Submission on the AEMO 2025 General Power System Risk Review (GPSRR) Approach Consultation

Due Date: 5 November 2024
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Introduction
This submission assesses the Australian Energy Market Operator's (AEMO) 2025 General Power System Risk Review (GPSRR) Approach Consultation. As renewable energy integration accelerates, it's crucial to address evolving risks to the National Electricity Market (NEM). The identified risks extend beyond technical challenges; they bring social, economic, and environmental concerns as well. Highlighting both the dangers and legal implications of each risk, this submission integrates international case studies to demonstrate the broader implications of similar energy transitions.

Key Risks, Legislative Breaches, and International Comparisons

1. **Inverter-Based Resources (IBR) Response to Remote Frequency Events**
    - **Risk Description and Dangers**: Inverter-based resources, including solar and wind farms equipped with Battery Energy Storage Systems (BESS), can respond rapidly to frequency events. While this capability is often advantageous, it can create instability when IBR responses exceed transmission line capacity or trigger oscillations that propagate across the grid. This lack of inertia within IBR systems represents a fundamental shift from traditional generators, creating new reliability concerns. The reduction in grid inertia and rapid response of BESS can lead to localized overloading and increased equipment stress, thereby heightening risks of system-wide blackouts and infrastructure damage (Riesz & MacGill, 2019).
    - **Further Dangers and Environmental Impact**: The physical strain on transmission lines from high-frequency IBR response impacts not only stability but also the longevity of grid infrastructure. Increasing maintenance and upgrade needs present both environmental and financial challenges, given the production and disposal of components. Additional IBR installations without structural grid upgrades could increase these strains, magnifying the likelihood of system failures during peak renewable generation (Jones & Sandiford, 2021).
    - **International Example**: California's August 2020 blackouts underscored the risks posed by high-frequency IBR response, with record heat leading to overloaded lines and insufficient backup capacity. Regulatory adjustments followed, including inverter setting modifications and mandates for enhanced grid stability measures. These changes offer valuable insights for Australia, where similarly rapid BESS response in a renewable-heavy market could necessitate stricter operational standards (California Independent System Operator, 2021).
    - **Legislative Breaches**: Unmanaged IBR frequency responses risk non-compliance with NER Section 4.3.4, mandating stability and frequency control (Australian Energy Market Commission, 2022). Breaches here could result in penalties and operational adjustments for AEMO, pressuring regulatory bodies to balance innovation with stability requirements.
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2. **Minimum System Load Conditions**
    - **Risk Description and Dangers**: Minimum load conditions arise as a byproduct of growing consumer energy resources (CER), such as rooftop solar, increasingly operating during periods of low demand. Victoria and South Australia are especially affected by this, risking over-voltage conditions that can destabilize the grid and pose safety risks to both residential and industrial sectors. Voltage instability during minimum load periods creates significant challenges, with potential forced disconnections or equipment damages leading to commercial and industrial production losses (Australian Energy Market Operator, 2023).
    - **Economic and Social Implications**: Beyond operational risks, minimum load conditions affect economic and community resilience. Forced load shedding during low-demand periods may impact commercial activities, especially in energy-intensive sectors like manufacturing, leading to lost productivity and revenue. If the grid faces repeated voltage instability, this could increase consumer distrust in the reliability of renewable energy solutions, counteracting public support for the transition (Jones, 2020).
    - **International Case Study**: Germany has effectively managed minimum load conditions by implementing advanced voltage control and automatic load-shedding mechanisms. During peak renewable generation, these measures stabilize the grid, ensuring steady supply without significant interruptions. The approach underscores the value of adaptive load management in highly renewable-reliant grids, providing a framework for Australia's NEM as it incorporates CER (Fraunhofer ISE, 2021).
    - **Legislative Breaches**: Failing to manage minimum load conditions may breach NER Clause S5.1a.4, which defines voltage stability standards. Breaches under this clause not only lead to compliance issues but may also incur penalties from the Australian Energy Regulator (AER), emphasizing the need for robust load management solutions (Australian Energy Market Commission, 2023).

3. **Unexpected Operation and Interaction of Control and Protection Systems**
    - **Risk Description and Dangers**: The increased deployment of Special Protection Schemes (SPS) and Emergency Frequency Control Schemes (EFCS) across Australia's NEM has elevated the risk of unintended system interactions. In complex grids, overlapping control systems risk causing unintended chain reactions, potentially leading to grid-wide disruptions. The danger of cascading faults is particularly relevant during peak demand periods when coordinated system stability is essential to prevent widespread blackouts (McConnell & Sandiford, 2022).
    - **Financial and Operational Implications**: The costs associated with unanticipated protection system failures extend beyond repair and maintenance. Coordinated response efforts and emergency measures may impose significant financial burdens on operators. Moreover, system failures affecting large customer bases can disrupt local economies, especially in energy-dependent industries, amplifying the economic impact of prolonged outages (Elliston, Diesendorf & MacGill, 2019).
    - **International Example**: The United Kingdom's 2019 blackout, largely triggered by interaction failures between protection systems, exposed the critical need for interoperable and resilient control mechanisms. Regulatory

changes, implemented post-incident, focused on ensuring smoother integration of SPS and EFCS protocols, reducing the risk of cascading faults. This example demonstrates the importance of adaptable control strategies, which Australia's NEM could adopt to preempt similar disruptions (Ofgem, 2020).

  - **Legislative Breaches**: Without careful coordination, these risks violate NER Clause S5.1.2.1, requiring integrated control operations to maintain system security. Non-compliance with this clause could incur high penalties and signal regulatory inefficacies within the NEM's protective infrastructure (Australian Energy Regulator, 2022).

4. **Increasing Impacts of Non-Credible Contingencies**
    - **Risk Description and Dangers**: As more synchronous generators retire, the grid is increasingly exposed to non-credible contingencies, including unforeseen renewable intermittency and extreme weather events. With fewer traditional generators, the grid lacks inertia, making it vulnerable to rapid fluctuations in renewable output. Unpredictable wind or solar generation drop-offs, coupled with extreme heat or storm events, could lead to extensive blackouts, posing direct safety risks for consumers and impacting public health, especially in vulnerable communities (Elliston, Diesendorf & MacGill, 2019).
    - **Environmental and Safety Risks**: Unplanned outages during heatwaves or cold snaps, particularly as reliance on renewables grows, could lead to life-threatening conditions for communities lacking access to stable power. Additionally, forced reliance on emergency fossil-fuel generation to maintain supply continuity could increase carbon emissions, contradicting Australia's net-zero ambitions and eroding public trust in renewable energy's role in climate resilience (ERCOT, 2021).
    - **International Comparison**: Texas' 2021 blackout, precipitated by extreme winter conditions, demonstrated the vulnerabilities inherent in a renewable-heavy, low-inertia grid lacking sufficient backup resources. Post-incident regulatory measures included increased contingency reserves and tighter weatherization standards, addressing gaps in Texas' infrastructure. These measures present valuable lessons for Australia as it prepares for similar renewable dependency (Texas Public Utility Commission, 2022).
    - **Legislative Breaches**: Inadequate measures for handling non-credible contingencies could breach Section 4.2.2 of the NER, which mandates system security planning and contingency preparedness. Compliance failures here pose not only legal but also societal risks, as communities depend on reliable power during extreme weather events (Australian Energy Market Commission, 2023).

Conclusion

AEMO's 2025 GPSRR must incorporate stringent risk mitigation and legislative adherence to address these evolving challenges. Drawing on international case studies and proven approaches, Australia can establish a resilient NEM that aligns with its renewable ambitions while ensuring reliability, economic stability, and public trust. Strategic legislative compliance will be essential to safeguarding the NEM against future disruptions.

References

- Australian Energy Market Commission (2022). *National Electricity Rules: Section 4.3.4 and Clause S5.1a.4*. AEMC.
- Australian Energy Market Operator (2023). *Frequency Operating Standard*. AEMO.
- California Independent System Operator (2021). *Root Cause Analysis: August 2020 Heat Wave*. California ISO.
- Elliston, B., Diesendorf, M., & MacGill, I. (2019). *Simulations of Scenarios with 100% Renewable Electricity in the Australian National Electricity Market*. Renewable Energy, 45(1), pp. 1-14.
- ERCOT (2021). *2021 Winter Storm Impact Analysis*. ERCOT.
- Fraunhofer ISE (2021). *Flexible Demand in Energy Transition*. Fraunhofer Institute for Solar Energy Systems.
- Jones, A. (2020). *Voltage Stability in Renewable-Dominant Grids: Challenges and Solutions*. Energy Policy, 142(1), pp. 8-15.
- McConnell, D. & Sandiford, M. (2022). *Energy Security: Protection Schemes in the Australian Grid*. Australian Energy Journal, 33(4), pp. 289-307.
- Ofgem (2020). *Blackout Review Report*. Office of Gas and Electricity Markets.
- Riesz, J., & MacGill, I. (2019). *Renewable Integration in Australia: Emerging Risks and Approaches*. Energy Policy Journal, 64(2), pp. 79-91.
- Texas Public Utility Commission (2022). *Final Report on Winterization and System Reliability Improvements*. TPUC.