. • If the operational arrangements require reactive power compensation from one or more production units: – a performance standard must be established for stability of the control system for settling time for a voltage step in that control mode (if a secondary control mode); and – the performance standards established under S5.2.5.2, S5.2.5.9, S5.2.5.10, S5.2.5.15, S5.2.6.1 and S5.2.6.2 will apply, as will S5.2.5.8 in respect of protection requirements.	Recording this requirement as a MVAr value provides a measure that will not change over time with changes to the power system. The electrically closest system strength node provides a published reference point for the assessment. Establishing a clear subset of performance requirements for situations in which a small subset of units is online solely for the purpose of reactive compensation can be expected to reduce the connection and ongoing compliance cost, at low risk to the power system.

5.2 Simplifying standards for small connections

Objectives

Streamline the connection process | Support efficient investment and operation

It is not efficient or appropriate to apply all standards universally to new schedule 5.2 connections irrespective of size. Some existing access standards have different size thresholds for different technologies (e.g. 5 MW for bidirectional units and 30 MW for generating units), however power system security risk is largely a function of plant size rather than technology.

The impact of proposed connections under schedule 5.2 needs to be considered in the context of its location and the potential cumulative impact of smaller plants with similar characteristics. A 30 MW size threshold, already existing in some access standards, may be inappropriately high for some networks, particularly in Tasmania as a small power system connected to the rest of the NEM only through a DC system.

Simplifying access requirements for small plant, where appropriate considering the potential network impacts, will help to streamline the connection process, and reduce the cost to consumers.

Proposed amendments

Table 8 Amendments to streamline connection requirements for small connections

Amendment summary	Reasons
In S5.2.5.7, S5.2.5.8 and S5.2.5.13, define a 'relevant system' for a production system or synchronous condenser as one with a nameplate rating equal to or greater than 30 MW (or MVA as relevant) or, if lower, 5% of the largest credible contingency event defined in the frequency operating standards.[25]	Defines a threshold for exemption from relevant requirements of these access standards allowing for adjustment with reference to local network requirements.
In S5.2.5.7 (partial load rejection), restrict the application of the AAS and MAS to relevant systems – see definition above.	The requirement for continuous operation after a load reduction event is excessive for small connections with relatively minor impact. Tripping of such units would reduce the supply-demand imbalance following a large load loss situation, so is unlikely to impact power system security adversely.
In S5.2.5.8 (protection from power system disturbances), restrict the application of the AAS and MAS to relevant systems – see definition above.	This change applies the requirement for emergency frequency reduction consistently based on plant size relative to the largest contingency in a region, not differentiating based on transmission/distribution or technology. Including larger distribution-connected plant instead of smaller bi-directional plant or small transmission-connected plant gives more impact for less overall effort, improving efficiency. As bidirectional units must provide primary frequency response, changing the size requirement on bi-directional plant should not materially reduce resilience, while there may be significant benefit in including larger distribution-connected plant.
In S5.2.5.13 (voltage and reactive power control), restrict the application of the following MAS requirements to relevant systems: • Testing facilities sufficient to establish dynamic operational characteristics of control systems. • Excitation control system characteristics	Broadens existing lower threshold for IRS to be equivalent to generating systems, as appropriate given their impact is likely to be similar based on size.

5.3 NER S5.2.5.2 - Quality of electricity generated

Objective

Streamline the connection process

Issues

The access standard with respect to harmonic distortion refers to a defunct Australian standard – AS1359.101 (1997). The replacement Australian standard is an older version of the International Electrotechnical Commission (IEC) standard that is also listed in the clause, IEC 60034-1.

[25] Currently in the NEM, this is only relevant for Tasmania, for which the largest credible contingency event has been defined as 144 MW. This would make the relevant system threshold approximately 7 MW.

Proposed amendments

Table 9 Amendment for quality of electricity generated

Amendment	Reasons
In S5.2.5.2, remove reference to AS1359.101 as a plant standard for harmonic voltage distortion.	Removes redundant standard.

5.4 NER S5.2.5.4 - Response to voltage disturbances

The durations and associated voltage ranges for which generating systems are required to remain in continuous uninterrupted operation (CUO) for during voltage disturbances are specified in NER S5.2.5.4. Having generating systems maintain CUO during voltage disturbances prevents cascading generation outages and associated interruptions to electricity supply.

5.4.1 Over-voltage requirements for medium voltage and lower connections

Objectives

Streamline the connection process | Support efficient investment and operation

Issues

The current AAS of NER S5.2.5.4, focused on high voltage (HV) transmission level over-voltages and long durations, was based on the European 'ENTSO-E' requirement for plant connected to a 400 kV system[26] and can be met using a transformer tap changer. The long-duration overvoltage requirements of S5.2.5.4 may be difficult for plant to meet when directly connected to the network without a tap-changing transformer between the units and the connection point.

At lower voltages, plant is often directly connected. While the ENTSO-E has lower requirements for these instances, the NER apply the same requirements regardless of the connection voltage.

For plant directly connected at medium voltage (MV) without a tap-changing transformer, it would be reasonable to allow a NAS that applied the over-voltages at the nearest HV connection. However, the access standard does not currently include flexibility to consider application of the over-voltages at a location other than the connection point.

Considering the renewable energy zones and designated network assets where a connection point for a large plant may be at the MV side of a step-up transformer, the issue can arise for any size connection.

[26] At https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOL_2016_112_R_0001#d1e1043-1-1.

Proposed amendments

Table 10 Amendments for MV or lower connections

Amendment summary	Reasons
Amend S5.2.5.4 to add an NAS provision as follows: • Applicable to connection at nominal voltage less than 66 kV with no automatic tap-changing transformer between the units and the connection point. • If NSP and AEMO agree, voltage variations can be measured at the electrically closest location with a nominal voltage of 66 kV or higher, instead of the connection point. a location with nominal voltage higher than the connection point. Remove S5.2.5.4(c), which restricted negotiation of CUO capabilities below the AAS based on plant size.	Adds flexibility in the negotiation process to permit a simpler and less costly solution to meeting the access standard for MV or lower connections, irrespective of plant size, where this can be achieved without adverse impacts on the network or power system operation.

5.4.2 Continuous uninterrupted operation for over-voltages above 130%

Objectives

Support efficient investment and operation

Streamline the connection process

Align with best power system performance

Issues

The current drafting of NER S5.2.5.4 leaves the upper voltage for CUO for the first 20 milliseconds (ms) of a disturbance undefined, requiring compliance for voltages 'above 130%' for at least 20 ms. This represents an unbounded obligation for a risk that the connection applicant is unable to control. Unachievable technical requirements create uncertainty and unreasonable risk, and in some circumstances can be detrimental to power system security and resilience. Industry consultation revealed differing interpretations of the current wording, with some reading 'above 130%' as 'at least 130%'.

In reviewing the requirements for extreme over-voltage conditions, AEMO noted that the NER does not currently address the need for both NSPs and connected parties to manage their facilities in a way that minimises repeated switching surges (i.e. slow front over-voltages above the levels in the system standards (NER S5.1a.4)). Repeated switching surges:

- Will likely cause plant deterioration over time.
- May cause repeated tripping and non-compliances.
- Could be mitigated by various means, which could be more practical and efficient than requiring connected plant to ride through repeated surges but would require investigation of the causes.

Finally, the voltages in NER S5.2.5.4 are generally considered to be power frequency root mean square (RMS) values, to be consistent with the system standards in NER S5.1a.4. However, this is not explicit and has the potential to be interpreted differently.

Proposed amendments

Table 11 Amendment to Continuous uninterrupted operation for over-voltages above 130%

Amendment summary	Reasons
In S5.2.5.4(a)(1), replace 'over 130%' with 'at least 130%'. In the AAS for S5.2.5.8, add a requirement that voltage-related protection systems must not disconnect plant within 20 ms. Also in S5.2.5.8 require that protection settings be set to maximise the plant's capability to remain in operation for abnormal power system conditions for while maintaining safe and stable operation of the plant within safety margins consistent with good electricity industry practice.	Establishes a limit such that plant can meet the AAS of S5.2.5.4 if able to remain in CUO for 20 ms at marginally above 130% of nominal voltage. Provides for relevant disconnection settings in both access standards to be considered together, to facilitate optimal balance of plant capabilities with positive power system outcomes.
Add complementary obligations on NSPs and Schedule 5.2 Participants to minimise the risk of switching surges, as follows: • In Schedule 5.1 (Network performance requirements), add a requirement for NSPs to design their network and insulation coordination to avoid causing a network user's plant to experience recurring switching surges. • In S5.2.3, add a requirement for Schedule 5.2 Participants to design their plant so that operation does not cause network or other users' equipment to experience recurring switching surges. • In NER 5.7.2, add provision for interconnected registered participants (or non-registered Schedule 5 Participants) to request an assessment of the other party's equipment, not only a test.	Implements recommendations to improve management and coordination, and facilitate investigation of recurrent switching surges by those best placed to do so. Contributes to improved plant and power system performance and more efficient investment and risk management.
In S5.2.5.4, add an explicit statement that nominal voltage references are to RMS power system frequency voltages at the connection point.	Provides certainty to avoid differences of interpretation delaying the connection process.

5.4.3 Clarifying CUO for moderate voltage disturbances

Objectives

Streamline the connection process	Support efficient investment and operation

Issues

The AAS and MAS for NER S5.2.5.4 requires a generating system or IRS to be capable of CUO where a power system disturbance causes the voltage at the connection point to vary within 90%-110% of normal voltage. The meaning of CUO in this context can have different interpretations, causing uncertainty and potentially material cost for connecting inverter-based plant to address small changes in active or reactive power in response to voltage disturbances, where there may be no material benefit to power system operation.

The current rule can be interpreted as requiring no active power reduction or change in reactive power capability for up to 20% voltage change (90-110%). Compared with the current rule, the proposed change materially reduces the capital cost especially for inverter-based plant.

Proposed amendments

Table 12 Amendments to clarify CUO for disturbances 90-110% of nominal voltage

Amendment summary	Reasons
Add general requirements to qualify S5.2.5.4(a)(6) and S5.2.5.4(b)(3) as follows: • Reactive capability must be maintained in accordance with the capability established under S5.2.5.1, and active power must not reduce, for variations of up to 10% of connection point voltage within 90-110% of nominal voltage. • But for these purposes, disregard changes due to transient or expected responses, losses, energy source availability and any other factors the NSP and AEMO consider reasonable. • For variations greater than 10% within this range, allow reasonable temporary reductions in active power and reactive power capability if corrected by tap-changing transformer action.	Clarifies the meaning of the CUO requirements for voltage disturbances within the 90-110% range, allowing practical flexibility for minor, expected or inherent responses typically associated with inverter-based connections, where reasonable in the circumstances. The 10% aligns with NSP obligations for voltage not to vary more than 10% except as a result of a contingency event.

5.5 NER S5.2.5.5 - Response to disturbances following contingency events

5.5.1 Definition of end of a disturbance for multiple fault ride through

Objectives

Streamline the connection process | Support efficient investment and operation

Issues

NER S5.2.5.5 describes requirements for generating systems and IRS to remain in CUO for multiple successive faults (multiple fault ride through, or MFRT). The access standard specifies that the minimum clearance from the end of one disturbance and the commencement of the next disturbance may be 0 ms for the AAS or and 200 ms for the MAS, but does not define the end of a disturbance.

This gives rise to the potential for different interpretations, increasing uncertainty and the potential to create unnecessarily onerous obligations. For example, it is possible to interpret the AAS to require ride through of 15 faults consecutively with no voltage recovery between them. The probability of this occurring is very low and requiring plant capability to do so would be inefficient.

Proposed amendments

Table 13 Amendment to define the end of a disturbance

Amendment summary	Reasons
In S5 2.5.5: • Add a new provision specifying that a disturbance is taken to end when the voltage recovers to and remains within the range 90% to 110% of nominal voltage at the connection point for at least 20 ms. • Align paragraphs (d)(5) and (k)(3) so they both refer to the 'time difference between the end' of a disturbance, and remove different uses of the word 'clearance'.	Provides clear definition of each fault in a sequence by specifying a voltage recovery criterion. Promotes consistent interpretation by aligning the form of wording for the AAS and MAS, which are intended to refer to the same interval

5.5.2 Refining compliance requirements for multiple fault ride-through requirements

Objectives

Align with best power system performance	Streamline the connection process
Support efficient investment and operation	Improving power system resilience

Issues

The MAS for MFRT is for plant remain in CUO for up to 6 disturbances that are over 200 ms apart within a 5-minute window, subject to a set of qualifications about the nature of the disturbances (individually and as a sequence).

This presents an impediment to some connections because, given the very large number of possible fault combinations, assessments can generally only establish a non-compliance, as opposed to proving compliance for all possible disturbance combinations under different power system conditions. Further, simulation models cannot capture all types of conditions that might cause a plant to trip. This has resulted in connection applicants having to undertake extensive simulation studies, which are time consuming, expensive, and yet still inconclusive.

The present rule, with its focus on meeting multiple fault ride through conditions under all circumstances, disincentivises the disclosure of conditions that would cause the plant to trip for potential combinations of disturbances within the envelope described by the minimum access standard. Having a rule that incentivises disclosure of limitations by allowing carve out of specific limitations, while otherwise maintaining the requirement for the 6 disturbances within 5 minutes, benefits all parties: For the Connection Applicant, it allows performance to be specified in its performance standard that allows for known limitations. For the NSP and AEMO it improves visibility of those conditions under which a plant could trip, which allows them to be taken into account for operational and planning purposes.

The focus on limitations would facilitate a risk-based approach to assessment. Where the limitation would pose an unacceptable power system risk, the disclosure would promote dialogue on how to mitigate the risk, which might include measures to mitigate the risk on the power system or the plant. For example, risk from a trip condition associated with unbalanced faults occurring at specific time intervals, which could arise for a plant mechanical resonance condition, might be mitigated by changing an auto-reclosure time on near-by circuits. On the other hand, where the risk level was sufficiently low, the requirement would be to document the declared limitations, which would then be carved out of the performance requirements.

Proposed amendments

Table 14 Amendments to refine compliance requirements for MFRT

Amendment summary	Reasons
In 5.2.5.5(l), amend the qualifying conditions for the minimum sequence of 6 faults within 5 minutes to exclude technology-related specific limitations disclosed to the NSP and AEMO. Add a new provision allowing a NAS to include, where agreed by the NSP and AEMO, a specified plant limitation for which the plant is not required to remain in CUO for a given set of disturbance conditions. The required response of the plant to those conditions must also be specified, to be as close to CUO as reasonably practicable.	Facilitates dialogue between connection applicants, NSPs and AEMO regarding combinations of power system disturbances for which plant cannot meet CUO, allowing for more collaborative and efficient management of risk, reasonable limits on simulations, and the disclosure and management of legitimate plant limitations that may prevent CUO. Where limitations are disclosed, the risk can be managed either by accepting them, if the risk is low or by other mechanisms to mitigate the risk.

5.5.3 Reduction of fault level below minimum for which the plant is tuned

Objectives

Streamline the connection process | Support efficient investment and operation

Issues

Most technical standards are studied considering fault levels expected for system normal and single outage conditions, for a range of generation dispatch conditions. MFRT is different, in that it considers non-credible combinations of conditions. Currently, the MFRT rule excludes material reductions of power transfer capability from the conditions for which the plant must remain in CUO, but does not contemplate that multiple faults could reduce the fault level at the connection point below the level for which the plant was tuned.

Control system tuning affects the dynamic performance of the plant, including the damping of its controls during disturbances.

Transparency of plant tuning will assist future assessment of whether tuning of plant is still adequate considering the changes in the power system over time (including retirement of synchronous plant). At present the fault levels for which the plant is tuned are not recorded, so this information is lost. Recording it in an accessible document, such as the releasable user guide (RUG), will facilitate review and, if required, retuning at a later time.

Proposed amendments

Table 15 Amendments for fault levels and tuning affecting MFRT capability

Amendment summary	Reasons
In S5.2.5.5(d) and (l), exclude from the CUO requirement conditions where the three phase fault level at the connection point falls below the minimum for which the plant was required to be tuned, as specified by the NSP. Require the NSP to specify the minimum for tuning as the higher of: • the three-phase fault level derived from the short circuit ratio recorded for S5.2.5.15, and • the minimum fault level at the electrically closest system strength node combined with the single network element outage that would most reduce the fault level at the connection point.	For the AAS and MAS, removes any obligation to remain in CUO below the minimum fault levels for which the plant has been tuned. Requires the minimum fault level for tuning to be set by reference to objectively ascertained parameters.
In the information to be provided from a Schedule 5.2 Participant under S5.2.4, include a requirement for information to reflect control system turning consistent with the three phase fault levels in S5.2.5.5, which must be recorded in the RUG.	Ensures required tuning levels are recorded, allowing for review and retuning in future if necessary.

5.5.4 Active power recovery after a fault

Objectives

Streamline the connection process | Support efficient investment and operation

Issues

The AAS of NER S5.2.5.5 requires active power recovery within 100 ms of clearance of a fault to at least 95% of the level existing just prior to the fault. However, the 2023 'Efficient reactive current access standards for inverter-based resources' rule change amended the MAS requirement to refer to the recovery of positive sequence voltage at the connection point to remain between 90% and 110% of normal voltage.

For inverter-based technology, the plant's MVA is reduced in proportion to voltage. Below 90% of connection point voltage, the plant is expected to inject additional reactive current to support voltage, which is typically at the expense of active power. In combination, these factors mean that recovery of active power post-fault is dependent on voltage recovery post-fault. The voltage at the connection point post-fault can be affected by external factors as well as by the behaviour of the plant itself. It therefore makes sense for the AAS to use a consistent approach to the MAS, linking the active power recovery to the voltage recovery, but with a higher performance requirement that aligns with best power system performance. This would appropriately recognise the performance of inverter based technologies in the AAS, helping to streamline the connection process.

Depending on the nature of the disturbance that caused the voltage to drop, other changes to the power system operating conditions may occur simultaneously and affect the response of connected plant following the disturbance. For example, the plant may respond to oppose a phase angle or frequency change that may occur on switching of a line to clear a fault, and this can affect the recovery of active power to pre-disturbance level. These responses are expected from synchronous machines and GFM inverters, and are beneficial for system strength. Allowing for them is consistent with efficient investment in the NEM, and streamlines the connection process for these types of plant.

In some circumstances, power system conditions or energy source availability may be such that power transfer capability is reduced, so that the plant is unable to recover to its pre-disturbance level. This concept exists in the current access standard, but amendments are proposed to improve clarity.

Proposed amendments

Table 16 Amendments for active power recovery after a fault

Amendment summary	Reasons
Move these access standards to a separate new clause S5.2.5.5A	See section 8.5
In new S5.2.5.5A: • Define the end of a disturbance in the same way as for the MFRT requirements in S5.2.5.5. • In the AAS for both synchronous and asynchronous production units and the MAS for synchronous units, include a separate active power response requirement for a frequency disturbance, referable to an active power level consistent with the S5.2.5.11 performance standard and the operation of the plant in accordance with NER 4.4.2(c1) for primary frequency response (PFR). • In the MAS for asynchronous production units, add a reference to the PFR rule for consistency.	Makes synchronous and asynchronous requirements equivalent and achieves consistency of the AAS with the recently revised MAS. This amendment streamlines the connection process and aligns the rules with best power system performance.
In the MAS allow for inertial response and phase jump response as well.	Allows for expected and beneficial responses that modify the active power recovery.
Instead of referring to the active power recovering, refer to reaching 95% of pre-disturbance active power within a specified time.	Clarifies the requirements of the standard, thus simplifying the requirements of the connection process.

5.5.5 Rise time, settling time and commencement time for reactive current injection

Objectives

Remove impediments for connection of GFM inverters

Align with best power system performance

Streamline the connection process

Issues

NER S5.2.5.5 includes requirements applicable to asynchronous plant for reactive current injection during a disturbance. These are intended to achieve fast, stable response during faults. Reactive current injection during a disturbance:

- Assists the generating system or IRS to remain in service during the disturbance.
- Provides voltage support to the local network that can assist stability.

The Review identified several issues with the AAS:

- The defined terms 'rise time' and 'settling time' relate to step changes, but have been applied to fault responses where the voltage input may not be a step or even step-like.
- The assessment band for the settling time definition depends on the magnitude of the response. For a shallow fault, the small voltage change can give rise to an error band that is too small for a meaningful assessment of settling time. In effect, test criteria have been defined that depend on inputs, but the input has not been adequately specified.
- In high system impedance conditions, the reactive current response is likely to influence the voltage measured at the unit's terminals. This is expected, but even in simulations, makes the voltage and response less step-like.
- In some types of technology, including GFM inverters, the response may not settle over the time of the fault, due to slower dynamics of the control systems occurring during the fault. This is not an indication of an incorrect response. The response may be acceptable and adequately controlled, but the assessment criterion does not allow it to meet the AAS.
- The rise time measurement can also be affected if the response during a fault does not settle, as it depends on the maximum change. For instance, the response might rise rapidly, flatten, then rise again, which can affect the rise time calculation.
- The reactive current response is required to be directly proportional to the voltage change, but the voltage profile itself may not be 'adequately damped' according to the definition of that term.
- Even when a simulated fault is step-like, if the fault is unbalanced the measured voltage including positive and negative sequence elements may also not be 'adequately damped', although the response is entirely satisfactory.

The MAS requirements for reactive current injection were amended by the 2023 'Efficient reactive current access standards for inverter-based resources' rule change. A number of further amendments are now required for consistency or to improve understanding:

- The addition of a response 'commencement time' to the AAS, as previously added to the MAS, but with a higher performance requirement to align with best power system performance.
- Removal of the settling time requirement from the AAS, due to the issues outlined above.
- A definition of the term 'adequately controlled', used in the MAS without explanation, and which can replace 'adequately damped'.

Proposed amendments

Table 17 Amendments for rise time, settling time and commencement time

5.5.6 Commencement of reactive current injection and clarity on reactive current injection location

Objectives

Align with best power system performance	Streamline the connection process
Remove impediments for connection of GFM inverters	

Issues

At present, the AAS for asynchronous generating systems under NER S5.2.5.5(g)(1) requires the reactive current response for an undervoltage to commence in an under-voltage range 85% to 90%, and an overvoltage range of 110% to 115%, of normal voltage.[27]

The intended effect of this requirement is for reactive current injection to start as close to nominal voltage as possible to manage voltage excursions quickly. However, it implicitly assumes that the plant has a low voltage ride through threshold, and a two-tier control-strategy whereby voltage control passes from power plant controller to the production unit for reactive current injection during a fault.

In practice, not all asynchronous systems operate in this way. Some have response based on the magnitude of the voltage change rather than the voltage threshold. Some, like GFM, respond instantaneously to oppose a change in voltage. In addition, while two-tier voltage control is common, and encouraged by some technical standards (especially NER S5.2.5.13), it is not necessarily the best strategy for low system strength conditions. For controllers that provide voltage control response at the unit level rather than at a plant controller level, the present AAS and MAS are not appropriate owing to the technology-specific form of the clause.

As currently framed, this clause does not promote best power system performance. Response that arrests the change a voltage disturbance more quickly and closer to the pre-disturbance value will provide a better outcome for the power system, whereas the current standard provides an upper bound on the response commencement.

The 5% range is not workable for most generating systems or IRS that have a step up transformer with on-load tap-changer between the production units and the connection point. This is because there is a difference in the voltage at the connection point compared with the unit terminals that changes as a function of the tap position and the active and reactive power output of the generating system or IRS. A 5% range is often not practically achievable for a medium or large system with reactive power range consistent with the AAS of NER S5.2.5.1. It is typically only achievable for systems connected directly to the power system without an intervening step-up transformer. The existing provision for a different

[27] These rule change proposals include a change from *normal voltage* to *nominal voltage* at the connection point.

range to be agreed, but retaining the 5% band between upper and lower voltages, does not address the practical issue.

The proposed amendments would also add to the AAS the concept that commencement time, as well as rise time, can be measured at an agreed location other than the connection point. This provision is currently in the MAS for asynchronous plant and may help to simplify the performance description in the standard for some connections.

Proposed amendments

Table 18 Amendments for commencement and location of reactive current injection

Amendment summary	Reasons
Move these access standards to a separate new clause S5.2.5.5A	See section 8.5
For the AAS for asynchronous production units, require reactive current response to an under-voltage event to commence when or before voltage reaches 85% of nominal voltage at the connection point, and for an over-voltage event when or before voltage reaches 115% of nominal voltage at the connection point.	Allows for a faster reaction time in line with best power system performance, and aligns the AAS with the MAS.
Clarify in the general requirements that reactive current rise time and commencement time can be measured at a location other than the connection point, where agreed with the NSP and AEMO.	Acknowledges that the required reactive current connection might better be linked to a point in the network.
Require under the general requirements (and not within the MAS) that all elements of reactive current response must be recorded, including: • the location for measurement of reactive current injection level as a function of voltage; • the location of measurement of commencement time and rise time; and • the response initiating conditions, including the location at which it is measured, noting that rise time and commencement time might be measured at a different location.	Recording these elements can be expected to improve accountability for the response.

5.5.7 Consideration of unbalanced voltages and clarity on reactive current injection volume

Objectives

Align with best power system performance | Streamline the connection process

Issues

The amount of reactive current injection/absorption affects:

- The ability of a generating system or IRS to remain online during under-voltage or over-voltage events.
- The level of voltage support provided by the generating system to the power system in the local area during voltage disturbances.

Reactive current injection beyond maximum continuous current is not required, and IBR plants typically have a current limit. This means that, for deep faults, plants with high active current injection will typically operate at a limit for reactive current injection. The current AAS requires asynchronous production units to have facilities to provide reactive current injection of at least 4%/% voltage drop and absorption of at least 6%/% voltage rise. The requirement is generally taken to be for positive sequence injection or absorption, although that is not specified.

This is not an optimal standard as it:

- Does not specify the desired performance outcome, which in turn determines how the plant should be tuned.
- Does not align with the nature of most faults, as unbalanced rather than balanced faults.

Generating systems with large collector systems (e.g. large wind farms) may have difficulty in achieving the AAS level of reactive current injection at the connection point, without additional capital expenditure to reduce impedances of the collector system or transformer, or additional dynamic reactive plant. In high fault level conditions, the installation may run into fault level limitations of equipment if low impedance transformers are used. The injection of high levels of positive sequence currents during unbalanced fault conditions may lead to sub-optimal outcomes including over-voltages on unfaulted phases.

The present drafting of the rule with the words “facilities capable of” in NER S5.2.5.5(f) and (n)(1) was intended to indicate that the facilities should be capable of the defined level of injection, but settings set to levels appropriate for the conditions at the connection point. For example, a connection where the injection level was set low to accommodate high fault level conditions initially, might have settings adjusted higher if the maximum fault level drops over time due to synchronous machine retirements. However, the drafting does not appear to have been clear enough to convey this intent, and not all stakeholders applying the technical standards are aware of the original intent.

Consideration of performance for unbalanced faults may also lead to a view that the operation of the power system is best served by prioritising negative phase sequence injection over positive phase sequence injection, at a particular location. There is a potential trade-off between the use of reactive current to balance faults and minimise the deviation of positive sequence voltages from normal operating levels. With this prioritisation, a positive sequence injection of 4%/% and absorption of 6%/% may not be achievable.

The concepts in the proposed amendments incorporate:

- A control objective, which assists in determining optimal performance outcomes.
- An AAS requirement for the plant to have facilities capable of at least 4%/% injection and 6%/% absorption, with the actual settings to be based on tuning to meet the control objective.
- An AAS requirement for controls that can act to correct voltage unbalance (typically either on a phase basis or by means of negative phase sequence currents). This promotes better outcomes for unbalanced faults compared with only controlling positive sequence currents.
- A clarification to the general requirement that allows the required levels of reactive current injection and absorption to be measured at an agreed point other than the connection point, e.g. unit terminals. It should be clear that the levels calculated for any other point must be consistent with achieving the required access standard performance at the connection point.

- Guidance on documenting the unbalanced fault performance for the plant.

Proposed amendments

Table 19 Amendments for unbalanced voltages and reactive current injection volumes

Amendment summary	Reasons
Move these access standards to a separate new clause S5.2.5.5A	See section 8.5
Define a 'control objective' for balanced and unbalanced faults and transient over-voltages, to minimise the deviation of voltage on each phase from pre-disturbance values, while maintaining stable control.	This provides a consistent performance- based method for establishing the tuning of the plant.
In new S5.2.5.5A, for asynchronous production units: • AAS requirement is to have facilities capable of at least 4%/% and 6%/% injection/absorption for changes in positive sequence voltage (applying to both balanced and unbalanced voltage disturbances). • Add an AAS requirement for facilities capable of providing negative sequence current or equivalent contributions to oppose unbalanced voltages during a disturbance, while the MAS responses (as per the current rules) should not contribute excessively to voltage rise on unfaulted phases during unbalanced faults. • For both AAS and MAS, specify that the actual required responses (within the relevant capability range) are to be agreed at levels consistent with achieving the defined control objective.	The control objective guides the actual performance required, maintaining the AAS capability but allowing flexibility on plant settings for reactive current injection, aligning with optimal outcomes for the power system considering plant capabilities. Aligns the AAS with best system performance by requiring either inherent response or control response that opposes voltage unbalance.
Record in the performance standard (allowing that response may be different for different fault types): • Facilities for reactive current injection and absorption and • Response to balanced voltage disturbance, as the positive sequence reactive current response as a function of positive sequence voltage deviation. • Response to voltage unbalance, as either: – negative sequence reactive current response, as a function of negative sequence voltage; – reactive current response on each phase, to phase unbalance, in % current per % voltage deviation; – another method agreed with AEMO and the NSP. • Control priority (active current vs reactive, and/or positive vs negative sequence).	Clear documentation of expected facilities and performance improves certainty and accountability. Includes flexibility to account for implementation differences between OEMs and technologies.
Include in the general requirements (paragraph (u)(2)) wording to confirm the intent that the specification and measurement of reactive current response at another agreed location must be at levels consistent with the access standard at the connection point.	Removes ambiguity

5.5.8 Metallic conducting path

Objective

Streamline the connection process

Issues

S5.2.5.5(a) states: 'In this clause S5.2.5.5 a fault includes a fault of the relevant type having a metallic conducting path.' This does not add any particular clarity to the description of faults in the clause. Power system faults can generally have paths that are combinations of metallic and non-metallic conducting paths (for example an arcing fault through a transmission line and ionised air to ground). There is no apparent reason why a metallic conducting path might otherwise be excluded, but the statement could create room for debate about the application of the requirements to non-metallic conducting paths. The range of views expressed on this clause in the Review indicated there was no consensus about its meaning or intent. AEMO considered whether absence of this clause would alter the way the S5.2.5.5 fault ride through requirements were interpreted by a power systems engineer, and concluded that it would not, so is proposing that the clause be deleted.

Proposed amendments

Table 20 Amendment for metallic conducting path

Amendment summary	Reasons
Delete S5.2.5.5(a).	Removes ambiguity.

5.5.9 Reclassified contingency events [Standard – non fast track – amendment]

Objectives

Align with best power system performance | Streamline the connection process

Issues

NER S5.2.5.5(c)(1) requires generating systems and IRS to remain in CUO for credible contingency events. By definition, a 'credible contingency event' of itself is not fixed or constant size. While the largest credible contingency in normal power system conditions does not change frequently, in abnormal conditions AEMO can reclassify if available information indicates a reasonable possibility that additional or multiple plant could disconnect or reduce operation because of those conditions. [28]

For the purposes of establishing a performance standard, this means there is no fixed limit on the size of any resulting disturbance that the connected plant must ride through, as what constitutes a credible contingency can be different at any point in time. This creates uncertainty and potential compliance risk for connection applicants and a lack of transparency for power system operation, given that ride through capability is not infinite. Providing guidance on the application of credible contingency events should allow limits to be established commensurate with maintaining power system resilience appropriate for reasonably anticipated normal and abnormal conditions.

[28] NER 4.2.3A

Proposed amendments

Table 21 Amendments for reclassified contingency events

Amendment summary	Reasons
In S5.2.5.5, add a provision qualifying the credible contingency event reference in paragraphs (c) (AAS) and (k) (MAS). For the purposes of the access standards, limit the scope of a credible contingency event to: • Credible contingency events used by the NSP for its network planning under S5.1.2.1 • Non-credible contingency events specified by AEMO that are routinely expected to be reclassified as credible contingency events under clause 4.2.3A in reasonably anticipated abnormal conditions, and are likely to cause a significant disturbance at the schedule 5.2 plant's connection point. Include in S5 2.4(e1) a general requirement for the NSP to provide a connection applicant with information about any other matters(which would include about reclassified events) that either it or AEMO may need to specify, nominate or require for the purposes of any access standard, sufficient to cover information about credible contingency events.	Facilitates the establishment of reasonable limits on the size of disturbances for which plant must remain in CUO, based on expected power system resilience needs.

5.6 NER S5.2.5.7 – Partial load rejection

5.6.1 Application of minimum generation to energy storage systems

Objective

Streamline the connection process

Issues

Under NER S5.2.5.7, the requirement to remain in CUO following a load reduction event is currently subject to the loading level remaining above the minimum generation required for continuous stable operation. Initial consideration of this issue was to how the minimum generation for continuous stable operation related to batteries, but subsequent feedback questioned the value of this rule for plant other than synchronous generators (for instance synchronous condensers).

Experience of the assessment of this rule over the five years since it was extended to asynchronous plant indicates little has been gained from that change. By the same logic there would be little gained from applying it to battery systems or synchronous condensers, noting that both types of plant must meet other schedule 5.2 access standards for voltage and frequency disturbances and contingencies.

Limiting the application of this requirement to synchronous generation would reduce unnecessary duplication of requirements and reduce the time and resource requirements needed for compliance assessments.

Proposed amendments

Table 22 Amendments for application of partial load rejection

Amendment summary	Reasons
Apply S5.2.5.7 only to synchronous generation.	Limits the requirement to the plant that is affected by the issue to be addressed.

5.6.2 Clarification of meaning of CUO for NER S5.2.5.7

Objectives

Align with best power system performance | Streamline the connection process

Issues

The AAS requires that relevant plant must be capable of CUO during and following a power system load reduction of 30% from its pre-disturbance level or equivalent impact from separation of part of the power system in less than 10 seconds.

The Review identified two issues with this clause as currently drafted:

- Ambiguity about the interpretation of 'capable of' in this context, specifically whether that means such capability is always required. As load reduction events cannot be anticipated in advance, from a power system perspective the plant is expected to maintain settings that will always provide the necessary response.
- The definition of CUO only allows for substantial reductions in output after fault clearance when allowed by specified performance standards, which currently exclude NER S5.2.5.7. The clause is otherwise silent on the reduction in active power which would inevitably result from the frequency or inertial response to the loss of load.

Proposed amendments

Table 23 Amendments to clarify CUO for partial load reduction

Amendment summary	Reasons
In S5.2.5.7, replace the term "be capable of" with "remain in".	Clarifies the required performance.
Amend the definition of CUO in Chapter 10 to permit active power and reactive power changes to oppose a voltage variation or frequency variation.	Ensures that beneficial responses are permitted

5.7 NER S5.2.5.8 – Protection of generating systems from power system disturbances

5.7.1 Emergency over-frequency response

Objectives

Align with best power system performance

Streamline the connection process

Support efficient investment and operation

Issues

NER S5.2.5.8(a)(2) describes three options for a generating system of 30 MW or more and an IRS for bidirectional units of 5 MW or more to reduce their active power rapidly, in the event of an over-frequency event. The Review considered the following main issues associated with this clause:

- NER S5.2.5.8(a)(2)(ii) requires the reduction in output to be completed within 3 seconds of the frequency reaching the upper limit of the extreme frequency excursion tolerance limits, but at this level generating systems and IRS are permitted to trip (considering NER S5.2.5.3 and S5.2.5.8(a)(1)), so the response might be too late to be useful.
- NER S5.2.5.8(a)(2)(i)(B) requires a response that reduces the plant's output by at least half, within 3 seconds of the frequency exceeding a threshold, but some plant (e.g. some hydro generating units) cannot physically achieve a reduction in output at the required rate safely. The same limitation might also arise with NER S5.2.5.8(a)(2)(ii), which describes a response proportional to frequency deviation. The third option (tripping the plant) is not desirable as it could reduce the inertia of the power system, increasing the rate of change of frequency.
- There are different size criteria for the application of this requirement based on whether or not a system includes bidirectional units. This distinction appears to have been based on registration thresholds, but for this technical requirement there is no reason to differentiate based on technology.
- Currently the requirements only apply to transmission-connected plant, but do not apply to distribution connected plant, even when larger than 30 MW. There is no technical reason to exclude plant based on its connection to transmission or distribution.

From a power system perspective, a response proportional to frequency deviation is preferred as this provides a smooth reduction in active power output while helping to reduce frequency excursions. The least preferred response is tripping, because it can also exacerbate a disturbance by causing the rate of change of frequency to increase and can also cause local voltage disturbance. A fast ramp back is preferred over tripping. Providing a more preferable form of response, with some flexibility if necessary on the time to achieve the required reduction, or on the level of reduction itself, may result in more optimal performance than resorting to tripping the plant.

Provision of PFR is not a substitute for performance requirements under this clause as plants may have different levels of performance accepted under the PFR framework.

Proposed amendments

Table 24 Amendments for emergency over-frequency response

Amendment summary	Reasons
In S5.2.5.8: • Create an AAS and MAS for over-frequency response requirements, where the AAS requires frequency droop response and the MAS allows disconnection. • Provide that an NAS can only be accepted to the extent that physical plant limitations prevent compliance with the AAS, and to that extent an NAS may include: – Droop response that is smaller or slower than the AAS (as reasonable). – Rapid active power reduction, by fast ramping in preference to disconnection, at an agreed frequency trigger level and time lag. • Express the remaining provisions of the existing MAS as general requirements. • Make the 50% reduction requirements subject to the plant remaining above a minimum generation level for continuous, stable operation, where applicable. • Amend the AAS to require the necessary active power reduction to have been completed by 3 seconds after frequency reaches a level 0.5 Hz below the upper limit of the extreme frequency excursion tolerance band, provided the rate of change of frequency does not exceed the maximum established for the plant under S5.2.5.3.	Provides a clearer structure consistent with other access standards, creating an AAS aligned with best power system performance with disconnection (as the MAS) being an option only where preferable responses are not feasible. Acknowledges the need for synchronous generation maintain a minimum continuous level of generation. Corrects and clarifies the frequency conditions for commencement or completion of the response, to ensure capability is sufficient to assist frequency recovery and sufficiently flexible to ensure a range of plant capabilities can provide a suitable and compliant response. Coordination of the completion of the response with a frequency less than the upper limit of the extreme frequency excursion tolerance band aligns the AAS better with best power system performance.
Amend the application criteria for S5.2.5.8 requirements to: • Apply the same size threshold irrespective of the type of plant, being 30 MW (or 30 MVA) or if smaller, 5% of any applicable maximum credible contingency size in the frequency operating standard. • Remove the reference to transmission-connected, for the AAS and MAS.	Makes the standard technologically and locationally neutral. The size threshold allows for adaptation for (currently) the smaller power system in Tasmania, where the same size plant would have a larger impact on power system frequency than for the mainland system.

5.7.2 Protection settings to maximise capability to ride through disturbances

Objectives

Improving power system resilience

Issues

It is common for plant protection settings to be fixed just outside the required access standard conditions for CUO for frequency, Rate of change of frequency (RoCoF) and voltage. This fails to utilise capability that is available at no incremental cost, in circumstances where the plant is capable of safely remaining in operation for a materially wider operating range. In abnormal conditions, generally it will be more beneficial for power system resilience for plant to remain connected for as long as it can continue to operate stably and safely.

Proposed amendments

Table 25 Amendment to Protection settings to maximise capability to ride through disturbances

Amendment summary	Reasons
In S5.2.5.8, add a requirement for a schedule 5.2 plant's protection settings to be set to maximise its capability to remain in operation for abnormal power system conditions for which the plant is not required to disconnect under any performance standard, while maintaining safe and stable operation of the plant within safety margins consistent with good electricity industry practice.	Facilitates improved power system resilience at no incremental cost.

5.8 NER S5.2.5.10 – Protections to trip plant for unstable operation

Objectives

- Align with best power system performance
- Streamline the connection process
- Support efficient investment and operation
- Improving power system resilience

Issues

The AAS for NER S5.2.5.10 requires generating systems and IRS to have a protection system that trips the plant when it is operating unstably. This is intended to protect the network from active power, reactive power and voltage instabilities caused or amplified by a generating system or IRS.

In recent years, there has been uncertainty in the interpretation and application of the AAS and MAS. This caused delays and potentially suboptimal outcomes in multiple connection projects for asynchronous generating systems. For example, there are concerns over:

- Whether asynchronous generating systems should be disconnected without considering their contribution to the instability.
- Whether a prompt disconnection is the best solution for a modern grid with high penetration of asynchronous generation.
- What types of instabilities should be covered under NER S5.2.5.10.

In recent years, several oscillatory events have been experienced in multiple NEM states with different levels of oscillation severity and frequency. These events needed to be individually investigated by NSPs and AEMO to identify (as far as possible) which generating systems and IRS were contributing to the instability. Some events required manual disconnection of the plant contributing to the instability because there was no automatic system to eliminate the instability or disconnect the plant.

This is not sustainable for a power system with a large and steadily increasing number of asynchronous generating systems and IRS.

Nevertheless, there are potential problems with disconnecting based solely on an oscillation or instability at the connection point. In particular, an oscillation at the connection point may occur whether the plant is participating in it or not, and its participation may damp the oscillation, so disconnection based on the presence of an oscillation at the connection point alone might disconnect the wrong plant, and exacerbate the oscillation or cause a supply deficit.

Key to resolving this is to be able to determine the contribution of the plant to the instability. There are some systems being developed to achieve this goal, including a system based on assessment of phasor measurement unit (PMU) data which AEMO is developing, and some commercially available systems that analyse connection point data, but the technology is still evolving.

Another way to address the problem is to trget multiple strategies for eliminating instability in preference to tripping the plant, referred to in the proposed NER amendments as a 'hierarchy of actions'. These may be sequenced to try less invasive actions first, or implement different actions at different trigger levels. As the approach is expected to evolve over time, the proposed access standard has been written to provide flexibility for a range of solutions, which can be tailored, considering the power system risk, for the size and location of the plant.

Proposed amendments

Table 26 Amendments for protections for unstable operation

Amendment summary	Reasons
Change the heading of S5.2.5.10 to 'Detection and response to unstable operation.	Recognises that a range of responses may be preferable to tripping
Amend the AAS for asynchronous production units to require: • Facilities capable of detecting instability in voltage, reactive power and active power and automatically disconnecting the plant for unstable behaviour with configurable triggers and settings. • Automatic and prompt execution of a configurable hierarchy of response actions on detection of instability, as agreed with the NSP and AEMO. • Any action that involves plant tripping to account for available automated information on the plant's contribution to the instability. Amend the MAS to apply minimum requirements to schedule 5.2 plant that can change the voltage at its connection point by more than 1%, for system normal or planned outage conditions (considering its reactive power range under S5.2.5.1), as follows: • Capability to detect instability of voltage, reactive power and, where relevant, active power. • For asynchronous production units, a process agreed with the NSP and AEMO to manage oscillations promptly on detection. • For synchronous production units or synchronous condensers, a protection to disconnect for sustained pole slipping, if the NSP or AEMO requires.	Provides flexibility to use available capability for connected plant to promptly respond to instability when detected, in a manner that is likely to be proportionate and efficient having regard to power system needs and plant capabilities. Allows for detection, monitoring and response of the plant's own contribution to instability as those capabilities mature.
For the AAS, all production systems 100 MW or more and synchronous condenser systems 100 MVA or more must have access to a PMU to send data to the NSP and AEMO, and capability to receive information about contribution to oscillations from an AEMO facility where available. For the MAS, the same requirements apply only where required by the NSP or AEMO.	Allows for both a local and a future centralised system to identify plants contributing to the instability, for visibility and control of response, with size thresholds balancing risk and efficiency.

Amendment summary	Reasons
Include general requirements to specify that: • Measures to eliminate the instability are to be prioritised over disconnection • Requirements referable to instability are to be determined with regard to the power system stability guidelines (NER 4.3.4(h)) • The NSP or AEMO may require capability to send data from detection systems to their control centres. • The NSP may require capability to receive a remote tripping signal from the NSP.	Confirms that disconnection should generally be considered as a last resort, if not otherwise possible to resolve instability. Power system stability guidelines describe what constitutes instability in relation to various types of conditions, including oscillations.

5.9 NER S5.2.5.13 – Voltage and reactive power control

5.9.1 Voltage control at unit level and slow setpoint change

Objectives

Remove impediments for connection of GFM inverters	Align with best power system performance

Issues

Voltage control of asynchronous plant is typically implemented through a power plant controller (PPC). The PPC controls the voltage by sending the units active and reactive power commands. The PPC controls voltage at the connection point or some other location nominated in the GPS, usually with voltage droop control.

Issues with this type of PPC control include:

- It can be less stable than unit-level voltage control in low system strength conditions, due to the cycle time of the PPC and variable communication delays between the PPC and individual units.
- It is inherently less resilient to communication failures between the PPC and the production units.

Application of voltage control at unit level avoids these problems and is also well-suited to GFM inverter technology.

Under the present rules, compliance with the setpoint-related risetime and settling time requirements can be affected when unit-level voltage control is used on distributed systems like solar and wind farms because of potential delays between units responding to a setpoint change. Response to power system disturbances is potentially improved compared with PPC fast voltage control[29].

Potentially poorer setpoint related performance can be an impediment to implementation of unit-level voltage control, even though a fast setpoint change is not important for the power system and can be detrimental. Nevertheless, setpoint-related performance requirements are useful for confirmation of stability because they are easier to test during commissioning than power system disturbance-related

[29] Note combinations of fast unit level voltage control with a slow outer loop control may also be configured in a manner that reduces the problems described above. The current rules similarly disincentivise use of this type of control, for the same reason.

performance requirements (it is difficult to set up test conditions to cause a step of sufficient magnitude on the power system to test the performance).

To navigate these conflicting requirements AEMO has made some changes to the setpoint-related performance requirements (see section 5.9.2) and also included an explicit allowance for ramp-limits to be applied to setpoint changes. If ramp-limits are applied to setpoint controls there will be no argument about compliance with fast responding setpoint performance under normal operating conditions. Setpoint ramp-limits have the added benefit of protecting the power system from power system disturbances caused by too large voltage setpoint steps that might be inadvertently applied. Ramp-rate limits on setpoint changes have been traditionally applied to large synchronous machines for this reason.

Proposed amendments

Table 27 Amendments for unit-level voltage control and slow setpoint change

Amendment summary	Reasons
Amend the general requirements of S5.2.5.13 to permit the application of limits on the rate of change of setpoint (rate limits) to a schedule 5.2 plant for normal operating conditions and, if so, the performance standards must record details of the rate limits applied.	Better supports the use of control strategies that align with best power system performance, particularly at low system strength conditions, including for grid forming inverters.
Use of ramp limiters may be applied to voltage, reactive power and power factor modes. Note: for voltage control allowance has been made to remove ramp rate limits for test purposes. For the power factor and reactive power (primary mode, AAS) a longer settling time has been allowed for setpoint step with an over-damped response.	Slow setpoint changes are also appropriate for power factor and reactive power setpoint changes, for the same reasons.

5.9.2 Optimise power system performance over expected fault level (system impedance) range – Voltage control

Objectives

Align with best power system performance | Improving power system resilience

Issues

The AAS and MAS for NER S5.2.5.13 both measure the performance for voltage control in terms of the rise time and settling time, with the AAS requiring a faster response. Settling time is used as a measure of stability for this requirement, but a long settling time can also arise from an over-damped response, which would also be associated with a long rise time.

In recent years the retirement of synchronous generation, the location of generation in areas with higher impedance and the increase in GFL inverters has resulted in a trend towards lower system strength. Experience has shown that:

- GFL inverters have tended to be less stable at low system strength.

- Changing generation dispatch patterns mean there is generally a larger range of system strength conditions experienced in the network.
- At higher system strength responses are slower, but stable (longer rise time and settling time, if over-damped).
- At lower system strength responses are faster, but less stable (shorter rise time and settling time, unless significantly under-damped).
- If controls are set to meet the AAS for rise time and settling time for low system impedance conditions, the response may be unnecessarily oscillatory for high system impedance conditions and is more likely to be unstable for multiple contingency events.

The effect of power system impedance on plant performance has been examined as part of this review. Expected performance is for plant controls to be slower but more stable at low system impedance conditions (strong system), and conversely faster and less stable at high system impedance (weak system). The current rules are silent on the range of impedance values to which the plant should be tuned. Practically the stability under weak conditions is of highest importance, because that is when the system is most likely under stress, but it is important for plant to have reasonable performance balancing speed and stability considerations under normal operating conditions. Therefore AEMO has proposed in this rule change to define the range of conditions for tuning to be from typical to high system impedance conditions. The latter has a proposed definition, which can be determined based on published information, whereas the typical conditions are undefined, but would be expected to cover dispatch scenarios and network configurations and demand scenarios that are usually found (similar to the approach applied under the current rules). The definition of the upper level allows the performance requirements to be better focused on the weak system conditions, in circumstances where risetime and settling time at AAS level cannot be simultaneously met for high and typical system impedance levels. The typical to high impedance range also de-emphasises the slower performance at low system impedance conditions, which is less critical for the power system's performance.

AEMO suggests the power system is best served if generators prioritise stability over speed of response. For a NAS, the rule change proposes prioritising stability, if the AAS cannot be met for the full range of system impedance conditions.

Achieving a two second reactive power rise time does not necessarily improve power system performance. A three second rise time has been proposed instead for the AAS.

As described in the previous section, speed of response is of value for voltage disturbances, but not for setpoint changes. Setpoint changes are, however, used for testing purposes as a convenient way to apply a step change, and check plant response for stability and alignment to a model. AEMO proposes to apply the reactive power rise time requirement to a voltage disturbance (rather than for a setpoint change as per the present NER), while retaining a performance requirement to assess settling time for a setpoint change. For setpoint changes of power factor and reactive power the proposed requirement is further differentiated on whether the response overshoots the sustained change or is oscillatory (i.e underdamped or critically damped) in which a 5 second settling time applies or otherwise (i.e. an over-damped response) 30 seconds settling time applies. Slow, well-damped setpoint change response for power factor and reactive power should be incentivised as this is appropriate to align with best power system performance.

In the MAS only typical impedance levels are required to be assessed, but longer settling times are also permitted, and the prioritisation of stability still applies, so these plants are more incentivised to be a bit slower, which is acceptable.

Additional issues identified from stakeholder feedback in the Review included:

- A plant controller may wind-up when either there is a setpoint change or a voltage disturbance that causes a limiter to operate. When the change is reversed there can be a delay in response that may lead to over-voltages or under-voltages being unnecessarily prolonged. Applying a settling time requirement on response that causes operation **out of** a limit (not only into it) would incentivise a more appropriate response.
- Stable response to power system disturbances is the single most important performance requirement, and is addressed in schedule 5.2 by settling time requirements. However, settling time can only be properly calculated with a step in the input quantity (in this case voltage). To address this, AEMO proposes to clarify the disturbance using 'step-like' as a term which AEMO considers will be properly understood and appropriately applied by power system engineers in the given context.
- Flexibility should be provided in the MAS to permit settling times greater than 7.5 seconds, if the NSP agrees. In some unusual cases, interaction with the controls of other plants can lead to longer settling times, but with no stability issues.

Note: As the concept of primary and secondary operating modes has been proposed with lower compliance requirements on secondary modes, there is an overlap here between the issues and proposed changes described here and in section 5.9.4.

Proposed amendments

Table 28 Amendments for voltage control

Amendment summary	Reasons
In the AAS for S5.2.5.13, require: • For asynchronous plant only, rise time less than 3 seconds for a voltage disturbance between 2% and 5%, not into a limit, for the maximum system impedance and typical system impedance level nominated by the NSP. • For all schedule 5.2 plant, settling times of less than 5 seconds (not into a limit) and less than 7.5 seconds (into a limit) for a voltage change between 2% and 5% or 5% voltage setpoint change, for typical and highest system impedances. • 7.5 second settling time also to apply to steps out of a limit (that is, if the limiting device was operating at the start of the voltage change. In the MAS, for the current 7.5 second settling time requirement (applicable for voltage steps not into a limit), permit a longer settlement time if agreed by the NSP. Present maximum rise time and settling time requirements in table form for the AAS and MAS, reflecting control mode differences discussed in section 5.9.4.	Allows for efficient and proportionate tuning of connected plant to be flexible given the network impedances, with the objective of prioritising stability over speed of response for best power system performance.

Amendment summary	Reasons
In the general requirements for S5.2.5.13, include a requirement for the NSP to specify, to be recorded in the RUG, the highest and typical system impedance values (for tuning and assessment), with: • Highest system impedance being consistent with the system impedance at voltage close to nominal for a typical dispatch pattern and network configuration that corresponds to the minimum three phase fault level at the electrically closest system strength node, in combination with the network outage that would cause the greatest reduction in the three phase fault level at the connection point. • Typical system impedance being a value the NSP considers representative of a typical network configuration and typical levels of schedule 5.2 plant in service.	
Responses to prioritise stability if AAS performance cannot be met	

5.9.3 Materiality threshold on settling time error band

Objective

Streamline the connection process

Issues

NER S5.2.5.13 requires calculation of settling time for each of voltage, reactive power and active power for steps of voltage, reactive power and power factors for operation in those modes. As 'settling time' is currently defined in the NER, its calculation depends on the response remaining within a 10% error band. This means that, for a small transient change, the error band becomes very small and the settling time calculation becomes meaningless. This becomes a compliance issue because:

- Active power excursions, especially, tend to be quite small for the step changes contemplated in S5.2.5.13.
- For voltage and reactive power, similar issues may arise, particularly in the compliance testing scenario where noise and measurement error are present, when the error bands for calculating settling time are too small.

Proposed amendments

Table 29 Amendments for settling time error band

Amendment summary	Reasons
In the general requirements for S5.2.5.13, provide that a settling time requirement for that clause is taken to be met if, for a voltage step in any mode or for a voltage setpoint step, the magnitude of error does not exceed the greater of the value calculated from the settling time definition and: • For active power, the higher of +/- 0.5 MW or +/-2% of the Pmax recorded in the performance standard for clause S5.2.5.1. • For reactive power, +/- 0.5 MW or +/-2% of the reactive power capability under the performance standard for clause S5.2.5.1. • For voltage, +/-0.5% of nominal voltage.	Allows scaling of the error band relative to the size of the plant ensuring that the calculation of settling time returns a meaningful value. Should reduce the effort dealing with non-compliances associated with the existing poor definition and lack of materiality consideration.

5.9.4 Multiple modes of operation and treatment of voltage settling time for reactive power and power factor modes

Objectives

Align with best power system performance

Streamline the connection process

Support efficient investment and operation

Issues

NER S5.2.5.13 has an AAS requirement for generating systems and IRS to:

- operate in multiple modes (voltage control, reactive and power factor);
- switch between modes; and
- be able to do so through remote control in response to a command from AEMO.

In practice, most plant will operate in one mode over its life, although there are some exceptions.

Requiring operation in three modes means all the activities of connection and ongoing compliance must be repeated for multiple modes. This is a non-trivial cost over the life of the plant if only one mode is ever likely to be used. There is potential to streamline the connection process by defining one primary mode (which is used most of the time) and a secondary mode (generally for testing and other abnormal conditions). Requirements for operation in secondary mode could be comparatively light-handed given the lower risks to the power system associated with infrequent operation in that mode.

In some cases, settling time requirements are applied to quantities that are not controlled by the relevant mode. For example, in reactive power and power factor modes voltage is not controlled, so it is not appropriate to assess compliance against voltage settling time.

These three elements in combination (primary and secondary modes, lower compliance requirements for secondary modes, and eliminating irrelevant requirements for settling time assessment), will significantly reduce the cost and effort for verification of compliance, at connection, commissioning and over the life of the plant.

Proposed amendments

Table 30 Amendments for multiple modes of operation and related settling times

Amendment summary	Reasons
In the AAS for S5.2.5.13: • Require voltage control mode to be the primary operating mode unless the NSP requires a different primary mode, in which case voltage control must be the secondary mode. • Plant must operate in primary mode in normal operation. Secondary mode is for testing, abnormal power system conditions or abnormal plant operating conditions. • Require the ability to switch between control modes (existing requirement). • Where voltage is the secondary mode, omit the rise time requirement, • For secondary modes, only require assessment for typical system impedance (see section 5.9.2 for explanation on typical system impedance), because probability of high impedance operating conditions while operating in this mode is very low, and to test compliance there would need to be performance requirements for typical impedance conditions. In the AAS and MAS: • For power factor and reactive power modes: – Remove the requirement to assess voltage settling time • For reactive power mode: – Remove the requirement to assess active power settling time Note: MAS continues to require only a single mode of operation.	Takes an appropriate risk-based approach to testing and compliance, allowing connections to be streamlined but not compromising power system performance. Simplifies assessment and compliance by removing impractical or inappropriate requirements.

5.9.5 Interaction with system strength services

Objectives

Align with best power system performance

Streamline the connection process

Support efficient investment and operation

Issues

A plant that has an adverse impact on system strength may elect to pay a system strength service provider (SSSP) to provide these services. This should be considered in the assessment of S5.2.5.13.

Proposed amendments

Table 31 Amendments for impact on power system operation modes

Amendment summary	Reasons
Include in the general requirements of S5.2.5.13 a provision that, where a Schedule 5.2 Participant has elected to pay the system strength charge (under NER 5.4.3B(b1)), assessments for the S5.2.5.13 access standard must consider the performance required to be provided by the SSSP at the relevant system strength node.	The system strength services provided by a SSSP should be considered when assessing compliance with this schedule. This amendment ensures this.

5.10 NER S5.2.5.16 - Voltage phase angle shift

Objectives

Streamline the connection process

Issues

S5.2.5.16 relates to connected plant's response to a power system disturbance, which is the focus of S5.2.5.8. Integrating this requirement into S5.2.5.8 would streamline and clarify the application of the rules. This is a minor change, intended only to relocate the requirement into the relevant part of the NER, for clarity purposes.

Proposed amendment

Integrate this requirement into S5.2.5.8 (as per draft clause S5.2.5.8(b)) and delete S5.2.5.16.

5.11 Definitions of CUO, rise time and settling time

5.11.1 CUO - recognition of frequency response mode, inertial response and active power response to angle jump

Objectives

Remove impediments for connection of GFM inverters

Align with best power system performance

Streamline the connection process

Improving power system resilience

Issues

The definition of CUO does not currently anticipate inertial response, active power response opposing phase angle jumps and primary frequency response. The absence of any allowance for such responses may disincentivise their provision, even though they are beneficial to the operation of the power system.

Proposed amendments

Table 32 Amendments to CUO definition

Amendment summary	Reasons
Modify the CUO definition and relevant access standard clauses to permit responses opposing voltage phase angle jumps and frequency changes, including inertial response during disturbances	Ensures beneficial responses are not inadvertently prevented.

5.11.2 Rise time – explicitly disregards longer-term dynamics and external influences

Objectives

Align with best power system performance | Streamline the connection process

The issue

The NER currently has an unusual definition of rise time, as:

> 'in relation to a *control system*, the time taken for an output quantity to rise from 10% to 90% of the maximum change induced in that quantity by a step change of an input quantity.'[30]

As written, the definition provides a longer time for a response that has a higher overshoot of the sustained change. It is more usual to describe the rise time in terms of 10% - 90% of the sustained change.

The definition is used in NER S5.2.5.5 and S5.2.5.13. In S5.2.5.5, reactive current injection, especially for longer faults, may be affected by longer term dynamics of other controls (such as pitch controllers on wind farms) or external influences, which can interfere with the calculation of these quantities. This issue of longer-term dynamics has also been observed for grid forming inverters. Likewise in S5.2.5.13, the effect of longer-term dynamics should be disregarded for calculation of the risetime, or misleading results can be obtained.

Proposed amendments

Table 33 Amendment to definition of Rise time

Amendment summary	Reasons
Modify the definition of rise time in Chapter 10 as follows: • In relation to a control system, the time taken for an output quantity to rise from 10% to 90% of the mean sustained change induced in that quantity by a step change of an input quantity, disregarding longer-term dynamics and influences external to the generating system, following the step change.	Helps streamline the connection process by focusing the definition on what needs to be measured to align with best system performance, which is the fast initial response, and de-emphasises effect of the longer term dynamics.

5.11.3 Settling time – error band and materiality considerations

Objectives

Align with best power system performance | Streamline the connection process

Issues

The NER currently has a non-standard definition of settling time, with two parts based on the ratio of the maximum deviation to the sustained change:

[30] National Electricity Rules, Version 203, Chapter 10 p. 1423.

In relation to a *control system*, the time measured from initiation of a step change in an input quantity to the time when the magnitude of error between the output quantity and its final settling value remains less than 10% of:

(a) if the sustained change in the quantity is less than half of the maximum change in that output quantity, the maximum change induced in that output quantity; or

(b) the sustained change induced in that output quantity.[31]

This is intended to allow settling time to be calculated when the sustained change is very small, as well as when it is large. It attempts to deal with error band size, but the calculation still leads to unworkably small error bands when the maximum and sustained changes are small. AEMO proposes to address this by explicitly managing the error bands for small changes in NER S5.2.5.13.

In conjunction with the proposes changes to NER S5.2.5.13, and removing settling time from NER S5.2.5.5A, the definition can be simplified to a more standard form.

Proposed amendments

Table 34 Amendment to definition of settling time

Amendment summary	Reasons
In conjunction with materiality thresholds described for P, Q and V in the context of settling time under S5.2.5.13, modify the settling time definition in Chapter 10 as follows: • In relation to a control system, the time measured from initiation of a step change in an input quantity to the time when the magnitude of error between the output quantity and its final settling value remains less than 10% of the sustained change induced in that output	Makes the error bands for settling time consistent as the ratio of sustained change to maximum induced change increases. This targets the definition to its purpose aligning with best power system performance and should reduce confusion that may slow the connection process.

[31] National Electricity Rules, Version 203, Chapter 10 p. 1429.

6 Access standards for HVDC links

This section outlines AEMO's proposed NER amendments (primarily in schedule 5.3a) to improve the access standards for HVDC links[32], based on Review recommendations with the objectives described in section 3.

6.1 NER S5.3a.8 - Reactive power capability

Objectives

Incorporate impact and capability of HVDC links	Align with best power system performance
Support efficient investment and operation	Improving power system resilience

Issues

At present the reactive power requirements for HVDC links are specified as power factor range. In contrast, the reactive power requirements for inverter-based generation and IRS are specified in terms of its capability to support the operation of the power system by injecting or absorbing reactive power.

However, modern HVDC links have the same capability to provide reactive power as generating systems and IRS, which can therefore be provided at low incremental cost with important benefits for managing the voltage profiles in the AC power system. It is therefore important to fully and accurately capture the reactive power capability of HVDC links under the access standards, in the same way as schedule 5.2 plant.

Proposed amendments

Table 35 Amendments for reactive power capability

Amendment summary	Reasons
Amend S5.3a.8 to apply the equivalent reactive power capability requirements in the AAS and MAS for S5.2.5.1 to HVDC links, by reference. Apply equivalent provisions for NAS and general requirements as under S5.2.5.1.	Aligns reactive power capability requirements for HVDC links with those for schedule 5.2 plant.

[32] Currently limited in schedule 5.3a to MNSP facilities, but proposed to extend to all HVDC links as explained in section 4.

6.2 NER S5.3a.13 & S5.3a.14 - Response to disturbances in the power system

6.2.1 Voltage disturbances

Objectives

Incorporate impact and capability of HVDC links	Align with best power system performance
Support efficient investment and operation	Improving power system resilience

Issues

Currently the voltage ride through requirement in NER S5.3a.13 for HVDC links is to maintain CUO for the range of voltage conditions permitted in the system standards. The system standards for voltage magnitude in NER S5.1a.4 only contemplate the allowable voltages following credible contingency events. By contrast, the voltage ride through requirements for inverter-based systems are significantly more rigorous than the voltage conditions permitted in the system standards, with access standards designed to provide a reasonable level of resilience to the power system for many non-credible contingency events.

Modern HVDC links have similar voltage disturbance capability as inverter-based generation and battery systems. However, the value of this is not currently captured by the technical requirements in NER schedule 5.3a.

The impact of an HVDC link tripping is similar to tripping a schedule 5.2 plant of similar size. For example, the trip of Basslink was until recently the largest credible contingency event in Victoria. HVDC links may be large, and tripping will impact both ends of the link, so the impact on the power system can be significant. The resilience of the power system would therefore be improved by aligning the voltage disturbance ride through requirements for HVDC links with those in NER S5.2.5.4.

Proposed amendments

Table 36 Amendments for voltage disturbances

Amendment summary	Reasons
Amend S5.3a.13 to apply the equivalent voltage disturbance power capability requirements in the AAS and MAS for S5.2.5.4 to HVDC links, by reference. Apply equivalent provisions for general requirements as under S5.2.5.4.	Aligns voltage disturbance capability access standards for HVDC links with those for schedule 5.2 plant.

6.2.2 Frequency disturbances

Objectives

- Incorporate impact and capability of HVDC links
- Align with best power system performance
- Support efficient investment and operation
- Improving power system resilience

Issues

Currently the frequency ride through requirement for HVDC links is to maintain CUO for power system frequency within the frequency operating standards[33]. The equivalent frequency ride through requirements for generating systems and IRS in NER S5.2.5.3 are generally consistent with this but are expressed in greater detail, including an AAS and a MAS.

Modern HVDC links have similar frequency disturbance capability to inverter-based generation and IRS. In addition, the importance for power system security of a HVDC link maintaining CUO for a frequency disturbance is similar to that for a generating system or IRS of a similar size.

Therefore, given the capability of the respective technology and the impact on the power system security are similar, the frequency disturbance ride through requirements for HVDC links should ideally be aligned with those in schedule 5.2.

Proposed amendments

Table 37 Amendments for frequency disturbances

Amendment summary	Reasons
Amend S5.3a.13 to apply the equivalent frequency disturbance power capability requirements in the AAS and MAS for S5.2.5.3 (including RoCoF) to HVDC links, by reference. Include a general requirement allowing flexibility for operational arrangements designed to minimise the power system impacts of tripping of the HVDC link where this is necessary.	Aligns frequency disturbance capability access standards for HVDC links with those for schedule 5.2 plant.

6.2.3 Fault ride through requirements

Objectives

- Incorporate impact and capability of HVDC links
- Align with best power system performance
- Support efficient investment and operation
- Improving power system resilience

[33] NER S5.3a.13(a)(1).

Issues

NER S5.3a.13 defines the required performance for HVDC links regarding disturbances in the power system, which does not include a requirement for fault ride through capability.

NER S5.3a.14 explicitly allows disconnection of a market network service facility to protect it from disturbances, but only in conditions for which the facility is not required to withstand under another provision of the NER. There are no clearly defined ride through requirements.

Similarly, there is no requirement for HVDC links to respond (by supplying or absorbing reactive current) and recover following a disturbance.

Modern HVDC links have similar fault ride through and response capability as inverter-based generation and IRS, with the benefits for power system security of maintaining CUO for faults being similar to that for a generating system or IRS of a similar size.

Therefore, given the capability of the respective technology and the impact on the power system security are similar and these capabilities can be provided at low incremental cost, the fault ride through, response and recovery requirements for HVDC links (including for multiple faults) should be aligned with those in schedule 5.2.

Proposed amendments

Table 38 Amendments for fault ride through

Amendment summary	Reasons
Replace S5.3a.14 with an AAS and MAS aligning disturbance ride through, response and recovery requirements with the equivalent AAS and MAS for S5.2.5.5 and S5.2.5.5A, by reference. Apply equivalent provisions for NAS and general requirements as under S5.2.5.5 and S5.2.5.5A.	Aligns fault ride through (including MFRT) capability, disturbance response and power transfer recovery for HVDC links with the equivalent requirements for schedule 5.2 plant.

6.3 NER S5.3a.4 – Monitoring and control requirements

6.3.1 Remote monitoring and protection against instability

Objectives

- Incorporate impact and capability of HVDC links
- Align with best power system performance
- Improving power system resilience

Issues

HVDC links can participate in power system instabilities in a similar manner to inverter-based generation systems and IRS. However, there are currently no access standard in schedule 5.3a addressing remote monitoring and protection against instability for HVDC links. To improve the ability to monitor, control and analyse instabilities in the power system, the remote monitoring and protection requirements for HVDC links should therefore be generally aligned with those in NER S5.2.5.10. This will provide a coordinated approach to IBR instability that can be applied to all plant likely to participate in a controller instability.

Responses may include disconnection but, given disconnection of an HVDC link that forms an interconnector is likely to have significant impacts on the operation and security of the power system, this capability should not be an AAS requirement unless agreed with the NSP and AEMO.

Proposed amendments

Table 39 Amendments for remote monitoring and stability protection

Amendment summary	Reasons
Amend S5.3a.4.1 to add AAS and MAS requirements equivalent to the data communication aspects of S5.2.5.10, including access to a PMU and the receipt of information or trip signals, as required. For HVDC links, no minimum size threshold is proposed for these requirements. Add a new S5.3a.4.2 to align with the remaining requirements for detection and protection against inverter instability requirements in NER S5.2.5.10, except for the AAS, automatic disconnection capability is not a fixed requirement.	Aligns the remote monitoring and protection against inverter instability requirements for HVDC links with the equivalent requirements for schedule 5.2 plant, with minor modifications to recognise the potential impact of HVDC interconenctors.

6.4 New standards

6.4.1 Voltage control

Objectives

- Incorporate impact and capability of HVDC links
- Align with best power system performance
- Support efficient investment and operation

Issues

Modern HVDC links have the capability to provide AC voltage control independently at each AC terminal. However, currently schedule 5.3a does not specify the AC voltage control requirements for HVDC links.

A change in the active power transfer over a HVDC link can have a material impact on the AC voltage at both its AC terminals. Control of the AC system voltages would be improved significantly if HVDC links were required to control the voltage or reactive power at its AC terminals in a similar manner to generating systems and IRS, as specified in NER S5.2.5.13.

Proposed amendments

Table 40 Amendments for voltage control

Amendment summary	Reasons
Add a new clause S5.3a.15 to apply AC voltage control and reactive power control capabilities to HVDC links equivalent to those in NER S5.2.5.13, by reference.	Aligns voltage and reactive power control requirements for HVDC links with the equivalent requirements for schedule 5.2 plant,

6.4.2 Active power dispatch

Objectives

Incorporate impact and capability of HVDC links

Align with best power system performance

Support efficient investment and operation

Issues

The flow of active power on HVDC links needs to be controlled in a similar manner to the dispatch and ramping of scheduled production units, and currently this requirement is not included in schedule 5.3a. To facilitate achievement of the NEM's active power requirements are met, improving system resilience, it is important to capture this capability in the access standards for HVDC links.

This supports efficient operation by placing the responsibility for active power control with the operators of connected facilities. As such, connection applicants are incentivised to make efficient investment decisions regarding active power control.

Proposed amendments

Table 41 Amendments for active power dispatch

Amendment summary	Reasons
Add a new clause S5.3a.16 to apply active power control requirements for HVDC links equivalent to those in NER S5.2.5.14, including for dispatch and ramping.	Aligns active power control requirements for HVDC links with the equivalent requirements for schedule 5.2 plant,

6.5 System strength [Standard – non fast track – amendment]

Objectives

Streamline the connection process

Support efficient investment and operation

Issues

At present, HVDC links that are not able to operate stably and remain connected at a short circuit ratio of 3.0 or lower do not have the same express ability as generating systems and IRS to meet this requirement by procuring services from a system strength service provider or third party. Including a corresponding right for HVDC link owners and operators may allow for more efficient solutions and reduce both the costs and time to connect.

Proposed amendments

Table 42 Amendments for reactive power capability

Amendment summary	Reasons
Allow HVDC links to procure system strength from a third party when they are unable to meet their system strength requirements.	Allowing HVDC links to procure system strength may support efficient operation and investment, and streamline the connection process.

7 Access standards for loads [Standard – non fast track – amendment]

This section outlines AEMO's proposed NER amendments (primarily in schedule 5.3) to improve the access standards for loads, based on Review recommendations with the objectives.

As explained in section 4 of AEMO's final report on the Review, these rule change proposals only put forward a limited number of initial NER amendments. AEMO expects that more detailed technical amendments will be proposed following a separate review of the potential impacts and capabilities of the large load technologies, with the possibility of a voluntary technical specification as an interim step.

These initial proposed amendments represent a reasonable set of requirements with sufficient flexibility to monitor and manage any material adverse impacts of the very large load projects that are already at various stages of planning or development. These include hydrogen electrolysers using a range of technologies that could scale up to several hundred megawatts each in the next few years, and multiple new very large data centres between 100 MW and 600 MW.

7.1 Recording ride through capability of new loads

Objectives

Incorporate impact and capability of large loads

Improving power system resilience

Issues

There is no current requirement for large loads to provide any level of ride through performance. The ride through capability of some loads is not currently well understood and is likely to change as technologies mature. However, AEMO and the NSP's ability to efficiently manage system security and meet the system standards require depends on understanding the ride through capability of large loads. Should such large loads trip because of a disturbance or fault in the power system, there is a risk of cascading outages of other loads and generation network failure and consequential asset damage and black outs unless generation is significantly and quickly reduced.

There are a limited number of existing very large loads connected in the NEM, typically aluminium smelters, ore refineries, mines and large datacentres. To date, the impacts of these individual large loads on the operation of the power system could be considered in isolation from other loads because they have generally been electrically and geographically distant from each other.

However, connection enquiries and public announcements suggest additional very large, often co-located, loads will be developed in the near future. Some new loads may have dynamic behaviours that pose challenges for operation of the power system. The location of very large loads in electrical proximity to each other or to inverter-based generation increases the risk of interactions between them or power system responses that in combination are more detrimental to the power system than the responses considered separately. It is necessary to consider the cumulative impact of multiple loads tripping in response to a common event such as a voltage or frequency disturbance, or a fault or sequence of faults in the power system. If the loads are unable to ride through the disturbance or faults, then multiple cascading load trips might occur, resulting in a much larger contingency event compared to the tripping of a single individual large load.

Where loads connect in clusters, such as in hydrogen hubs with multiple connections within a facility and multiple connecting parties, large amounts of load are more likely to be affected by the same power system disturbance, impacting both system frequency and the local network. The NER currently do not require loads to ride through contingency events. Therefore, where there is a risk of multiple loads tripping for a contingency event, the potential risks to the power system are managed by the relevant NSP and AEMO through power system design and operation, and the risk to power system frequency is managed by AEMO. When planning the network, the NSP must seek to ensure the system standards are met. NER schedule 5.1 requires NSPs to apply planning criteria required to achieve adequate levels of network power transfer capability for the common good of network users, including various stability criteria that can be impacted by load response to power system disturbances. This amendment to the access standards for the connection of large loads will support the stable operation of the network. It would reduce the cost of managing the power system risk from such contingencies, which otherwise would be by more expensive means such as network augmentation (additional capital expenditure) and procurement of additional frequency control ancillary services (additional operational expenditure).

Proposed amendments

Table 43 Amendments for reactive power capability

Amendment summary	Reasons
Include in the information provisions of S5.3.1 the ability for the NSP, in consultation with AEMO, to request information about the ride through capability of a load intending to connect to its network. Based on information provided under this provision, add a new clause S5.3.4A providing discretion for the NSP to require the ride through capability to be recorded in the performance standards, with a copy to be provided to AEMO.	Allows NSPs and AEMO to be informed of ride-through capability of large loads in the connection process where appropriate, and incorporate any impact in operational management strategies. The absence of a size threshold allows visibility and experience to be gained by understanding the technical capabilities of prototype plants which are proof-of-concept for large load installations.

7.2 NER S5.3.3 – Protection systems and settings

Objectives

Align with best power system performance

Support efficient investment and operation

Improving power system resilience

Issues

Some protection systems and settings may materially limit the ride through capability of a load below its inherent capability, thus reducing the resilience of the power system. Setting protections to maximise ride through performance within appropriate safety margins consistent with good engineering practice provides benefit to both the Schedule 5.3 Participant (less downtime) and the power system (less impact from power system disturbances).

This requirement is uncontroversial and does not require any additional capability from connection applicants, but could improve the resilience of the power system by:

- Reducing any unnecessarily for conservative protection settings that otherwise limit any inherent ride through capability of connecting loads.
- Facilitating greater understanding of the ride through capability of new loads by AEMO and NSPs.

Proposed amendments

Table 44 Amendments for load protection systems and settings

Amendment summary	Reasons
Amend the general requirements in S5.3.3(c) to require cooperation between the NSP and the Schedule 5.3 Participant on the design and implementation of protection system and settings so as to maintain operation in accordance with the performance standards, and also to maximise capability to remain in operation for disturbances where the plant is not otherwise required to disconnect, subject the technical capabilities of the plant, safe operation, and safety margins consistent with good electricity industry practice.	Aligns this requirement for load with equivalent provisions in proposed S5.2.5.8(b5), to discourage unnecessarily conservative protection settings. Maintains clear ability to disconnect in accordance with other performance standards or in other circumstances required by the NSP or AEMO (including in the provision of ancillary services).

7.3 NER S5.3.10 – Load shedding facilities

7.3.1 Emergency under-frequency ramp down of large loads

Objectives

Incorporate impact and capability of large loads

Improving power system resilience

Issues

Currently large loads must make 60% of their loads available to emergency under-frequency load shedding schemes. Although the definition of load shedding refers to the reduction or disconnection of load, the NER currently only contemplate the provision of load shedding by disconnection in blocks. Some loads may be more flexible with the ability to ramp down their load in an emergency rather than disconnection. This can provide greater flexibility to meet power system needs more efficiently, potentially avoiding more widespread load shedding and providing potential benefits to those users by limiting the amount of their load reduction where feasible.

AEMO notes that disconnection capability would still be required for interruptible load that has fast ramp-down capability, as it is possible that RoCoF conditions may be such that ramp down is not sufficient for managing underfrequency events.

Proposed amendments

Table 45 Amendments for emergency under-frequency ramp down of loads

Amendment summary	Reasons
Amend S.5.3.10 to allow for provision of interruptible load by way of fast ramp down, in addition to the capability to disconnect load blocks during an under frequency event, with the performance standards to record the nature of the capability and quantities and rates of fast ramp down capability where applicable.	Allows for a ramped down response where the capability exists, and for the performance standards to record the associated parameters.
Amend 4.3.5 and the definitions of *interruptible load* and *load shedding* to be consistent with the potential for fast ramp down capability as well as disconnection, and to make those provisions consistent with each other.	

7.4 New access standard for instability monitoring and prevention

Objectives

Incorporate impact and capability of large loads

Improving power system resilience

Issues

Loads, particularly large inverter-based loads, may contribute to instability in the NEM in a similar way to schedule 5.2 plant. However, access standards for instability monitoring and prevention do not currently apply to load connections. Providing the ability to apply corresponding stability monitoring and instability response requirements to large inverter based loads will assist in meeting NEM system standards supporting its efficient operation and reliability and security.

Based on feedback during the Review, AEMO proposes to limit the application of these requirements to loads where the NSP or AEMO considers the inverter-based load component could reasonably contribute to instability at its connection point. A further threshold is proposed for the MAS, with the effect that there is no minimum requirement if the inverter-based load component cannot change the voltage at its connection point by more than 1%. These limits allow flexibility and discretion to apply the requirements only to plant where there is a system stability risk, pending the outcomes of further technical review.

Proposed amendments

Table 46 Amendments for instability monitoring and protection for loads

Amendment summary	Reasons
Add a new clause S5.3.12 to specify an AAS and MAS for detection and response to instability for schedule 5.3 plant equivalent to the requirements in S5.2.5.12, including equivalent PMU and data communication requirements based on size. Limit the application of S5.3.12 to plant including inverter based load that is a large inverter based resource, where AEMO or the NSP consider that it could contribute to instability in voltage, active power or reactive power at its connection point. Apply S5.3.12 to the whole of an integrated facility that may be constituted by more than one schedule 5.3 plant (i.e. with multiple connection points). Limit the MAS to relevant schedule 5.3 plant where the inverter based load can change voltage at the connection point by at least 1%.	Aligns the requirements for instability monitoring and protection for inverter-based loads with those applicable to schedule 5.2 plant, but providing discretion and flexibility to apply only where appropriate based on the impact of the inverter-based load and including all integrated operations.

7.5 Minimum short circuit ratio

Objectives

Incorporate impact and capability of large loads

Improving power system resilience

Issues

While inverter-based loads present a risk to system stability when there is insufficient system strength, inverter-based loads are less understood and some of these loads may require more system strength than other inverter-based resources. Some types of hydrogen production technology employ thyristor-based converters whereas others use insulated gate bipolar transistor based technology. Thyristor-based technology typically requires a higher short circuit ration (SCR) to enable commutation of the thyristors. They may not be able to operate with an SCR of 3.0, as currently required by NER S5.3.11.

Further, NER S5.3.11 applies to plant that includes IBR, without any size threshold. It therefore has the potential to capture load with small IBR components for which the cost of the SCR requirement could far outweigh any system benefits.

AEMO therefore proposed that the application of NER S5.3.11 is limited to inverter-based load that is a large inverter based resource, as defined in the system strength impact assessment guidelines, and flexibility is added to allow the NSP and AEMO discretion to agree a higher minimum SCR. This will allow appropriate consideration of the connection in the context of local system requirements, and can be reconsidered in future when the system strength requirements are better understood.

Proposed amendments

Table 47 Amendments for load SCR requirements

Amendment summary	Reasons
Amend S5.3.11 to limit the application of that clause to inverter based loads that are large inverter based resources, as defined in the system strength impact assessment guidelines (noting these may be periodically amended). Include provision for the NSP and AEMO to agree a higher minimum SCR value than 3.0, having regard to expected three phase fault levels at the connection point.	Applies size requirements determined by reference to what is determined as 'large' IBR by the guidelines from time to time, and provides flexibility on SCR value to address known issues for some load technologies pending further technical review.

8 Other NER amendments

AEMO has identified several other NER provisions that could be updated to support the substantive changes proposed in this document, better reflect the intent of the rules, reduce the potential for ambiguity or improve outcomes consistent with the NEO. This section summarises these proposed amendments.

8.1 Extension of time for complex issues in future access standard reviews [Standard – non fast track – amendment]

Objective

Align with best power system performance	Improving power system resilience
Streamline the connection process	Support efficient investment and operation

Issues

NER 5.2.6A requires that AEMO must complete each technical requirements review within 12 months of publishing the approach paper.

The Review has evaluated a high volume of matters, many of which have been highly technical in nature and have required extensive consultation. On some significant matters AEMO has not been able to develop a final position, within 12 months, with sufficient confidence to determine how the NER require amendment. To consider these issues and develop rule change proposals, AEMO intends to undertake further public consultation as part of a separate technical review.

Future NER 5.2.6A reviews may also require more time than currently allowed given the complexity of the issues considered in the Review, the pace of the transition to net zero, the evolution of technologies and services, and engagement with an increasingly diverse range of stakeholders.

AEMO recognises the value of undertaking the Review in a timely manner, but an inflexible 12-month timeframe for future reviews may not allow for the necessary analysis and consultation to develop of fit-for-purpose rules giving effect to the Review criteria.

Proposed amendments

Table 48 Amendments for access standard review timing

Amendment summary	Reasons
In 5.2.6A, include a provision allowing AEMO to extend the timeframe for review of certain matters under NER 5.2.6A by publishing a notice with reasons, where the 12-month timeframe is insufficient given the complexity or difficulty of the matters under consideration or a material change in circumstances.	Aligns with similar provisions in NER 8.9 for extension of consultation timeframes, and is consistent with other NER/NEL provisions allowing the AER or AEMC to extend review timeframes.

8.2 Updating references to superseded standards

Objective

Streamline the connection process | Align with best power system performance

Issues

Many references in the NER to industry standards are out of date. Referring to superseded standards may cause confusion in the connection process and does not promote best practice.

Proposed amendments

Table 49 Amendments to update references to superseded standards

Amendment	Reasons
Amend the references to AS/NZS 61000.3.6 and AS/NZS 61000.3.7 (with or without dates) in S5.1.5, S5.1.6 S5.1a.5 and S5.1a.6 to the latest versions TR IEC 61000.3.6 and TR IEC 61000.3.7, without dates.	Removes references to superseded standards.

8.3 Removing the definition of 'voltage' and 'normal voltage'

Objective

Streamline the connection process | Support efficient investment and operation

Issues

The existing definition of 'voltage' in Chapter 10 does not align with its engineering interpretation and its use in different contexts throughout Chapter 5 and elsewhere in the NER. The term 'voltage' is best understood from an engineering perspective in the context where it is used.

The definition of 'normal voltage' has also not proven useful because electrical equipment is designed for standard voltages and associated over-voltage and insulation withstand levels. Designation of a connection point or network bus to have a 'normal voltage' higher than nominal voltage would require either bespoke equipment or equipment rated for the next higher standard voltage, which would impose substantially higher capital costs on the connection or the part of the network to which it was applied.

On this basis, the continued use of these defined terms adds no value and conversely has the potential to cause confusion and delay in negotiating access standards.

Proposed amendments

Table 50 Amendment for voltage-related terms

Amendment summary	Reasons
Delete the definition of voltage in Chapter 10	Removes the potential for confusion, thus streamlining the connection process. An alternative definition is not proposed as voltage is best interpreted in the context where it is used.
Delete definition of 'normal voltage' in Chapter 10 and (where required) replace NER references to 'normal voltage' with 'nominal voltage'.	Removes confusion by consistently using the more clearly defined 'nominal voltage'.
Delete 5.3.11 (NSPs to advise AEMO of changes to normal voltages)	Requirement is redundant with the removal of the concept of normal voltage.
Un-italicise the term 'voltage' throughout the NER, when not used in conjunction with a composite defined term.	Consequential on removal of the definition

8.4 Rated active power and maximum demand

Objectives

Streamline the connection process	Support efficient investment and operation

Issues

The defined terms 'rated active power' and 'rated maximum demand' are problematic as they refer to production units operating at nameplate rating. The nameplate rating for inverter-based units is the same as their MVA rating. Inverter-based units in the NEM are not operated at nameplate rating, but the context in which these terms are used in the access standards indicates they were intended to describe the maximum operating level or maximum consumption level respectively.

Similar issues can arise for

- synchronous machines where a generator is rated higher than maximum permitted output at the connection point would allow;
- connections that have maximum output limited by some equipment other than the production units – for example, by a transformer rating.

Rated active power is used in S5.2.5.1, S5.2.5.13 and S5.2.5.15. Literal reading of the rated active power definition in the context of S5.2.5.1 implies a higher AAS requirement for reactive power for plant of certain configurations or technology type than generating systems or IRS of the same maximum sent out active power. This is not consistent with the intent of the clause, and could result in additional capital expenditure to meet the higher requirement.

For S5.2.5.13, the term rated active power is used to describe the active power output at which the stator must be able to operate at 105%. However, the generating unit may not be capable of operating at its rated active power if the associated turbine is not rated to the same level. (Note that there could be a workaround in this case, referring to the nameplate rating of the turbine, but negotiating this outcome would cost additional time.)

For S5.2.5.15, the use of 'rated active power' to calculate the SCR is problematic for inverter based equipment because it changes the divisor of the SCR calculation for the purpose of this clause, effectively increasing the performance requirement beyond that intended by a minimum SCR of 3. This might lead to a requirement for additional mitigation measures at higher capital cost and design effort.

Rated maximum demand is used in S5.2.5.1 (from the Integrating Energy Storage Systems rule), and like rated active power references the nameplate rating and is used to calculate the reactive power requirement. Its application can also lead to an overstatement of the AAS reactive power requirement compared with the intent of the clause.

Proposed amendments

Table 51 Amendments for rated active power and rated maximum demand

Amendment summary	Reasons
Adapt definition of 'active power capability' for use instead of rated active power for all Schedule 5.2 access standards, and used also in relation to the use of short circuit ratio in NER 5.3.4C and 6A.23.5(j). In addition: • Clarify that capability should reflect the recorded active power capability in the performance standards, that is, at the connection point. (Note that bid validation data are terminal quantities, so to convert to connection point quantities an allowance must be made for auxiliary load and losses). • For simplicity and consistent with a common understanding of maximum output 'Pmax', confirm that the active power capability refers to the maximum sent out capacity for a generating system or integrated resource system with all units operating. Where an access standard needs to refer to the maximum capacity of operating production units, the standard itself needs to recognise the necessary adjustment.	These amendments better align the access standards with their intent.
Delete 'rated active power' definition. Replace in relevant rules with existing defined term *active power capability*.	
Delete 'rated maximum demand' definition. Replace in relevant rules with existing defined term *maximum demand*.	
Change definition of 'short circuit ratio' to address an issue with the definition of the term 'rated active power'.	

8.5 Other clarifications and streamlining of rules

Objectives

- Streamline the connection process
- Support efficient investment and operation

Issues

AEMO has identified, through its detailed review, a few aspects of the NER that may be ambiguous, confusing or not aligned with the intent of either the current rules or proposed amendments. Drafting amendments to these provisions and definitions are proposed to support the substantive changes, improve clarity, promote consistent understanding and facilitate a smoother and faster negotiation process - thereby contributing to the achievement of the NEO.

The list of amendments noted in this section is not comprehensive. Other drafting changes proposed by AEMO are marked in the proposed draft rule, with explanatory drafting notes where the reason for the proposed changes might not be self-explanatory. These include minor drafting amendments to remove redundant provisions, reduce duplication and correct minor errors, omissions or inconsistencies.

Proposed amendments

Table 52 Amendments for other clarifications and streamlining

Amendment summary	Reasons
Add provision in NER 5.3.4A(b) to incorporate common assessment criteria for negotiated access standards, to consider the expected performance of the existing power system, considered projects and known projects for connection that the NSP reasonably considers will proceed, in the range of expected power system conditions.	Allows the removal of several corresponding, but inconsistently worded, requirements from several individual access standards.
Separate S5.2.5.5 into two clauses. In S5.2.5.5 retain the AAS and MAS requirements for single and multiple fault ride through capability, with associated NAS and general requirements. Create a new S5.2.5.5.A, which covers the AAS and MAS for reactive current, reactive power and active power responses to disturbances (including different requirements for synchronous and asynchronous plant), with associated NAS and general requirements.	Makes the requirements currently contained in S5.2.5.5 easier to follow, by separating ride through/MFRT requirements (applicable to all technologies) from disturbance response and recovery requirements (different for synchronous and asynchronous).
Change the definition of 'AEMO advisory matter' to add all existing and new access standards in which AEMO has an advisory role, including S5.3.5 which was previously missing.	Supports the proposed amendments to add or remove access standards, and corrects existing omission
Change the definition of 'disconnect' to refer to preventing the flow of electricity to or from connected equipment, replacing 'at the connection point'	Use of the term throughout the schedules and the broader NER is frequently not intended to refer to all flow at the connection point.
Add a definition of 'minimum operating level' to the glossary, referring only to generation and not bidirectional units. Remove from S5.2.5.11. Delete the definition of 'maximum operating level' in S5.2.5.11 and instead use a less prescriptive description in S5.2.5.11(i)(3) with reference to nameplate rating and limits consistent with other relevant performance standards.	Minimum operating level used in S5.2.5.7 and S5.2.5.8 as well as S5.2.5.11. Bidirectional units must move linearly between production and consumption, so will not have a minimum. Current maximum operating level definition is problematic because it does not recognise applicable limits and uses inconsistent values.
Change the definition of 'negotiated access standard' to remove reference to a connection agreement	It is performance standards (as agreed), not access standards (as set out in the NER), that are included in a connection agreement.
Change the definition of 'power transfer' so it is not limited to transfer between connection points, and instead reflects actual usage of power transfer/power transfer capability in the NER (across a connection element, across a connection point or between network locations).	Corrects existing definition to be consistent with usage.
Change the definition of 'reactive power capability' to an amount of reactive power that a plant is capable of supplying to or absorbing from the network at its connection point (allowing for that capability to be defined in the performance standards (under S5.2.5.1) or potentially defined in a connection agreement for non-schedule 5 plant).	Clarifies, consistent with S5.2.5.1, that this capability is not a single maximum number or rate, not unidirectional, not limited to production units, and not necessarily specified in a connection agreement.

Glossary

This document uses many terms that have meanings defined in the NER. The NER meanings are adopted unless otherwise specified.

Term	Definition
AAS	Automatic access standard
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
CUO	Continuous uninterrupted operation
ENTSO-E	European Association for the Cooperation of Transmission System Operators (TSOs) for electricity
GFL	Grid following
GFM	Grid forming
HV	High voltage
HVDC	High voltage direct current
IBR	Inverter-based resource/s
IEC	International Electrotechnical Commission
IRP	Integrated Resource Provider
IRS	Integrated resource system/s
ISP	Integrated System Plan
MAS	Minimum access standard
MFRT	Multiple fault ride through
MVA	Megavolt-ampere
MVAr	Megavolt-ampere reactive
MV	Medium voltage
MW	Megawatt
MNSP	Market Network Service Provider
NAS	Negotiated access standard
NECA	National Electricity Code Administrator
NEL	National Electricity Law
NEM	National Electricity Market
NEO	National electricity objective
NER	National Electricity Rules
NSP	Network Service Provider
OEM	Original equipment manufacturer
PFR	Primary frequency response
Pmax	maximum active power
PMU	phasor measurement units
PPC	power plant controller
The Review	AEMO review of technical requirements for connection (pursuant to NER 5.2.6A)

Term	Definition
RUG	releasable user guide
RMS	Root mean square
RoCoF	Rate of change of frequency
SSSP	System strength service provider

Attachments

This document has three attachments, submitted as separate files:

- Attachment A is AEMO's request to make a rule using the fast track process in section 96A of the NEL (without initial consultation on the proposal prior to the AEMC's draft determination).
- Attachment B is AEMO's request to make a rule under its standard NEL consultation process.
- Attachment C is a mark-up of NER extracts with all AEMO's proposed amendments. The amendments are presented together for convenience, as many amendments proposed in the standard request relate to (or build on) changes in the fast track request. The proposed amendments are colour coded to distinguish between the fast track and standard requests, and include drafting notes to explain some consequential amendments and corrections that may not be directly explained in this Overview.