02 Feb 2023

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Submissions in response to consolation paper on efficient reactive current access standards - Draft Determination - ERC0272

I welcome this opportunity to make a submission to consultation on efficient reactive current access standards - Draft Determination.

The draft rule is highly aligned with AEMC the system strength framework rule change in the National Electricity Rules (NER), which coordinates the supply and demand sides of the system strength framework [1].

Under system strength framework, on the supply side, the minimum fault level specified by AEMO for system strength nodes under clause S5.1.14 ensures the necessary levels of system strength for effective operation of network and generator protection equipment and the efficient level of system strength for IBR connection and operation (hosting capacity and constraint alleviation).

On the demand side, the minimum access standards for relevant generators, loads and market network service providers (MNSPs) requires relevant plant to remain connected and operate stably at a short circuit ratio (SCR) of 3.0 for voltage phase angle shift limits less than 20 degrees at the connection point [2] under clause S5.2.5.15 and S5.2.5.16.

In the draft determination, clauses S5.2.5.5 has been amended to prescribe more suitable reactive current response and active power recovery response for IBRs at different stages of fault event including entering fault, during fault and exiting fault which facilities IBRs to fulfil clause S5.2.5.15 and S5.2.5.16 especially in low system strength parts of the power system.

With the enforcement of the draft determination, I strongly believe that it will lower the cost of renewable generator connections and facilitate faster negotiation of connection agreements between project developers, NSPs and AEMO as stated in the draft determination.

In this response letter, I would like to discuss further on two topics. Firstly, how the new definition of continuous uninterrupted operation (CUO) will affect the Assessment Methodology in section 3.3.2 in [3]. It is very important to clarify assessment methodology for CUO as fulfilment of CUO normally requires **additional 10-15%** (of the installed plant capacity) reactive power equipment installation. Secondly, how to address the potential retriggering issue and resultant instability issues [4] in the existing power plants which have been designed to fulfil present clause 5.2.5.5.

1. Further Clarification on CUO Assessment Methodology

The draft determination has provided clarifications on the definition of CUO. The definition of continuous uninterrupted operation has been updated as' not exacerbating or prolonging the disturbance such that it would result in a subsequent disturbance for other generating systems, except as required or permitted by its performance standards'. This is a big amendment among the other changes as the previous CUO requirement which has been clarified in [3] normally requires **additional 10-15%** (of the installed plant capacity) reactive power equipment to be installed to fulfil. However, how the definition will affect CUO assessment methodology has not been fully clarified.

To obtain transparent and straightforward communication and avoid over-design of the power plants due to CUO assessment methodology specified in [3] it would be great for the OEMs and developers if Ref [3] could be updated according to the new definition of the CUO.

I hope this request can be passed to AEMO, the owner of Ref [3].

2. Correction plan for the existing power plants

In [5], it has been clearly explained 'what can happen when there is too much reactive current injection?' and how the effect of the fast active power recovery on the voltage profile and voltage stability. However, many old power plants which have been designed according to previous Clause 5.2.5.5 has potential risks to suffer retriggering with a high K factor, voltage depression with fast active power recovery etc. The problems will become prominent with increasing renewable energy penetration.

Should any plan be made to re-tune the power plants according to the coming Clause 5.2.5.5?

A possible option has been proposed in [6] as follow.

In [6], it has been highlighted the potential instability during the full impact assessment (FIA) for new plant connection process caused by existing plants which has been previously tuned to fulfil old Clause 5.2.5.5 but connected grid becomes weak due to increased penetration. I have included my suggestion to in response to System Strength Instruments Issues Paper as below.

Q39 Are there any other issues relevant to the Stability Assessment methodology that AEMO ought to take into account?

Under the Amending Rule, for Applicants who elect to pay the system strength charge, the Connecting NSP will need to carry out a Stability Assessment using a methodology to be set out in the SSIAG.

Like the Full Assessment, a Stability Assessment would be performed via EMT modelling for a range of disturbances, however, it is reduced in the observability of variables (observation of system voltages at key system nodes). This approach is considered to be aligned with the requirement to ensure stable voltage waveform in a steady state as well as following the contingency, but not during the event.

If the voltage waveform stability is not satisfactory and SSSP fails to adjust its plans to stabilise the voltage, the identified issues will therefore need to be addressed either by the Applicant (where associated with its own plant configuration), or by operational arrangements that will apply unless (and until) sufficient system strength services are available.

In my opinion, there might be worth to perform full impact assessment (FIA) for further investigation if the SSSP fails to achieve satisfactory voltage waveform stability upon completion of stability assessment. The reasons are listed as below:

Firstly, the new connecting generator has obligation to fulfil amending rule S5.2.5.15 and S5.2.5.16 with which it can remain connected and operate stably at a short circuit ratio (SCR) of 3.0 for voltage phase angle shift limits less than 20 degrees at the connection point. It is expected that new connecting has superior SCR/phase shift withstand capability compared to some of or most of the existing generators. Therefore, it has less tendency to initiate unstable control interaction (inverter instability) or cause oscillatory voltage following the contingency. As a result, the instability cannot be easily addressed by tuning of the new connecting generator or its re-configuration.

Secondly, integrating new connecting generator (let limiting the discussion with grid following type based IBRs) in general reduces the SCR (by any SCR definition) seen from the committed generators under the same system strength node. If one or some of the existing generators could not withstand reduced SCR, it might exhibit oscillatory behaviour in the system strength nodes as shown in Figure.3[1]. The above-mentioned existing generator(s) are the root cause of the instability.

Measures could be taken to identify these generators having less low SCR withstand capability and control improvement and control parameters re-tuning can be carried out to reduce the demanded system strength level for maintaining the voltage waveform stability for the area. This will be beneficial for the future new connecting generators in the area as well.

Thirdly, the NER S5.2.5.5 has very demanding requirement for reactive current injection during fault and active power recovering post fault in the AAS. The high reactive current injection has the potential to cause instability due to hunting or retriggering of the LVRT control logic especially during shallow fault and furthermore could cause issues with the generating unit's ability to detect fault clearance locally by sensing the restoration of voltages.[2]

Further, projects which have fulfilled AAS with grid following type IBRs has difficult in operating stably under reduced or low SCR conditions. This is because when voltage has been cleared by protection e.g., removing one of faulted transmission line, the active power increases rapidly and flow on larger impedance of the circuit which will drive voltage down again and cause a further voltage dip.

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[1] Amendments to AEMO instruments for Efficient management of system strength rule pg43.

[2] NATIONAL ELECTRICITY RULE CHANGE PROPOSAL, Reactive current response to disturbances (clause S5.2.5.5), GE International Inc, Gold wind Australia, Siemens Gamesa Renewable Energy and Vestas Australia

The large amount of reactive current injection will drive IBRs voltage high and thus out of fault again. The retriggering FRT has the potential to cause instability as well.

The exiting generators fulfilling S5.2.5.5 have potential to cause instability following contingency. Therefore, it is good to investigate the voltage waveforms for these generators to determine whether they are the troublemakers.

Fourthly, based on previously experience with FIA, there were many occasions that the tunings have been required for SVCs or system level coordination of voltage and reactive power control in a large area.

It is recommended that the above-mentioned three possible instability contributors (or more) should be considered with FIA to determine root cause of voltage waveform stability and reduce the demanded system strength level for the given system strength node. I understand tremendously endeavour is needed to remove these bottlenecks of voltage waveform instability. However, if it is not being addressed carefully at the initial stage of evolving do no harm obligation to system strength framework, they could always be root cause of voltage waveform instability in many new connecting generator stability assessments. The resulting voltage waveform instability cannot be remediated by new connecting generator self-tuning. As a result, there is tendency that the new connecting generator will need to pay system strength remediation (SSR) in addition to system strength service (SSS).

This is contradicted with the aims of evolving do no harm obligation to system strength framework which is aimed for more effective use of system strength services and sharing the associated costs more efficiently between consumers and connecting parties

On the other hand, if FIA has been performed where stability assessment fails, it has potential to reduce the need of the efficient level of system strength for the future connecting IBRs stable operation by improving the existing generators withstand capability of low SCR grid and better system level coordination of voltage & reactive power control strategy / proper tuning of SVCs etc. Together with the enforcement of new minimum access standards, less voltage waveform stability is expected to see in the future and less efficient level of system strength is expected to be needed for stably operating of IBRs during steady state and following contingency.

3. Reference

[1] System strength final determination, pg94.

[2] National Electricity Amendment (Efficient management of system strength on the power system) Rule 2021 No. 11

[3] Australian Energy Market Operator, Clarification of generator technical performance requirements (S5.2.5)

[4] 220623 Bo Yin - ERC0272.pdf Submissions in response to consolation paper on efficient reactive current access standards for inverter-based resources.

[5] Efficient reactive current access standards - Draft Determination - ERC0272

[6] yin-bo.pdf (aemo.com.au) Submission in response to System Strength Instruments Issues Paper