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Merryn York

Executive General Manager, System Design

Response to AEMO 2023 Technical Requirements Recommendations

Lodged via email: contact.connections@aemo.com.au

Dear Merryn,

Akaysha Energy is an Australian based owner, operator and developer of utility renewables. We specialise in large scale Battery Energy Storage Systems (BESSs) and are proud to work on a NEM pivoting project: the Waratah Super Battery (WSB) – installing 850 MW of BESS in NSW to support the local energy transition via dynamic system support and security services.

As an organisation we appear new to the NEM, however the Akaysha team draws experience from members, who have been involved in renewables and energy transition in Australia over the last decade: from very early projects like Murra Warra Wind Farm to recent storage technologies, such as, Hazelwood BESS. Our experience spans across development to construction and operations and have seen projects through several versions of the NER.

We note here a few high-level comments and included subsequently are commentary on recommendations providing more detailed views.

- The general principles that guided the workshops and discussions to lead to the recommendations embraced inverter technology performance. We felt that it provided very objective standards from a power systems perspective, where consensus can be reached across all parties.
- A reiterating theme is the provision for Grid Forming (GFM) performance and future proofing some of the rule specificities. Given our position as BESS owners, GFM inverter technology is the baseline algorithm we intend to implement as we strongly believe in the efficient and economical capabilities of GFM solutions to provide power system support as the grid evolves with increased renewable generation.

- Practicality and the ability to prove and appropriately assess a performance required by the Rules is something we strongly support. Simulations are a great way to de-risk design decisions and scan for red flags in a controller early on, however, the theoretical nature of simulations never represents the full picture.

Thank you for reviewing our response. Should there be any queries, please reach out to Inez Zheng via Inez.Zheng@akayshaenergy.com.au

Best regards,

[redacted]

Nick Finch,

Chief Engineer

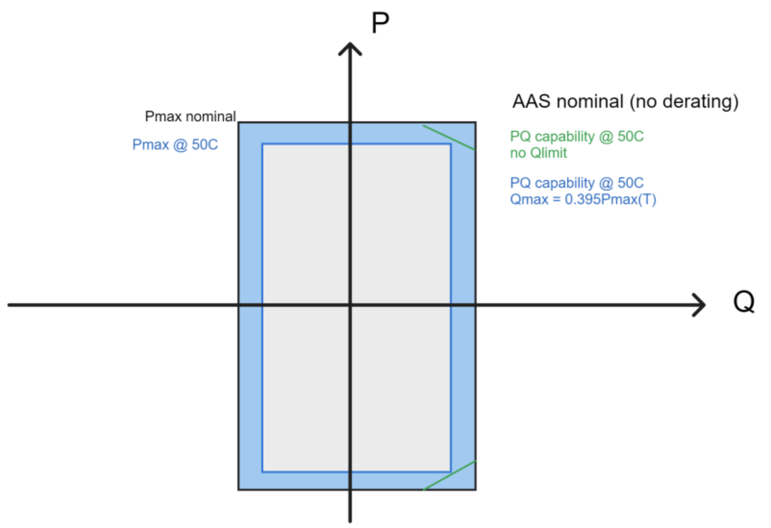
1. NER S5.2.5.1 – Reactive power capability

1.1 Treatment of reactive power capability considering temperature derating

Generally, Akaysha supports the capturing of ambient temperature in S5.2.5.1 to better manage the inconsistencies that currently face projects across jurisdictional differences whilst considering temperature derating.

- Considering the lifetime of the plant, also across technologies, it is important to put the ambient temperature parameter into context of the realistic operating environments. For example, a SF site in Northern QLD is going to have a very different maximum and minimum operating temperature to inverters / converters in a WTG nacelle 200m off the ground in Tasmania.
- We are not in favour of AEMO electing to standardise the temperature based reactive power performance as a function of 0.395Pmax(T). Many inverter OEMs by default implement a maximum current limit part of the temperature derating functionality. This means that given that most GPS compliant plants are set to Qpriority, where even at Pmax, the Qmax that is capable to be delivered is more than 0.395Pmax(T). We believe that,
    - From a system perspective, it would be beneficial for the grid to have more reactive capability available since the generators already have the capacity installed. As per AEMO's comment regarding NEO requirements, Akaysha believes that it would be prudent to leverage existing plant capability that is installed for CUO requirements at 35C, and
    - From a control algorithm / product design perspective, this new feature is an added layer of live sensor derived response and a technically difficult point of failure that doesn't add value to the inverter's performance or product integrity. We are supportive of the GPS modelling and capturing temperature derating but we believe that the practical temperature derating should remain at the inverter level without an overarching site POC forced derating layer.

As an example, the following sketch demonstrates the maximum capability for an arbitrary plant with respect to AAS at a nominal temperature before the inverter starts to derate e.g. 35C (black) and at 50C, where green indicates the 50C performance with no explicit Qlim and blue indicates the 50C performance with linear scaling of 0.395Pmax(T).



1.2 Compensation of reactive power when units are out of service

Akaysha supports the clarity that would be required in the GPS to capture the performance whilst units are out of service.

- We agree that the 0.5% threshold should be further analysed technically and may consider particular POC physical connection arrangements such as OHL and UGC lengths, and IBR features that are at play e.g. various line drop compensation methods that may be in action during servicing / outages.
- For BESSs the maximum active power drawn by auxiliary loads (may also be discussed further in S5.3 recommendations) is a difficult quantity to consider in a point in time. The maximum load would mostly come due to HVAC on extremely hot days and in the time period where the BESS may be charging (e.g. during peak noon and high solar generation). The chances of this is fairly small in the total operation BESS life span. We would recommend for AEMO to consider the context of this GPS capture to ensure the accuracy and appropriateness in what the value would be used for in operation planning.
- S5.2.5.2 compliance is mentioned here and rightly so – Akaysha support discussing this further as given the rapid uptake of highly conservative harmonic filters in especially weak POCs with every IBR project being connected, there are so many dimensions to unpack here. In general, we believe specific operating behaviours should be captured in the GPS to ensure any reactive capability associated with a plant to meet S5.2.5.2 compliance does not deteriorate the network for other parties in the vicinity and downstream from the POC. Specifically,
    - Harmonic filters are often designed in the GPS Connection Application phase, where simulations to demonstrate compliance are based off OEM Norton equivalent data, conservative network impedance points and highly conservative POC site estimations of the existing background. There are several workstreams in the industry and globally that looks at better ways to represent IBR behaviours with respect to power quality – ARENA is funding some research, a few CIGRE C4 Working Groups and IEC standard reviews. Recent literature on power quality that has looked at simulation data / results when compared with on-site measurements show large errors and differences. We therefore would urge AEMO to discuss with SMEs and NSPs around operating a harmonic filter when the IBR is offline. We believe suitable plans should be assessed according to POC operational site measurements instead of laboratory data and consider any flow on impacts to other network users.

2. NER S5.2.5.2 – Quality of electricity generated

2.1 Reference to plant standard

As mentioned in response to S5.2.5.1 reference to S5.2.5.2 compliance, there are many industry and global workstreams looking to review power quality standards and assessment with respect to IBR. The current assessment methodologies result in significant economic burdens on IBR connections, with many renewable projects having to budget millions for reactive assets to meet compliance based on highly conservative simulation derived results. The simplification and assumptions in the methodology may not be the best suited to capture IBR performance and experience from projects across jurisdictions show a great diversity amongst NSPs with respect to addressing S5.2.5.2 compliance. We appreciate this may be outside of AEMO's scope of decisions in this review but would strongly recommend other workstreams to investigate.

3. NER S5.2.5.4 – Generating system response to voltage disturbances

3.1 Clarification of CUO in the range 90% to 110% of the normal voltage

Akaysha are in support of the proposed recommendations.

4. NER S5.2.5.5 – Generating system response to disturbances following contingency events

4.1 Active power recovery after a fault

Akaysha supports the consistent conditions for active power recovery post fault with a synchronous machine, where Grid Forming (GFM) technologies emulate synchronous and inertial responses are expected to behave similarly. Though, as the technology evolves, GFM may show behaviours that could be better than a synchronous machine and taking the best of both synchronous and asynchronous performances. It would be recommended for AEMO to incorporate any GFM voluntary specification details in this NER clause update.

We believe that PFR should be referenced here. Any drafting should be discussed with AEMC and be reviewed in parallel with some of the frequency rule change workstreams that are in action.

4.2 Reactive current injection recommendations

Akaysha are strongly in support of these changes and recommendations to draw learnings and similarities from the recent reactive current MAS change.

Standardising the unbalanced fault details to be captured into the GPS is not a surprising suggestion given that recent GPSs have asked for the proposed. Our experience with OEMs however is that the positive sequence / negative sequence ratios are a difficult value to obtain and set in stone based off power system simulations.

- We recommend further consulting OEMs on their preferences on what is ideal to capture.
- We note that unbalanced faults are much more realistic in operation than 3phg faults, however, given the permutations of faults that could be studied, we recommend taking a realistic and stochastic approach in capturing this into the GPS.
- Testing such performance would be rather difficult in real life. Akaysha considers the most simple and direct GPS criteria as the most beneficial for the network and proponents. Given the IBR technologies are evolving fast, we recommend cautious consideration to ensure this level of detail may not be cumbersome for future plant updates during their 20-30 year lifespan.

5. NER S5.2.5.10 – Protection to trip plant for unstable operation

5.1 Requirements for stability protection on asynchronous generating systems

Akaysha supports the clarification of the S5.2.5.10 requirements. We support the detection of instability based off POC measurements and see that the recommended requirements aim to be inclusive of measurement technology / devices that are up and coming. One point to note is on the capability of disconnection for oscillatory behaviour. We recommend making an explicit note that the generator only disconnects upon receiving a disconnect signal from AEMO or an NSP as depending on the operating state, sudden disconnection may need to be assessed for broader risks with respect to impacts on the power system. Akaysha's recommendation would be that minor system instabilities should not trigger automatic disconnection of very large generation assets.

6. NER S5.2.5.13 – Voltage and reactive power control

6.1 Clarification of when multiple modes of operation are required

We support the simplification of reactive power control modes into a primary and secondary mode. It may be worth discussing with inverter OEMs to understand the switching control and whether there's any differences between "CUO" and "FRT" performance in a GFM algorithm.

6.2 Impact of a generating system on power system oscillation modes

We would like to further understand from AEMO around the assessments that are required to support MAS in "do not harm" in the existing network damping. We appreciate the call out of the new system strength framework that would allow any IBR that pays the System Strength Cost to pay for services that mitigate any instabilities that the IBR may impact the network. The reference to oscillation modes here suggest simulation results from a Small Signal Model. From our experience of working with new inverter OEMs, SSAT models are not a common requirement and may take a few rounds of NSP / AEMO review iterations to setup. We suggest that this clause may allow relaxation to better support new OEMs coming to the NEM and keep the barrier to entry manageable.

7. Definition – continuous uninterrupted operation (CUO)

7.1 Recognition of frequency response mode, inertial response and active power response to an angle jump.

Whilst many new IBRs are connecting to weaker areas of the grid, where the minimum SCR is below 5, some projects are still connecting to strong system strength nodes, where minimum SCR can be above 10. It is important for AEMO to consider and be inclusive of the CUO performance with respect to various SCR conditions for the following points,

- In strong SCR connections, typical faults that may enter LVRT in weaker POCs may stay just beyond the CUO 0.9 – 1.1pu voltages but hover between the LVRT entry POC voltage threshold (e.g. 0.85pu) and 0.9pu. Phase angle jumps can also be larger in stronger grids for instantaneous minor faults that are of a different X/R ratio, where a transient frequency can be seen go up to 10 degrees for a 1PHG fault. Due to the POC voltage staying within the CUO range, phase angle response is not encouraged under the current interpretation of the CUO even though this is the expected behaviour from the inverters / PPC droop control. Ways that reduce or remove the active power deviation without accounting for transient frequencies could limit the IBR capability to provide Very Fast FCAS.
- It would be diligent of AEMO to consider the relevant practicalities of CUO active power performance with respect to PLL inverter measurements being 3ph and not single phase responses. Akaysha is well in favour of considering active power response as an “arrest” to frequency change rather than an isolated “do no harm”.
- To reiterate the FCAS performance importance for BESS project economics, anything that is added here should not discourage fast frequency performance as we believe this is a critical feature coming to play in lieu of declining inertia in the grid. The Very Fast FCAS contingency market starting 09/10/23 considers a 1s timeframe, many OEMs are starting to implement local frequency droops at the inverter terminals, where the responses are almost immediate. Likewise, in GFM inverters, any phase jump would initiate an immediate active power spike often in transient periods. We believe strongly that requirements in CUO should not disincentivise the fast frequency and virtual synchronous machine control features.
    - From our discussion and experience with OEM technologies, some inverters implement a “delay” in order to avoid the aggressive frequency droop response to the frequency phase jump transient on fault entry and exit. The “delay” is often set between 200-250ms at the PPC level. Using SA as an example, where the OTR Fast Frequency Response (FFR) response time sets a precedent of 250ms, the conflicting trade-off in performance and what is desired for a low inertia grid is feature inhibiting.