Draft report Stakeholder feedback template:

AEMO Review of technical requirements for connection (NER 5.2.6A)

Stakeholders making a submission on the recommendations set out in the AEMO draft report may use the below template to provide feedback. Please consider the confidentiality disclaimer at the end of this document.

Stakeholder: APD Engineering

General comment: It is recommended that the proposed rule amendments allow AEMO to provide a clear guideline for implementation and assessments of the rule amendments. This guideline will provide uniform interpretation of the rules and assessment across the NEM. It is recommended that this guideline is made available in unison with the implementation of these rule amendments to minimise the impact upon connection projects.

Schedule 5.2 Conditions for Connection of Generators

Issue	Schedule 5.2 Generator Recommendation feedback
NER S5.2.1 – Outline of requirements	
Application of Schedule 5.2 based on plant type instead of registration category and extension to synchronous condensers	APD agrees with AEMO that more clear and unambiguous definitions should be provided for synchronous generators, synchronous condensers, IBRs, BEES, IRPs etc., These definitions are required to provide more clarity in applying the S.5.2.5 performance rules. For example, the present rules for S5.2.5.5 (disturbance response) includes different categories and describes performance standards for synchronous plants alone, asynchronous plants alone, both synchronous and asynchronous plants in addition to AAS, MAS and negotiated access differentiation. This makes the schedule more complex and difficult to understand and interpret. If a clear categorisation of the participants is made it is possible to define the performance standards according to the individual type and technology separately. Taking the example of S5.2.5.5, the schedule may have separate sub parts defining the performance for synchronous generators, syn cons, IBRs, BEES, IRPs separately without any mix-ups making it clearer and more distinctive according to the generation type.
NER S5.2.5.1 – Reactive power capability	
Voltage range for full reactive power requirement	APD support amendments to this clause Option 3, but proposed AEMO consider the following aspects. The S5.2.5.1 reactive power capability assessment is typically a critical path item for new projects as this can impact the size of the generating system (e.g., number of inverters). It is noted that the proposed rule change will limit the requirement for full reactive power capability to a 10% voltage band around a **centre point nominated by the NSP**. For this rule change to streamline the connection process, it is recommended that a clearly defined process is implemented to streamline nomination of a voltage “centre-point” including: • Timeframe obligation under the rules for the NSP to confirm a suitable voltage centre-point. • Standardised documentation for confirming voltage centre-point which is then included in a connection application package. A practical difficulty faced by the generator proponents: Change to the nominated voltage centre-point by the NSP during the project due diligence would significantly delay the overall connections process, as we have seen this often does occur in the current process and this should be avoided through the implementation of a formal process accompanying this rule change. Any rule obligation on NSPs to avoid such a thing is welcome.

Issue	Schedule 5.2 Generator Recommendation feedback
	Observation: The gradual reduction in reactive supply capabilities above 10 % band to zero at +10 % voltage above normal operating voltage is suggested. However, it should be noted that in some parts of the network far from load centres currently synchronous generators are often operated at their full reactive capability, for example at 1.08 to 1.09 pu PoC voltage, to support voltage at load centres. When the synchronous generators are replaced with IBRs with limited reactive support at high voltage range there will a possibility to compromise the reactive support at load centres. Such impacts of this rule change also need to be considered. It should be practically considered by assessing how the generators are operated historically in different parts of the network with respect to their PoC voltage and their reactive power generation before making a final rule determination.
Treatment of reactive power capability considering temperature derating	Inverters in the NEM are typically configured in a "Q Priority" mode where reactive power is prioritised in cases of inverter nameplate derating due to voltage or temperature changes. Therefore, the implementation of a dynamic temperature dependent reactive power capability, may require the Original Equipment Manufacturer (OEM) to implement temperature dependent reactive power limitations in the Power Plant Controller (PPC) in the case of a typical solar farm. This, however, may prove considerably more complicated to implement and test when compared to temperature dependent active power that can be managed by an external SCADA system that adjusts active power setpoint based on ambient temperature. For the proposed rule change streamlines connections, it is recommended that acceptable case examples are provided for a range of technology types to ensure a consistent assessment approach by AEMO and NSPs. Case examples would include the required OEM documentation for a new generator connection application for demonstrating compliance when proposing a temperature derated reactive power capability. This is referring to the provided formula of, Qmax (T) = 0.395 Pmax (T), and Qmin (T) = -0.395 Pmax(T). For operating temperature T at the connection point.
Compensation of reactive power when units are out of service	

S5.2.5.1, S5.2.5.5, S5.2.5.7, S5.2.5.8, S5.2.5.10

Simplifying standards for small connections	For S5.2.5.5, the proposed change states that the technical assessment **could omit** reactive current injection requirements. Since this is not proposed to be an AEMO advisory matter, it is implied that the performance standard will still need to be negotiated with the NSP. From the proposed wording it is unclear whether assessments of positive to negative sequence reactive current would be required. This should be clarified to reduce the risk of required reassessments during project due diligence.

NER S5.2.5.1 – Reactive power capability

NER S5.2.5.1 – Reactive power capability	Setting Qmin/Qmax based on the reactive power for 5 % voltage change at POC for distribution connection has the following ambiguities: 1. 5 % voltage change is a function of POC Fault Level (FL, grid impedance) and hence the assessment FL also need to be specified by the NSPs. 2. How to categorise distribution or transmission connections? For example, in TAS, 110 kV is defined as transmission connection whereas in many parts of mainland 132 kV connections are considered as distribution connections. Hence the voltage levels of distribution connection need to be defined. It is recommended that the proposed rule directs AEMO to provide a clear guidelines in regard to implementation and assessments on the changes through this rule. Such guidelines will provide uniform interpretation of the rule and assessments across NEM. Any delay in issuing such guidelines will impact the connections under new rule.

NER S5.2.5.2 – Quality of electricity generated

NER S5.2.5.2 – Quality of electricity generated	APD supports the correction/removal of reference to any superseded standards (Option 2). From APD's experience, different NSPs have different methodology and calculation methods for assessing this schedule. To make the assessment uniform NEM, AEMO or combined NSP forum must produce a set of guidelines on the harmonic assessment methodology.

NER S5.2.5.4 – Generating system response to voltage disturbances

Reference to plant standard	

Issue	Schedule 5.2 Generator Recommendation feedback
	APD supports the correction/removal of reference to any superseded standards (Option 2). From APD's experience, different NSPs have different methodology and calculation methods for assessing this schedule. To make the assessment uniform across the NEM, it would be beneficial for AEMO or combined NSP forum to produce a set of guidelines on the harmonic assessment methodology.

NER S5.2.5.4 – Generating system response to voltage disturbances

Overvoltage requirements for medium voltage and lower connections	We agree with the AEMO recommendation to more clearly define overvoltage requirements.
Requirements for over voltages above 130%	We agree with the AEMO recommendation to more clearly define overvoltage requirements.
Clarification of continuous uninterrupted operation in the range 90% to 110% of normal voltage	APD supports AEMOs recommendation to make amendments to the definition for *continuous uninterrupted operation* in relation to NER S5.2.5.4(6). The steps proposed are a considered a welcome amendment to better clarify the expectations from Generators and will hopefully reduce the variance in standards and assessment methodologies used through the NEM. However, we would like to propose further aspects of this be considered. In our experience there has typically been a lot of debate around the required operating point and control modes that need to be used to assess *continuous uninterrupted operation* within the voltage range of 0.9pu and 1.1pu for this schedule. We would propose that the definition also include specification if the plant must be able to achieve these requirements under all control modes provided under NER Schedule S5.2.5.13 automatic access standard (b)(2A) or S5.2.5.13 minimum access standard (d)(2A), or only in specific control modes. It is proposed if assessment is needed in reactive power control mode, reassessment in power factor control may not be required. We would also propose AEMO also consider further amendments to the classification to clarify if fault response takeover controls should not be allowed to be triggered in the S5.2.5.1 operating region under some or all control modes. We propose this could be allowed if the response is demonstrated to have no change to active power output, and to provide more reactive power support to the network than if the takeover controls had not trigger. With the proposed updates to S5.2.5.1 capability curves, we anticipate this may also bring significantly more modelling studies due to an increase in operating points (corner points) that must be assessed to demonstrate compliance. It is recommended a guidance paper be produced to limit the potential increase in studies required for this update. Attention should be given to starting voltages and setpoints. In addition, the 5s ramp may be considered as too long for this assessment, we consider this should be limited to 1s or 2s for an automatic access standard and longer duration ramps may be applied for a minimum access standard.

NER S5.2.5.5 – Generating system response to disturbances following contingency events

Definition of end of a disturbance for multiple fault ride through	AEMO should consider some practical difficulties for MFRT compliance: (i) MFRT capability varies between the generator technology. Some technology types, due their inherent capabilities with well-designed control systems will be able to meet the MFRT requirements with ease. However, technologies like Type 3 wind turbines, even with optimum controller designs, when subjected to series of faults in short time frames will lead to the plant's mechanical failure (eg; overloading of gear-train drive). Hence while formulating rule amendments the inherent limitations of such plants should be accommodated.

Issue	Schedule 5.2 Generator Recommendation feedback
	(ii) While defining consecutive faults the plant's under voltage (UV) protection settings are to be considered. For example, consider two consecutive faults, the first with primary clearance time and the second a CBF with a total clearance time exceeding 500 ms. Some generators set their UV setting as 0.5 s due to various limitations of the plant. Under such circumstance meeting the consecutive MFRT will not be possible. (iii) The review has already considered the difficulty in defining MFRT fault sequence for assessments. The NER should provide more clarity on the fault sequences that will be acceptable to AEMO, NSP and the proponent. We understand this has been proposed and highly support this decision.
Form of multiple fault ride through clause	APD welcomes the suggested options 2 and 5. Even though best efforts to achieve AAS are to be made, this may not be possible to due to plant and network limitations. To handle such situations a suitable negotiation framework must be developed in the rules that will facilitate an efficient negotiation for a performances level between AAS and MAS.
Number of faults with 200 ms between them	APD agrees with the recommended option 2. However, when a technological limitation such a mechanical load limits are evidenced the rules should provide sufficient flexibility to negotiate the time gap between the faults for assessments.
Reduction of fault level below minimum level for which the plant has been tuned	APD requests AEMO to consider the following observations in regard to the recommended option 4 and 6: (i) The connecting NSP defines minimum and maximum fault levels (FL) at PoC. The minimum FL determined by the NSP is not corresponding to N system but to N-1 or sometimes N-2 conditions. The plant is assessed and remediated for this minimum FL prescribed by NSPs. In order to accommodate any fault level reduction during MFRT events and to make the plant operate satisfactorily under those network conditions will further burden the plants. (ii) It is not always possible to make the plant ride-through reduced MFRT FL conditions just by setting changes. It may require additional remediation to compensate the performance which will increase the cost of connection. (iii) Tuning a controller for the worst MFRT conditions may not guarantee satisfactory performance for normal FL ranges.
Active power recovery after a fault	APD accepts AEMO's recommended changes to align the active power recovery time with the voltage recovery. However, in many occasions it has been noted that the active power recovery is also interpreted as an requirement for MFRT faults. Since some technologies, like type 3 wind turbines, struggle to meet recovery time standards for subsequent faults due to mechanical loading limits and hence it would be good to clarify in the amended rule that the active power recovery time is applied for isolated faults only.
Rise time and settling time for reactive current injection	APD agrees with the recommendations. In the draft rule, the term 'adequately damped' has been replaced with 'adequately controlled'. APD understands the rationale for this update as described in the draft determination. However, APD sees this as an item for differences in opinion among AEMO, NSPs, OEMs and proponents in comparison to the previous term with a more prescriptive definition in the Glossary (Chapter 10 of the Rules). This new term will be part of the normal next, i.e. not italicized. This may lead into some form of ambiguity among stakeholders similar to the term 'maximum continuous current'. Therefore, APD strongly recommends the new rules should include a clear and concise definition of the term 'adequately controlled' in the Glossary.
Commencement of reactive current injection	APD agrees with the recommendations for large reticulation systems. A wider margin might be required between the Vpoc and Vterm for the commencement of the Iq response to accommodate the variations in Vpoc for different operating points, i.e. in voltage droop control. For example, for a plant with voltage droop control Vref=1.05pu and 12.7% droop on Pmax (5.16% on Qbase), Vpoc varies in the range of ~1.0-1.1pu. Assume the grid transformers' OLTC regulates the Vterm close to the 1.0pu all the time. In order to ensure the Iq response is started when Vpoc drops to 0.85pu under all operating scenarios, i.e. Qmax and Qmin, the generators need to start the Iq response when Vpoc drops by a step size in a range of 0.25pu (1.1->0.85pu) to 0.15pu (1.0->0.85pu). This means the LVRT threshold should be higher than 0.85pu. On the other hand, there is a requirement from some TNSPs on the CUO in response to the voltage disturbances (S5.2.5.4) as to the generating system must remain in CUO when Vpoc drops to 0.9pu under all operating scenarios. This means when the plant operates in Qmax (Vpoc= 1.0pu) a 0.1pu drop occurs and in Qmin (Vpoc= 1.1pu) a 0.2pu drop happen for 0.9pu disturbance. A corresponding voltage step at the terminals will result in 0.9pu and 0.8pu level which the later triggers LVRT. To streamline connections, a standardised assessment methodology in connection with reactive current injection commencement should be included to ensure that the industry applies a consistent approach for the assessing reactive current response. Other definitions could be used, but there would need to be a clear and unambiguous definition of all terms to avoid existing issues in the due diligence phase where there can be different interpretations on these performance aspects.

Issue	Schedule 5.2 Generator Recommendation feedback
Clarity on reactive current injection volume and location and consideration of unbalanced voltages	(i) No further comments
Metallic conducting path	APD agrees with the recommendations
Reclassified contingency events	The following observations are made: (i) Requiring compliance for a non-credible contingency classified as credible contingency will require further assessments to show compliances, this requirement for NSPs to specify given contingencies as credible should be made to be publicly available information available to all participants at commencement of a project. (ii) If AEMO's recommendations are accepted, NSPs must define the list of reclassed contingencies to be included in the assessments including the reclassed constrained operating conditions (such as reduced generation levels, reduced flow limits etc.,) for each reclassed contingency against which the plant is assessed.

NER S5.2.5.7 – Partial load rejection

Application of minimum generation to energy storage systems	APD agrees with the recommendations
Clarification of meaning of continuous uninterrupted operation for NER S5.2.5.7	Could AEMO provide further clarity on the opposition to angle jump and frequency change. Normally in a system where a significant amount of load has been lost, the angle and frequency will change (both are linked) and the generators react to these changes through their governing action. In addition to angle and frequency changes, there will be voltage deviations regulated by the voltage controls. Further clarity is requested on how the proposed rule change will impact the assessment requirements.

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

Emergency over-frequency response	APD makes following observations: (i) Option 2: It should be noted that some generators conform to Primary Frequency Response (PFR) requirements, but have exemptions from certain performance due to the limitations of their technology type. Any performance criteria considered in S5.2.5.8 that is based upon PFR conformity should also consider the agreed PFR performance or limitations in the technology. An example of how this would be worded might be "Subject to the agreed PFR performance, the generator provides proportional active power reduction etc.," (ii) Agree with other options 3,4, 5 and 6.

NER S5.2.5.10 – Protection to trip plant for unstable operation

Requirements for stability protection on asynchronous generating systems	APD's comments on the recommended Option 3 for AAS: (i) The option 3 recommendation does not cover synchronous generators. Generally, pole slip protection is used to trip the plant. However it should be noted that such protection devices can only operate once pole slip happens (plant becomes unstable). However, the present AAS states the protection must be capable of tripping plant when a condition that would lead to pole slipping. It is not known if such a protection is available and hence we recommend the present AAS should be amended to specify the plant be tripped when a pole slip condition is detected. (ii) The oscillation magnitude threshold for disconnection should be specified by the NSP. (iii) It is not clear if the PMU analysis results are to be shared with AEMO in real-time. APD agrees with MAS recommendations.

NER S5.2.5.13 – Voltage and reactive power control

Issue	Schedule 5.2 Generator Recommendation feedback
Voltage control at unit level and slow setpoint change	Voltage control at unit level is a good option, however the following points should be considered: (i) Unlike the synchronous plants, the IBR plants, such as wind farms, can be scattered over a wide area with a different network impedance to the connection point. To achieve a required voltage and reactive support at PoC, different reference voltages need to be applied at each terminal. (ii) Usually in steady state 33 kV reticulation buses will be operated close to 1 pu. The proposed voltage regulation scheme should consider the tap positions of transformers to ensure the desired outcome is achieved (iii) How to test the controller performance with multiple unidentical inverters? Will performance be assessed at each of the inverters and connection point? When a 5% step change is applied at each of the inverters, how shall the performance at POC be assessed as this response will differ for different plant?
Realignment of performance requirements to optimise power system performance over expected fault level (system impedance) range – Voltage control	AEMO recommendations for Options 3 and 7 are agreeable, however it is unclear if option 7 is allowing a GPS to go below a MAS level. It is proposed the impedances are not to be recorded in the GPS, as these may change over the life of the plant. It should be noted, any nearby dynamic reactive plant or generating systems (including asynchronous systems) may influence the response times in practice, so the ability to verify compliance in practice must be considered. It recommended that these requirements not be overly simplified to be based on fault level alone. Some NSPs require S5.2.5.13 assessed in PSSE NEM cases. To assess the settling time for maximum system impedance, does it mean the base case need to be tuned with a fault level at connection point exactly equal to the maximum system impedance provided by the NSP?
Materiality threshold on settling time error band and voltage settling time for reactive power and power factor setpoints	APD supports Option 2 and 3. However, the AEMO recommended Options 2 and 3 do not address the issue of the network disturbances on the settling time calculated signals. For example, a voltage step change test could trigger a nearby filter or reactor switching which leads to a secondary disturbance and subsequently longer settling time. Under such circumstances the study results with such secondary disturbances should be excluded from the settling time compliance assessments.
Clarification of when multiple modes of operation are required	Agree with the AEMO recommended option 2
Impact of a generating system on power system oscillation modes	Following comments are made in regard to the recommended Option 2: (i) Option 2 AAS requires the plant to have stabilisers that are capable of providing positive damping and is silent on the enablement of such device. (ii) The option is also silent on the acceptable level of positive damping by the stabiliser. (iii) Usually, the stabiliser will be designed to target a particular range of frequency where the damping will be effective. However the power system is expected to have both low frequency (from traditional plants) and high frequency (from IBRs) modes. To manage these extremes it will be a challenge for the POD design. Alternatively, it will be possible to have gain roll off above certain frequencies, however this approach may not meet the positive damping provision requirement. (iv) It is understood that in Option 2, NSPs will advise the mode frequencies over which positive damping is expected. Following the rule amendments AEMO's guidelines will be required on the assessment methodology for this clause. AEMO is requested to consider these practical issues while finalising on Option 2.
Definition – continuous uninterrupted operation	
Recognition of frequency response mode, inertial response and active power response to an angle jump	

Schedule 5.3a Conditions for connection of MNSPs

Issue	Schedule 5.3a HVDC Recommendation feedback
NER S5.3a.1a Introduction to the schedule	
Alignment of schedule with plant-type rather than registration category	
NER S5.3a.8 – Reactive power capability	
Reactive power	
NER S5.3a.13 – Market network service response to disturbances in the power system	
Voltage disturbances	
Frequency disturbances	
Fault ride through requirements	
NER S5.3a.4 – Monitoring and control requirements	
Remote monitoring and protection against instability	
New standards	
Voltage control	
Active power dispatch	

Multiple Schedules

Issue	Multiple schedule Recommendation feedback
NER Multiple clauses	
References to superseded standards	

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