windlab

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Australian Energy Market Commission
Lodged via: https://www.aemc.gov.au/rule-changes/efficient-reactive-current-access-standards-inverter-based-resources

Re: ERC0272 Efficient Reactive Current Access Standards for Inverter-Based Resources

Windlab welcomes the opportunity to provide a submission on the AEMC's consultation paper for the proposed *ERC-0272 Efficient Reactive Current Access Standards for Inverter-Based Resources* rule change which was released on 26th May 2022.

This submission focuses on four key topics:

1. Windlab discusses the requirements of reactive current injection into a fault and proposes only ONE of two alternatives is required:
    - Minimum access standard is reduced to 0.5% and is moved to the *generating unit terminals; OR*
    - Minimum access standard is reduced to 0% and remains at the *point of connection*
2. Windlab proposes the removal of *reactive current settling time* as a redundant and ultimately arbitrary requirement which has little technical benefit
3. Windlab proposes that the *reactive current rise time* requirement is changed through one of the following:
    - Remains at 40ms, but is moved to the *generating unit terminals* and only begins counting once voltage at the terminals crosses the detection threshold; OR
    - Increased to 70ms if assessed at the *point of connection* as proposed by the wind turbine OEMs
4. A discussion on the compatibility with the *Efficient management of system strength frameworks* rule change.

The proposed changes should:

- Reduce stranded asset risk and reduce total cost of electricity supply for consumers;
- Accelerate investment in renewable energy by reducing costs, making more projects commercially viable and reducing the amount of issues identified through the grid connection process;
- Have no degradation in technical performance (as it is a *minimum access standard* and TNSPs can still request more to meet whatever the system requirements are);
- Reduce voltage stability problems; and
- Be compatible with the intention and philosophy of the *ERC0300 efficient management of system strength on the power system* rule change which was introduced 21st October 2022

The following sections will deep dive into each of these topics.

Reactive Current Injection Support During Fault *Minimum Access Standard*

In assessing this proposal, it is worth reviewing the technical fundamentals behind the behaviour associated with this clause:

- A synchronous machine acts as a voltage source and has an inherent, electromagnetic response to voltage deviation (such as that of a fault) by injecting high amounts of reactive current to support its voltage *at its terminals*. Due to the history of the NEM, the transmission has been built to the location of synchronous machine, so the *point of connection* is near the *generating unit terminals* of each unit.
- Inverter based generators generally can be considered to act as a current source in normal operation, however when voltages fall below certain thresholds, they switch into a “low voltage ride through mode” (LVRT mode) which is a fast voltage control mode that replicates the behaviour of synchronous machines by injecting reactive current based on voltage at their terminals. Where the performance differs is that a typical *generating system* may involve many *generating units* and that this occurs at multiple control points across the *generating system* based on the voltage at each unit.
- At a system level, the benefit of this behaviour is that during a fault, the *generating units* will support both system voltages across the network and promote voltage stability (ie, avoiding oscillations or swinging transient behaviour)
- Another important note is that the amount of current provided by a synchronous machine is based on the impedance in front of it. Most faults tend to have a high X/R ratio (due to mostly transmission lines and transformers being in between the fault and the *generating unit* terminals) and hence the current provided is reactive. However, if the fault had a high resistive component, then the response would be largely active current. Furthermore, when residual voltage are close to zero – the entire concept of reactive or active current (which are derived quantities) disappear – it is just “current” – and cannot be assessed.

The current *minimum access standard* of 2% reactive current injection is at risk of stranded assets (through the procurement of STATCOMs or synchronous condensers where they may not be required to meet system performance), higher cost of energy (by making some projects unviable due to the extra cost of additional plant) and poorer performance (increased risk of transient voltage stability issues and less frequency support).

It should be emphasized that the parameter being changed is the **minimum access standard only.** Under the negotiation framework, **the TNSP still has the ability to ensure the optimal solution is found to meet system performance requirements of the local network** and ask any level up to the *automatic access standard***.** As such, **reducing this minimum access standard should have no detrimental effect to system performance at all –** all it will do is shift the engineering responsibility from the AEMC to the TNSP (who already have the responsibility to protect voltage stability).

Windlab believe that there are two ways this can be done:

1. **Option A - The rules should be changed to define this requirement at the *generating unit terminals*, in which case a *minimum access standard* of 0.5% is appropriate**

    a) This change would **most accurately reflect the *actual* technical requirement for grid stability** – that inverters must try to support and control their voltages *at their terminals*, based on their *terminal voltage* – and as a result successful voltage support, their terminal voltages *will* be relatively higher than the *point of connection*

    b) **The *minimum access standard* of 0.5%** is proposed to be set to accommodate weak grids where **higher LVRT k-factor settings may result in large voltage spikes on fault recovery**, **result in over-voltages on the un-faulted phases** (for single phase or two phase faults) or alternative *generating systems* with **synchronous condensers, STATCOMs or other plant which may provide substantial reactive current already**, in which case a lower setting at the *generating unit terminals* may be optimal. However, it should be emphasized that this would only be the *minimum access standard,* and in most scenarios, it would be expected that higher *negotiated access standards* or *automatic access standards* will be selected unless the generator can justify a lower standard on technical performance (trade off) or economic grounds (where grid performance is still adequate)

    c) **Easy to assess, tune and validate compliance to** – this requirement would be directly reflected in the inverter low-voltage ride-through gains (LVRT k-factors) parameters – this avoids extensive and complex PSCAD simulations being required at "every possible operating point for every possible fault" to validate that the proposed *performance standard* is met, of which PSCAD modelling isn't even always accurate (due to simplified assumptions like aggregation of inverters and lack of accurate transformer saturation models)

    d) **Compliance monitoring -** The AEMC has implied that assessing compliance to this would require high speed power quality metering on every inverter, but this would not be required. Compliance can be assessed on a **"type testing" basis through power quality meters being installed on the closest/furthest inverter in each "collector group"** – this aligns to the current process for other performance standards applying at *generating unit terminals* such as S5.2.5.8. Inverters with identical design, identical FAT testing and identical settings will behave identically at their terminals, so type testing should be adequate for compliance monitoring and assessment. Alternatively, compliance assessment can be undertaken through **PSCAD model overlays at the *point of connection*** – the PSCAD model can be used to validate the performance at the terminals, then assess the contributions at the *point of connection* and compared to site measurements at the *point of connection* – identical results would imply that the *generating units* are doing what they are supposed to do.

e) Moving this to the *generating unit terminals* would **mitigate the risk to grid stability posed by high frequency oscillations caused by "LVRT re-triggering"** which are often introduced due to needing to tune "harsh step changes of current" when transitioning into low voltage ride through (LVRT) mode to achieve certain requirements at the *point of connection* (ie, a common low-voltage ride through (LVRT) mode Iq injection is calculated by *Iq = Iq_prefault + k * (a – V_terminal)*, where *Iq* is the reactive current, *V_terminal* is the terminal voltage and *k*/*a* are parameters, the best stability is achieved by setting the "*a*" parameter to be equal to the LVRT entry threshold allowing smooth increase in current when transitioning into the LVRT mode, but under current rules "*a*" must often be set a lot higher than the entry threshold, risking "LVRT re-triggering" due to step changes in current output)

2. **Option B -** As an alternative to Option A, if the AEMC determine that the requirement must be at the *point of connection* **- revise the *minimum access standard* of reactive current injection that generators need to provide at the *point of connection* from 2% to 0%**

   a) The drawbacks of defining the access standard at the *point of connection* are numerous:

      - Promotes inverters to artificially reduce their *active current injection* during shallow faults to reduce the related *reactive current losses* across the reticulation systems, posing a risk to frequency support

         - **Important Note:** The AEMC's consultation paper references the "100ms active power recovery requirement" after the fault, but the issue is more about active current injection *during* the fault, where the residual voltage may be relatively high (eg, a shallow fault where voltage only drops to 0.7pu)

      - Promotes aggressive tuning of "a-factors" and "k-factors" to allow the inverters to achieve current injection requirements remote to their termianls that pose a risk to voltage stability (discussed above)

      - Force the installation of STATCOMs or synchronous condensers at the *point of connection* for generating systems with long transmission lines or large reticulation networks, whether the TNSPs actually need them or not (eg, due to other voltage support already being available on the network)

      - Risks over-voltages on the healthy phases (un-faulted phases) where many inverters do not have the capability to limit current injection only onto the faulted phase

- Risks instability where multiple generating systems are connecting to the same connection point and are tuned on the limits of stability to achieve this requirement

b) **However, if the access standard must be defined at the *point of connection* it is critical to reduce the *minimum access standard* to 0%**

- The TNSP will still have the ability to require up to 4% as required by the actual grid requirements in the area - this will empower the TNSP to achieve more optimal voltage stability outcomes based on actual local voltage dynamics
- More reactive current isn't always better, and the negotiation framework must be leveraged to ensure a "one size fits all" approach is not being taken that ignores the complex and local grid-dynamics
- The PSCAD wide area assessment process undertaken by the TNSP as part of the grid connection process will identify if local voltage support issues during fault are an issue in the local area and if needed, a higher negotiated access standard can be requested.
- It will allow the TNSP to make a call between the complex trade-off between:
    - Reactive current (voltage) support on the faulted phase
    - Avoiding over-voltages on the unfaulted phases
    - Active current (frequency) support
    - Transient voltage stability during and immediately after the fault
- Avoids stranded asset risk of expensive STATCOMs or synchronous condensers being installed where they are not needed

Settling Time

Windlab strongly believe that the requirement for *settling time* does not achieve any actual benefit for technical performance, but does provide an arbitrary requirement which can be tricky to deal with. **Windlab propose the settling time requirement be entirely removed from Clause S5.2.5.5.**

The ***rise time*** **plays an important role in ensuring a fast enough response** from the inverters to support the fault and is an important technical characteristic to define. Similarly, the ***adequately damped response*** **requirement ensures that the response is stable and does not oscillate**.

The *settling time* on the other hand is a duplicate of *adequately damped response* in ensuring that the response settles, however it also has the unintended consequence of providing requirements on avoiding a "tapered" response.

A "tapered" response may result due to the following scenario:

1. The fault occurs and voltage at the terminals drops to a lower value

2. The inverter enters "LVRT" mode and is tuned to rapidly increase its current to meet the "rise time" requirement

3. This, along with other responses from other generators cause the voltage to rise

4. The higher voltage means that the LVRT calculation is actually injecting more Iq than is strictly required. To avoid instability however, the inverter may be tuned to have a "filtered", "delayed" or "ramped" decrease in reactive current to the increase in voltage which "decays" the reactive current over a longer time

5. The overall result is a fast reactive current rise time that might occur within 40ms of detection to its peak value, followed by a slowly decaying, but stable reactive current that tapers over a period of up to 1000ms

This response is desirable – a fast response to the fault to support the voltage, followed by a response that actually *exceeds* the requirement of the GPS in terms of reactive current injection that remains stable and adequately damped. However, due to the tapered response which results in a higher reactive current injection than required, it means the settling time may exceed 1000ms despite being a technically desirable response and would be assessed as non-compliant.

Rise time

Windlab propose one of the following:

1. **Option A) Rise time to be increased from 40ms to 70ms, as proposed by the wind turbine OEMs; or**

2. **Option B) Rise time to remain at 40ms, however assessment to be at the *generating unit terminals* and be calculated from the point of detection, rather than fault inception.**

The S5.2.5.5 reactive current rise time requirement of 40ms is generally achievable when assessed at the *generating unit terminals* from when the voltage falls below the LVRT threshold and the inverter activates its fault response..

However, the challenge with this clause is that **when the voltage at the *connection point* falls, it falls at a slower rate at the *generating unit terminals***. This means that the voltage at the terminals may only fall below the LVRT thresholds anywhere from **10-30ms** after it occurs at the *point of connection*. For instance, a step change response in voltage at the *connection point* may appear as a ramped response at the *generating unit terminals.* This doesn't leave adequate *rise time* for the response from the inverter.

Compatibility with the Efficient Management of System Strength Rule Change

The consultation paper did touch on a very important issue, which is compatibility with the recent *efficient management of system strength rule change*. The stranded asset risk the incompatibility of that the existing S5.2.5.5 rules and the new system strength rule presents cannot be underestimated.

- The new system strength framework envisages scale-efficient procurement of system strength plant (such as synchronous condensers) by the TNSP that may provide system strength to multiple *generating systems* in a local network. The *generating systems* would then pay for this investment via a system strength charge.
- System strength and voltage support for faults are closely linked as technical concepts (for synchronous machines and grid-forming inverters they are almost one in the same) and a synchronous condenser will provide more than enough reactive current during fault to support local grid-voltages in a part of the network
- However, under current rules, the *reactive current injection during fault* requirements of S5.2.5.5 must be provided from behind the *point of connection* and cannot be procured elsewhere. Large *generating systems* may need to install reactive support plant to achieve this performance standard.
- Connecting generators that are forced to install reactive plant to meet the *reactive current injection requirement* would most likely opt to install their own synchronous condenser to self-remediate for system strength and not pay the *system strength charge*
- This will result in TNSPs investing in system strength plant and being unable to recoup these costs from generators, which will instead by passed to consumers

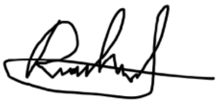
Similar situations have played out on projects under existing frameworks, where a *generating system* has found itself short of system strength and reactive power capability under Clause S5.2.5.1. The TNSP has offered to procure a scale efficient solution and charge services to the *generating system* to remediate as is permitted under the rules. However, the *generating system* identifies that it is non-compliant to S5.2.5.5 and needs plant behind the *connection point* to meet the requirements and hence opts instead to install its own synchronous condenser instead of procuring services from the TNSP.

Conclusion

Windlab hopes that the AEMC implement this critical rule change as soon as possible to promote the urgent need for fast investment in renewables while ensuring stable grid performance.

This rule change will enable TNSPs to leverage their expertise and deep knowledge of the complex voltage dynamics of their networks to achieve the best for system performance, while reducing energy costs for consumers, de-risking grid connection process and accelerating investment. A “one size fits all” approach doesn’t apply to such a localised phenomenon such as voltage dynamics, so a wide negotiating bandwidth is critical for TNSPs and generators to achieve the most optimal solutions.

Best Regards,



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About Windlab

As background, Windlab is a 100% Australian-owned renewable developer (owned by Squadron Energy and Federation Asset Management), which has operated in the industry for over 20 years.

It has completed nine projects contributing over 1GW to the NEM and has over 1GW of capacity under construction or asset management. Windlab has a massive development pipeline of 50 projects with a combined capacity exceeding 10GW.