ElectraNet

4 September 2023

[redacted]
A/Head of Network Planning
SA Power Networks

GPO Box 77
Adelaide SA 5001

Via email: [redacted]

Dear [redacted]

Re: Power factors at connection points – system security impact

We refer to the Transmission Connection Agreement between ElectraNet Pty Limited (**ElectraNet**) and SA Power Networks ABN 13 332 330 749 (**SAPN**) dated 3 October 2018 (**TCA**). Capitalised terms in this letter have the same meaning in the TCA, and italicised terms have the same meaning in the National Electricity Rules (**Rules**).

We also refer to our 21 September 2022 letter in which we advised that the flow of capacitive power from the distribution system is contributing to the occurrence of unacceptably high voltage levels on the SA transmission system, especially at times of low demand. Such flows are not compliant with the Technical Obligations included in Schedule 6, Part B item 3 of the TCA, as provided for in Schedule 5.3.1a(d) of the Rules, for no capacitive flow from the distribution system to the transmission system at 66 kV connection points at all loading levels.

In that letter we requested that SA Power Networks develop and implement a plan to identify and remedy the non-compliances by addressing power factors at 66 kV connection points.

Thank you for your 27 October 2022 letter and ongoing engagement on this matter, including recently sharing your proposed reactor program for 2025–2030.

Further to our letter of 23 August 2023 you have requested that ElectraNet describe:

- the circumstances in which connection point power factors outside of the ranges agreed in the TCA can impact on the ability to maintain system security; and
- when and where these system security issues arise.

You sought this information to help you identify available options to resolve the non-compliances.

Background – Transmission network voltage control

A key aspect of managing the transmission network is to ensure adequate voltage control to:

1. maintain satisfactory steady-state voltage levels; and
2. ensure dynamic voltage stability following contingency events.

Key existing sources of dynamic voltage control on the South Australian electricity transmission system include:[1]

- static var compensators (SVCs) at Para and South East; and
- synchronous condensers at Davenport and Robertstown.

ElectraNet draws on the above sources to provide dynamic voltage control by maintaining an appropriate level of dynamic reactive power reserve during system normal conditions.

ElectraNet reserves an appropriate level of dynamic reactive power by operating its and synchronous condensers within a normal operating target range of 0 – 25 Mvar (inductive). This reserves a total of 332 Mvar of dynamic inductive reactive power capability, SVCs consisting of 150 Mvar on the SVCs and 182 Mvar on the synchronous condensers. We are currently undertaking the Transmission Network Voltage Control RIT-T, to enable the SVCs to achieve their desired pre-contingent operating range at forecast low transmission system loading levels and expecting SA Power Networks compliance with the TCA.

Our analysis indicates that this addresses the risk of overvoltage events occurring after critical contingencies, which would otherwise breach the requirements of schedules S5.1a.4 and S5.1.8 of the National Electricity Rules.

Requirement for no capacitive power at 66 kV connection points

ElectraNet has observed that increasing reverse capacitive power flows at connection points between our two networks are causing the SVCs to be operated outside the ranges specified above and at present levels, will continue to do so after completion of our Transmission Network Voltage Control RIT-T.

This curtails ElectraNet’s ability to use the SVCs to respond to potential system disturbances. In turn, this compromises system security by jeopardising ElectraNet’s ability to maintain dynamic voltage stability following critical contingencies.

ElectraNet has also, at times, switched out the Magill to East Terrace 275 kV cable to manage high steady state voltages. This is an emergency action that reduces the redundancy of electricity supply into the Adelaide CBD.

ElectraNet and AEMO are exploring the ability to operate the South Australian transmission system with only a single dispatched conventional generating unit. This will further reduce the availability of

[1] Dispatched generators are also potential sources but we are increasingly concerned that these will not be available during future contingency events. The Torrens Island BESS will be an available source after it has been commissioned.

reactive power support from generation and increase the reliance on ElectraNet's SVCs and synchronous condensers to provide dynamic reactive power control.

Following the successful inter-network testing of Project EnergyConnect it is expected that there will be times when the South Australian transmission system operates with no dispatched conventional generator unit, further increasing the reliance on ElectraNet's SVCs and synchronous condensers.

There is therefore a need for SAPN to ensure that capacitive reactive power does not flow into the transmission network from 66 kV distribution connection points. This is consistent with the requirements of the TCA Schedule 6, Part B item 3 and schedule S5.3.5 of the Rules for 66 kV connection points.

Acceptance of lagging power factors

We acknowledge that to ensure no flow of capacitive reactive power (no leading power factor) from 66 kV distribution connection points and due to the limits of switched reactors, it will be necessary to accept a lagging power factor. This lagging power factor may at times not comply with the limits specified in the TCA schedule 6, part B item 3, as provided for in Schedule 5.3.1a(d) of the Rules, for 66 kV connection points.

For load levels less than 30% of the agreed maximum demand (AMD) at a connection point, ElectraNet is willing to accept power factors at 66 kV connection points that are less than 0.95 lagging (i.e., inductive reactive power flows), provided that the amount of inductive reactive power at each connection point does not exceed the amount that corresponds to a 0.95 lagging power factor at 30% of the connection point's AMD. For load levels from 30% of connection point AMD and above, the agreed power factor range of 0.95 lagging to unity will continue to apply. This arrangement is as shown by the area contained within the blue lines in Figure 1. ENET will consider increasing or even removing the 30% limit in the above clause at TCPs with smaller AMD (such as <300MW). This is to allow for cost-effective reactor sizes to be chosen".

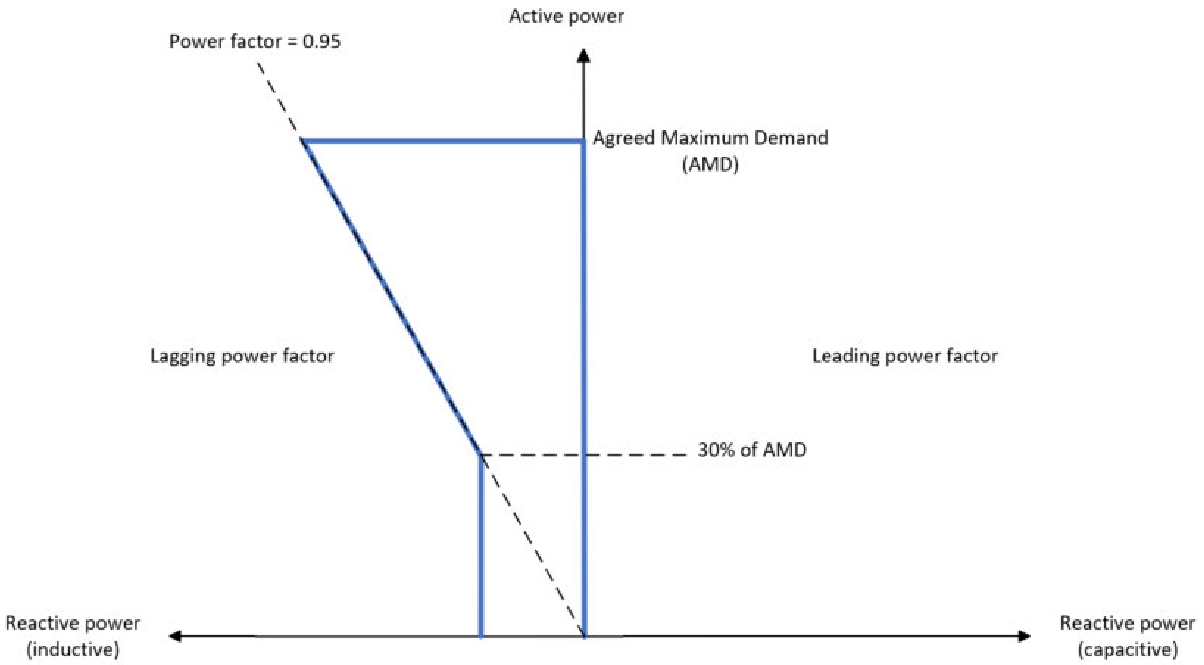

Figure 1

The above arrangement regarding power factors and reactive power flows for load levels less than 30% of connection point AMD should be documented in the next revision of the TCA.

Risk of transformer over-fluxing

In addition to the above issues relating to voltage stability of the transmission system, technical literature[i] indicates that transformers subject to capacitive reactive power flowing from the load side to the grid side of the transformer may be at an increased risk of over-fluxing, due to increase of the magnetising current and core losses. This would have a thermal impact on the transformer and reduce its lifespan. Additionally, it can result in markedly increased harmonics and increase the likelihood of an internal transformer fault. This risk would be exacerbated at high demand times.

To manage this risk, it may be necessary to reduce the transformer rating at such times, reducing the capacity to supply load at that connection point. We plan to investigate this risk further.

Yours sincerely

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Manager Network Planning

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i For example: Rajarshi Roychowdhury *et al*, "Stepping Up to the Future With Power Transformers: Power Transformer Asset Management Strategies: State of the Art and Recommendations for the Future" *IEEE power&energy magazine* 21, no. 2 (March/April 2023):40-50. https://doi.org/10.1109/mpe.2022.3230889.