

Technical Requirements for sub 5 MW DER Connections – Final Consultation Report

November 2025





We acknowledge the Traditional Custodians of the land, seas and waters across Australia. We honour the wisdom of Aboriginal and Torres Strait Islander Elders past and present and embrace future generations.

We acknowledge that, wherever we work, we do so on Aboriginal and Torres Strait Islander lands. We pay respect to the world's oldest continuing culture and First Nations peoples' deep and continuing connection to Country; and hope that our work can benefit both people and Country.

'Journey of unity: AEMO's Reconciliation Path' by Lani Balzan

AEMO Group is proud to have launched its first [Reconciliation Action Plan](#) in May 2024. 'Journey of unity: AEMO's Reconciliation Path' was created by Wiradjuri artist Lani Balzan to visually narrate our ongoing journey towards reconciliation - a collaborative endeavour that honours First Nations cultures, fosters mutual understanding, and paves the way for a brighter, more inclusive future.

Important notice

Purpose

The purpose of this publication is to report on the consultation process and provide explanatory information about the development of AEMO's guideline for distributed energy resources. It relates only to the version of that guideline published as at the date this document was last updated.

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1 Introduction

1.1 Purpose and scope

This final consultation report summarises the consultation process undertaken by the Australian Energy Market Operator (AEMO) to develop its guideline¹ for distributed energy resources (DER) connections below 5 megawatts (MW) (“sub 5 MW DER”) in the National Electricity Market (NEM). The report explains AEMO’s reasons for including the technical performance requirements specified in the guideline for sub 5 MW DER, where they are not covered by either:

- AS/NZS 4777.2:2020 for low voltage (LV) connected inverter-based DER², or
- National Electricity Rules (NER) Schedule 5.2 (S5.2), typically applied to connections 5 MW and above.

The guideline outlines technical requirements that AEMO considers appropriate to maintain the security and reliability of the NEM bulk power system, given increasing uptake of DER in this size range.

The guideline does not consider or specify technical requirements for performance aspects that are only expected to impact the local distribution network. Distribution network service providers (DNSPs) should carefully consider how to address any overlaps between the guideline and other relevant aspects of the DNSP connection process.

The guideline does not replace the need to include performance requirements in the connection agreement between a DER proponent and the DNSP. Rather, the guideline is intended as a resource for DNSPs to develop connection policies that incorporate a minimum set of AEMO-recommended performance requirements supporting the integrity of the bulk power system.

1.2 Background and consultation

DNSPs typically specify technical performance requirements for sub 5 MW DER connections in their connection guidelines. DNSPs have adopted differing approaches to performance requirements that can affect outcomes in the bulk power system.

AEMO undertook a review of technical requirements for sub 5 MW DER connections and published a consultation report with proposed bulk power system requirements in September 2024³. Table 4 of that report outlined a draft set of proposed settings for different technical requirements.

AEMO’s review considered the potential cumulative impact of a high volume of sub 5 MW DER connections over time, given the large number in DNSP connection pipelines and projected into the future.

¹ DNSP Guideline, *Technical Requirements for sub 5 MW DER Connections*, November 2025, at <https://www.aemo.com.au/-/media/files/initiatives/engineering-framework/2025/Technical-Requirements-for-sub-5-MW-DER-Connections-DNSP-Guideline>

² In this context LV refers to 230 volts (V)/400 V inverters. The scope of AS/NZS 4777.1:2024 allows for its application to inverter energy system (IES) connections at voltages above 1,000 V alternating current (ac) (high voltage (HV) connections), where low voltage (LV) load is part of the connection. AEMO understands that the requirement for local load was included so that AS/NZS 4777.1:2024 could not be applied to a DER installation, such as a solar PV installation, that is large and connected at a higher voltage but consists of LV inverters. Such DER installations should be covered by alternative standards, such as NER S5.2 or those being proposed by this review, depending on the installation size.

³ AEMO, *Technical Requirements for 200 kW to 5 MW DER connections*, September 2024, at https://www.aemo.com.au/-/media/files/initiatives/engineering-framework/2024/aemo_technical-requirements-for-200kw-to-5mw-der-connections_sept-2024_final_.pdf.

Submissions on the consultation report were received from a range of parties, including DNSPs, original equipment manufacturers (OEMs), energy retailers and industry bodies. A summary of the feedback is provided in Section 1.3.

Based on this feedback, AEMO prepared a draft guideline outlining recommended technical requirements for sub 5 MW DER and consulted further with DNSPs. Their additional feedback is discussed in Section 1.4 of this final consultation report and has been accounted for in the final published guideline.

AEMO considers the guideline as an interim measure prior to the development of a national standard covering connections in this sub 5 MW DER category.

1.3 Summary of submissions on AEMO consultation report

Table 1 lists the stakeholders who provided submissions to AEMO's September 2024 consultation report.

Table 1 Stakeholders who provided submissions

Stakeholder name	
AGL	Ergon Energy and Energex
Ausgrid	RBPE
Clean Energy Council (CEC)	SMA
Enel X	Standards Australia
Energy Australia (EA)	

Table 2 summarises the material issues raised in the submissions, with a more detailed breakdown of feedback and AEMO responses in Appendix A1.

Table 2 Summary of feedback to consultation report

Theme	Raised by
Consistency in standards and collaboration across industry (discussed further in Section 2.2)	AGL, CEC, Enel X, Ergon Energy and Energex, SMA, Standards Australia
Standards development (discussed further in Section 2.3)	AGL, Ausgrid, CEC, EA, Ergon Energy and Energex, RBPE, SMA, Standards Australia
System requirements (discussed further in Section 3)	EA, Enel X, Ergon Energy and Energex, RBPE, SMA
Technical requirements relating to ramp rates (discussed further in Section 3.7)	AGL, EA, Ergon Energy and Energex, SMA
Modelling and monitoring (discussed further in sections 2.5 and 3.6)	AGL, Ausgrid, EA, Enel X, Ergon Energy and Energex
Implementation approach (discussed further in Section 2.2)	Ausgrid
Other matters (discussed further in Appendix A1.7)	Ausgrid, Enel X, Ergon Energy and Energex, SMA

1.4 Feedback on the draft guideline

AEMO developed a draft guideline based on Appendix A1 of the public consultation report, taking account of stakeholder feedback. This draft was shared with DNSPs and discussed at a workshop, focusing on the technical requirements that AEMO identified as having potential impacts on bulk power system security and some additional topics including modelling,

commissioning, compliance, and aggregated DER. A summary of the feedback on the draft guideline is provided in Table 3, with discussion of the detailed feedback and AEMO's responses in the cross-referenced sections.

Table 3 Summary of feedback on draft guideline

Theme	Description
Scope of standards (discussed further in Section 2.1)	The scope of the guideline should be clarified and applied to 5 MW – 30 MW DER exempted from registration.
Frequency ride-through (discussed further in Section 3.1)	Different settings for frequency ride through should apply in the Mainland and Tasmania to align with the frequency operating standard (FOS) and AS/NZS 4777.2:2020.
Rate of change of frequency (RoCoF) ride-through (discussed further in Section 3.2)	Suggested clarifying the term “remain in operation” to align with AS/NZS 4777.2:2020.
Voltage ride-through (discussed further in Section 3.3)	Clarify whether the obligation applies at all levels of active power output. Suggested that an additional obligation to operate between 0% and 30% voltage for 150 milliseconds (ms).
Phase angle shift ride-through (discussed further in Section 3.4)	Consider defining the ride-through requirement in terms of the DER not having any vector shift or similar relay or protective function that acts upon voltage phase angle shifts less than 20 degrees at the connection point.
Active power curtailment (discussed further in Section 3.5)	Clarification whether curtailment is remote disconnection or via the power plant controller (PPC).
Remote monitoring (discussed further in Section 3.6)	The requirements need to consider the cost of implementing.
Ramp rate (discussed further in Section 3.7)	Clarification of some sought for exemption related to frequency control and the priority of protection schemes.
Frequency droop (discussed further in Section 3.8)	Clarifying the DNSP's role when approving a more aggressive droop.
Matters to include in the guideline (discussed further in Section 2.2)	Suggestion that the guideline should also include other requirements such as voltage control mode, reactive capability, protection requirements, power quality, performance during faults.
Modelling (discussed further in Section 2.5)	Clarify what, if any, modelling requirements would be imposed through the guidelines.
Commissioning (discussed further in Section 2.5)	Clarify what, if any, commissioning requirements would be imposed through the guidelines.
Compliance and implementation (discussed further in Section 2.6)	<ul style="list-style-type: none"> • Need clarification on how compliance with the guideline will be assessed. • Suggest a clear roadmap/timeline for the national standard. • A clear roadmap for implementing a national standard is required.
Aggregated DER (discussed further in Section 2.1)	Need clarification on how the guideline should be applied to aggregated <5 MW DER systems.

1.5 Compliance with the guideline

AEMO has worked with Standards Australia (committee EL-064) on a proposal for the Australian adoption of the International Electrotechnical Commission (IEC) Technical Specification *IEC 62786-1:2023 Distributed energy resources connection with the grid – Part 1: General Requirements*. The proposal has been formally submitted to Standards Australia by the committee.

AEMO considers that progressing this work through Standard provides an effective pathway to address requirements covered in the guideline. AEMO will continue to engage collaboratively with the EL-064 to ensure alignment during the development process and facilitate an effective and coordinated transition to a new Australian Standard. This process is

expected to cover the bulk power system requirements in the guideline and also consider distribution network requirements, relying heavily on input from DNSPs, OEMs and other stakeholders in the development process.

It is expected that compliance issues would be considered in the development of the Australian Standard.

Accordingly, the guideline is intended as an interim measure prior to the development of the national standard covering connections in this category. For that reason, AEMO does not consider that a product certification process should be adopted based on the guideline.

1.6 Relationship to the CER Roadmap

AEMO acknowledges that workstreams forming part of the National Consumer Energy Resources (CER) Roadmap are considering the technical regulation of CER. Specifically, the national regulatory framework for CER to enforce standards [T.2] workstream is considering arrangements for the effective technical regulation of CER devices and services.

At the time of publication, the definition of CER under consideration for regulation by the T.2 workstream has not been confirmed (whether it may refer to all devices below 100 kilowatts [kW] or extend to include larger capacity resources).

AEMO is working closely with CER Roadmap leads and program management to ensure that the technical regulation for sub 5 MW devices is managed either by the Roadmap processes or via this review, guideline and prospective Australian Standard.

1.7 Glossary

Terms that are defined in the NER have the same meanings when used in this document. Table 4 lists frequently used abbreviations.

Table 4 Abbreviations

Abbreviation	Meaning
AAS	automatic access standard
AEMO	Australian Energy Market Operator
ALFC	automatic load frequency control
BESS	battery energy storage system
CEC	Clean Energy Council
CENELEC	European Committee for Electrotechnical Standardization
CER	consumer energy resources
CSIP-AUS	Common Smart Inverter Profile for Australia
DER	distributed energy resources
DNSP	distribution network service provider
EA	Energy Australia
FCAS	frequency control ancillary service/s
FOS	frequency operating standard
HV	high voltage (in this context means not LV)

Abbreviation	Meaning
Hz	hertz
IBR	inverter-based resource/s
IEC	International Electrotechnical Commission
kVA	kilovolt ampere/s
kVAr	kilovolt ampere/s reactive
kW	kilowatt/s
LV	low voltage (with reference to AS/NZS 4777.1:2024)
MAS	minimum access standard (with reference to NER S5.2)
ms	milliseconds
MSL	Minimum System Load
MVA	megavolt ampere/s
MW	megawatt/s
NEM	National Electricity Market
NER	National Electricity Rules
NSP	network service provider
OEM	original equipment manufacturer
PFR	primary frequency response
PPC	power plant controller
PFR	primary frequency response
PV	photovoltaic
PVNSG	PV non-scheduled generation
RoCoF	rate of change of frequency
S5.2	Schedule 5.2 of the NER
SCADA	supervisory control and data acquisition
SOC	state of charge

2 Scope and implementation approach

This section summarises the main topics and related issues raised in submissions to the consultation report and DNSP feedback on the draft guideline. A detailed summary of submissions to the consultation report and AEMO's responses is provided in Appendix A1.

2.1 Coverage of technical requirements

2.1.1 Issue summary and submissions

In the submissions received by AEMO from DNSPs, several comments were made regarding the scope of the guideline:

- Some DNSPs recommended that the guideline should apply only to high voltage (HV) connections 1.5 megavolt amperes (MVA) to 5 MVA.
- Others proposed that it should be limited to systems within the 1.5 MVA to 5 MVA size range.
- One DNSP sought clarification regarding DER with a nameplate rating between 5 MW and 30 MW, which may be exempt from registration and potentially not required to demonstrate compliance with NER S5.2.

Another question was whether the proposed guideline and subsequent Australian Standard should be applied to existing legacy stand-alone generating systems that also wish to connect to the grid. An example was given of an existing backup diesel generating unit installed to provide supply during an outage of grid supply, which the owners now also wish to connect to the grid.

2.1.2 AEMO's conclusion

The focus of AEMO's review was to address the gap in coverage between DER connections covered by AS/NZS 4777.2:2020 and those covered by NER S5.2, for performance requirements relevant to the security of the bulk supply system. Following the changes to AS/NZS 4777.1 in 2024, AEMO has clarified the scope of the guideline based on DER and connection voltage, and NEM DER registration categories. This is summarised in Table 5 and Table 6.

Based on DER and connection voltage

During a workshop held with DNSPs in June 2025, gaps were identified between the requirements outlined in AS/NZS 4777.2:2020 and those in the NER S5.2 requirements. Additionally, the updates to AS/NZS 4777.1 in 2024 (AS/NZS 4777.1:2024) changed the scope and applicability of AS/NZS 4777.2:2020, including:

- removal of the previous 200 kilovolt amperes (kVA) maximum capacity threshold,
- applicability to LV systems with nominal voltage of 230 volts (V)/400 V, in accordance with AS IEC 60038,
- potential applicability to LV inverter energy systems installations connected to the grid at high voltage, and
- exclusion of inverter energy systems connected to dedicated HV networks with no local LV load.

The removal of the 200 kVA threshold from the scope has implications for which systems are subject to AS/NZS 4777.1:2024 versus those that fall under the scope of the proposed new guideline or the NER S5.2 requirements.

AEMO has developed the following table as a guide to identifying the applicable standards or requirements for different DER and connection voltage or use cases, noting that there is potential for overlap.

Table 5 Applicable requirements based on DER and connection voltage

Connection type	Description	Size range (MW)	Applicable requirements
HV connected	LV inverter-based systems, with HV load	< 5 MW	New Guideline
	LV inverter-based systems, without LV load	< 5 MW	New Guideline
	LV inverter-based systems, with LV load	< 5 MW	AS/NZS 4777.2:2020
	LV inverter-based systems, other than 230/400 V nominal values	< 5 MW	New Guideline
	HV inverter-based systems	< 5 MW	New Guideline
LV connected	LV inverter-based systems	< 1.5 MW ^A	AS/NZS 4777.2:2020
HV connected/LV connected	Synchronous generation	< 5 MW	New Guideline

A. This threshold may vary by DNSP, based on location within the network and their specific connection policies; 1.5 MW appears to typically be the maximum size for DERs to be connected at LV network.

Individual and aggregated DER of 5 MW or more

One DNSP requested clarification from AEMO about whether the guideline will apply to each individual generating system under 5 MW within an aggregation of 5 MW or more.

Another DNSP suggested that AEMO clarify whether generating systems in the 5 MW to 30 MW range – those exempt from registration – should comply with the NER S5.2 or with the newly proposed guideline.

The following table is a guide to identifying the applicable standards or requirements that are likely to apply to aggregated DER and exempted generation 5 MW and above.

Table 6 Applicable requirements for individual or aggregated DER 5 MW or more

Topic	Description	Size range	Applicable requirements
Generating or integrated resource system	Aggregation of multiple DER that together meet the definition of a generating system or integrated resource system (being comprised of multiple generating units), for which a person must register as a Generator or Integrated Resource Provider and is not exempted by AEMO.	Aggregate system rating \geq 5 MW	NER S5.2
DER aggregation	Individual DER within an aggregation that is not considered as a single generating system or integrated resource system, where automatic exemptions apply to the individual DER.	< 5 MW ^A	See Table 5 for individual DER requirements
Exempt generating or integrated resource system	DER for which AEMO has approved an exemption from registration, where the exemption conditions do not require the DER to demonstrate compliance with NER S5.2.	System rating 5 MW – 30 MW	New Guideline ^B
	DER for which AEMO has approved an exemption from registration, where the exemption conditions require the DER to demonstrate compliance with NER S5.2.		NER S5.2

A. Any generating systems > 5 MW included in the aggregation would be treated under NER S5.2.

B. The current standard for exempted registration follows NER S5.2. It is at the discretion of the DNSP to choose whether to comply with NER S5.2 or adopt the new proposed guideline.

Legacy DER generating systems

To minimise the potential for gaps in coverage, the guideline will be capable of application to all sub 5 MW DER systems that operate connected to the grid. This includes legacy backup generating units, such as diesel generators, that previously only operated for a loss of supply but could potentially synchronise to the NEM grid. AEMO expects that the existence of such legacy DER generating systems would be considered when developing an Australian specific standard.

2.2 Consistency across DNSPs

2.2.1 Issue summary and submissions

At present, technical performance requirements for DER systems that are not covered by either AS/NZS 4777.2:2020 or NER S5.2 are determined by individual DNSPs as part of their connection process. Stakeholders noted advantages of consistency across DNSPs for performance requirements (for both AEMO's areas of focus and DNSP requirements) through the development of a harmonised guideline applying to all NEM DNSPs.

Other stakeholders, however, considered this may be too prescriptive for some circumstances, and that DNSPs should have discretion when setting requirements for individual DER projects based on their local network's specific circumstances. Some stakeholders considered that DNSPs should only be given this discretion with the agreement of the Australian Energy Regulator (AER).

Stakeholders also considered that AEMO should engage further with OEMs and ensure the guideline and any prospective standard align with other relevant industry initiatives.

2.2.2 AEMO's conclusion

AEMO acknowledges the benefits of harmonising technical requirements across DNSPs. At this stage, however, AEMO's guideline is focused on performance relevant to bulk power system security. AEMO has collaborated with DNSPs and industry to develop the guideline, aiming for consistency across DNSPs in bulk power system requirements for applicable DER connections, and providing clarity for OEMs and project developers with respect to these requirements.

The guideline does not include performance aspects solely relating to DNSP local network needs. These requirements remain at the discretion of individual DNSPs according to their connection policies. AEMO acknowledges that DNSPs may have other technical requirements specific to their local networks.

The guideline is not intended to replace the existing DNSP connection agreements, rather it serves as a recommended minimum set of technical performance requirements for bulk power system security. DNSPs are expected to apply the guideline requirements in conjunction with their local requirements, ensuring both bulk system security and local network reliability and stability objectives are achieved.

The technical requirements in the guideline, and the industry consultation undertaken for this review, provide a strong foundation for bulk power system considerations in the Standards Australia process aimed at formalising a national standard for DER connections not covered by AS/NZS 4777.2:2020 or NER S5.2 (see Section 2.3). This process is expected to also address local distribution network requirements.

The future development of an Australian Standard may allow for technical flexibility (where necessary or desirable) by including a range of allowable performances. However, there is no clear justification for the AER (or any other body) to have an additional role administering the negotiation of these requirements between DNSPs and DER project proponents.

AEMO does not consider the guideline as the appropriate place to include detailed arrangements for how system performance could be assessed and compliance determined. It is expected that performance requirements developed through Standards Australia would include methods for testing and conformance assessment, and potentially a process for certification of approved sub 5 MW DER systems. However, it is noted that product certification is best suited to LV connected equipment where the connection point voltage would be equivalent to the voltage on the terminals of the inverter. Product certification is less effective where the DER system includes a transformer between the connection point and the inverter terminals. AEMO is continuing to engage on compliance and conformance through the National CER Roadmap workstreams.

2.3 Development of an Australian Standard

2.3.1 Issue summary and submissions

AEMO considered that technical performance requirements should be based on or align with an existing international standard where possible. The review identified IEC Technical Specification IEC TS 62786-1 *Distributed energy resources connection with the grid - Part 1: General requirements*⁴ as covering the principles and technical requirements relevant for both distribution network and bulk power system operation.

Several stakeholders supported the adoption of the IEC TS 62786-1 as an Australian Standard. However, others considered that the EN 50549-2 Standard was a more appropriate starting point for an Australian Standard.

The CEC also considered that the scope of AS/NZS 4777.2:2020 and connections covered by this standard was not clear, and hence this would impact any Australian Standard for DER not covered by AS/NZS 4777.2:2020 and NER S5.2.

2.3.2 AEMO's conclusion

AEMO maintains its view that IEC TS 62786-1 provides the most suitable basis for establishing an Australian Standard for sub 5 MW DER (other than systems covered by AS/NZS 4777). Standards Australia has expressed support for working with AEMO and other stakeholders on the potential Australian adoption of IEC TS 62786-1.

AEMO understands that the EN 50549-2 standard was developed by the European Committee for Electrotechnical Standardization (CENELEC) Technical Committee CLC/TC 8X “System aspects for electrical energy supply” as a product standard, serving as technical reference for defining national requirements under the European Network Code Requirements for Generators. As a product standard, it could be appropriate for LV connected DER systems, as the voltage on the terminals of the inverters would also essentially be the connection point voltage.

By contrast, IEC TS 62786-1:2023 was developed by IEC Technical Committee TC 8 “System aspects of electrical energy supply” Joint Working Group JWG10 as a technical specification applying at the point of connection to the grid. This would

⁴ IEC Technical Specification 62786-1 IEC TS 62786-1:2023 Distributed energy resources connection with the grid - Part 1: General requirements, at <https://webstore.iec.ch/en/publication/62452>.

be more appropriate for DER systems connected at a higher voltage via a transformer where the connection point voltage differs from the voltage on the terminals of the inverters.

Further AEMO understands that the IEC TS was informed by the European requirements in EN 50549, with CENELEC experts also part of IEC TC8 JWG10, ensuring alignment. In addition, the Standards Australia mirror committee for IEC TC 8 (Standards Australia committee EL-064) participated in the development of IEC TS 62786-1:2023.

AEMO has clarified the scope of the DER connections covered by AS/NZS 4777, following by the changes to AS/NZS 4777.1 in 2024. This is summarised in Section 2.1.

2.4 Point of application

2.4.1 Issue summary and submissions

RBPE raised concerns that applying technical requirements for DER at the point of connection rather than at the inverter terminals can add very substantial costs and complexity to projects. However, RBPE indicated that for certain technical requirements, there is minimal practical difference between applying them at point of connection and inverter terminal:

- Frequency (including RoCoF) – frequency measurements will be effectively the same at both point of connection and inverter terminal.
- Voltage – while there may be some difference due to current and impedance between the two points, this is typically small, (generally less than 1% and unlikely to exceed 10%, except in rare situations).
- Phase angle jump – there is no difference in phase angle jump between the point of connection and inverter terminal, between the LV side or HV side of the transformer.

RBPE also made the point that implementing requirements at the point of connection in existing installations can often be technically challenging and costly.

One DNSP also proposed that a prioritisation framework should allow for DNSPs to specify the performance requirement at inverter terminal rather than at the point of connection, particularly in cases where on-site loads are part of critical infrastructure, such as hospitals or airports.

2.4.2 AEMO's conclusion

AEMO acknowledges this feedback and has reflected it in the guideline. The application point for relevant technical requirements will be left to the discretion of DNSPs. However, where specific requirements (such as remote monitoring) are explicitly specified to be applied at either the inverter or the point of connection, these should be applied as stated.

2.5 Modelling and commissioning

2.5.1 Issue summary and submissions

AEMO did not specifically indicate in its consultation report whether modelling would be required to assess the performance of sub 5 MW DER and their impact on the system. The level of modelling would be a matter for DNSPs to consider when assessing applications for sub 5 MW DER systems to connect, including whether alternative approaches

would be more effective and efficient. Similarly, AEMO did not specify what commissioning and testing would be required for connecting DER covered by the guideline.

AEMO received further feedback from DNSPs on both modelling and commissioning of the DER covered by the draft guideline. Different DNSPs proposed a range of requirements, some of which would be similar to larger generating systems, while others proposed no additional modelling requirements at all. Similarly, some DNSPs proposed commissioning tests equivalent to the R2 testing requirements for larger generating systems, while others proposed spot checks, or relying on the proponent to fulfil its obligations to meet the requirements.

2.5.2 AEMO's conclusion

AEMO considers that the modelling and commissioning requirements for sub 5 MW DER should be determined by the relevant DNSP and the connection proponent.

The guideline does not include a specific requirement for modelling or commissioning. This should be considered by the individual DNSPs and potentially included in a subsequent Australian Standard.

2.6 Compliance

2.6.1 Issue summary and submissions

As discussed in Section 1.5, compliance with the technical requirements is not prescribed by the guideline. Several submissions emphasised the importance of effective compliance arrangements for the requirements proposed, including the need for a robust compliance monitoring and reporting framework. Related to this, one DNSP recommended broader consideration of the overall framework, with clearly defined roles and responsibilities for different parties, particularly for handling non-compliance issues.

Other submissions sought clarification about whether compliance should be assessed at the site level, at the point of connection with the DNSP network or at the plant level.

2.6.2 AEMO's conclusion

AEMO concludes that DNSPs are best placed to manage site-level compliance through their connection processes. However, AEMO acknowledges the monitoring and enforcement challenges, and supports and encourages DNSP practices that could help build confidence that connecting DER will conform to technical requirements, including model provision, type testing and laboratory bench testing from OEMs, and monitoring.

As discussed in Section 2.4, the review has left the point of application for technical requirements to DNSPs, noting that DNSP practices might vary depending on system size, connection voltage and location within the network. This reflects in feasible ways to assess and validate conformance with technical requirements:

- Smaller installations (closer to 200 kW size) may be more amenable to DER device or product level testing and generic models.
- Larger MW-scale DER connections are typically engineered systems with site-level design decisions potentially impacting performance at the point of connection. More detailed models, enabling simulation under plausible grid conditions, and testing at the time of commissioning may be more appropriate for these conditions.

AEMO is advocating for the requirements in the guideline, and the associated compliance and testing framework, to be incorporated through the proposed modified Standard (IEC TS 62786-1), while adoption and compliance arrangements are formalised through the National CER Roadmap. The proposed National CER Technical Regulatory framework is intended to provide broad compliance mechanisms for device requirements, and installations. However, at this stage, it is unclear the extent to which it will capture devices and installations of this size and nature, if these systems are not included, alternative compliance monitoring and enforcement arrangements will need to be considered.



3 Technical requirements

AEMO has considered nine key focus areas for the technical requirements for DER systems not captured by AS/NZS 4777 or NER S5.2. This section discusses the requirements for each of these key focus areas and, in some cases, different requirements have been defined for:

- new connections and connection alterations of inverter-based DER including generation and storage,
- new connections and connection alterations of synchronous generation, and
- relevant changes to the operation of legacy plant in relation to the network, such as existing standby generation seeking to synchronise with the DNSP network.

Other technical requirements not considered in this guideline that do not relate to the security of the bulk supply system will be managed at the discretion of the DNSP. These include power factor, reactive power, reactive current injection during faults, protection requirements, power quality and fault current contribution.

3.1 Frequency ride-through

3.1.1 Issue

Tripping of DER generation for low frequency would exacerbate both the frequency deviation and RoCoF. Therefore, ensuring ride-through capability for frequency excursions and RoCoF are both important requirements that support power system security.

Tripping of DER generation at frequency above 50 hertz (Hz) will tend to reduce the frequency excursion; however, if a large amount of generation is tripped, the loss of supply can turn an over-frequency event into an under-frequency event. Tripping of batteries that are charging can also adversely affect a frequency excursion event.

3.1.2 Proposal in public consultation report

AEMO’s consultation report proposed to align the requirements for inverter-based resources (IBR) to the widest range specified in AS/NZS 4777.2 and the requirements for synchronous generation to the FOS.

This gave the following technical requirements for frequency ride-through:

DER classification	Proposed performance level
IBR	The requirements are aligned with AS/NZS 4777.2 <ul style="list-style-type: none"> • 45.0 Hz to 52.0 Hz the DER shall be capable of supplying rated active full output^A. • 49.5 Hz to 55.0 Hz multiple mode inverters with energy storage, must be capable of charging.
Synchronous generation	Requirements are aligned with the FOS for islanded conditions. <p><u>Mainland:</u></p> <ul style="list-style-type: none"> • 49.5 Hz to 50.5 Hz, continuously • 49.0 Hz to 49.5 Hz and 50.5 Hz to 51.0 Hz, for at least 10 minutes • 47.0 Hz to 49.0 Hz and 51.0 Hz to 52.0 Hz, for at least 2 minutes <p><u>Tasmania:</u></p> <ul style="list-style-type: none"> • 49.0 Hz to 51.0 Hz, continuously

DER classification	Proposed performance level
	<ul style="list-style-type: none"> • 48.0 Hz to 49.0 Hz and 51.0 Hz to 52.0 Hz, for at least 10 minutes • 47.0 Hz to 48.0 Hz and 52.0 Hz to 55.0 Hz for at least 2 minutes
Legacy plant	Performance to be agreed with DNSP based on plant capability with appropriate safety margins.

A. This requirement exceeds the requirements of the system standards so could be 47 Hz to 52 Hz with the agreement of the DNSP.

3.1.3 DNSP feedback on the draft guideline

Some DNSPs considered the full range of frequencies in AS/NZS 4777.2:2020 was too broad and recommended the frequency ride through requirements be better aligned to the FOS and automatic access standard (AAS) NER S5.2.5.3. In addition, it was recommended that the ride-through terminology of “remain in continuous operation for” be adopted for the guideline to better align with AS/NZS 4777.2:2020.

3.1.4 AEMO’s conclusion

AEMO considers that introducing the recovery time of up to 10 minutes and stabilisation time of up to 2 minutes from the FOS aligns the IBR with the AAS in NER S5.2.5.3. While this appears less arduous than the equivalent requirements in AS/NZS 4777.2:2020, in practice this aligns with performance requirements for larger IBR and synchronous generation, and hence the performance of the bulk supply system.

3.1.5 Guideline requirement

The following requirements are specified in the guideline:

DER classification	Performance level in the guideline (updated requirements are marked in red)
IBR and Synchronous generation	<p>The capability should be aligned with the FOS for islanded conditions.</p> <p><u>Mainland:</u></p> <ul style="list-style-type: none"> • At frequencies from 49.5 Hz to 50.5 Hz, the DER shall be capable of remaining in continuous operation. • At frequencies from 49.0 Hz to 49.5 Hz and 50.5 Hz to 51.0 Hz, the DER shall be capable of remaining in continuous operation for at least 10 minutes • At frequencies from 47.0 Hz to 49.0 Hz and 51.0 Hz to 52.0 Hz, the DER shall be capable of remaining in continuous operation for at least 2 minutes <p><u>Tasmania:</u></p> <ul style="list-style-type: none"> • At frequencies from 49.0 Hz to 51.0 Hz, the DER shall be capable of remaining in continuous operation. • At frequencies from 48.0 Hz to 49.0 Hz and 51.0 Hz to 52.0 Hz, the DER shall be capable of remaining in continuous operation for at least 10 minutes • At frequencies from 47.0 Hz to 48.0 Hz and 52.0 Hz to 55.0 Hz, the DER shall be capable of remaining in continuous operation for at least 2 minutes
Legacy plant	Performance to be agreed with DNSP based on plant capability with appropriate safety margins.

3.2 RoCoF ride-through

3.2.1 Issue

As discussed in Section 3.1, DER generation or charging batteries tripping due to a high RoCoF would exacerbate a frequency disturbance.



3.2.2 Proposal in consultation report

AEMO’s consultation report proposed to align the requirements for IBR with AS/NZS 4777.2:2020 and the FOS, and to align the requirements for synchronous generation with the FOS. This gave the following technical requirements for RoCoF ride-through:

DER classification	Proposed performance level
IBR	The capability should be aligned with AS/NZS 4777.2 and the FOS <ul style="list-style-type: none"> • ± 4 Hz/s for duration of 250 ms; and • the FOS requirement for ± 1 Hz/s over any 500 ms period
Synchronous generation	The capability should be aligned with the FOS <u>Mainland:</u> <ul style="list-style-type: none"> • ± 1 Hz/s over any 500 ms period; and • ± 3 Hz/s over any 300 ms period <u>Tasmania:</u> <ul style="list-style-type: none"> • ± 3 Hz/s over any 250 ms
Legacy plant	Performance to be agreed with DNSP based on plant capability with appropriate safety margins.

3.2.3 DNSP feedback on the draft guideline

A DNSP suggested that the ride-through terminology be changed to “remain in continuous operation for” when describing the operation during a disturbance.

3.2.4 AEMO’s conclusion

AEMO changed the ride-through terminology to “remain in continuous operation for” when describing the operation during a RoCoF disturbance.

3.2.5 Guideline requirement

The following requirements are specified in the guideline:

DER classification	Performance level in the guideline (updated requirements are marked in red)
IBR	The DER shall be capable of remaining in continuous operation for RoCoF up to: <ul style="list-style-type: none"> • ± 4 Hz/s for duration of 250 ms; and • the FOS requirement for ± 1 Hz/s over any 500 ms period
Synchronous generation	The DER shall be capable of remaining in continuous operation for RoCoF up to: <u>Mainland:</u> <ul style="list-style-type: none"> • ± 1 Hz/s over any 500 ms period; and • ± 3 Hz/s over any 300 ms period <u>Tasmania:</u> <ul style="list-style-type: none"> • ± 3 Hz/s over any 250 ms
Legacy plant	Performance to be agreed with DNSP based on plant capability with appropriate safety margins.



3.3 Voltage ride-through

3.3.1 Issue

Voltage disturbances in the transmission system, such as line faults, can be reflected down into the distribution network. If large amounts of DER trip for transmission faults it can cause voltage disturbances, and changes in power flows that may result in line overloading and supply-demand imbalances that lead to frequency excursions. Therefore, the technical requirements for ride-through for voltage excursions are a key consideration for maintaining power system security.

3.3.2 Proposal in consultation report

AEMO’s consultation report proposed to align the over-voltage requirements with the system standard in NER S5.1a.4⁵.

For under-voltages, AEMO proposed to align with the more arduous of AS/NZS 4777.2:2020 protection time delays for passive anti-islanding and the minimum access standard (MAS) in NER S5.2.5.4. However, AEMO considered that the AS/NZS 4777.2:2020 requirements to cease generation for voltage less than 78% after 400 ms was not appropriate for larger DER. This gave the following technical requirements for voltage ride-through:

DER classification	Proposed performance level
IBR	<p>The DER shall be capable of remaining in continuous operation for:</p> <ul style="list-style-type: none"> • Up to 130% for up to 60 ms, unless disconnection is required by the DNSP^A • Up to 125% for up to 100 ms, unless disconnection is required or allowed by the DNSP • Up to 120% for up to 350 ms • Up to 115% for up to 900 ms • Continuously for 90 - 110% • Down to 78% for up to 10000 ms • Down to 70% for up to 2000 ms • Down to 30% for up to 1000 ms <p>At connection point for HV connections At unit terminals or connection point for LV connections</p>
Synchronous generation and legacy plant	<ul style="list-style-type: none"> • Performance to be agreed with DNSP based on plant capability with appropriate safety margins.

A. The DNSP may require disconnection of the inverters between 120% and 130% of nominal voltage.

3.3.3 DNSP feedback on the draft guideline

One DNSP suggested that DNSPs should be able to impose a ride-through requirement for voltages between 0% and 30% of nominal voltage for up to 150 ms.

Another DNSP considered that the proposed single-phase ride-through requirement is higher than the MAS in NER S5.2.5.4, hence results in unreasonable increase in connection cost. The DNSP suggested this be reduced to align with the MAS.

Lastly, one OEM suggested aligning requirements with two-levels of under-voltage and over-voltage as shown in IEC 62786-1.

⁵ Note that the proposed level of performance for over-voltage is based on a descending series of steps and is thus slightly less arduous than the system standard in NER S5.1a.4 which is based on lines between vertices.



3.3.4 AEMO’s conclusion

AEMO agrees that individual DNSPs could add a requirement to be able to operate between 0% and 30% of nominal voltage for up to 150 ms where they considered it important for the operation of their networks.

AEMO notes that the proposed single-phase ride-through requirement is no more arduous than AS/NZS 4777.2:2020, however agreed that the DNSP should have discretion to replace the requirement with a level commensurate with the MAS in NER S5.2.5.4.

AEMO clarified this with the OEM, where the proposed requirements have been aligned with existing standards, including:

- NER S5.1a.4 for over-voltage, and
- AS/NZS 4777.2:2020 and MAS NER S5.2.5.4 for under-voltage.

3.3.5 Guideline requirement

The following requirements are specified in the guideline (% of nominal voltage at the connection point):

DER classification	Performance level in the guideline (updated requirements are marked in red)
IBR	<p>The DER shall be capable of remaining in continuous operation at any active power for:</p> <ul style="list-style-type: none"> • >125% to 130% for up to 60 ms, unless disconnection is required by the DNSP^A • >120% to 125% for up to 100 ms, unless disconnection is required or allowed by the DNSP • >118% to 120% for up to 350 ms • >110% to 118% for up to 900 ms • Continuously for 90 - 110% • <90% to 78% for up to 10000 ms • <78% to 70% for up to 2000 ms • <70% to 30% for up to 1000 ms • <30% to 0% for up to 150 ms, if required by the DNSP. <p>Alternatively, the DNSP can agree to apply the Minimum Access Standard in NER S5.2.5.4.</p> <p>The requirement applies:</p> <ul style="list-style-type: none"> • at the connection point for HV connections • at unit terminals or connection point for LV connections
Synchronous generation and legacy plant	Performance to be agreed with DNSP based on plant capability with appropriate safety margins.

A. The DNSP may require disconnection of the inverters between 120% and 130% of nominal voltage.

3.4 Phase angle ride-through

3.4.1 Issue

Line faults and similar contingency events are often accompanied by network switching (for example, to clear the fault), which is associated with voltage phase shifts on the power system. If large amounts of DER trip for voltage phase shifts it can cause voltage disturbances, and changes in power flows that may result in line overloading and supply-demand imbalances that lead to frequency excursions. Therefore, the technical requirements for ride-through for voltage phase shifts are a key consideration for maintaining power system security.



3.4.2 Proposal in consultation report

AEMO’s consultation report proposed to align the voltage phase shift requirements with those in AS/NZS 4777.2:2020. This gave the following technical requirements for phase angle ride-through:

DER classification	Proposed performance level
IBR	<p>The DER shall be capable of remaining in continuous operation for:</p> <ul style="list-style-type: none"> • Single-phase disturbance, 60 degrees • Three-phase disturbance, 20 degrees <p>Note: in AS/NZS 4777.2:2020 the requirements are at inverter terminal level, but this standard only applies to LV connections, the phase angle at inverter terminals is approximately the same as the connection point.</p>
Synchronous generation and legacy plant	Performance to be agreed with DNSP based on plant capability with appropriate safety margins.

3.4.3 DNSP feedback on the draft guideline

One DNSP noted that the equivalent ride-through requirement in the MAS in NER S5.2.5.16 states that the DER must not include any vector shift or similar relay or protective function that acts upon voltage phase angle which might operate for phase angle changes less than 20 degrees at the connection point. The DNSP was therefore concerned how much modelling would be required to test compliance with this requirement.

3.4.4 AEMO’s conclusion

AEMO agrees that compliance with the phase angle ride-through should not introduce an additional need for modelling. Therefore, AEMO considers that the DNSP should be given an option to apply a requirement equivalent to the MAS for phase angle ride-through. NER S5.2.5.16 has since been deleted, but there is an equivalent provision in NER S5.2.5.8(b6) for this requirement.

3.4.5 Guideline requirement

The following requirements are specified in the guideline:

DER classification	Performance level in the guideline (updated requirements are marked in red)
IBR	<p>The DER shall be capable of remaining in continuous operation for at-least:</p> <ul style="list-style-type: none"> • 60 degrees for single-phase disturbances • 20 degrees for three-phase disturbances <p>Alternatively, the DNSP may agree to the DER not including any vector shift or similar relay or protective function that acts upon voltage phase angle which might operate for phase angle changes less than 20 degrees.</p> <p>Note: in AS/NZS 4777.2:2020 the requirements are at inverter terminal level, but this standard only applies to LV connections, the phase angle at inverter terminals is approximately the same as the connection point.</p>
Synchronous generation and legacy plant	Performance to be agreed with DNSP based on plant capability with appropriate safety margins.

3.5 Active power curtailment

3.5.1 Issue

Under high DER generation and low demand conditions, there are some scenarios in which actions are required to maintain operational demand above minimum thresholds required for system security. This may include curtailment of DER generation. For jurisdictions that already have curtailment capabilities for distributed photovoltaic (PV) and PV non-scheduled generation (PVNSG), this is activated by the DNSP in accordance with the Minimum System Load (MSL) framework⁶.

3.5.2 Proposal in consultation report

AEMO's consultation report proposed that DNSPs can curtail active power or disconnect the DER, through remote control⁷.

3.5.3 Stakeholder feedback on the consultation report

AGL and **EA** supported consistent requirements for remote monitoring and power curtailment but recommended applying these only to systems above 1 MW. **Ausgrid** recommended that AEMO consider using the Common Smart Inverter Profile for Australia (CSIP-AUS) as a communication pathway for remote monitoring and active power curtailment.

AEMO does not have specific information on the relative cost of active power curtailment via supervisory control and data acquisition (SCADA) for smaller DER projects but agrees it could be high. However, AEMO notes that the need for remote curtailment is expected to increase as the penetration of small DER increases, and that some form of remote curtailment is required on DER to manage system security.

3.5.4 DNSP feedback on the draft guideline

Some DNSPs considered that clarification was needed if active power curtailment is remotely operated at the connection point recloser or in the power plant controller (PPC).

One DNSP also asked for clarification for this requirement to apply based on power transfer capability at the connection point.

3.5.5 AEMO's conclusion

AEMO considers that the capability of remote disconnection and reconnection should serve as a minimum requirement, but it would be more equitable to implement remote active power curtailment through the PPC to allow sharing any curtailment necessary, especially as the penetration of DER increases in the future. AEMO considers that the approach to active power curtailment should be agreed with the DNSP.

AEMO also considers that the requirement to remotely curtail active power could be applied at either the terminals of the DER or at the connection point. This should be agreed with the DNSP.

⁶ See <https://www.aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/managing-distributed-energy-resources-in-operations/managing-minimum-system-load>.

⁷ This includes curtailment on the instruction of AEMO such as during a system restoration.

3.5.6 Guideline requirement

The following requirements are specified in the guideline:

- There should be capability at the site to receive a control signal from designated DNSP interface points to (at minimum) disconnect the DER or curtail DER active power to a level specified by DNSP.
 - The capability is intended to be available and used if the DER is required to be curtailed for system security.
 - DNSPs may require more dynamic controls and limiting on-site.
- This curtailment can be achieved in different ways, including:
 - disconnecting and reconnecting the DER, or
 - curtailment through the PPC.

3.6 Remote monitoring

3.6.1 Issue

The ability to predict changes in load and non-scheduled generation is key to forecasting for market dispatch and an input into both power system operation planning in the short term, and power system augmentation in the longer term. Forecasting for all these timeframes relies on quality data. Of particular interest for forecasting are insights such as active power output and curtailment status (curtailed/not curtailed) or an equivalent quantity.

Feedback of active power and other quantities such as connection point voltage or reactive power output may also be important for distribution management systems and might be required by DNSPs.

It is important to note that any requirement for monitoring is not expected to result in signals being transmitted to AEMO directly, rather such signals would be directed to the relevant DNSP.

3.6.2 Proposal in consultation report

AEMO's consultation report proposed that for DER systems 200 kW and above, there should be remote monitoring of:

- active power level, and
- active power curtailment status (active/inactive).

The implementation method for this monitoring should be agreed with the DNSP.

3.6.3 Stakeholder feedback on the consultation report

AGL, Enel X, EA and another DNSP representative said that SCADA and NEM-grade metering requirements create significant costs and barriers for customers, especially in the 200 kW to 1 MW range. **Ausgrid** suggested that relying on traditional SCADA pathways such as DNP3 could limit flexibility and increase costs unnecessarily.

AEMO agrees that the relative cost of SCADA for smaller DER projects can be high. Therefore, it is recommended that the requirements be specified by the DNSP, allowing the use of cost-effective options where available. AEMO considers that

DNSPs should collectively review their monitoring options and, where appropriate, begin to specify harmonised approaches across their networks.

3.6.4 DNSP feedback on the draft guideline

One DNSP considered that it may be too costly to monitor all DER system 200 kW and above.

Another DNSP considered that an agreed output level from the DER system should apply in the event of a communication failure.

3.6.5 AEMO's conclusion

AEMO remains of the view that monitoring of all DER systems 200 kW and above will become increasingly more important as their penetration increases.

AEMO also considered the need for fall-back settings for DER systems to provide an agreed level of output during a communications failure. While widespread failures may impact the bulk supply system, most events are more likely to impact DNSPs' ability to dynamically manage network constraints in the first instance. Fall-back settings are not yet widely applied, so there is not yet an approach that is considered optimal for all use cases and networks. AEMO raised the need for fall-back settings in its submission to the consultation on Technical Standards for CER interoperability⁸ as part of the National CER Roadmap. In the meantime, the application of fall-back settings should be left to the discretion of the DNSPs.

AEMO updated the monitoring requirements in the guideline to enhance the capability to analyse system behaviour more effectively following disturbances. In addition to supporting system analysis, this capability will also benefit long-term operational forecasting by providing improved visibility of DER performance and assist DNSPs in verifying whether DER behaviour aligns with the relevant models and in capturing the necessary data.

The methods by which DNSPs retrieve the measurements are left to their discretion. For instance, smaller-scale systems may use CSIP-AUS, while larger-scale systems may be monitored via SCADA.

3.6.6 Guideline requirement

For DER systems with a capacity of 200 kW and above, there should be remote monitoring at the site to collect and communicate data to designated DNSP interface points, both:

- aggregated by DER technology – quantities aggregated by DER technologies onsite (for example, solar inverters, batteries), and
- site-level – measured at the point of connection with the DNSP's network.

Data should be collected at a sampling interval ≤ 60 seconds (except for the site voltage measurement) and communicated to the DNSP in (near) real time.

Accuracy

- DER-level data is required to be captured at $\pm 4\%$ of accuracy, consistent with AS/NZS 4777.2:2020 Table 2.5.
- Site-level data is required to be captured at $\pm 1\%$ of accuracy.

⁸ See <https://consult.dceew.gov.au/natl-cer-roadmap-tech-priorities-consult>.

Table 7 Remote monitoring requirements

Measurement point	Required data point	Description	Units	Notes
Aggregated by DER technology	Active power	Active power generated/consumed by PV/battery energy storage system (BESS)	kW/-kW	Min, Max, Average
	Reactive power	Reactive power generated/consumed by PV/BESS	Kilovolt amperes reactive (kVAr)/-kVAr	Min, Max, Average
	Battery state of charge (SOC)	Battery state of charge (usable)	%	Min, Max, Average
Site level	Active power	Active power exported/imported from the site	kW/-kW	Min, Max, Average
	Reactive power	Reactive power exported/imported from the site	kVAr/-kVAr	Min, Max, Average
	Active Power Curtailment Status ^A	Active/Inactive	-	-
	Site voltage	Alternating current (AC) voltage over the period measured at meter board. Per phase with ≤200 ms measurement interval	V	Min, Max, Average
Gross Load ^B	Active Power ^C	Site level active power - \sum (DER aggregated by technology) active power	kW	Min, Max, Average
	Reactive Power ^C	Site level reactive power - \sum (DER aggregated by technology) reactive power	kVAr	Min, Max, Average

A. Referring to the active power curtailment focus area in the same table, above, specifically relating to management for system security, such as system restoration or maintaining minimum load events. This control signal is distinct from, and takes precedence over, any market-based signals related to price responsiveness.

B. Gross Load = Site imported power + \sum DER generation - Site exported power - \sum DER consumed.

C. These values are derived through additional calculations based on the active and reactive power data from the DER aggregation by technology and site level, as presented in the rows above. Detailed formula is shown in note B.

3.7 Ramp rate

3.7.1 Issue

Some DER are capable of fast ramping and there can be significant financial incentive to respond to spot market prices in the NEM. However, large volumes of non-scheduled DER (< 5 MW) ramping rapidly and simultaneously can have adverse impacts on the power system’s operation.

Rapid ramping of DER – ramping that operates faster than the NEM’s 5-minute interval – can introduce mismatches between supply and demand that increase the variability of power system frequency. This could lead to an increased requirement for regulation frequency control ancillary services (FCAS) and cause the generation and storage systems that provide primary frequency response (PFR) to operate more often, potentially leading to higher maintenance costs and reduced DER equipment life.

3.7.2 Proposal in consultation report

AEMO’s consultation report proposed that for DER connected to HV network the maximum rate of active power change should not exceed 20% of rated active power per minute, except for the following permitted exceptions:

- fast frequency response (FCAS),

- PFR when the frequency is outside the deadband,
- low battery charge condition less than 20% in a battery energy storage system (BESS) when exporting,
- when net output of a hybrid DER is being controlled at the connection point,
- when operating in an intentional island (and frequency control is required), and
- where a DER run-back scheme may be agreed with the DNSP.

3.7.3 Stakeholder feedback on the consultation report

Some stakeholders considered that the proposed 20% ramp rate limit for BESS would reduce the economics of these assets. They recommended revisiting this requirement when unscheduled BESS volumes significantly impact power system operations. AEMO acknowledges that imposing a rate ramp limit could reduce the economics of some projects, but this must be considered against the prospect of higher FCAS costs for participants as a whole. AEMO also notes the 20% per minute requirement is equivalent to the requirements in AS/NZS 4777.2:2020 for LV connected systems and the automatic access standard in NER S5.2.5.14.

One stakeholder considered that the proposed 20% ramp rate limit should be revised to 20% of the rated active power of the DER for consistency. Similarly, it considered that for a BESS the proposed 20% ramp rate limit should be revised to 20% of the rated export + rated import. Also, it noted that some generators have a significantly lower export rating than their nameplate rating, and applying the limit based on rated export may create unnecessary restrictions.

3.7.4 DNSP feedback on the draft guideline

DNSPs were generally supportive of the proposed ramp rate limit and exemptions but recommended some amendments including:

- rewording fast frequency response (FCAS) to avoid misinterpretation as very fast FCAS/FFR,
- clarifying that exemption applies to all FCAS markets including regulation FCAS,
- rewording PFR outside deadband as providing active power in response to significant frequency deviations, and
- removing the specific percentage for battery storage systems operating at low charge levels.

One DNSP suggested the prioritisation framework should provide for DNSPs to determine the performance requirement at inverter terminals (instead of connection point) in some cases where on-site loads are part of critical infrastructure (hospital, airport).

3.7.5 AEMO's conclusion

AEMO agrees with the general comments from DNSPs.

AEMO also considers that the application point for the technical requirements will be left to the discretion of DNSPs, as reflected in Section 2.4.

3.7.6 Guideline requirement

The following requirements are specified in the guideline:

The maximum ramp rate for DER output should not exceed:

- 20% of maximum generation or maximum consumption per minute for DER acting solely as generator or load (for example, distributed PV), or
- 20% of (maximum generation + maximum consumption) per minute for bidirectional DER (for example, BESS)⁹ moving from generation to consumption or vice versa.

Possible exemptions

AEMO considers there are some situations where higher ramp rate may be reasonably supported. The permitted exceptions are as below:

- when providing contingency or regulation FCAS,
- when providing active power in response to significant frequency deviation (outside of agreed deadbands discussed in Section 3.8),
- there is a low battery charge condition in a BESS when exporting (the specification of this requirement should be negotiated with the DNSP),
- when net output of a hybrid DER is being controlled at the connection point,
- when operating in an intentional island (and frequency control is required), or
- when operating in accordance with a generator run-back scheme agreed with the DNSP.

Functional prioritisation

In line with the overarching intent of AS/NZS 4777.2:2020, protection functions take precedence over operational modes during abnormal voltage or frequency conditions. While ramp rates support smooth transitions, they are secondary to disturbance withstand requirements.

Application of the prioritisation framework may occur either at connection point or inverter level, at the DNSP's discretion.

Other forms of management (such as market participation, flexible connections and local network support) may be implemented through the requirements for participation, through agreement with the DNSP, AEMO and other relevant parties – including specification of the response required and how the response is ordered within the prioritisation of functions.

The prioritisation level includes the required responses and the order of activation, as described below.

⁹ Consistent with the interpretation for bi-directional units in the NEM (for example, a battery storage system) refer to Section 3.5.1.4 of AEMO's *Application Guide for Registration as an Integrated Resource Provider in the NEM* (at https://www.aemo.com.au/-/media/files/electricity/nem/participant_information/registration/2024/application-guide-nem-integrated-resource-provider.pdf?rev=0d0dbe6f4bf94850895fd74355499cae&sc_lang=en). Furthermore, the Dispatch Procedure refers bidirectional unit moves from generation to consumption or vice versa during a trading interval and the ramp rates are calculated based on formula in Appendix C of *Power System Security Guidelines* (at https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/power_system_ops/procedures/so_op_3705-dispatch.pdf?la=en). For example, a 1 MW battery storage system with 1 MW maximum generation and 1 MW consumption is allowed ramp rate of up to 0.4 MW/minute.

Disturbance performance, local limits, and emergency disconnection (Level 1 – 3)

- **Level 1: Disturbance withstand**
 - The system must be capable of continuous operation during defined voltage and frequency disturbances in accordance with the disturbance withstand capability timeframes specified in Section 3.1.5, 3.2.5, 3.3.5 and 3.4.5 – until the duration exceeds time limits of the DNSP’s passive anti-islanding settings.
- **Level 2: Automatic disconnection**
 - Notwithstanding Level 1, the system may be automatically disconnected from the power system by a local or remote control scheme, initiated by the DNSP under certain abnormal and emergency conditions.
- **Level 3: Generation and/or site-level export limit**
 - Limits may be applied by the DNSP on system output or site-level export for local network or power system security.

Grid support functions (Level 4 – 5)

- **Level 4: Sustained operation for frequency disturbances**
 - The system must be capable of sustained operation in accordance with the frequency deviations specified in Section 3.8.6.
- **Level 5: Voltage and reactive power control**
 - Reactive power support and power factor requirements, in accordance with agreement between the DER operator and the DNSP.

Ramp rate (Level 6)

- **Level 6: Power rate limit**
 - The maximum ramp rate as outlined above, in the transition between different functions and responses, noting the exemptions listed above.

3.8 Frequency droop

3.8.1 Issue

If a severe supply-demand mismatch occurs, often due to a power system event (such as the tripping of a large quantity of load or generation), it is highly beneficial that DER provide an automatic active power response that opposes the frequency deviation caused by the event.

The response that AEMO considers would provide most useful capability for system operations would be a frequency droop response, providing an active power response proportional to the frequency deviation outside of a deadband.

3.8.2 Proposal in consultation report

AEMO’s consultation report proposed a 5% frequency droop response with deadband of:

- 49.5 – 50.5 Hz (Mainland), and

- 49.0 – 51.0 Hz (Tasmania).

A lower (more aggressive) droop may be agreed with the DNSP when FCAS is being offered.

3.8.3 Stakeholder feedback on the consultation report

Some stakeholders considered that the proposed deadbands are too narrow and may impose a cost impact on affected DER proponents. One stakeholder considered that the proposed deadbands should not apply to systems smaller than 1 MW. Another stakeholder proposed aligning the frequency droop settings with AS/NZS 4777.2:2020 for string inverters, with consultation report settings applying to central inverters.

3.8.4 DNSP feedback on the draft guideline

One DNSP suggested that the requirement for a more aggressive droop should not be as agreed with the DNSP, rather it should be determined between AEMO and the DER proponent.

3.8.5 AEMO's conclusion

AEMO considers that a deadband of 49.5 to 50.5 Hz would not be arduous as it would only require a frequency response to non-credible contingencies and some interconnector network outages. This is also similar to the requirements of DER captured by AS/NZS 4777.2:2020.

AEMO also considers that requiring all generation and battery systems to have a similar droop and deadband would give the most coordinated response as they would all share the impact evenly. At the same time, a deadband of 49.5 to 50.5 Hz means that smaller systems would only need to respond to more extreme events, unless they want to participate in contingency FCAS markets.

In addition, AEMO remains of the view that any proposed implementation of a more aggressive droop setting should be considered by the DNSP during the connection process, to assess any potential impacts on the local network.

3.8.6 Guideline requirement

Provide 5% frequency droop response outside a deadband of:

- 49.5 – 50.5 Hz (Mainland), and
- 49.0 – 51.0 Hz (Tasmania).

A more aggressive frequency response (lower droop and/or narrower deadband) may be agreed with AEMO for the provision of frequency control ancillary services, subject to DNSP endorsement.

3.9 Protection reflecting DER capability

3.9.1 Issue

Modern DER are typically quite robust to a range of power system disturbances and may be capable of performance substantially better than mandated ride-through requirements. Where capability exceeds the ride-through requirements, it



is beneficial to the bulk power system for the DER to remain connected, as tripping would usually result in a local power system disturbance.

3.9.2 Proposal in consultation report

AEMO's consultation report proposed that, subject to DNSP requirements, protection settings to maximise capability beyond ride-through requirements for voltage, frequency and RoCoF, within safe operating limits consistent with good engineering practice.

3.9.3 Feedback

AEMO did not receive feedback on this issue, either on the consultation report or from DNSPs on the draft guideline.

3.9.4 Guideline requirement

The requirements specified in the guideline remain unchanged from the consulted proposal.

A1. Summary of feedback on the consultation report

A1.1 Consistent standards and collaboration across industry

Table 8 provides a summary of feedback on the industry alignment and AEMO’s responses.

Table 8 Detailed unified requirement approach feedback and the AEMO response

Issue raised	AEMO’s response
<p><u>Unified approach of requirements between AEMO and DNSPs</u></p> <p>SMA thought that individual DNSP requirements lead to unnecessary costs and complexity.</p> <p>SMA recommended a unified set of DER requirements to streamline processes and reduce bespoke rules.</p> <p>AGL thought any critical performance requirements missing from IEC TS 62786-1 should be standardised within the proposed guideline to prevent variation across DNSPs.</p> <p>Standards Australia noted that additional issues beyond those related to the security of the bulk supply system should also be considered when developing a common standard.</p> <p>Standards Australia recommended that if AEMO is seeking to mandate the IEC TS62786-1 specification in either the NER or a new guideline, that reference to an Australian adoption would best support current industry practice in Australia for implementation of legislated standards. If an IEC standard is mandated, future updates will automatically apply when the standard is updated without the option for any consultation or transition periods within Australia.</p>	<p>AEMO considers that the technical performance requirements in AS/NZS 4777 and NER S5.2 are generally fit for purpose and should be maintained for the relevant classes of DER as the NEM power system evolves.</p> <p>AEMO acknowledges the benefits of harmonising technical requirements across DNSPs for DER not captured by AS/NZS 4777.2:2020 nor NER S5.2. AEMO also considers that DER performance requirements not related to the security and operation of the bulk supply system (e.g. DNSPs local network needs) should be developed as part of the Standards Australia process (in conjunction with DNSPs and industry stakeholders).</p> <p>AEMO considers the technical requirements in the new guideline, and the undertaken industry consultations, provide a strong foundation for bulk power system considerations in the Standards Australia process aimed at formalising a national standard for DER connections not covered by AS/NZS 4777.2:2020 or NER S5.2</p>
<p><u>Common implementation guideline</u></p> <p>Ergon Energy and Energex supported developing an implementation guideline with DNSPs, leading to unified requirements across DNSPs.</p> <p>Ergon Energy and Energex recommended this approach over embedding standards in the NER.</p>	<p>AEMO agrees the benefits of developing guideline with DNSPs, harmonising the technical requirements related to bulk power system security.</p> <p>AEMO considers the development of an implementation guideline with DNSPs is the best first step towards a unified set of requirements for sub 5 MW DER.</p>
<p><u>Consistency across DNSPs</u></p> <p>Ergon Energy and Energex believed that a guideline would avoid the need for two DER Technical Standards in the NER and improve consistency.</p> <p>AGL thought aligning technical requirements for 200 kW to 5 MW DER connections across all DNSPs in the NEM would minimise costs and complexity.</p> <p>AGL recommended consistent implementation of the proposed guideline to avoid material deviations across networks.</p> <p>CEC supported the goal of reducing inconsistencies in DNSP connection frameworks for 200 kW–5 MW assets to simplify the process for developers and installers.</p> <p>EA thought that guidelines should be consistent across DNSPs and incorporated into the regulatory framework rather than being discretionary.</p> <p>CEC supported creating a centralised product list to verify compliance with standards, streamlining processes for DNSPs.</p> <p>CEC recommended that AEMO consult with DNSPs to agree on this centralised list and avoid jurisdictional discrepancies in compliance.</p>	<p>AEMO agrees that a common set of requirements agreed and implemented for DER by all DNSP would provide greater clarity for connecting DER.</p> <p>AEMO considers the customised nature of sub 5 MW DER installations would limit the utility of a centralised product list, however, recognises that DNSPs can work with industry to establish such a list if this can streamline processes under a new guideline or Australian Standard.</p>

Issue raised	AEMO's response
<p><u>AEMO engagement with OEMs</u></p> <p>CEC recommended that AEMO engage more directly with OEMs to refine technical requirements and ensure they align with industry needs.</p> <p>CEC supported creating a centralised product list to verify compliance with standards, streamlining processes for OEMs.</p> <p>One DNSP representative recommended that AEMO work closely with inverter manufacturers to establish a type testing and certification process during the guideline development phase. This DNSP representative thought such collaboration would minimise the need for extensive DNSP due diligence while promoting efficiency and consistency across the industry.</p> <p>Enel X recommended that exemptions be provided for load management activities to allow businesses flexibility.</p>	<p>AEMO consulted with several OEMs in the development of its consultation report. AEMO also expects that the OEMs would engage with the implementation of these recommendations in both an initial guideline and any future Australian Standard(s).</p> <p>See above comment on AEMO's consideration with respect to a centralised product list for DER products supporting sub 5 MW installations.</p> <p>AEMO considers certain exemptions, with respect to ramp rate limits, should be available (see Section 3.7.6).</p>
<p><u>Alignment with other initiatives</u></p> <p>One DNSP representative thought that the proposed requirements should align with ongoing AEMO-driven initiatives and rule changes, such as the SCADA Lite solution and ERC0352 (Integrating Price-Responsive Resources into the NEM), to ensure future compatibility. The same DNSP representative recommended that AEMO future-proof new technical requirements to avoid unnecessary changes and inefficiencies in implementation.</p> <p>Enel X recommended that technical guidelines align with broader policies, including the CER Integration Roadmap and rule changes.</p>	<p>Agreed. AEMO will continue to consult with other project teams within AEMO and externally to ensure consistency and alignment with its approach.</p>

A1.2 Implementation approach

Table 9 provides a summary of feedback on the implementation approach and AEMO's responses.

Table 9 Implementation approach feedback and the AEMO response

Issue raised	AEMO's response
<p><u>Discretion for DNSPs to adjust requirements</u></p> <p>One DNSP representative requested that the guideline explicitly state that DNSPs have the discretion to diverge from the standard technical requirements in specific cases.</p> <p>The same DNSP representative thought this flexibility would be essential for large connections in weak grid areas and for projects involving grid-forming inverters.</p>	<p>AEMO considers that the need for DNSPs to be able to diverge from the Australian adoption of IEC TS 62786-1 should be considered when the Australian Standard is developed. This could include ranges of allowable performance, to give some bounded flexibility where it may be desirable or necessary.</p>
<p><u>DNSPs seeking AER approval</u></p> <p>EA recommended that DNSPs seek AER approval for deviations from regulatory connection obligations to reduce regional inconsistencies.</p>	<p>AEMO considers that any variation in the technical performance for individual DER systems should be described in sufficient clarity in the Australian Standard.</p> <p>An additional AER function for determining the technical performance requirements for individual DER systems would be administratively burdensome and would require a rule change to implement.</p>
<p><u>Guidelines as a short-term measure</u></p> <p>Ausgrid supported the introduction of guidelines for technical requirements as a short-term measure to ensure clarity and consistency among DNSPs.</p> <p>Ausgrid recommended that AEMO concurrently work on developing an Australian Standard through Standards Australia but prioritise the guideline to prevent delays in implementation.</p> <p>AGL supported initially introducing requirements via a guideline as the fastest and most effective approach.</p>	<p>AEMO agrees that a guideline would be an effective interim measure to provide a harmonised approach to the performance requirements for the DER systems not captured by AS/NZS 4777.2:2020 and NER S5.2. In addition, the application of this guideline would inform the Standards Australia process for developing the relevant Australian Standard.</p>

Issue raised	AEMO's response
<p>AGL recommended eventual standardisation of settings to improve clarity and ensure compliance.</p> <p>RBPE did not support introduction of a guideline as it would not help with the stated aim of providing increase certainty and consistency for the industry.</p>	
<p><u>Activation of legacy systems</u></p> <p>AGL did not support retroactive application of guidelines to legacy systems and recommended limiting requirements to new installations.</p> <p>AGL requested further clarification on how aggregated asset requirements, and legacy plant performance would be enforced.</p> <p>Enel X thought that investment in legacy resources should not be abandoned by new requirements.</p> <p>Enel X recommended that activating legacy resources into market-responsive activities should not trigger the application of new technical requirements.</p>	<p>AEMO agrees that the requirements should not be applied retrospectively. The exception may be systems such as standby generators if they apply to operate when connected to grid. When connected to the grid, such legacy systems have the potential to affect the local operation of the grid, and collectively they could potentially affect the security of the bulk supply system if they had sufficient capacity.</p> <p>AEMO agrees to provide clarity on the application of the guideline on aggregated assets and this is addressed in both consultation report and the guideline.</p>
<p><u>Other matters relating to the implementation approach</u></p> <p>CEC recommended that AEMO avoid requiring interim certifications for technical requirements before a finalised Australian Standard is adopted to prevent OEMs from needing to re-certify products.</p>	<p>AEMO does not consider that the guideline should specify how performance should be assessed and compliance determined. Therefore, AEMO agrees that a certification process is not appropriate for the guideline.</p> <p>AEMO notes that a unified performance developed by Standards Australia could include methods for determining compliance. This could potentially include a process of certification.</p> <p>AEMO also notes that product certification is best suited to LV connected equipment where the connection point voltage would be equivalent to the voltage on the terminals of the inverter. Product certification is less effective where the DER system includes a transformer between the connection point and the inverter terminals.</p>

A1.3 Development of an Australian Standard

Table 10 provides a summary of feedback on the development of an Australian Standard and AEMO's responses.

Table 10 Development of an Australian Standard feedback and the AEMO response

Issue raised	AEMO's response
<p><u>EN 50549-2 Standard over IEC TS 62786-1 for DER</u></p> <p>SMA supported adopting EN 50549-2 over IEC TS 62786-1, recommending it for better suitability and fewer delays.</p> <p>CEC supported adopting EN 50549-2 over IEC TS 62786-1, citing that the former is a more robust and established standard, whereas the latter is still a draft technical specification.</p> <p>CEC recommended that AEMO avoid developing temporary technical requirements based on IEC TS 62786-1 while waiting for an Australian Standard to prevent duplicate certification requirements.</p>	<p>AEMO notes that Standards Australia is supportive of the adoption of IEC TS 62786-1 incorporating country specific parameters for Australia.</p>
<p><u>Support of IEC TS 62786-1 Standard</u></p> <p>Ergon Energy and Energex supported adopting IEC TS 62786-1 for systems under 5 MW, with modifications.</p> <p>Ergon Energy and Energex thought the Standards Australia process should be followed, considering it is supported by a relevant technical committee, and recommended ensuring the IEC specification is not mandated without adoption as an Australian Standard to allow for future updates.</p> <p>AGL supported adopting international standards like IEC TS 62786-1 for sub 5 MW HV connected DER, recognising its potential for improved</p>	<p>AEMO notes that Standards Australia is supportive of the adoption of IEC TS 62786-1 incorporating country specific parameters for Australia.</p> <p>AEMO agrees with adopting IEC TS 62786-1 for systems under 5 MW, provided they are not under the scope of AS/NZS 4777.1:2024.</p> <p>AEMO also agrees that country-specific parameters should be included within the Australian adoption of IEC 62786, rather than a separate guide or in the NER.</p>

Issue raised	AEMO's response
<p>compliance and consistency. AGL thought any critical performance requirements missing from IEC TS 62786-1 should be standardised within the proposed guideline to prevent variation across DNSPs.</p> <p>EA recommended that AEMO consider implementing IEC TS 62786-1 rather than adopting select components. EA thought that partial adoption could introduce unnecessary complexity and confusion.</p> <p>Standards Australia said it would be pleased to collaborate with AEMO on the proposed approach. It also considered that country-specific parameters should be included within the Australian adoption of IEC 62786, rather than a separate guide or in the NER.</p>	
<p><u><i>AS/NZS 4777 application</i></u></p> <p>CEC thought that AEMO's recommendations were inconsistent regarding whether AS/NZS 4777.1:2024 or AS/NZS 4777.2:2020 applies to 200 kW–5 MW systems.</p> <p>CEC recommended that AEMO clarify if the full AS/NZS 4777.2:2020 standards apply to all sub-5 MW systems or just certain aspects and explicitly state whether requirements are for individual systems or aggregated systems.</p> <p>Ausgrid thought that the boundaries between AS/NZS 4777.2:2020 requirements and Appendix A1 technical requirements were ambiguous.</p> <p>Ausgrid recommended a detailed demarcation of parameters to avoid overlap or gaps in requirements.</p> <p>RBPE recommended if DER requirements would be across AS/NZS 4777.1:2024 and the proposed requirements, the amendment of AS/NZS 4777.1:2024 should be done to help clarify and avoid compliance risks</p>	<p>AEMO notes that AS/NZS 4777.1:2024, and hence AS/NZS 4777.2:2020, apply to LV-connected DER of any size, but note that in practice the maximum DER that can be connected at LV is approximately 1 MW. This includes DER connected at a higher voltage using LV inverters and a transformer where there are low voltage loads as part of the connection.</p> <p>AEMO's recommended requirements in Appendix A1 of its consultation report would only apply to DER systems not captured by AS/NZS 4777.1:2024 or by NER S5.2.</p>
<p><u><i>Low voltage (LV) and high voltage (HV) standards</i></u></p> <p>AGL thought clear definitions for HV and LV connections, size categories, and blended rules are necessary to avoid ambiguity.</p> <p>Ergon Energy and Energex supported IEC TS 62786-1 for HV connections and the Australian Standard AS/NZS 4777.2:2020 for LV connections, suggesting its application for ≤1.5 MW systems.</p> <p>Ergon Energy and Energex noted potential incentives to connect at LV to avoid stricter HV standards and recommended reviewing requirements for large LV-connected systems.</p> <p>AGL thought that AS/NZS 4777.1:2024 and AS/NZS 4777.2:2020 should apply to all micro-DER and include LV loads for systems up to 5 MW.</p> <p>RBPE thought that a clear scope of AS/NZS 4777.2:2020 be limited to DER systems less than 1.5 MW and that the Requirement document's scope covers from 1.5 MW up to less than 5 MW.</p>	<p>AEMO considers that the scope of the Australian adoption of IEC TS 62786-1 should be clear to minimise any ambiguity with the scope of AS/NZS 4777.1:2024.</p> <p>AEMO notes that there may be incentives to connect at either HV or LV depending on which requirements are more arduous. However, this would be one criterion for determining the most commercially viable DER system. Also, both the performance requirements recommended by AEMO for HV connections and the relevant aspects of AS/NZS 4777.2:2020 have been designed to manage the security and operational impacts on the bulk supply system.</p>

A1.4 System requirements

Table 11 provides a summary of feedback on the system requirements and AEMO's responses.

Table 11 AEMO's response to submission about system requirements

Issue raised	AEMO's response
<p><u><i>Ride-through standards</i></u></p> <p>SMA thought that ride-through standards would assist in managing abnormal power system conditions.</p> <p>EA thought that ride-through settings are important but difficult to verify in practice.</p> <p>EA recommended that a clear methodology be developed to determine when and how performance is assessed.</p>	<p>AEMO agrees that the ride-through requirements have the potential to better manage abnormal power system conditions but are primarily to make the system secure for credible contingency events and resilient to more severe non-credible contingency events.</p> <p>AEMO agrees that it may be difficult to assess ride-through capability. In practice this could be with factory testing of inverters or with detailed power system models.</p>

Issue raised	AEMO's response
<p>One DNSP representative recognised the challenges in enforcing ride-through performance requirements from the connection point to the inverter level without dynamic models.</p> <p>RBPE thought that minimum ride-through settings should be specified in the proposed requirements document.</p>	
<p><u>Inverter-based systems</u></p> <p>Ergon Energy and Energex thought that performance aspects of IEC TS 62786-1 could also apply to synchronous generation under 200 kVA.</p> <p>One DNSP representative recommended investigating whether performance requirements could be defined at the inverter terminals instead, allowing local DNSPs to determine when dynamic models are necessary for specific projects.</p> <p>The same DNSP representative thought that standardising ride-through settings at the inverter level would simplify compliance, certification, and industry adoption while reducing the need for project-specific modelling.</p>	<p>AEMO agrees that aspects of IEC TS 62786-1 could also apply to synchronous generation under 200 kVA as these generators would not be captured by AS/NZS 4777.2:2020.</p> <p>AEMO agrees that there may be merit in allowing performance to be assessed at the inverter terminal instead of the connection point. This would have the advantage that the performance of the inverters could be known from factory tests, in combination with the settings, reducing the need for detailed modelling.</p> <p>AEMO also considers that assessing the performance at the inverter terminal would give equivalent results for the areas of focus related to the security of the bulk supply system. However, some care would be required for voltage excursion and phase angle shift ride-through where the performance would depend on the transformer at the connection point.</p>
<p><u>Frequency response and deadband considerations</u></p> <p>EA thought that droop response requirements should allow for a wide deadband to minimise cost impacts.</p> <p>Enel X thought that frequency response should be coordinated to prevent unintended consequences.</p> <p>Enel X recommended that large deadbands (>0.5Hz) be applied to prevent poorly coordinated responses.</p> <p>EA considered that frequency response with a deadband should not apply to systems smaller than 1 MW.</p> <p>RBPE proposed aligning the frequency droop settings with AS/NZS 4777.2:2020 for string inverters, with consultation report settings applying to central inverters.</p>	<p>AEMO considers that a deadband of 49.5 to 50.5 Hz would not be arduous as it would only require a frequency response to non-credible contingencies and some interconnector network outages. This is also similar to the requirements of DER captured by AS/NZS 4777.2:2020.</p> <p>AEMO also considers that requiring all DER and battery systems to have a similar droop and deadband would give the most coordinated response as they would all share the impact evenly. At the same time, allowing a deadband of 49.5 to 50.5 Hz means that smaller systems would only need to respond to more extreme events, unless they want to participate in contingency FCAS markets.</p>
<p><u>Reactive power control and system strength</u></p> <p>Ergon Energy and Energex supported provisions for reactive current contributions during faults and amendments related to system strength (e.g., short circuit ratio withstand).</p> <p>One DNSP representative noted that the current consultation scope does not include voltage and reactive power controls but thought these factors are critical for network stability.</p> <p>The same DNSP representative recommended that the testing and certification process account for DNSP-preferred voltage and reactive power control methods while ensuring that inverters can still meet the proposed DER technical requirements.</p> <p>RBPE suggested that the technical requirements identified by AEMO as being of interest to DNSPs only (such as reactive power, P(U) requirement, primary and backup protection settings and modelling requirements) should at least be specified in the technical guideline.</p>	<p>AEMO did not consider reactive power control and the provision of system strength as they do not directly relate to security and operation of the bulk supply system.</p> <p>AEMO agrees it would be desirable to have a unified set of requirements for DER not captured by AS/NZS 4777.2:2020 nor NER S5.2. However, AEMO also considers that DER performance requirements not related to the security and operation of the bulk supply system should be developed by the Australian Standards process, in consultation with DNSPs and industry stakeholders.</p>

A1.5 Technical matters

Table 12 provides a summary of feedback on technical matters and AEMO's responses.

Table 12 AEMO's responses to submissions about technical matters

Issue raised	AEMO's response
<p><u>Ramp rate clarification</u></p>	

Issue raised	AEMO's response
<p>Ergon Energy and Energex supported greater clarity around ramp rate requirements.</p> <p>AGL requested further clarification on how ramp rate limits would be enforced.</p>	<p>AEMO considers that the requirement that the ramp rate should not exceed 20% of rated power/minute is clear. AEMO notes that the permitted exceptions may require some clarification or be subject to agreement with the DNSP.</p>
<p><u>Ramp rate challenges for BESS</u></p> <p>AGL thought the proposed 20% ramp rate limit for BESS challenges the economics of these assets. It recommended revisiting this requirement when unscheduled BESS volumes significantly impact power system operations.</p> <p>EA recommended delaying the implementation of a 20% per minute ramp rate limit for BESS until more data is available.</p> <p>EA thought that imposing such limits now could negatively impact commercial operations.</p>	<p>AEMO notes that imposing a rate ramp limit could reduce the economics of some projects. However, this would be at the expense of higher FCAS costs for other participants.</p> <p>AEMO also notes the 20% per minute requirement is equivalent to the requirements in AS/NZS 4777.2:2020 for LV connected systems and the automatic access standard in NER S5.2.5.14 for systems greater than 5 MW.</p>
<p><u>Ramp rate limit consistency</u></p> <p>One DNSP representative:</p> <ul style="list-style-type: none"> thought that the proposed 20% ramp rate limit should be revised to 20% of the rated active power of the generating plant for consistency, thought that for a BESS the proposed 20% ramp rate limit should be revised to 20% of the rated export + rated import, noted that some generators have a significantly lower export rating than their nameplate rating, and applying the limit based on rated export may create unnecessary restrictions, and recommended that generator runback scenarios be included as permitted exceptions to the ramp rate rule. 	<p>AEMO agrees that it was the intent that the ramp rate applies to the rated active power.</p> <p>AEMO agrees to apply ramp rate of 20% for DER solely acts as generator or 20% for bidirectional DER (such as BESS) moving from generation to consumption or vice versa.</p> <p>AEMO agrees that a faster ramp should be allowed when the DER is responding to a runback action, or potentially is engaged in load management.</p>
<p><u>Other matters relating to ramp rates</u></p> <p>SMA supported applying power limits based on net export capacity instead of generation capacity.</p>	<p>AEMO considers that the 20% could either apply to the active power rating of the BESS or the site, with the agreement of the DNSP, as this would be unlikely to impact the bulk supply system.</p>

A1.6 Modelling and commissioning

Table 13 provides a summary of feedback on the modelling and commissioning requirements and AEMO's responses.

Table 13 AEMO's responses to submissions about system modelling and commissioning

Issue raised	AEMO's response
<p><u>Alternatives to SCADA</u></p> <p>Ergon Energy and Energex thought options like Automatic Load Frequency Control (ALFC) and CSIP-AUS should be further explored to minimise costs.</p> <p>AGL thought that SCADA and NEM-grade metering requirements create significant costs and barriers for customers, especially in the 200 kW to 1 MW range.</p> <p>Ausgrid thought that relying on traditional SCADA pathways such as DNP3 could limit flexibility and increase costs unnecessarily.</p>	<p>AEMO agrees that the relative cost of SCADA for smaller DER projects can be high. Therefore, it is recommended that the requirements be specified by the DNSP, with effective and cheaper options being made available.</p> <p>AEMO considers that DNSPs should collectively review their monitoring options and, where appropriate, begin to specify harmonised approaches across their networks.</p>
<p><u>Modelling requirements for DNSPs</u></p> <p>AGL thought modelling requirements should be clear and minimised to avoid unnecessary complexity for sub 5 MW systems.</p> <p>AGL supported clear guidelines, stating steady-state modelling is sufficient for sub 5 MW DER and dynamic modelling should not be required.</p>	<p>AEMO considers that the modelling requirements for sub 5 MW DER should be determined by the relevant DNSP and the connecting DER. However, AEMO considers that its recommendations, for bulk power system requirements, enable a much-reduced need for modelling than would otherwise be necessary.</p>
<p><u>Power curtailment requirements</u></p>	

Issue raised	AEMO's response
<p>AGL supported consistent requirements for remote monitoring and power curtailment but recommended applying these only to systems above 1 MW.</p> <p>Ausgrid recommended that AEMO consider using CSIP-AUS as a communication pathway for remote monitoring and active power curtailment.</p> <p>EA considered that active power curtailment should not apply to systems smaller than 1 MW.</p>	<p>AEMO does not have specific information on the relative cost of active power curtailment via SCADA for smaller DER projects but agrees it could be high. However, AEMO considers that the need for remote curtailment is expected to increase as the penetration of small solar PV DER increases. Therefore, AEMO considers that some form of remote curtailment may eventually be required on all DER.</p> <p>AEMO considers that the active power curtailment implementation requirements should be specified by the DNSP.</p>
<p><u>Data utilisation</u></p> <p>Enel X thought that AEMO had not demonstrated how remote monitoring data would provide cost-effective insights.</p> <p>Enel X recommended that DNSPs should only collect necessary location- and technology-specific data.</p>	<p>AEMO considers that as the proportion of generation from small DER increases, there will be an increasing need for remote monitoring of these systems to improve the accuracy of forecasting systems. AEMO does note that the threshold for remote monitoring can be reviewed when the Australian adoption of IEC TS 62786-1 is developed.</p>

A1.7 Other matters

Table 14 provides a summary of feedback on matter outside the consultation questions and AEMO's responses.

Table 14 AEMO's responses to submissions about other matters

Issue raised	AEMO's response
<p><u>Micro embedded generation</u></p> <p>Ergon Energy and Energex recommended reviewing the definition of micro embedded generation in the NER to ensure appropriate treatment of larger systems.</p>	<p>AEMO agrees, as the scope of AS/NZS 4777.1:2024 has changed since the definition of micro embedded generation was included in the NER. This may have contributed to some confusion.</p>
<p><u>Regulatory consistency for ≥5 MW Systems</u></p> <p>Ergon Energy and Energex supported introducing consistent regulatory requirements for LV connected ≥5 MW generating systems to prevent bypassing the regulatory framework.</p>	<p>AEMO agrees and notes that DER systems greater than 5 MW could be covered by NER S5.2, even if they are LV connected, and are also covered by AS/NZS 4777.2:2020. However, AEMO understands that most LV networks can only accommodate connections up to about 1.5 MW.</p>
<p><u>Expedited connections</u></p> <p>Ergon Energy and Energex thought that applying expedited connections for all sub 5 MW systems might lead to substandard outcomes at the network and system level.</p>	<p>AEMO considers that substandard outcomes for expedited connections are unlikely as the proposed technical requirements closely align with both the requirements of AS/NZS 4777.2:2020 and NER S5.2.</p>
<p><u>Gap in current cybersecurity regulation</u></p> <p>SMA recommended addressing gaps in cybersecurity for DER in the 200 kW to 30 MW range.</p>	<p>AEMO considers that cyber security is an important requirement in its own right and covered by other Australian regulatory requirements.</p>
<p><u>Market participation and considerations</u></p> <p>Enel X:</p> <ul style="list-style-type: none"> recommended that guidelines allow DER assets to participate in multiple services (for example, FCAS, load management). thought that DER participation in multiple markets should not be hindered by rigid guidelines. thought that the agility of price-responsive resources is a market design issue rather than a technical performance characteristic. thought that many businesses optimise DER deployment based on risk management strategies rather than strict technical performance. 	<p>AEMO has only made recommendations for minimum technical performance requirements in relation to the security of the bulk supply system.</p> <p>AEMO considers that the proposed guideline and resulting Australian Standard should only impose necessary requirements for security and network performance. This should not prevent the DER covered from providing other services such as FCAS, provided they meet all the associated requirements of providers of those services.</p>

Issue raised	AEMO's response
<p><u>Clarifications</u></p> <p>Ausgrid thought that the definitions of "coordinated" and "common connection point" used in the <i>Consultation Paper</i> were unclear and could lead to misinterpretation.</p> <p>Ausgrid recommended providing detailed definitions and examples to ensure stakeholders understand the application of these terms.</p>	<p>AEMO considers that these definitions can be clarified in the interim guideline and in any prospective Australian adoption of IEC TS 62786-1.</p>
<p><u>Sub 5 MW aggregate generator registration</u></p> <p>Ausgrid thought that AEMO should explicitly detail registration exemption criteria for sub 5 MW aggregate generators in its guide to ensure stakeholders understand when exemptions apply.</p> <p>Ausgrid supported AEMO maintaining its advisory capacity for aggregate connections while recommending that AEMO clarify if requirements will be adopted for these aggregations as though they are single generators.</p> <p>Ausgrid thought that the criteria for when sub 5 MW connections are required to register as a Generator or Integrated Resource Provider were ambiguous.</p> <p>Ausgrid recommended AEMO provide examples of boundary cases and specify whether connection configuration or intended services provided to AEMO influence registration requirements.</p>	<p>DNSPs would not have a regulatory obligation to apply the initial guideline, effectively allowing the DNSPs some flexibility in how it is applied. AEMO also considers that the developed Australian Standard should consider some exemptions to provide stakeholders with clarity of what could be exempted.</p> <p>While AEMO is concerned about the aggregate performance of DER in relation to the security of the bulk supply system, it would not be efficient for AEMO to have an advisory function for individual DER projects below 5 MW.</p> <p>AEMO notes that there is a long-standing exemption to registration for sub 5 MW generating systems and integrated resource systems that meet the conditions for automatic exemption published in AEMO's guide to registration exemptions.</p> <p>AEMO encourages DNSPs with sub 5 MW aggregated DER connections to consider potential to assess system security implications for exempt generation connections</p> <p>AEMO also considers that boundary cases could be considered during the development of the Australian Standard.</p>