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By e-Submission
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Dear James

Investigation into System Strength Frameworks in the NEM

WSP (formally Parsons Brinckerhoff / PB Power) is an international consultancy and has an overall interest in the efficient and effective management of the Australian power system and appreciates that this requires careful coordination between both proponents and network service providers / operators. WSP has firsthand engineering experience with the System Strength Framework having connected generators both prior and post the fault level rule change.

Interconnected power systems are complex in nature and requires careful coordination between all parties in both planning and operating the power system. WSP do not represent any stakeholders or their views whether they be proponents, network service providers / operators and the comments provided below are on this context.

We understand that the changing generation mix with increasing levels of inverter connected generation present new challenges in terms of operating and maintaining a stable power system. However, it is also important to understand the implications of these requirements on the National Electricity Objective (NEO) and that the requirements are based on sound engineering reasoning to ensure efficient investment in the industry.

WSP welcomes the Commission's investigation into system strength frameworks in the NEM as it is an area of uncertainty in the connection process and there is a material opportunity for improvement.

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1. SYSTEM STRENGTH DEFINITION

Clarifying the definition of 'system strength' is imperative as the loose use of the term creates uncertainty around the particular technical issue of concern. WSP understands that the original intent of the term 'system strength' was to characterise the control system instabilities and/or interactions associated with Power Electronics (PE) connected technology. However, the term has now become a 'catch-all' phrase for various technical issues (most of which are not new issues to power systems).

Grid following inverters (the majority of what is currently deployed in the NEM) require a stable voltage in order to accurately track the voltage and respond in a stable manner. The concept of 'system strength' introduced as part of the fault level rule change was to address this need for grid following inverters. However, there is no clear definition to capture either of the following phenomenon associated with PE connected technology:

1. Ability to operate stably in weak networks with or without a disturbance
2. Prevent control systems interactions resulting in undamped or poorly responses

The traditional definition of system strength as stated by the Commission is that

> *"System strength is a characteristic of an electric power system that relates to the size of the change in voltage following a fault or disturbance on the power system. Essential levels of system strength are required to be continuously to maintain a secure power system. Low levels of system strength can jeopardise the ability of generators to operate correctly." (para 10).*

Where a PE interfaced generator is not able to operate stably, it is likely due to either a control system instability or control system interaction resulting in active and/or reactive power oscillations (which then impact voltage and frequency stability), which can be caused by control parameter settings. The latter of which are clearly defined in the Power System Stability Guidelines and managed through existing mechanisms.

The reliance of a definition of 'system strength' based purely on fault current is misleading and generalises the problem as PE interfaced generation can and do contribute to fault current and hence does not clearly describe the technical problem to be overcome.

AEMO in their recent Renewable Integration study defined system strength as:

> *"System strength is a complex concept, and an area of emerging understanding internationally. Definitions vary across jurisdictions and continue to evolve as the international power system community's collective understanding of power system phenomena continues to grow.*
>
> *AEMO sees system strength as the ability of the power system to maintain and control the voltage waveform at any given location in the power system, both during steady state operation and following a disturbance".*

This is an overly generic definition which is likely to result in confusion and delays, hence the importance of the need for a consistent definition to be utilised by all parties.

2. 'SYSTEM STRENGTH' AS A SERVICE

Stable operation of PE interfaced generation is a fundamental requirement for power system security and stability. Hence any network support necessary for PE interfaced generation to operate stably cannot be optionally enabled, it must always be present in the network. This is similar to the need for both dynamic and static reactive power which is required for ensuring voltage stability.

Technical solutions that allow additional PE interfaced generation to connect and operate beyond a beyond a minimal level may have a market benefit and would provide locational signals like areas with a high MLF.

3. 'SYSTEM STRENGTH' BEST PLANNED AND MANAGED CENTRALLY

WSP agrees that some of the issues associated with PE interfaced generation connecting in the NEM as specified in 1, are best planned for and managed centrally by a party such as a TSNP. WSP in principle supports the position put forward in the rule change request by TransGrid in ERC0300[1] subject to review of the detail around the proposed approach.

4. NEED FOR MEETING THE AUTOMATIC ACCESS STANDARD WILL EXASPERATE 'SYSTEM STRENGTH' ISSUES

4.1 IMPACT OF MEETING THE GTPS RULE CHANGE AND SYSTEM STRENGTH

The concept of 'system strength' is in some cases being used as a catch-all when technical issues are identified during the connection process. Oscillations caused by controller interactions are often seen during the FIA process. Such oscillations in power systems are not a new concept and have historically been resolved by re-tuning or slowing controllers while still ensuring system response is adequate. There are pre-existing oscillations in the power system, for example the system mode that involves a low frequency mode involving all the (synchronous) generators in the system. "System strength" oscillations (often poorly described, i.e. is it purely voltage or is there a power oscillation?) may occur due to a number of underlying issues, attributed to a "weak system" - unless this is directly related to PE interfaced controller instability / interaction, it is more likely related to high reactive power injection requirements into a network which is already operating at the stability margin. This has occurred in several locations due to the pursuit of "automatic" standards reactive responses setting high gains into control systems while expecting stable voltages at marginal levels of power transfer which defies sound power engineering practice.

WSP acknowledges that the system strength framework review is not focussing on the recent GTPS rule change, however there is an inherent link between the two in that tuning inverter controls with high gains will result in oscillations and prevent other generators from connecting if controllers of other devices in the power system are not tuned to compensate (which is not possible under the 'do no harm' framework). WSP understands that the commissions intent with the GTPS rule change was to demonstrate 'capability' to meet the Automatic Access Standard rather than require it at a particular connection location, however experience to date is that this distinction is not made in practice.

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[1] https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system?utm_medium=email&utm_campaign=Pending+notification+-+6+May+2020&utm_content=Efficient+management+of+system+strength+on+the+power+system&utm_source=www.vision6.com.au

4.2 ASSESSING THE POTENTIAL IMPACT OF CONTROL SYSTEM RELATED INTERACTIONS/INSTABILITIES ON A PROJECT

It is presently not possible for connecting parties to forecast these technical challenges and the corresponding impacts / potential for curtailment. The inability of projects to study the wide area network models that have been developed by NSPs/AEMO leave projects at risk of control system instabilities / interaction issues being identified during the FIA – this is after the full connection application has been submitted. A significant volume of engineering work is often repeated following the NSP or AEMO rejecting a project and finding to have an adverse impact on the network resulting in costly delays.

5. DO NO HARM FRAMEWORK

The main challenges associated with the "do no harm" framework are:

- There is a lack of transparency when assessing the impact of a connecting party on the rest of the power system
- There is an expectation that new connecting parties need to resolve existing problems on the power system (which is not reasonable).
- Does not allow flexibility in negotiating performance as it requires connecting parties to both meet the Automatic Access Standard for their performance standards, and at the same time, not cause interactions with other plant (which is at odds with good control tuning). Power systems require coordinated planning and tuning of individual components as a whole and it is not possible to tune one component in isolation and at the same time expect system standards to be met.
- Does not provide transparency in differentiating between new issues versus future issues (which are a planning problem).

One of the solutions to managing control system instabilities/interactions associated with PE interfaced generation is to make the network less susceptible to voltage changes by installing synchronous machines such as synchronous condensers or directing synchronous generators to remain online. However, what is evident since the fault level Rule Change was first passed is that System Strength remediation is often most effective at a location that is not on the Generator side of the connection point. The strength of an ac system is directly related to the network impedance being high and the ac system mechanical inertia being low (Kundur).

Where remediation schemes such as a Synchronous Condenser are located on the network side of the Connection Point (which could be kms a way), this creates a regulatory challenge in terms of the asset and whether it is a generator asset, network asset and also other complications as highlighted by TransGrid[2]. Furthermore, the framework only addresses the problem from a piecemeal approach with projects solving for only what is perceived to be their "share" of the missing MVA of fault current. This leads to an expensive and poor outcome with multiple small rotating machines (synchronous condensers) installed behind connection points in numerous remote network locations. In some case projects are being required to solve the same problem twice or three times over due to the lack of coordination and transparency over the issue.

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[2] https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system?utm_medium=email&utm_campaign=Pending+notification+-+6+May+2020&utm_content=Efficient+management+of+system+strength+on+the+power+system&utm_source=www.vision6.com.au

6. NEED FOR EFFICIENT RE-TUNING TO MANAGE THE POWER SYSTEM

One solution to manage instabilities/interactions associated with PE interfaced generation (which does not require new equipment) is to retune controllers. Re-tuning controllers in the power system is not a new concept and is a requirement to accommodate changes in the power system. To manage this with an increasing number of PE interfaced generation, it requires a centralised coordination approach and any barriers to re-tuning and revision of performance standards appropriately to be removed.

One example of this is the West Murray issue where 'system strength' related oscillations risks were engineered out through controller tuning. By focussing on the overall power system and being flexible on the performance of individual generator GTPSs (by not having to meet the Automatic Access Standard for the sake of it), the problems associated with PE interfaced generation can be managed more efficiently.

7. RESPONSIBILITY FOR DECLARING A 'SYSTEM STRENGTH' SHORTFALL

This currently sits with AEMO; however, it might be more appropriate for this to be with the TNSPs so any shortfalls can be identified early. TNSPs are well placed to identify shortfalls early given:

1. They undertake Full Impact Assessments and assess suitability of System Strength Remediation schemes of various connecting parties in their region
2. They have direct exposure to connection enquiries and applicants and can hence often foresee Fault Level shortfalls prior to AEMO (as an example, prior to AEMO's notice of a Fault Level shortfall in Queensland, some local generators in far north Queensland were being constrained due to 'System Strength')
3. TNSPs are also responsible for the network protection, the protection settings and protection upgrades. Given that a shortfall of fault current it is claimed that system protection will fail, the TNSP is best positioned to resolve the shortfall in fault current and couple it with advances in system protection design and implementation.
4. The minimum strength framework causes significant delays in projects through requiring the FIA to be undertaken at the end of the connection application process. This can effectively put a project back to the beginning when issues are identified in the control tuning through the FIA assessment. It would be preferable to solve tuning issues and perform the FIA at an earlier stage in the development of the connection package to avoid excessive costs and delays to projects.
5. TNSPs are responsible for network planning (in most cases), given that the strength of an ac system is directly related to the network impedance, network upgrades and planning should be considered in the solution to the "weakness".

8. EVOLVING FRAMEWORKS

8.1 CHARACTERISATION OF A CENTRALLY COORDINATED MODEL

Provided the centrally co-ordinated model is designed so that it can deliver, then this is more likely to promote system security.

8.2 MARKET BASED DECENTRALISED MODEL

A decentralised model is unlikely to sufficiently provide a solution – more likely to create market power within a region or enable services in the wrong area to where the issue resides.

It is unlikely to provide services above the essential / minimum level in the right location in the absence of centralised planning.

8.3 MANDATORY SERVICE PROVISION

Refer Section 2

8.4 ASSESSMENT AS PART OF ACCESS STANDARD

A network solution through the centralised approach will be far better than the uncoordinated solution that a single generator can provide through an access standard. Provided a centrally coordinated solution will ensure stable operation of PE interfaced generation by managing the power system (either operationally or via technology solutions), we do not see a need to propose an access standard.

Furthermore, until such that time that a clear and objective definition of 'system strength' can be agreed upon, it would not be possible to quantify the requirements in an access standard.

To the extend the access standard covers the conditions under which a generator can meet its performance standards (e.g. minimum level of synchronous fault current at the connection point in the absence of any other PE connected equipment), then there might be value in documenting this for the purposes of informing the central planning / coordinating authority.

8.5 GENERAL COMMENTS

Subject to the technology providing the solution, it may not be practical to 'dispatch' solutions.

Most synchronous condensers do not get "dispatched" they usually operate 24x7 unless out for maintenance. The short-term operational timeframe will impact the operational life due to thermal cycling and result in further complexities in planning and operating the power system.

The present focus has been on asynchronous generation operating in a power system with primarily synchronous generation. Modern PE interfaced generation such as batteries are able to operate in a virtual synchronous generator mode which mimics the performance of a synchronous generator. Such a mode is likely to have a positive impact on the power system and should be considered.

We welcome the opportunity to discuss any of the afore mentioned items in further detail with the Commission.

Yours sincerely

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