Connections & Power Systems Advisory Pty Limited
hello@cpsadvisory.com.au
www.cpsadvisory.com.au
PO Box Q972
Queen Victoria Building
NSW 1230

24 August 2022

Australian Energy Market Operator (AEMO)
via email contact.connections@aemo.com.au

NER S5.2.5.10 Guideline Consultation

Dear AEMO,

Connections & Power Systems Advisory Pty Limited ("CPSA") welcomes the opportunity to provide a submission to S5.2.5.10 guideline development consultation process.

CPSA is an engineering consultancy firm with a focus on grid connection with a team that has over 5 GW of experience connecting generators and loads to the National Electricity Market. We have experience working with network businesses, the market operator, generators, load customers and hence a range of experience. We do not represent any particular industry group and our submission is based on ensuring there is a pragmatic approach to managing the power system and enabling an orderly transition of the energy sector.

Clause 5.2.5.10 of the NER was originally intended to apply to synchronous generators and the need to provide pole slip protection. Interim updates were made to the NER to include references to asynchronous generators and the Power System Stability Guidelines (PSSG) however we believe these gaps in the NER and the PSSG have not been fully addressed and should be the focus of change.

Our high-level comments are:

- The PSSG requires revision to provide clarity on the type of stabilities of concern and what type of protection systems required.
- Revisions to the PSSG should include a new classification of stability for "Converter Stability" which would cover the issues related to asynchronous generators.
- The need for ensuring the possible failure modes, types of converter instabilities and/or interactions are understood, including their frequency and magnitudes.
- The need to consider not only reactive power oscillations, but also active power oscillations.
- Interactions between plant can only be assessed at a system level and it is unlikely that we will be able to determine if a single generator is a source of interactions in real-time by monitoring the terminal quantities of that generator in isolation.

1. Opportunities and/or challenges that exist for implementing a suitable protection system to meet the S5.2.5.10 access level requirements, for example available technology and areas requiring further development.

Differentiating between a generator causing an oscillation versus responding to a network oscillation is not a trivial task. In theory it is possible to assess the phase angle relationship between reactive power and voltage, however in practice this is not a simple exercise as seen by the intermittent power system oscillations issues in the West Murray region[1] which are still unresolved.

Assessing the relationship between voltage and reactive power will not be a 'silver bullet' solution. In strong networks (where the generator is small relative to the rest of the network / other generators), the voltage changes for a given reactive power change would be very small (often undetectable from changes due to other devices on the power system). This methodology is reliant upon the generator being sufficiently large relative to the rest of the power systems to have a material impact on voltage. For example, a 200 MW project connecting to a system with a fault level of 7,000 MVA would only effect a voltage change of ~1.12 % of the nominal voltage at rated reactive power. This would be very difficult to differentiate from background variations in the voltage due to other plant. Consideration should instead be given to assessing the change in the plant output as a percentage of its rating (e.g., assess P changes as a percentage of its rated active power and Q changes a percentage of its rated Q).

Wider network oscillations and/or interactions requires investigation at the system level. The West Murray oscillations including the intermittent 19 Hz oscillations observed in April 2022 requires information from various parts of the network to assess the cause. Assessing an individual generator in isolation would not identify if a generator is responding to an external oscillation or the primary cause of the oscillation. A more effective option for assessing wide network interactions would be obtaining data (alarms or using a type of stability index) from individual generators and then creating alarms for AEMO and / or the NSP and then undertaking offline or real-time investigations / assessments to identify trends and patterns depending on which plant is in service.

Differentiating between power quality and stability issues. Some small oscillations are likely to present power quality issues rather than stability or security issues. Where there isn't a stability or security risk, action should be limited to alarming rather than tripping.

---

[1] https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/west-murray

2. Clarity of the S5.2.5.10 access standard requirements, including how unstable operation is defined, conditions that are considered unstable and how they are assessed in accordance with the Power System Stability Guidelines.

The Power System Stability Guidelines (PSSG) requires revision to account for asynchronous generators and 'converter instability'. Clause S5.2.5.10 of the NER was originally written to ensure the provision of pole slip protection for synchronous generators. This clause was then updated to include high level requirements for asynchronous generators with detail to subsequently be included in the PSSG. The PSSG was never updated however and should be updated to account for the converter driven instability. We understand that the intent of this consultation process is to clarify requirements for S5.2.5.10 of the NER, however we believe that the details of the particular instabilities should be covered in the PSSG and wording in the NER also clarified. A form of stability called "Converter Stability" should be included in the PSSG similar to that in the revised "Definition and Classification of Power System Stability"[2].

The importance of identifying the type of instabilities and/or interactions is paramount. Controller instabilities and /or interactions can result for various reasons. The oscillation frequency, magnitude and quantities affected depend on the particular failure mode and/or impact with adjacent plant. Some typical issues that could result in oscillations are presented below based on project experience.

- PPC interactions (a slower timeframe than inverter level interactions and generally balanced in response across the three phases)
- Fault Ride Through (FRT) retriggering due to poor coordination between PPC and inverter FRT thresholds
- Inverter PLL instability (where the PLL can no longer accurately track the voltage vector)
- Q control loop instability due to PPC to power meter or PPC to inverter comms loss
- P oscillations due to interactions between solar PV inverter MPPT controllers and Q controllers
- P oscillations due to blade imbalances in wind turbine generators

We understand that all the instabilities may not be able to be defined, however it is important that we understand what the possible failure scenarios are, the impact on the plant output that they will have and then design a scheme based on the expected output variations of the plant.

Specify measurements quantities and thresholds. The quantities to be measured, their pickup setting ranges and time delays should be defined to allow designers / solutions providers to design a scheme.

[2] https://ieeexplore.ieee.org/document/1318675/authors#authors

3. The approach to develop, agree, implement and commission a suitable protection system with the NSP and AEMO, including consideration of nearby plant and their interaction/contribution (desired or undesired) to unstable operation.

A phased roll out would be preferable. Having a phased role out starting with only an alarming function initially until confidence is gained on the scheme to ensure dependability, prior to undertaking any tripping or ramping down of the plant is paramount. The sequence for the roll out should be phased depending on the OEM for the solution and the technology it is applied to (e.g., wind, solar PV or BESS).

Importance of bench testing and injection testing on site. Once quantities to be measured and thresholds have been agreed upon, a bench test should be undertaken to confirm expected performance. This can be either based on a standard set of waveforms or project specific waveforms. Injection tests should be undertaken on site in the form of end-to-end testing to ensure the appropriate alarms (and tripping if appropriate) is implemented correctly as part of the commissioning phase of the project.

Detection methodology should not be limited to delta V vs delta Q. Reliance on this relationship only is often not practical when trying to detect wider network interactions. For wider network interactions, consideration should also be given to active power and reactive power changes as a percentage of the plant rating. Wider network interactions should only raise alarms to alert the network operator so that offline or real time assessments can be made as to what may be causing the oscillation.

Criteria to apply in assessing a suitable scheme. Key principles applied to protection schemes would be directly relevant to an instability detection scheme. They are as follow:

- *Selectivity* – the scheme should be selective and only isolate those inverters or groups of inverters that are causing the instability.
- *Sensitivity* – the scheme should be sufficiently sensitive to detect oscillations of the frequency and magnitude of interest based on the expected failure modes.
- *Secure* – the scheme should not operate for oscillations associated with normal operating conditions or following contingency or protected events.
- *Redundancy* – Redundancy requirements should be specified. It may not necessarily require duplication of schemes; however, it should be independent of the control devices and not rely on the same communications network that the control equipment relies upon.

We appreciate the opportunity to provide this submission and welcome the opportunity to discuss any of the afore mentioned in further detail with the AEMO.

For any further information, please contact Winodh Jayewardene at winodh.jayewardene@cpsadvisory.com.au.

Yours sincerely

Winodh Jayewardene
Managing Director