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Calculating system strength quantities in the NEM

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This document sets out a proposed methodology for calculating the 'system strength quantity' (SSQ) for a relevant NEM connection that, in AEMO's view, best aligns with the intended outcomes expressed in the final determination of the *National Electricity Amendment (Efficient management of system strength on the power system) Rule 2021.*

While AEMO has taken reasonable care in the preparation of this document, it should not be construed as legal or technical advice, and assumes a reasonable technical understanding and familiarity with the subject. This document reflects AEMO's views as at the 'last updated' date in the heading.

AEMO has informed the AER of the proposed SSQ calculation methodology discussed in this document, as it is not consistent with the SSQ formula as drafted in clause 6A.23.5 of the National Electricity Rules (NER). Connecting NSPs are encouraged to consider using the proposed methodology to reflect the rules' intent and engage with the AER directly on any compliance concerns they may have.

Issue statement

Background

This document builds on a position presented by AEMO in its 2023 consultation draft report on amendments to the System Strength Impact Assessment Guidelines (SSIAG)[1], to implement the 2021 rule. The SSIAG prescribe a methodology for the calculation of the reduction in available fault level (ΔAFL) resulting from a connection, used in determining the general system strength impact to be self-remediated by an applicant – should it choose to do so rather than paying a system strength charge towards centralised system strength services.

The system strength charge (SSC) comprises three components, one of which is the SSQ. Unlike ΔAFL, the SSQ formula is prescribed in the NER itself, not the SSIAG.

Intended representation of SSQ

The intent of the final rule, as expressed in the AEMC's final determination[2], was for the value of SSQ for a new connection to represent the estimated system strength it would consume, equating to the general system strength impact that would otherwise require remediation:

> "this 'quantity' [SSQ] is an estimate of the consumption of system strength" (p.133).
>
> "[the] magnitude of general system strength impact that [the connection applicant] would need to remediate … is equivalent to the SSQ" (p.153).

AEMO identified that applying the SSQ formula in the NER, without adjustment, could significantly overstate the quantity of system strength required to support each connection. Overstating the estimated system strength need affects both planning for the overall amount of system strength service procured, and the system strength charge for connecting parties.

[1] AEMO, Amendments to the System Strength Impact Assessment Guidelines Draft Report and Determination, 12 January 2023, page 25 and Appendix C: https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/notice-of-consultation-and-draft-determination.pdf

[2] AEMC, Efficient management of system strength on the power system, Rule determination, 21 October 2021: https://www.aemc.gov.au/sites/default/files/2021-10/ERC0300%20-%20Final%20determination_for%20publication.pdf

NER definition of SSQ

NER 6A.23.5(j) defines the SSQ for a connection point as the product of:

(1) the *short circuit ratio*; and

(2) the *rated active power*, rated *power transfer capability* or *maximum demand* for the *system strength connection point.*

each as agreed in accordance with clause S5.2.5.15, clause S5.3.11 or clause S5.3a.7 (as applicable) and recorded in the relevant *performance standards* for the *plant connected* at the [*connection point*].

The underlined text indicates that, for SSQ purposes, the short circuit ratio (SCR) is the minimum SCR at which the relevant plant can operate stably and remain connected (referred to as the 'Withstand SCR'), and not the *short circuit ratio* as defined in NER Chapter 10 (representing actual SCR at a connection point).

Proposed Withstand SCR adjustment

The use of Withstand SCR alone to determine the SSQ recognises the plant's capability to operate in low SCR conditions, but cannot account for fundamental stability limits and non-linearities governing the maximum power transfer and voltage stability between two transfer buses, which are the responsibility of the connecting NSP and not within the design responsibility of the connecting party.

To appropriately recognise system limitations, AEMO considers that the calculation of SSQ should be adjusted by applying a stability coefficient. This is an approximate value providing a representation of minimum factors, such as power transfer and voltage stability limitations, below which recent studies indicate voltage instability is likely to occur without any additional system strength or reactive power support[3,4]. A constant value of 1.2 is assumed for this coefficient. The same value is applied under the SSIAG in determining the reduction in available fault levels caused by a connection.

The adjustment yields a formula for SSQ of:

$$SSQ = (\mathrm{SCR}_{\mathrm{withstand}} - 1.2) \times \mathrm{P}_{\mathrm{rated}}$$

Applying this coefficient will equate the SSQ for a connection with its ΔAFL. To avoid any potential inconsistency, AEMO proposes to make a minor amendment to the ΔAFL formula in the SSIAG, in order to remove the direct reference to SSQ.

Following publication of this document, AEMO will commence a rule change proposal to the AEMC, to align the SSQ with the proposed methodology. AEMO will then allow a period of time to observe the operation of the new system strength framework before considering a more comprehensive rule change to address the full range of operational issues identified by the industry.

Where can I find more information?

Questions about system strength impact assessments and SSQ calculations for specific connection projects should be addressed to the connecting Network Service Provider.

For general enquiries, please contact AEMO's Information and Support Hub via:

supporthub@aemo.com.au or call 1300 236 600

[3] B. Badrzadeh, Z. Emin, S. Goyal, S. Grogan, A. Haddadi, A. Haley, A. Louis, T. Lund, J. Matevosyan, T. Morton, D. Premm, S. Sproul, ''System Strength'', CIGRE Science and Engineering Journal, Vol. 21, February 2021.

[4] T. Lund, H. Wu, H. Soltani, J. G. Nielsen, G. K. Andersen and X. Wang, "Operating Wind Power Plants Under Weak Grid Conditions Considering Voltage Stability Constraints," in IEEE Transactions on Power Electronics, vol. 37, no. 12, pp. 15482-15492, Dec. 2022.