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Australian Energy Market Operator

By email: gpsrr@aemo.com.au

Dear Sir/Madam

2023 General Power System Risk Review Approach Paper

Transgrid welcomes the opportunity to respond to the Australian Energy Market Operator's (**AEMO**) General Power System Risk Review (**GPSRR**) approach paper. As the jurisdictional planner, operator and manager of the transmission network in NSW and the ACT, Transgrid is keen to assist AEMO in ensuring energy system risks are identified and appropriate arrangements are in place for managing the priority risks.

Transgrid has been collaborating closely with AEMO through joint planning on the development of the GPSRR. We are supportive of AEMO's amendments to the GPSRR as it provides clarity to the market in managing risks to the network. It plays an important role in prioritised risks comprising events and conditions that could lead to cascading outages or major supply disruptions on the network.

Transgrid also welcomes AEMO's consideration of whether the systems and tools used by system operators in the NEM are fit for purpose to manage emerging power system risks throughout the energy transition.

During 2022, we engaged global power system expert consultants PowerRunner to help us assess and define the initiatives needed for Transgrid to be capable of operating the NSW power system securely with up to 100% instantaneous renewable energy generation by 2025 – our *System Security Roadmap*. This includes:

- New network infrastructure and services needed to maintain the technical operating envelope (voltage control, system strength, inertia and power quality, etc.) in a future with low or no synchronous generation; and
- The organizational capability and capacity to meet the growing volume and complexity of work to plan, manage and operate a renewable power system, including advanced, digital tools to modernize control rooms and additional human resources and training requirements.

PowerRunner found that our existing capabilities to plan, manage and operate the NSW power system (while suitable for current conditions) are already operating at full capacity and are not capable of being scaled to manage power system security into the future. Without a significant uplift, this could contribute to an increase in power system security incidents, including a growing risk of catastrophic, system-wide outages. Overall, PowerRunner estimated that, if unmitigated, the growth in system complexity in NSW could result in a 570% increase in the risk of unserved energy arising from system security incidents by 2030, compared to a 2022 base.

Transgrid's System Security Roadmap has also identified several initiatives that can help to mitigate this risk, including:

- **Situational awareness and real-time decision support tools** – Alarm analytics, decision support, forecasting and visibility of network conditions and asset health for control room operators.
- **Digital twin technology** – A digital representation of physical transmission assets, used for simulations, planning and modelling, vital to better plan for, maintain and operate our grid.
- **Increased staffing levels and training** – Additional people, skillsets and training to support the increasing requirements and complexity of network planning, asset monitoring and system operations.

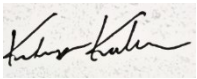
Collectively, PowerRunner has assessed that these initiatives may mitigate as much as 60% of the risk increase to 2030, by improving Transgrid's capability and capacity to plan, manage and operate the NSW power system – providing insurance against the increasing risk to energy consumers of power system outages. This investment is projected to deliver net benefits of $863.3 million over 10 years. Even if the amount of benefits is only one fifth of those calculated by experts, the investment will have more than paid for itself.

AEMO's 2022 Integrated System Plan has also identified that "Uplifting System Operator and Network Service Provider capabilities in operational systems, processes, real-time monitoring, and power system modelling will be essential to have the tools to maintain secure operation of the NEM power system as it transitions to significant penetrations of inverter-based resources including DER". Transgrid agrees that these issues and risks are likely to be relevant to AEMO, Transmission Network Service Providers (**TNSP**) and Distribution Network Service Providers (**DNSP**) across the NEM, and indeed, all power system operators globally that are navigating the energy transition.

Based on these findings, Transgrid recommends that the 2023 GPSRR include a review of the sufficiency of existing capabilities of system operators across the NEM to maintain safe, reliable and secure operations in the context of increasing power system complexity. Transgrid's System Security Roadmap has highlighted that this may be a significant risk with the potential to give rise to catastrophic system events, and it should therefore be assessed in the GPSRR alongside other critical system risks. However, there is also the potential for effective risk mitigation with an uplift in technology, systems and human resourcing, which could be implemented across the sector.

We look forward to working with AEMO to further refine and implement the GPSRR methodology. If you require any further information or clarification, please feel free to contact Fiona Orton, General Manager Innovation & Energy Transition (Fiona.Orton@transgrid.com.au). Further information and background is provided as an appendix.

Yours faithfully



Kasia Kulbacka

A/Executive General Manager – Network
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Appendix – System Security Roadmap project background

Increasing operating complexity

Australia's energy transition is leading to a greater complexity in the NEM's power system. Two decades ago, eight coal generators (representing twenty units with 12GW of capacity) provided almost all of NSW's power needs. Under the Step Change scenario outlined in the 2022 ISP, only two coal generators (four units) are forecasted to remain in NSW by 2030. The decrease in synchronous capacity is expected to be replaced by pumped hydro, battery storage, hundreds of wind and solar generators, and millions of rooftop solar systems, providing 29 GW of additional power.

The role of AEMO's and TNSP control rooms is to ensure the power system operates securely, within a complex technical envelope. When there is a disturbance on the grid, the disturbance can push the system outside this envelope. Once this occurs, control room operators must react immediately to bring the system back within the secure envelope. Otherwise, the situation can escalate, leading to cascading failures that cause major outages. Based on Transgrid's control room contingency analysis data, it is already twice as likely for a contingency event to push us outside the secure technical envelope as it was in 2019, because of the energy transition experienced to date.

In order to manage this complexity and maintain the power system within a secure operating envelope, grid operators have to continuously monitor a vast volume of rapidly changing data. The amount of real-time operational decisions required to keep the grid in the envelope is increasing month on month. For insistence, there are currently 40,000 alarms sounding in Transgrid's control rooms per month.

Implications of increasing complexity

The US-Canada Power System Outage Task Force (2004) found that the common factors in every major outage in the US and Canada between 1965 and 2003 included the inability of system operators to forecast events on the system, failure to ensure the system operation was within safe limits, ineffective communication and inadequate training of operating personnel[1]. The events of California's 24-hour blackout[2] in 2011 and the UK's national blackout[3] in 2019 cascaded from minor incidents to blackouts in part because of a lack of analytics and situational awareness in control rooms. Therefore, the consequences of a lack of information and training of grid controllers can be catastrophic.

PowerRunner has assessed how increasing system complexity translates into increased risk of system security incidents on Transgrid's network, and identified initiatives to mitigate this risk. The analysis found that the technology and operational changes forecasted to 2030 would make it increasingly challenging for Transgrid to plan, manage and operate the NSW power system securely.

PowerRunner estimated that, if unmitigated, the growth in system complexity in NSW could result in a 570% increase in the risk of unserved energy arising from system security incidents by 2030, compared to a 2022 base– either as a result of load shedding required to return the power system to a secure operating state and/or as a result of insecure power system conditions that causes either load or generation to be lost. This includes the possibility for cascading failures to cause catastrophic, system-wide outages.

[1] https://www.energy.gov/sites/default/files/oeprod/DocumentsandMedia/BlackoutFinal-Web.pdf
[2] https://www.nerc.com/pa/rrm/ea/September%202011%20Southwest%20Blackout%20Event%20Document%20L/AZOutage_Report_01MAY12.pdf
[3] https://www.ofgem.gov.uk/sites/default/files/docs/2020/01/9_august_2019_power_outage_report.pdf

Transgrid believes that this may be the first time that a quantitative assessment has been undertaken of the risks and potential consequences associated with increasing power system complexity.

This 570% increase in supply interruptions considered:

- Coal generation retirements, reducing inertia and system strength buffers on the system
- The growth in renewable generation capacity and new technologies, increasing the variability in generation output and impacts on voltage and frequency
- The growth in distributed solar, leading to lower minimum demands, voltage issues, variable generation and implications on load shedding
- Impact of multiple Renewable Energy Zone Network Operators, leading to more complex interfaces between operations teams
- The construction and commissioning of major transmission projects, requiring prolonged outages / reduced redundancy on transmission lines

PowerRunner has assessed that Transgrid's existing operational tools and capabilities are already at full capacity. Without mitigation, these risks could lead to unacceptable impacts:

- These risks will increase the likelihood of system security incidents occurring on the transmission network, which could lead to high levels of unserved energy.
- The potential for non-compliance with obligations under the National Electricity Rules (NER), including clause 4.2.6 which requires the operation of the power system in a secure operating state, including returning to a satisfactory operating state following a credible contingency, and clause S5.1 which requires the planning, design and operation of the power system in accordance with defined power system standards (for network reliability, frequency variations, voltage, voltage fluctuations, voltage unbalance, stability, etc.).