ADDENDUM TO FINAL REPORT: RECOMMENDED TECHNICAL STANDARDS FOR GENERATOR LICENSING IN SOUTH AUSTRALIA

ADVICE TO ESCOSA

August 2017

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

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Version control

Version	Release date	Changes
1	August 2017	Initial release

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1. SUMMARY

1.1 Background

The Essential Services Commission of South Australia (ESCOSA) is reviewing the regulatory, licensing, and associated arrangements for connection of new electricity generators in South Australia (SA), and sought advice from AEMO in relation to two matters:

- The currency of the existing special licence conditions relating to technical standards for wind farms connecting to SA's electricity network.
- Whether there is merit in additional or amended technical requirements being imposed on other inverter-connected generation technologies (for example, photovoltaics (PV)).

ESCOSA released an Issues Paper on 2 December 2016, setting out the scope and issues to be considered in its review into licensing arrangements for connection of generation in SA.

In March 2017, AEMO provided detailed advice to ESCOSA on the above matters in its report *Recommended Technical Standards for Generator Licensing in South Australia* (March advice).[1]

On 1 May 2017, ESCOSA released a Draft Report as part of its Inquiry into the licensing arrangements for generators in South Australia.

Stakeholders were then invited to express their views on the matters raised in the Draft Report (including the advice received from AEMO). As part of this consultation, ESCOSA and AEMO also held a workshop for stakeholders and other interested participants. Consultation on the Draft Report closed on 9 June 2017, and 15 submissions were received by ESCOSA and AEMO. (See Section 2 for detail on consultation and feedback.)

ESCOSA has asked AEMO to update the March advice, taking into consideration the feedback from stakeholders and any further learnings since that time.

1.2 Document purpose

This document represents AEMO's revised advice to ESCOSA on these matters. It takes into account the lessons and feedback gathered by AEMO and ESCOSA since March 2017, including:

- Stakeholder feedback to ESCOSA's Issues Paper.
- Stakeholder feedback to ESCOSA's Draft Report (including AEMO's March advice).
- Analysis into the 28 September 2016 Black System event in SA.
- Learnings from AEMO's Future Power System Security program[2].
- Other informal AEMO consultations with equipment manufacturers and stakeholders.
- Lessons from international Grid Codes.
- Learnings from collaboration with AEMC in developing the *Managing power system fault levels* Rule change[3]

This updated advisory document is presented as an addendum to the March advice and should be read in conjunction with that advice.

[1] AEMO. *Recommended technical standards for generator licensing in South Australia*, March 2017. Available at: http://www.escosa.sa.gov.au/ArticleDocuments/1048/20170331-Inquiry-RecommendedTechnicalStandardsGeneratorLicensingSA-AEMOadvice.pdf.aspx?Embed=Y.

[2] AEMO's Future Power System Security (FPSS) Program seeks to ensure that system security is maintained in the NEM as the generation mix continues to change. FPSS reports and analysis are available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/FPSSP-Reports-and-Analysis

[3] AEMC 2017, *Managing power system fault levels*, Draft rule determination, 27 June 2017, Sydney, available at: http://aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels

1.3 Document structure

This document is structured as follows:

- Section 1 – Introductory summary of process to date
- Section 2 – A summary of stakeholder feedback received and AEMO's response to this feedback.
- Section 3 – AEMO's revised recommendations to ESCOSA, including justifications for changes since the March advice.

1.4 Principles guiding AEMO's advice

AEMO's March advice stated a number of guiding principles that have been used as a basis for AEMO's recommendations. These are summarised below for context.

Long-term interests of consumers

ESCOSA's final decision on generator licence conditions must have regard to its primary statutory objective, which is to protect the long-term interests of SA consumers with respect to the price, quality, and reliability of essential services.

AEMO has sought to ensure that these recommendations are consistent with this objective.

A national approach to technical standards

AEMO seeks to maintain a NEM-wide, technology-neutral approach to generator performance standards, and believes that the long-term interests of consumers will be best met with a consistent national Rules framework.

The need for these state-based technical standards in South Australia is a clear indication that the generally applicable generator performance standards, as defined in the National Electricity Rules (NER), require updating urgently to reflect the needs of the changing power system so as to ensure its continued safety, security and reliability. AEMO believes the NER should be updated as soon as practicable, and is in the process of drafting an urgent Rule change proposal to the Australian Energy Market Commission (AEMC), proposing appropriate revisions. AEMO is also exploring options to align technical standards for generation in Western Australia with those in the NEM.

In the interim, to guarantee the capabilities of the generation fleet in SA, AEMO appreciates it as appropriate to maintain special licence conditions that apply only in SA. Putting in place these interim arrangements in South Australia, however, does not mean that changes to the generally applicable generator performance standards across the NEM under the NER can be delayed, however, as similar issues may well arise in other jurisdictions and it is important that the standards are consistent across the NEM.

The final recommendations to ESCOSA in this report will therefore form the foundation of AEMO's Rule change request to the AEMC. Ideally, any new licence conditions imposed by ESCOSA would be transitional arrangements that are eventually able to be repealed, in whole or in part, when the technical standards in the NER are updated.

Looking to the future

In developing these recommendations, AEMO has sought to establish a set of generator technical standards that will be capable of supporting a secure power system throughout the transition away from a power system structured around centrally connected, thermal generation.

A characteristic of this transition is the displacement of synchronous generation[4] by non-synchronous generation.[5] Changes to the generation mix have occurred at a faster pace in South Australia than in the rest of the NEM. Since AEMO's previous advice to ESCOSA on generator licence conditions in 2010, the proportion of non-synchronous generation capacity in the SA region has increased from 20% to over 43%, with this trend expected to increase in the future.

AEMO has considered how all necessary system services could reasonably be provided under a number of plausible future scenarios, including:

- Increasing periods where less synchronous generation is dispatched.
- Periods where no synchronous generation would be economically dispatched within the region.
- Periods of low, zero, or negative operational demand[6] due to increasing volumes of generation within the distribution network.

Under such scenarios, synchronous generators alone will no longer provide sufficient system security services[7]. Alternative means of procuring these services must be found, whether from non-synchronous generators (where it is reasonable to do so) or as network or non-network services (where services are still required under low operational demand scenarios).

Historically, system operators have relied on the inherent characteristics of synchronous generators to manage power system security. Non-synchronous generators such as wind and solar were viewed as peripheral technologies that were not expected to manage power system security. In fact, many grid codes were initially designed so these generators would trip off in response to a frequency or voltage disturbance. With increasing penetrations of wind and PV, non-synchronous generators are no longer fringe players. These technologies are now core elements of the SA power system.

AEMO's advice recommends that all types of generators should be required to incorporate cost-effective features that will allow them to contribute towards a secure and resilient power system

Applying technical standards only where efficient to do so

The recommendations in this document are designed to be applied as part of a broader package of reforms.

Technological improvements over the last decade mean modern plant often includes additional functionality that can help to stabilise the power system, but these capabilities may not be provided without a standard that requires them.

AEMO's recommendations are designed to take advantage of technological developments that provide additional capability at low additional cost.

Higher standards have only been recommended where AEMO considers that a technical standard applied to generators is likely to be the most efficient way of addressing an identified technical issue.

It is unlikely to be efficient to require generators to solve all technical issues arising as a result of the energy transition. Where it is no longer efficient to source the requisite system services from generation, there are a range of alternative solutions, including establishing market frameworks and/or identifying new roles for network businesses to play in maintaining a secure power system.

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[4] Synchronous generators can be fuelled using coal, gas, diesel, hydro, solar thermal, or geothermal sources. They produce electricity via a rotating shaft with a stator and rotor that is directly connected to the power system by electromagnetic coupling

[5] Non-synchronous generators include wind farms, or solar PV generators, and batteries that export power to the grid. They are connected to the power system by power electronics and do not have an electromagnetic coupling directly connecting the generator to the network

[6] Broadly, this means SA's entire electricity demand could be offset by rooftop PV (which is treated as "negative load" because it is located behind the electricity meter, on a customer's premises). In this case, surplus rooftop PV generation would be exported interstate via an interconnector. More formally, operational demand in a region is demand that is met by local scheduled generating units, semi-scheduled generating units, and non-scheduled intermittent generating units of aggregate capacity ≥ 30 MW, and by generation imports to the region. It excludes the demand met by non-scheduled non-intermittent generating units, non-scheduled intermittent generating units of aggregate capacity < 30 MW, exempt generation (such as rooftop PV, gas tri-generation, and very small wind farms), and demand of local scheduled loads.

[7] These non-energy system services include voltage control, frequency control, synchronous inertia, and provision of fault current.

Conditions should apply to all generation types, not just wind

Unless there are unavoidable technical reasons why a given technology cannot provide a particular service characteristic, AEMO recommends that standards should apply to all generation types greater than 5 MW, a level consistent with AEMO's standing registration exemption for small generating systems. [8]. The recommendations in this paper refer to generating systems that exceed this threshold.

Any generating unit installed today is likely to remain in service for at least the next 20 years, and will plausibly need to operate when there is very little synchronous generation online. Accordingly, AEMO is recommending that ESCOSA apply consistent licence conditions on all new generators (regardless of technology), such that the SA generation fleet is equipped with the capabilities it needs to provide a secure and resilient power supply for the life of the assets.

Where there are intrinsic physical differences between synchronous and non-synchronous generators, the final licence conditions may need to articulate two similarly intentioned licence requirements.

Applying this philosophy, AEMO has focused on the fundamental needs of the system, as well as what can reasonably be expected from all generators in the future. In some cases this will increase the range of capabilities expected from synchronous generation, while also acknowledging it is no longer practical to treat non-synchronous generators as fringe players.

Application of conditions to existing generators

Much of the current generation fleet in SA will remain in service for a similar timeframe to any new generating units and in order to improve system security and resilience outcomes in the shorter term, consideration should be given to deriving additional capability from the current generation fleet.

Accordingly, AEMO recommends that ESCOSA consider how some capabilities could be obtained from existing generation in South Australia, with due regard to:

- The physical limitations of some existing generating units.
- The likely cost of enabling the capability for each generating unit.
- The incremental benefits that would be gained by enabling existing generating units.

If ESCOSA implements this recommendation, AEMO proposes to work with ESCOSA and stakeholders on a case by case basis to undertake this assessment of the existing generation fleet.

1.5 Summary of changes to AEMO's recommendations

AEMO's March advice included recommended changes to licence conditions in the following areas:

- Reactive power capability.
- Provision of dynamic reactive power.
- Voltage control capability.
- Disturbance ride-through.
- System strength.
- Active power control capability.
- System restoration.

AEMO's updated recommendations to ESCOSA in Section 3 largely reflect AEMO's earlier advice in each of the above areas, with the key changes summarised below in Table 1.

[8] For more information, refer to AEMO's Guide to NEM Generator classification and exemption, available at: http://www.aemo.com.au/-/media/Files/PDF/Generator-Classification-and-Exemptions-Guide.pdf

Table 1 Summary of key changes to AEMO recommendations

Focus area	Comments on changes since March advice
Disturbance ride-through – General principles	A series of general principles were proposed that applicants should note. On further review, AEMO has decided that these principles warrant application as a specific licence condition.
Disturbance ride-through – Reactive current injection requirements	Based on feedback from stakeholders, AEMO has updated its March advice to: • Amend the wording of reactive current injection criteria applicable to synchronous generators. • Include additional information to assist with interpretation of reactive current injection requirements for synchronous and non-synchronous plant.
Disturbance ride-through – Active power injection requirements	In response to stakeholder feedback, AEMO has clarified the slowest rate of active power recovery that may be acceptable.
Disturbance ride-through – Multiple low voltage disturbance ride-through	In response to stakeholder feedback, AEMO has: • Clarified the total number of low voltage faults new entrant generators must have the capability to ride through. • Provided further information on how longer duration shallow voltage faults are considered.
Disturbance ride-through – High voltage disturbance ride-through	Based on stakeholder feedback raising concerns about the original over voltage withstand durations, AEMO has amended the withstand durations for temporary over voltages in the 110–115% range and the 115–120% range.
System strength – an NSP licence condition to maintain an agreed short circuit ratio at the connection point	Based on the AEMC's June 2017 draft determination on the *Managing power system fault levels* Rule*, AEMO no longer considers it necessary for ESCOSA to develop an additional NSP licence condition in this area.
System strength – A generator licence condition to meet its GPS at the connection point for the range of short circuit ratios agreed with the NSP in the connection agreement	As in the previous recommendation, AEMO believes this issue can best be addressed through the *Managing power system fault levels* Rule change currently being assessed by the AEMC.
Active power control capability – ability to limit rate of change of active power	AEMO has clarified the wording of this recommendation to ensure the intent is clear.
Active power control capability – ability to provide real-time information about active power control settings	While AEMO can request this information under S5.2.6.1 of the NER, there is no current requirement for Generators to have the necessary SCADA signals. Accordingly AEMO has amended its recommendation to focus the revised licence condition on ensuring the generator has the appropriate capabilities. Use of this capability will be determined by AEMO under its existing NER powers.
Active power control capability – registration for frequency control ancillary services (FCAS)	This previously proposed requirement has been removed following feedback from stakeholders, and pending the outcomes of: • AEMO's Ancillary Services Technical Advisory Group (AS TAG) process. • Current trials for provision of FCAS from new entrant wind generation. • Outcomes from the AEMC's Frequency Control Frameworks Review.
System restoration	AEMO has proposed amended requirements in this area following feedback from stakeholders that suggested the requirements as originally stated may result in damage to generating systems and other items of plant.

* AEMC 2017, *Managing power system fault levels*, Draft rule determination, 27 June 2017, Sydney, available at: http://aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels

AEMO has also revised the wording of its final recommendations to make them more readily applicable as licence conditions.

Full details of AEMO's revised recommendations to ESCOSA are provided in Section 3.

2. SUMMARY OF SUBMISSIONS RECEIVED

2.1 Consultation undertaken

As noted in Section 1.1, ESCOSA published its Draft Report on 1 May 2017, together with AEMO's March advice, and allowed approximately two months for submissions from stakeholders.

To facilitate the submissions process, ESCOSA hosted a day-long consultative forum, in conjunction with AEMO, on 16 May 2017. The forum included presentations with targeted question and answer sessions on each of the major areas of focus of AEMO's technical recommendations.

ESCOSA and AEMO received 15 submissions in response to the Draft Report (including AEMO's March advice), from a variety of stakeholders:

- NGO/Industry groups (SACOME, Energy Networks Australia, SACOSS)
- Generators/retailers (Energy Australia, Origin Energy, Pacific Hydro, Snowy Hydro, Engie).
- Original Equipment Manufacturers (Siemens-Gamesa, Vestas).
- Developers (Tilt Renewables, REACH Solar).
- Network Service Providers (NSPs – TasNetworks, ElectraNet).
- Government (SA Department of Premier and Cabinet, Energy and Technical Regulation (ETR) Division).

It is important to note that the industry stakeholders who responded operate not only in South Australia but also in other regions of the NEM.

This feedback has complemented other consultation by AEMO with market participants, industry groups, original equipment manufacturers, developers, NSPs, and Government since the commencement of ESCOSA's review in July 2016 and in the preparation of AEMO's Final Report on the Black System in South Australia on 28 September 2016.[9]

[9] AEMO. *Black System South Australia – 28 September 2016*, March 2017. Available at: http://aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Integrated-Final-Report-SA-Black-System-28-September-2016.pdf.

2.2 Issues summary

Table 2 presents a summary of issues raised by stakeholders on the technical recommendations presented in AEMO's March advice, and of AEMO's response to the issues raised.

Table 2 Submissions – issues summary

Focus area	Issue raised	Raised by	AEMO response
Disturbance ride-through – Reactive current injection & absorption	Reactive current injection from non-synchronous plant typically stops at 20% of residual voltage, reactive current absorption typically stops at 20% above nominal voltage. Synchronous generation may not be capable of settling times no greater than 60 ms.	Origin Vestas ElectraNet	AEMO has clarified expectations for reactive current absorption at low voltage and clarified application of settling time to synchronous generators.
Disturbance ride-through – Active power injection requirements	The technical recommendation as proposed in the draft report does not provide guidance on how the level of active power recovery that may be negotiated.	Vestas Pacific Hydro	AEMO has proposed amended wording for this recommendation, clarifying that the expected level of active power recovery will be assessed on a case-by-case basis between 100 and 500 ms.
Disturbance ride-through – Multiple low voltage disturbance ride-through (LVRT)	The proposed recommendation does not specify a limit to the number of faults that plant must ride through. Unlimited voltage ride through risks damage to plant and protection equipment. Number of faults should be capped at an agreed level. It may not be possible to design systems to ride through unlimited number of faults (both voltage and frequency).	Vestas Origin Energy Australia	AEMO has proposed a maximum number of faults and a cumulative time period for multiple LVRT, including shallow faults.
Disturbance ride-through – High voltage disturbance ride-through	Meeting the proposed over voltage withstand capability requirements may be costly and affect the lifespan of generating system components.	Siemens-Gamesa	AEMO has reduced the proposed level of over voltage withstand capability following consideration of international grid codes.
Disturbance ride-through –Frequency disturbance ride through	Origin suggested that the proposed rate of change of frequency (RoCoF) withstand requirements for new generators risk damage. Almost impossible for existing generation to meet requirements. ElectraNet was generally supportive of proposed amendments to the level of RoCoF for which generators can maintain continuous uninterrupted operation in the context of amendments to NER clause S5.2.5.3.	Origin ElectraNet	AEMO maintains that a level of RoCoF withstand capability as close as possible to the recommended levels should be negotiated for new entrant synchronous plant in SA.
System strength – a generator licence condition to meet its GPS at the connection point for the range of short circuit ratios agreed with the NSP in the connection agreement	Opposed to general requirement of SCR and X/R – capability is dependent on control system tuning, and additional compensation equipment	Vestas	AEMO maintains that requiring susceptible items of plant within the connecting party's generating system must be capable of operating correctly down to a minimum short circuit and X/R ratio is a sensible complementary policy while the AEMC is developing the *Managing power system fault levels* Rule change.

Focus area	Issue raised	Raised by	AEMO response
Active power control capability – ability to limit rate of change of active power	Introducing of limits on the rate of change of active power output from new generators as proposed by AEMO, may unfairly penalise new entrants and their ability to respond to price events from the market.	Energy Australia	AEMO has clarified the wording of this recommendation and will consider this issue in further work. AEMO maintains that it may be necessary to limit the rate of change of active power output from generators in the future due to potential impacts to system security if large and unexpected changes in generation output occurs.
Active power control capability – registration for FCAS	Participation in FCAS markets is currently voluntary and issues relating to frequency performance in the NEM are being investigated through a number of industry reviews and trials.	Pacific Hydro REACH Solar Origin	AEMO has removed this proposed requirement awaiting the outcomes of: • AEMO's Ancillary Services Technical Advisory Group (AS TAG) process. • Current trials for provision of FCAS from new entrant wind generation. • Outcomes from the AEMC's Frequency Control Frameworks Review.
Other matters of interest to ESCOSA – Ability to assist with system restart	Vestas suggested that if ESCOSA's proposed requirement relates to availability of backup power systems to support auxiliary loads while import from grid is not possible, then it cannot be met, as wind farm backup power may be limited to 30 minutes. Some generators may be at risk of damage if required to provide voltage control at low or zero load for longer than 30 minutes when assisting with system restart. Voltage control arrangements for system restart should be consistent with other NER obligations that relate to NSPs.	Vestas Origin ElectraNet	AEMO has clarified the basis of this recommendation and amended it to take consideration of the period of time for which each generating system is able to operate only on auxiliaries while provided voltage support to the power system during restart.

3. REVISED RECOMMENDATIONS

3.1 How to interpret revised recommendations

The revised recommendations provided in this section take into account the lessons and feedback gathered by AEMO and ESCOSA since March 2017, including:

- Stakeholder feedback to ESCOSA's Draft Report including AEMO's March advice.
- Stakeholder feedback to ESCOSA's Issues Paper.
- Final analysis of the 28 September 2016 state-wide blackout in SA.
- Learnings from AEMO's Future Power System Security program.
- Other informal AEMO consultations with equipment manufacturers and stakeholders.
- Lessons from international Grid Codes.
- Learnings from collaboration with AEMC in developing the *Managing power system fault levels* Rule change[10]

As noted, these revised recommendations have been written as an addendum to the March advice and should be read in conjunction with that advice.[11]

Where AEMO's recommendations have changed significantly from its March advice, supporting justification is provided in this addendum, otherwise the reasons for AEMO's final recommendations are provided in the March advice.

The wording of these final recommendations has also been amended in places to make them more easily applicable as licensing conditions.

3.2 Format of revised recommendations

AEMO's revised recommendations are provided in Section 3.3 below.

For simplicity, AEMO has structured its final recommendations in a tabular format, including the following information for each final recommendation:

- Relevant focus area (such as disturbance ride-through).
- Reference to relevant section of AEMO's March advisory report to ESCOSA.
- Related NER Clause(s).
- Summary of AEMO's March recommendation.
- Details of why AEMO's final recommendations differ from its March advice (if at all).
- Detailed final recommendations to ESCOSA on amended licence conditions.
- Guidance notes to support interpretation of AEMO's final recommendations (not to be included in the final licence conditions).

[10] AEMC 2017, *Managing power system fault levels*, Draft rule determination, 27 June 2017, Sydney, available at: http://aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels

[11] AEMO. *Recommended technical standards for generator licensing in South Australia*, March 2017. Available at: http://www.escosa.sa.gov.au/ArticleDocuments/1048/20170331-Inquiry-RecommendedTechnicalStandardsGeneratorLicensingSA-AEMOadvice.pdf.aspx?Embed=Y.

3.3 Summary of revised recommendations

"Report Section" refers to the relevant section of AEMO's March 2017 advice to ESCOSA: *Recommended technical standards for generator licensing in South Australia*, available at: http://www.escosa.sa.gov.au/ArticleDocuments/1048/20170331-Inquiry-RecommendedTechnicalStandardsGeneratorLicensingSA-AEMOadvice.pdf.aspx?Embed=Y. All references to AEMO's March 2017 advice to ESCOSA refer to the same report.

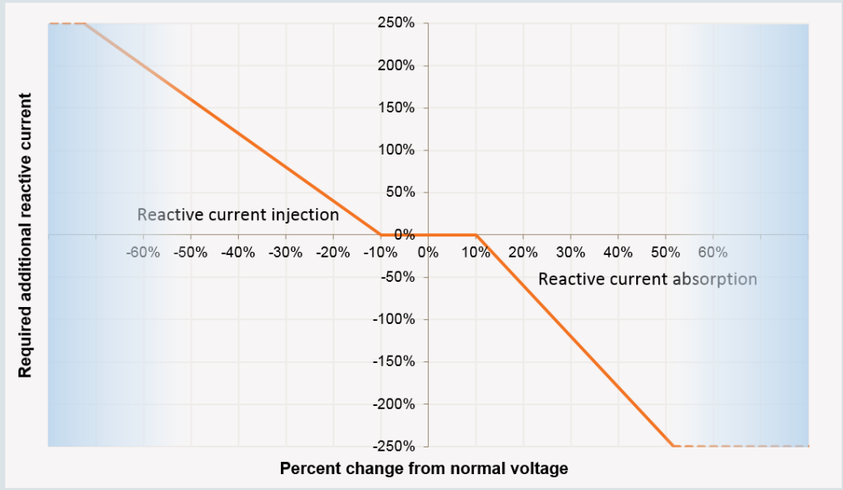
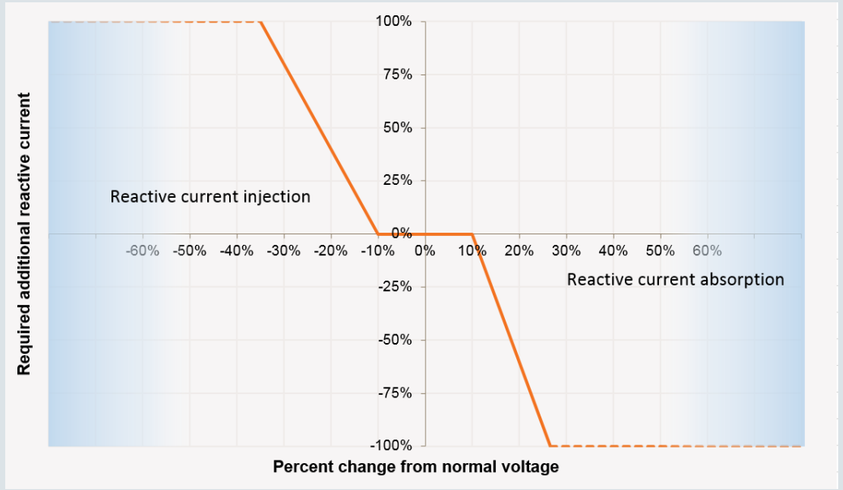
Table 3 Revised technical recommendations

#	Report section	Focus area	Related NER Clause(s)	Summary of interim recommendations	Supporting notes (issues raised/justification of final recommendations)	Revised final recommendation to ESCOSA
1	2.3.1	Reactive power capability	S5.2.5.1	AEMO recommends that ESCOSA replace current special licence conditions 10.1, 10.2, and 10.3 relating to reactive power capability with the set of recommended licence conditions described in Chapter 3 of AEMO's March 2017 advice to ESCOSA.	Refer to justification in AEMO's March 2017 advice to ESCOSA.	AEMO recommends that ESCOSA replace current special licence conditions 10.1, 10.2, and 10.3 relating to reactive power capability with the set of recommended licence conditions described below (refer recommendations 4 and 5).
2	2.3.2	Provision of dynamic reactive power	S5.2.5.1	AEMO recommends that the current dynamic reactive power requirements conditions in clause 10.4 of the ESCOSA special licence conditions be removed and replaced with specific requirements relating to disturbance ride-through. These requirements are described in detail in Chapter 3 of AEMO's March 2017 advice to ESCOSA.	Refer to justification in AEMO's March 2017 advice to ESCOSA.	AEMO recommends that ESCOSA replace current special licence conditions 10.4 relating to dynamic reactive power capability with the recommended licence conditions described below (refer recommendations 4 and 5).
3	2.3.3	Voltage control capability	S5.2.5.5 S5.2.5.13	Generators should comply with the newly worded clauses 10.5, 10.6, and 10.7 regarding voltage control	Refer to justification in AEMO's March 2017 advice to ESCOSA.	The generating system which the licensee is authorised to operate under this licence should comply with the following newly worded clauses 10.5, 10.6, and 10.7 regarding voltage control: 10.5 The generating system operated by the licensee must be capable of control by a fast-acting, continuously variable, voltage control system. The voltage control system must be able to receive a local and remote voltage setpoint. 10.6 The generating system operated by the licensee must have the capability to operate at either a set reactive power level, or a set power factor, which is able to be set locally or remotely at any time. 10.7 The voltage, power factor or reactive power control mode of a non-synchronous generating system operated by the licensee must be capable of: (a) being overridden by the disturbance ride through requirements (conditions in items 4 to 11 in this table) during a power system disturbance; and (b) automatically reverting to the selected control mode when the disturbance has ceased.
4	3.3.1	Disturbance ride-through – General principles	S5.2.5.4	To provide context for AEMO's recommendations related to disturbance ride-through capability, applicants should note:	In AEMO's March 2017 advice to ESCOSA a series of general principles were proposed that applicants should note. Upon further review, AEMO has decided	A non-synchronous generating system must meet the following requirements: • The LVRT activation threshold – as measured at the low voltage (LV) terminals of the generating units and other relevant items of plant (including, but not limited to dynamic reactive power plant) must not be less than 85% of nominal voltage. • Maintain continuous uninterrupted operation for voltage disturbances wherever specified in licence conditions.

<table>
<tr><th>#</th><th>Report section</th><th>Focus area</th><th>Related NER Clause(s)</th><th>Summary of interim recommendations</th><th>Supporting notes (issues raised/justification of final recommendations)</th><th>Revised final recommendation to ESCOSA</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Expected LVRT/HVRT withstand requirements, irrespective of generating system transformer’s tap position.
The LVRT activation threshold.
Definition of continuous uninterrupted operation.</td><td>that these principles warrant application as a specific licence condition. AEMO has adjusted its final recommendations accordingly.
This licence condition only-applies to non-synchronous generators. [12]</td><td>Where low voltage ride-through (LVRT) and high voltage ride-through (HVRT) requirements in the NER are specified in respect of the connection point, the withstand capability of individual generating units is to be determined at the low voltage (LV) side of the generating unit’s transformer. All individual generating units must remain connected for connection point voltages within the LVRT/HVRT withstand requirements, irrespective of the generating system transformer’s tap position.
_____
Notes:
For the purpose of this licence condition, continuous uninterrupted operation for voltage disturbances means that for voltage disturbances within the continuous operating range (i.e. connection point voltage fluctuating within 90% and 110% of normal voltage), active power must be maintained (unless there has been a change in the intermittent power source) and reactive power must be managed to meet voltage control requirements. This definition is provided to allow parties to interpret obligations for voltage disturbance under this license condition and is intended to complement rather replace the existing NER definition.</td></tr>
<tr><td>5</td><td>3.3.1</td><td>Disturbance ride-through – Reactive current injection requirements</td><td>S5.2.5.5</td><td>Require new entrant generators to be able to meet reactive current injection requirements during and subsequent to contingency events.
In response to stakeholder feedback on application to synchronous generators, AEMO has amended the wording of reactive current injection criteria (specifically settling time).
AEMO has also included additional information to assist with interpretation of reactive current injection requirements for synchronous and non-synchronous plant</td><td>Refer to justification in AEMO’s March 2017 advice to ESCOSA.
Identified issues include:
- Cut-off for reactive power injection based on LV conditions
- Cut-off for reactive power injection based on HV conditions
- Application of reactive current injection criteria to synchronous generators</td><td>The generating system which the licensee is authorised to operate under this licence must comply with the following:
The generating system must supply additional capacitive reactive current (reactive current injection) of up to 4% of the maximum continuous current of the generating system (in the absence of a disturbance) for each 1% reduction of connection point voltage below 90% of normal voltage, as shown in Table 4. This requirement applies at the LV terminals of the generating units and other relevant items of plant (including, but not limited to dynamic reactive power plant) for power system disturbances resulting in a voltage reduction of up to 100% of normal voltage at the connection point.
The generating system must supply additional inductive reactive current (reactive current absorption) of up to 6% of the maximum continuous current of the generating system (in the absence of a disturbance) for each 1% increase in connection point voltage above 110% of the normal voltage, as shown in Table 4 below. This requirement applies at the LV terminals of the generating units and other relevant items of plant (including, but not limited to dynamic reactive power plant).
The reactive current injection must be maintained until the connection point voltage returns to within the range of 90% to 110% of normal voltage.
Table 4 Reactive current injection requirements<table><tr><th>Reactive current response</th><th>Current injection gain (%)</th><th>Current absorption gain (%)</th><th>Minimum amount of contribution as percentage of rated current</th><th colspan="2">Speed of contribution</th></tr><tr><th></th><th></th><th></th><th></th><th>Rise time (ms)</th><th>Settling time (ms)</th></tr><tr><td>Synchronous</td><td>4</td><td>6</td><td>250</td><td>30</td><td>N/A</td></tr><tr><td>Non-synchronous</td><td>4</td><td>6</td><td>100</td><td>30</td><td>60</td></tr></table>The amount of reactive current injection required may be calculated using phase-to-phase, phase-to-ground, or sequence components of voltage. For the last method, the ratio of negative-sequence to positive-sequence current injection must be confirmed with ESCOSA for various types of voltage disturbances.
The generating system which the licensee is authorised to operate under this licence should comply with the following response characteristics for reactive current injection:
A *rise time* (as defined in clause S5.2.5.13 of the NER) no greater than 30 milliseconds (ms) and a s*ettling time* (also as defined in clause S5.2.5.13 of the NER) no greater than 60 ms applies to reactive current injection requirements. The settling time requirement does not apply to synchronous machines.
For a non-synchronous generating system, the reactive current injection requirements described above apply for all pre-disturbance reactive power control modes (voltage control, power factor control, or reactive power control).</td></tr>
</table>

[12] ‘LVRT/HVRT threshold characteristics and obligations to maintain continuous uninterrupted operation in the context of this license recommendation are only relevant to non-synchronous generation. The existing NER provisions for continuous uninterrupted operation and obligations to ride through under voltage events remain suitable for describing the performance of synchronous plant.

#	Report section	Focus area	Related NER Clause(s)	Summary of interim recommendations	Supporting notes (issues raised/justification of final recommendations)	Revised final recommendation to ESCOSA
						• The reactive current response must be *adequately damped* as defined in the NER (Glossary, Chapter 10). • Reactive power consumption upon application of a fault must not exceed 5% of maximum continuous rated current of the generating system and limited to the duration of rise time. • The post-fault reactive power contribution of the generating system must be sufficient to ensure that the connection point voltage is within the following range for continuous uninterrupted operation: – Voltages over 110% for the durations permitted under NER clause S5.1a.4; – 90% to 110% of normal voltage continuously; – 80% to 90% of normal voltage for a period of at least 10 seconds; and – 70% to 80% of normal voltage for a period of at least 2 seconds. _____ Notes: • A graphical representation of these requirements is provided below in Figure 1 and Figure 2 for explanatory purposes. • It should be noted that the term '*settling time'* does not apply to synchronous machines in the context of fault current contribution because: – *Settling time* as defined in S5.2.5.13 relates to the delay in a *control system* between a change in input signal and the associated change in output quantity. – Unlike non-synchronous plant, the fault current contribution of synchronous generators is provided through an intrinsic and uncontrolled response. – The fault current contribution of synchronous generators does not settle during the fault due to presence of large DC components in the fault current. This is unlike a power electronic controlled system such as a wind turbine or solar inverter where the DC component is practically eliminated. • Note that voltage disturbances in this condition are defined at the connection point, while performance characteristics are defined at the LV terminals the generating units and other relevant items of plant (including, but not limited to dynamic reactive power plant). Accordingly, the final reactive current injection/absorption limits at LV terminals will be determined by generating system component impedances behind the connection point - as indicated by the dotted lines in Figure 1 and Figure 2.

#	Report section	Focus area	Related NER Clause(s)	Summary of interim recommendations	Supporting notes (issues raised/justification of final recommendations)	Revised final recommendation to ESCOSA
						Figure 1 Reactive current injection requirements for synchronous generators  **Figure 2 Reactive current injection requirements for non-synchronous generating system** 
6	3.3.1	Disturbance ride-through – Active power injection requirements	S5.2.5.5(b)(2)	Require new entrant generators to be able to restore active power to at least 95% of the level existing just prior to the fault between 100 and 500 ms after disconnection of the faulted element. The exact	Refer to justification in AEMO's March 2017 advice to ESCOSA. Some stakeholders have requested clarification on the slowest level of active	The generating system must be capable of restoring active power to at least 95% of the level existing just prior to a fault between 100 and 500 ms after disconnection of the faulted element, with recovery no slower than 500ms. The exact active power recovery time must be specified by ESCOSA. Transient active power consumption upon application of a fault must not exceed one power frequency cycle and must not exceed 5% of the maximum continuous rated current of the generating system.

#	Report section	Focus area	Related NER Clause(s)	Summary of interim recommendations	Supporting notes (issues raised/justification of final recommendations)	Revised final recommendation to ESCOSA
				active power recovery time should be determined by AEMO and ElectraNet for each specific connection depending on specific requirements. Transient active power consumption upon application of a fault should not exceed set limits.	power recovery that may be acceptable AEMO considers that assessment of active power restoration time should be made on a case-by-case basis as impacts of generator performance vary considerably according to generation type and network location. Notwithstanding this, AEMO has included a lower limit on active power recovery of 'no slower than 500ms' to more clearly specify the range of expected performance for active power recovery.	
7	3.3.1	Disturbance ride-through – Multiple low voltage disturbance ride-through	S5.2.5.4 S5.2.5.5	Require new entrant generators to be able to meet multiple low voltage disturbance ride through requirements.	Refer to justification in AEMO's March 2017 advice to ESCOSA. AEMO received stakeholder feedback from Origin and Vestas requesting: • Clarity on the total number of low voltage faults new entrant generators must have the capability to ride through. • Further information on how longer duration shallow voltage faults are considered. AEMO has proposed amendments to description of 5 minute interval and the total number of faults in response to stakeholder feedback. Further, based on stakeholder feedback, the total fault duration was reduced from 1800 ms to 1500 ms to ensure the requirements can be met by as wide a range of technologies as possible,	Multiple low voltage disturbance ride-through The generating system – including each the generating units and other relevant items of plant (including, but not limited to dynamic reactive power plant) – must be capable of withstanding both of the following within a 5-minute interval: 1. Any combination of voltage disturbances causing the voltage at the respective LV terminals of the equipment to drop below 85% of the nominal voltage for a total duration of 1,500 ms regardless of disturbance type, duration, and residual voltage at the generating unit's terminals. The total number of voltage disturbances for which successful ride-through is required will be limited to 15. Each fault can be a solid fault resulting in 100% voltage drop at the connection point whose duration not exceeding the longest time expected to be taken for the breaker fail protection system to clear the fault, as set out in Table S5.1a.2 of National Electricity Rules. 2. A single worst-case long-duration shallow voltage disturbance, causing the voltage at the connection point drop to 70-80% of the normal voltage for a total duration of 2000 ms. 3. Subject to compliance with the above requirements, the generating system is not required to withstand any additional voltage variation exceeding ±10% of nominal voltage experienced at the respective LV terminals within 30 minutes from the commencement of the first such variation. For synchronous generating systems, the ability to withstand a certain number of faults will be dictated in-part by the physical design of the proposed generating units. Synchronous generators must be able to withstand the above combination of disturbances, unless otherwise agreed with ESCOSA and documented in this licence condition. _____ Notes: Some equipment manufacturers currently use control settings that act by counting the number of successive faults. The requirement to withstand a total duration of multiple faults must override any such manufacturer control settings. Where it is necessary to include protection settings that act on the number of faults, three or more different settings must be applied across the generating system to minimise loss of generation due to simultaneous disconnection of all individual generating units. In any case, the generating system must successfully ride through the total disturbance duration specified above. The proposed licence condition seeks to maximise the fault ride-through capability of new generators, within the physical limits of leading modern generation technology.

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					This revised level is still above the maximum historical duration of faults that has occurred in the SA.	For a non-synchronous generating system, the most critical factor in setting an acceptable level of generator performance is the total fault duration is, as it determines the amount of heat dissipated across the dynamic braking chopper or dump resistor connected to the DC-link in power electronic converters. Such a scheme is universally used for all modern type 3 and 4 wind turbines for enhanced fault ride-through capability. AEMO has consulted with multiple non-synchronous manufacturers and understand that they are able to comply with the proposed conditions - often as a standard feature in their latest products. For synchronous generators, the most critical factor in setting an acceptable level of generator performance is the number of faults they must withstand. In its submission to the Consultation, Origin Energy recommended imposing a practical limitation on the number of ride through events that generators would be expected to perform against. The proposed limit of 15 faults is based on the maximum number of historical faults within 2, 30, and 120 minute intervals in ElectraNet's transmission network, as highlighted in AEMO's final report into the 28 September 2016 SA black system. The Danish[A] and German Grid Codes are the only grid codes known to AEMO with precise requirements on multiple fault ride-through capability. The need for definition of requirements for repeated disturbances has been acknowledged in a special report by the United States national reliability body, the North American Electric Reliability Corporation (NERC).[B] However, at the time of writing, no specific requirements have been defined. Examples of conditions where successful fault ride-through response is required include: 1. Up to 12 faults each cleared within 120 ms (with any magnitude of voltage dips) + one 2000 ms fault resulting in connection point voltage to drop to 0.7 pu. 2. Up to 15 faults each cleared within 100 ms (with any magnitude of voltage dips) + one 2000 ms fault resulting in connection point voltage to drop to 0.7 pu. 3. Up to 5 faults each cleared within 220 ms + 4 faults each cleared within 100 ms (with any magnitude of voltage dips) + one 2000 ms fault resulting in connection point voltage to drop to 0.7 pu.
8	3.3.1	Disturbance ride-through – High voltage disturbance ride-through	S5.2.5.4 S5.1a.4 S5.1.4	Require new entrant generators to be able to meet high-voltage disturbance ride-through requirements.	Refer to justification in AEMO's March 2017 advice to ESCOSA. Based on stakeholder feedback raising concerns about the original over voltage withstand durations, AEMO has amended the withstand durations for temporary over voltages in the 110–115% range (from 1800s to 1200s) and the 115–120% range (from 30s to 20s). The reduction from 1800 s to 1200 s makes the requirements consistent with findings[C] used to support development of the ENSTSO- E network code for mainland Europe.[D] These over voltage withstand levels have been considered in investigations by CIGRE[E] indicating that all transmission network elements tested by the	The generating system must have a level of over voltage withstand capability consistent with the levels shown in Table 5 below, unless otherwise agreed with ESCOSA. The generating system must maintain continuous uninterrupted operation for temporary over voltage durations as detailed in its licence. **Table 5 Required over voltage withstand capability** **Temporary over voltage (% of normal voltage)** | **110–115** | **115–120** | **120–125** | **125–130** | **130–140** Duration(s) | 1,200 | 20 | 2 | 0.2 | 0.02 Notes: • The HVRT capability is nominally defined at the LV terminals of the generating units. However, for the purpose of compliance with high-voltage disturbance ride-through requirements, the point of compliance can be defined as the connection point or LV terminals of the generating units as agreed on a case-by-case basis with AEMO and relevant NSP. • The proposed requirements apply irrespective of the size of the positive - and negative - sequence phase angle shifts. Detailed power system modelling has been undertaken by AEMO to support review of the Black System event in SA on 28 September 2016. Further detail on this work can be found in Appendix X of AEMO's final incident report.[F] This work has highlighted the importance of temporary generator over voltage withstand capability to avoid the tripping of generators following the credible and non-credible separation of the SA region from the rest of the NEM. AEMO's modelling of credible and non-credible separation scenarios for the SA region has indicated that, without an adequate level of over voltage withstand capability as set out in Table 5, new entrant generators may trip off following a credible or non-credible separation event. NER S5.1.4 requires TNSPs to plan and design the transmission network to control transient and steady-state voltage magnitude for credible contingencies and protected events, within the envelope described by system standard clause S5.1a.4. Clause S5.1.4 (a) suggests that under the NER, NSPs cannot set the automatic standard for S5.2.5.4 for a new generator at a level beyond the system standard set out in S5.1a.4.

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					CIGRE Working Group are capable of meeting over voltages of up to %115 for 1200 s. The reduction from 30s to 20s on over voltages of up to 120% reflects stakeholder feedback, while still being adequate to ensure sufficient time for disconnection of all transmission and distribution capacitor banks.	The recommended levels for over voltage withstand in Table 5 exceed the level of the system standard and cannot be easily negotiated by an NSP under the current NER framework. For these reasons, AEMO recommends that as an interim measure to reduce the risk of a cascading outages following a credible or non-credible separation event, ESCOSA require a level of over voltage withstand capability be negotiated on case-by-case basis for new entrant generators as close as possible to the recommended levels. In the longer term, AEMO suggests that the development of necessary over voltage withstand capability required for the power system to remain within system standard S5.1a.4 for credible contingencies and protected events, would be the responsibility of ElectraNet in accordance with NER S5.1.4. It is expected that the necessary over voltage capability could be supplied at least cost with a combination of generator performance requirements (i.e. over voltage withstand capability) and the use of network plant (e.g. Static VAR Compensators (SVCs)).
9	3.3.2	Disturbance ride-through – Partial load rejection	S5.2.5.7	Require generators to meet the automatic access standard requirements defined under NER clause S5.2.5.7.	Refer to justification in AEMO's March 2017 advice to ESCOSA. Requirements for synchronous generators in relationship to this recommendation are covered under S5.2.5.7. A license condition is required for non-synchronous generators in this regard as these generators are expressly excluded from this clause.	A non-synchronous generating system must be capable of continuous uninterrupted operation during and following a power system load reduction of 30% from its pre disturbance level or equivalent impact from separation of part of the power system in less than 10 seconds, provided that the loading level remains above minimum load.
10	3.3.3	Disturbance ride-through – Frequency disturbance ride-through	S5.2.5.13	Require generators to be able to meet amended performance requirements for frequency disturbance ride-through.	Refer to justification in AEMO's March 2017 advice to ESCOSA.	A non-synchronous generating system must be capable of continuous uninterrupted operation for any combination of the following rate of change of frequencies: • ±4 Hz/s for 250 ms; • ±3 Hz/s for 1 s, until such time as power system frequency breaches the extreme frequency excursion tolerance limits (defined in the NER, and set in the Reliability Panel's Frequency Operating Standards).[G] A synchronous generating system must be capable of continuous uninterrupted operation for a range of RoCoF intensities as determined by ESCOSA, and documented in the licence. _____ Notes: Unlike non-synchronous generating systems that interface with the network via a converter, synchronous generation is directly connected to the power system via electromagnetic coupling. As a result, there are physical limits to the intensity and duration of RoCoF exposure that each synchronous generator can withstand before suffering damage. ESCOSA should seek the highest possible performance from new synchronous generators, noting the physical limits of these machines.
11	3.3.4	Disturbance ride-through – Voltage	S5.2.5.8	Restrict application of vector shift and similar types of relays	Refer to justification in AEMO's March 2017 advice to ESCOSA.	The generating system must not include any vector shift or similar relay/protective function acting upon voltage phase angle which might operate for phase angle changes less than 20 degrees.

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		phase angle shift				
12	5.3.2	System strength	n/a	Consider an NSP licence obligation to maintain a short circuit ratio at each connection point within a range agreed in the relevant connection agreement	AEMO believes this issue can be best addressed through the AEMC's *Managing power system fault levels* system strength Rule change.[H] The AEMC's draft determination on this Rule change was published on June 27th 2017 and recommends an enhanced framework in the NER that requires network service providers (NSPs) to maintain the system strength at generating system connection points above an agreed minimum level under a defined range of conditions.	AEMO is not recommending an NSP licence condition for maintaining system strength at the connection point.
13	5.3.2	System strength	n/a	A generator licence condition to meet its GPS at the connection point for the range of short circuit ratios agreed with the NSP in the connection agreement (and which the NSP has undertaken to maintain).	As with item 12, AEMO believes this issue can best be addressed through the Rule change currently being assessed by the AEMC on *Managing power system fault levels* Rule change.[H]	AEMO is not recommending generator licence to address operation of the generating system if levels of system strength are below what is stipulated in the generating system's GPS.
14	5.3.2	System strength	n/a	Require susceptible items of plant (such as individual generating units and dynamic reactive power support plant) within the connecting party's generating system to be capable of operating correctly down to the following levels at the HV terminals of each item of plant: • Minimum short circuit ratio of 1.5. • Minimum positive sequence X/R ratio of 2 (ratio of system	This recommendation was supported by ElectraNet in its submission, which it thought was justified given the current state of generation dispatch and number of proposals for non-synchronous generation in the state. In its submission, Vestas noted its opposition to a general requirement of SCR and X/R capability, noting that this capability is dependent on control system tuning, and	Susceptible items of plant (including, but not limited to, individual generating units and dynamic reactive power plant) within the connecting party's generating system must be capable of operating correctly down to the following levels at the HV terminals of each item of plant: • Minimum short circuit ratio of 1.5. • Minimum positive sequence X/R ratio of 2. The above criteria should apply in conjunction and no criterion can override another. Where an even lower tolerance exists (as may be required to satisfy recommendation 13), the actual plant tolerance is to be documented in this licence condition. Any departure from the proposed capability may be determined by ESCOSA based on demonstrated plant performance from dynamic electro-magnetic transient (EMT) power system analysis.

#	Report section	Focus area	Related NER Clause(s)	Summary of interim recommendations	Supporting notes (issues raised/justification of final recommendations)	Revised final recommendation to ESCOSA
				inductive to resistive impedance). The above criteria should apply in conjunction and no criterion can override another.	additional compensation equipment. The costs to consumers associated with incorporating increasing volumes of non-synchronous generation in SA will be minimised if generators are capable of operating down to low short circuit ratios. This will allow more generators to be located near one another without necessitating additional network augmentation or constraining generator output to manage weak system conditions. Until an alternative methodology can be proposed that provides an equitable and transparent signal at the connection point, the proposed capability at the HV terminals of susceptible plant within the connecting party's generating system appears the most practical way of minimising costs to future generators and, ultimately, customers.	
15	6.3.1	Active power control capability	S5.2.5.11	All new entrant generators should have the capability to provide an automatic active power response to a change in system frequency	Refer to justification in AEMO's March 2017 advice to ESCOSA.	The generating system shall have following capabilities: • It must be capable of automatically providing a proportional increase or decrease in active power output, in response to falling and rising power system frequency respectively. – An active power response to changing power system frequency must be provided with no delay, beyond that required for stable operation, or inherent in the plant controls, once frequency leaves the deadband. – The steady state droop setting of this active power response must be adjustable in the range 2% to 10%. – The frequency deadband for this response must be adjustable in the range from 0 to +/- 1.0 Hz. (The droop characteristic is defined with respect to the registered MW capacity of the generating system (Pmax) and applies from 50 Hz (rather than from the dead-band limits).) • It must be capable of sustaining a response to abnormal frequency conditions for at least 10 minutes, subject only to inherent limits on energy resource availability. • Response to rising and falling frequency may be different, in both deadband and droop settings, and in the response shape or characteristics. Different levels of droop may be applied for different levels of frequency change.

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16	6.3.2	Active power control capability	S5.2.5.14	All new entrant generators should have the capability to be controlled by NEM Automatic Generation Control (AGC) signals on a 4-second basis	Refer to justification in AEMO's March 2017 advice to ESCOSA.	The generating system must have the following AGC capabilities: • It must have active power control capabilities that allow it to participate in existing NEM arrangements requiring Automatic Generation Control. This includes arrangements used for automatic dispatch of generation, and for frequency regulation. • At a minimum, the AGC based controls must have: – The ability to receive and respond to a remotely determined active power control setpoint, updated at a rate of every 4 seconds, transmitted to the generating system. (This is over and above the requirement of S5.2.5.14 of the NER, which only requires a scaling of active power setpoints.) – The capability to provide the following information to AEMO: o Actual active power output. o Maximum raise limit. o Minimum lower limit. o Maximum raise ramp rate. o Maximum lower ramp rate. Notes: Any request for this information would be made by AEMO under NER S5.2.6.1 or provided by a generator as a part of the dispatch process under NER 3.8.2.
17	6.3.3	Active power control capability	S5.2.5.14	All new entrant generators should have the capability to limit the rate of change of active power within the timescale of a dispatch period	Refer to justification in AEMO's March 2017 advice to ESCOSA. Advice updated to indicate use of central dispatch process to advise rate limits. Advice updated to clarify that down ramp limits are exempted for variable input energy. Wording of the requirements has been simplified from the original proposed text.	The generating system shall have the following capabilities to control the rate of change of active power: • It must be capable of limiting the rate of change of active power, both upwards and downwards. • It must be capable of implementing different active power rate limits for operation in the normal operating frequency band and for contingency events. (For example, different rate limits may be specified for responding to a remote active power setpoint change, or for responding to a special protection scheme trigger following a contingency event.) • It must be capable of setting a ramp rate limit with accuracy of within 10%. (That is, the variation in active power within the time period specified for the active power rate limit may not deviate by more than 10% from a straight line trajectory between the initial and final active power setpoints determined by the rate limit.) Notes: • Limits on active power ramp rates when responding to a change in energy market target or dispatch limit would be advised by AEMO using existing central dispatch processes described in NER clause 3.8.21. • NSPs may choose to specify additional ramp rate limits, beyond any energy market ramp limit set by AEMO through the central dispatch process. • A generator is not expected to comply with a limit on the rate of reduction in active power, where the reduction in active power is due to energy resource availability for intermittent generating systems beyond the generating systems reasonable control.
18	6.3.4	Active power control capability	S5.2.6 (b)	All plant is required to provide real time information about their active power control systems to AEMO in order to support its role as independent system operator.	Refer to justification in AEMO's March 2017 advice to ESCOSA. Amended requirements to reflect AEMO's revised policy on notification of active power controls for existing and new entrant generators AEMO has the ability to request this information under S5.2.6.1 of the NER, however there is not	The generating system must have the capability to provide real-time information about its active power control settings to AEMO. The mode of operation of the generating system's active power control system must be capable of being provided in real-time to AEMO via SCADA. This capability shall include the value of any key active power control system limits or settings which may change during real-time operation.

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					currently a requirement on Generator's to have the necessary SCADA signals. Accordingly AEMO has amended its recommendation to focus the revised licence condition on ensuring the generator has the appropriate capabilities. Use of this capability will determined by AEMO under its existing NER powers.	
19	6.3.5	Active power control capability	2.2.6(a)	New entrant generators should be required to register as ancillary service generating units for the provision of both regulation and contingency FCAS	This previously proposed requirement has been removed: • Following feedback from stakeholders including Tilt, Origin and Snowy Hydro. • Awaiting the outcomes of current trials for provision of FCAS from new entrant wind generation. These trials will clarify if the MASS in its current form can be applied to wind and solar farms. • Awaiting the outcomes of AEMO's Ancillary Services Technical Advisory Group (AS TAG) process.	This previously proposed requirement has been removed. No additional licence conditions are recommended.
20	7.3.1	Simulation models	n/a	Recommends that, as a part of the licence application process for new generators, ESCOSA emphasise to generators to the importance of providing suitable pre-validated models and data representing their generating system and all elements of associated protection systems to AEMO in accordance with principles set out on this report	Refer to justification in AEMO's March 2017 advice to ESCOSA. While no licence condition is recommended, AEMO encourages intending participants to note the potential need for more sophisticated power system models in order for NSPs and AEMO to assess the generators true performance in the SA power system.	No additional licence conditions are recommended.

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21	8.3.2	System restoration	n/a	To assist with system restoration following a potential black system event, AEMO recommends that ESCOSA require assessment of a set of capabilities that can be used during system restoration from new entrant generators	Refer to justification in AEMO's March 2017 advice to ESCOSA. AEMO has proposed amended requirements in this area following feedback from stakeholders, including Origin and Vestas that extended operation of plant on auxiliaries may result in damage to generating systems and other items of plant.	The applicant shall achieve and maintain for the term of its licence, a capability specified by ESCOSA in the following areas: 1. the generating system shall be capable of operation with auxiliary loads only while system load is being restored, for an agreed duration as specified by ESCOSA ; 2. the generating system – including each the generating units and other relevant items of plant (including, but not limited to dynamic reactive power plant) – must have the capability to provide steady-state and dynamic reactive power when operating with auxiliary loads only and while system load is being restored. _____ Notes: • To provide a useful contribution, generating systems should be able to supply at least 20% of their maximum steady-state reactive power capability and full dynamic reactive power capability when operating with the auxiliary load or under light load conditions. • The ability to operate with auxiliary loads while system load is being restored is only required where a sufficient minimum fault level is available from online synchronous machines. • Successful operation with auxiliary load or while system load is being restored and provision of static and dynamic reactive power capability must be demonstrated during the commissioning and compliance testing, and must be verified following any significant modifications to the generating system and its individual components. • Any EMT-type simulation models submitted to AEMO must account for operation with auxiliary loads. • AEMO is aware that this capability is not inherent in the basic design of many types of generating system. As such AEMO recommends that ESCOSA seek a minimum of thirty minutes and a maximum of three hours capability in regard of this clause, and only where it does not require the installation of significant additional auxiliary plant with the generating system (e.g. batteries).

A Energinet.DK, 2016,Technical regulation 3.2.5 for wind power plants above 11 kW, available at: https://www.energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/El/55986-10_v1_Grid%20Code%203%202%205_v%204%201-30%20%20September%202010.pdf.
B ERC, 2012. *Special Assessment Interconnection: Requirements for Variable Generation*, available at: http://www.nerc.com/files/2012_IVGTF_Task_1-3.pdf.
C ENSTO-E, 2012 *Network Code on Requirements For Grid Connection Applicable to All Generators Frequently Asked Questions,* available at: http://www.acer.europa.eu/Media/News/Documents/120626%20-%20NC%20RfG%20-%20Frequently%20Asked%20Questions%20(2).pdf.
D ENSTO-E, 2016 *Network Code on Requirements For Grid Connection Applicable to All Generators* available at:*http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0631&from=EN.*
E Cigre WG 33.10,1998, *Temporary Overvoltages: Withstand Characteristics of Extra High Voltage Equipment*, Electra No.179 August, pp. 39-45.
F AEMO. *Black System South Australia – 28 September 2016*, March 2017. Available at: http://aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Integrated-Final-Report-SA-Black-System-28-September-2016.pdf.
G Current version: AEMC, 2009, Application of Frequency Operating Standards During Periods of Supply Scarcity, available at: http://www.aemc.gov.au/getattachment/436495bb-89b9-4da6-b258-e24437df9b8a/Frequency-Operating-Standards-(Mainland).aspx.
H Refer to AEMC's website for further information: http://www.aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels.

MEASURES AND ABBREVIATIONS

Units of measure

Abbreviation	Unit of measure
Hz	Hertz
kV	Kilovolt
kVA	Kilovolt-amp
ms	Millisecond
MW	Megawatt
s	Second

Abbreviations

Abbreviation	Expanded name
AC	Alternating current
AEMC	Australian Energy Market Commission
AGC	Automatic Generation Control
DC	Direct current
DER	Distributed Energy Resources
EMT	Electromagnetic transient
ENA	Energy Networks Association
ESCOSA	Essential Services Commission of South Australia
FCAS	Frequency control ancillary services
FFR	Fast frequency response
GPS	Generator performance standards
HVRT	High voltage ride-through
LV	Low voltage
LVRT	Low voltage ride-through
NEM	National Electricity Market
NER	National Electricity Rules
NSP	Network service provider
PV	Photovoltaic
RoCoF	Rate of change of frequency
SA	South Australia
SCADA	Supervisory Control and Data Acquisition
SCR	Short circuit ratio
TNSP	Transmission Network Service Provider