ESCO
Pacific

Dominic Adams
Australian Energy Market Commission
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Tuesday 7th November 2017

Dear Dominic,

National Electricity Amendment (Generator Technical Performance Standards) Rule 2017 (ERC0222)

ESCO Pacific (ESCO) is a leading Australian developer of utility scale solar farms with a proven track record of developing projects from early stage feasibility through to project commissioning. Our most recent project, the 116 MW Ross River Solar Farm, is currently under construction and we have more than 1,500 MW of projects currently in our pipeline.

ESCO welcomes the opportunity to provide comment on the rule change request and supports many of the proposed revisions. The generation mix in the NEM is changing more rapidly than at any time since its inception. The technical requirements in Chapter 5, which were originally based around the capabilities of synchronous generation, should be revised to ensure the maximum performance of asynchronous generation can be obtained in the most cost-effective manner, as required by the NEO.

AEMO's proposed rule change is timely and opens the conversation on how the NER's technical requirements can be improved to provide the maximum support to the system in a cost-effective manner at a time of rapidly changing generator characteristics. To continue the dialog, ESCO Pacific have raised several points on the proposed rule change and suggested changes where appropriate.

Proposed Revised Definition and Interpretation of Continuous Uninterrupted Operation

The new definition of Continuous Uninterrupted Operation (CUO), proposed in this rule change request, has in fact been required by AEMO for all new connections since late 2016 in advance of the approval of this rule change request being formalized in the NER.

The historical interpretation of CUO was to simply require that the generator did not trip during and after a disturbance. However, the new interpretation is that active power must be maintained at the same level during and after a disturbance, which is inconsistent with past practices and with AEMO's own documentation [4]. The retrospective application of this new definition on existing applications has been problematic, as discussed later in this letter.

This interpretation is different again to the wording in the rule change request, which states that active power should not vary to meet CUO, which could be interpreted such that active power output must remain unmoved for a three-phase fault at the generator connection point, which is clearly impossible for any type of generator.

The definition of CUO is crucial to the application of many of the technical standards, so it is disappointing that there was little discussion on the reason for the change in definition in the submitted rule change request.

The rationale for why a generator must maintain pre-contingent active power output for an event where the connection point voltage goes to 90% of the normal voltage indefinitely, and at any time, has not been made clear. ESCO Pacific is not aware of a precedent or a credible contingency for which the transmission or most distribution network voltages remain at 90% up for any significant length of time, barring the event being a precursor to a system collapse. Compounding this is the fact that power system elements are usually operated at voltages of around 102% to 105% of the normal voltage, so in practice the voltage drop that generators must withstand is 12% to 15%.

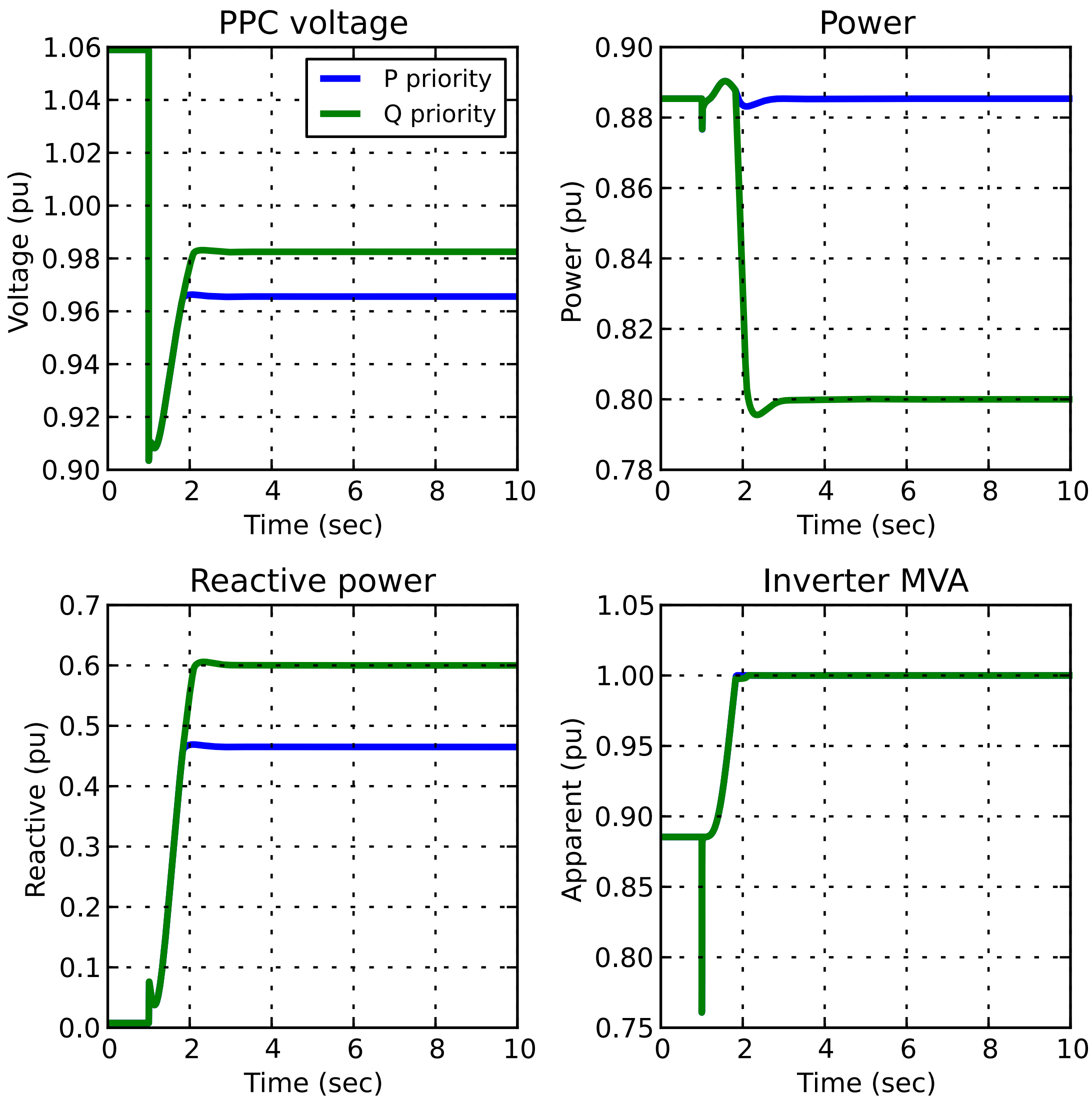

Figure 1: Comparison of responses where P can reduce to provide reactive power down to a power factor of 0.8 for a sustained remote voltage depression. In this case, the HV bus voltage is 2% higher when allowing the reduction in active power, but does not meet the definition of CUO.

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In terms of power system stability, this requirement to maintain active power comes at a cost of providing reactive power to the network, which is required to support network voltages. As such, it seems counterintuitive to restrict the provision of reactive power when the network voltages are low for the sake of preventing even a small reduction in active power output.

To demonstrate the impact of the new interpretation, Figure 1 above shows the response of two identical generating systems, one where the control system maintains active power output and the other where the controller will allow active power output to reduce to provide reactive power for voltage support. In the case where active power must be maintained the POC voltage is 2% lower than if the generator were able to reduce active power output to provide voltage support to the system.

Since frequency control is a system-wide issue and voltage control is a local issue, it does not make sense to limit the reactive power response of generator to a local voltage issue for the sake of a relatively small amount of active power which could be dispatched from elsewhere.

One response to this issue may be to suggest installing more inverters and larger transformers, but the fact remains that there is a finite amount of current which can be provided by any generating system and it should be apportioned as efficiently as possible to maintain power system stability whether it is voltage, frequency or transient stability. This is not the case with the new definition of CUO.

Finally, the new definition of CUO and its application in the proposed rules is extremely onerous, requiring a generating system to maintain full active power output when the connection point voltage is 70% for two seconds and 80% for ten seconds. Although AEMO have stated in the supplementary material that this is not the intention, the revised definition of CUO does not address this discrepancy.

ESCO suggest the following changes are made to the definition of CUO and the requirement under S5.2.5.4:

- The proposed changes to the minimum access standard for S5.2.5.1 are adopted to ensure new generators have some voltage control capability.
- The previous interpretation of CUO is retained and clearly defined in the NER
- For a voltage disturbance of less than 5% at the connection point from the "normal voltage" (being the voltage that the element normally operates at, distinct from the *nominal voltage* or the *normal voltage* as defined in the NER), active power should be maintained at the pre-disturbance power.
- For sustained voltage disturbances of more than 5% at the connection point, the generating system can reduce its active power output by up to 20% (or other suitable figure) to provide reactive power for voltage support during the disturbance.

ESCO agrees that the CUO definition should be revised so there is no ambiguity about what the NER requires. The current definition is unclear. However, ESCO considers the new definition proposed by AEMO could be substantially improved to maintain the integrity of the grid without imposing unnecessary costs on generators, and thereby electricity customers.

AEMO's proposed transitional arrangements

There are significant cost implications to immediately transitioning to a new set of rules regardless of the stage that a project has reached. This transition has severely impacted several projects which have already reached financial close or are under construction, and were then faced with the choice of either procuring additional plant or reducing their maximum power output to meet the new requirements. The specification, procurement and installation of additional plant causes construction delays resulting in delayed generation costing the generator significant revenue and potentially exposing them to Liquidated Damages under the terms of their Power Purchase Agreement. This cost of either new plant or reduced energy production was obviously unaccounted for prior to financial close and for a medium sized solar farm could easily be several million dollars.

In a hypothetical example given here, the new definition of CUO is applied to a solar farm which is already under construction and additional inverters are required to account for the derating at lower voltages as this was not accounted for in the initial design.

The most efficient method utilizing inverters is to ensure each inverter is evenly loaded with active power output to obtain the maximum reactive capability from the overall system, as shown in Figure 2 below. If a project is already under construction, it will then require significant rework and potential reconstruction of the solar farm reticulation network, inverter placement etc., resulting in delays in commissioning and potential liquidated damages as previously mentioned.

Retrospectively implementing a 'reinterpretation' of a definition, yet to be included in the NER, is contrary to the NEO. Imposing these requirements after projects have agreed GPS, signed connection agreements and/or achieved Financial Close is not efficient investment in or operation of the generating system and therefore is not in the long-term benefit to consumers. This is particularly true as the material benefit to power system security has yet to be substantiated.

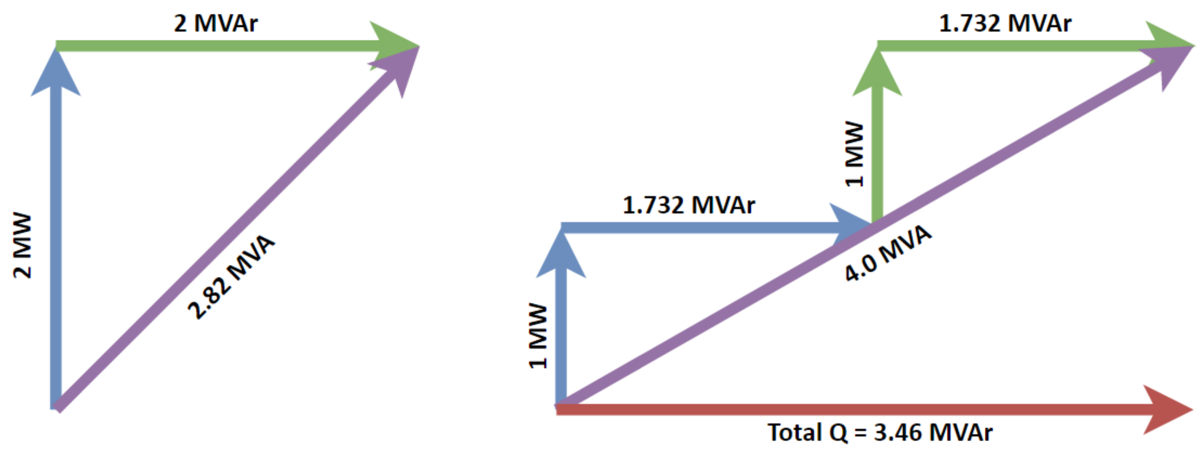


Figure 2: Reactive power capability of a generating system providing 2 MW with two 2.0 MVA inverters. On the left, one inverter (blue) provides 2 MW of active power, while the other (green) provides 2 MVAr of reactive power and the system has a reactive capability of only 2 MVAr. On the right, each inverter provides 1 MW, allowing 1.732 MVAr from each inverter for a total system capability of 3.46 MVAr with no additional primary plant.

ESCO Pacific recognizes that the solar industry is developing very quickly in Australia and by the time a rule change is finalized there could be significant amounts of generation built while a rule change is contemplated.

However, should AEMO consider that an immediate change to connection standards is required to maintain system security, then it should widely consult with the industry and explain and defend its rationale for the urgency of the change of requirements. After such consultation, it might be reasonable for earlier stage projects (those yet to undertake, or undertaking, grid connection studies) to be required to meet the new requirements in advance of an implemented rule change. Such consultation did not occur with the 'reinterpretation' of the CUO.

However, even in such urgent cases, projects that have agreed GPSs, achieved financial close or signed connection agreements must be exempted from any new requirements to avoid unacceptable sovereign risk. The additional costs and potential delays in generation cannot be retrospectively applied to generators after financial close and/or under construction. Besides the potentially significant detrimental impact on the economic viability of the particular project, it's likely that financial institutions will re-evaluate the risk margin appropriate for new generator in the NEM. This would increase financing costs resulting in higher electricity prices for businesses and residences - contrary to the NEO.

Issues with the current negotiating framework and reduction in system size thresholds

AEMO's comment that many connection applicants aim for a lower level of performance is generally true and could be construed as the economically rational decision when not considering the value of power system security (a "tragedy of the commons"). It is also a technically rational decision if the negotiated access standard does not result in decreased network reliability. There are a combination of factors which contribute to this, including the cost of meeting the automatic access standard and the lack of understanding about the needs of the power system.

However, ESCO has also found that in some cases AEMO and the NSPs will request the automatic access standard in the first instance for several clauses. Given the sheer number of wind and solar connection applications which have been made over the last two years, the insistence on the automatic standard is likely due to the administrative burden of negotiating with literally hundreds of proponents in a process which was designed for only a few connections per year.

In some cases, it may be that the requirement to meet a standard is well known within AEMO and the NSPs due to an incident elsewhere, yet they are unable to share it with the industry due to confidentially requirements. This creates the inefficient outcome of each proponent having to repeat the same lengthy process and work through the same problems to then reach the same conclusion as others who have come before them.

The cost of negotiating performance standards is in the order of hundreds of thousands of dollars per connection, especially if a consultant is engaged to carry out the technical studies. Given that the cost of negotiation is relatively fixed, the impact on systems less than 30 MW may be harder to bear. It will also place a significant burden on AEMO and the NSPs if all 5 MW systems must be negotiated, modelled and reviewed. The cost of consequential delay is difficult to estimate but could be significant if the delay stretches into months.

Mandating active power control

It has been recently documented that NEM frequency control mechanisms are not providing the optimal frequency control in the NEM, with AEMO documenting a significant degradation in mainland frequency control between 2013 and 2017 [1] [2]. As discussed in [3], the creation of the FCAS markets appears to have produced the perverse outcome that many synchronous generators have turned off their governors if not being paid to provide regulation FCAS, reducing the primary frequency control mechanisms of the power system and degrading the frequency regulation. As such, improving the overall frequency control of the NEM in the short term will require significant changes than can be captured in this rule change.

While it may be true that no asynchronous plant has yet participated in FCAS markets, this is likely because energy markets are almost always more valuable than FCAS markets and that because asynchronous generation is either semi-scheduled or non-scheduled it may not reliably provide energy to the FCAS markets. Therefore, it does not make sense for generators with zero marginal cost to forego their energy production and bid into frequency control markets, especially if they have committed their energy production to PPAs. Therefore, this requirement may not offer much value to the NEM if the objective is to promote competition in FCAS markets.

However, with the imminent introduction of large scale battery storage, frequency control will likely become far more accessible and to a considerable number of market participants, improving competition in FCAS markets. It would therefore be more efficient to encourage energy storage devices to be able to participate in FCAS markets rather than new generation.

Power System Modelling

A substantial portion of the negotiation of performance standards is centered around power system modelling. Since many of the performance standards cannot be confirmed by test, the accuracy of the power system models is essential in assessing network performance. The importance of this is reflected in the effort AEMO, NSPs and generators put in to model testing and validation.

There are a number of lessons learnt by ESCO relating to power system modelling in the context of the connection process which could certainly be improved resulting in more accurate studies, which are crucial to system security. It is impossible to model system performance if the models and modelling tools used are unsuitable for the task.

1. The models provided by inverter manufacturers are generally of a good quality, although sometimes issues with the models are found. As discussed in the previous section, AEMO and the NSPs have a good visibility with respect to the quality of these models as all connections go through them, but they do not feel they can request improvements in the models from the manufacturers where problems are identified. They may also not be able to share these lessons with proponents due to confidentiality. Conversely, customers such as ESCO can request improvements in

models and performance from the suppliers but do not have the same knowledge about the problems that AEMO and the NSPs have encountered, so many of the same issues and mistakes end up being repeated in subsequent connection processes.

2. The current standard modelling tool (PSS/E) uses a positive sequence RMS model of the power system. As the network is moving towards asynchronous / power electronic based generation, the positive sequence equivalent model is not always adequate to study compliance of a generating system and in many cases can give optimistic results (for example, persistent unbalanced faults where phase voltages are different cannot be assessed with PSSE).
3. Detailed EMT modelling of generating systems is performed in PSCAD. However, NEM wide models are not available in PSCAD so the interaction between nearby generating systems cannot be easily assessed. Even if such a model were available, the simulation time for even a short simulation could be many hours, resulting in days or weeks of processing time to consider all simulations needed for a connection study. As generating system models in PSSE cannot be easily translated into PSCAD, the use of another package creates the additional burden of maintaining a second software package.

Other products such as PowerFactory can perform unbalanced load flow, balanced RMS, unbalanced RMS and EMT in a single tool. However, despite the lower price and better capabilities of this package it is not commonly used in the NEM but is used by some NSPs NSW and Queensland. Models from PowerFactory and other packages are not accepted by AEMO unless a conversion fee is also paid. If significant resources are going to be allocated to developing NEM models in PSCAD (which has very limited compatibility with PSS/E), it would be more efficient to take this opportunity to move to an all-in-one tool, rather than working around the limitations of the incumbent tools.

It would be valuable to all participants if a process of information sharing could be established while also maintaining the required confidentiality. Such sharing would reduce the demand on NSPs and AEMO to answer repetitive questions and proponents would have access to the issues and resolutions found elsewhere, rather than having to reinvent the wheel with each new inverter type.

Assessment of Performance Standards

In many cases the review of a connection application and performance standards can vary between NSPs and AEMO, or even between individuals within an organization. In addition to the information sharing discussed at the end of the previous section, an updated guide to how performance standards should be assessed and tested would be tremendously valuable to the industry and would provide a starting point for performance standard assessment. AEMO have previously published such a document [4] which could be updated and revised periodically to include recent learnings with asynchronous plant and weak networks.

Other Changes to Technical Standards

ESCO have made several miscellaneous comments to the proposed rule in the attached PDF [SD1] which have come from prior experience in testing and commissioning many types of generators throughout the NEM. ESCO suggests that if changes are being made to Chapter 5 of the NER through this rule change request then it would be prudent to tidy up some other requirements and definitions in this chapter. Some of the more salient point in SD1 are discussed in more detail as follows.

S5.1a.4

The new performance standard that requires generators to ride through a connection point voltage of 1.4 pu 20 ms is likely to be too onerous, as the transformer ratio and network impedance between the connection point and the inverters can result in an inverter terminal voltage of more than 1.4 pu, which is beyond the capability of most inverters.

S5.2.5.1

ESCO strongly supports AEMO's view that the previous minimum standard for this clause was inadequate. All generators should be required to reactive power to the system and their proposal – where the minimum requirement is proportional to the requirements of the local system – is a good one. Since many parts of the network have at least one element controlling the local voltage (e.g. tap changers, shunts or dynamic reactive plant), determining what the actual requirement is for this clause and proving compliance may be difficult. For example, if a generator is to be connected to the same substation as a large SVC it must completely overpower the SVC before the voltage can be changed. Specifiying a ratio, as is done in the automatic standard, may be beneficial for the minimum access standard.

S5.2.5.3

The proposed requirement of +3Hz/sec for one second would result in a frequency of 53 Hz, which is higher than extreme frequency excursion tolerance limit. It is recommended that the ROCOF requirements are restricted to the absolute frequency limits.

S5.2.5.5

The requirement to ride through 15 credible contingency events (faults) in a five minute period does not make much sense. This many faults would surely be a precursor to a system collapse and as with the requirements under S5.2.5.4, the basis or precedent for requiring generators to ride through so many faults occurring in such a brief period is unknown.

It is not clear whether synchronous machines would be able to ride through this many faults without sustaining serious mechanical damage. As such, the minimum access standard appears to prevent any new synchronous generation connecting in the NEM.

Ignoring the resulting plant damage from the proposed requirements, if these 15 faults are applied at the right intervals it would be possible to make any synchronous machine become unstable and trip. Similarly, if they are applied 20 seconds apart then most synchronous generating systems would probably be able to remain stable. Therefore, this requirement is impossible to assess in any meaningful way.

Furthermore, the minimum access standard requirement of 15 faults with a total time of 1000 ms equates to an average fault length of 66.7 ms per fault, which is shorter than the shortest fault clearance time requirement in the NER.

Since these requirements are either impossible to occur, impossible to assess or impossible to comply with (or a combination of the three) and appear to have come from the SA system black event, a better approach would be to discard the proposed requirements and for AEMO to coordinate the fault ride through settings of generators in a particular area or region so if multiple faults are experienced there is not a common mode of failure among multiple generators, as was experienced in South Australia.

The minimum access standard requirement to provide 2% capacitive current for each 1% reduction in connection point voltage is not practical in weak networks as this can cause overvoltages within the generating system after the fault has cleared, or during the fault in the case of unbalanced faults. It is recommended that a minimum of 1% iq/dV is proposed, with a requirement that the largest practical value is used for the minimum expected fault level.

Calculating the rise and settling times of reactive current could be difficult if the requirements are in the tens of milliseconds. Measuring compliance could be even more difficult depending on how stable the local system is.

<u>S5.2.5.7</u>

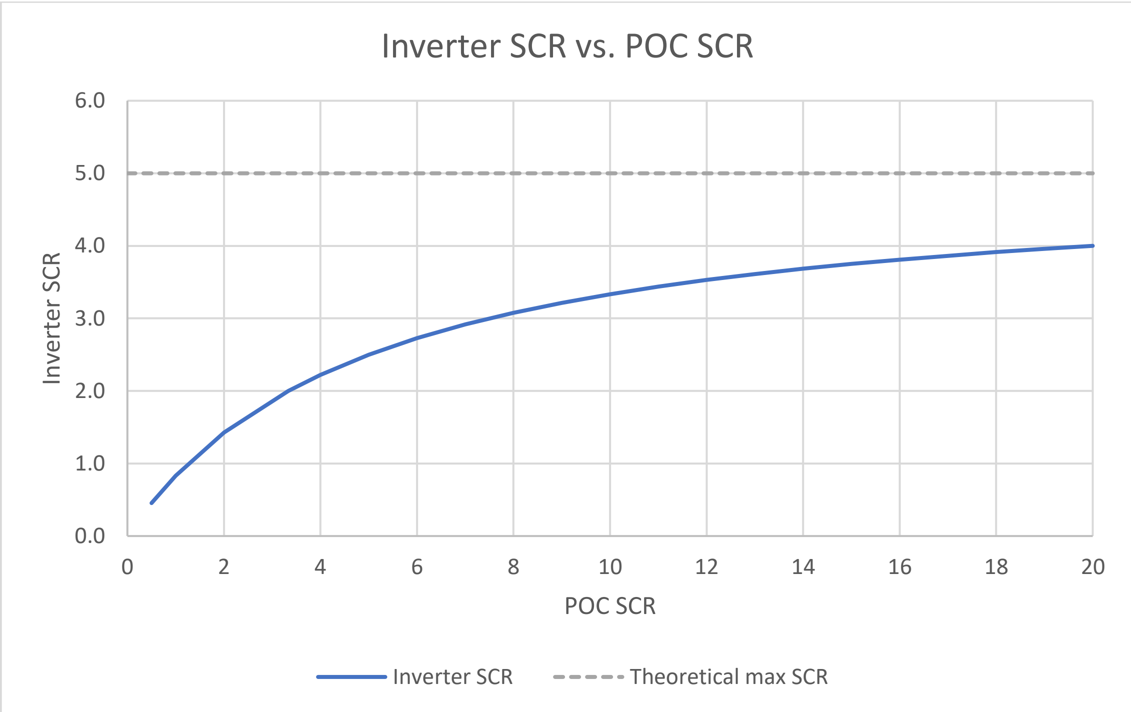
It does not make sense to expect a generator maintain its active power output (as required by the new definition of CUO) should the system load reduce by 30% of its initial level. Regardless, it has never been particularly clear what this clause seeks to achieve which is not already covered in other performance standards – mainly S5.2.5.3, S5.2.5.4 and S5.2.5.11. ESCO recommended that this performance standard is removed from the NER all together.

<u>S5.2.5.13</u>

The requirement to be able to adjust the voltage set point continuously in the range of +/-5% (or +/-2% in the minimum access standard) without the aid of a tap changer will be difficult when connecting to a strong system, as voltages within the generating system can become excessively high. It will also be difficult for synchronous machines to absorb enough reactive power to reduce network voltages, as synchronous machine can generally only absorb half they amount of reactive power that they can produce. ESCO suggest removing these requirements and being more specific in the requirements of S5.2.5.1.

<u>S5.2.5.15</u>

The proposed requirement of maintaining CUO down to an SCR of 3.0 at the connection point results in a SCR of less than 2.0 at the inverter terminals, which is not in line with the guaranteed performance of most commercially available inverters. As shown in the table below the SCR at the connection point should be about 3.5 to ensure an SCR of at least 2.0 at the inverter terminals.



In most cases the capability of an inverter to operate at low SCRs is determined by the tuning of the control systems. If the controller is tuned to get the optimum performance at a strong connection point, it will probably not meet the performance standards at a very weak connection point. Finally, as with some other proposed performance standards, it is not clear how this requirement will be assessed.

Summary

ESCO are pleased to offer these comments on the proposed rule change and are looking forward to continue being part of the process. We will contact you in the near future to request a meeting to further discuss our submission and answer any questions you might have.

Kind regards,

Patrick Rossiter

Grid Connections Manager, ESCO Pacific

Supporting Documents

SD1 – Proposed rule change with marked up comments

References

[1] Frequency Monitoring – Three Year Historical Trends (9 August 2017)
https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/2017-06-Frequency-Monitoring---Three-Year-Historical-Trends.pdf

[2] Frequency Monitoring – Three Year Historical Trends (23 December 2016)
https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/2016-10-Frequency-Monitoring----Three-Year-Historical-Trends.pdf

[3] Fast Frequency Service – Treating the symptom not the cause?
http://www.pacifichydro.com.au/files/2017/04/170302-Pacific-Hydro-Finkel-Review-Submission-Reference-Material.pdf

[4] Guidelines For Assessment Of Generator Proposed Performance Standards
https://www.aemo.com.au/-/media/Files/PDF/guidelines_for_assessment_of_generator_proposed_performance_standards.pdf