AUSTRALIAN ENERGY MARKET COMMISSION

RULE

Rule determination

National Electricity Amendment (Improving the NEM access standards - Package 1) Rule 2025

Proponent
AEMO

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About the AEMC

The AEMC reports to the energy ministers. We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the energy ministers.

Acknowledgement of Country

The AEMC acknowledges and shows respect for the traditional custodians of the many different lands across Australia on which we all live and work. We pay respect to all Elders past and present and the continuing connection of Aboriginal and Torres Strait Islander peoples to Country. The AEMC office is located on the land traditionally owned by the Gadigal people of the Eora nation.

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Summary

1 The Commission has made a more preferable final rule (hereafter 'final rule') to improve the technical requirements for National Electricity Market (NEM) connection (known as access standards) contained in Chapter 5 of the National Electricity Rules (NER) and its accompanying schedules. It also makes a series of corresponding changes to Chapter 10 of the NER (the Glossary) and several consequential changes throughout the NER. This is in response to a fast-track rule change request submitted by the Australian Energy Market Operator (AEMO) on 4 April 2024, which AEMO developed through extensive consultation in its access standards review during 2022-23.

2 The NEM access standards define the permissible range of technical performance that connection applicants must meet before connecting to the NEM. However, some existing access standards are no longer fit for purpose in a NEM with an increasingly large number of inverter-based resources. For example, some existing standards:

- unintentionally disincentivise beneficial grid-forming responses
- do not account for increasing connections at a sub-transmission or distribution level
- do not fully utilise available plant performance
- refer to defunct or out of date standards.

3 The final rule will make the NEM access standards fit for purpose in a world where inverter-based resources are more prevalent. It will also add more prescription and clarity to the access standards, which will help to reduce costs and time for connecting parties, NSPs and AEMO in negotiations undertaken when connecting plant.

4 With the energy transition underway, the NEM is growing and changing to continue to deliver secure, reliable and affordable electricity to millions of Australians whilst achieving the government's emissions reduction targets. AEMO's 2024 Integrated System Plan (ISP) sets out that on the optimal development path, AEMO considers that grid-scale variable renewable energy would triple by 2030 and increase by six-fold by 2050. Utility scale batteries would increase by five-fold by 2030 and six-fold by 2040.[1]

5 To support this growth and deliver the energy transition in accordance with the National Electricity Objective (NEO)[2], new NEM connections need to be approved at a much faster rate than at present to keep up with the pace of the transition. At the same time, it is also important that there is a continued focus on keeping the whole system stable and reliable throughout the transition.

6 The final rule will improve the access standards to:

- align them with best power system performance needs
- better utilise already available plant capability
- minimise ambiguity and clarify application to different technologies
- support efficient investment in and operation of the NEM
- remove impediments for connection of grid-forming inverters
- broaden their application to synchronous condenser connections
- broaden their application to all high voltage direct current (HVDC) links
- account for potential impacts and beneficial capabilities of HVDC links.

1 AEMO, 2024 Integrated System Plan, p 11.
2 Section 7 of the NEL.

The final rule has been shaped by AEMO's review of technical requirements for connection

7 Under clause 5.2.6A of the NER, AEMO is required to conduct a review of the NEM access standards at least once every five years. AEMO conducted its first such review in 2022-23, undertaking extensive public consultation (three rounds), and identified numerous opportunities to improve the existing access standards and their application.

8 AEMO then submitted a fast-track rule change request to the Commission to give effect to the final recommendations from its review. In light of AEMO's extensive consultation, the Commission decided to fast-track this rule change request and bypass the consultation paper stage. On 5 December 2024, the Commission published a draft determination and draft rule in response, broadly reflecting AEMO's proposals.

The final rule largely maintains the draft rule, although it also makes several additional clarifications and revisions in response to stakeholder feedback

9 The Commission received 23 submissions on its draft determination and draft rule. While these submissions were all broadly supportive of the draft rule, some submissions sought additional clarifications, suggested alternative approaches or raised concerns with some aspects of the draft rule. These are discussed throughout Chapters 3–7 and in appendix D of this final determination, as relevant.

10 After considering all feedback and undertaking further technical analysis, including a stakeholder workshop, the Commission's final rule largely maintains the draft rule. However, it also makes several additional clarifications and revisions to address stakeholder concerns, as relevant, and minimise the risk of any unintended consequences. These changes ensure that the final rule best achieves the intended policy outcomes. These include:

- Clarifying reactive power capability requirements and providing NSPs with additional flexibility to determine mid-point voltage on a forward-looking basis
- Requiring plant control system tuning range to be set based on system impedances rather than fault levels to improve consistency
- Improving the flexibility of the transitional provisions to allow ongoing connection applications to choose to apply either all, or some, of the new access standards.

11 The Commission also decided not to proceed with some of its draft rule proposals, which primarily include the temperature derating requirements in clause S5.2.5.1 and automatic execution of actions upon instability detection in clause S5.2.5.10.

The final rule is in the long-term interests of energy consumers

12 The Commission assessed the final rule against the criteria outlined below and considers it will contribute to advancing the NEO by:

- **Supporting safety, security and reliability** — The improved access standards will increase power system resilience by better utilising already available plant capability to withstand disturbances, including for HVDC links, and broadening application to synchronous condensers needed for system security.
- **Contributing to emissions reduction** — The improved access standards will accelerate the connections process and support new investment required to meet Australia's emissions

reduction targets by making the access standards more prescriptive to minimise ambiguity and clarify their application to different technologies.

- **Promoting innovation and flexibility** — The improved access standards will promote innovation and flexibility in the power system by removing impediments for connecting grid-forming inverters and increase investment efficiency by broadening the options available for connection applicants under different circumstances.
- **Reducing connection process costs and complexity** — The improved access standards will contribute to lowering overall connection costs for most applicants. They will also reduce the burden on network service providers (NSPs) and AEMO and simplify their function by streamlining the connections process, providing clarity and reducing the need for negotiations.

13 The Commission has made a more preferable final rule because we have made various consequential amendments that seek to add clarity and ensure the final rule reflects the intended policy outcomes and best advances the NEO while addressing stakeholder concerns.

The final rule will amend the NEM access standards to apply them by plant type

14 The final rule will amend the NEM access standards to apply them by plant type. This is in contrast to the current situation, where they apply by registration category, which relates to the owner or operator of the plant. The Commission considers that applying these standards by plant type will ensure a consistent approach to managing system security for similar types of connecting plant, irrespective of the persons connecting, especially considering the increasing variety of persons and plant connecting to the power system.

- Schedule 5.2 will apply to all generating systems, integrated resource systems and synchronous condenser systems (collectively known as schedule 5.2 plant).
- Schedule 5.3 will apply to all plant that consume electricity from a network, including a distribution network or a source of load within an integrated resource system (collectively known as schedule 5.3 plant).
- Schedule 5.3a will apply to any HVDC system with a power transfer capability of 5 MW or more (known as schedule 5.3a plant).
- The persons to which the obligations apply will be captured by new definitions of Schedule 5.2 Participant, Schedule 5.3 Participant and Schedule 5.3a Participant.

The final rule will amend the access standards for generators, integrated resource systems and synchronous condensers

15 The final rule will introduce a suite of reforms to the access standards for generators, integrated resource systems and synchronous condensers to align with best power system performance, streamline the connection process, improve power system resilience and support efficient investment.

- In clause S5.2.5.1 (Reactive power capability):
  - Reduce the voltage range for full reactive power requirements.
  - Require reactive capability considering temperature derating to be recorded.
  - Clarify requirements for the compensation of reactive power when production units are out of service.
- Simplify standards for small connections (less than 30 MW in the mainland and less than 7 MW in Tasmania) that are unlikely to have material adverse impacts on the power system.

- In clause S5.2.5.2 (Quality of electricity generated), delete a reference to a superseded Australian Standard.
- In clause S5.2.5.4 (Response to voltage disturbances):
  - Allow the point of application for over-voltage requirements to be negotiated for medium and low voltage connections.
  - Clarify requirements for over-voltages above 130% and introduce obligations to minimise recurring switching surges.
  - Clarify the meaning of 'continuous uninterrupted operation' for moderate voltage disturbance requirements.
- In clause S5.2.5.5 (renamed to Disturbance ride-through capability):
  - Define the end of a disturbance for multiple fault ride through.
  - Allow disclosure of plant limitations to comply with multiple fault ride through requirements.
  - Relax fault ride through requirements for system impedances above plant tuning level.
  - Delete reference to a metallic conducting path.
- Move parts of clause S5.2.5.5 into a new clause S5.2.5.5A (Responses to disturbances following contingency events) and:
  - Amend the requirements for active power recovery after a fault.
  - Amend rise time, settling time and commencement time requirements for reactive current injection following a disturbance.
  - Amend arrangements for the commencement of reactive current injection and provides clarity on reactive current injection location.
  - Clarify the response requirements for balanced and unbalanced faults, and recognise negative sequence current responses.
- In clause S5.2.5.7 (Partial load rejection):
  - Limit its application to synchronous generation only.
  - Clarify the meaning of continuous uninterrupted operation for this clause.
- In clause S5.2.5.8 (Protection from power system disturbances):
  - Strengthen and streamline emergency over-frequency response requirements.
  - Require plant protection settings to be set to maximise capability to ride through disturbances.
  - Move the vector shift requirement from clause S5.2.5.16 into this clause.
- In clause S5.2.5.10 (renamed to Detection and response to unstable operation), add new requirements for instability detection and response.
- In clause S5.2.5.13 (Voltage and reactive power control):
  - Remove impediments to unit-level voltage control.
  - Prioritise stability over the speed of a plant's response across a range of system impedances.
  - Add materiality thresholds on settling time error bands.
  - Amend and clarify requirements for multiple modes of operation and treatment of voltage settling time for reactive power and power factor modes.
  - Recognise system strength services provided by system strength service providers.
  - Require NSPs to specify the typical and highest system impedances for plant tuning.

- In Chapter 10 (Glossary):
  - Add several new definitions including minimum operating level, production system, schedule 5 / 5.2 / 5.3 / 5.3a plant and participant, synchronous condenser system, etc.
  - Amend several definitions including active power capability, AEMO advisory matter, continuous uninterrupted operation, performance standard, rise time, settling time, etc.
  - Delete the definitions of normal voltage, RMS phase voltage, voltage, rated active power and rated maximum demand.
- Other related changes:
  - Add a general obligation on NSPs and Schedule 5.2 Participants to ensure that their connected plant does not cause switching surges beyond levels contemplated during insulation coordination.
  - Expand the right of testing under clause 5.7.2 to also allow for assessments, such as computer simulations, instead of only physical tests.

The final rule will amend the access standards for HVDC links

16 The final rule will amend the access standards for HVDC links contained in schedule 5.3a to align them with those applicable to schedule 5.2 plant.

17 The Commission considers that modern HVDC links have similar power system impacts and capabilities as inverter-based generation and integrated resource systems. Hence, similar requirements for reactive power, disturbance ride through, response, recovery, remote monitoring and control will apply to HVDC links as schedule 5.2 plant. Applying consistent requirements to all schedule 5.2 and schedule 5.3a plant at a low incremental cost will improve clarity for the design of HVDC links, promote investment certainty and more efficiently support reliability of supply in a coordinated manner.

The final rule will make other consequential NER amendments

18 In its rule change request, AEMO also proposed several other amendments to the NER. These are either related to AEMO's proposed amendments to the schedule 5 access standards, or seek to clarify the intent of the existing rules where ambiguity may have created confusion or uncertainty.

19 The final rule will make consequential amendments to support the intent of the final rule by clarifying inconsistencies, reflecting amended definitions, removing redundant provisions and reducing duplication. Such changes will promote the long-term interests of consumers by making the final rule clear for stakeholders to understand and follow, minimising confusion. These consequential amendments are made to Chapters 3, 4, 5, 5A, 6A, 7, 8, 9, 10 and 11.

The final rule includes transitional provisions to allow choosing a mix of old and new standards and minimise disruption to ongoing connections

20 The final rule will commence on **21 August 2025**. The transitional provisions in the final rule will apply the new or old access standards, depending upon which stage of the connections process a connection applicant is at, on the commencement date.

21 For all connections that have already received an enquiry response that details the technical requirements and details of the associated automatic, minimum and negotiated access standards, but have not yet received an offer to connect, the existing access standards (or 'old access standards') will continue to apply to that connection.

22 For these cases, the connection applicant may choose to apply some or all of the new access standards (described in this final rule) for their connection, subject to approval by the NSP (and AEMO, for AEMO advisory matters). This will ensure that the chosen mix of access standards and any associated arrangements is practically workable and will not adversely affect power system security.

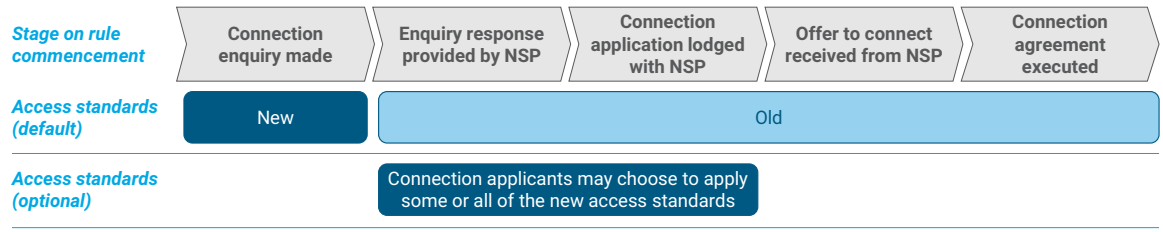
23 If an applicant chooses to apply all of the new access standards, then no NSP or AEMO approval of this choice will be required. The new access standards will apply for the purposes of negotiating access standards (clause 5.3.4A) and determining performance standards.

24 If a connection has not yet received an enquiry response, then the new access standards must apply to that connection. In this case, there will be no option to be able to apply the old access standards.

25 The final rule does not affect any existing connection agreements or modify any performance standards of existing plant. However, NSPs must document the performance standards of their existing synchronous condensers or HVDC links (including any *considered projects*) with respect to the new access standards. The performance standards do not have to meet the new minimum access standards.

26 If, at the commencement date, an application to amend existing performance standards was already submitted, then the old access standards will apply by default (unless otherwise agreed by all parties). All future amendments to performance standards will be subject to the new access standards, excluding any technical requirements that are not present in existing connection agreements.

Figure 1: New access standards will apply by default for connection enquiries that have not received an NSP response by 21 August 2025; otherwise, the old access standards will apply



Note: To the extent of any inconsistency between this figure and the NER, the NER prevails.

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1 The Commission has made a final determination to improve the NEM access standards

This final determination is to make a final rule in response to a fast-track rule change request submitted by AEMO. The final rule will improve the technical requirements for NEM connection (known as access standards) contained in Chapter 5 of the NER and its accompanying schedules. It also makes a series of corresponding changes to Chapter 10 of the NER (the Glossary) and several consequential changes throughout the NER.

1.1 The final rule will make the NEM access standards more fit for purpose and reduce connections costs and time

The access standards contained in schedules 5.2, 5.3 and 5.3a of the NER define the permissible range of technical performance that connection applicants must meet before connecting to the NEM (see Box 1 below for a detailed overview).

Box 1: Overview of access standards for the connection process

To establish a new connection under Chapter 5 of the NER (following the process in rule 5.3 or 5.3A), a connection applicant and the connecting NSP must agree on a set of performance standards for the connecting plant within the parameters set by the access standards in the applicable schedule (schedules 5.2, 5.3 or 5.3a). Each access standard relates to a technical requirement for the performance of the connecting plant, regarding its impact on the broader power system. Most (but not all) access standards have two components:

- **Automatic access standard** — connection cannot be refused if the plant meets this.
- **Minimum access standard** — connection must be refused if the plant does not meet this.

This format with a permissible range of 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 costs. In addition, the need for plant to meet a mandatory level of technical performance was likely to vary between different locations within the NEM. In light of this, NECA introduced flexibility in access standards by specifying a negotiating range, subject to a mandated minimum.

The negotiation framework in the NER requires a connection applicant to propose standards that are as close as practicable to the automatic access standards. A proposed standard below the automatic access standard, down to and including the minimum access standard, is a negotiated access standard. AEMO reviews and provides advice to NSPs on negotiated access standards for several technical requirements, where there is potential to impact power system operation. These are referred to as 'AEMO advisory matters', as defined in Chapter 10 of the NER.

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 rule 4.15.

The Commission's final rule will improve the access standards to:[3]

- **Align them with best power system performance needs** — Redefine some automatic access standards to make them less onerous and improve guidance on negotiated access standards to better align with power system needs. This will ensure that automatic access standards are achieved on a more consistent basis, leading to better power system performance, compared with a negotiated access standard. This will reduce the need for lengthy negotiations, and save time and costs.
- **Better utilise already available plant capability** — Add more flexibility to the access standards to better utilise already available plant performance capability to improve power system resilience to contingency events. This will reduce the risk of interruptions to electricity supply, without material additional cost.
- **Minimise ambiguity and clarify application to different technologies** — Minimise ambiguity in the access standards and clarify their application to different technologies to streamline and accelerate the connection of new generation. This acceleration is necessary to bring on new renewable and battery projects to deliver Australia's emissions reduction targets and deliver associated benefits for electricity consumers.
- **Support efficient investment in and operation of the NEM** — Allow access standards to be better tailored to power system performance needs and broadening the options available for connection applicants under different circumstances. This will increase investment efficiency by only requiring capability that is necessary for the power system and allowing for more cost-effective alternatives, thereby resulting in longer-term cost benefits for consumers.
- **Remove impediments for connection of grid-forming inverters** — Improve access standards to facilitate the connection and operation of grid-forming inverters, in a way that best utilises their capabilities. This will support power system security as traditional forms of synchronous generation retire by allowing for beneficial grid-forming inverter responses, such as response to phase angle jumps and inertial response.
- **Broaden their application to synchronous condenser connections** — Apply appropriate access standards to standalone synchronous condensers (i.e. not part of a generating or integrated resource system) to allow clear and consistent regulation of their performance. This will support efficient provision of system security services.
- **Broaden their application to all HVDC links** — Broaden the application of schedule 5.3a to include all future HVDC links to promote certainty for investment in HVDC links as to what technical standards they will need to meet. This will have flow on effects of helping to effectively and efficiently support the reliability of supply in a coordinated manner.
- **Account for potential impacts and beneficial capabilities of HVDC links** — Account for the significant power system impacts as well as benefits of improved capabilities of modern HVDC links in the access standards. This will provide clarity for the design of HVDC links, in coordination with network planning, to achieve overall efficient investment and power system operation.

1.2 The final rule has been shaped by AEMO's review of technical requirements for connection

Clause 5.2.6A of the NER requires AEMO to conduct a review of some or all of the technical requirements set out in schedules 5.2, 5.3 and 5.3a of the NER at least once in every five year

3 For a detailed overview of how AEMO considers its rule change request would advance the NEO, refer to section 3 of AEMO's rule change request document: Overview of rule change proposals to improve NEM access standards, available from the AEMC website.

period (AEMO may conduct a review more frequently if it considers necessary). Clause 5.2.6A allows AEMO to exercise its discretion to set the scope of its review to address the most pressing needs of the power system.

AEMO conducted its first ever such review in 2022-23, undertaking extensive public consultation (three rounds).[4]

Specifically, AEMO held multiple technical industry workshops and bilateral / multilateral meetings with several stakeholders, including NSPs, generators, developers, original equipment manufacturers (OEMs), Clean Energy Council (CEC), Energy Users Association of Australia, Australian Energy Council (AEC), Energy Networks Australia (ENA), and the Reliability Panel. This consultation was staged over the course of a year and comprised of:

- Issues scoping and approach paper (October 2022)
- Draft report (March 2023)
- Update report and proposal for draft NER amendments (July 2023)
- Final report (December 2023)

AEMO's review identified numerous opportunities to improve the existing access standards and their application. AEMO then submitted two rule change requests (one fast-track and one standard) to the Commission to give effect to AEMO's final recommendations from its review. This final determination pertains to AEMO's fast-track rule change request (Package 1).[5]

In light of AEMO's extensive consultation on the nature and content of the rule change request, the Commission decided to fast-track AEMO's rule change request in accordance with section 96A of the NEL and bypass the consultation paper stage. On 5 December 2024, the Commission published a draft determination and draft rule in response, broadly reflecting AEMO's proposals. The draft rule recognised that some existing access standards are no longer fit for purpose in an increasingly inverter-based resources connected NEM. They may unintentionally disincentivise beneficial grid-forming responses, refer to defunct standards or do not account for increasing connections at a sub-transmission or distribution level. The Commission's draft rule sought to address all these issues.

1.3 The final rule largely maintains the draft rule, although it also makes several additional clarifications and revisions in response to stakeholder feedback

The Commission received 23 submissions on its draft determination and draft rule. These submissions were all broadly supportive of the draft rule. However, some submissions sought additional clarifications or suggested alternative options on the draft rule while raising concerns with some aspects of the draft rule. In assessing the submissions received, the AEMC staff engaged directly with several stakeholders to better understand their views and resolve potential misunderstandings. We conducted a workshop on 27 March 2025 to test our revised thinking and gather additional feedback from all stakeholders who had provided a formal submission to the draft determination.[6]

After thoroughly considering all feedback and undertaking further analysis, the Commission's final rule makes several additional clarifications and revisions to address stakeholder concerns, as

4 See AEMO review of technical requirements for connection (NER clause 5.2.6A) for more information on AEMO's review and the consultation process.
5 The AEMC is progressing AEMO's Package 2 rule change request separately following a standard process.
6 Workshop slides are available online on the AEMC website.

relevant, and minimise the risk of unintended consequences. The Commission has also decided not to proceed with some draft rule amendments, which include not requiring, for example:

- In clause S5.2.5.1(a1), no temperature derating at ambient temperatures below 50°C.
- In clause S5.2.5.1(d1), any temperature derating to represent a proportional derating of active and reactive power at the equipment level, projected to the connection point (unless otherwise agreed with the NSP and AEMO).
- In clauses S5.2.5.10(a) and S5.3a.4.2(a), accounting for any available automated information about a plant's contribution to instability and automatic execution of a hierarchy of actions upon instability detection.

While the Commission's final rule still largely reflects AEMO's recommendations in its rule change request, the Commission considers that this more preferable final rule incorporating stakeholder feedback will better advance the NEO.

1.4 The final rule will support broader improvements that are being made to the connections process to assist with meeting Australia's emissions targets

The final rule would support the AEMC's and AEMO's broader connections reform agenda:

- In 2021, AEMO and the CEC established the Connections Reform Initiative (CRI) to address concerns with delays and increasing complexity in NEM connections. A number of reforms have been identified and been implemented through this initiative to help improve the connections experience.[7]
- The Commission's 2024 *Enhancing investment certainty in the R1 process* rule change made several reforms to a key component of connections, known as the R1 process.[8] The R1 process refers to connection applicants demonstrating to AEMO and the NSP that its plant is capable of meeting or exceeding its performance standards so that it may be registered as a participant in the NEM. The final rule:
  - formalises the commencement and conclusion of the R1 process through timely notifications by NSPs and AEMO[9]
  - clarifies the obligations of all parties during the R1 process and introduced a time frame for AEMO to determine whether it is satisfied of a plant's capability to meet or exceed its performance standards[10]
  - removes barriers to sensible revisions of a generator's performance standards by amending clause 5.3.4A(b)(1A) which sets out the requirements for a negotiated access standard
  - requires AEMO and NSPs to provide written reasons for additional data and information requests during the R1 process[11]
  - allows AEMO to conditionally register connection applicants, subject to terms and conditions as explained in its *registration and information resource guidelines*[12]

7 Connections Reform Initiative.
8 AEMC, Enhancing investment certainty in the R1 process, Rule determination, 27 June 2024.
9 Clause 5.3.7A.
10 Ibid.
11 Ibid.
12 Clauses 2.1.3(b)(4), 2.1.3(d)(2A) and 5.3.7A(j)(2).

  - requires AEMO to add new information in its *registration and information resource guidelines* to describe how it assesses plant capability and considers adverse power system impacts during the R1 process.[13]
- Along with this rule change request, AEMO has also submitted another rule change request ('Package 2') that is currently being progressed along a standard rule change process.[14] It seeks to amend Schedule 5.3 to introduce a set of requirements with sufficient flexibility to monitor and manage any material adverse impacts of prospective large load projects that are currently at various stages of planning and development. The Commission published a consultation paper for the Package 2 rule change on 8 May 2025. We note that Package 2 is closely related to and would be informed by this final determination ('Package 1').
- AEMO intends to conduct further in-depth reviews of the access standards for loads and grid-forming inverter technology, as noted in AEMO's rule change request.[15] Any such reviews would need to consider the access standards applicable at the time, including any that will be implemented through this rule change.

Furthermore, the final rule supports a broader shift in the connections process, from NSPs dealing with only a handful of connection applications at a time a decade ago, to handling hundreds of applications simultaneously nowadays.[16]

This increased volume of projects in the connections queue can slow down the connections process due to:

- broad range of plant types and configurations seeking connection across the NEM, which may sometimes necessitate complex remodelling and simulations during the negotiation of performance standards
- shortage of power engineers across the energy industry.

To promote efficient and timely investment for new projects connecting to the NEM, the final rule will make some access standards slightly more prescriptive to:

- better manage the surge in connection applications received by NSPs
- reduce reliance on technical expertise and judgement of NSPs and AEMO, given the shortage of power engineers.

Importantly, by reducing connection time and costs, the final rule will accelerate new renewable deployment and incentivise new investment, thereby contributing to meeting Australia's emissions reduction targets.

1.5 Outline

The remainder of this final determination is structured as follows:

Chapter 2: The final rule will contribute to the energy objective — Sets out how this final determination will contribute to the advancement of the NEO.

Chapter 3: The final rule will amend the access standards to apply them by plant type — Describes the elements of the final rule that will 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.

13 Clause 11.171.2.
14 AEMC, Improving the NEM access standards — Package 2.
15 AEMO, rule change request, p 19.
16 For example, AEMO's March 2025 Connections Scorecard shows a total of 573 projects in the connections queue, from enquiry to commissioning.

Chapter 4: The final rule will amend the access standards for generators, integrated resource systems and synchronous condensers — Describes the elements of the final rule (primarily in schedule 5.2) that will improve the access standards for generators, integrated resource systems and synchronous condensers.

Chapter 5: The final rule will amend the access standards for HVDC links — Describes the elements of the final rule (primarily in schedule 5.3a) that will improve the access standards for HVDC links.

Chapter 6: The final rule will make other consequential NER amendments — Describes other elements of the final rule that are intended to either align the function of specific rules with their intent, reduce ambiguity, or improve outcomes consistent with the NEO.

Chapter 7: The final rule includes transitional provisions for existing network plant and ongoing connections — Describes the transitional provisions that apply to existing network plant, considered projects and ongoing connections, including the flexibility to opt to apply a mix of old or new access standards for some cases.

2 The final rule would contribute to the energy objective

2.1 The Commission must act in the long-term interests of energy consumers

The Commission can only make a rule if it is satisfied that the rule will or is likely to contribute to the achievement of the relevant energy objective.[17]

For this rule change, the relevant energy objective is the NEO. The NEO is:[18]

> 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 targets statement, available on the AEMC website, lists the emissions reduction targets to be considered, as a minimum, in having regard to the NEO.[19]

2.2 We must also take these factors into account

2.2.1 We have made a more preferable final rule

The Commission may make a rule that is different, including materially different, to a proposed rule (a more preferable rule) if it is satisfied that, having regard to the issue or issues raised in the rule change request, the more preferable rule is likely to better contribute to the achievement of the NEO.[20] For this rule change, the Commission has made a more preferable final rule. The reasons are set out in section 2.3 below.

2.2.2 We have made a differential rule to not apply this final rule in the Northern Territory

The Commission has decided to make a differential rule so that the final rule does not have effect in the Northern Territory and no amendments to the NER as applied in the Northern Territory (NT NER) will need to be made as a result of the final rule.

Most of the amendments in the final rule relate to rules in the NER that do not currently apply to the Northern Territory, relevantly Chapter 3, Chapter 4, numerous clauses in Chapter 5, schedules 5.1a to 5.3a, schedule 5.5, schedule 5.6, Chapter 6A and Chapter 7. However, some of the amendments in the final rule relate to rules currently in effect in the Northern Territory, including certain clauses in Chapter 5 and definitions in Chapter 10 of the NER.

The Commission carefully considered whether a differential rule could be made which only includes the amendments that are appropriate to the NT NER and which meet the policy objectives of this rule change. The Commission sought feedback from stakeholders and consulted with the Northern Territory Department of Mining and Energy (DME). The DME

17 Section 88(1) of the NEL.
18 Section 7 of the NEL.
19 Section 32A(5) of the NEL.
20 Section 91A of the NEL.

considers that a uniform rule would not achieve the NEO as it would increase costs, complexity and ambiguity in the Northern Territory.[21] A differential rule to adopt parts of the final rule (but not all of the final rule) was also considered by the DME and AEMC to likely present challenges given the complexities of the final rule as well as the limited timeframe for making the final determination and rule. Given the potential consequences of adopting the final rule (in whole or parts) in the NT NER and the complexities of implementation, the DME considers that a differential rule that disapplies the entirety of the final rule from adoption into the NT NER is a suitable solution.

See appendix C.4 for more details on the Commission's considerations and the legal requirements for making electricity rules in the Northern Territory.

2.3 How we have applied the legal framework to our decision

The Commission must consider how to address the opportunity to improve the NEM access standards against the legal framework.

We identified the following criteria to assess whether the proposed rule change, no change to the rules (business-as-usual), or other viable, rule-based options are likely to better contribute to achieving the NEO:

- **Safety, security and reliability** – This criterion was selected to consider the safe reliable, and secure operation of the power system. The operational security of the power system depends on whether connecting plant and equipment can operate within the technical access standards contained in the NER, and not present significant system security risks. Improving access standards can ensure alignment with the best system performance and improve power system resilience.
- **Emissions reduction** – This criterion was selected as the efficiency of the connections process, which relies on access standards being fit for purpose and applied appropriately, has an impact on timely connection of renewable energy generation and storage to the power system. Accordingly, the market and regulatory arrangements for grid connections should efficiently contribute to the achievement of government targets for reducing Australia's greenhouse gas emissions.
- **Innovation and flexibility** – This criterion was selected as the Commission considers innovation and flexibility important principles for improving the access standards. This is both from the perspective of process innovations and innovations in finding solutions to system security issues uncovered through application of the access standards.
- **Implementation considerations** – This criterion was selected to assess the potential benefits versus costs of this rule change, including timing and interrelationships with other reforms and processes. Further, we consider that the cost and complexity of implementation and ongoing regulatory and administrative costs to all market bodies, participants and consumers must be balanced. This includes being clear on the roles for market bodies and participants, supporting efficient investment and operational decisions, and promoting transparency and predictability.

These assessment criteria reflect the key potential impacts – costs and benefits – of the rule change request, for impacts within the scope of the NEO. The Commission has undertaken regulatory impact analysis to evaluate the impacts of the various policy options against the assessment criteria. Appendix B outlines the methodology of the regulatory impact analysis.

21 Northern Territory Department of Mining and Energy, submission to the draft determination, p 1.

The Commission's final rule is largely consistent with the proposed amendments to the access standards in AEMO's rule change request. However, this final rule is a more preferable rule since the Commission has incorporated stakeholder feedback throughout the rule and made various other consequential amendments that seek to add clarity and ensure that the rule reflects the intended policy outcomes. This will better support the assessment criteria listed above than the proposed rule by increasing the likelihood that these criteria may be met. Some of the key differences between the final rule and AEMO's rule change request include:

- Adding a new civil penalty provision in clause 5.2.2(e) to consolidate and streamline several existing civil penalty provisions
- Clarifying reactive power capability requirements and providing NSPs with additional flexibility to determine mid-point voltage on a forward-looking basis
- Introducing reasonable endeavours obligations to prevent slow front over-voltages from degrading plant
- Requiring plant control system tuning range to be set based on system impedances rather than fault levels to improve consistency
- Omitting some proposed amendments including no temperature derating and automatic execution requirements based on stakeholder opposition

The rest of this section explains why the final rule best promotes the long-term interest of consumers when compared to other options, including those proposed by AEMO and the status quo.

2.3.1 The final rule would support safety, security and reliability

The Commission's final rule will improve the access standards to better utilise already available plant performance capability to increase power system resilience to contingency events, without material additional cost. For multiple fault ride through requirements, the improved access standards will also allow carve-out for plant specific limitations to be recorded, where the automatic access standard is not practically achievable or may place an unmanageable risk on the participant. Incentivising disclosure of known limitations will enable risk mitigation plans to be in place, resulting in a more resilient power system. Refer to section 4.5.2 of this final determination for further details on amendments to clause S5.2.5.5 pertaining to multiple fault ride through requirements.

The final rule will also apply appropriate and consistent regulation to synchronous condensers across the NEM. This will advance the NEO by enhancing power system security and electricity supply reliability that depend on continuous support from synchronous condensers. Refer to Chapter 3 for more details on how the final rule will broaden the application of access standards to synchronous condensers.

Furthermore, the final rule broadens the application of schedule 5.3a to all future HVDC links, and amends the access standards to account for the significant power system impact and benefits of improved capabilities of modern HVDC links. This will advance the NEO by promoting investment certainty for HVDC systems to support supply reliability in a more efficient and coordinated manner, and improve power system security. Refer to Chapter 5 for more details on how the final rule improves access standards for future HVDC links.

2.3.2 The final rule will contribute to emissions reduction

The Commission's final rule will make the access standards more prescriptive to minimise ambiguity and clarify their application to different technologies, without compromising system

security or supply reliability. This will reduce unnecessary delays and resources required for lengthy negotiations between connection applicants, NSPs and AEMO.

Clarified access standards with greater prescription will also provide more information and investment certainty to the market. These will advance the NEO by accelerating the connections process and signalling new investment for new generation, interconnection and network support facilities required to transition to a net-zero energy system and deliver on Australia's emissions reduction targets. Refer to Chapter 3 for more details on how the final rule will clarify the application of access standards. Refer to Chapter 4 and Chapter 6 for more details on how the final rule will reduce ambiguity in clause S5.2.5 together with some definitional changes in the Glossary.

2.3.3 The final rule will promote innovation and flexibility

The Commission's final rule will remove unnecessary technology-related restrictions for connecting grid-forming inverters. This will promote 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. This will also promote efficient investment in, and utilisation and operation of, electricity infrastructure in the NEM (including new technologies), which is likely to result in longer-term benefits to consumers in line with the NEO.

2.3.4 The final rule will reduce connections costs and complexity

The Commission's final rule will reduce the overall costs for most connection applicants, although costs may increase for some applicants to comply with the new access standards. The final rule will also reduce the burden on AEMO and NSPs and simplify their function by streamlining the connections process, providing clarity and reducing the need for negotiations. In this regard, the final rule will be an important milestone in the broader connection reform agenda, as discussed earlier in section 1.4.

3 The final rule will amend the access standards to apply them by plant type

Box 2: Overview of this chapter

- Currently, the technical requirements under schedules 5.2, 5.3 and 5.3a apply to different types of registered participants.
- AEMO proposed that these schedules should each apply to different types of plant rather than to the registration category which relates to the owner or operator of the plant.
- The Commission considers that aligning these schedules by plant type would ensure a consistent approach to managing system security for similar types of connecting plant, irrespective of the persons connecting.
- It is important for technical requirements and obligations to apply by plant type, especially considering the increasing variety of persons and plant who are connecting and expected to connect to the NEM.
- The final rule will apply the requirements and obligations under schedules 5.2, 5.3 and 5.3a by plant type:
  - Schedule 5.2 will apply to all generating systems, integrated resource systems and synchronous condenser systems (collectively known as *schedule 5.2 plant)*
  - Schedule 5.3 will apply to all plant that consumes electricity from a network, including a distribution network or a source of load within an integrated resource system (collectively known as *schedule 5.3 plant)*
  - Schedule 5.3a will apply to any high voltage direct current (HVDC) systems with a power transfer capability of 5 MW or more (known as *schedule 5.3a plant*).
- The persons to which the obligations apply would be captured by new definitions of *Schedule 5.2 Participant, Schedule 5.3 Participant* and *Schedule 5.3a Participant* (see Table 3.1).
- The final rule also makes various structural and clarifying amendments throughout Chapter 5.

Note: This chapter broadly relates to Section 4 of AEMO's rule change request.

3.1 The current access standards do not apply consistently to equivalent types of plant

In its rule change request, AEMO noted that the access standards in the NER are expressed as obligations on specified types of registered participant.[22] Currently,

- Schedule 5.2 applies to registered generators and integrated resource providers[23]
- Schedule 5.3 applies to market customers in respect of their market connection points, non-registered customers in respect of their connection to a network, and distribution network service providers (DNSPs) in respect of their networks[24]
- Schedule 5.3a applies to market network service providers (MNSPs) in respect of their market network service facilities.[25]

However, the application of access standards by the type of registration category means that there can be situations where equivalent plant do not face equivalent technical requirements and obligations. For example:

- A synchronous condenser that is operated by a Registered Participant as a Generator or Integrated Resource Provider is currently subject to schedule 5.2, while a stand-alone synchronous condenser that is operated either by an NSP or another party that is not required to register is not subject to schedule 5.2.[26]
- An integrated resource system with a source of load connected to the network through a market connection point is subject to schedule 5.3 as a Market Customer, but an equivalent integrated resource system with the same load that does not have a connection point classified as a market connection point may not be automatically subject to schedule 5.3.
- An HVDC system that is operated by a MNSP is subject to schedule 5.3a, but an equivalent HVDC system operated by a regulated or exempt network is not subject to schedule 5.3a.

The impact of a plant on the power system depends on its characteristics, and not by the registration status of the person who operates the plant. If consistent access standards are not applied to some plant due to their registration status, it may pose a significant security risk to the power system, especially if AEMO or the AER has limited visibility of some plant's performance standards. Moreover, without consistent obligations, these plant could interact with the power system in a way that may cause damage to the network or to other plant, which degrades power system resilience and performance.

Throughout AEMO's review, stakeholders supported addressing this issue to ensure that the schedules are applied based on plant type, rather than registration categories.[27] In response to the draft determination, some NSPs and HVDC operators had specific concerns about some changes to the application framework — these are addressed in section 3.2 below.[28]

22 AEMO, rule change request, p 20.

23 Clause S5.2.1.

24 Clause S5.3.1a.

25 Clause S5.3a.1a.

26 A stand-alone synchronous condenser operated by an NSP is not required to register. However, it is currently unclear whether a stand-alone synchronous condenser operated by an existing Registered Participant is required to register, or can register as an Integrated Resource Provider. CS Energy has submitted a rule change request to the AEMC to create a new registration category for synchronous condensers. The AEMC has not yet initiated this rule change request. Regardless of the outcome of this rule change request, all stand-alone synchronous condensers would be subject to schedule 5.2 under the final rule.

27 AEMO review of technical requirements for connection (NER clause 5.2.6A), Draft Report, p 25; Draft Recommendations Update Report, p 28; Appendix A1 to Draft Recommendation Update Report, pp 5-7, 63-65.

28 Submissions to the draft determination: APA, p 7; Ausgrid, p 2; ElectraNet, pp. 1-2; ENA, p 2; Essential Energy, p 2; Marinus Link, p 3; Transgrid, p 4.

3.2 The final rule will align the standards and obligations with the type of plant to which they apply

The Commission's final rule amends the access standards application framework to apply them based on the type of plant that is connecting, rather than the registration status of the owner or operator. The final rule will:

- amend clauses S5.2.1, S5.3.1a and S5.3a.1a and the Glossary in Chapter 10 to define *schedule 5.2 plant, schedule 5.3 plant* and *schedule 5.3a plant*
- define the persons to which the obligations under each schedule apply as *Schedule 5.2 Participants, Schedule 5.3 Participants* and *Schedule 5.3a Participants*
- remove references to registration types (for example, *Generator, Integrated Resource Provider, Customer*) and replace them with references to *Schedule 5.2/5.3/5.3a Participant*, where applicable and relevant[29]
- add provisions to cover cases where an NSP is a *Schedule 5.2 Participant* or a *Schedule 5.3a Participant* to require NSPs to establish, document and apply performance standards for that plant (recognising that no formal negotiation process is necessary where an NSP is incorporating *schedule 5.2 plant* and *schedule 5.3a plant* into its own network).[30]

Table 3.1 summarises the changes to the application of each schedule and explains the definition of schedule 5.2/5.3/5.3a plant and participants.

Table 3.1: Changes to the access standard application framework under the final rule

Schedule	Plant covered	Persons covered
Schedule 5.2	• *generating systems* • *integrated resource systems* (loads in an integrated resource system not essential to the operation of the system will be schedule 5.3 plant instead) • *synchronous condenser systems*[1]	*Schedule 5.2 Participants* — that is: • any Connection Applicant or party to a connection agreement with the NSP[2] who is, or intends to be, a Registered Participant for a schedule 5.2 plant • any Connection Applicant or party to a connection agreement with the NSP who has appointed, or intends to appoint, an intermediary for that schedule 5.2 plant • any Connection Applicant or party to a connection agreement with the NSP who has received, or intends to apply for, an exemption from registering as a Generator or Integrated Service Provider, or who is entitled to an automatic exemption (but only to the extent that the NSP considers the connection would otherwise adversely affect other Network Users) • any Connection Applicant or party to a connection agreement with the NSP, for a synchronous condenser system with a combined nameplate rating of 5 MVA or more, or only to the extent that

29 Some of these changes affect existing civil penalty provisions in the NER, and may slightly affect the scope of persons to whom the civil penalty provisions apply. The Commission recommends that these amended clauses should continue being civil penalty provisions, but that their tiering remain unchanged. See appendix C.5 for more information.

30 Final rule, clauses 5.2.3(c1), S5.2.1, S.5.3a.1a. See also section 7.1 for more information on the transitional provision requiring NSPs to determine and document performances standards for its existing schedule 5.2 plant or schedule 5.3a plant.

Schedule	Plant covered	Persons covered
		the NSP considers the connection would otherwise adversely affect other Network Users • the NSP whose network incorporates the schedule 5.2 plant, where the plant has a combined nameplate rating of 5 MW/MVA or more, and will not be subject to a connection agreement with a third party for the operation of that plant
Schedule 5.3	• loads, both standalone and part of an *integrated resource system* • *distribution networks*	*Schedule 5.3 Participants* — that is: • any Connection Applicant or party to a connection agreement with the NSP who is, or intends to be, a Registered Participant for a schedule 5.3 plant, or who wishes to connect to a transmission network • any Connection Applicant or party to a connection agreement with the NSP who has appointed, or intends to appoint, an intermediary for that schedule 5.3 plant • any other Connection Applicant or party to a connection agreement with the NSP for schedule 5.3 plant, but only to the extent that the NSP considers the connection would otherwise adversely affect other Network Users
Schedule 5.3a	• HVDC links	*Schedule 5.3a Participants* — that is: • any person who is, or intends to be, the MNSP for an HVDC link • any NSP (or person exempted from the requirement to register as an NSP) whose HVDC link is, or will be, interfaced only with its own AC network or connected to the AC network of another NSP

Source: Final rule, clauses S5.2.1, S5.3.1a, S.53a.1a, Glossary.

Note: This table is provided to aid stakeholders in understanding the final rule. To the extent of any inconsistency between the table and the NER, the NER prevails.

[1] *Synchronous condenser system* will be a new defined term that is defined as "a system comprising one or more synchronous condensers that are not part of a generating system or integrated resource system including, for the purposes of Chapter 5, auxiliary or reactive plant that is necessary for the system to meet its performance standards." This will capture any stand-alone synchronous condensers.

[2] The wording of "a party to a connection agreement with the NSP" was added in the final rule to ensure that the application of the schedules continue to apply to persons beyond the connection process (that is, after they are no longer considered to be a Connection Applicant).

3.2.1 The final rule will broaden the application of schedule 5.2 to include synchronous condenser systems

In recent years, the Commission has completed several rule changes relating to the provision of system security services that are vital to ensuring that essential system services are provided throughout the energy transition. For example, the *Efficient management of system strength on the power system* rule change expanded the system strength framework to ensure that sufficient fault

levels and stable voltage waveforms are provided throughout the power system.[31,32] These security services are expected to be provided by a mix of generators, integrated resource providers, network equipment and synchronous condensers.

As a result, the Commission considers that it is likely that the future power system may have more synchronous condensers connected to the NEM than in the past. It is vital that access standards are applied consistently to all future connecting synchronous condensers to ensure that they can provide network support, system strength and/or inertia safely and securely without adversely affecting other network users or the power system.

Under the final rule, all synchronous condensers will be subject to the access standards in schedule 5.2. This applies to all connecting synchronous condensers operated by a Registered Participant, by an NSP, by an intermediary or third party, or by any person who is not required to register or has been granted an exemption from registration.

Importantly, some access standards in schedule 5.2 will not apply to synchronous condensers, while other access standards will apply, but with modifications.[33] This is to account for the fact that synchronous condensers do not provide active power; otherwise, certain requirements would be irrelevant or cannot be met by synchronous condensers.

In responses to the draft determination, while ENA and Transgrid were supportive of the general principle that obligations should apply based on plant type rather than registration category, they were concerned that the application of schedule 5.2 to all synchronous condensers could lead to significant delays in commissioning and installing synchronous condensers.[34] This has been addressed through the final rule's transitional provision for existing network schedule 5.2 plant or schedule 5.3a plant, as at the commencement date — see section 7.1 for more information.

3.2.2 The final rule will broaden the application of schedule 5.3a to include HVDC links that are not operated by a market network service provider

As noted in section 3.1, two equivalent HVDC links that are operated by different persons (one as a regulated NSP, and one as a market NSP) are currently subject to different technical requirements. As more HVDC links are likely to be commissioned in the future, it is vital that a consistent set of technical requirements apply to them, regardless of the registration status of the operators.

Under the final rule, all persons who operate HVDC links will be subject to schedule 5.3a. This includes any person who operates (or will operate) an HVDC link that is connected to other NSPs' networks, or is (or will be) wholly contained with the person's own network.[35]

In its submission to the draft determination, Marinus Link considered that the final rule should extend the processes, rights and protections of NSPs to all parties who will be regulated NSPs, regardless of which party is the connection applicant.[36] It also noted that the existing overarching connection process (generally set out throughout rule 5.3 of the NER) is not suitable for large HVDC links like Marinus Link, as the actual process between parties resembles joint planning.[37]

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31 AEMC, Efficient management of system strength on the power system, Rule determination, 21 October 2021.

32 In addition, the Improving Security Frameworks for the energy transition rule change aligned the inertia framework with the system strength framework so that transmission network service providers (TNSPs) may better coordinate their investments, while providing AEMO with the ability to enable system security contracts in operational time frames.

33 Where exclusions or modifications to the final rule apply to synchronous condenser systems, they are noted in the first paragraph of the sub-clauses in S5.2.5 and S5.2.6.

34 Submissions to the draft determination: ENA, p 3; Transgrid, pp 3-4.

35 Final rule, clause S5.3a.1a(b).

36 Marinus Link, submission to the draft determination, p 3.

While the Commission acknowledges Marinus Link's concerns, the Commission considers that broader considerations of the connection framework in the NER for large HDVC links should be considered and consulted on in a separate rule change process. In this way, the focus of consultation would be on the suitability of the connection framework and the roles and responsibilities of parties for HVDC connections, rather than on the specific technical requirements in Schedule 5.

3.2.3 NSPs must determine performance standards for schedule 5.2 or schedule 5.3a plant that form (or will form) part of their network

Under the final rule, NSPs must determine and document appropriate performance standards for their own schedule 5.2 or schedule 5.3a plant, including any alterations.[38] When determining or altering performance standards that are AEMO advisory matters, NSPs will be required to consult with AEMO and follow its advice.[39] This is consistent with the principle that AEMO oversight is necessary for all connected plant regarding AEMO advisory matters.

In response to the draft determination, some stakeholders were concerned that the work required to demonstrate compliance against both schedule 5.1 and 5.2 for their synchronous condensers could be very costly and demand many hours of technical engineering work.[40] However, the final rule relieves NSPs from needing to meet the standards set out in schedule 5.1, but only in respect of their schedule 5.2 or schedule 5.3a plant.[41] In this way, NSPs do not need to demonstrate compliance against two different schedules for plant that will be incorporated into their network.

Importantly, there is no formal 'negotiation process' that NSPs are required to follow when determining and documenting the performance standards for plant that are (or will be) part of its network. NSPs will have the flexibility to determine the performance standards for their schedule 5.2 or 5.3a plant that will result in a cost-effective solution to address any particular need.

The approval process described in clause 5.3.4A(b1)-(i) or the alteration process under clause 5.3.9 will not apply to network-operated schedule 5.2 or 5.3a plant.[42]

Note that, for existing schedule 5.2 or schedule 5.3a plant that form part of a network, or plant that form part of an NSP's *considered project*, as at the commencement date of the rule, the performance standards of these plant can be below the minimum access standard — see section 7.1 for more information.

We consider that power system security will benefit from consistent technical requirements on all synchronous condensers and HVDC links, regardless of the owners or operators of the plant.

3.2.4 The final rule does not broaden the application of schedule 5.3 to new persons

Despite the final rule introducing a new defined term of 'Schedule 5.3 Participants' to refer to persons who are subject to schedule 5.3, the definition does not broaden the set of persons who are currently subject to schedule 5.3. Although the final rule reframes the application of schedule 5.3 to refer to plant type rather than intended registration status, in practice, the scope of persons will not be affected by the final rule — see Table 3.2 for a comparison.

37 Ibid. Marinus Link also gave examples where the Connection Applicant and the NSP for a particular HVDC link may not be clear, especially if the HVDC link is jointly planned, designed, constructed and commissioned between multiple NSPs.

38 Final rule, clauses 5.2.3(c1) and S5.2.1(b1).

39 Final rule, clause S5.2.1(b1).

40 Submissions to the draft determination: APA, pp 10-11; ElectraNet, pp 1-2; ENA, p 2.

41 Final rule, clause S5.1.1(h).

42 As discussed in the following submissions to the draft determination: ENA, p 3; Transgrid, pp 4-5.

Table 3.2: The scope of Schedule 5.3 is not broadened by the final rule

Persons to whom Schedule 5.3 applied before the final rule	Corresponding persons to whom Schedule 5.3 will apply after the final rule
Market Customer	A connection applicant (or party to a connection agreement with the NSP) in respect of a schedule 5.3 plant who: • is (or intends to be) the Registered Participant for the plant • has appointed (or intends to appoint) an intermediary for the plant.
Non-registered Customer	A Connection Applicant (or the party to a connection agreement with the Network Service Provider), but only to the extent that the Network Service Provider considers that the connection or operation of the schedule 5.3 plant would otherwise adversely affect the quality or security of network services to other Network Users.
DNSP for its distribution network	A connection applicant (or party to a connection agreement with the NSP) in respect of a schedule 5.3 plant who wishes to establish a connection to a transmission network.

Refer to clause S5.3.1a of the final rule.

Some DNSPs were concerned that the definitional changes to schedule 5.3 may affect how NSPs may apply schedule 5.3 to connecting parties, affording NSPs a binary choice only (that is, to apply the entirety of schedule 5.3, or not at all).[43] However, the Commission considers that the final rule better clarifies the applicability of schedule 5.3:

- under the existing NER, prior to the final rule, schedule 5.3 could have potentially applied to any Network User, irrespective of their potential impact on the power system (see clause S5.3.1a(a)(4))
- the final rule clarifies that schedule 5.3 applies to non-registered persons who are connecting a load, but only to the extent that the DNSP considers the connection would otherwise adversely affect the quality or security of network service to other Network Users.[44]

The wording of 'only to the extent…' means that DNSPs will have discretion to apply parts of schedule 5.3 if it considers that only those parts need to be applied to a connection to avoid adverse power system effects.[45]

Ausgrid and Essential Energy also raised concerns regarding the classification of 'large load', citing the System Strength Impact Assessment Guidelines (SSIAG).[46] The Commission notes that the final rule does not amend the definition of *large inverter based resource* or *large inverter based load* or schedule 5.3's applicability to *large inverter based loads*.[47]

43 Submissions to the draft determination: Ausgrid, p 2; Essential Energy, p 2.

44 This applies to any *large inverter based resource* who may not be intending to be a Registered Participant, noting that at least clause S5.3.11 must apply to these connections as per clause 4.6.6 and the SSIAG.

45 Final rule, clause S5.3.1a(a1)(2).

46 Submissions to the draft determination: Ausgrid, pp 2-3; Essential Energy, p 2.

47 NER clause 5.3.1A(c)(4) states that persons who seek connection for a *large inverter based resource* is a connection applicant under rule 5.3A. The final rule clarifies that this also includes *retail customers* in addition to *non-registered DER providers*.

While the Commission acknowledges the concerns raised by Ausgrid and Essential Energy about the SSIAG's definition of *large inverter based resources*, this particular issue is out of scope for this rule change.

Nevertheless, in anticipation of a growing number of large loads, AEMO is seeking to revise the technical requirements that apply to large loads through its 'large loads access standard review' and is currently consulting with stakeholders on it.[48] In addition, the Commission is separately consulting on whether the definition of 'large loads' should be addressed in the *Improving the NEM Access Standards — Package 2* rule change, and welcomes stakeholder feedback to that process.[49] Such matters may therefore be addressed by these processes.

3.3 The final rule will make consequential structural amendments throughout the NER

In its review, AEMO identified that various clauses in Chapter and other clauses require substantial amendment to accommodate its proposed amendments to apply the access standards by plant type.[50] AEMO's rule change request sought to clarify certain ambiguous issues and improve the legal drafting of Chapter 5, as well as related provisions elsewhere in the NER.[51]

The Commission's final rule implements the vast majority of AEMO's proposed changes, but with some minor differences and additions.[52] The most substantive elements of the consequential amendments to Chapter 5 will:

- amend the name of the *template for generator compliance programs* to *template for compliance programs* throughout the NER, as the template will apply to Registered Participants who may not be generators (for example, NSPs in respect of their schedule 5.2 and 5.3a plant, or any Registered Participants who are also Schedule 5.3 Participants for loads)[53]
- amend the table in clause 5.1.2 to more comprehensively cover the different types of connection or access sought
- reframe clauses 5.1A.1 and 5.1A.2 to apply to all connections under Chapter 5, and replaces references to *Registered Participants* with *Connection Applicants*[54]
- consolidate several existing tier 1 civil penalty provisions that obliged Registered Participants to comply with their connection agreements into clause 5.2.2(e), which the Commission recommends classifying as a tier 1 civil penalty provision[55]
- replace references to Generators, Integrated Resource Providers or Registered Participants with references to Connection Applicants or Schedule 5 Participants, where relevant and applicable; because rule 5.3 must apply to persons beyond those intending Generators and

48 See AEMO's website for more information on the Large Loads Review.

49 AEMC, Improving the NEM access standards – Package 2, Consultation Paper, Chapter 2.

50 AEMO review of technical requirements for connection (NER clause 5.2.6A), Draft recommendations update report, pp 28-31.

51 For a summary of AEMO's proposed structural changes to Chapter 5, see AEMO's rule change request, pp 22-25.

52 See AEMO's proposed draft rule.

53 See clauses 4.15(c)-(ca), 8.8.1(2B), 8.8.3(a)(6), 8.8.3(ba), 11.23.2, 11.23.3 and 11.23.4. See also the new definition of *performance standard* in Chapter 10 of the final rule, as well as section 6.5 of this determination for more information.

54 The final rule deletes clause 5.1A.1(c) which is no longer necessary due to the reframing of clause 5.1A.2 to refer to *Connection Applicants* rather than *Registered Participants*.

55 Clause 5.2.2(e) of the final rule consolidates obligations for each category of registered participant, almost all of which are currently tier 1 civil penalty provisions. The obligations that would be consolidated by clause 5.2.2(e) are clauses 5.2.3(b), 5.2.3(g1), 5.2.3A(d), 5.2.4(a), 5.2.4(f), 5.2.5(a), 5.2.5(c), 5.2.5A(a) and 5.2.5A(c). See Appendix C.5 for more information on the Commission's proposal to recommend this clause as a tier 1 civil penalty provision.

Integrated Resource Providers (for example, loads intending to connect to a transmission network will be Schedule 5.3 Participants, where rule 5.3 must apply)[56]

- amend clauses 4.14, 5.3.7, 5.3.8, 5.3.9 and 5.3.12 to extend the requirements of establishing and changing performance standards, as well as notifying AEMO and the AER, to Schedule 5.2/5.3/5.3a Participants (which may include non-registered participants)[57]
- in clause 5.7.4, expand the requirement for Network Service Providers to institute and maintain a compliance program for its facilities to its schedule 5.2, 5.3 or 5.3a plant, as applicable.[58]
- amend clauses S5.2.4, S5.3.1 and S.5.3a.1 to extend confidentiality obligations and information provision requirements to non-registered Schedule 5.2/5.3/5.3a Participants.

All of these amendments will ensure that the changes to the access standard application framework in the final rule do not have the unintented consequence of creating regulatory or administrative barriers in the connection process. In various places, it will also address various inconsistencies throughout Chapter 5 that currently exist, improving its clarity. The final rule also ensures that the final rule will not unfairly apply requirements to registered participants (or intending registered participants) but not to other Schedule 5 Participants.

56 See the final rule's changes to clauses 5.2.3(d)(11), 5.3.1, 5.3.1A, 5.3.4A(b), 5.3.4B, 5.3.6(j), 5.3.7(f3)-(h), 5.3.8(b) and (f), 5.3.9, 5.3.10, 5.3.11, 5.3.12, 5.3.13, 5.3A.1, 5.3AA, schedule 5.5 and schedule 5.6.

57 The final rule also amends rule 4.14(p) to allow AEMO, the NSP (if applicable) and the Schedule 5 Participant to modify performance standards wherever 5.3.9 may not apply. See AEMO's fact sheet for more information of the performance standard change mechanisms.

58 NSPs should already have compliance programs for their existing Schedule 5 plant that are part of their network (for example, any existing synchronous condensers or HVDC links that are not subject to a connection agreement). This provision ensures that any future schedule 5 plant that are part of an NSP's network have compliance programs for their performance standards, which is a vital part of the AER's compliance and oversight function, as described in rule 4.15 of the NER.

4 The final rule will amend the access standards for generators, integrated resource systems and synchronous condensers

This section outlines the Commission's final NER amendments (primarily in schedule 5.2) to advance the NEO by improving the access standards for generators, integrated resource systems and synchronous condensers.[59,60]

4.1 Clause S5.2.5.1 — Reactive power capability

Reactive power is necessary to control voltages to enable power to flow from generation to load. Generating systems, integrated resource systems and synchronous condensers provide reactive power capability to absorb reactive power to reduce connection point voltages and inject reactive power to increase them. This capability allows plant to control voltages at their connection points, thus facilitating the flow of power through the network. Reactive power enables active power flows by providing the out-of-phase power required to form the magnetic and electric fields necessary to move AC power through the network and transform it to beneficial end use.

4.1.1 The final rule will reduce the voltage range for full reactive power requirements

Issues

Existing clause S5.2.5.1 automatic access standard arrangements require generators and integrated resource providers to provide full reactive power capability over a 20 per cent voltage range. This is 0.395 times the rated active power of the generating system, over the normal operating voltage range of 90 per cent to 110 per cent of normal voltage. This requirement ensures that, irrespective of plant active power output, the plant is designed to be capable of injecting or absorbing this amount of reactive power for any voltage within the normal operating voltage band.

Generators and Integrated Resource Providers (IRPs) have the primary responsibility to regulate connection point voltages by absorbing reactive power to reduce voltages when they are high and injecting reactive power to increase voltages when they are low. This promotes voltage stability and system security by maintaining connection point voltages close to nominal. In addition, the existing automatic access standard also requires full reactive power capability to inject reactive power to increase voltages when they are high and absorb reactive power to decrease voltages when they are low. This capability is unrelated to, and not useful for, regulating connection point voltages but is currently required over the entire 20 per cent normal operating voltage range from 90 per cent and 110 per cent on a continuous basis.

While the capability to inject reactive power to increase voltages when they are high and absorb reactive power to decrease voltages when they are low is not useful for regulating connection point voltages, it is available for NSP and AEMO direction and may be useful for managing network voltages in the vicinity of the connection point under certain circumstances and in certain network locations. However, requiring this capability over the full range of normal operating voltages, being 90 per cent to 110 per cent of nominal, from all generators and IRP connecting at the automatic access standard, irrespective of the connection point circumstances, may be

59 AEMO, rule change request: Overview of rule change proposals to improve NEM access standards, section 5.

60 Detailed stakeholder feedback and AEMO's analysis can be found at AEMO review of technical requirements for connection (NER clause 5.2.6A).

inefficient. Requiring reactive power capability unrelated to generator and IRP voltage regulation obligations imposes costs associated with the design of plant that are unlikely to be justified for most plant connecting at the automatic access standard.

Consequences

An automatic access standard that requires all generators to bring capabilities over the full normal operating voltage range that are unrelated to their primary role of regulating connection point voltages, and without consideration of connection point needs will increase connection costs beyond efficient levels. Increased reliance on negotiation will therefore be required to align capabilities with power system needs. This leads to longer connection processes, higher costs, and higher resource requirements. An automatic access standard that does not reflect efficient outcomes in its design may therefore be inconsistent with efficient operations and investment in the long-term interests of consumers.

The Commission's final rule

Box 3: Reducing voltage range for full reactive power capability

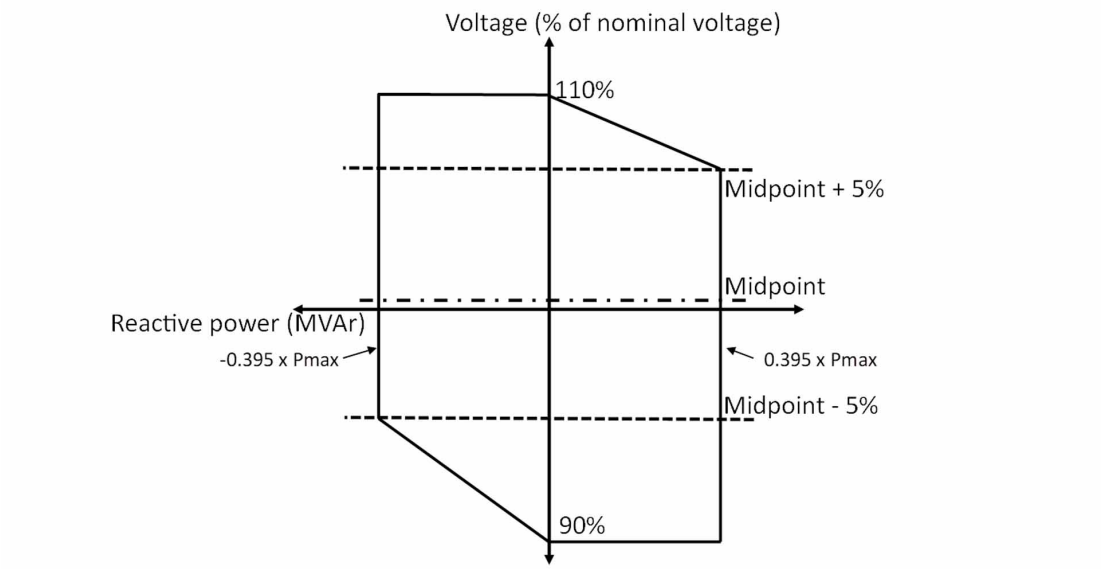
The Commission's final rule makes the following changes to the automatic access standard under clause S5.2.5.1 (as illustrated in Figure 4.1):

- Limit the full reactive power capability requirement (corresponding to 0.395 times maximum active power) to a 10 per cent voltage band centred on a mid-point voltage nominated by the NSP (which will be within the range 95 per cent to 105 per cent of connection point nominal voltage).
- For voltages below the 10 per cent full capability voltage band down to 90 per cent require reactive injection capability at least 0.395 times maximum active power.
- For voltages above the 10 per cent full capability voltage band up to 110 per cent require reactive absorption capability at least 0.395 times maximum active power.
- For voltages from the lower limit of the 10 per cent full capability voltage band to 90 per cent, decrease the requirement linearly with voltage from -0.395 times maximum active power to 0 megavolt ampere reactive (MVAr).
- For voltages from the upper limit of the 10 per cent full capability voltage band to 110 per cent, decrease the requirement linearly with voltage from 0.395 times maximum active power to 0 megavolt ampere reactive (MVAr).

Additional changes support this amendment, including using re-defined active power definitions, and flexibility to reflect changes in the number of units online in the reactive power capability required.

- Clarify maximum active power (Pmax) using an amended definition of active power capability instead of rated active power.
- Provide, as a general requirement, the basis on which maximum active power and reactive power capability may be reduced with fewer than all production units in service. This requirement provides for a reduction of capability with less production units in service accounting for the plant topology.

Figure 4.1: The automatic access standard voltage range for reactive power capability



Source: AEMO
Note: This diagram is included in the final rule as Figure S5.2.1 immediately following clause S5.2.5.1(a1).

Changes from draft to final rule

The final rule reflects the draft rule with two amendments in response to stakeholder submissions:

- Remove the requirement that the mid-point voltage reflects 'typical power system conditions' in clause S5.2.5.1(a0)(3). These changes provide additional flexibility for the NSP to determine a mid-point voltage on a forward-looking basis, which will enhance the NSP's ability to consider changing power system conditions over the transition.
- Clarify that the automatic access standard capability for integrated resource systems under the automatic access standard is the higher of their active power capability and maximum demand in clause S5.2.5.1(a0)(2)(ii)(A). Asymmetric reactive power capability for integrated resource systems with different maximum demand and active power capability is provided for in a negotiated access standard.

The Commission's rationale for the final rule

The Commission's final determination is to make a final rule that is largely the same as the draft rule; however amendments to the draft rule in the final have been made relating to the mid-point voltage and obligations for integrated resource systems, which are discussed below.

The Commission retains its view that the existing automatic access standard that requires all generating systems and integrated resource systems to bring full reactive power capability to absorb and inject reactive power across the entire 20 per cent normal operating voltage band, irrespective of connection point conditions, imposes unreasonable costs on connecting parties. The final rule addresses this issue by reducing the automatic access standard capability to inject reactive power to increase voltages when they are above nominal, and absorb reactive power to decrease voltages when they are below nominal from the full 20 per cent normal operating voltage range to a 10 per cent band based around a mid-point voltage determined by the NSP.

The Commission considers that the final rule promotes the NEO as it balances NSP and connecting plant costs and benefits in a way that minimises connection costs while allowing

capability to be aligned with system needs at the connection point. It aligns requirements with best power system performance, streamlines the connection process, and supports more efficient investment and operation.

In making its final rule, the Commission considered stakeholder submissions to the draft determination noting that connecting parties supported the draft rule.[61] The Commission also considered NSP submissions that preferred retaining the existing automatic access standard.[62] The Commission particularly considered NSP views on the value of capability under clause S5.2.5.1 to increase voltages when they are high and decrease them when they are low for maintaining acceptable voltages in the broader network thereby avoiding the need for investment in additional network reactive plant.[63]

The Commission considers its final rule addresses NSP concerns while also achieving more efficient overall outcomes. A smaller 10 per cent reactive capability band that can be adjusted via the mid-point voltage will achieve cost savings for connecting parties, relative to the existing automatic access standard, while also providing the NSP with capability to direct when needed, consistent with connection point circumstances. The existing arrangements require all connecting generators to bring a full capability across the entire normal operating voltage range irrespective of connection point needs. A capability that can be tailored to the connection point will lead to more efficient outcomes in the long-term interests of consumers than the existing automatic access standard.

The Commission also considered several other stakeholder points including:

- That 'latent' reactive power capability from connecting plant would be lost under the final rule.[64] The Commission has addressed NSP concern about the loss of 'latent' reactive power capability in final rule clause S5.2.5.1(f)(5) that requires all additional reactive capability, over and above the level required by the performance standard, to be recorded and therefore available to the NSP for direction.[65]
- Uncertainty on whether the 'mid-point voltage' in clause S5.2.5.1 and the 'target voltage' in clause S5.1.4(c) represented the same or a different quantity.[66] The mid-point voltage in the final rule and the target voltage in clause S5.1.4(c) are separate quantities. The final rule's mid-point voltage is a forward-looking parameter for biasing reactive power capability and therefore has a function specific to clause S5.2.5.1.
- The negotiation principles that will apply to manage network-specific impacts need to be clarified.[67] The Commission does not consider additional negotiation principles required to address network-specific impacts at the connection point, as suggested by ENA. The negotiation framework set out in Chapter 5, including the principles and guidance in Chapter 5 Part B, provides a framework for addressing specific connection point impacts in a negotiated access standard.

61 Submissions to the draft determination: Akaysha Energy, p 3; APA, p 11; Shell Energy, p 2; Tesla, p 2; Vestas, p 2; Windlab, p 3.

62 Submissions to the draft determination: Transgrid, p 5; ElectraNet, p 2, ENA, p 3.

63 This may include the value of absorbing reactive power when connection point voltages are low to address nearby distribution network over voltages given distributed PV feed in, or injecting reactive power when connection point voltages are high to support voltages such as those at the other end of a nearby radial transmission line under high load conditions.

64 Transgrid, submission to the draft determination, p. 5

65 Clause S5.2.5.1(f)(5) was also included in the draft rule.

66 APA, submission to the draft determination, p 11.

67 ENA, submission to the draft determination, p 2.

The final rule provides additional flexibility for the NSP to set the mid-point voltage on a forward-looking basis

The Commission's final rule provides additional flexibility for the NSP to set the mid-point voltage on a forward-looking basis. This flexibility allows the mid-point voltage to reflect changing power system conditions over the course of the transition. This change takes into account both the submissions by NSPs proposing an adjustable midpoint voltage that could be changed to address changing needs,[68] and connecting parties who requested clarity on how the mid-point voltage would be set and that single mid-point voltage value only should be utilised.[69]

The Commission's final rule does not make the mid-point voltage adjustable as proposed by NSPs. An adjustable mid-point voltage represents a fundamental departure from the NER's connections framework where performance standards apply for the lifetime of the plant.[70] Such a change would introduce inappropriate levels of risk for connecting parties given the need to design plant capabilities at the time of investment. Such uncertainty would likely be detrimental to investment and maintaining reliability consistent with the long-term interests of consumers.

The Commission however agrees that the power system is changing and considers that NSPs should have the flexibility to set the mid-point voltage that best reflects their understanding of how network conditions may change over time. This flexibility allows connection point requirements to be tailored to maximise overall efficiency benefits. NSPs, via their planning processes, have the best information to assess future system needs relevant to the mid-point voltage. This flexibility to take a forward-looking view on the mid-point voltage is particularly important given that clause S5.2.5.1 reactive power capability is documented in the performance standards and set for the lifetime of the connecting asset.

Therefore, the final rule clause S5.2.5.1(a0)(3) no longer requires the mid-point voltage to reflect typical connection point conditions. This will allow a forward-looking view consistent with changing network conditions over the transition.

The final rule clarifies the automatic access standard requirements for integrated resource systems with different maximum demand and active power capability

The Commission's final rule clarifies reactive power capability obligations for integrated resource systems with different maximum demand and active power capability. Different maximum demand and active power capability lead to different automatic access standard reactive power capability requirements depending on whether the integrated resource system is generating or acting as a load.

This issue was raised by Transgrid and EPEC in their submissions to the draft determination.[71] Transgrid and EPEC's submissions raised the risk that asymmetric integrated resource system reactive power capability may cause detrimental connection point voltage steps when integrated resource systems change mode.

The final rule clarifies in clause S5.2.5.1(a0)(2)(ii)(A) that integrated resource system reactive power capability is based on the higher of the active power capability and maximum demand for the purposes of the automatic access standard. The Commission considers that the automatic access standard should reflect plant capability that does not create adverse voltage impacts when changing operational mode. The Commission understands that the majority of connecting

68 Submissions to the draft determination: Transgrid, p 5; ENA, p 2; Essential Energy, p 2.

69 Submissions to the draft determination: CEC, p 10; APA, p 11; SMA, p 3.

70 Unless plant changes trigger renegotiation under a clause 5.3.8 process.

71 Submissions to the draft determination: EPEC, p 5; Transgrid, p 5.

integrated resource systems have symmetric reactive power capabilities and will therefore be unaffected by this clarification. A small number of connecting integrated resource systems will have asymmetric reactive power capabilities. For these plant, a negotiated access standard is appropriate given the need to consider the acceptability of any connection point voltage impacts when changing mode while agreeing to a performance standard.

4.1.2 The final rule will clarify and amend reactive power capability requirements considering temperature derating

Plant reactive power capability is a function of temperature. Different technologies provide differing levels of cooling with some technologies (e.g. inverter systems with water cooling) that can operate without derating across a wide range of ambient temperatures. However, there is a maximum operating temperature over which a plant will not be able to operate continuously.

Issues

Clause S5.2.5.1 expresses reactive power capability requirements as a function of active power but is silent on temperature derating. The Commission understands this silence has led to differing interpretations of this requirement and inconsistencies, and uncertainty in the interpretation of the standard. The Commission also understands the standard is currently unclear what value of active power should be used to define the reactive power requirements when derating with temperature.

Consequences

An access standard that is silent on temperature derating can create uncertainty in negotiations given different interpretations between NSPs on generator and integrated resource system performance with temperature. There is a risk that silence on temperature may see important information on temperature derating not recorded in a performance standard.

The Commission's final rule

Box 4: Clarifying and amending reactive power capability requirements considering temperature derating

The Commission's final rule requires a performance standard to record plant performance with temperature. The final rule:

- Adds a definition for temperature derating where plant capacity is materially affected by ambient temperature.
- Requires the performance standard to document the maximum operating temperature and any derating up to that temperature.

Changes from draft to final rule

The final rule omits the following draft rule amendments:

- For the automatic access standard to be achieved with no temperature derating below 50 degrees Celsius.
- For a negotiated access standard to include temperature derating that must represent a proportional derating of active and reactive power at the equipment level, projected to the connection point (unless the NSP agrees otherwise).

The Commission's rationale for the final rule

The Commission's final rule implements a general requirement for temperature derating to be recorded in the performance standards. The Commission considers this approach will best promote the NEO as it is low-cost and will ensure a plant performance with temperature is understood for the purpose of system operation and maintaining system security.

The Commission has made a final rule that ensures transparency of plant performance with temperature while also responding to stakeholder concerns with significant elements of the draft rule. Stakeholders – particularly those who represent connecting parties were particularly concerned that the draft rule requirement for no temperature derating below 50 degrees was inappropriate and made the automatic access standard unachievable,[72] and that there were significant technical issues and barriers to achieving a proportional derating of active and reactive power.[73] Two stakeholders supported the draft rule.[74]

The Commission's final rule responds to this stakeholder feedback and represents an incremental improvement to existing arrangements for managing temperature de-rating in the connection process, which are managed by individual NSPs. The Commission understands that NSPs have long-standing approaches to managing temperature derating and in light of stakeholder concerns has removed several draft rule elements (further discussed below).

While there is potential for greater clarity in the rules regarding temperature derating, additional technical consideration is required prior to rules implementation. The Commission recommends AEMO consider temperature derating arrangements further in its next review of the access standards.

The final rule does not include an automatic access standard requirement of no derating for temperatures below 50 degrees Celsius

The Commission has omitted the draft rule requirement for no temperature derating below 50 degrees Celsius following significant stakeholder concern.[75]

After considering this feedback, the Commission agrees that a 50-degree automatic access standard requirement is inappropriate. While ambient temperatures are increasing, an automatic access standard requiring no derating for temperatures under 50 degrees is inconsistent with an automatic access standard that represents reasonably achievable capability by best performing plant. The Commission particularly notes submissions that indicate wind turbines could trip for temperatures under 50 degrees,[76] and that a negotiated access standard would be required for all but a small number of plant.[77]

The Commission considers a requirement that sees most plant unable to achieve the automatic access standard will increases costs associated with negotiation as well as reduce certainty and increase connection process complexity. The Commission has not elected to impose a lower temperature threshold at this time as it considers the market provides an incentive for investment in plant capable of best possible plant-temperature performance given the financial benefits associated with market prices that apply during high temperatures.

72 Submissions to the draft determination: Akaysha Energy, p 3; APA, p 11; Vestas, p 2; Transgrid, p 7; Windlab, p 3.
73 Submissions to the draft determination: Akaysha Energy, p 3; CEC, p 9; SMA, p 2; Vestas, p 2.
74 Submissions to the draft determination: Tesla, p 2; Shell Energy, p 2.
75 Submissions to the draft determination: Akaysha Energy, p 3; APA, p 11; Transgrid, p 7; Vestas, p 2; Windlab, p 3.
76 Submissions to the draft determination: Vestas, p 2; Windlab, p 3; Transgrid, p 7.
77 Submissions to the draft determination: Akaysha Energy, p 3; APA, p 11.

The final rule does not include a general requirement for proportional derating of active and reactive power with temperature

The Commission's final rule does not include the draft rule's proposed negotiated access standard requirement for proportional derating of active and reactive power. Stakeholder feedback indicated that non-linear plant derating performance and plant control system characteristics made such a requirement inappropriate.[78]

While the Commission acknowledges the additional clarity a requirement relating active and reactive power derating would bring to clause S5.2.5.1, it considers that further technical consideration in AEMO's next access standard review is required prior to inclusion in the access standards.

4.1.3 The final rule will clarify requirements for the compensation of reactive power when units are out of service

Generating systems, integrated resource systems, and other schedule 5.2 facilities have harmonic filters, internal reticulation, and other auxiliary systems that produce or absorb reactive power. When the facility is connected to the power system but not generating, the reactive power produced or absorbed by these systems has implications for network voltages.

Issues

Under existing arrangements, reactive power requirements when a facility is connected but not generating are determined under clause S5.3.5. That standard is designed for loads and specifies reactive power requirements in terms of minimum lagging power factor and excludes leading power factors.

Existing arrangements are suitable for thermal generator auxiliary systems, which generally have lagging power factors given the amount of machine loads associated with crushers, conveyors, etc. This approach is, however, not fit for inverter-connected plant, which generally have leading power factors given the reactive influence of large, lightly loaded internal reticulation systems when the plant is not generating and capacitive filtering systems to address harmonic content produced by inverter switching.

Consequences

Inappropriate standards that are not fit for purpose increase the cost and uncertainty associated with the connection process.

The Commission's final rule

Box 5: Clarifying requirements for the compensation of reactive power when units are out of service

The Commission's final rule is for an automatic and minimum access standard requirement that will replace the existing requirement for a performance standard for auxiliary plant under clause S5.3.5. The final rule sets out automatic and minimum access standard requirements for units that are electrically connected but not otherwise in service and will include:

78 Submissions to the draft determination: Akaysha Energy, p 4; CEC, p 9; SMA, p 3; Vestas p 2.

- An automatic access standard requirement for no impact on connection point voltage compared with the plant being fully disconnected.
- A minimum access standard requirement that any connection point voltage impact is limited to 1 per cent unless a higher percentage is agreed with the NSP.
- Exemption for connection point voltage impacts when operating in voltage control mode and in accordance with an NSP direction.
- Guidance that voltage impact is to be assessed in steady state conditions and for the highest system impedance value nominated by the NSP under clause 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.

Additional general requirements in clause 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.
- Require the performance standards to document operational arrangements necessary to address any adverse connection point voltage impacts when there are fewer than all production units in service.
- 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 standard established under clauses 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 clause S5.2.5.8 in respect of protection requirements.

Changes from draft to final rule

- The final rule provides for the connection point voltage impact from the generator operating in voltage control mode and for operational actions in response to an NSP direction.
- The final rule provides for the performance standards to document operational arrangements necessary to address any adverse connection point voltage impacts when there are fewer than all production units in service.

The Commission's rationale for the final rule

The Commission's final rule is the same as the draft rule which limited the allowable connection point voltage impact when the plant is electrically connected but not otherwise in service. The Commission considers that the final rule will promote the NEO as it clarifies arrangements in a way that updates them, making them fit for purpose for inverter-connected plant, streamlines the connection process and supports efficient connection applications and associated investment needs in the NEM.

The Commission has considered stakeholder submissions to the draft determination in making its final rule. Stakeholders expressed a range of views and concerns on the draft rule. In particular, the automatic access standard requirement for no steady state connection point voltage impact was considered unachievable by some stakeholders due to switching transients and during plant

energisation,[79] that the automatic access standard precluded operation in voltage control mode when not generating active power,[80]stakeholders also requested additional clarity on key terminology,[81] and APA suggested that the requirement be limited based on the aggregate size of connected non-generating production units.[82]

The Commission has retained the draft rule as its final rule but clarified circumstances where a voltage impact at the connection point is acceptable, and provided for the performance standards to document operational arrangements to address connection point voltage impacts when there are fewer than all production units in service (discussed further below). The Commission notes that switching transient and plant energisation concerns are addressed by the final rule being a steady state requirement, and that key terminology can be interpreted consistent with their general meaning. Specifically, that a plant not otherwise in service is one with its production units not active in the market, either generating or consuming active power (not counting auxiliary active power load) and not dispatched for a market ancillary service. The Commission does not consider limiting the requirement based on the aggregate size of connected but non-generating production units to be appropriate given that the final rule threshold is based on the voltage impact of the plant which is the natural measure to judge whether reactive power compensation is required.

The final rule promotes system security consistent with best performing plant. The minimum access standard provides for some impact on voltage thereby providing flexibility to negotiate a higher connection point voltage impact in a small number of cases where automatic access standard may be inappropriate or unachievable.

The final rule clarifies circumstances where a voltage impact at the connection point is acceptable

The Commission has clarified arrangements in response to concerns that the automatic access standard for no steady state connection point voltage impact when electrically connected but not otherwise in service precluded benefits from generators operating in alternate reactive power control modes, such as voltage control, which by its nature impacts connection point voltages.[83]

The Commission agrees that the final rule should not preclude operation in alternate reactive power control modes when connected but not generating active power. The Commission appreciates that solar PV plant commonly operates in voltage control mode at night. The Commission's intent is for the rule to operate as a do no harm obligation rather than to preclude beneficial operation while the plant's production units are not generating active power.

The Commission has therefore created an exception in the final rule clause S5.2.5.1(i) to allow operation in voltage control mode. An additional exception to allow operational action in response to NSP directions as a means of compliance has also been included to provide an additional means of achieving the auto standard.

The final rule provides for the performance standards to document operational arrangements necessary to address any adverse connection point voltage impacts when there are fewer than all production units in service

The Commission has retained draft rule clause S5.2.5.1(e1) obligation in the final rule that requires reactive power capability to be reduced in a manner consistent with the plant's topology

79 Submissions to the draft determination: Windlab, p 4; Akaysha Energy, p 4.
80 Submissions to the draft determination: APA, p 11; Transgrid, p 8.
81 Submissions to the draft determination: CEC, p 10; SMA, p 3.
82 APA, submission to the draft determination, p 12.
83 Submissions to the draft determination: APA, p 11; Transgrid, p 8.

and the number of operating production units. The final rule also includes an additional provision that requires the performance standards to document any operational arrangements necessary to address any adverse connection point voltage impacts when fewer than all production units are in service.

The Commission has included this additional provision in response to Transgrid's submission to the draft determination.[84] Transgrid requested that the final rule be for a proportional reduction in reactive power capability with fewer than all production units in service. Transgrid considered that the draft rule was unclear and could lead to circumstances that may adversely affect connection point voltages when the majority of production units were out of service.[85]

The Commission does not consider that a proportional reduction in reactive power capability with fewer units in service, as requested by Transgrid, is appropriate, given that connection point capability will not naturally be proportionally reduced with the number of production units in service. The connection point capability impact of an out-of-service production unit will depend on where that unit sits within the topology of the plant and the plant impedances between the connection point and the unit. However, the Commission considers that the final rule should address Transgrid's concerns by providing for the performance standards to record operational actions to address adverse connection point voltage impacts when there are fewer than all production units in service.[86]

The Commission also considered Akaysha Energy's question on whether limitations to BESS output, given its state of charge, reflect a BESS unit that is out of service for the purposes of S5.2.5.1(e1).[87] The Commission considers BESS state of charge is an energy source availability matter and does not determine whether a BESS unit is out of service for the purposes of S5.2.5.1(e1). A BESS unit is in service if it remains active in the market and available to charge or discharge irrespective of its state of charge.

4.2 Simplifying standards for small connections

4.2.1 The final rule will simplify standards for small connections

Issues

Applying access standards to all plant in the power system, irrespective of size, is inefficient. This is because the power system impact of smaller plant does not always warrant the application of relatively onerous access standards. However, the impact of smaller plant can be cumulative and can depend on the number and size of plant connected in a local area of the network and whether their performance adversely affects other network users or the network itself.[88] AEMO can assist NSPs to help determine the individual and cumulative impacts of smaller plant on the power system through its advisory role in the connections process.[89]

Consequences

Currently, some existing access standards have different size thresholds for different technologies (for example, 5 MW for bidirectional units and 30 MW for generating units — see clause S5.2.5.8(a1)). Power system impacts depend generally on plant size rather than technology type,

84 Transgrid, submission to the draft determination, p. 6

85 Ibid.

86 Operational arrangements could include a requirement to disconnect balance of plant, such as a harmonic filter, if a certain number of production units are out of service.

87 Akaysha Energy, submission to the draft determination, p. 4

88 AEMO review of technical requirements for connection (NER clause 5.2.6A), Final Report, p 34

89 See Chapter 10 for the NER for definition of 'AEMO advisory matter', and the changes to that definition in the final rule.

and so the Commission considers that these types of distinctions between plant types should be avoided. However, there are requirements that are unnecessarily onerous for smaller plant. As such, there are opportunities to relax these requirements where they may reduce costs for connection applicants without compromising on power system security.

The Commission's final rule

Box 6: Simplifying standards for small connections

The final rule will specify size thresholds for certain access standards where a small connection is unlikely to have an adverse effect on the power system:

- In the automatic and minimum access standards for clause S5.2.5.7 (Partial load rejection for synchronous generation), exempt production systems that are less than 30 MW on the mainland and less than 7 MW in Tasmania from these access standards
- In the automatic and minimum access standards for clause S5.2.5.8 (Protection from power system disturbances), apply consistent technology-neutral thresholds for emergency over-frequency response requirements, being 30 MW and 7 MW on the mainland and in Tasmania, respectively.
- In the minimum access standard for clause S5.2.5.13 (Voltage and reactive power control), restrict the application of the following minimum access standard requirements to systems above 30 MW and 7 MW on the mainland and in Tasmania, respectively:
  - Testing facilities sufficient to establish dynamic operational characteristics of control systems (see clause S5.2.5.13(d)(2) in the final rule)
  - Excitation control system characteristics (see clause S5.2.5.13(d)(4) in the final rule)

The rule will also amend an existing 30 MW threshold in the minimum access standard for clause S5.2.5.3 (Response to frequency disturbances) to be 30 MW on the mainland and 7 MW in Tasmania.

Changes from draft to final rule

- None

Note: A different threshold in Tasmania is due to the threshold being defined as the lesser of 30 MW and 5 per cent of the largest credible contingency event as defined in the Frequency Operating Standard. In Tasmania, 5 per cent of the largest credible contingency is currently 7 MW.

The Commission's rationale for the final rule

The final rule will simplify the connection requirements for small connections where they are unlikely to have a material adverse impact on the power system. Since the number of small connections are likely to grow throughout the energy transition, the final rule will promote the NEO by streamlining the connection process and supporting efficient investment.

In response to the draft determination, Windlab and Transgrid either supported or had no objections to these thresholds, while Shell Energy suggested an alternative approach to setting a 30 MW or 7 MW threshold.[90] It suggested that assessing the possible impact that a small generator has on the system and setting the size limit accordingly. However, the Commission considers that the potential system impact of schedule 5.2 plant can be highly variable, depending on the location in the network, system strength conditions, nearby plant, and many other factors.

90 Submissions to the draft determination: Shell Energy, p 2; Transgrid, p 8; Windlab, p 4.

Maintaining a consistent threshold to exempt small connections that are unlikely to have any material impact, in respect of specific technical requirements, is clearer.

In its submission to the draft determination, APA stated that there have been examples of modified nameplate ratings in MW to qualify for AEMO standing exemptions using 4.99 MW nameplate ratings, in cases where the MVA rating may have been higher than 5 MVA. [91] APA also noted that AEMO uses a conversion factor of 1 when converting between MVA ratings and MW for registration requirements.[92]

The Commission considers that, although APA's suggestion has merit, the thresholds associated with registration and classification are distinct from the technical requirement thresholds in schedule 5.2. A conversion factor of 1 between MVA and MW ratings may not be appropriate for all plant in the context of specific technical requirements, and determining an appropriate conversion factor for the purposes of those schedule 5.2 requirements was not consulted on during AEMO's review. As such, to avoid any unintended consequences that may arise with specifying a fixed conversion factor of 1, the Commission has not adopted APA's suggestion in its final rule.

4.3 Clause S5.2.5.2 — Quality of electricity generated

Clause S5.2.5.2 sets out the access standards for plant to minimise harmonic distortion when connected to the power system. Harmonics can degrade the performance of other plant and facilities throughout the network, and generally reduces power system stability and performance.

4.3.1 The final rule will delete a reference to a superseded Australian Standard

Issues

Clause S5.2.5.2 refers to a superseded Australian Standard (AS1359.101), which is an older version of the international standard already specified in the clause (IEC 60034-1).

The Commission's final rule

Box 7: Deleting a reference to a superseded Australian Standard

In clause S5.2.5.2(a), the final rule will remove the reference to AS1359.101 as a plant standard for harmonic voltage distortion.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission's final rule will remove this reference to a superseded standard, as it provided no value during the connections process. In this regard, the final rule will promote the NEO by streamlining the connection process. Most stakeholders did not comment on to this proposed change in the draft determination, although EPEC, Shell Energy and Windlab explicitly supported the change.[93]

91 APA, submission to the draft determination, p 10.
92 AEMO, Generator Guide to Registration Exemptions and Production Unit Classifications, p 5.
93 Submissions to the draft determination: EPEC Group, p 3; Shell Energy, p 2; Windlab, p 5.

4.4 Clause S5.2.5.4 — Response to voltage disturbances

This clause sets out the access standards that determine how plant should respond to over-voltages or under-voltages. These voltage disturbances can be caused by a wide variety of faults, contingencies, switching surges or lightning. This clause is important for requiring plant to be able to remain in continuous uninterrupted operation for some amount of time (depending on the magnitude of the voltage disturbance) to minimise the risk of cascading outages that can be caused by plant tripping.

4.4.1 The final rule will allow the point of application for over-voltage requirements to be negotiated for medium and low voltage connections

Issues

The existing automatic access standard for clause S5.2.5.4 is based on European ENTSO-E over-voltage requirements.[94] However, the European requirements are for plant connected to a 400 kV system, meaning that the current automatic access standard may not be appropriate for many medium or low voltage connections

Consequences

Many plant that connect to medium or low voltage areas of the network are not able to meet the automatic access standard. This is because they are often connected to the network directly, with no automatic tap-changing transformer between the plant and the connection point. This makes it very difficult for these plant to be able to remain in continuous uninterrupted operation for the long durations stated in the automatic access standard.

The Commission's final rule

Box 8: Allowing the point of application to be at the nearest HV location for medium and low voltage connections for a negotiated access standard

The final rule will:

- In the negotiated access standard in clause S5.2.5.4(c1), allow the point of application to be the electrically closest location with a nominal voltage of 66kV or above, upon agreement between the NSP and AEMO.
- Delete clause S5.2.5.4(c) which limits negotiation based on plant size.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that distribution-connected plant should not be subject to significantly more onerous requirements than transmission-connected plant, unless different requirements are warranted due to technical characteristics of where they are connecting in the system. This may occur more frequently, especially as the number of distribution connections is likely to increase in the future.

94 AEMO, rule change request, p 32. The ENTSO-E requirement is available here — see Article 16, clause 2.

Recognising that applying the over-voltage requirements at the connection point may be too onerous for medium or low voltage connections, the Commission considers that adding flexibility in the negotiated access standard to move the point of application to the nearest location at or above 66kV is appropriate. This will allow these connection applicants without a tap-changing transformer to propose to move the point of application where they identify that meeting the automatic access standard would be too costly or impractical.

The change also allows NSPs or AEMO to reject negotiated access standard proposals where the nearest 66kV location is electrically very distant, which could have the effect of reducing the over-voltage requirements for the connecting party to near-zero. This is because tap-changing transformers located elsewhere in a distribution network could overly shield the connection applicant's plant from any over-voltages it would otherwise experience at its connection point. If a fault occurs near the connection point, then these tap-changing transformers in the network may not sufficiently shield the plant, potentially causing it to trip.

The Commission notes that connection applicants can continue to propose a negotiated access standard that is applied at the connection point, provided it is no less onerous than the minimum access standard as described in clause 5.2.5.4(b). Therefore, the Commission considers that this amendment strikes the right balance between negotiation flexibility and AEMO/NSP discretion to move the point of application.

The final rule will also delete clause S5.2.5.4(c) in the negotiated access standard, which unreasonably restricts negotiation based on plant size. The Commission considers it important that all connection applicants are able to propose negotiated access standards subject to consistent requirements.

Stakeholders largely supported the amendments to the negotiated access standard in S5.2.5.4, with some supporting comments in submissions.[95] The Commission considers that these amendments will promote the NEO as they support efficient investment and operation of plant through increased negotiation flexibility.

4.4.2 The final rule will bound requirements for over-voltages above 130%

AEMO's proposal for amending the requirements for over-voltages above 130% can be divided into three primary sub-issues, and are numbered accordingly in each sub-section below.

Issues

The automatic access standard in clause S5.2.5.4(a)(1) currently requires that plant must be capable of remaining in continuous uninterrupted operation for a transient over-voltage of over 130% for at least 20 milliseconds. However, the wording of 'over 130%' can be interpreted as an unbounded obligation, with all plant meeting the automatic access standard being required to remain in continuous uninterrupted operation for any arbitrarily high over-voltage.

Relatedly, the voltages in clause S5.2.5.4 are not explicitly defined as root-mean-square voltages, and may be interpreted differently.

Consequences

If participants interpret 'over 130%' to mean that for a plant to achieve the automatic access standard, it must be able to remain in continuous uninterrupted operation for 20 milliseconds for any arbitrarily high over-voltage, then this is an unachievable standard that cannot be met. This

95 Submissions to the draft determination: APA, p 12; Shell Energy, p 2; Tesla, p 2; Transgrid, p 8; Windlab, p 5.

creates uncertainty and does not promote connection applicants to realise power system benefits through their plant investments.

The Commission's final rule

Box 9: Bounding requirements for over-voltages above 130%

The final rule will clarify that the automatic access standard should not be interpreted as an unbounded obligation on connection applicants:

- In the automatic access standard in clause S5.2.5.4(a)(1), replace 'over 130%' with 'at least marginally exceeding 130%', and clarify the boundaries of the voltage ranges specified in clauses S5.2.5.4(a)(2)-(8) and S5.2.5.4(b)(1)-(5) to minimise the potential for misinterpretation.
- In clause S5.2.5.4(a0)(3), clarify that references to voltages are root-mean-square voltages measured either phase to phase or phase to ground, expressed as a percentage of the *nominal voltage* or its phase to neutral equivalent, as relevant to the disturbance.

Changes from draft to final rule

- Make corresponding clarifying changes to the minimum access standard at clause S5.2.5.4(b)(1)-(5).
- Amend the local definition of voltage to better capture RMS voltages (see also section 6.3).

The Commission's rationale for the final rule

The Commission considers that connection applicants should not face an unbounded obligation to meet the automatic access standard. An unbounded obligation places unacceptable risk on connecting parties by exposing plant to potentially extreme or unrealistic conditions, which does not promote efficient investment and operation.

The intent of the automatic access standard is to incentivise plant to be able to ride-through some transient disturbances, which could be caused by lightning or switching of plant or network elements. Importantly, as discussed in our draft determination, the intent is not for plant to be capable of riding through **any** arbitrarily high over-voltage disturbance.[96] To better align the wording of the clause with its intent, the Commission proposed to modify the wording of clause S5.2.5.4(a)(1) to:

> at least marginally exceeding 130% of *nominal voltage* for a period of at least 0.02 seconds after T(ov).

In response to the draft determination, several stakeholders supported the draft rule,[97] while some stakeholders preferred a defined upper bound for the ride through requirement rather than the words 'marginally exceeding 130%'.[98] In general, these stakeholders considered that the words 'marginally exceeding' may lead to different interpretations amongst different parties, or that the assessment of compliance against S5.2.5.4 may remain ambiguous.

96 AEMC, draft determination, p 27.
97 Submissions to the draft determination: APA, p 12; Shell Energy, p 3; Tesla, p 2; Transgrid, p 9; Windlab, p 5.
98 Submissions to the draft determination: Akaysha, p 4; APA, p 12; CEC, p 11; EPEC, p 3; gridmo, p 2; SMA, p 4; Vestas, p 2.

The Commission previously considered introducing an upper boundary of 131% into the automatic access standard.[99] However, upon further consideration, the Commission considers that adopting an upper boundary of 131% would be too arbitrary and would have no clear linkage to the system standards in clause S5.1a.4. In addition, it may unintentionally limit any latent plant capability that may exist to withstand over-voltages greater than 131%.[100] While the Commission acknowledges and appreciates that an upper bound for testing to meet the automatic access standard may be useful for connection applicants, the risk of unintentionally limiting plant capability to 131% outweighs the benefits.

As a result, we consider that the final rule's wording of 'at least marginally exceeding 130%' provides sufficient clarity to satisfy the engineering intent of the clause, without unnecessarily introducing a new and arbitrary value into the automatic access standard. This drafting does not imply that plant must be able to ride through any arbitrarily high over-voltage.

In relation to concerns that there is no clear upper bound for testing, the Commission envisions that connecting plant could be first assessed against any higher over-voltage – for example, 135%. If the plant fails to remain in continuous uninterrupted operation for 20 ms at this over-voltage level, the plant could be assessed against an over-voltage of 134%; repeating this process until either:

- the plant can remain in continuous uninterrupted operation for 20ms for an over-voltage greater than 130% (even if that over-voltage is 130.1%), meaning it meets the automatic access standard and the highest over-voltage level it can withstand is recorded in the performance standards; or,
- the plant cannot remain in continuous uninterrupted operation, meaning the applicant must propose a negotiated access standard.

Note that the above assessment example is for illustrative purposes only, and the Commission is not recommending any particular assessment methodology for the automatic access standard in S5.2.5.4.

In summary, the wording change to the automatic access standard contributes to the NEO, as it will align the requirement with best power system performance and the engineering intent of the clause, promoting power system resilience and efficient investment. Finally, the final rule also clarifies that references to 'voltage' in clause S5.2.5.4 refer to root mean square voltages. This will reduce the likelihood of any misinterpretation or disputes arising during the connections process. See section 6.3 for more information on the change to the definition of RMS voltage in this clause.

4.4.3 The final rule will introduce obligations to minimise the occurrence of switching surges that may cause plant degradation

Issues

In its review, AEMO identified that there is no explicit requirement in the NER for NSPs and connected parties to operate their facilities in a way that minimises switching surges (which are also known as transient slow front over-voltages).[101] Repeated switching surges can increase the likelihood of plant tripping and can deteriorate or damage plant over time.

99 AEMC, workshop slides, p 24.

100 For example, if a plant is capable of withstanding an over-voltage of 135% for 20ms, then under the proposal in the stakeholder workshop, the performance standard that would be recorded in a connection agreement would only specify that the plant must not trip for over-voltages up to 131% for 20ms, even though the plant has a higher ride-through capability. This is because performance standards cannot be set at levels higher than the corresponding automatic access standard – for example, see NER 5.3.4A(i), 5.3.5(a), 5.3.6(b)(1), 5.3.6(b2)(3), 5.3.7(c) and S5.1.1.

101 AEMO review of technical requirements for connection (NER clause 5.2.5.6A), Appendix A1 to Draft Recommendations Update Report, pp 22-23; Final report, p 37.

Consequences

The requirements in clause S5.2.5.4 are related to the system standards for power frequency voltage described in clause S5.1a.4. However, clause S5.1a.4 is silent on over-voltages of more than 130%, meaning there is no explicit obligation on an NSP to minimise these over-voltages from occurring.

The Commission notes that the existing obligations within the NER for parties to undertake and agree upon insulation coordination.[102] However, proper insulation coordination does not, on its own, guarantee that the operation of connected plant will not cause switching surges that may degrade other connected plant. The switching of plant or facilities could still cause switching surges above the over-voltage levels considered during insulation coordination — in which case, a test (or assessment) under clause 5.7.2 would be appropriate to determine the root cause.[103]

As a result, without an explicit obligation on parties to minimise the occurrence of such switching surges, there may not be an appropriate hook for Registered Participants to request such a test or assessment under clause 5.7.2(a).

Box 10: Introducing reasonable endeavours obligations to prevent slow front over-voltages from degrading plant

In clauses S5.1.4A and S5.2.3(b)(4A), the final rule will require NSPs and Schedule 5.2 Participants to use reasonable endeavours to ensure that the switching of its network elements or operation of its plant does not cause other plant to experience switching surges that are greater than the levels contemplated by relevant insulation coordination.

Changes from draft to final rule

The drafting of clauses S5.1.4A and S5.2.3(b)(4A) has been modified to:

- clarify that the existing insulation coordination requirements in the NER still apply
- clarify that the operation of network elements or of schedule 5.2 plant should not cause over-voltages greater than what was contemplated during insulation coordination
- remove ambiguity through the phrase 'recurring slow front over-voltages'
- ensure that parties are not responsible for **any** slow front over-voltage described above, but instead have a general responsibility to reasonably prevent causing them through the operation of their plant.

The Commission's rationale for the final rule

The Commission considers that an obligation for NSPs and Schedule 5.2 Participants to ensure that they do not cause switching surges that may degrade plant over time is important. Although the existing insulation coordination requirements in the NER should minimise or eliminate exposure to these surges, unintended or unforeseen interactions between network elements or connected plant may still cause surges that can cause plant to trip.

In addition, if an applicant wishes to connect a plant with capability meeting or exceeding the automatic access standard, it should reasonably expect that it is not frequently exposed to (and expected to ride-through) slow front over-voltages that may be caused by poor engineering practices from the NSP or other Schedule 5.2 Participants. These new obligations promote good

102 See clauses S5.2.3(b)(4), S5.3.9(i), S5.3a.3 and S5.3a.12.

103 See section 6.1 for the final rule's changes to clause 5.7.2 that will allow for Registered Participant to request an assessment, instead of a test, of other Registered Participants' plant.

engineering practices and promote power system security by explicitly codifying that the operation of plant should minimise slow front over-voltage disturbances as much as reasonably possible.

In response to the draft determination, Vestas submitted that the inclusion of this requirement on schedule 5.2 plant may lead to unnecessary requests from the NSPs to demonstrate compliance.[104] While the Commission acknowledges Vestas' concern, we consider that the NER should not set out allowable assessment methodologies or tests for compliance, with guidelines being better suited for this task.[105]

Essential Energy considered that the rationale behind implementing the obligations required further explanation and consultation.[106] In response, the Commission has further explained the issue, consequences and rationale in this final determination.

In its submission, Transgrid considered that the clauses S5.1.4A and S5.2.3(b)(4A) of the draft rule were unnecessary, citing existing insulation coordination requirements and the fact that the transient over-voltage at a connection point and the switching surge are not directly related.[107] As explained above, the operation of network elements or other plant may still cause undesirable switching surges, even if all appropriate insulation coordination requirements and standards were adhered to. Additionally, although switching surges and transient over-voltages are not directly related and do depend upon other factors (including insulation coordination and surge arrestor placement), the obligations will assist in helping parties determine the root cause of recurring switching surges by using the process in clause 5.7.2, if needed.

4.4.4 The final rule will clarify the meaning of 'continuous uninterrupted operation' for moderate voltage disturbance requirements

Issues

AEMO has noted that the meaning of 'continuous uninterrupted operation' in the context of clause S5.2.5.4 has been interpreted in various different ways.[108] It also noted that these different interpretations can cause uncertainty and impose material costs for connecting plant, with limited benefits to power system operation and security.[109]

Consequences

Different interpretations of continuous uninterrupted operation in clause S5.2.5.4 can create uncertainty for connecting parties as to the level of capability they should aim to achieve and must demonstrate for compliance or registration. Clarifying the meaning of continuous uninterrupted operation is especially important for inverter-based plant, where reactive power capability is dependent on the network voltage, and where temporary active power reductions can occur due to weather conditions (such as unexpected cloud cover or reduced wind speed).

The Commission's final rule

104 Vestas, submission to the draft determination, p 2.

105 However, if the NSP request relates to the *capability assessment* required for registration (colloquially referred to as the R1 process), then NSPs must ensure that their request is made in accordance with the *registration information resource and guidelines*. See clause 5.3.7A(f)-(h) of the NER.

106 Essential Energy, submission to the draft determination, p 2; AEMC, Workshop slides, slide 24.

107 Transgrid, submission to the draft determination, p 3.

108 AEMO review of technical requirements for connection (NER clause 5.2.5.6A), final report, p 39.

109 AEMO, rule change request, p 34.

Box 11: Clarifying the meaning of 'continuous uninterrupted operation' for disturbances within 90-110% of nominal voltage

The final rule will add clauses S5.2.5.4(e1), (e2) and (e3) which qualify what 'continuous uninterrupted operation' means for voltage disturbances within 90-110% of nominal voltage:

- For voltage variations of up to 10%, reactive capability (as per performance standard established under clause S5.2.5.1) must be maintained and active power must not reduce. Parties may use of tap-changing transformers, plant switching and overload capability in order to meet this requirement.
- Transient responses, frequency deviations, expected phase angle changes and any other factors the NSP and AEMO consider reasonable are to be disregarded.
- Reductions in active power or reactive power capability caused by energy source availability, losses and any other factors agreed with the NSP and AEMO are permitted.
- For voltage variations greater than 10%, reasonable temporary alterations in active power output and reactive power capability, corrected by tap-changing transformer responses (or by any other operational arrangement agreed with the NSP and AEMO), are permitted.

Changes from draft to final rule

- The drafting of clause S5.2.5.4(e2)(1) now clarifies that the requirement to remain in continuous uninterrupted operation (as described in clause S5.2.5.4(e1)) persists, regardless of whether a tap-changing transformer is used.
- The drafting of clause S5.2.5.4(e3) was modified so that, for voltage variations greater than 10% within the range of 90% to 110% of nominal voltage, plant without a tap-changing transformer must correct alterations in active power output and reactive power capability through any operational arrangement as agreed with the NSP and AEMO.

The Commission's rationale for the final rule

The final rule provides greater clarity and will ensure that different interpretations of the term "continuous uninterrupted operation" do not lead to connection being subject to inconsistent requirements, with potentially significant cost implications depending on interpretation. It sets the expectation that schedule 5.2 plant must maintain their active power output and reactive power capability for certain voltage disturbances, while also providing flexibility for parties to agree to disregard minor deviations which may be the result of good engineering practices (for example, expected phase angle changes due to grid-forming capability) or which may be out of the plant's control (for example, weather conditions).

Several stakeholders supported the Commission's proposal in the draft rule to clarify the meaning of continuous uninterrupted operation for this clause, with some stating that it would likely reduce the capital cost of projects and would better contribute to the NEO.[110]

However, ENA and Transgrid raised strong concerns about the draft rule allowing plant to use tap-changing transformers as a way to either minimise or relieve the requirement of remaining in continuous uninterrupted operation.[111] The Commission notes that the intent of the draft rule was not to allow a pathway to less onerous continuous uninterrupted operation requirements through

110 Submissions to the draft determination: Akaysha, p 5; APA, p 12; EPEC, p 3; Shell Energy, p 3; Tesla, p 2; Vestas, p 2; Windlab, p 5.

111 Submissions to the draft determination: ENA, p 3; Transgrid, p 9.

the use of tap-changing transformers, but instead to explicitly allow the use of such equipment to assist in meeting the continuous uninterrupted operation requirement.[112] To clarify this, the wording of clause S5.2.5.4(e2)(1) has been modified as follows for the final rule:

> onload *tap-changing transformers, plant* switching and overload capability may be used to assist in meeting the requirements of subparagraphs (e1)(1) and (e1)(2).

Transgrid also noted that for voltage variations that are greater than 10%, but still within the range of 90% to 110% of nominal voltage, the draft rule's expectation for plant that do not have a tap-changing transformer was unclear.[113] The final rule clarifies that active power output and reactive power capability may change, provided that those changes are corrected by a tap-changing transformer, or other operational arrangements as agreed with the NSP and AEMO.[114]

The final rule's clarifications to the meaning of continuous uninterrupted operation and description of acceptable plant responses will promote the NEO. It better incentivises optimal plant performance, streamlines the connection process by minimising ambiguity, and avoid unnecessary costs in meeting a standard that does not promote power system security.

4.5 Clause S5.2.5.5 — Disturbance ride-through capability

Clause S5.2.5.5 describes the requirements for plant to remain in continuous uninterrupted operation for multiple successive faults (known as multiple fault ride through), provided each fault or sequence of faults meets a specified set of conditions. In particular, this clause describes the requirements for:

- Response to contingency events and network faults, including multiple disturbances, for generating systems.
- Reactive current injection and absorption during faults, and active power recovery following faults.
- Responses following recovery from faults, in conjunction with the continuous uninterrupted operation definition.

This clause seeks to improve system security by requiring plant to ride through multiple faults and provide beneficial responses without tripping, which could further exacerbate the impact of such faults, unless required or permitted under the performance standards.

4.5.1 The final rule will define the end of a disturbance for multiple fault ride through

Issues

While clause S5.2.5.5 specifies that the minimum clearance between the end of one disturbance and the commencement of the next disturbance may be zero milliseconds for the automatic access standard and 200 milliseconds for the minimum access standard, it does not define the end of a disturbance for the purpose of this clause.

112 Tap-changing actions can take minutes to respond. If plant solely relied upon a tap-changing transformer during a voltage disturbance, and did not take any other action as part of its voltage control strategy, then it would not meet the requirements of remaining in continuous uninterrupted operation described in (e1), as both active power and reactive power will reduce until the tap-changing action is completed.

113 Transgrid, submission to the draft determination

114 Clause S5.2.5.5(e3) of the final rule. If operational arrangements are agreed with the NSP and AEMO, then the details of the arrangements must be recorded in the performance standards, pursuant to paragraph (f).

Consequences

This gives rise to the potential for different interpretations of when a disturbance can be taken to end, increasing uncertainty and creating unnecessarily onerous obligations. For example, it is possible to interpret the automatic access standard 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 is inefficient, as noted by AEMO in its review and rule change request.

The Commission's final rule

Box 12: Defining the end of a disturbance for multiple fault ride through

The final rule will, in clause S5.2.5.5:

- Specify that a disturbance is taken to end when the voltage at the connection point recovers to within 90% to 110 % of nominal voltage and remains within that range for at least 20 milliseconds.
- Align paragraphs (d)(5) and (l)(3) so they both refer to 'the time difference between the end of one disturbance', and remove different usages of the word 'clearance'.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that the final rule will clarify the nature of disturbances that need to be tested for multiple fault ride through by specifying a voltage recovery criterion and reduce the likelihood of misinterpretation of the clause. This will promote the NEO as it will streamline the connection process, and support efficient investment and operation.

The Commission's draft rule to clarify the end of a disturbance was supported by APA, Windlab, Akaysha Energy and Transgrid.[115] In particular, APA noted that clarifying disturbance end time resolves different misinterpretations of next disturbance commencement time and defines clear performance requirements for multiple fault ride through sequences for assessments.[116] Windlab noted that this change would ensure that each fault is seen as a distinct event, precluding the extreme back-to-back fault sequences that were permissible according to the existing rules. Hence, it has always been unofficially accepted with NSPs and AEMO that such fault sequences should not be applied when studying a plant's multiple fault ride through capability. It is much better to have these extreme cases explicitly precluded from the test set.[117]

Transgrid suggested amending the automatic access standard to require ride through of at least two successive disturbances, i.e. where a second disturbance commenced immediately after the voltage at the connection point recovered to within 90%-110% of the nominal voltage (without waiting for 20 milliseconds).[118] The Commission considers the likelihood of a second disturbance occurring in less than 20 milliseconds after the end of one disturbance to be quite low. Therefore,

115 Submissions to the draft determination: APA, p 12; Windlab pp 5-6; Akaysha Energy, p 5; Transgrid pp 9-10.
116 APA, submission to the draft determination, p 12.
117 Windlab, submission to the draft determination, pp 5-6.
118 Transgrid, submission to the draft determination, pp 9-10.

requiring plant to demonstrate capability to ride through such an unlikely occurrence does not provide any additional benefits.

Transgrid further suggested that simultaneous occurrence of multiple faults (for example, lightning strikes causing multiple transmission line outages) should be considered in the assessment of multiple fault ride through capability. The Commission considers it outside the scope of this rule change to extend the existing automatic access standard in clause S5.2.5.5 to require ride through of two (or more) simultaneous or overlapping disturbances, i.e. where a second disturbance commenced before the voltage at the connection point recovered to within 90%-110% of the nominal voltage after going outside that range due to a previous disturbance. The existing requirements in clause S5.2.5.5(d) and (l) correspond to a 'series' of disturbances rather than simultaneous disturbances. The Commission's objective is only to clarify the end of a single disturbance in this series and thereby avoid any misinterpretation of the rules to require assessment of simultaneous disturbances under this clause. The Commission also notes that most stakeholder submissions in AEMO's review supported defining the end of a disturbance.[119] Hence, the Commission has decided to retain the language of the draft rule without any change.

4.5.2 The final rule will allow disclosure of plant limitations to comply with multiple fault ride through requirements

Issues

The minimum access standard in clause S5.2.5.5 is that a plant must remain in continuous uninterrupted operation for a series of up to six disturbances that are over 200 milliseconds apart within any five minute window, subject to a set of qualifications about the nature of the disturbances (individually and as a sequence). AEMO's rule change request identified that the existing minimum access standard presents an impediment to some connections because:[120]

- Simulation models cannot capture all possible disturbance combinations under different power system conditions that might cause a plant to trip.
- Assessments can generally only establish non-compliance, as opposed to proving compliance for all possible disturbance combinations.

Consequences

This has resulted in connection applicants having to undertake extensive simulation studies, which are time-consuming, expensive, and still inconclusive. The requirement to meet multiple fault ride through conditions under all circumstances also disincentivises the disclosure of conditions that will cause a plant to trip for potential combinations of disturbances within the envelope described by the minimum access standard.

The Commission's final rule

Box 13: Allowing disclosure of plant limitations for multiple fault ride through compliance

The final rule will:

- Add a new clause S5.2.5.5(r2) allowing a negotiated access standard to include a specified plant limitation in respect of which the NSP and AEMO agree that the plant is not required to

119 AEMO review of technical requirements for connection (NER clause 5.2.6A), Appendix 2 to Final Report, p 37.
120 AEMO, rule change request, p 36.

remain in continuous uninterrupted operation for a specified combination of power system disturbances or associated conditions.

- Require that if combinations of power system disturbances or associated conditions are specified under clause S5.2.5.5(r2), the plant's response for each combination must also be included in the negotiated access standard, and must be as close to continuous uninterrupted operation as reasonably practicable.
- Require that any agreed plant limitations must not reduce the overall number of disturbances in a given period for which the plant is required to remain in continuous uninterrupted operation below the minimum access standard in clause S5.2.5.5(l).
- Amend the qualifying conditions in the minimum access standard clause S5.2.5.5(l) to exclude specified plant limitations agreed with the NSP and AEMO in accordance with the new clause S5.2.5.5(r2).

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission agrees with AEMO's view that incentivising disclosure of limitations by allowing carving out specific limitations, while otherwise maintaining the requirement to ride through a series of six disturbances within any five minute period, will benefit all parties:[121]

- For Connection Applicants, it will allow plant performance to be recorded in the performance standards together with known limitations for which a plant is not required to remain in continuous uninterrupted operation.
- For NSPs and AEMO, it will improve visibility of conditions under which a plant could trip, allowing them to be taken into account for operational and planning purposes, and require an appropriate plant response to reduce the risk of plant tripping.

This will facilitate dialogue between connection applicants, NSPs and AEMO regarding such disclosed limitations, enabling more efficient and collaborative management of the risk by either accepting it, if the risk is sufficiently low, or identifying mechanisms to mitigate it. 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 nearby circuits, as suggested by AEMO.[122]

This amendment was supported by Windlab, APA and Transgrid in response to the Commission's draft determination. In particular, Windlab noted that with sufficient knowledge of a plant's voltage control strategy, it is often possible to identify a worst-case sequence of faults that could result in plant tripping. This amendment encourages developers to proactively identify and share potential tripping scenarios with the NSP and AEMO during the connection application process, with the ultimate goal of mitigating risk through a negotiated access standard.[123] APA also noted that certain technologies may have limitations in riding through different combinations of faults. This amendment enables managing the risk of non-compliance for un-modelled known plant limitations.[124]

121 AEMO, rule change request, pp 36-37.
122 AEMO, rule change request, p 36.
123 Windlab, submission to the draft determination, p 6.
124 APA, submission to the draft determination, p 13.

Transgrid noted that any request for exemption from remaining in continuous uninterrupted operation for a specified combination of power system disturbances or associated conditions on the basis of a specified plant limitation should be supported by evidence in the form of hardware-in-loop or emulator tests.[125] While the Commission acknowledges Transgrid's feedback, it notes that since the new clause S5.2.5.5(r2) requires NSP agreement, the NSP can ask for reasonable evidence to accept a negotiated access standard as per clause 5.3.4A(b2) to satisfy itself both of the plant's limitation and, importantly, the required response which must also be documented. The Commission further considers that the NER tends not to prescribe any specific assessment methods and suggests referring to AEMO's Dynamic Model Assessment Test Guideline for more information on acceptable forms of evidence.[126]

Transgrid further recommended defining a standard suite of distinct tests for assessing compliance with this clause.[127] These tests should be applicable across the NEM, with the option to supplement them with additional fault ride through scenarios if deemed necessary by the connecting NSP, based on the specific location. The Commission notes that AEMO had considered this suggestion in its review as it could simplify and reduce work. However, AEMO did not pursue it further as it considered that a lack of location-specific contingencies made a NEM-wide standard test suite less useful. Instead, AEMO concluded that a smaller set of more targeted studies could provide better outcomes to identify plant limitations in the surrounding network.[128] The Commission also notes that Transgrid's latter suggestion for NSPs to propose location-specific studies was strongly opposed by a majority of stakeholders in AEMO's review including some NSPs, leading AEMO to withdraw that proposal from its final recommendations.[129] Hence, the Commission does not consider it appropriate to introduce this requirement in the final rule.

Akaysha Energy raised concerns about the risks of this amendment resulting in multiple rounds of modelling requests by NSPs for all possible variations of fault scenarios, with OEMs being unwilling or unable to perform multiple rounds of tests for scenarios that may be extremely fringe.[130] The Commission disagrees with this view and notes that it would be up to the connection applicant to propose scenarios for exemption under clause S5.2.5.5(r2) as part of a negotiated access standard proposal, not AEMO or the NSP. If the applicant does not propose any scenarios for exemption, clause S5.2.5.5(r2) would become irrelevant for them. The Commission further clarifies that AEMO and the NSP cannot propose any scenarios to test for plant limitations, it is up to the applicant to identify any limitations. The Commission's objective here is to provide connecting plant with the flexibility to request exemption from remaining in continuous uninterrupted operation for scenarios where any known plant-specific limitations prevent them from doing so. Akaysha Energy also proposed requiring NSPs and AEMO to establish scenarios for which continuous uninterrupted operation would not be required, assuming that in all other scenarios it would be required.[131] The Commission considers that this proposal offers less flexibility, and does not encourage disclosure of limitations.

The Commission notes that this amendment was also well-supported by stakeholders in AEMO's review.[132] After considering all feedback, the Commission has decided to retain the language of the draft rule without any change. The final rule will promote the NEO as it will align the

125 Transgrid, submission to the draft determination, p 10.
126 AEMO, Dynamic Model Acceptance Test Guideline.
127 Transgrid, submission to the draft determination, pp 10-11.
128 AEMO review of technical requirements for connection (NER clause 5.2.6A), Appendix 2 to Final Report, p 39.
129 AEMO review of technical requirements for connection (NER clause 5.2.6A), Appendix 2 to Final Report, pp 38-40.
130 Akaysha Energy, submission to the draft determination, p 5.
131 Ibid
132 AEMO review of technical requirements for connection (NER clause 5.2.6A), Appendix 2 to Final Report, pp 38.

requirements with best power system performance, improve power system resilience, streamline the connection process, and support efficient investment and operation.

4.5.3 The final rule will require NSPs to specify the highest system impedance for plant tuning and relax fault ride through requirements for system impedances above plant tuning level

Issues

Most technical access standards are assessed considering fault levels (or system impedances) expected for system normal and single outage conditions, for a range of generation dispatch conditions. Access standards for multiple fault ride through in clause S5.2.5.5 are different in that they consider non-credible combinations of conditions. With this context, AEMO's review identified the following issues pertaining to fault levels with the existing access standards for multiple fault ride through:[133]

- Multiple fault ride through requirements do not consider that multiple faults could reduce the fault level at the connection point below the level for which a plant was tuned, although they exclude material reductions in power transfer capability from the conditions for which a plant must remain in continuous uninterrupted operation.
- It is unclear for what minimum fault levels are plant required to be tuned.
- The fault levels for which plant have been tuned are not recorded.

Consequences

Since the existing Rules do not incentivise it, simulation studies generally do not account for fault level reduction at the connection point while analysing various series of faults for compliance assessment under clause S5.2.5.5. However, this may not accurately reflect a real-world scenario in the power system, allowing a plant to demonstrate compliance in theory for certain series of faults, when in reality it might trip if those faults reduced the fault level below its capability limit. Such an optimistic assessment of multiple fault ride through capability creates a risk to system security that is currently not being considered in system planning and leaves ambiguity about the level of plant performance required.

In addition, requiring a plant to remain in continuous uninterrupted operation for fault levels below which it has been tuned puts unnecessary obligations on plant performance. Control system tuning affects the dynamic performance of a plant, including the damping of its controls during disturbances. Ambiguity in minimum fault levels can result in a control system tuning range that sub-optimally utilises available plant performance range. Lack of recorded information about plant tuning hinders future assessment of whether tuning is still adequate, considering changes in the power system over time (including retirement of synchronous plant).

The Commission's final rule

Box 14: Requiring NSPs to specify the highest system impedance for plant tuning and relaxing fault ride through requirements for system impedances above plant tuning level

The final rule will:

- In the general requirements in clause S5.2.5.13(m):

133 AEMO, rule change request, p 37.

  - Require the NSP to nominate the highest and typical system impedances at the connection point for tuning of plant controls and assessment of compliance for the purposes of clauses S5.2.5.1, S5.2.5.5 and S5.2.5.13.
  - Require the highest system impedance to be 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 single network element outage that would cause the greatest reduction in the three phase fault level at the connection point.
  - Allow discretion to NSPs and AEMO to nominate a different value of the highest system impedance, accounting for actual plant capability and locational factors.
  - Require the Schedule 5.2 Participant to record the highest and typical system impedances nominated by the NSP in the releasable user guide.
- In clause S5.2.4(c)(3), require the Schedule 5.2 Participant to record the levels used for plant tuning, including the X/R ratio of the power system observed from the connection point, in the releasable user guide.
- In both the automatic access standard in clause S5.2.5.5(d) and the minimum access standard in clause S5.2.5.5(l), exclude from the continuous uninterrupted operation requirement events that would result in the system impedance at the connection point being above the highest system impedance for which the plant must be tuned, as nominated by the NSP under clause S5.2.5.13(m).

Changes from draft to final rule

- Replaced reference to the minimum three phase fault level with the highest system impedance to ensure consistency across clauses S5.2.5.1, S5.2.5.5 and S5.2.5.13.
- Removed reference to short circuit ratio recorded under clause S5.2.5.15.

The Commission's rationale for the final rule

The Commission's final rule will:

- Remove ambiguity by requiring the minimum three phase fault level (highest system impedance) for plant tuning to be set by reference to objectively ascertained parameters.
- Remove unnecessary obligation on plant performance by allowing plant to not remain in continuous uninterrupted operation if the three phase fault level at the connection falls below plant tuning minimum.
- Reduce simulation burden by limiting the series of disturbances to be simulated only to the extent that the three phase fault level at the connection point remains above plant tuning minimum.
- Increase the accuracy of compliance assessment by taking fault level reduction (system impedance increase) into account, and enable any associated system security risks to be appropriately considered.
- Facilitate review and retuning of control systems in future, if necessary, by recording plant tuning levels in an accessible document, i.e. the releasable user guide.

This amendment was supported by Shell Energy and Windlab in response to the Commission's draft determination.[134] In particular, Windlab noted that this amendment would facilitate faster connections as it would reduce the likelihood that engineering time and negotiation efforts are spent on edge cases with vanishing likelihood of occurrence in the real system.[135] TasNetworks suggested allowing NSPs and connecting parties to negotiate minimum fault levels to enable tuning the connecting plant to a fault level optimised for the network at the connection point. TasNetworks also noted that the electrically closest system strength node may be physically distant from the connection point, and consideration must be given to existing and future plant that may be sharing the system strength at that location.[136] The Commission agrees with TasNetworks and has modified clause S5.2.5.13(m) to allow NSPs, AEMO and the connection applicant to agree to a different minimum fault level (highest system impedance) value to account for actual plant capability and locational factors, if needed.

Transgrid agreed with the Commission's view that assessment of multiple fault ride through capability without considering fault level reduction due to multiple outages could lead to overly optimistic results. However, Transgrid objected to allowing plant to not remain in continuous uninterrupted operation for fault levels at the connection point below plant tuning minimum, noting that a non-credible multiple disturbance event (e.g. severe storms, bushfires, etc.) could lead to multiple network element outages. In Transgrid's view, the resulting fault level at the connection point could then be much lower than the minimum three phase fault level with a single network element outage.[137] The Commission considers that AEMO's proposed solution is already quite stringent, as it anticipates a scenario with a weak system (nearest system strength node operating at minimum fault level) combined with the single network element outage that would cause the greatest reduction in fault level at the connection point (in other words, the most significant network element outage, and not just any single network element outage). Hence, the Commission considers that its final rule incorporates a substantial fault level range over which plant will be required to be tuned and ride through faults.

The Commission further notes that during AEMO's access standards review, AEMO had met with several NSPs to discuss their methodology for determining the fault level range for which plant are expected to remain in continuous uninterrupted operation. Using the minimum three phase fault level at the nearest fault level node in conjunction with a single network outage was identified as a way to apply a consistent approach.[138] The Commission understands that Transgrid also follows a very similar approach currently. This approach allows for secure network operation considering planned or forced network outages. Hence, the Commission considers AEMO's proposed approach in clause S5.2.5.13(m) to be robust and well-aligned with the methodology currently being applied by NSPs and has decided to retain this approach in the Commission's final rule. The Commission also notes that none of the other NSPs and ENA objected to this approach in response to the Commission's draft determination or in subsequent discussions.

Transgrid proposed that rather than allowing full exemption from continuous uninterrupted operation requirements for fault levels below the plant tuning minimum, plant should be required to operate stably and remain connected up to the lowest fault level that they have the capability to do so.[139] Transgrid also suggested recording this lowest fault level. However, the Commission

134 Submissions to the draft determination: Shell Energy, p 4; Windlab, p 6.
135 Windlab, submission to the draft determination, p 6.
136 TasNetworks, submission to the draft determination, p 2.
137 Transgrid, submission to the draft determination, p 11.
138 AEMO review of technical requirements for connection (NER clause 5.2.5.6A), Appendix 2 to final report, p 44.
139 Transgrid, submission to the draft determination, p 11.

considers that determining this lowest fault level would require a lot more analysis, which does not align with the Commission's objective to streamline the connection process, and still leave a high degree of regulatory risk for the connection applicant. The Commission is aware that AEMO's Connection Application Checklist requires connection applicants to provide confirmation from the plant manufacturer of the minimum short circuit ratio and X/R ratio at which the plant can operate satisfactorily (at the connection point and at generating unit terminals), supported by evidence such as factory acceptance test reports.[140] However, the Commission notes that the plant manufacturer can specify such plant operating limits under any control system settings, which do not necessarily have to be with the same settings used for compliance assessment with other S5.2.5 clauses. Hence, the Commission does not consider this approach for determining the minimum fault level at which a plant can operate stably and remain connected to be generally applicable.

Transgrid also noted that the draft rule's proposal to use the short circuit ratio value recorded in the performance standard for clause S5.2.5.15 is not appropriate since clause S5.2.5.15 allows use of settings that may be different to the settings required for compliance with other S5.2.5 clauses. The Commission agrees with Transgrid's feedback and has removed the reference to clause S5.2.5.15 in clauses S5.2.5.5(d)(10) and (l)(9) of the final rule. In relation to this, the Commission notes that AEMO's rule change request and the Commission's draft rule proposed specifying the plant tuning range based on the minimum three phase fault level. However, upon further consideration, the Commission finds it more appropriate to use the highest system impedance instead of the minimum three phase fault level, in order to apply a consistent range for plant tuning and compliance assessment across all relevant access standards clauses S5.2.5.1, S5.2.5.5 and S5.2.5.13. The Commission considers that it does not make much difference from a power system studies perspective whether system impedances or three phase fault levels are specified. The Commission's rationale for using the system impedance is discussed further in section 4.10.2. This approach was tested with stakeholders at the 27 March workshop and received no objections except from Transgrid for reasons discussed above, while Vestas supported it.

After considering all feedback, the Commission has decided to retain the draft rule's intent, while replacing the minimum three phase fault level with the highest system impedance as nominated by the NSP and recorded by the Schedule 5.2 Participant in the releasable user guide. The Commission considers that the final rule will promote the NEO as it will streamline the connection process, and support efficient investment and operation.

4.5.4 The final rule will delete references to a metallic conducting path

Issues

Clause 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 additional clarity to the description of faults in the clause.

140 AEMO, Generator Connection Application Checklist, 3 May 2021, p 7.

Consequences

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 faults). There is no apparent reason why a metallic conducting path might otherwise be excluded from clause S5.2.5.5, but the existing wording could create room for debate about the application of this clause to non-metallic conducting paths.

The Commission's final rule

Box 15: Deleting references to a metallic conducting path

The final rule will:

- In clause S5.2.5.5(a), delete the specific reference to "a fault includes a fault of the relevant type having a metallic conducting path".
- In the Chapter 10 Glossary definition of short circuit fault, delete "metallic".

Changes from draft to final rule

- Deleted the word "metallic" from the definition of short circuit fault as a consequential amendment, for consistency.

The Commission's rationale for the final rule

AEMO's review found a lack of consensus about the original meaning or intent of the reference to a metallic conducting path, indicating that there is potential for confusion.[141] For example, it could be interpreted to exclude high impedance faults from multiple fault ride through requirements.[142] Therefore, by deleting the reference to a metallic conducting path, the Commission's final rule will remove ambiguity about requirements to ride through faults with non-metallic conducting paths. The Commission considers that a high impedance fault in the power system is unlikely to impact fault ride through capability of a generating system.[143] In this regard, this amendment will not alter the practical application of the fault ride through requirements in clause S5.2.5.5.

This amendment was supported by Transgrid, Shell Energy and Windlab in response to the draft determination, while no other stakeholder objected to it.[144] Therefore, the Commission has decided to retain the draft rule amendment. The Commission's final rule also deletes the reference to "metallic" in the definition of short circuit fault as a consequential amendment suggested by AEMO in its submission to the draft determination.[145] The Commission considers that removing this ambiguity in both instances will streamline the connection process, which will promote the NEO.

141 AEMO, rule change request, pp 44-45; AEMO review of technical requirements for connection (NER clause 5.2.5.6A), Appendix A1 to Draft Recommendations Update Report, p 41; Appendix 2 to final report, p 52.

142 Ibid.

143 Ibid.

144 Submissions to the draft determination: Transgrid, p 13; Shell Energy, p 4; Windlab, p 6.

145 AEMO, submission to the draft determination, p 11.

4.6 Clause S5.2.5.5A — Responses to disturbances following contingency events

The final rule will move parts of clause S5.2.5.5 (the disturbance response and recovery requirements) into a new clause S5.2.5.5A to improve the clarity of the rules drafting.[146]

Following a fault or voltage disturbance, the response of all plant connected to the power system is critical to avoid plant tripping, voltage decline, load disconnections and power system instability. This new clause sets out the access standards for the volume, timing and characteristics of reactive current injection to ensure optimal power system resilience.

4.6.1 The final rule will amend the requirements for active power recovery after a fault

Generators and integrated resource providers are required to provide a rapid reactive current response to stabilise voltages during a fault. For inverter-based technology, when a fault causes a voltage below 90% of the nominal connection point voltage, the plant is required to inject reactive current, which is typically at the expense of active current and power. Active power must rapidly recover when the fault clears, and voltage returns to the normal voltage band, to minimise the effect on frequency and the continued supply to consumers.

Issues

Existing automatic access standard arrangements under clause S5.2.5.5 require active power recovery to at least 95% of the level that existed just prior to the fault within 100 milliseconds of a fault's clearance. This post-fault requirement may not be achievable or desirable under certain circumstances.

Active power recovery time frames depend on network conditions and the recovery of voltage following a fault, which can be affected by a range of external factors that are not within the connecting party's control. The rate of active power recovery may also be affected by power system frequency conditions and the provision of primary frequency response and other frequency control services. A strict requirement to recover active power within 100 milliseconds is therefore unlikely to appropriately reflect generator response to actual power system conditions and may be interpreted as precluding the provision of frequency response services such as primary frequency response.

The 2023 *Efficient reactive current access standards for inverter-based resources* rule change changed the minimum access standard for active power recovery requirements to address some of these issues.[147] This change linked active power recovery to voltage recovery to link the recovery of active power to voltage conditions at the connection point. The automatic access and minimum access standards are therefore now expressed differently which may affect the efficiency of the performance standard negotiating process.

Consequences

Automatic access standards that are unachievable under some circumstances undermine effective assessment of ongoing compliance with technical obligations. The lack of clarity on the plant's ability to provide frequency response services during the active power recovery period further undermines the provision of essential system security services.

146 The disturbance response and recovery requirements are different for synchronous and asynchronous plant, whereas the fault ride-through requirements are the same for all technologies. Separating these out makes these clauses easier to follow.

147 AEMC, Efficient reactive current access standards for inverter-based resources, Rule determination, 20 April 2023.

This undermines clear achievable obligations that provide investor confidence. Automatic access standards that are not consistently expressed may lead to ambiguity in negotiated access standard negotiations, which increases uncertainty and cost-affecting investment and the maintenance of NEM reliability.

The Commission's final rule

Box 16: Amending the requirements for active power recovery after a fault

The Commission's final rule links the requirement to recover active power post fault to connection point voltage recovery and explicitly accounts for frequency response and the provision of primary frequency response. The final rule:

- Links the active power recovery requirement to a new definition of the end of a disturbance in the same way as the for multiple fault ride through requirements.
- Instead of referring to active power recovering, the final rule enhances clarity by referring to reaching 95% of pre-disturbance active power within a specified time.
- automatic access standard for both synchronous and asynchronous production units, and the minimum access standard for synchronous units, include a separate active power response requirement for a frequency disturbance. This requirement refers to an active power level consistent with the clause S5.2.5.11 performance standard, and the operation of the plant in accordance with clause 4.4.2(c1) for primary frequency response.
- Include a reference to primary frequency response in the minimum access standard for asynchronous units.
- Allow for inertial response and phase jump response in the minimum access standard.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission's final rule mirrors the draft rule. The Commission considers its final rule will promote the NEO as it qualifies and clarifies active power recovery in a manner that better reflects actual power system conditions consistent with enhancing ongoing compliance with performance standards. Aligning the expression of the automatic access standard and minimum access standard requirements in the final rule will also facilitate efficient negotiation and enhance investor certainty and confidence as it will streamline the connection process and support efficient investment and operation.

The final rule better reflects actual power system conditions by linking the requirement to recover active power after a fault to connection point voltage recovery and explicitly accounting for frequency response and the provision of primary frequency response. The Commission considers that a strict requirement in the current automatic access standard that does not reflect actual power system conditions and requirements is inappropriate. The Commission particularly notes the absence of frequency-related response qualifiers and a lack of clarity on the end of the voltage disturbance in this regard.

Stakeholders generally supported the draft rule.[148] Both APA and Windlab noted that modifying the definition of when a disturbance ends to be 20ms after voltage has returned to the normal

148 Submissions to the draft determination: APA, p 13; Windlab, p 6.

operating band aligns the active power recovery with the actual causal active power control response of the system. The Commission agrees that the additional 20ms provides for a more appropriately controlled active power recovery.

EPEC suggested the requirement could be qualified as 'taking account of inertial effects or rotor dynamics' to account for synchronous plant active power recovery being delayed due to the rotor angle.[149] The Commission does not consider such a qualification appropriate, given rotor dynamics are an inherent part of a synchronous generating system response that is required to meet the active power recovery requirement.

4.6.2 The final rule will amend rise time, settling time and commencement time requirements for reactive current injection

A rapid reactive current response to a fault is necessary to support voltages, maintain power system stability, and provide fault current for protection system operation when a disturbance occurs that sees connection point voltages depart from the normal operating voltage band of 90 per cent to 110 per cent of normal voltage. If voltage disturbances are not arrested by the rapid injection or absorption of reactive current, system security and the capacity of nearby generators and loads to remain connected to the power system may be compromised.

Issues

Unlike synchronous plant, which have an electromagnetically inherent response to voltage disturbances, inverter-connected asynchronous plant require a control system and plant capability design that provides a fast but stable reactive current response during a fault.

Clause S5.2.5.5 currently specifies an acceptably fast yet stable response for asynchronous plant by requiring a response rise time and settling time that is also adequately damped. While these requirements describe control system responses to ideal step change inputs, which are established and well understood, they do not reflect actual fault voltage profiles which may not be a step or step-like.

AEMO considers settling time, which describes the time taken for a step response to settle close enough to its target value, is a criterion that is only applicable to certain, simple faults with step characteristics that are rarely seen in practice.[150] For more complex voltage faults, which commonly occur in actual power system operation, the settling time requirement may not be a meaningful assessment of reactive current response adequacy. The assessment band for the settling time definition also 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.[151]

The requirement for an adequately damped response may not best reflect a desirable or achievable response in some circumstances.[152] 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. An adequately damped response may also not be achievable given power system conditions when the post fault voltage profile itself is not 'adequately damped' according to the definition of that term.

149 EPEC, submission to the draft determination, p 3.
150 AEMO, rule change request, pp 39-40; AEMO review of technical requirements for connection (NER clause 5.2.6A), Draft Report, pp 58-60.
151 Ibid.
152 Ibid.

The minimum access standard requirements for reactive current injection were amended by the 2023 *Efficient reactive current access standards for inverter-based resources* rule change to address some of these issues in the minimum access standard.[153] The minimum and automatic access standards are now expressed differently with implications for clarity and the negotiating efficiency.

Consequences

A standard that is framed around requirements that do not reflect actual power system conditions does not support clear ongoing compliance with technical standards. A lack of clarity on ongoing compliance does not support security and reliability in the NEM.

The Commission's final rule

Box 17: Amending rise time, settling time and commencement time requirements for reactive current injection

The Commission's final rule will:

- Omit the settling time requirement in the automatic access standard at clause S5.2.5.5A(g)(2).
- Add a commencement time of 10 milliseconds to the automatic access standard at clause S5.2.5.5A(g)(2) and clarify that this is for a response opposing the voltage deviation.
- Replace the requirement for an adequately damped response with one that is adequately controlled. A new definition of adequately controlled is proposed below and at clause S5.2.5.5A(b)(1).
- Qualify that the automatic access standard and minimum access standard rise time requirement is to be assessed for step-like voltages.

Under the final rule, adequately controlled will mean that:

- the response of the schedule 5.2 plant to transient over-voltage or transient under-voltage achieves the agreed level of reactive current injection or absorption within the duration of the relevant disturbance, considering:
  - the expected positive and negative sequence reactive current response
  - the expected active current response
  - stable control when operating at and transitioning into and out of limits
- and does not cause or exacerbate:
  - voltages beyond the levels and durations specified in the system standards or (if more restrictive) agreed under clause S5.2.5.4; or
  - voltage oscillations that are not consistent with achieving the system standards or could adversely affect the ability of other schedule 5.2 plant to remain in operation during the disturbance.

Changes from draft to final rule

- The final rule adds further clarification that an adequately controlled response is one that does not cause or exacerbate voltage oscillations that are not consistent with achieving the system standards.

153 AEMC, Efficient reactive current access standards for inverter-based resources, Rule determination, 20 April 2023.

The Commission's rationale for the final rule

The Commission's final rule retains the draft rule language with a minor clarification to address the scope of allowable oscillations in the definition of adequately controlled. The Commission retains its view that existing requirements are useful as idealised tests to characterise control system performance, but insufficiently reflect or support ongoing compliance in real-world conditions. The Commissions considers its final rule will promote the NEO by better reflecting performance under actual power system conditions, encouraging a fast response supporting voltage stability, and enhancing clarity and negotiating efficiency by aligning the expression of the automatic access standard with the minimum access standard following the changes made in the 2023 *Efficient reactive current access standards for inverter-based resources* rule change.[154]

The Commission considered a range of stakeholder views in making its final rule.[155] The Commission particularly noted:

- Transgrid's preference for the settling time requirement to be retained as it was a standardised and well-understood control system parameter,[156]
- Whether the use of 'transient' over/under voltage is appropriate given those terms are defined differently in international standards, in particular IEC 60071-1,[157]
- Requests for additional information on the definition of commencement time, or reactive response at commencement,[158] and how assessment would be performed using a step-like response.[159]

After considering stakeholder submissions, the Commission retains its view that the final rule will better support system security and promote the NEO by aligning requirements with real-world conditions than maintaining existing arrangements.

While the Commission appreciates the value of idealised tests, such as settling time, for characterising control system response, It retains its view from the 2023 *Efficient reactive current access standards for inverter-based resources* rule change, that settling time is not a reliable measure of the adequacy of a reactive current response to a fault, because it was premised on the most onerous types of faults having a step response, which is not true in practice.[160]

The Commission has used the term transient in its ordinary meaning, which is that "transient" means temporary, transitory, or short-lived disturbance in a system.[161] While the Commission acknowledges that transient is defined differently in some international standards, the NER uses transient according to its general meaning in other areas including S5.2.5.3, and S5.1a.3.

The Commission also recognises a stakeholder desire for additional clarification, particularly on commencement time, but considers the new definition of adequately controlled, together with the initiating conditions set out in final rule clause S5.2.5.5A(n), work together to sufficiently specify the nature of the reactive response and when it must commence.

The final rule clarifies the scope of oscillations covered by the definition of adequately controlled

154 AEMC, Efficient reactive current access standards for inverter-based resources, Rule determination, 20 April 2023.
155 Submissions to the draft determination: CEC, p 12; EPEC, p 3; Gridmo, p 2; SMA, p 4; Transgrid, p 12; Vestas, p 2.
156 Transgrid, submission to the draft determination, p 12.
157 Transgrid, submission to the draft determination, p 12.
158 Submissions to the draft determination: Gridmo, p 2; Transgrid, p 12, EPEC, p 3.
159 Vestas, submission to the draft determination, p 2.
160 AEMC, Efficient reactive current access standards for inverter-based resources, Rule determination, 20 April 2023, p 14.
161 Oxford English dictionary definition

The Commission agrees with Transgrid's submission that the draft rule definition of adequately controlled needed clarification on the scope of the oscillations that were acceptable in an adequately controlled response. Transgrid raised concerns that the draft rule definition appeared to allow sustained or underdamped oscillations as long as they did not adversely affect the ability of other *schedule 5.2 plant* to remain in operation during the disturbance.[162]

The Commission has therefore clarified the definition of an adequately controlled response as being one that does not cause or exacerbate voltage oscillations that are not consistent with achieving the system standards. This complements the existing draft rule requirement for an adequately controlled response to not cause or exacerbate voltage oscillations that could adversely affect the ability of the schedule 5.2 plant to remain in operation during the disturbance. Together, these requirements implement a general do no harm obligation that addresses harm to other participants and the NSP. The final rule, therefore, supports the overall objective that an adequately controlled response is one that supports a secure and stable outcome.

4.6.3 The final rule will amend arrangements for the commencement of reactive current injection and provides clarity on reactive current injection location

Reactive current injection during fault conditions requires a response that senses the voltage disturbance and rapidly responds once the connection point voltage leaves the range 90 per cent to 110 per cent of normal voltage. This requirement is intended for reactive current injection to start as close to nominal voltage as possible to manage voltage excursions quickly.

Issues

At present, the automatic access standard for asynchronous generating systems under clause S5.2.5.5(g)(1) requires the reactive current response for an under-voltage to commence in an under-voltage range 85 per cent to 90 per cent, and an over-voltage range of 110 per cent to 115 per cent, of normal voltage. However, this requirement implicitly assumes that the plant has a low voltage ride through threshold, 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 a specified voltage threshold. Grid forming inverters respond instantaneously to oppose a change in voltage. AEMO considers the technology specific form of the existing clause, in that it specified triggering voltage thresholds, is inappropriate for low system strength conditions and for plant with controllers that provide voltage control response at the unit level rather than the plant controller level.[163]

AEMO also identified other issues including that the 5 per cent automatic access standard response range is not workable for most generating systems or integrated resource systems that have a step-up transformer with on-load tap-changer between the production units and the connection point.[164] A 5 per cent range is also often not practically achievable for a medium or large system with reactive power range consistent with the automatic access standard of clause S5.2.5.1. It is typically only achievable for systems connected directly to the power system without an intervening step-up transformer.

162 Transgrid, submission to the draft determination, p 12.
163 AEMO, rule change request, pp 41-42.
164 Ibid.

AEMO's rule change request also identified a lack of clarity in existing arrangements on where the location for measurement of reactive current injection level as a function of voltage.[165] While flexibility to adjust the measurement location was present in existing arrangements, there is a low level of understanding and appreciation of this flexibility as currently expressed.

Consequences

An automatic access standard which is inappropriate or unachievable for certain technologies including grid forming technologies does not align requirements with best power system performance, streamline the connection process, and removes impediments for connection of grid forming inverters.

The Commission's final rule

Box 18: Amending arrangements for the commencement of reactive current injection and clarifying reactive current injection location

The final rule will:

- For the automatic access standard 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
  - Over-voltage event when or before voltage reaches 115% of nominal voltage at the connection point
- 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.
- Require in the general requirements (and not under the minimum access standard) 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.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission's final rule is the same as the draft rule on commencement of reactive current injection and adds clarity on reactive current injection location.

The Commission considers amending the voltage conditions at which a reactive current response commences will arrest the change in voltage following disturbance more quickly and closer to the pre-disturbance value.[166] This will provide a better outcome for the power system than under existing arrangements. The final rule therefore will promote the NEO by better reflecting actual

165 Ibid.
166 Ibid.

technology capabilities, aligning with best power system performance, streamlining the connection process, and removing impediments to the connection of grid forming inverters.

The final rule will change the automatic access standard from a response range to a requirement to commence above 85 per cent and below 115 per cent of normal voltage. This is to accommodate grid forming inverters which respond inherently to a voltage disturbances rather than in response to connection point voltage declining below a response threshold. The Commission particularly considers enhancing arrangements supporting grid forming inverter connection to be important given the role of these inverters for future power system security, in accordance with the NEO.

The Commission considered stakeholder views which requested clarity on whether the point of assessment was at the terminals or connection point.[167] The final rule clause S5.2.5.5A(s) of the final rule provides flexibility to define the reactive response at the terminals or connection point. The access standards are defined at the connection point by default, but where the NSP agrees, there is flexibility to measure the response at the terminals but with the measured requirement adjusted to reflect impedances between the connection point and terminals. The Commission considers additional guidance from AEMO and NSPs on both of these matters will assist stakeholder clarity in each of these areas. Clarifying the ability to measure reactive current commencement at locations other than the connection point will provide additional flexibility allowing performance standards that best reflect power system conditions and the connecting plant.

The Commission also considers the changes that align automatic access standard requirements with minimum access standard changes made in the recent *Efficient reactive current access standards for inverter-based resources* rule change supports effective negotiation.[168]

4.6.4 The final rule will clarify the response requirements for balanced and unbalanced faults, and recognise negative sequence current responses

Issues

The current automatic access standard for asynchronous systems in clause S5.2.5.5(f) requires them to have facilities capable of at least 4% of reactive current injection or 6% of reactive current absorption for each 1% decrease or increase of voltage at the connection point, respectively. This requirement is generally interpreted to be for positive sequence injection or absorption.

Consequences

Most faults on the power system are unbalanced faults, rather than balanced faults.[169] For unbalanced faults, positive sequence current injection or absorption only is not necessarily the optimal response, and could lead to over-voltages on unfaulted phases.[170] Instead, negative sequence current responses may sometimes be preferred and be more closely aligned with best power system outcomes.

167 Submissions to the draft determination: CEC, p 12; SMA, p 4.

168 AEMC, Efficient reactive current access standards for inverter-based resources, Rule determination, 20 April 2023.

169 A balanced fault is one that affects all three phases equally (such as a three-phase to ground fault), whereas an unbalanced fault affects each phase differently (such as a phase-to-phase or phase-to-ground fault).

170 Excessive reactive current injection may also lead to temporary over-voltages on all three phases, cause inverters to exit low voltage ride through (LVRT) mode before the fault is cleared, or cause the withdrawal of active power. See AEMC, Efficient reactive current access standards for inverter-based resources, Rule determination, pp 62-64.

However, the current rules do not explicitly promote the use of negative sequence currents for unbalanced faults, nor describe the desired power system outcome that plant responses should aim to achieve.

The Commission's final rule

Box 19: Defining a control objective for both balanced and unbalanced faults, and recognise that negative sequence current contributions may contribute to better system outcomes

The final rule will:

- Define a **control objective** in clause S5.2.5.5A(b)(2) 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.
- In the automatic access standard in clause S5.2.5.5A(f):
  - Require that asynchronous production units must have facilities capable of at least 4% and 6% of reactive current injection or absorption, respectively, for each 1% decrease or increase of positive sequence voltage at the connection point (applying to both balanced and unbalanced voltage disturbances).
  - Require that asynchronous production units must have facilities capable of supplying or absorbing negative sequence current (or equivalent contributions) to oppose unbalanced voltages during a disturbance.
- Specify in both the automatic and minimum access standard (in clause S5.2.5.5A(n)) that the required responses must be consistent with achieving the **control objective**.
- In clause S5.2.5.5A(t), require that the performance standards must record the response to balanced and unbalanced faults and transient over-voltages, including details of the facilities, the positive and/or negative sequence reactive current response (or some other method agreed with AEMO and the NSP), and details of control priority.
- In clause S5.2.5.5A(s)(2), clarify that the reactive current contribution and voltage deviation may be measured and assessed at a location other than at the connection point where agreed by AEMO and the NSP, and that the response must be set at levels consistent with the access standard at the connection point.

Changes from draft to final rule

- Rectifying minor drafting inconsistencies between the automatic access standard and minimum access standard in clauses S5.2.5.5A(f)(1) and S5.2.5.5A(f)(2)

The Commission's rationale for the final rule

Given the wide range of capabilities of inverter-based plant and facilities, the final rule defines a control objective to guide how parties should tune their plant, minimising the risk that plant settings and responses lead to sub-optimal power system outcomes, consistent with AEMO's proposal. By explicitly including negative sequence responses into the access standard, the final rule will also better align the requirements with best power system performance and will better recognise the capability of inverter-based plant, which will promote the NEO.

In addition, the Commission considers that performance standards should record sufficient details regarding plant response and control priority during unbalanced faults, given that the majority of faults on the power system are unbalanced faults.

Some stakeholders supported the proposed changes in our draft determination.[171] However, Vestas considered that introducing negative sequence response into the NER would be challenging for both the regulator and for proponents who may need to perform additional work to demonstrate compliance.[172] The Commission notes that the existing access standards, prior to our final rule, already require any negative sequence responses to be documented and explained.[173] The final rule better clarifies how negative sequence current responses should be recorded in the performance standards.[174]

Other stakeholders had various suggestions for improvements and clarifications – see appendix D for the Commission's consideration of these suggestions.

4.7 Clause S5.2.5.7 — Partial load rejection

This clause describes the requirements for plant to remain in continuous uninterrupted operation in case of a sudden power system load reduction (occurring in less than 10 seconds). This clause contributes to system security by preventing a potential cascade of plant tripping events and resulting power outages as a consequence of sudden load reduction of up to 30% for the automatic access standard and up to 5% for the minimum access standard.

4.7.1 The final rule will limit the application of clause S5.2.5.7 to synchronous plants only

Issues

This clause currently applies to all types of generating systems as well as integrated resource systems, which could include generating units, loads and bi-directional units. Moreover, under this clause, the requirement to remain in continuous uninterrupted operation following a load reduction event is currently subject to the loading level remaining above the minimum generation required for continuous stable operation.

Consequences

Clause S5.2.5.7 was originally drafted for synchronous generating systems, considering that some synchronous machines may have difficulty in maintaining their plant prime mover in stable operation for a load rejection event. This clause was extended to include all types of generating systems in 2018 by the *Generator technical performance standards* rule change, and subsequently to also include integrated resource systems in 2021 by the *Integrating energy storage systems into the NEM* rule change.[175],[176] However, AEMO's review found no benefit from extending this requirement to plant other than synchronous production units.[177] This is because asynchronous plant and batteries are inherently able to remain connected during load rejection events, questioning the need for them to explicitly prove compliance with this requirement. In addition, batteries are unlikely to have a minimum generation level for continuous stable operation since they can transition smoothly between generating and consuming power.

171 Submissions to the draft determination: Akaysha, p 6; Shell Energy, p 4; Windlab, p 7, Transgrid p 13.
172 Vestas, submission to the draft determination, p 3.
173 NER, clause S5.2.5.5(u)(3).
174 Clause S5.2.5.5A(t) of the final rule.
175 AEMC, Generator technical performance standards, Rule determination, 27 September 2018.
176 AEMC, Integrating energy storage systems into the NEM, Rule determination, 2 December 2021.
177 AEMO, rule change request, p 46.

The Commission's final rule

Box 20: Limiting application of S5.2.5.7 to synchronous production units only

The final rule will:

- Apply clause S5.2.5.7 only to synchronous production units.
- Amend the title of clause S5.2.5.7 to "Partial load rejection for synchronous production units"

Changes from draft to final rule

- None

The Commission's rationale for the final rule

Load rejection is most likely to affect synchronous production units only.[178] Hence, the Commission considers that excluding asynchronous plant and batteries from clause S5.2.5.7 will reduce:

- unnecessary duplication of requirements with limited benefits
- time and resources needed for compliance assessments

This will help streamline the connection process, which will promote the NEO. The Commission's formulation in the final rule allows for Tasmania to have a lower threshold, based on materiality in relation to the maximum credible contingency event size as specified in the frequency operating standard, while preserving a general threshold of 30 MW for other regions.

This amendment received strong support from several stakeholders in submissions responding to the Commission's draft determination.[179] The CEC welcomed this amendment noting that this clause is typically not problematic for asynchronous plant and will reduce modelling requirements. However, the ENA and Transgrid opposed this amendment, noting that partial load rejection may lead to simultaneous voltage and frequency disturbances, the impacts of which are not adequately covered by the separate assessment of voltage and frequency disturbances under other schedule 5.2 clauses.[180] While the Commission agrees that partial load rejection can lead to simultaneous voltage and frequency disturbances, asynchronous plant generally do not have any difficulty withstanding a partial load rejection. The Commission further considers that clause S5.2.5.7 is not intended to test for plant capability to withstand simultaneous voltage and frequency disturbances. Moreover, the Commission notes that all the applicable voltage and frequency standards in other schedule 5.2 clauses would still apply during simultaneous voltage and frequency disturbances. There are built-in allowances in those standards to account for them.

The ENA and Transgrid also raised concerns that limiting the application of clause S5.2.5.7 to synchronous generation does not adequately consider emerging plant technologies such as grid-forming asynchronous plant and the need for their load rejection performance during islanded operation. The Commission considers that excluding asynchronous plant from this clause does not and should not limit their ability to remain in continuous uninterrupted operation when islanded. Nevertheless, the Commission notes that AEMO has initiated a separate review of grid-forming technology access standards, including requirements for islanded operation, which is expected to result in another rule change proposal to address this issue more rigorously.[181] After

178 As currently defined in the NER, this includes synchronous bidirectional units but excludes synchronous condensers.
179 Submissions to the draft determination: Akaysha Energy, Tesla, Shell Energy, Vestas, Windlab and CEC.
180 Submissions to the draft determination: Transgrid, p 14-16; ENA, p 3.
181 AEMO, Grid-forming technology access standards review - OEM kickoff workshop slides, 4 December 2024.

considering all feedback, the Commission has decided to retain the language of the draft rule without any change.

4.7.2 The final rule will clarify the meaning of continuous uninterrupted operation for clause S5.2.5.7

Issues

This clause requires that a relevant plant must "be capable of" continuous uninterrupted operation during and following a power system load reduction or equivalent impact from separation of part of the power system in less than 10 seconds.

Consequences

AEMO's rule change request identified two issues with this clause as currently drafted:[182]

- There is ambiguity in the interpretation of "be capable of" in this context, specifically whether such capability must always be enabled or not.
- The definition of continuous uninterrupted operation in chapter 10 only allows substantial reductions in active power and reactive power after fault clearance when allowed by specified performance standards, which currently excludes clause S5.2.5.7. However, the definition does not explicitly allow reduction in active power and reactive power during a disturbance to provide frequency or inertial response to load reduction, even though it does allow contributing active and reactive current as required.

The Commission's final rule

Box 21: Clarifying meaning of continuous uninterrupted operation for partial load reduction

The final rule will:

- Amend clause S5.2.5.7 to:
  - Replace the term "be capable of" with "remain in"
  - Permit varying active power and reactive power to the extent required to oppose a voltage variation or frequency variation
- Amend the definition of continuous uninterrupted operation in Chapter 10 to:
  - Allow contributing active power and reactive power during a disturbance
  - Refer to "required or permitted by performance standards" without referring to specific clauses in order to be more general and consistent

Changes from draft to final rule

- Replaced the term "be capable of" with "remain in" also in clauses S5.2.5.3(b)-(c), S5.2.5.4(a)-(b), S5.3.9(c) and S5.3a.12(c) as consequential amendments for consistency based on the same argument as changes to clause S5.2.5.7.

The Commission's rationale for the final rule

These amendments under the final rule will:

- Clarify that clause S5.2.5.7 requires a plant to "remain in" continuous uninterrupted operation during and following a partial load reduction event, not just "be capable of" doing so. As load

182 AEMO, rule change request, p 47.

reduction events cannot be anticipated in advance, a plant must maintain settings that will always provide the necessary response.

- Ensure that beneficial responses to oppose voltage or frequency variation are permitted.

Gridmo supported replacing "be capable of" with "remain in" in its submission to the Commission's draft determination, noting that it will reduce ambiguity. Gridmo also suggested reviewing other instances in clause S5.2.5 for similar amendments, such as in clause S5.2.5.1.[183] Following Gridmo's suggestion, the Commission's final rule makes identical amendments in several other clauses to reduce ambiguity (as listed in the box above). However, the Commission has not made this change in clause S5.2.5.1 which pertains to capability requirements rather than remaining in continuous uninterrupted operation. Transgrid supported amending the definition of continuous uninterrupted operation in Chapter 10 and permitting varying active and reactive power, noting that these will make the performance requirements clearer in its submission to the Commission's draft determination.[184] These amendments did not receive any objections from any stakeholder.

Hence, the Commission has decided to retain the language of the draft rule, with the consequential amendments noted above. The Commission considers that removing ambiguity will help streamline the connection process, and permitting beneficial responses will help align with best power system performance, which will promote the NEO.

4.8 Clause S5.2.5.8 — Protection from power system disturbances

Clause S5.2.5.8 describes the requirements for plant to automatically reduce output power or disconnect in response to an over-frequency event. A reduction in output acts to lower the frequency of the system and thereby contributes to system security. The NEM still has several generating systems not currently providing primary frequency response, for which a response under clause S5.2.5.8 is valuable, as a contribution to managing a power system over-frequency event. This clause also serves to protect generating systems from power system disturbances by requiring them to disconnect under certain conditions.

4.8.1 The final rule will strengthen and streamline emergency over-frequency response requirements

Issues

The minimum access standard for clause S5.2.5.8(a)(2) currently describes three options for a generating system of 30 MW or more and an integrated resource system with bidirectional units of 5 MW or more to rapidly reduce active power in an over-frequency event.

Consequences

AEMO's review and subsequent rule change identified the following consequences associated with these three options:

- Clause 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 plant are permitted to trip (considering clauses S5.2.5.3 and S5.2.5.8(a)(1)), so the response might be too late to be useful.
- Clause S5.2.5.8(a)(2)(i)(A) 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

183 Gridmo, submission to the draft determination, p 3.
184 Transgrid, submission to the draft determination, p 16.

generating units) cannot physically achieve a reduction in output at the required rate safely. The same limitation might also arise with clause S5.2.5.8(a)(2)(ii), which describes a response proportional to the frequency deviation.

- Clause S5.2.5.8(a)(2)(i)(B) provides a third option to disconnect the plant, which is not desirable as it could reduce the power system inertia, leading to an increase in the rate of change of frequency.

AEMO's review and subsequent rule change also identified the following limitations with the application criteria of this clause:[185]

- 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.
- 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 a plant based on its connection to transmission or distribution.

The definition of 'disconnect' does not allow plant to disconnect other than at the connection point.

- The NER defines 'disconnect' as: 'The operation of switching equipment or other action so as to prevent the flow of electricity at a connection point.' The definition does not specify the location of switching, but does specify the outcome — that is, 'so as to prevent flow of electricity at a connection point'. In some circumstances, there may be some ambiguity in the definition as to whether it requires preventing all flow of electricity (including reactive power) through the connection point.

The Commission's final rule

Box 22: Strengthening and streamlining emergency over-frequency response

The final rule will in clause S5.2.5.8:

- For over-frequency response requirements, create an automatic access standard requiring frequency droop response, where droop has the meaning given in clause S5.2.5.11(a), and a minimum access standard allowing disconnection.
- For the automatic access standard:
  - 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 clause S5.2.5.3.
  - Make the 50% reduction requirements subject to the plant remaining above a minimum generation level for continuous, stable operation, where applicable.
  - Require any protection systems that operate based on measured voltage (as defined in clause S5.2.5.4(a0)(3)) must not commit to disconnect the relevant system or any of its operating production units within 20 milliseconds of the commencement of an over-voltage disturbance (exceeding 110% of nominal voltage) at the connection point.

185 AEMO, rule change request, pp 48-49.

- Provide that a negotiated access standard can only be accepted to the extent that physical plant limitations prevent compliance with the automatic access standard, and to that extent a negotiated access standard may include:
  - Droop response that is smaller or slower than the automatic access standard (as reasonable).
  - Rapid active power reduction, by fast ramping in preference to disconnection, at an agreed frequency trigger level and time lag.
- Amend the application criteria 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 for the relevant region. The latter allows a lower threshold for Tasmania (currently) while preserving a general threshold of 30 MW for other regions.
  - Remove the reference to transmission-connected, for the automatic and minimum access standards.

The final rule will amend the definition of disconnect in Chapter 10 to prevent the flow of electricity "to or from connected equipment" rather than "at a connection point".

Changes from draft to final rule

Amended clause S5.2.5.8(a2) to clarify that:

- Protection systems referred to are those that operate based on measured voltage as defined in clause S5.2.5.4(a0)(3), rather than "any voltage-related" protection system, which was in the draft rule.
- Protection systems must not "commit" to disconnect, rather than "act" to disconnect, within 20 milliseconds of "the commencement" of an over-voltage disturbance at the connection point.
- Over-voltage disturbance refers to voltage at the connection point exceeding 110% of nominal voltage, consistent with the requirements in clause S5.2.5.4.

The Commission's rationale for the final rule

The Commission considers that these amendments will:

- provide a clearer structure consistent with other access standards, creating an automatic access standard aligned with best power system performance, with disconnection in the minimum access standard being an option only where preferable responses are not feasible
- acknowledge the need for synchronous generation to maintain a minimum continuous level of generation
- correct and clarify 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
- coordinate the completion of the response with a frequency less than the upper limit of the extreme frequency excursion tolerance band to better align the automatic access standard with best power system performance
- make the standard technologically and geographically neutral. The size threshold allows adaptation for Tasmania's smaller power system, where the same size plant would have a larger impact on power system frequency than on the mainland

- allow for disconnection somewhere other than at the connection point while keeping ancillary plant in service.

These will promote the NEO as they will align the requirements with best power system performance, streamline the connection process, and support efficient investment and operation. The Commission considers that there is no benefit in specifying either a maximum ramp rate or a specific droop setting, as all technologies are covered by these requirements, and different technologies and plant have different capabilities.

Akaysha Energy, Windlab, Tesla, Transgrid, EPEC Group and the CEC supported these amendments in their submissions responding to the Commission's draft determination.[186] Windlab preferred these amendments as they explicitly allow negotiating the active power reduction rate for technologies that are not physically capable of achieving the automatic access standard rate, particularly wind turbines. APA noted that the automatic access standard could result in a plant having an overall compliant droop control system for the entire frequency range up to 52 Hz, but slightly poorer over-frequency performance between 50.15 Hz and 51.5 Hz. Based on historical events, the NEM will require better active power reduction capability for frequencies above 51 Hz to avoid load shedding. APA suggested considering requirements to reduce active power proportionately above a certain threshold or general requirements to record active power percentage reduction for frequencies above 50.5 Hz to maintain linear performance through the over-frequency range.[187] The Commission considers the automatic access standard in the final rule to provide the best combination of performance requirements. Having the time response linked to the upper limit of the extreme frequency excursion tolerance band (52 Hz for mainland) in the existing rules is not workable in practice because many generators are set to trip at 52 Hz, and it is probable that the power system would not be able to operate at that frequency.

Transgrid suggested clarifying explicitly in the negotiated access standard clause S5.2.5.8(b4) that frequency droop response is preferred over fast ramping. However, the Commission finds this unnecessary since the automatic access standard already requires droop response, with a specific negotiated access standard being acceptable only to extent that physical plant limitations prevent compliance with the automatic access standard. Transgrid also proposed to change "before the expiry of 3 seconds after the frequency reaches" to "within 3 seconds after the frequency reaches" for consistency with other sections of the NER. However, the Commission considers that this could lead to misinterpretation that the droop response should start within 3 seconds, whereas the intent is that the response should be completed within a 3 second window. Hence, the Commission has decided to retain the draft rule language in the final rule.

Gridmo noted that clause S5.2.5.8(a2) could be misinterpreted to imply that plant must not disconnect for any over-voltage disturbance. Therefore, Gridmo suggested clarifying that protection systems must not act to disconnect within 20 milliseconds of "the commencement of" an over-voltage disturbance.[188] EPEC Group noted that 20 milliseconds may be quicker than the physical response of breakers and suggested replacing "not act" with "not commit" to disconnect within 20 milliseconds. The Commission agrees that both these suggestions provide more clarity and has included them in its final rule.

186 Submissions to the draft determination: Akaysha Energy, p 7; Windlab, p 7; Tesla, p 2; Transgrid, p 16; EPEC Group, p 4; CEC, p 13.
187 APA, submission to the draft determination, p 13.
188 Gridmo, submission to the draft determination, p 2.

4.8.2 The final rule will require plant protection settings to be set to maximise capability to ride through disturbances

Issues

It is common for plant protection settings to be fixed just outside the required access standard conditions for continuous uninterrupted operation for frequency, rate of change of frequency and voltage.

Consequences

This fails to utilise plant capability that is available at no incremental cost, in circumstances where a plant is capable of safely remaining in operation for a materially wider operating range.

The Commission's final rule

Box 23: Utilising maximum available capability to ride through disturbances

The final rule, in the general requirements for clause S5.2.5.8, will require that:

- Except as otherwise required by AEMO or the NSP, a schedule 5.2 plant's protection settings must 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.
- Vector shift protection or similar protective functions must not operate for phase shifts less than 20 degrees (moved here from clause S5.2.5.16).

Changes from draft to final rule

- None

The Commission's rationale for the final rule

Under abnormal conditions, it will generally be more beneficial for power system resilience for a plant to remain connected for as long as it can continue to operate stably and safely. Hence, the Commission considers that this amendment will facilitate improved power system resilience at no incremental cost, which will promote the NEO.

Akaysha Energy, Windlab, Tesla and Transgrid supported this amendment in their submissions responding to the Commission's draft determination.[189] Shell Energy did not support this amendment noting that the possible unintended consequences from operating a plant well outside the required access conditions were unclear.[190] The Commission notes that the final rule explicitly states that plant protection settings must be maximised while maintaining safe and stable operation of the plant within safety margins consistent with good electricity industry practice. This implies that plant are required to give due consideration to safety margins to minimise any unintended consequences. The Commission further notes that the final rule allows different protection settings to be agreed with AEMO or the NSP to account for any specific plant capability limitations or other factors, if necessary. The Commission also anticipates appropriate testing to be done during commissioning to further verify optimum plant protection settings to

189 Submissions to the draft determination: Akaysha Energy, p 7; Windlab, p 7; Tesla, p 2; Transgrid, p 16.
190 Shell Energy, submission to the draft determination, p 5.

maximise the plant's capability to remain in operation for abnormal power system conditions while maintaining safe and stable operation of the plant within safety margins.

Gridmo also opposed this amendment due to concerns that even if a plant is fully compliant with the automatic access standard, the reviewing party could commence negotiations of not enough capability being offered or require further verification if the plant could offer more capability. This would add unnecessary negotiation and slow down the connection process.[191] The Commission's intent is to ensure that plant capability is not artificially limited simply to meet the performance standards, noting that the obligation is to 'meet or exceed' the performance standards.

The Commission notes that some stakeholders in AEMO's review commented that better alternatives to vector shift protection for the detection of islanding exist, such as topology-based schemes.[192] The Commission clarified in the draft determination that this amendment does not exclude or require any specific islanding detection scheme to be in place. It only prohibits the operation of vector shift protection or similar protective functions for phase shifts less than 20 degrees, for plant using such protective functions. This will be maintained by the final rule.

4.8.3 The final rule will move the vector shift requirement from clause S5.2.5.16 to clause S5.2.5.8

Issues

The current minimum technical requirements for vector shift protection relays has its own clause in schedule 5.2. It is inconsistent with the rest of schedule 5.2 for such a specific requirement to have its own clause.

The Commission's final rule

Box 24: Moving the minimum requirement for vector shift protection or similar functions to clause S5.2.5.8

The final rule will delete clause S5.2.5.16 and move these requirements into a new clause S5.2.5.8(b6) as part of the general requirements.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that the vector shift protection requirement will be better aligned with clause S5.2.5.8, which relates to the requirements for protection systems generally. Akaysha Energy, Vestas and Windlab supported this amendment in their submissions responding to the Commission's draft determination.[193]Vestas considered that this will reduce engineering effort to perform another series of studies for clause S5.2.5.16. This minor amendment did not receive any objections from any stakeholder. Hence, the Commission has decided to retain it in its final rule. This will streamline and clarify the application of the rules, which will help streamline the connection process, in accordance with the NEO.

191 Gridmo, submission to the draft determination, p 3.

192 AEMO review of technical requirements for connection (NER clause 5.2.6A), Appendix 2 to Final Report, p 56.

193 Submissions to the draft determination: Akaysha Energy, p 7; Vestas, p 3; Windlab, p 8.

4.9 Clause S5.2.5.10 — Detection and response to unstable operation

Clause S5.2.5.10 describes the requirements for plant to not cause any instability at the connection point. This clause serves to prevent any unstable operation from having an adverse impact on power system security.

4.9.1 The final rule will add new requirements for instability detection and response

Issues

The existing automatic access standard in clause S5.2.5.10 requires plant to have a protection system that trips them for unstable operation. This is intended to protect the network from active power, reactive power and voltage instabilities caused or amplified by a plant. However, currently there is no explicit requirement for a plant to have the capability to detect instability at the connection point and determine its contribution to the instability. The existing rules also do not have any provisions for asynchronous plant to undertake appropriate actions to manage the instability other than disconnection.

Consequences

Several NEM states have seen multiple oscillatory events in recent years with different levels of oscillation severity and frequency.[194]

These events needed to be individually investigated by NSPs and AEMO to identify the plant contributing to the instabilities, as accurately as possible.[195] 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 approach is not sustainable for a power system with a large and steadily increasing number of asynchronous plant. However, there are potential problems with disconnecting a plant based solely on the detection of oscillations or instability at the connection point, which may occur regardless of plant participation. In fact, a plant might be damping the oscillations, so disconnection based on the presence of an oscillation at the connection point alone might disconnect the wrong plant, which could exacerbate the oscillations or cause a supply deficit.

Moreover, there has been uncertainty in the interpretation and application of the automatic access standard and minimum access standard, causing delays and potentially sub-optimal outcomes in multiple connection projects for asynchronous plant in the past. For example, some concerns are:

- What types of instabilities should be covered under clause S5.2.5.10?
- Should plant be required to disconnect without considering their contribution to instabilities?
- Should plant be required to have the capability to detect their contribution to instabilities?
- Is prompt disconnection the best solution for a modern grid with high penetration of asynchronous plant?

The Commission's final rule

Box 25: Adding new requirements for instability detection and response

The final rule will:

194 AEMO, rule change request, p 50.
195 Ibid.

- Amend the automatic access standard for asynchronous production units to require:
  - Facilities to detect instability in voltage, reactive power and active power at the connection point
  - Facilities capable of disconnecting units for unstable behaviour, with configurable enablement conditions and settings agreed with the NSP and AEMO
  - On detection of instability, prompt execution of a hierarchy of actions based on configurable trigger conditions, thresholds and timeframes agreed with the NSP and AEMO and recorded in the performance standards.
- Amend the minimum access standard to:
  - Introduce an application threshold to apply it only for schedule 5.2 plant that can change the voltage at its connection point by more than 1% from the voltage with the plant not electrically connected, for system normal or planned outage conditions (considering the range of reactive power and active power capability established under clause S5.2.5.1).
  - Require facilities to detect instability in voltage, reactive power and, where relevant, active power at the connection point.
  - For asynchronous production units, require a process to manage instability at the connection point promptly on detection, in a manner agreed with the NSP and AEMO and recorded in the performance standards
  - For synchronous production units or synchronous condensers, require a protection system to disconnect them for sustained pole slipping, if required by the NSP or AEMO.
- Introduce a new requirement that all production systems with active power capability of 100 MW or more and synchronous condenser systems with a combined nameplate rating of 100 MVA or more, must have:
  - For the automatic access standard, access to a phasor measurement unit to send data for the system to AEMO and the NSP, and capability to receive information from AEMO relating to the system's contribution to instability, when available, in a form nominated by AEMO.
  - For the minimum access standard, the same as above, if required by the NSP or AEMO.

Changes from draft to final rule

- Omit the proposed amendment requiring any hierarchy of actions that includes disconnection to account for available automated information on the plant's contribution to the instability.
- Omit the proposed amendment explicitly requiring automatic execution of actions.
- Require the agreed hierarchy of actions under the automatic access standard and the agreed process under the minimum access standard to be recorded in the performance standards.

The Commission's rationale for the final rule

The Commission considers that the final rule will:

- recognise that a range of responses may be preferable to disconnection
- provide 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, considering power system needs and plant capabilities
- allow for detection, monitoring and response of the plant's own contribution to instability as those capabilities mature

- allow for both a local and a future centralised system to identify plant contributing to the instability, for visibility and control of response, with size thresholds balancing risk and efficiency.

The Commission notes that submissions responding to the draft determination contained no in-principle objection to requiring facilities for instability detection. Akaysha Energy noted that it currently installs such equipment at all its sites but has disabled trip signalling on all of them.[196] However, several stakeholders objected to disconnecting plant on the basis of any available automated information about a plant's contribution to instability.[197] There were also major concerns about disconnecting the wrong plant and exacerbating instabilities. Transgrid noted that any implementation of tripping should be considered with caution and should only be applied in cases of significant instability.[198] APA flagged that most current instability detection systems have not fully demonstrated their capability to determine a plant's contribution to oscillations and hence, cannot be considered proven to be used for threshold-based disconnection.[199] Tesla noted that moving from AEMO's current offline, time-consuming processes to an online detection and response system would require substantial investment, particularly in SCADA interfaces and local detection mechanisms. Tesla recommended further consultation, trials, and testing before finalising any changes.[200]

Akaysha Energy, while being supportive of a move to a more automated process with better integration of detection systems to manage disconnections, noted that this will require more work on trials and testing before the best approach is finalised. Akaysha Energy recommended postponing this specific change until more testing and trials have been undertaken, and AEMO establishes guidance on interpretation of response requirements to this clause.[201] The CEC noted that oscillation detection systems in the NEM are in their infancy and currently being trialled, and that the CEC members have raised concerns around automatic disconnection in the absence of a proven scheme. The CEC recommended that automatic disconnection not take place until a solution is proven, otherwise this could have an adverse impact on the power system.[202] AGL supported having facilities to detect instability and the capability to disconnect units for unstable behaviour. However, AGL considered that requiring immediate manual disconnection after receiving instructions from AEMO and the NSP would strike the right balance without introducing an unnecessary risk to power system security.[203] Windlab had similar views.[204]

In light of all feedback received, the Commission considers it prudent to take a more cautious approach at this stage. Hence, the final rule no longer explicitly requires that any actions in response to an instability that involve disconnection must account for available automated information on a plant's contribution to the instability or automatic execution of those actions. The Commission acknowledges that instability detection technologies are still maturing and disconnecting the wrong plant could exacerbate instabilities, hence, automatic disconnection may need greater certainty. However, the final rule retains the requirement to install facilities capable of instability detection and disconnection (including the ability to send/receive data remotely) as this will:

196 Akaysha Energy, submissions to the draft determination, p 7.
197 Submissions to the draft determination: APA, p 14; Akaysha Energy, p 7; Tesla, pp 2-3; CEC, p 13; AGL, pp 1-2; Windlab, p 8.
198 Transgrid, submission to the draft determination, p 19.
199 APA, submission to the draft determination, p 14.
200 Tesla, submission to the draft determination, pp 2-3.
201 Akaysha Energy, submission to the draft determination, p 7.
202 CEC, submission to the draft determination, p 13.
203 AGL, submission to the draft determination, pp 1-2.
204 Windlab, submission to the draft determination, p 8.

- Allow AEMO and NSPs to conduct controlled field trials and develop better strategies to manage instabilities in a coordinated manner.
- Enable conducting additional studies to determine plant contribution to instability and mitigate system security risks from automatic disconnection.

The AEMC staff discussed this revision at the 27 March workshop, and it was well-supported by the majority of stakeholders. Some stakeholders noted that automatic disconnection could be necessary to protect plant from damage in certain cases. Transgrid supported the overall policy intent but preferred retaining the automatic execution requirement. The Commission notes that the final rule still requires prompt execution of a hierarchy of actions (automatic access standard) or a process (minimum access standard) to manage instability upon instability detection, which can include automatic execution if agreed by the NSP and AEMO. Hence, the final rule does not preclude automatic execution of actions, including disconnection, even though it no longer explicitly requires it. Also see appendix D for the Commission's consideration of several other comments pertaining to clause S5.2.5.10 received in submissions to the draft determination.

The Commission considers that the final rule presents a balanced approach to reduce power system security risk while avoiding unintended consequences, which will further the NEO. The hierarchy of actions required under the automatic access standard must be agreed with AEMO and the NSP. The Commission considers that scrutiny of the proposed triggers, conditions and actions will avoid the potential for increased risk to power system security that might arise from simply tripping a plant that detects an oscillation at its connection point. These changes will promote the NEO as they will align the requirements with best power system performance, improve power system resilience, streamline the connection process, and support efficient investment and operation.

4.10 Clause S5.2.5.13 — Voltage and reactive power control

While clause S5.2.5.1 describes the reactive power capability that is required from plant, and clause S5.2.5.4 describes the continuous uninterrupted operation requirements for plant following a voltage disturbance, clause S5.2.5.13 describes the required performance of a plant's control system. The control system governs how plant adjusts its reactive power output to support network voltages and power system stability. Improperly tuned control systems can inadvertently cause greater instabilities in response to a fault, which may also depend upon network conditions or the behaviour of nearby plant.

4.10.1 The final rule will remove impediments to unit-level voltage control

Issues

The current setpoint-related rise time and settling time requirements of clause S5.2.5.13 is not well suited for connection applicants who wish to use voltage control strategies at a unit level.

Consequences

Typically, a power plant controller controls the voltage of the entire plant by sending global commands to each unit in the plant. However, this type of control can be less stable than unit-level control in low system strength conditions and is less resilient to communication failures between the power plant controller and the individual units. Moreover, grid-forming inverters often utilise and benefit from unit-level voltage control.

When using unit-level voltage control, compliance with the current setpoint-related rise time and settling time requirements in clause S5.2.5.13 is often difficult, and may not provide a clear power

system benefit. This can unnecessarily delay the connections process, especially for many grid-forming inverter-based plant.

The Commission's final rule

Box 26: Remove impediments to implementing unit-level voltage control

The final rule will:

- In the general requirements at clause S5.2.5.13(n), specify that limits on the rate of change of setpoint (rate limits) may be applied to schedule 5.2 plant for normal operating conditions. If used, the performance standard must record details of the rate limits applied.
- By the inclusion of Table S5.2.1, the use of ramp limits can be applied to setpoint changes when plant is operating in voltage, reactive power and power factor modes.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

With grid-forming technology expected to be more common throughout the energy transition, the Commission considers that clarifying the voltage control requirements will remove any unnecessary impediments to grid-forming technologies. This is essential to support efficient investment in new connections that will support the stability of the power system, in accordance with the NEO.

Transgrid and Windlab both supported this change in their submissions to the draft determination.[205]

4.10.2 The final rule will prioritise stability over the speed of a plant's response across a range of system impedances

Issues

The requirements in clause S5.2.5.13 for voltage control use maximum rise times and settling times as a measure of stability. However, fast rise or settling times do not always imply stable responses, especially when the range of system impedances experienced in a network can be very large and volatile. Due to synchronous generator retirement and increasing amounts of inverter-based resources connecting to the system, networks are expected have less system strength on average, with the levels of system strength (and consequently, system impedances) being more closely correlated to generator dispatch profiles.

Consequences

If plant controls are set only with low system impedance conditions in mind, the response may not be appropriate for high system impedance conditions, and is more likely to be unstable. For example,

- At low system impedances (high system strength conditions), responses are generally slower, but more stable.

205 Submissions to the draft determination: Transgrid, p 20; Windlab, p 8.

- At high system impedances (low system strength conditions), responses are generally faster, but less stable.

AEMO considers that stability should generally be prioritised over the speed of a response, but this is also not explicitly considered in the negotiated access standard within clause S5.2.5.13.[206] This could potentially lead to plant meeting the automatic access standard, but still exhibiting unstable behaviour under certain system conditions, risking power system security.

The Commission's final rule

Box 27: Prioritising stability over speed of responses across a range of typical to highest system impedances

The final rule will:

- In the automatic access standard at Table S5.2.1:
  - For asynchronous units only, require a rise time of less than 3 seconds for a voltage disturbance between 2% and 5%, for the typical and maximum system impedances as nominated by the relevant NSP
  - For all schedule 5.2 plant, require 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 maximum system impedances
  - The 7.5 second settling times also apply to steps out of a limit.
- In the minimum access standard at Table S5.2.2:
  - Permit a longer settling time than the current requirement of 7.5 seconds if agreed by the NSP
- In the negotiated access standard at clause S5.2.5.13(f), prioritise stability of response under high impedance conditions if the automatic access standard cannot be met.
- In the general requirements under clause S5.2.5.13(m), require the NSP to nominate, and the Schedule 5.2 participant to record in the relevant Releasable User Guide, the typical and highest system impedance values at the connection point that will be used for tuning of controls and assessment of compliance for clauses S5.2.5.1, S5.2.5.5 and S5.2.5.13, where:
  - The typical system impedance is a value that the NSP considers representative of a typical network configuration and typical levels of schedule 5.2 plant in service
  - Unless otherwise agreed by the NSP and AEMO, the highest system impedance must be 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 single network element outage that would cause the greatest reduction in the three phase fault level at the connection point.

Changes from draft to final rule

- Clarified that the range of system impedances nominated by the NSP for tuning of controls will be used across clauses S5.2.5.1, S5.2.5.5 and S5.2.5.13, consistent with the changes to clause S5.2.5.5.
- Clarified that the system impedances nominated by the NSP must be at the connection point.

206 AEMO, rule change request, pp 53-54.

- Allowed discretion to the NSP and AEMO to agree to use a different methodology to determine and nominate the highest system impedance at the connection point.
- Clarified that the highest system impedances must consider a 'single network element outage' under the conditions described in clause S5.2.5.13(m)(1) (the draft rule had unintentionally omitted the words 'single' and 'element').

The Commission's rationale for the final rule

As the current access standards were written at a time when the system only experienced a narrow range of system impedances, the Commission considers it sensible to adjust the requirements of clause S5.2.5.13 to reflect the reality of the current power system. This will enable connection applicants to better align their plant performance with optimal power system outcomes, which will promote the NEO.

The final rule's explicit prioritisation of stability in the negotiated access standard will also provide flexibility for connection applicants to negotiate their voltage control capability where the automatic access standard is not practical, while still promoting optimal plant performance for the system. This will help improve power system resilience, contributing to the NEO.

Consistent with the Commission's reasoning for amending clause S5.2.5.5 for multiple fault ride through requirements (see section 4.5.3), the final rule requires NSPs to nominate the range of impedances (from typical to highest) that the connecting schedule 5.2 plant must be tuned to and assessed against.

Akaysha, CEC, Vestas and Windlab supported the Commission's draft rule on this issue, with some welcoming clearer expectations that may help reduce simulation work and model tuning iteration cycles.[207] The CEC and EPEC requested clarification on how NSPs will calculate and nominate the range of impedances, or questioned whether the changes would add more studies to the existing assessment process.[208] Meanwhile, Transgrid disagreed with the use of a typical system impedance in the access standard and considers the concept is misleading, citing several reasons.[209]

Although calculation and detailed assessment matters are generally best left to guidance material, the Commission considers that a typical system impedance should be consistent with a system normal Operations and Planning Data Management System (OPDMS) snapshot that may be provided by AEMO during the connections process. While the Commission acknowledges that generation types and dispatch patterns can cause the impedance to vary significantly, the snapshot can be modified to incorporate any nearby considered projects, while ensuring that plant tuning and controls are focused on low to typical system strength conditions.[210] This is an improvement over the current access standard, where the range of fault levels (or system impedances) that the plant should be tuned to are not specified; as EPEC noted, current assessments are often conducted over the entire range of minimum to maximum short circuit ratios. This is a very large range that results in extra work for the proponent, without always

207 Submissions to the draft determination: Akaysha, p 7; CEC, p 14; Vestas, p 3; Windlab, pp 8-9.

208 Submissions to the draft determination: CEC, pp 14-15; EPEC, p 4.

209 Transgrid, submission to the draft determination, p 20.

210 This is consistent with AEMO's feedback in its final report — see AEMO review of technical requirements for connection (NER clause 5.2.6A), Appendix 2 to Final Report, p 67.

resulting in material power system benefits due to a lack of focus or prioritisation of system stability.

As discussed in section 4.5.3, the Commission considered whether expressing the range system conditions in terms of fault level, instead of impedances, would provide greater benefit to parties. Following stakeholder feedback from the 27 March workshop, the Commission considers that expressing the range of conditions as an impedance range is slightly preferable, because clause S5.2.5.13 deals with plant tuning and controls during normal operation, rather than fault conditions.[211] Although the range of impedances will also be used for fault conditions for the purposes of clause S5.2.5.5, it is easy to convert between an impedance and the corresponding fault levels after a disturbance, so the Commission sees no issue with expressing this range an impedance range.

4.10.3 The final rule will add materiality thresholds on settling time error bands

Issues

Clause 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 currently defined in the NER, settling time calculation is based on the output quantity reaching within a 10% error band.

Consequences

For a small transient change, the error band becomes very small and the settling time calculation becomes meaningless. This can give rise to issues with compliance assessment since:

- active power excursions, in particular, tend to be quite small for the step changes contemplated in clause S5.2.5.13
- voltage and reactive power, particularly in the compliance testing scenario where noise and measurement errors are present, may face challenges with settling time calculation when error bands are in the order expected for noise.

The Commission's final rule

Box 28: Adding materiality thresholds on settling time error bands

In general requirements at clause S5.2.5.13(l), 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 using the definition of settling time and:

- For active power, the higher of ±0.5 MW or ±2% of the maximum active power (Pmax) recorded in the performance standard for clause S5.2.5.1
- For reactive power, the higher of ±0.5 MVAr or ±2% of the reactive power capability recorded in the performance standard for clause S5.2.5.1
- For voltage, ±0.5% of nominal voltage.

Changes from draft to final rule

- None

211 AEMO review of technical requirements for connection (NER clause 5.2.6A), Draft report, p 79.

The Commission's rationale for the final rule

The Commission considers that the final rule will:

- allow scaling of the error band relative to the size of the plant ensuring that settling time calculation returns a meaningful value
- reduce unnecessary effort during the connection process in dealing with non-compliance associated with the existing poor definition and lack of materiality consideration.

Windlab supported the Commission's proposal in its submission to the draft determination, stating that it would have expedited the connection process for previous Windlab projects.[212] EPEC considered that the proposed amendment to clause S5.2.5.13(l) was not clear on whether the error is intended to be a dynamic or steady state measurement. It also suggested reconsideration on the active and reactive power thresholds as a 2% change for low Pmax values may be comparable with signal noise.

The Commission intends that the error band for determining whether settling time requirements have been met is a calculated band, while the determination of whether the response stays within the error band must necessarily be a dynamic measurement. Additionally, if a 2% change is too small, then the relevant threshold will be +/- 0.5 MW or MVAr, which should be large enough to distinguish from signal noise.

The CEC recommended that the 2% thresholds should be amended to refer to the 'maximum reactive power capability', instead of simply the 'reactive power capability,' as the reactive power capability can vary for different active power outputs.[213] However, we note that *reactive power capability* will be a defined term with a new definition under the final rule, and is determined with reference to the maximum active power (or Pmax) in clause S5.2.5.1. As such, the Commission does not consider that additional clarification is required in clause S5.2.5.13(l).

Through the final rule's introduction of materiality thresholds for settling time error bands, assessment and compliance against S5.2.5.13 should be clearer and reduce any related delays in the connections process. This will help streamline the connection process and will contribute to the NEO.

4.10.4 The final rule will amend and clarify requirements for multiple modes of operation and treatment of voltage settling time for reactive power and power factor modes

Reactive power capability can be used in several ways to support the power system and facilitate power flows. Production units generally use their reactive power capability to control voltages at the connection point by injecting reactive power to increase voltages and absorbing reactive power to reduce voltages. In addition to voltage control, production units can maintain a ratio between active power and reactive power, being the power factor, or directly controlling the amount of reactive power to a target.[214] Operation in power factor and reactive control modes is less common than for voltage control.

Issues

The existing automatic access standard of clause S5.2.5.13 requires a generator and integrated resource provider to operate in multiple reactive power control modes, switch between modes, and be able to do so through remote control in response to a command from AEMO. Requiring operation in three modes requires all the activities of connection and compliance to be repeated

212 Windlab, submission to the draft determination, p 9.

213 CEC, submission to the draft determination, p 14.

214 Note: Power factor is defined as the ratio of active power to apparent power, which is fundamentally related to reactive power.

for each mode. This is a non-trivial cost over the life of the plant if only one mode is ever likely to be used. Requiring full connection assessment and compliance with each mode may be overly onerous without justifiable power system benefits.

The compliance arrangements specified in clause S5.2.5.13, applying to each mode of operation, are specified for voltage control but not for power factor or reactive control modes. In reactive power and power factor modes, voltage is not directly controlled, so it is not appropriate to assess compliance against voltage settling time for these modes. Also, the speed and stability requirements for power factor and reactive power modes are too specific and will benefit from additional flexibility.

Consequences

Automatic access standards that require compliance and assessment of reactive power connection modes that are seldom if ever used slow the connection process and impose unjustifiable costs on connecting applicants. This does not support an efficient connection process or support efficient investment and operation.

The Commission's final rule

Box 29: Amending and clarifying requirements for multiple modes of operation and treatment of voltage settling time for reactive power and power factor modes

The Commission's final rule is to make the following changes to the automatic access standard in clause S5.2.5.13:

- In clause S5.2.5.13(b)(2A), require that voltage control mode must be the primary control mode, unless the NSP requires a different primary mode; in which case, voltage must be the secondary control mode.
- In clause S5.2.5.13(b)(2A), also specify that plant must operate in primary mode in normal operation, while secondary mode is for testing, abnormal power system conditions or abnormal plant operating conditions.
- In Table S5.2.1, where voltage is the secondary mode, omit the rise time requirement.
- In Table S5.2.1, for secondary modes, only require assessment for typical system impedance because probability of high impedance operating conditions while operating in this mode is very low, and to test compliance there will need to be performance requirements for typical impedance conditions.

The final rule will, in the automatic access standard and minimum access standard in Table S5.2.1 and clause S5.2.2, respectively:

- remove the requirement to assess voltage settling time for power factor and reactive power modes
- remove the requirement to assess active power settling time for the reactive power mode.

Changes from draft to final rule

- In Table S5.2.1, in the automatic access standard, for voltage or reactive power as the secondary control mode, import the settling time requirements for a setpoint change for reactive power or power factor as primary.
- In Table S5.2.1, in the automatic access standard, include settling time criteria for reactive power and power factor as primary in the automatic access standard.

The Commission's rationale for the final rule

The Commission's final rule is largely the same as its draft rule in relation to multiple modes of operation and treatment of voltage settling time for reactive power and power factor modes. The Commission retains its view that the existing automatic access standard that required operation in all three modes, with the capability to switch between them, imposes costs that are unjustified by the potential system security benefits.

Under the final rule, the automatic access standard maintains the requirement for the capability to operate in multiple modes of operation, but better promotes efficient outcomes by aligning capability with actual system needs. The final rule will maintain the flexibility for AEMO and the NSP to manage abnormal power system conditions including changes in power flows following separation events by requiring a generator to switch modes of operation.

In response to the draft determination, many stakeholders broadly supported the proposed changes.[215] However, there were also a wide variety of suggestions to Table S5.2.1 and S5.2.2 to improve clarity, correct drafting errors, or to slightly modify the intent of the proposed changes.[216]

The CEC and Transgrid noted that the draft rule did not include secondary control mode settling time requirements for the automatic access standard in Table S5.2.1.[217] The CEC also noted that it would be difficult to demonstrate performance without a requirement for a setpoint change.[218] After further consideration, the Commission has imported the settling time requirements for a setpoint change for reactive power or power factor as primary. This will make it easier to determine and assess a performance standard when voltage or reactive power is a schedule 5.2 plant's secondary control mode.

Transgrid also suggested reducing the settling time requirement in the automatic access standard for reactive power and power factor as primary operating modes, and considered that it was unclear why there was a large disparity in requirements between limiter and non-limiter activation.[219] The Commission agrees that settling time criteria should be specified for limiter activation, and has incorporated:

- a 7.5 second settling time requirement, when the response overshoots the sustained change, or the response is oscillatory
- a 30 second requirement otherwise.

This is consistent with settling time requirements for a voltage disturbance, as proposed in the draft rule. By including these changes, the final rule better clarifies the expectation for operation into a limit for these control modes, promoting power system security.

In making the final rule, the Commission also considered several other suggestions provided by stakeholders in submissions to the draft determination. See appendix D for more information on the Commission's consideration of each suggestion.

The Commission considers the final rule will address this issue and promote the NEO by aligning requirements with best power system performance, streamlining the connection process, and supporting efficient investment and operation.

215 Submissions to the draft determination: Akaysha Energy, pp 7-8; CEC, p 14; Shell Energy, p 5; Tesla, p 3; Transgrid, p 21; Vestas, p 5.
216 Submissions to the draft determination: CEC, p 14; EPEC, p 5; gridmo, p 2; SMA, p 4; Transgrid, pp 21-23.
217 Submissions to the draft determination: CEC, p 14; Transgrid, p 22.
218 CEC, submission to the draft determination, p 14.
219 Transgrid, submission to the draft determination, p 22.

The Commission considers its final rule takes an appropriate risk-based approach to testing and compliance, allowing connections to be streamlined but not compromising power system performance align the requirements with best power system performance.

4.10.5 The final rule will recognise system strength services provided by system strength service providers

Issues

A plant that has an adverse impact on system strength may elect to pay the relevant system strength service provider (SSSP) to provide these services.

Consequences

The system strength services provided by the SSSP (or that may be provided in the future) is not currently considered in clause S5.2.5.13. This means that where a schedule 5.2 participant has paid the system strength charge, the requirements on the schedule 5.2 plant will be overly onerous as it does not consider the system strength (and associated voltage and reactive power control) provided by the SSSP.

The Commission's final rule

Box 30: Ensure that assessments for clause S5.2.5.13 should consider the system strength services to be provided by a SSSP

The final rule will, in the general requirements at clause S5.2.5.13(o), include a requirement that where a connection applicant has elected to pay the system strength charge for its plant, the assessment for the access standard should take into account the services that would be provided by the relevant SSSP.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that participants who pay the system strength charge (rather than self-remediate their adverse system strength impact) should expect that system strength services will be provided by the relevant SSSP. Therefore, when performing assessments and demonstrating compliance against clause S5.2.5.13, the SSSP's services should be considered alongside the plant's performance.

This will help deliver the benefits of the system strength framework by not imposing any unnecessary costs on the connection applicant that may not be required due to the SSSP's services. This will promote the NEO as it will support efficient investment and operation for connecting inverter based plant.

In response to the draft determination, Transgrid and Vestas requested clarity as to how connection applicants may face less onerous requirements under clause S5.2.5.13 if they pay the system strength charge, referring to the Commission's draft determination.[220] The Commission wishes to clarify that the intent of new clause S5.2.5.13(o) is to ensure that the SSSP's services are taken into account, which may or may not improve the performance of the plant. For example,

220 Submissions to the draft determination: Transgrid, p 22; Vestas, p 3.

the damping performance of the plant may be improved by a network synchronous condenser provided by the SSSP.[221] However, clause S5.2.5.13(o) does not relieve the connecting schedule 5.2 plant from the requirements in clause S5.2.5.13.

4.11 Definitions of continuous uninterrupted operation, rise time and settling time

Chapter 10 of the NER defines the terms "continuous uninterrupted operation", "rise time" and "settling time", which are used throughout schedules 5.2, 5.3 and 5.3a. These definitions serve to provide clarity on the meaning and application of these terms in the respective clauses.

4.11.1 The final rule will amend the definition of continuous uninterrupted operation to recognise frequency response mode, inertial response and active power response to angle jump

Issues

The definition of continuous uninterrupted operation is used in clauses S5.2.5.3, S5.2.5.4, S5.2.5.5 and S5.2.5.7, which relate to ride through requirements for frequency disturbances, voltage disturbances, contingency events and partial load rejection, respectively. The definition is also used in clause S5.2.5.8, in reference to those other clauses. Although the definition applies to multiple types of disturbances, it fails to adequately account for the types of responses that can occur under these disturbances.

Consequences

Such responses may be beneficial for some disturbances and permissible for others given those benefits. In particular, the definition of continuous uninterrupted operation does not currently anticipate active power response opposing phase angle jumps and primary frequency response including inertial response opposing frequency changes.[222] The absence of any allowance for such responses may disincentivise their provision, despite being beneficial to power system operation.

The Commission's final rule

Box 31: Amending the definition of continuous uninterrupted operation to recognise beneficial responses

The final rule will modify the definition of continuous uninterrupted operation and relevant access standard clauses to permit inherent or programmed responses opposing voltage phase angle jumps and frequency changes, including inertial response during disturbances.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The final rule will:

- ensure that beneficial responses are not inadvertently prevented

221 See AEMO's review of technical requirements for connection, Draft report p 62.

222 Refer to AEMO's review of technical requirements for connection, Draft report pp 91-92, for additional technical discussion on these responses.

- remove impediments and speed up connection process for grid-forming inverters, since inertial response is programmed in grid-forming inverters rather than inherent.

This will promote the NEO as it will align the requirements with best power system performance, streamline the connection process, and improve power system resilience.

4.11.2 The final rule will amend the definition of rise time to explicitly disregard longer-term dynamics and external influences

Issues

Rise time is currently defined in Chapter 10 of the NER 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.

Consequences

AEMO's review and subsequently the rule change request identified two adverse consequences of the current definition:

- The definition provides a longer time for a response with a higher overshoot (i.e. maximum change). It is more usual to describe the rise time in terms of 10% - 90% of the mean sustained change.
- The definition is used in clauses S5.2.5.5 and S5.2.5.13. In clause 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. Similarly, in clause S5.2.5.13, the effect of longer-term dynamics should be disregarded for rise time calculation, or misleading results can be obtained.

The Commission's final rule

Box 32: Amending the definition of rise time

The final rule will amend the definition of rise time in Chapter 10 to:

- Refer to the "mean sustained change" rather than the "maximum change" induced
- Disregard longer-term dynamics and influences external to the generating system, following the step change.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The final rule will help 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-emphasise the effect of longer-term dynamics. Hence, the Commission considers the final rule will promote the NEO.

4.11.3 The final rule will simplify the definition of settling time

Issues

Settling time is currently defined in Chapter 10 of the NER in two parts based on the ratio of the maximum deviation to the sustained change.

> 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

Consequences

The assessment band for settling time depends on the magnitude of the change. This is intended to allow settling time to be calculated when the sustained change is very small, as well as when it is large. However, when both maximum and sustained changes are small (e.g. in case of a shallow fault), the error band can be too small for a meaningful assessment of settling time.

The Commission's final rule

Box 33: Amending the definition of settling time

The final rule will delete paragraph (a) from the definition of settling time in Chapter 10, in conjunction with materiality thresholds described for P, Q and V in the context of settling time under clause S5.2.5.13.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that a simplified definition will reduce confusion about whether paragraph (a) or (b) of the current definition applies to error calculation. The final rule also makes AEMO's proposed change to explicitly manage the error bands for small changes by amending clause S5.2.5.13 in conjunction with removing settling time from clause S5.2.5.5A.[223] This will promote the NEO as it will align the requirements with best power system performance and streamline the connection process.

223 Refer to section 4.10.3 and section 4.6.2 for these amendments.

5 The final rule will amend the access standards for HVDC links

This section outlines the Commission's final NER amendments (primarily in schedule 5.3a) to advance the NEO by improving the access standards for HVDC links[224], based on the recommendations in AEMO's review and rule change request.[225]

5.1 Clause S5.3a.8 — Reactive power capability

Reactive power is necessary to control voltages and enable power to flow from generation to load. Reactive power capability is provided by generators and integrated resource providers to control voltages at their connection points. HVDC connections also contribute reactive power capability. The Commission's final rule aligns access standards for HVDC connections with the capability brought by modern HVDC converter plant.

5.1.1 The final rule will align the reactive power capability of HVDC links with schedule 5.2 plant

Issues

At present, the reactive power requirements for HVDC links in clause S5.3a.8 are specified through power factor ranges. The power factor is the ratio of real power to apparent power, which describes how much reactive power is being absorbed or supplied.[226] In contrast, the reactive power requirements in schedule 5.2 are specified in terms of its capability to inject or absorb reactive power depending on the voltages at its connection point.

However, modern HVDC links have the same capability of generating systems or integrated resource systems to provide reactive power, which can 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.

Consequences

Existing arrangements are not consistent with HVDC links efficiently delivering capabilities to support the power system. As the power system transitions, reactive capability will become more important given the variability of power flows in a future power system with higher proportions of inverter-based plant. Hence, existing arrangements are inefficient as more expensive reactive capability will be required from other sources.

The Commission's final rule

Box 34: Aligning HVDC reactive power capability with schedule 5.2 plant

- Amend clause S5.3a.8 to apply the equivalent reactive power capability requirements in the automatic and minimum access standards for clause S5.2.5.1 to HVDC links, by reference.

224 Currently limited to MNSP facilities in schedule 5.3a, but would be amended to extend to all HVDC links as described in Chapter 3.

225 Refer to section 6 of AEMO's rule change request document Overview of rule change proposals to improve NEM access standards available from the AEMC website. Detailed stakeholder feedback and AEMO analysis can be found at AEMO review of technical requirements for connection (NER clause 5.2.6A).

226 For example, a power factor of 1 means that there is no reactive power being supplied or absorbed, while a power factor of 0.9 means that approximately 0.436 VAr of reactive power is being supplied or absorbed for every 1 VA of apparent power.

- Apply equivalent provisions for negotiated access standard and general requirements as under clause S5.2.5.1.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission's final rule reflects its draft rule. The Commission considers the final rule promotes the NEO by effectively supporting system security by aligning modern HVDC reactive power capability with power system needs. No stakeholder objections or comments were received to the draft rule.

Existing HVDC reactive power requirements no longer reflect the reactive power capabilities from modern power electronic based HVDC converters. Modern HVDC can reasonably achieve the same reactive power capabilities required under clause S5.2.5.1 for schedule 5.2 plant. The final rule to align reactive power capability requirements for HVDC links with those for schedule 5.2 plant is efficient as it unlocks the inherent capabilities of modern HVDC voltage source converters and will avoid the requirement to invest in more expensive reactive power capability from other sources to support voltages in the network. This will promote the NEO as it will align requirements with best power system performance, improve power system resilience and support efficient investment and operation.

5.2 Clauses S5.3a.13 & S5.3a.14 — Response to disturbances in the power system

Clause S5.3a.13 describes the continuous uninterrupted operation requirements for HVDC links in response to disturbances in the power system, which serve to maintain system security. Clause S5.3a.14 defines the abnormal power systems conditions under which HVDC links are permitted to automatically disconnect in order to protect themselves. These clauses are important since the continuous uninterrupted operation of HVDC links is critical to prevent islanding and support adequacy of supply, system strength and inertia in the NEM.

5.2.1 The final rule will align voltage disturbance requirements for HVDC links with schedule 5.2 plant

Issues

Currently, the voltage ride through requirement for HVDC links is to maintain continuous uninterrupted operation for the range of voltage conditions permitted in the system standards (at clause S5.1a.4).[227] However, the requirements for schedule 5.2 plant to remain in continuous uninterrupted operation at clause S5.2.5.4 cover a wider range of voltage conditions permitted in the system standards. They are also significantly more rigorous to provide better power system resilience for many non-credible contingency events.

Consequences

Despite modern HVDC links having similar voltage disturbance capability to inverter-based plant, the requirements between clauses S5.2.5.4 and S5.3a.13 are not consistent. Moreover, if large HVDC systems do not have the same capability as schedule 5.2 plant, then the likelihood that it

227 Clause S5.3a.13(a).

trips in response to a voltage disturbance is increased, potentially creating a cascading outage that risks power system security.[228]

The Commission's final rule

Box 35: Aligning voltage disturbance requirements for HVDC links with schedule 5.2 plant

- Amend clause S5.3a.13 to apply the equivalent voltage disturbance power capability requirements in the automatic and minimum access standards for clause S5.2.5.4 to HVDC links.
- Apply the general requirements of clause S5.2.5.4 into the general requirements of clauses S5.3a.13.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that the power system will significantly benefit from aligning the voltage ride through requirements for HVDC links to the requirements in clause S5.2.5.4. As modern HVDC links have similar capabilities to inverter based plant, having similar access standards for HVDC links will improve power system resilience to a wider range of voltage disturbances at low incremental cost, which will promote the NEO.

Moreover, by adopting an automatic access standard and minimum access standard for this requirement, a connection applicant for an HVDC link has the added flexibility of negotiating a suitable performance standard in circumstances where meeting the automatic access standard is too onerous. This will deliver power system benefits from HVDC links in a more cost-effective manner than the status quo because there is currently no negotiation range available to HVDC connection applicants in cases where meeting the fixed standard in existing clause S5.3a.13 may be too costly or impractical. This will also promote the NEO by supporting more efficient investment and operation.

5.2.2 The final rule will align frequency disturbance ride through requirements for HVDC links with schedule 5.2 plant

Issues

Currently the frequency ride through requirement for HVDC links is to maintain continuous uninterrupted operation for power system frequency within the frequency operating standards.[229] The equivalent frequency ride through requirements for generating and integrated resource systems in clause S5.2.5.3 are generally consistent with this but are expressed in greater detail, including automatic and minimum access standards.

Consequences

Modern HVDC links have similar frequency disturbance ride through capability as inverter-based generation and integrated resource systems. In addition, the importance for power system

228 As noted by AEMO in its rule change request at p 63, Basslink (until recently) was the largest credible contingency event in Victoria. If an HVDC like Basslink trips, plant on both ends of the link are also more likely to trip, significantly impacting the power system.

229 Clause S5.3a.13(a)(1).

security of an HVDC link maintaining continuous uninterrupted operation for a frequency disturbance is similar to that of a generating system or integrated resource system 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 be aligned with those in schedule 5.2.

The Commission's final rule

Box 36: Aligning frequency disturbance ride through requirements for HVDC links with schedule 5.2 plant

The final rule will:

- Amend clause S5.3a.13 to apply the equivalent frequency disturbance ride through requirements in the automatic and minimum access standards for clause S5.2.5.3 (including rate of change of frequency) 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.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that aligning the requirements for HVDC links with those for generating systems and integrated resource systems will allow the frequency disturbance ride-through capability of the voltage source converters used in HVDC links to be made available to the power system. This will improve system security by increasing the resilience of HVDC systems during frequency disturbances, in accordance with the NEO. The incremental cost of the additional resilience is expected to be relatively small given that all future HVDC systems are expected to use voltage source converters, and therefore the Commission considers that the benefits associated with this change outweigh the costs. This will promote the NEO by supporting more efficient investment and operation.

This amendment was supported by Shell Energy in its submission to the draft determination.[230] APA noted that HVDC links may connect to two jurisdictions with different frequency operating standards, and that it may be necessary to amend the general requirements accordingly.[231] The Commission considers that it is not necessary to adopt this suggestion, because the frequency requirements in S5.3a.13 apply for the relevant frequency ranges defined for the region where the terminal of the DC link applies. In practice, there will likely be separate connection agreements and sets of performance standards for each terminal that connects to different NSPs, meaning that there should not be any confusion as to which frequency operating standard should apply.

230 Shell Energy, submission to the draft determination, p 6.
231 APA, submission to the draft determination, p 9.

5.2.3 The final rule will align fault ride through, response and recovery requirements for HVDC links with schedule 5.2 plant

Issues

Clause S5.3a.13 defines the required performance for HVDC links regarding disturbances in the power system, which does not include requirements for fault ride through capability. Clause S5.3a.14 explicitly allows disconnection of a market network service facility to protect it from disturbances, but only for conditions under which it is not required to continuously operate or withstand under another provision of the NER. However, there is no requirement for HVDC links to respond (by supplying or absorbing reactive current) and recover following a disturbance.

Consequences

Power system security depends on the ability of the network, load and generation plant to operate continuously following faults that are somewhat likely to occur, including multiple faults associated with non-credible contingencies. A lack of clearly defined fault ride through, response and recovery requirements for HVDC links similar to schedule 5.2 plant currently presents a risk to system security.

The Commission's final rule

Box 37: Aligning fault ride through, response and recovery requirements for HVDC links with schedule 5.2 plant

The final rule will:

- Replace clause S5.3a.14 with automatic and minimum access standards aligning disturbance ride through, response and recovery requirements with the equivalent automatic and minimum access standards for clauses S5.2.5.5 and S5.2.5.5A, by reference.
- Apply equivalent provisions for negotiated access standard and general requirements as under clauses S5.2.5.5 and S5.2.5.5A, respectively.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that modern HVDC links have similar fault ride through and response capability as inverter-based generation and integrated resource systems, with the benefits for power system security of maintaining continuous uninterrupted operation for faults being similar to that for a generating system or integrated resource system of a similar size. Moreover, voltage source converters used in modern HVDC systems operate using the same principles as the inverters in solar, wind and battery energy storage systems. Therefore, given that the capabilities of the respective technologies and their impacts on 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. This will promote the NEO as it will align requirements with best power system performance, improve power system resilience and support efficient investment and operation.

This amendment was supported by Shell Energy in its submission to the draft determination.[232] APA noted that clause S5.2.5.5A includes additional definitions (e.g., clauses S5.2.5.5A(b)(1) and (2)) beyond the disturbance end time, which are not included under clause S5.3a.14 or referenced in the general requirements of clause S5.3a.14(e). APA understood that definitions are automatically considered when interpreting the relevant clauses and do not require specific references.[233] The Commission agrees with this interpretation. APA also noted that the voltages at each connection point of an HVDC link may recover at different rates following a fault. APA suggested clarifying the definition of the end of a disturbance for multiple fault ride through in this context. The Commission notes that the schedule 5.3a performance requirements apply separately at each individual connection point of an HVDC link. Hence, a disturbance at each connection point should be measured separately. For clarification, the Commission also notes that as per clause S5.3a.1a(d)(2) of the final rule, references to a connection point are to each of the connection points.

5.3 Clause S5.3a.4 — Monitoring and control requirements

Clause S5.3a.4 describes the remote monitoring and control requirements for HVDC links including the required communications equipment. This clause is essential to provide real time HVDC link data required by AEMO to discharge its market and power system security functions as set out in Chapters 3 and 4 of the Rules, respectively.

5.3.1 The final rule would align remote monitoring and control requirements for HVDC links with schedule 5.2 plant

Issues

Schedule 5.3a currently has no requirements for remote monitoring and protection against instability for HVDC links.

Consequences

HVDC links can participate in power system instabilities in a manner similar to inverter-based generation systems and integrated resource systems. This presents a risk to system security in the absence of any remote monitoring and control requirements for instabilities.

The Commission's final rule

Box 38: Aligning remote monitoring and control requirements for HVDC links with schedule 5.2 plant

The final rule will:

- Amend clause S5.3a.4.1 to add automatic and minimum access standards requirements equivalent to the data communication aspects of clause S5.2.5.10 for asynchronous plant, including access to a phasor measurement unit and the receipt of information or trip signals, as applicable. For HVDC links, no minimum size threshold is proposed for these requirements.
- Add a new clause S5.3a.4.2 to align with the remaining requirements for detection and protection against inverter instability in clause S5.2.5.10 for asynchronous plant. Automatic

232 Shell Energy, submission to the draft determination, p 6.
233 APA, submission to the draft determination, p 9.

disconnection capability will not be a fixed requirement except for the automatic access standard.

Changes from draft to final rule

- Amended to reflect corresponding changes in clause S5.2.5.10.

The Commission's rationale for the final rule

The Commission considers that to improve the ability to monitor, control and analyse instabilities in the power system, remote monitoring and protection requirements for HVDC links should be generally aligned with those in clause S5.2.5.10 for asynchronous plant. This amendment will provide a coordinated approach to inverter based resource instability that can be applied to all plant likely to participate in a controller instability. This will promote the NEO as it will align requirements with best power system performance and improve power system resilience.

The Commission also considers that while disconnection could be one of the responses to instability, disconnecting an HVDC interconnector is likely to have significant impacts on the operation and security of the power system. Hence, capability to automatically disconnect on instability detection will not be an automatic access standard requirement, in accordance with the NEO, unless agreed with the NSP and AEMO, in order to make sure that the operation and security of the power system is considered by these parties that have responsibility for this.

The final rule refers to 'connection point or pole (as applicable)' under clauses S5.3a.4.1(a)(1) and S5.3a.4.1(b)(1). This is important to clarify so that it can cater to a bi-pole HVDC link where both poles connect behind the same connection point. In this case, the Commission understands that it is possible for one pole to become unstable and the other to provide damping, with separate monitoring requirements therefore desirable in order to have more accurate visibility and better control.

5.4 New standards

The current requirements in schedule 5.3a are silent on the voltage and active power control capabilities of HVDC links. However, the impact of these links on the power system can be significant and can present themselves as large contingencies during the operation of the NEM. Despite this, the current access standards in schedule 5.3a are not as detailed or comprehensive as they are in schedule 5.2, even though the power system impact could be similar (and in some cases greater) than schedule 5.2 plant. Creating new access standards for HVDC links that are aligned with the standards in schedule 5.2 will support power system security through efficient investment in the capabilities of new HVDC links.

5.4.1 The final rule will align voltage control and reactive power control requirements with schedule 5.2

Issues

The current access standards do not contain any voltage control standards for HVDC links. However, HVDC systems have the capability to control voltage independently at each terminal.

Consequences

Currently, the Rules are silent on the voltage control capability required from HVDC links. The power system will greatly benefit from creating new standards for HVDC links that are similar to the voltage control access standards for generating systems and integrated resource systems.

The Commission's final rule

Box 39: Creating new access standards for voltage control for HVDC links by reference to clause S5.2.5.13

The final rule will add a new clause S5.3a.15 to apply AC voltage control and reactive power control capabilities to HVDC links equivalent to those in clause S5.2.5.13 (but with some minor modifications suitable for HVDC links).

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The final rule will ensure that voltage control requirements for HVDC links aligns with the equivalent requirements for schedule 5.2 plant in clause S5.2.5.13.[234] Given that HVDC links have similar voltage control and reactive power capabilities to inverter-based plant, the power system will greatly benefit from applying consistent requirements on all schedule 5.2 and schedule 5.3 plant at a low incremental cost. Moreover, it will incentivise HVDC connection applicants to make efficient decisions through negotiation of its performance standards where meeting the automatic access standard may be too costly or impractical. This will promote the NEO as it will align requirements with best power system performance and support efficient investment and operation.

5.4.2 The final rule will align active power control requirements with schedule 5.2

Issues

Existing requirements under schedule 5.3a does not require active power flows on HVDC links to be controlled in a manner like dispatch of scheduled production units. The absence of arrangements does not reflect the capabilities of modern HVDC links and therefore efficiently support power system needs.

The active power control capabilities of HVDC links are no different to those from other inverter-connected plant.

Consequences

Existing arrangements do not realise active power control capabilities that are inherent in modern HVDC links. These arrangements will not support efficient investment and operation as active power control capabilities will be required from higher cost sources, increasing overall costs for consumers.

234 The proposed amendments to clause S5.2.5.13 are intended to improve power system resilience in the context of networks likely to experience a broader range of network impedances — see Section 4.10.

The Commission's final rule

Box 40: Creating new access standards for active power control for HVDC links

The final rule will add a new clause S5.3a.16 to apply active power control requirements for HVDC links equivalent to those in clause S5.2.5.14, including for dispatch and ramping.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The final rule will ensure that active power requirements for HVDC links align with the equivalent requirements for schedule 5.2 plant. This will support efficient operation by placing the responsibility for these requirements with the operators of connected HVDC facilities, which is appropriate because the active power control capabilities of HVDC plant are the same as inverter-based plant. As such, connection applicants are incentivised to make efficient investment decisions regarding active power and voltage control. It is important to capture this capability in the access standards for HVDC links to facilitate the achievement of the NEM's active power requirements and improve power system resilience, which will be in the long-term interests of consumers.

6 The final rule will make other consequential NER amendments

In its rule change request AEMO also proposed several other amendments to the NER. These are either related to AEMO's proposed amendments to the schedule 5 access standards, or seek to clarify the intent of the existing rules where ambiguity may have created confusion or uncertainty.[235]

The final rule will make such consequential amendments to Chapters 3, 4, 5, 5A, 6A, 7, 8, 9, 10 and 11. These amendments are made to related clauses of the NER to support the intent of the final rule by clarifying inconsistencies, removing redundant provisions and reducing duplication. Such changes will promote the long-term interests of consumers, in accordance with the NEO, by making the final rule clearer for stakeholders to understand and follow, minimising confusion.

6.1 The final rule will expand rights of testing to include assessments

Issues

NER 5.7.2 allows any Registered Participant to request a test of other equipment that is owned or operated by another Registered Participant if it considers that the equipment may not comply with the NER or with a connection agreement. However, the clause only contemplates physical tests, and does not explicitly allow for assessments (that is, computer simulation studies) to be conducted. These tests can be very costly and may necessitate significant changes to normal plant operation, potentially making them financially unattractive for many Registered Participants, who may have to bear significant costs.

While consulting on proposed changes to S5.2.5.4 relating to voltage disturbance ride-through requirements above 130% of nominal voltage, AEMO considered that it would beneficial to allow parties to be able to request an assessment to determine the root cause of any switching surges that may be affecting plant.[236] Accordingly, it also proposed this change in its rule change request.[237]

The Commission's final rule

Box 41: Allow Registered Participants to request an assessment instead of a physical test

The final rule will:

- In clause 5.7.2, allow Registered Participants to request an assessment of other Registered Participants' equipment if they have reasonable grounds to believe that the equipment may not comply with the NER or the connection agreement.
- In clause 5.7.2(b), clarify that AEMO does not need to be involved in tests or assessments that do not require (or may cause) an outage or change to normal operation of any power system equipment.

Changes from draft to final rule

Amended clause 5.7.2(b) to require any assessment that requires (or may cause) an outage or

235 AEMO, rule change request, pp 78-79.
236 AEMO review of technical requirements for connection (NER clause 5.2.6A), Draft Recommendations Update Report, p 16; Final Report, pp 38-39.
237 AEMO, rule change request, p 34.

change to normal operation of any power system equipment to be conducted at a time agreed by AEMO, for completeness.

The Commission's rationale for the final rule

The Commission considers that extending the right of parties to request an assessment of another party's equipment will encourage parties to more efficiently investigate and address the cause of any abnormal behaviour or phenomena. For example, if a participant is experiencing unexpected switching surges (see section 4.4.3), they may request a simulation study of the NSP's equipment that the participant believes is causing the surges.

As the cost of simulation studies is generally far lower than the cost of a physical test, and may not require AEMO to be involved, the final rule promotes more cost-effective options to resolve any suspected non-compliances by using simulation software in lieu of a physical test. These assessments will generally not affect normal operation, and so AEMO does not need to be involved to schedule outages or implement any arrangements that would otherwise be needed for a physical test.[238]

In its submission, Transgrid supported the draft rule's proposal to allow parties to request an assessment, but considered that it did not clearly provide the choice between testing or assessment for cost-effective purposes.[239] The Commission considers that the rule drafting at clause 5.7.2(a) clearly provided Registered Participants the choice of either a test or an assessment. A Registered Participant's choice would be guided by what is likely to be practical and cost-effective (given that the requester bears the costs, if no non-compliance is determined — see clause 5.7.2(d)).

Transgrid also noted that clause 5.7.2(b) did not mention the requirement of notifying AEMO for any assessments that may cause an outage or change to normal operation of equipment. For the sake of completeness, the Commission has added the words 'or assessment' in 5.7.2(b) to address this point. However, we highlight that the vast majority of assessments should not cause any outages or changes to normal operation, as they are very likely to be simulation studies which need no physical interaction with connected plant.[240]

By expanding the range of options that parties have to rectify suspected non-compliances, it promotes power system resilience by minimising the risk of material degradation of plant or network equipment, which contributes to the NEO.

6.2 The final rule will remove references to superseded standards

Issues

The NER currently contains a number of references to standards that are either defunct or superseded. Given these standards are outdated, such references on longer provide no value to the connections process.

The Commission's final rule

238 Final rule, clauses 5.7.2(b) and (i).

239 Transgrid, submission to the draft determination, p 24.

240 For these assessments, AEMO does not need to be notified of the assessment or provided with a copy of a report following the assessment — see clauses 5.7.2(b) and (i) of the final rule.

Box 42: Removing references to superseded standards

The final rule will substitute references to AS/NZS 61000.3.6 and AS/NZS 61000.3.7 in clauses S5.1a.5, S5.1a.6, S5.1.5 and S5.1.6, with references the latest versions of relevant International Electrotechnical Commission standards, IEC/TR 61000.3.6 and IEC/TR 61000.3.7.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The Commission considers that these references to superseded standards does not provide any value in the connections process. The final rule updates the references to the international standard as it is good regulatory practice to make them current. We have also decided to update these clauses by not including a date (as is the case currently in the Rules). This will make the clauses more robust to future changes and will avoid them becoming superseded in the future.

In response to the draft determination, EPEC suggested that to avoid confusion as to which standard version should apply for each connection, the version at the time of the connection enquiry could be 'locked in,' with the standard of the version being captured in the performance standards.[241] Transgrid were also concerned that updating references to the latest international standard may increase the potential for conflict between the existing network and future requirements, and may also subject the NER to external changes without a rule change process.[242]

Although the Commission acknowledges these concerns, we note that NER clause 1.7.1(i) states that:

> a reference to a document or a provision of a document includes an amendment or supplement to, or replacement or novation of, that document or that provision of that document.

Updates to external documents are not automatically a concern, and can occur quite frequently without any industry consultation. For example, the *targets statement* prepared by the AEMC can be updated at the Commission's discretion without any specific industry consultation, and affects how AEMO must prepare the ISP.[243]

The Commission also notes that the references to standards in S5.1a.5 and S5.1a.6 are largely related to network planning levels, where networks must always **plan** their network to comply with the latest standard. The final rule will not require the retroactive amendment of existing network plant or connection agreements; however, the Commission expects that any expansion or replacement of network plant should always seek to achieve the latest applicable standard.

Updating references to the relevant up-to-date international standards will provide more value to the connections process by providing better clarity with respect to the obligations under the system standards.

241 EPEC, submission to the draft determination, pp 5-6.
242 Transgrid, submission to the draft determination, pp 24-25.
243 NER, clause 5.22.3(b).

6.3 The final rule will delete the definition of 'voltage' and 'normal voltage' and clarify references to RMS voltages

Issues

The existing definition of 'voltage' in Chapter 10 of the NER does not align with its engineering interpretation. The current definition of 'voltage' is:

> The electronic force or electric potential between two points that gives rise to the flow of electricity.

This definition can create confusion in the connections process if different parties have different views on what this term means.

In addition, the Rules define the term 'normal voltage', describing the voltage at a connection point which may be up to 10% higher or lower than the network's nominal voltage. NSPs may notify AEMO it wishes to change the normal voltage of a connection point, and AEMO may approve such a request.[244] The normal voltage at any connection point in the NEM has only been changed twice: once to raise the normal voltage, and again to return it to the previous level at nominal voltage.[245]

The Commission's final rule

Box 43: Removing the definition of 'voltage' and references to 'normal voltage', and clarify references to RMS voltages

The final rule will:

- Delete the definitions of *voltage* and *normal voltage* in the Chapter 10 of the NER.
- Replace references to *normal voltage* with *nominal voltage*.
- Delete the definition of *RMS phase voltage*, but clarify in clauses S5.1.4, S5.2.5.4, S5.2.5.5, S5.2.5.5A and S5.2.5.8(a2) that voltages in these clauses refer to root mean square voltages.
- Delete clause 5.3.11 which described the process for NSPs to change the *normal voltage* of a connection point.

Changes from draft to final rule

- Clarify that, for the purposes of S5.2.5.4, S5.2.5.5 and S5.2.5.5A, references to voltage are to root mean square *power system frequency* voltage at the *connection point* measured either phase to phase or phase to ground, expressed as a percentage of the *nominal voltage* or its phase to neutral equivalent, as relevant to the disturbance.

The Commission's rationale for the final rule

The Commission considers that the current NER definition of voltage is not appropriate because it is not consistent with standard engineering practice. Therefore, it does not provide value to parties during the connections process. The term 'voltage' could refer to a variety of different values, such as (but not limited to) the root-mean-square voltage, the peak-to-peak voltage, the average voltage or the positive sequence voltage, depending on the context.

244 Clause 5.3.11.

245 AEMC, Changes to normal voltage, Rule determination, 28 February 2013, p 8.

Transgrid considered that the Commission should exercise caution in changing or removing the definition to voltage, and preferred that the NER should be explicit what kind of voltage is intended in each context.[246] The Commission agrees with the sentiment that, wherever necessary, the quantity of 'voltage' should be clarified in the clause itself, with the final rule taking this approach (for example, see clause S5.2.5.4(a0)(3) of the final rule). Regardless, this would mean that any remaining global definition would provide little to no value, so the Commission considers that its deletion should not have any unintended consequences.

Similarly, the Commission considers that deleting the definition of 'normal voltage' will minimise any potential confusion or delay that could be caused by the confusion of this term with 'nominal voltage'.[247] Changes to normal voltages can impose significant costs on connecting plant by requiring bespoke equipment that is rated at a non-standard voltage. Given that changes to normal voltage have only occurred twice, and there are no clear benefits from modifying a connection point's normal voltage to be different to the nominal voltage of the network, the Commission considers that the concept of 'normal voltage' is not providing any value to the power system or to parties.[248]

The CEC agreed with the Commission's proposal to delete the term 'normal voltage' from the NER, also noting that the term has not been utilised in recent years.[249]

In summary, we consider that it is appropriate to delete these two definitions to remove any potential for delay and confusion in the connections process, and to promote good regulatory practice.

Changes to clarification of RMS voltage in clauses S5.2.5.4, S5.2.5.5, S5.2.5.5A and S5.2.5.8(a2)

While preparing the final rule, the Commission also considered that it would be better to clarify that RMS voltages can be measured either phase to phase or phase to ground, depending on the type of disturbance. The current definition only contemplates measuring voltages between each pair of phases, but not phase to ground, which is an inaccurate description of how RMS voltage is commonly calculated for these clauses.

6.4 The final rule will amend definitions of rated active power and rated maximum demand

Issues

The definitions of rated active power and rated maximum demand in Chapter 10 of the NER are important for a number of access standards:

- rated active power is used for reactive power capability (clause S5.2.5.1), reactive power and voltage control (clause S5.2.5.13), and short circuit ratio (clause S5.2.5.15) access standards.
- rated maximum demand is used for clause S5.2.5.1.

However, the existing definitions are problematic as they refer to production units operating at 'nameplate rating'. The Commission understands that 'nameplate rating' is interpreted differently for inverter based and synchronous units. Nameplate rating for inverter-based resources is interpreted as an apparent power MVA rating, rather than an active power MW rating as is

246 Transgrid, submission to draft determination, p 26.

247 The final rule will also delete clause 5.3.11, which describes the process for NSPs to request to AEMO a change to the normal voltage of a connection point.

248 AEMO, rule change request, pp 76-77.

249 CEC, submission to the draft determination, p 15.

standard for synchronous plant. This situation creates uncertainty in the application of the above standards and can lead to adverse outcomes which inefficiently increase costs for connecting parties.

The Commission's final rule

Box 44: Deleting definitions of rated active power and rated maximum demand

The final rule will:

- Delete the definition of *rated active power*. Replace in relevant rules with existing defined term active power capability.
- Delete the definition of *rated maximum demand*. Replace in relevant rules with existing defined term maximum demand.
- Change the definition of *short circuit ratio* to address an issue with the definition of the term 'rated active power'
- Adopt the following 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 clauses 5.3.4C and 6A.23.5(j).
  - The maximum amount of *active power* that may be transferred to a *connection point* from a *generating system* or *integrated resource system* as specified or proposed to be specified in a *performance standard* or *connection agreement*.
  - For a generating system or integrated resource system that is a scheduled resource, the active power capability is equivalent to the aggregate of the maximum generation quantities specified in the bid validation data for all its production units, after accounting for auxiliary load and losses within the relevant system.

Changes from draft to final rule

- None

The Commission's rationale for the final rule

The final rule is the same as the draft rule. The Commission retains its view that existing arrangements are not aligned with the intent of the relevant access standards given the different interpretation of plant 'nameplate rating'.[250] Existing definitions result in excessively high reactive power capability requirements and short circuit ratio obligations are not consistent with efficient outcomes.[251]

The Commission considers the final rule addresses the issues with existing arrangements and promotes the NEO as it enhances the clarity of various access standards, leading to decreased administrative costs and delay associated with the connections and negotiations process.

The final rule amendments will clearly align standard requirements with active power capability, and result in outcomes consistent with the intent of the relevant standards. The final rule will

250 AEMO, rule change request, pp 77-78.

251 For the purposes of clause S5.2.5.1, a literal reading of the rated active power definition in the context of clause S5.2.5.1 implies a higher reactive power capability automatic access standard for some technologies. This outcome is not consistent with the intent of the clause and could result in additional capital expenditure. For clause S5.2.5.15, use of 'rated active power' to calculate the short circuit ratio is problematic for inverter-based equipment. It changes the denominator for the short circuit ratio calculation for the purpose of this clause, effectively increasing the performance requirement beyond that intended by a minimum short circuit ratio of 3. This might lead to a requirement for additional mitigation measures at higher capital cost and design effort.

clarify that capability should reflect the recorded active power capability in the performance standards, that is, at the connection point.[252]

For simplicity and consistent with a common understanding of maximum output power (Pmax), the final rule confirms 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 will need to recognise the necessary adjustment.

The Commission considered stakeholder submissions from Shell Energy and Transgrid in making its final determination. Transgrid proposed that the definition of active power capability referring to number of in-service units rather than bid validation data as bid validation data is not available for plant in the connection process,[253] and Shell Energy proposed that MVA should be used when comparing plant capacity to short circuit level instead of active power capability which is measured in MW.[254]

The Commission's final rule aligns the definition with its intent being to reflect active power (MW) rather than MVA which is the interpretation of 'nameplate rating' for inverter connected plant. The Commission therefore considers its final rule to be clearer overall and therefore better supports compliance across the affected standards than using MVA as suggested by Shell Energy. In regard to Transgrid's comment, the Commission has retained the reference to bid validation data as it is useful to confirm that the active power capability and bid validation data should always be consistent, rather than to imply the bid validation data determines Pmax in the connection process.

6.5 The final rule will clarify and streamline several clauses of the NER

Issues

AEMO has identified various aspects of the NER that may be ambiguous, confusing or not aligned with the intent of the current rules or proposed amendments.[255] It has proposed amendments to streamline and clarify the clauses that are related to its other proposed amendments in its rule change.

The Commission's final rule

Box 45: Clarifying and streamlining related NER clauses

The final rule will:

- In clause 5.2.1(b) (Obligations of all Registered Participants), consolidate several requirements to comply with or not adversely affect the achievement of system standards in clauses 5.2.4, 5.2.5 and 5.2.5A, which reflects the objective in 5.1A.2(c) and reappears in some technical requirements throughout Schedule 5.

252 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.

253 Transgrid, submission to the draft determination, p 25

254 Shell Energy, submission to the draft determination, p 7.

255 AEMO, rule change request, pp 78-79.

- Amend clause 5.3.4A(b)(2) (Negotiated Access Standards) to reflect the objective in clause 5.1A.2(c) and the obligations on all Registered Participants to not adversely affect the achievement of the system standards.
- Clarify wording in clause 5.3.4A(b)(1A) to refer explicitly to the 'existing' performance standard, and align language consistent with the rest of the clause to be 'less onerous' instead of 'below' an access standard.
- Amend the table in clause 5.3.9(d) to include proposed new clause S5.2.5.5A in the 'power converter', 'reactive compensation plant', 'excitation control system', 'voltage control system' and 'protection system' rows.
- In clauses S5.2.5.3(b)-(c), S5.2.5.4(a)-(b), S5.3.9(c) and S5.3a.12(c) amend wording from 'must be capable of *continuous uninterrupted operation*' to 'must remain in *continuous uninterrupted operation*' to clarify that the relevant plant must actually remain in continuous uninterrupted operation in response to a disturbance, and not just be capable of remaining in continuous uninterrupted operation.
- Amend clause S5.2.5.7(c) and (d) to clarify that the combined loading level of the synchronous production units applies for the access standard in S5.2.5.7.
- Amend the definition of *AEMO advisory matter* to reflect the proposed new HVDC standards in schedule 5.3a, the deletion of clause S5.2.5.16, and the omission of clause S5.3.5 which already requires AEMO consultation.
- Amend the definition of *disconnect* to be broader than only the disconnection of flows at connection points.
- Add a new definition of *minimum operating level* to Chapter 10 for generating units, as it is proposed to be used in clauses S5.2.5.7, S5.2.5.8 and S5.2.5.11.
- In clause S5.2.5.11:
  - Delete the local definition of *minimum operating level*.
  - Delete the local definition of *maximum operating level,* as it refers to both *sent out generation* and *generation*, which may be different values, and does not account for other operating limits.
  - Add new sub-paragraphs (b)(1A) and (c)(1A) in the automatic and minimum access standards, respectively, to specify frequency control requirements during power transfer from the power system to a plant (for example, charging batteries). This complements the existing requirements in sub-paragraphs (b)(1) and (c)(1) for power transfer from the plant to the power system.
  - Amend paragraph (c) to swap 'and' and 'or' between sub-paragraphs (1)(i) and (2)(i) of the minimum access standard to align with the automatic access standard, as it was a typographical error.
- Amend clause S5.6(g) and the definition of *disconnect* to make clear that the equipment of a registered participant's facility would be disconnected, not the participant itself.
- Add a new clause S5.6(g1) which consolidates existing clauses S5.2.5.8(f) and S5.3a.14(e) stating that the NSP is not liable for any loss or damage incurred by the Schedule 5 Participant or any other person as a consequence of a fault on either the power system or within the Schedule 5 Participant's facility.
- Amend the definition of *access standard, negotiated access standard* and *performance standard* to clarify that performance standards are those that are either agreed upon an

documented in a connection agreement, or determined by a network service provider in respect of its own relevant plant and provided to AEMO under clause 5.2.3(c1); while 'access standards' are the technical requirements set out in the NER.

- Amend the definition of *power transfer* to remove references to connection points, as it is currently used in broader contexts (than simply the power transfer between two connection points).
- Amend the definition of *reactive power capability* to clarify that it is not a single maximum number or rate, nor unidirectional, not limited to production units, nor necessarily specified in a connection agreement.
- Amend the definition of *releasable user guide* to replace references to registration categories with *Schedule 5.2 Participant* and *schedule 5.2 plant*.
- Amend the definition of *plant* to include equipment involved in or supporting the generation, consumption or conveyance of electricity.
- Add a new defined term, *production system,* for ease of drafting, which refers to a generating system or an integrated resource system.
- Delete the definition of *RMS phase voltage* as it is made redundant through the clarifications in clauses S5.1.4 and S5.2.5.4.
- Amend the definition of *scheduled integrated resource system* to remove the words 'to the extent it is comprised of *production units'* to improve drafting clarity.
- Amend the definition of *synchronous condenser* to clarify that they do not generate or consumes active power, other than consumption for losses within the plant.
- Add a definition of *synchronous condenser system* that refers to a system with one or more synchronous condensers that are not part of a generating system or integrated resource system.
- Make several other minor formatting and grammatical changes to fix various typographical errors or to clarify wording.

Changes from draft to final rule

- Retain existing clause 5.1A.2(e), an objective to achieve long term benefits to Registered Participants in terms of cost and reliability of the national grid, which is complementary to the NEO and was proposed to be deleted by the draft rule.
- Retain existing negotiated access standard criteria in clauses S5.2.5.1(c), S5.2.5.4(d), S5.2.5.5(q), S5.2.5.12(c) and S5.2.8(d).
- Duplicate the existing negotiated access standard criteria from clause S5.2.5.5(q) in clause S5.2.5.5A(q1) due to the drafting choice to split up clause S5.2.5.5 into two clauses.

Note: Refer to the final rule and markup of Chapter 5 for more information on all proposed consequential and minor NER amendments.

The Commission's rationale for the final rule

The Commission agrees with the intent of AEMO's proposed changes to streamline and clarify various clauses and definitions to clarify aspects of the NER that may be confusing or misaligned with its proposed amendments. We consider it good regulatory practice to clarify and streamline relevant clauses, wherever possible, to minimise confusion, which will contribute to lowering costs for consumers associated with the connection process.

In its submission to the draft determination, the CEC strongly opposed the consolidation of common assessment criteria for negotiated access standards into 5.3.4A(b), contending that it could undermine the open access shallow connection arrangements in the NEM.[256] It also considered that changes to 5.3.4A should not be progressed until the completion of the Connections Reform Initiative (CRI) workstreams, or should be progressed following a standard rule change process (as opposed to a fast-track process).[257]

The Commission's intent in the draft rule was to streamline and clarify the drafting of Schedule 5 requirements by consolidating repeated wording and criteria that appears throughout the technical requirements in S5.2.5.1(c), S5.2.5.4(d), S5.2.5.5(q), S5.2.5.12(c) and S5.2.8(d). While the wording in each of the clauses differs slightly, some clauses provided for a less bounded discretion than what was proposed in the draft rule at 5.3.4A(b).[258] Nevertheless, to avoid any unintended consequences that could arise from this consolidation of assessment criteria, the Commission has reversed these changes by retaining the clauses listed above and deleting the addition to 5.3.4A(b) in the final rule.[259]

The CEC also opposed the addition of 'achievement of the *system standards*' in clause 5.3.4A(b)(2), stating that the responsibility for meeting the system standards lies with NSPs, not Schedule 5 Participants.[260] However, the Commission considers that this is not entirely accurate. This is because under the current NER:

- NSPs must not agree to access standards that are not consistent with achieving the system standards (see clause 5.1A.2(c) of the NER)
- Generators, Integrated Resource Providers and Customers must plan and design its facilities and ensure that they are operated to comply with the system standards (see clauses 5.2.4(a), 5.2.5(a) and 5.2.5A(a) of the NER)
- Network Service Providers must observe and apply the provisions of the system standards when complying with its obligations under schedule 5.1 (see clause S5.1.1 of the NER)
- In clauses S5.2.5.1(c)(1), S5.2.5.2(d), S5.3.1a(c), S5.3.2(c), S5.3.5, S5.3.6, S5.3.9, S5.3a.1a, S5.3a.5, S5.3a.8, S5.3a.9, S5.3a.12 and S5.3a.13 of the NER, Connection Applicants, Network Users or Market Network Service Providers must propose access standards that either help ensure all relevant system standards are met, or must ensure their equipment meets technical requirements that have been specified based on the system standards.

Also, the addition of 'achievement of the *system standards*' in clause 5.3.4A(b)(2) does not transfer obligations on NSPs under schedule 5.1 to Schedule 5.2 Participants. Instead, it ensures that the objective in clause 5.1A.2 (and expressed elsewhere) is observed by NSPs when deciding whether to accept or reject a negotiated access standard that has been proposed by a Schedule 5 Participant. Hence, the Commission has retained this addition to clause 5.3.4A(b)(2).

For more detail on the Commission's rationale for specific minor amendments, refer to the relevant sections in chapter 3, chapter 4 or chapter 5 pertaining to that the specific amendment.

256 CEC, submission to the draft determination, pp 2-8, 15-16.

257 Ibid., p 2.

258 For example, clause S5.2.5.4(d) provides AEMO and the NSP discretion to take into account the expected performance of 'other relevant projects', which the Commission considers is broader than 'projects for connection of Network Users that the NSP reasonably considers will proceed' (clause 5.3.4A(b) of the draft rule). While the CEC noted that, in practice, NSPs only consider committed projects that have executed an offer to connect, this is not explicitly captured by 'other relevant projects'.

259 The final rule also copies the requirement at S5.2.5.5(q) into S5.2.5.5(q1), which is necessary as a consequence of splitting out parts of clause S5.2.5.5 into S5.2.5.5A.

260 CEC, submission to the draft determination, p 15.

7 The final rule includes transitional provisions for existing network plant and ongoing connections

7.1 NSPs will be required to document performance standards for their existing schedule 5.2 or 5.3a plant and considered projects

Under the proposed changes to the access standard application framework, detailed in Chapter 3, NSPs will be required to determine and document performances standards applicable to any schedule 5.2 or schedule 5.3a plant that it may seek to incorporate as part of its network after the commencement date of the rule.[261] This refers to future NSP-owned synchronous condensers or HVDC links.[262]

To ensure that AEMO and the AER have full visibility of the performance standards of schedule 5.2 and 5.3a plant in the power system, the final rule includes a transitional provision that will require NSPs to document the performance standards for its existing synchronous condensers or HVDC links that are not subject to a connection agreement with another person.[263] NSPs must also document the performance standards of any synchronous condensers or HVDC links that form part of a *considered project,* as of 21 August 2025.[264]

NSPs must advise AEMO of these performance standards within 12 months of the commencement date of the rule.[265] This gives NSPs sufficient time to perform the tasks necessary to determine standards for its existing synchronous condensers and HVDC links, with reference to new schedule 5.2.

Importantly, these existing NSP schedule 5.2 or 5.3 plant (or plant that forms part of a *considered project)* do not need to meet the new minimum access standards that will be introduced in this final rule.[266] In addition, NSPs are only required to document performance standards to the extent consistent with the actual capability of their plant.[267] This allows AEMO and the AER to have a set of consistent performance standards for all schedule 5.2 or 5.3a plant, which aids regulatory compliance and enforcement. It also follows the principle that the application of this final rule will not affect the performance standards of existing plant that are already connected to the NEM or part of existing networks.[268]

In the final rule, the Commission has included schedule 5.2 or 5.3a plant that form part of *considered projects* into this transitional provision to reduce the likelihood of significant cost increases or delays to committed synchronous condensers and HVDC links. This addresses NSP concern that the draft rule would have led to unacceptable delays for their committed synchronous condenser projects which will not be commissioned as at the commencement date of the final rule.[269]

The Commission considers the final rule strikes the right balance between applying the new access standards consistently across future synchronous condensers and HVDC links, while

261 Final rule, clause 5.2.3(c1).

262 Note that clause 5.2.3(c1) and clause 11.186.2 of the final rule does not apply to any plant or network equipment that is not schedule 5.2 plant or schedule 5.3a plant, such as static var compensators (SVCs) or static synchronous compensators (STATCOMs).

263 Final rule, clauses 5.2.3(c1) and 11.186.2.

264 A *considered project* must have acquired the necessary land and easements, necessary planning and development approvals, have passed the RIT-T/RIT-D (if applicable) or have been included in a TAPR/DAPR, and construction must have commenced or the NSP must have set a firm date for it to commence. See NER, Chapter 10 Glossary, *considered project*.

265 Final rule, clause 11.186.2(b)(2)

266 Final rule, clause 11.186.2(c).

267 Final rule, clause 11.186.2(b)(1).

268 Final rule, clause 11.186.6.

269 Submissions to the draft determination: ENA, p 3; Transgrid, p 4;

minimising cost increases and delays for committed and vital network infrastructure that will deliver benefits for consumers.

7.2 Connection applicants will be able to elect to use the new access standards for ongoing connection processes

In developing transitional arrangements, the Commission has sought to ensure that the benefits of the changes to the access standards can be realised as soon as possible, while minimising any additional costs that may be associated with:

- connection applicants who have already completed a significant amount of design or technical work in accordance with the 'old' schedule 5 access standards, where changes to the technical requirements which can significantly affect the costs of procuring and purchasing equipment
- the ongoing negotiation of access standards before a connection agreement has been executed
- NSPs, AEMO and connection applicants agreeing upon which version of the access standards will be in force for a connection application or alteration.

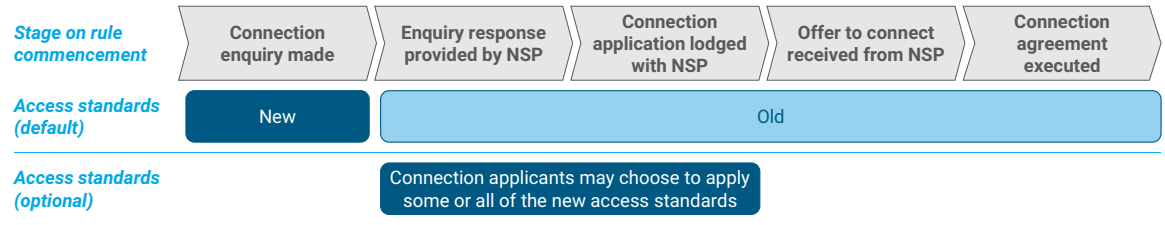
The Commission has included transitional provisions in the final rule which aim to maximise flexibility for connection applicants to determine which version of the access standards would minimise costly rework and design.

On the commencement date:

- if a connection enquiry has been made, but the NSP has not provided an enquiry response pursuant to clause 5.3.3(b1) or 5.3A.6, then the **new access standards apply**
- if the NSP has provided an enquiry response, then the **old access standards apply**.
- If the connection applicant has not yet received an offer to connect from the NSP, **the connection applicant may choose to apply some or all of the new access standards** for their connection.

Figure 7.1 provides an overview of which version of the access standards will apply to ongoing connections.

Figure 7.1: The rule's transitional provisions for the application of the new or old access standards



Note: This figure indicates which version of the access standards will apply to projects in the connections process on the commencement date of 21 August 2025. If connection applicants propose to use a mix of standards, the NSP and AEMO must approve or reject the proposal. No approval process is necessary if a connection applicant elects to use all of the new access standards. See clauses 11.186.1 to 11.186.6 of the final rule for more information. To the extent of any inconsistency between this figure and the NER, the NER prevails.

7.2.1 The draft rule included transitional provisions that would have applied the new access standards by default to many ongoing connection applications

The draft rule would have applied the new access standards by default to all connections where a connection enquiry has been made or where a connection application has been lodged.[270] Despite this, the rule would have also provided for connection applicants who had lodged a connection application to be able to continue using the old access standards, until the end of a transitional period.[271]

Although the transitional provisions largely mirrored the 2018 *Generator technical performance standards* rule, a few stakeholders noted that the draft transitional provisions may unintentionally limit flexibility for connection applicants in certain situations. For example, an applicant that may be close to completing their connection application under the old rules would then have to redo some work to comply with the new access standards, which may increase costs and add delays to their project.[272] Also, if a connection applicant was not able to negotiate all of their access standards within the transitional period using the old access standards, then the new standards would have automatically applied.[273] This may also cause unnecessary delays and rework to significantly progressed connections.

7.2.2 The final rule applies the old access standards to all connection processes that have had technical requirements specified by the NSP

To address these limitations, the final rule only applies the new access standards by default to connections where the NSP has not yet provided their connection enquiry response.[274]

In their response, NSPs must provide connection applicants with written details of all technical requirements that are relevant to the proposed plant, including the requirements of the automatic, negotiated and minimum access standards.[275]

If connection applicants have already received a response that contains technical requirements corresponding to the old access standards, and the connection applicant has not received an offer to connect, then the default position is that the old access standards will continue to apply to that connection process. This will mean that connection applicants who have invested significant time or money into preparing or progressing connection applications under the old access standards will not have to modify or redo their work, by default.

Additionally, if a connection applicant currently benefits from any transitional provisions that exist under Chapter 11 from previous Rules, those transitional provisions will continue to apply to that connection process after the commencement date of the final rule. For example, if a connection applicant meets the requirements under clause 11.143.9(a) (a transitional provision from the *Efficient management of system strength on the power system* Rule 2021*),* then clause 11.143.9 and the ability to choose 'new chapter 5' (as defined by that clause) instead of 'former chapter 5' will remain in force after our final rule's commencement date.[276]

In this way, any flexibility that is already provided to a connection applicant by virtue of a Chapter 11 provision will continue to exist for that connection applicant. This aligns with the objective of

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270 Draft rule, clauses 11.[XXX].3 and 11.[XXX].4.

271 Draft rule, clause 11.[XXX].4(e)-(g); Draft determination, pp 5-6.

272 CEC, submission to the draft determination, p 8.

273 Draft rule, clause 11.[XXX].4(e)-(g), and AEMO, submission to the draft determination, p 6.

274 Final rule, clause 11.186.4(a)-(b).

275 NER, clauses 5.3.3(b1), 5.3A.8 and S5.4B.

276 The definition of 'old access standards' at clause 11.186.1 of our final rule reinforces this by stating 'the applicable requirements for [an access standard] **as applicable immediately prior to the commencement date**'.

the final rule's transitional provisions; to maximise flexibility for connection applicants with processes underway on the commencement date.

7.2.3 Connection applicants may choose to use the new access standards for their connection

Although the old access standards will apply to most ongoing connections by default, the final rule allows connection applicants to choose whether they wish to use some or all of the new access standards for their connection.[277] The new access standards include many clarifications and improvements that aim to streamline the connection process, promote power system security and best plant performance. Giving connection applicants the choice to determine whether using the new access standards will benefit their connection will help to reduce any ongoing delays to ongoing connections processes.

The final rule also has no 'transitional period'. Instead, eligible connection applicants can always choose to use the new access standards, even for a long time after the commencement date of this rule. This removes the possibility of parties unnecessarily rushing to meet an arbitrary deadline to agree upon a set of access standards, so that particular transitional provisions will apply.

Connection applicants may revoke or modify their election to use the new access standards (provided they have not received an offer to connect) and may continue to progress their connection under the old access standards.[278]

7.2.4 The rule provides for a process for parties to agree to use a mix of old and new access standards for ongoing connection processes

In its submission, AEMO noted that the draft rule did not allow connection applicants to agree to a mix of old and new access standards.[279] There may be situations where a connection applicant may wish to apply only a subset of the new access standards to their connection. For example, a connection applicant may wish to apply:

- only new clause S5.2.5.7 to their connection and retain all other old access standards, so that their asynchronous plant does not have to demonstrate compliance against clause S5.2.5.7;[280] or
- only new clause S5.2.5.4 to their connection, and retain all other old access standards, so that they may be able to negotiate to apply the point of assessment at the electrically closest 66kV location, instead of at their connection point.[281]

In these scenarios, applying only some of the new access standards can help to speed up a connection process. However, care must be taken to ensure that a mix of old and new access standards is internally consistent, as there may be conflicting definitions, or references between old and new access standards which may not make mean that it is not practical or workable to apply a particular mixed standard. In the worst-case scenario, the application of a mix of standards may affect power system security, if differences cannot be properly reconciled.

To address this, the final rule provides NSP (and AEMO, for AEMO advisory matters) discretion to reject a connection applicant's proposal to use a mix of standards if it would adversely affect power system security, achievement of the system standards or quality of supply to other Network

277 Final rule, clause 11.186.4(c).
278 Final rule, clause 11.186.4(d)(2).
279 AEMO, submission to the draft determination, p 6.
280 See section 4.7.1.
281 See section 4.4.1.

Users.[282] NSPs may also reject a proposal to apply a mix of access standards if it considers the work required to reconcile differences is impractical (for example, would devote too many resources away for very limited power system or cost benefits).[283]

If a mixed standard is rejected, the NSP must provide written reasons for the rejection.[284] Written reasons do not need to be a formal letter, but must clearly explain why the NSP considers the proposed mix of standards is impractical or would affect power system security.

The connection applicant may then choose to continue their connection under the old access standards, all of the new access standards, or choose to propose another mix of standards.[285] In all cases, the NSP and AEMO may recover the costs of processing a proposal to apply a mix of standards.[286]

If a connection applicant wishes to apply all of the new access standards, then there is no NSP approval process – the new access standards will apply in their entirety.[287]

Given that there is no NSP approval required to apply all of the new access standards, it seems more likely that connection applicants would choose to apply all of the new access standards to their connection, rather than a mix. However, the Commission considers that each connection applicant is best placed to determine whether all of the new access standards, all of the old access standards, or a specific mix of old and new standards, would most benefit their particular connection. If a connection applicant determines that a mix of standards suits best, then it is in the connection applicant's best interests to ensure that they propose a mix of standards that is practical, consistent and does not affect power system security.

We consider that NSPs (or AEMO for AEMO advisory matters) may reject any proposal to apply a mix of standards that is internally inconsistent or not thoroughly considered, and thus impractical to apply. In this way, the provision minimises the risk of an overly onerous administrative burden that could be placed on NSPs or AEMO to process and accept a mixed access standard proposal.

The final rule's transitional arrangements provide a suitable balance between ensuring that ongoing connection processes are not unduly affected by the application of the rule and maximising the flexibility for applicants to choose to apply some or all of the new access standards. This will help reduce the likelihood of costly technical rework which may otherwise affect consumers.

7.3 Ongoing alterations to performance standards will use the old access standards by default

To minimise disruption to ongoing alteration processes on the commencement date, the final rule will continue to apply the old access standards to any process where a Schedule 5.2 or 5.3 Participant has already submitted an application to alter its existing performance standards under clause 5.3.9(b) or 5.3.12(b). However, the new standards may be used if:

- AEMO, the Schedule 5.2 or 5.3 Participant, and the NSP agree to apply the new access standards instead (for example, if there may be clear power system benefits from applying the new access standards to the alteration)

282 Final rule, clause 11.186.4(f)(4).
283 Ibid.
284 Final rule, clause 11.186.4(f)(5).
285 Final rule, clause 11.186.4(g).
286 Final rule, clause 11.186.4(i)(1).
287 Final rule, clause 11.186.4(e).

- in AEMO's reasonable opinion (for an AEMO advisory matter), it considers there will be an adverse impact on power system security or achievement of the system standards, as a result of applying the old access standards.[288]

However, for all future alterations to performance standards, or where a clause 5.3.9(b) or 5.3.12(b) application has not been submitted, the new access standards will apply when determining the requirements for a negotiated access standard.[289] This ensures that the final rule's benefits are realised as soon as possible to both new connections and new alterations, contributing to the NEO.

7.4 Updates to Power System Model Guidelines

In its submission to the draft determination, AEMO requested a transitional provision to allow it to update the Power System Model Guidelines and comply with the applicable consultation procedures.[290] It also considered that interim provisions may be required to interpret references to *Generator, Integrated Resource Provider, Network User, Customer* and *Market Network Service Provider* to mean the applicable *Schedule 5.2 Participant, Schedule 5.3 Participant or Schedule 5.3a Participant*.[291]

The Power System Model Guidelines is an important document that sets out detailed requirements for the provision of plant models, which includes data sheets, block diagrams, source code, and other documentation. Schedule 5 Participants must adhere to the requirements in the Power System Model Guidelines during the connections process, or when proposing to alter existing performance standards.[292]

The Commission has adopted AEMO's suggestion to include a new transitional provision in the final rule. It requires AEMO to update the Power System Model Guidelines within 4 months of the commencement date to take into account the changes from the final rule.[293] The deadline also provides stakeholders and future connection applicants with greater certainty as to when they should expect an updated version of the guidelines, which may inform their preparation of a connection enquiry or application.

Furthermore, the transitional provision provides that, until the guidelines are updated, references to the registration categories should be read as references to the relevant *Schedule 5 Participant*.[294] This provides regulatory clarity for all parties involved in the connections process, contributing to the NEO.

288 See clause 11.186.6(c) of the final rule.
289 See clause 11.186.6(b) of the final rule.
290 AEMO, submission to the draft determination, pp 7 and 11.
291 Ibid.
292 See clauses 5.3.9(b), 5.3.12(b), S5.2.4, S5.3.1, S5.3a.1 and S5.5 of the NER.
293 See clause 11.186.7(a) of the final rule.
294 See clause 11.186.7(b) of the final rule.

A Rule making process

A fast-track rule change process includes the following stages:

- a proponent submits a rule change request
- the Commission publishes a notice advising of its intention to initiate the rule change under a fast track process
- the Commission publishes a draft determination and draft rule (if relevant)
- stakeholders lodge submissions on the draft determination and engage through other channels to share their feedback
- the Commission publishes a final determination and final rule (if relevant).

You can find more information on the rule change process on the AEMC website.[295]

A.1 AEMO proposed to improve the NEM access standards

Under clause 5.2.6A, AEMO is required to conduct a review of the access standards at least once every five years. AEMO conducted its first such review in 2022-23, undertaking extensive public consultation, and identified numerous opportunities to improve the current access standards and their application. AEMO then submitted two rule change requests to the Commission to give effect to the final recommendations from its review.

One – the focus of this rule change request – AEMO proposed to be treated as a fast track rule change in light of the significant consultation that AEMO had undertaken. AEMO's rule change recognises that some existing access standards are no longer fit for purpose in an increasingly inverter-based resources connected NEM. They may unintentionally disincentivise beneficial grid-forming responses, or do not fully utilise available plant performance, or do not account for increasing connections at a sub-transmission or distribution level, or refer to defunct standards.

A.2 AEMO seeks to ensure the access standards are fit for purpose to support the energy transition

The access standards contained in schedules 5.2, 5.3 and 5.3a of the NER define the permissible range of technical requirements that connection applicants need to meet before being allowed to connect to the NEM. With the energy transition underway, the NEM needs to grow and change to continue delivering secure, reliable and affordable electricity to millions of Australians whilst achieving the government's emissions reduction targets. AEMO's 2024 Integrated System Plan (ISP) projects that on the optimal development path, grid-scale variable renewable energy would triple by 2030 and increase by six-fold by 2050.[296]

To support this enormous growth and deliver the energy transition in accordance with the NEO, new NEM connections need to be approved at a much faster rate than at present, while lowering connection costs and keeping the whole system stable and reliable throughout the transition. Given this context, AEMO's proposal seeks to make the NEM access standards more fit for purpose to support the energy transition and reduce connections costs and time.

295 See the AEMC website for more information on the rule change process: https://www.aemc.gov.au/our-work/changing-energy-rules
296 AEMO, 2024 Integrated System Plan, p 11.

A.3 AEMO's proposed rule

AEMO's proposal sought to improve the access standards and reduce connections costs and time by:

- aligning them with best power system performance
- streamlining the connection process
- removing impediments for connection of grid-forming inverters
- broadening their application to synchronous condenser connections
- broadening their application to all HVDC links
- accounting for potential impacts and beneficial capabilities of HVDC links

A.4 The process to date

On 14 November 2024, the Commission published a notice advising of its intention to initiate the rule making process in respect of the rule change request.[297] The Commission decided to fast-track this rule change request. This is because it concluded that the rule change request was consistent with the relevant recommendations of AEMO's review and adequate consultation with the public was undertaken during that review on the relevant recommendations.[298]

As the fast-track process applied to this rule change, the Commission did not publish a consultation paper upon initiation of the rule change process. On 5 December 2024, the Commission published a draft determination and draft rule, broadly reflecting AEMO's proposals.

The Commission received 23 submissions on its draft determination and draft rule. In assessing the submissions received, the AEMC staff engaged directly with several stakeholders to better understand their views and resolve potential misunderstandings. AEMC staff also conducted a workshop on 27 March 2025 to test the AEMC's revised thinking and gather additional feedback from all stakeholders who provided a formal submission to the draft determination.

297 This notice was published under section 95 of the NEL.

298 The decision to fast-track the rule change request was made under section 96A(1)(a) of the NEL.

B Regulatory impact analysis

The Commission has undertaken regulatory impact analysis to make its final determination.

B.1 Our regulatory impact analysis methodology

We considered a range of policy options

The Commission compared a range of viable policy options that are within our statutory powers. The Commission analysed these options: the rule proposed in the rule change request; a business-as-usual scenario where we do not make a rule; and a more preferable rule.

We identified who would be affected and assessed the benefits and costs of each policy option

The Commission's regulatory impact analysis for this rule change used qualitative methodologies. It involved identifying the stakeholders impacted and assessing the benefits and costs of policy options. The Commission drew upon submissions to the draft determination and stakeholder feedback to AEMO's review process for this analysis. The depth of analysis was commensurate with the potential impacts. The Commission focused on the types of impacts within the scope of the NEO.

Table B.1 summarises the regulatory impact analysis the Commission undertook for this rule change. Based on this regulatory impact analysis, the Commission evaluated the primary potential costs and benefits of policy options against the assessment criteria. The Commission's final determination has considered the benefits of the options relative to the costs.

Table B.1: Regulatory impact analysis methodology

Assessment criteria	Primary costs (Low, medium or high)	Primary benefits (Low, medium or high)	Stakeholders affected	Methodology QT = quantitative, QL = qualitative
Safety, security and reliability	Unintended consequences of amending performance standards leading to degraded system security (L)	**More efficient investment in, and operation of power system (H)** **Decreased costs and time taken to connect (H)** Improved system security & resilience (M)	• Connection applicants • NSPs • AEMO • AER • Market participants • Consumers	• QL: Stakeholder consultation on the costs of meeting and complying current access standards • QL: Stakeholder consultation on the potential cost savings by amending specific access standards
Emissions reduction	N/A	**Faster connections for new renewable generation and storage (H)**	• Connection applicants • AEMO • NSPs • Consumers	• QL: Stakeholder feedback to ensure new performance standards do not unintentionally stifle new connections and will facilitate faster connections
Innovation and flexibility	New standards may not properly account for future technologies (L)	Removal of impediments to connecting grid-forming inverters (M)	• Connection applicants • AEMO • NSPs	• QL: Consultation with grid-forming inverter OEMs to verify that new access standards would be preferable over existing standards
Implementation considerations	Increased enforcement & compliance costs (L)	**Decreased costs of negotiating access standards (H)**	• Connection applicants • AEMO • AER • NSPs	• QL: Feedback from market bodies (AEMO & the AER) regarding updates to administrative process, connection negotiations and enforcement. • QL: Feedback from NSPs and connection applicants on the current negotiation process during enquiry, registration and commissioning.

C Legal requirements to make a rule

This appendix sets out the relevant legal requirements under the NEL for the Commission to make a final rule determination.

C.1 Final rule determination and final rule

In accordance with sections 102 and 102A of the NEL, the Commission has made this final rule determination for a more preferable final rule in relation to the rule proposed by AEMO.

The Commission's reasons for making this final rule determination are set out in chapter 2.

A copy of the more preferable final rule is attached to and published with this final determination. Its key features are described in chapter 1. We have also published a mark-up of the amendments to the current rule to make it easier for stakeholders to navigate the changes.

C.2 Power to make the rule

The Commission is satisfied that the more preferable final rule falls within the subject matter about which the Commission may make rules.

The more preferable final rule falls within section 34 of the NEL as it relates to the activities of persons (including Registered participants) participating in the national electricity market or involved in the operation of the national electricity system.[299] Additionally, the more preferable final rule falls within the matters set out in schedule 1 to the NEL as it relates to item 11, being the operation of generating systems, transmission systems, distribution systems or other facilities.

C.3 Commission's considerations

In assessing the rule change request the Commission considered:

- its powers under the NEL to make the final rule
- the rule change request
- stakeholder input received by AEMO as part of its Access Standards Review
- the Commission's analysis as to the ways in which the final rule will or is likely to contribute to the achievement of the NEO
- the application of the final rule to the Northern Territory.

There is no relevant Ministerial Council on Energy (MCE) statement of policy principles for this rule change request.[300]

The Commission may only make a rule that has effect with respect to an adoptive jurisdiction if satisfied that the proposed rule is compatible with the proper performance of AEMO's declared network functions.[301] The more preferable final rule is compatible with AEMO's declared network functions.

299 Section 34(1)(a)(iii) of the NEL.

300 Under s. 33 of the NEL and s. 73 of the NGL the AEMC must have regard to any relevant MCE statement of policy principles in making a rule. The MCE is referenced in the AEMC's governing legislation and is a legally enduring body comprising the Federal, State and Territory Ministers responsible for energy. On 1 July 2011, the MCE was amalgamated with the Ministerial Council on Mineral and Petroleum Resources. In December 2013, it became known as the Council of Australian Government (COAG) Energy Council. In May 2020, the Energy National Cabinet Reform Committee and the Energy Ministers' Meeting were established to replace the former COAG Energy Council.

301 Section 91(8) of the NEL.

C.4 Making electricity rules in the Northern Territory

The NER, as amended from time to time, apply in the Northern Territory, subject to modifications set out in regulations made under the Northern Territory legislation adopting the NEL.[302] Under those regulations, only certain parts of the NER have been adopted in the Northern Territory.

As the more preferable final rule relates to parts of the NER that apply in the Northern Territory, the Commission is required to assess Northern Territory application issues, described below.

Test for scope of 'national electricity system' in the NEO

Under the NT Act, the Commission must regard the reference in the NEO to the 'national electricity system' as a reference to whichever of the following the Commission considers appropriate in the circumstances having regard to the nature, scope or operation of the proposed rule:[303]

1. the national electricity system
2. one or more, or all, of the local electricity systems[304]
3. all of the electricity systems referred to above.

Test for differential rule

Under the NT Act, the Commission may make a differential rule if it is satisfied that, having regard to any relevant MCE statement of policy principles, a differential rule will, or is likely to, better contribute to the achievement of the NEO than a uniform rule.[305] A differential rule is a rule that:

- varies in its term as between:
  - the national electricity systems, and
  - one or more, or all, of the local electricity systems, or
- does not have effect with respect to one or more of those systems

but is not a jurisdictional derogation, participant derogation or rule that has effect with respect to an adoptive jurisdiction for the purpose of s. 91(8) of the NEL.

A uniform rule is a rule that does not vary in its terms between the national electricity system and one or more, or all, of the local electricity systems, and has effect with respect to all of those systems.[306] Most of the amendments in the final rule relate to rules in the NER that do not currently apply to the Northern Territory, relevantly Chapter 3, Chapter 4, numerous clauses in Chapter 5, schedules 5.1a to 5.3a, schedule 5.5, schedule 5.6, Chapter 6A and Chapter 7. However, some of the amendments in the final rule relate to rules currently in effect in the Northern Territory, including certain clauses in Chapter 5 and definitions in Chapter 10 of the NER.

The Commission carefully considered whether a differential rule could be made which only includes the amendments that are appropriate to the NER as applied in the Northern Territory (NT NER) and which meet the policy objectives of this rule change. The Commission sought feedback from stakeholders and consulted with the Northern Territory Department of Mining and Energy (DME). The DME considers that a uniform rule would not achieve the NEO as it would increase costs, complexity and ambiguity in the Northern Territory.[307] A differential rule to adopt parts of the final rule (but not all of the final rule) was also considered by the DME and AEMC to likely present

302 These regulations under the NT Act are the National Electricity (Northern Territory) (National Uniform Legislation) (Modifications) Regulations 2016.
303 Clause 14A of schedule 1 to the NT Act, inserting section 88(2a) into the NEL as it applies in the Northern Territory.
304 These are specified Northern Territory systems, listed in schedule 2 of the NT Act.
305 Clause 14B of schedule 1 to the NT Act, inserting section 88AA into the NEL as it applies in the Northern Territory.
306 Clause 14 of schedule 1 to the NT Act, inserting the definitions of "differential Rule" and "uniform Rule" into section 87 of the NEL as it applies in the Northern Territory.
307 Northern Territory Department of Mining and Energy, submission to the draft determination, p 1.

challenges given the complexities of the final rule as well as the limited timeframe for making the final determination and rule. Given the potential consequences of adopting the final rule (in whole or parts) in the NT NER and the complexities of implementation, the DME considers that a differential rule that disapplies the entirety of the final rule from adoption into the NT NER is a suitable solution.

The Commission has decided to make a differential rule so that the final rule does not have effect in the Northern Territory and no amendments to the NT NER will need to be made as a result of the final rule. The Commission considers that, in light of the challenges identified above, a differential rule to not apply the final rule in the NT NER will, or is likely to, better contribute to the achievement of the NEO than a uniform rule or differential rule that applies parts of final rule.

C.5 Civil penalty provisions and conduct provisions

The Commission cannot create new civil penalty provisions or conduct provisions. However, it may recommend to the Energy Ministers' Meeting that new or existing provisions of the NER be classified as civil penalty provisions or conduct provisions.

The NEL sets out a three-tier penalty structure for civil penalty provisions in the NEL and the NER.[308] A Decision Matrix and Concepts Table,[309] approved by Energy Ministers, provide a decision-making framework that the Commission applies, in consultation with the AER, when assessing whether to recommend that provisions of the NER should be classified as civil penalty provisions, and if so, under which tier.

Following consultation with the AER, the Commission proposes to make the following civil penalty recommendations to the Energy Ministers' Meeting in relation to the final rule. The AER supports the civil penalty provision recommendations outlined in the final determination.

The Commission recommends to the Energy Ministers' Meeting that the following new clause should be classified as a tier one civil penalty provision.

Table C.1: New civil penalty provision recommendation(s)

Clause	Description of clause	Proposed classification	Reason for classification
5.2.2(e)	This new clause consolidates existing obligations on registered participants in respect of their connection agreements (specifically, existing clauses 5.2.3(b), 5.2.3(g1), 5.2.3A(d), 5.2.4(a), 5.2.4(f), 5.2.5(a), 5.2.5(c), 5.2.5A(a) and 5.2.5A(c)). The obligations are for these registered participants to plan, design, operate and maintain their plant in order to comply with the terms and conditions in their connection agreements.	Tier 1	Compliance with the provision is necessary to ensure appropriate supply security and reliability and failure to comply with this provision could result in consumer harm. Connection agreements set out the performance standards for plant that are set in accordance with the requirements in schedule 5. It is vital that parties comply with their performance standards and any associated terms and conditions (such as system strength remediation schemes) to ensure that the security of the NEM is not compromised. In the worst circumstances, non-compliance with connection agreements can have severe adverse effects and significant costs on other network users and consumers.

308 Further information is available at https://www.aemc.gov.au/regulation/energy-rules/civil-penalty-tools

309 The Decision Matrix and Concepts Table is available at: https://web.archive.org.au/awa/20210603104757mp_/https://energyministers.gov.au/sites/prod.energycouncil/files/publications/documents/Final%20-%20Civil%20Penalties%20Decision%20Matrix%20and%20Concepts%20Table_Jan%202021.pdf

The Commission also recommends that the Energy Ministers' Meeting retain the classification tiers for a number of existing civil penalty provisions that will be amended by the final rule.

Table C.2: Amended civil penalty provision recommendations

Clause	Description of amendment	Current classification	Reason to retain tier
3.6.3(b)(2)	The final rule deletes the glossary definition of 'voltage' and unitalicises the word 'voltage' in this clause.	Tier 3	As these amendments do not change the nature of these obligations, no change to the civil penalty tier is recommended.
3.6.3(b1)	The final rule deletes the definition of *rated active power* and replaces references to '*rated active power*' with '*active power capability*'.	Tier 3	As these amendments do not change the nature of these obligations, no change to the civil penalty tier is recommended.
4.3.5(a)	The existing obligation is for some Market Customers to have interruptible loads available. The final rule places this obligation on the relevant Schedule 5.3 Participant instead so that it lies with the owner or operator of the load, who may not be the Market Customer for the connection point.	Tier 1	As the intent of the amendment is to ensure the obligation sits with the relevant owner or operator, and not to change the nature of the obligation itself, no change to the civil penalty tier is recommended.
4.3.5(b)	The existing obligation is for some Market Customers to provide their interruptible load in 'manageable blocks'. The final rule places this obligation on the relevant Schedule 5.3 Participant instead.	Tier 1	As the intent of the amendment is to ensure the obligation sits with the relevant owner or operator, and not to change the nature of the obligation itself, no change to the civil penalty tier is recommended.
4.4.2(b)	The final rule substitutes 'generating units' and 'bidirectional units' with 'production units'.	Tier 1	As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
4.4.3, 4.5.2(b), 4.9.4(b), 5.7.4(a1), 5.13.1(d)	The final rule deletes the glossary definition of 'voltage' and unitalicises the word 'voltage' in these clauses.	Tier 1	As these changes do not change the nature of these obligations, no change to the civil penalty tier is recommended.
5.2.3(b)	The final rule streamlines the drafting of this clause and	Tier 1	As the amendment retains the obligation for NSPs to comply

Clause	Description of amendment	Current classification	Reason to retain tier
	enables common connection agreement obligations to be consolidated by 5.2.2(e).		with the standards in schedule 5.1, no change to the civil penalty tier is recommended.
5.2.3(c)	The final rule makes a minor grammatical correction for clarity.	Tier 2	As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.2.3(d)(11)	The final rule substitutes references to specific categories of Registered Participants with Connection Applicants and Network Service Providers (where relevant). This clause obliges Network Service Providers to provide to AEMO the information required from relevant Connection Applicants and Registered Participants under schedules 5.2, 5.3 or 5.3a, rather than limiting the obligation to the two categories of Registered Participants.	Tier 2	The amendment is intended to better capture that NSPs are obliged to provide all required information to AEMO from all connection applicants and/or registered participants. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.2.3(g)	The final rule broadens the application of this clause to all HVDC links (i.e. schedule 5.3a plant), regardless of whether an HVDC link is a market network service or not, consistent with the changes to schedule 5.3a.	Tier 1	The intent of the amendment aligns with broader changes to the application of schedule 5.3a. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.3.3(b1)	The final rule deletes the glossary definition of 'normal voltage' and removes a reference to 'normal voltage' in this clause that would have become redundant.	Tier 3	As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.3.4B(a2)	The final rule replaces 'generating system, integrated resource system or other connected plant' with 'plant', for brevity.	Tier 2	As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.3.4B(q)	The final rule replaces a reference to 'Registered Participant' with 'party'. This aligns with the intent of the final rule to apply the system strength mitigation requirement on schedule 5 plant that meet AEMO's definition of large inverter-based resource in its system	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.

Clause	Description of amendment	Current classification	Reason to retain tier
	strength impact assessment guidelines, who may or may not be registered participants.		
5.3.6(j)	The final rule replaces references to a Distribution Connected Resource Provider and a Market Network Service Provider with a link to rule 5.3AA(a)(2).	Tier 3	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.3.7(g)	The final rule replaces references to Registered Participants and certain categories with Connection Applicant and Schedule 5.2 Participant.	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.3.8(f)	The final rule replaces a reference to a 'Registered Participant' with 'NSP or a Schedule 5 Participant'. It also expands 'incorrect' information in relation to a performance standard with 'incomplete, inaccurate or out of date' information.	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. The obligation will be extended slightly to 'incomplete, inaccurate or out of date' information, which the Commission considers is a reasonable expansion of the provision. It will ensure that AEMO has complete visibility over all performance standards to maintain system security and resilience. As the nature of the obligation is largely unchanged, no change to the civil penalty tier is recommended.
5.3.9(b)(2)	The final rule replaces references to 'generating system/unit' with 'production units or synchronous condensers'.	Tier 2	The intent of the amendment aligns with the intent to broaden schedule 5.2 to synchronous condensers. As the nature of the obligation is largely unchanged, no change to the civil penalty tier is recommended.
5.3.9(h)	The final rule replaces a reference to 'Generator or Integrated Resource Provider' with 'Schedule 5.2 Participant'. It also links the requirement for the NSP and the Schedule 5.2 Participant to jointly notify AEMO of any	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. Linking this provision to clause 5.3.7 slightly changes the obligation, but will ensure that AEMO is aware of all relevant changes made

Clause	Description of amendment	Current classification	Reason to retain tier
	changes as a result of the clause 5.3.9 process to any information required to be provided to AEMO under clause 5.3.7, not limiting it to changes to a connection agreement.		through the clause 5.3.9 process, including any changes that may not be included in a connection agreement. The Commission considers that as this provision is similar in nature to clause 5.3.8(f) and therefore recommend that a similar tier 2 classification should apply.
5.3.10(a)	The final rule replaces references to 'Generator' with 'Schedule 5.2 Participant'.	Tier 1	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.3.12(b)	The final rule replaces 'Network User or Market Network Service Provider' with 'Schedule 5.3 Participant or Schedule 5.3a Participant'.	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.3.12(h)	The final rule makes changes throughout rule 5.3 to apply obligations to Schedule 5.3 and Schedule 5.3a Participants, and streamlines the Rules for clarity.	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.3.13(a)	The final rule replaces 'Network User or Market Network Service Provider' with 'Schedule 5.3 Participant or Schedule 5.3a Participant'.	Tier 1	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.7.2(h)	The final rule simplifies the drafting of this clause for brevity and clarity.	Tier 3	As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.7.2(i)	The final rule (in conjunction with changes to other paragraphs in clause 5.7.2) allows registered participants to request an assessment of equipment owned or operated by another registered participant if it believes	Tier 3	The amendment allows Registered Participants to be able to request an assessment (instead of a physical test) of equipment. The Commission considers that allowing parties to request an assessment (such as a simulation study) provides a

Clause	Description of amendment	Current classification	Reason to retain tier
	that the equipment may not comply with the NER or a connection agreement.		more cost-effective and simpler option to discover the root causes of any equipment behaviours that could be causing issues for the network or network users. The civil penalty provision currently obliges the Registered Participant who conducts a test to provide a report to AEMO and/or relevant registered participants. The amendment will extend this obligation to any Registered Participant who also conducts an assessment. The Commission considers that the expansion of the obligation will be minor, and therefore does not recommend changing the civil penalty tier classification for this clause.
5.7.4(a1)	The final rule requires NSPs to institute and maintain a compliance program for their schedule 5.2, 5.3 or 5.3a plant.	Tier 1	As NSPs can determine performance standards for plant that may not be subject to a connection agreement under clause 5.2.3(c1), it is critical that NSPs maintain a compliance program for the performance standards of these plant. The Commission recommends that the Tier 1 civil penalty continues to apply to this clause, as instituting and maintaining compliance programs are important to ensure power system security.
5.7.4(a3)	The final rule is consequential on the changes to clause 5.7.4(a1) to ensure that NSPs institute and maintain a compliance program for their schedule 5.2, 5.3 or 5.3a plant.	Tier 1	As NSPs can determine performance standards for plant that may not be subject to a connection agreement under clause 5.2.3(c1), it is critical that NSPs maintain a compliance program for the performance standards of these plant. The Commission recommends that the Tier 1 civil penalty continues to apply to this clause, as instituting and maintaining compliance programs are important to ensure power system security.

Clause	Description of amendment	Current classification	Reason to retain tier
5.20B.6(b)	The final rule consolidates clauses 5.20B.6(b) and (b1) by replacing 'generating unit' with 'production unit' for brevity.	Tier 2	As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
5.20C.4(b)	The final rule consolidates clauses 5.20C.4(b) and (b1) by replacing 'generating unit' with 'production unit' for brevity.	Tier 2	As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
S5.2.4(a)	The final rule replaces references to registration categories with 'Schedule 5.2 Participant', and 'generating system or integrated resource system' with 'schedule 5.2 plant'.	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
S5.2.4(b)	The final rule rewrites this clause to refer to 'Schedule 5.2 Participant', 'production systems', 'production units' or 'synchronous condenser systems' instead of referring to registration categories.	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
S5.3.1(a1)	The final rule replaces 'Network User' with 'Schedule 5.3 Participant'.	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.
S5.3a.1(a1)	The final rule replaces 'Market Network Service Provider' with 'Schedule 5.3a Participant'.	Tier 2	The intent of the amendment aligns with broader changes to the application of the access standard framework. As the amendment does not change the nature of the obligation, no change to the civil penalty tier is recommended.

The Commission proposes to recommend to the Energy Ministers' Meeting that the classifications for a number of provisions are removed given the relevant clauses have been deleted and therefore the current classifications are redundant.

Table C.3: Deleted civil penalty provision recommendations

Clause	Description of amendment	Reason
5.2.3(g1)	A Network Service Provider must comply with any terms and conditions of a connection agreement for its market network service facilities that form part of a system strength remediation scheme.	This clause will be made redundant by new clause 5.2.2(e).
5.2.3A(d)	A Market Network Service Provider must comply with any terms and conditions of a connection agreement for its connected plant that form part of a system strength remediation scheme.	This clause will be made redundant by new clause 5.2.2(e).
5.2.4(a)	A Customer must plan and design its facilities and ensure that its facilities comply with its connection agreement, all applicable performance standards, and the system standards. Note that this clause is not deleted but is completely replaced by a new clause that does not contain the existing obligation.	This clause will be made redundant by new clause 5.2.2(e).
5.2.4(f)	A Customer must comply with any terms and conditions of a connection agreement for its connected plant that form part of a system strength remediation scheme.	This clause will be made redundant by new clause 5.2.2(e).
5.2.5(a)	A Generator must plan and design its facilities and ensure that its facilities comply with its connection agreement, all applicable performance standards, and the system standards. Note that this clause is not deleted but is completely replaced by a new clause that does not contain the existing obligation.	This clause will be made redundant by new clause 5.2.2(e).
5.2.5(c)	A Generator must comply with any terms and conditions of a connection agreement that form part of a system strength remediation scheme.	This clause will be made redundant by new clause 5.2.2(e).

D Consideration of other issues raised in submissions

The AEMC received 23 submissions in response to its draft determination. This Appendix details the Commission's consideration of other relevant issues raised in submissions that were not discussed explicitly in the main body of this final determination.

Table D.1: Other issues raised in submissions to the draft determination

Clause and issue	Stakeholder view	AEMC response
S5.2.5.5 — Defining the end of a disturbance for multiple fault ride through	Shell Energy, p 3: Noted that further consideration is warranted on whether this rule meets the actual needs of the system and whether it should equally apply to both inverter connections and rotating machines. Inverter plant can relatively easily comply, but rotating plant generally cannot, due to the mechanical stresses that would be experienced by rotating plant. The very nature of a fault indicates that something has impacted the network, and plants need to be able to proactively protect against such things as mechanical damage, transient voltages and unbalanced loading.	Synchronous plant are already subject to multiple fault ride through requirements under the existing NER, which the Commission has not amended in this rule change. The Commission's final rule only clarifies when a disturbance can be taken to end for the purposes of clause S5.2.5.5, which is unrelated to the application of this clause to various types of plant. Furthermore, the Commission's final rule now allows connection applicants to request exemption from clause S5.2.5.5 requirements if any plant (including synchronous ones) cannot meet them due any plant specific limitations.
	Shell Energy, p 3: Noted that a 20ms dead time to determine faults fall within most voltage transducers cycle time, which would affect the perceived fault duration. Simulation of multiple events does not provide any real additional information than the simulation of a single event.	The Commission considers that voltage transducer cycle time does not seem to be relevant to simulations. In real life, if the end of a fault as indicated through measurement occurred within two output cycles of a voltage transducer then the fault duration might look a little longer, meaning compliance would be assessed from a little later. This appears to be a minor issue in practice, as faults in real life are seldom as clean as in simulations. The Commission disagrees that simulation of multiple faults does not provide any real additional information, considering that multiple faults can reduce the three phase fault level at the connection point below plant tuning minimum.
S5.2.5.5 — Allowing	Shell Energy, pp 3-4: Believes that the proposed	The Commission understands that resolution could have been challenging

Clause and issue	Stakeholder view	AEMC response
disclosure of plant limitations to comply with multiple fault ride through requirements	change is meant to capture rotating plant limitations discussed above. It is proposed that resolution should occur via dialogue between AEMO, NSPs and the connection applicants. Historically this has been challenging for connection applicants, as such, we encourage the AEMC to undertake further consultation on the impacts and the potential need for flexibility for rotating plant.	in the past as the existing rules did not explicitly allow for disclosure of plant specific limitations, which the final rule now addresses for all plant types (including synchronous ones).
	Transgrid, pp 9-10: Considered that if a disturbance is prolonged or exacerbated due to poorly tuned plant response (that is, causing the voltage to move beyond the 90-110 per cent range, even though the original disturbance has been cleared), it will be considered non-compliance with the continuous uninterrupted operation requirement.	The Commission considers that this would make compliance assessment under this clause significantly more stringent. Extensive studies and consultation are needed to consider this proposal. Moreover, it is unclear whether this additional requirement would present an entry barrier for some types of plant.
	Tesla, p 2: Noted that adding site-specific studies for multiple fault ride through will lead to additional costs and delays to the connection process, and point to the same results, and recommended modelling to verify requirements.	The Commission clarifies that the final rule does not add any requirement for site-specific studies. The Commission considers this to be a misunderstanding stemming from AEMO's review. AEMO's draft update report had initially proposed site-specific studies for multiple fault ride through, which was subsequently withdrawn from AEMO's final report (and rule change request).
	Transgrid, pp 10-11: Considered that existing the automatic access standard permits any combination of 15 different faults over a 5-minute period, with a 0 ms gap between just two successive faults, and any gap between the remaining faults. This variability in the sequence of faults makes it challenging to establish a consistent benchmark across plants connecting to the network.	As per the final rule clause S5.2.5.5(d)(5), "the minimum time difference between the end of one disturbance and the commencement of the next disturbance may be zero milliseconds". The Commission understands this to require ride through of any combination of 15 successive disturbances with 0 milliseconds gap, not just two successive disturbances. The Commission further clarifies that this requirement already exists under the current rules.

Clause and issue	Stakeholder view	AEMC response
S5.2.5.5 — Relaxing fault ride through requirements for system impedances above plant tuning level	Akaysha Energy, p 5: Considered it would be simpler to refocus multiple fault ride through requirements for the plant to not trip because of multiple faults than to define the system conditions for which it must remain in operation. OEMs and plant designers are reluctant to provide this certainty of performance for the number of faults events and the resulting system conditions. Furthermore, tuning of control parameters to meet performance for extremely rare multi-fault system scenarios (that have near zero chance of occurring) with result in sub-optimal normal performance.	The Commission considers that defining requirements for plant to not trip because of multiple faults is not much different from defining conditions for which plant must remain in operation. Hence, the Commission does not consider this to be an issue. Moreover, the provisions added by the final rule clauses S5.2.5.5(d)(10) and S5.2.5.5(l)(9) are exceptions rather than requirements for plant to remain in continuous uninterrupted operation. Allowing an exception for fault levels below plant tuning minimum means that, in practice, special tuning of control parameters should not be required to meet multiple fault ride through requirements. Hence, the final rule will allow more optimal tuning while balancing system security needs.
S5.2.5.5A — Clarifying the response requirements for balanced and unbalanced faults, and recognising negative sequence current responses	Akaysha Energy, p 6: Supported negative sequence injection requirements, but encouraged further description of objectives of negative sequence injection to assist OEMs and designers in appropriate tuning.	The overall objective of negative sequence current injection is to oppose unbalanced voltages during a disturbance, as described in clause S5.2.5.5A(f)(iii). This involves reducing excessive over-voltages in healthy phases, and lifting under-voltages in any faulted phases. The definition of "control objective" in clause S5.2.5.5A(b)(2) also reinforces this objective, taking into account both positive and negative sequence current responses. However, specific tuning to meet this objective will depend on local network conditions and connection configurations.
	Akasyha Energy, p 6; CEC, p 12: Suggested that clause S5.2.5.5A(t)(7) should instead require the proponent to detail any conditions for which a response is limited or cannot be provided, rather than the NSP all conditions considered relevant under which the current response is required.	If the plant response is limited under certain conditions, then this can be proposed as a negotiated access standard, subject to the minimum access standard and 5.3.4A. We note that the requirement under new clause S5.2.5.5A(t)(7) already existed, under clause S5.2.5.5(u)(4), and a change to this clause was not consulted on during AEMO's review.
	CEC, p 12: Recommended revising the wording of clause S5.2.5.5A(f)(1)(iii) to clarify that controlling unbalanced voltages on the network are out of the	The Commission considers that neither the control objective nor clause S5.2.5.5A(f)(1)(iii) require the plant to control negative sequence voltages on the network out of the generator's control. The 'unbalanced voltages'

Clause and issue	Stakeholder view	AEMC response
	reasonable control of a generator. SMA, p 4: Recommended revising the wording as voltage unbalance are not within the capabilities of a generator's control. Tesla, p 2: Recommended revising the wording of clause S5.2.5.5A(f)(1)(iii) to 'reduce over-voltage in unfaulted phases,' as it considered the draft wording did not fully capture the actual physical mechanism at play.	refer to the decrease in positive sequence voltage, and over-voltages on unfaulted phases, that occur after a fault at the connection point. While the Commission considers that Tesla's recommendation has merit, the final rule retains the draft wording. This is because any other control algorithms captured by 'or equivalent contributions' may have other effects beyond simply reducing voltages on unfaulted phases, but that nonetheless contributes towards the control objective.
	EPEC, pp 3-4: Requested specification of whether calculation of dI/dV is required for unbalanced faults, noting that enforcing dI/dV compliance during unbalanced faults may create competing objectives between positive and negative sequence current injections.	Calculation of dI/dV would be necessary for unbalanced faults, as per the list of faults described in clauses S5.2.5.5(c)(2) to (4); see clause S5.2.5.5A(f). The Commission recognises that there is a trade off between positive and negative sequence current responses, but the intent is that the control objective should guide the optimisation of positive and negative sequence current injection together. If the dI/dV factors specified in the AAS for positive sequence currents are not able to be met, a proponent may always negotiate a slightly lower factor that can be met, while achieving the control objective which prioritises stability.
	CEC, p 13; Transgrid, p 14; EPEC, p 4; Vestas, pp 2-3: Requested clarification on whether references to 'reactive current' throughout the clause should be positive sequence currents or otherwise. Noted inconsistencies between descriptions of voltage in the AAS and MAS.	We agree that these clarifications will be helpful. The final rule clarifies that clauses S5.2.5.5A(f)(1)(i)-(ii) and S5.2.5.5A(m)(1)(i)-(ii) refer to positive sequence currents with respect to 1 per cent changes in positive sequence voltage, and that the rise time and commencement time requirements at paragraphs (g) and (n) refer to the positive sequence current responses.
	Shell, p 4: Agreed with the intent of proposed changes, but encouraged the Commission to consult further with inverter experts.	The Commission notes that AEMO's review consulted widely with industry, including several OEMs. Some OEMs also responded to this rule change process. The Commission does not consider further consultation with OEMs is necessary, given the general support for these changes.

Clause and issue	Stakeholder view	AEMC response
	Transgrid, pp 13-14: Sought clarification on the scenarios in which limitations on reactive power response might be influenced by energy source availability. Considered it was unclear what kind of 'changed power system conditions' would prevent a plant providing a response.	The Commission notes that the allowance to provide a limited reactive current response due to changed power system conditions and energy source availability beyond the Schedule 5.2 Participant's control already exist in clauses S5.2.5.5(m) and (n).
	CEC, p 12; SMA, p 4; Tesla, p 2: Considered that clause S5.2.5.5A(t) should be limited to grid-following inverters as standard sequence component conversions does not provide additional value.	Recording the response in the performance standards is an important requirement for compliance and regulatory purposes, and already existed at clause S5.2.5.5A(u)(4). However, the final rule does allow the reactive current response to be recorded in another way that may be more meaningful, effective or concise — see clause S5.2.5.5A(t)(1)(iii).
S5.2.5.10 — Adding new requirements for instability detection and response	Transgrid, p 17: Suggested mandating AEMO to update the Power System Stability Guidelines to provide a clearer definition of "instability" in the context of clause S5.2.5.10 since instability can have broad definitions, which has led to numerous debates between stakeholders. To Transgrid's knowledge, it is impractical for the automatic access standard to require a protection system to cover all types of instability, whether large or small, short-term or long term. This could result in none of the asynchronous generators meeting the automatic access standard.	The Commission acknowledges Transgrid's feedback and understands that AEMO will consider updating the Power System Stability Guidelines upon publication of this final rule.
	Transgrid, p 17: Suggested revising the draft rule wording "disconnecting units for unstable behaviour" to "disconnecting via a trip or having the capability to disconnect via a trip of the entire generating system at once or in a controlled sequential manner for large generators, as agreed with AEMO and the NSP".	The Commission acknowledges this suggestion but considers it too prescriptive / specific for the requirements under this clause. The Commission notes that "disconnecting units" can involve disconnection of either a single unit or multiple units in a controlled sequential manner or the entire generating system at once, if necessary, without specifically prescribing it in the rules. The Commission further notes that the final rule requires the hierarchy of actions or process to be agreed with the NSP and

Clause and issue	Stakeholder view	AEMC response
		AEMO. This means that NSPs can negotiate specific actions or processes to be undertaken upon instability detection with Schedule 5.2 Participants.
	Transgrid, p 17: Noted that current rules use the phrase "promptly detection/disconnect". The detection time is critical for instability monitoring and suggest retaining the existing wording: "have facilities to promptly detect instability in voltage, reactive power and active power at the connection point".	This seems to be a misunderstanding, the existing clause S5.2.5.10(a) only refers to "disconnect it promptly" but does not refer to "prompt detection". The final rule also requires prompt execution in clauses S5.2.5.10(a)(1), S5.2.5.10(a)(2)(iii) and S5.2.5.10(b)(1)(ii).
	Transgrid, p 17: Recommended replacing "facilities capable of disconnecting units" with "a protection system capable of disconnecting units".	The Commission notes that the NER defines *facilities* as 'a generic term associated with the apparatus, equipment, buildings and necessary associated supporting resources,' which includes protection systems. The Commission also understands AEMO added 'facilities' in its final report to address feedback from Transgrid.
	Transgrid, pp 17-18: Suggested specifying a smaller threshold of 30 MVA instead of 100 MVA for synchronous condensers in clause S5.2.5.10(b)(2). Such smaller synchronous condensers are likely to be connected to weaker parts of the network for system strength remediation and can have a greater impact than larger generators connected to stronger parts of the network.	The Commission considers that reducing the size threshold will add costs for smaller connections. 100 MVA represents a reasonable threshold above which the inclusion of a phasor measurement unit would not reasonably represent a significant cost burden. In general, NSPs themselves may also need to independently invest in phasor measurement units in weaker parts of their network.
	ENA, p 2: Suggested requiring phasor measurement units for connections smaller than 100MW since AEMO's ISP highlights the future need to add phasor measurement units to networks under the optimal development path.	The Commission considers that while small connections are not required to be individually linked to a phasor measurement unit, this does not prevent NSPs from installing phasor measurement units at appropriate locations in the future, as highlighted in the ISP.
	Transgrid, p 18: Sought clarification regarding hybrid plants (i.e., solar or wind farms with synchronous	The Commission clarifies that the size threshold for the provision of a phasor measurement unit in a production system or synchronous

Clause and issue	Stakeholder view	AEMC response
	condensers behind their connection points). Specifically, will the 100 MW/100 MVA threshold apply to each individual component or the collective MVA size of the plant? Additionally, for hybrid plants with inverter-based resource aggregates of larger than 100 MW and synchronous condensers of 100 MVA (or smaller), will one phasor measurement unit be required for the synchronous condenser and one for the inverter-based resource aggregate? Is the 100 MVA size threshold for synchronous condensers applied on the basis of the connection point capacity (i.e., HV side of the MV/HV transformer) or the actual machine size at its terminal.	condenser system is effectively the connection point, as the final rule clauses S5.2.5.10(a)(3) and S5.2.5.10(b)(2) refer to the 'system'. This applies for all schedule 5.2 plant, including hybrid plant and synchronous condensers.
	Transgrid, p 18: Noted that usually pole slip protection will operate in the first or the second pole slipping unstable swing. Does sustained pole slipping referred to in clause S5.2.5.10(b)(1)(iii) pertains to when the generator does not have pole slip protection?	The Commission considers that synchronous condensers or generators can sometimes re-synchronise with the grid after a small number of pole slips without damage. If they cannot resynchronise, they will continue to pole slip. In some plant this will not cause damage, but it is likely to cause ongoing disturbance to the power system in the local area. The minimum access standard allows the NSP or AEMO to require disconnection in those circumstances through some sort of protection system. The NSP may need to exercise judgement as to what sustained means, as specifying a particular number of pole slips would be arbitrary.
	Transgrid, p 18: Recommended that the detail of voltage impacts in clause S5.2.5.10(b)(1) be left with the NSP as 1 per cent voltage change can have a significant impact in some areas of the network. Additionally, the assessment of 1 per cent could require some details to be discussed and agreed between different parties. Transgrid proposed the	The Commission clarifies that the 1 per cent voltage impact referred to clause S5.2.5.10(b)(1) only serves as a threshold criteria for the minimum access standard. Plant with a lower voltage impact are still expected to propose a standard that is as close as practicable to the automatic access standard as per clause 5.3.4A(b1), in negotiation with the NSP. The Commission considers that a negotiated access standard can account for differences in impact in different system and plant circumstances.

Clause and issue	Stakeholder view	AEMC response
	minimum threshold to be 0.5 per cent voltage change at minimum fault level (N-1 or system normal minimum fault level) based on the plant MVA rating. Transgrid has observed generators can swing P/Q up to the MVA rating when there is an instability as PPC (clause S5.2.5.1) limits may not work during certain conditions.	
	Transgrid, p 18: Recommended including "remote enablement and disablement signals" in addition to a remote tripping signal in clause S5.2.5.10(f).	The Commission considers that requiring capability to receive remote enablement / disablement signals would need further consultation and could add complexity and costs with unclear benefits.
	Transgrid, p 19: Noted that the automatic access standard requires "facilities to detect instability" only for asynchronous plant in clause S5.2.5.10(a)(2)(i) but not for synchronous plant in clause S5.2.5.10(a)(1). However, the minimum access standard in clause S5.2.5.10(b)(1) requires it for both synchronous and asynchronous plant, which is inconsistent with the automatic access standard.	The Commission notes that the automatic access standard for synchronous plant is for a known technology — pole slip protection which results in an action to trip the plant when the rotor loses synchronism with the stator. Hence, a separate detection system is not needed. Under the minimum access standard, pole slip protection is not mandatory unless requested by the NSP or AEMO. If a synchronous plant does not have pole slip protection, it still needs to manage its instability promptly which it can only do if it has ability to detect it. This is why 'facilities to detect instability' has been specified for all plant types in the minimum access standard.
	CEC, p 13: Noted that there should be a justified need for NSPs to request communicating information under clause S5.2.5.10(e), otherwise NSPs may require this unilaterally resulting in additional costs to projects.	The Commission considers that providing instability detection data to the NSP and AEMO can help them better understand the nature of the instability and coordinate the required responses among multiple plants in the vicinity. The Commission also considers the costs of any capability to communicate information to be generally insignificant compared to the costs of the plant itself, and far outweighed by the potential benefits to the power system provided by such capability.
	CEC, p 13: Asked to add an obligation for NSPs and	The Commission considers that if requiring installation of a phasor

Clause and issue	Stakeholder view	AEMC response
	AEMO to give written reasons to justify requesting a phasor measurement unit under the minimum access standard clause S5.2.5.10(b)(2)(i).	measurement unit, NSPs or AEMO would normally provide a reason for their request. Hence, the Commission does not consider adding an explicit obligation to this effect to be necessary.
	ElectraNet, p 2: Supported requiring a phasor measurement unit for larger systems but sought clarification on clause S5.2.5.10(a)(3)(ii) regarding the information to be received by generators, and what actions are required if NSP is to be involved.	The Commission understands that phasor measurement units are part of a system being developed by AEMO to help identify the source of an oscillation. Final rule clauses S5.2.5.10(a)(3)(ii) and S5.2.5.10(b)(2)(ii) will add a forward-looking capability for information to be received by plant once AEMO's system gets developed and utilised in the future. The Commission notes that the final rule only provides for capability to receive information rather than a requirement to do so at this stage. Further details on the information to be received from AEMO are expected to emerge once AEMO's system becomes operational.
S5.2.5.13 — Relaxation of minimum access standard requirements for smaller plant	ElectraNet, p 2: Opposed the relaxation of certain requirements in the minimum access standard of clause S5.2.5.13, considering it would create voltage control and reactive power coordination challenges in the future.	The Commission notes that the relaxations are limited to specific requirements in the minimum access standard. All plant will still have to propose a negotiated access standard as close as practicable to the AAS (as per clause 5.3.4A(b)). This amendment will allow greater flexibility for smaller plant to be able to negotiate those specific requirements, if necessary.
S5.2.5.13 — Power oscillation damping capability for asynchronous production units	Trinasolar, p 1: Proposed modifying clause 5.2.5.13(b)(4)(vii)(B) to read 'demonstrates an opposition to all voltage modulated frequencies as defined by AEMO for oscillation rejection testing for the range of system impedances nominated by the Network Service Provider under paragraph (m).'	The Commission notes that power oscillation damping capability can include active power damping, which may sometimes be required to damp inter-area oscillation modes — see the AEMC's 2018 *Generator technical performance standards*, Rule determination, p 132. However, Trinasolar's proposal is focused on opposing voltage oscillations, which is not equivalent to the current requirement in the Rules. As such, the Commission has not adopted this suggestion in the final rule.
S5.2.5.13 — Automatic access standard and Table	EPEC, p 5; gridmo, p 2: Noted that the settling times for setpoint changes are very long for overdamped responses, and requested that the final determination	As noted by AEMO in its Appendix to its Final Report (see pp 73-74), a slower overdamped response to a setpoint change may have long settling times, but this would be suitable for a reactive power or power factor

Clause and issue	Stakeholder view	AEMC response
S5.2.1	included specific scenarios to illustrate the purpose, or clarify why it was proposed.	mode of operation. Using settling time as a proxy measure for stability is more relevant to responses that are underdamped or oscillatory, hence the stricter 5-second settling time requirements in the final rule.
	gridmo, p 2: Noted that 'voltage as primary' states that 'setpoint input ramp rate limit, if applicable, may be disabled for test purposes,' and that this would make a difference between modelled performance and real plant performance.	By clarifying that setpoint input ramp rate limits can be disabled for testing particular aspects of controls, it will mean that there may be a difference between modelled performance and on-site commissioning — this is the expected outcome.
	SMA, p 4: Requested clarity on how rise and settling times will be assessed, or what will be required to provide evidence of compliance.	The Commission does not consider further prescription on assessment or compliance matters against clause S5.2.5.13 is necessary in the final rule.
	Transgrid, pp 22-23: Strongly disagreed that the reactive power rise time requirement for voltage control as primary should only be applicable to voltage disturbances. Recommended that the requirement be for both voltage disturbances and setpoint changes (or as agreed with AEMO and the NSP).	The Commission does not consider that a rapid voltage setpoint change, in the absence of a voltage disturbance, is necessary. Rapid or large voltage setpoint changes should not be used in the normal operation of the power system, as they may cause power system disturbances.
	Transgrid, p 23: Considered that because clauses S5.2.5.13(b)(3)(vii) and S5.2.5.13(b)(4)(v) refer to a step change of voltage setpoint or step-like change in voltage, this created a discrepancy with Table S5.2.1.	The wording in those clauses refers to both a step change of voltage setpoint, **or** a step-like change in voltage (which would be caused by a voltage disturbance). It does not imply that both requirements must apply in every scenario.
	Transgrid, p 23: Recommended improving the formatting and readability of Table S5.2.1 (for example, poor indentation and text alignment, missing footnote reference, and recommended rewording of 'without limiting device condition').	The Commission has incorporated Transgrid's suggestions in the final rule to improve the Table's formatting and readability.
S5.2.5.13 — Minimum access	Transgrid, pp 22-23: Questioned why the minimum access standard did not reference Table S5.2.2 for	This was a drafting error in the draft rule. The Commission has reworded clause S5.2.5.13(d)(5) accordingly.

Clause and issue	Stakeholder view	AEMC response
standard	asynchronous plant.	
S5.2.5.13 — Drafting errors	APA, p 14: Noted drafting inconsistencies between the automatic and minimum access standards in clauses S5.2.5.13(b)(2B)(iii) and S5.2.5.13(d)(2B)(ii).	The Commission has adopted APA's recommendations to rectify the inconsistency in the final rule.
	Transgrid, p 23: Noted drafting inconsistencies with '*reactive power* response range' and '*reactive power capability* range'.	The Commission has adopted Transgrid's recommendations to rectify the inconsistencies in the final rule.

Abbreviations and defined terms

AAS	Automatic access standard
AS/NZS	Joint Australian and New Zealand Standards
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
Commission	See AEMC
CUO	Continuous uninterrupted operation
DME	Northern Territory Department of Mining and Energy
DNSP	Distribution Network Service Provider
ENTSO-E	European Association for the Cooperation of Transmission System Operators (TSOs) for electricity
HVDC	High voltage direct current
IEC	International Electrotechnical Commission
IEC/TR	International Electrotechnical Commission Technical Report
IRP	Integrated Resource Provider
kV	Kilovolt
MAS	Minimum access standard
MCE	Ministerial Council on Energy
MVA	Megavolt-ampere
MVAr	Megavolt-ampere reactive
MW	Megawatt
MNSP	Market Network Service Provider
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
NT Act	*National Electricity (Northern Territory) (National Uniform Legislation) Act 2015*
OEM	Original equipment manufacturer
Pmax	maximum active power
Proponent	The individual / organisation who submitted the rule change request to the Commission
R1	Refers to the process between the execution of a connecting generator's connection agreement and the completion of market registration. It involves the connecting party preparing a detailed engineering design of their plant, a suite of technical models, a commissioning plan and other documentation to demonstrate to the NSP and to AEMO that the plant meets its performance standards.
RUG	Releasable User Guide
RMS	Root mean square
SSSP	System strength service provider

STATCOM	Static synchronous compensator
SVC	Static VAR compensator
TNSP	Transmission Network Service Provider
VA	Volt-ampere
VAR or VAr	Volt-ampere reactive