

Threat to the Security of Electricity Supplies to Victoria and NSW due to the flawed design of WRL, VNI West and Humelink transmission lines

1. Introduction

This report documents a serious threat to the security of electricity supplies to Victoria due to the flawed design of AEMO's Western Renewables Link (WRL) and AEMO/TransGrid's Victoria-NSW West interconnection (VNI West), collectively called WRL – VNI West. The same flaw is present in the design of TransGrid's Humelink project and the remainder of AEMO's 500 kV Super-grid stretching 3,000 kms from Melbourne to Sydney to Brisbane to Townsville. The lack of resilience of the Super-grid, is certain to result in widespread blackouts and extended electricity rationing in Victoria, NSW and Queensland. This will have major adverse impacts on Australia's economy and society and the vulnerability could be targeted by saboteurs or terrorists.

2. Criticality of Electricity Transmission

Electricity transmission is the essential backbone of the power system enabling society, industry, and public services such as hospitals, transportation, emergency response systems, and communication networks to operate. Avoiding single points of failure (SPoF's) in the grid is essential in preventing wide-scale blackouts due to the failure of a single key part of the grid. Interconnectors can be SPoF's as they transmit large amounts of power over long distances from remote generators and between regions and states. If an interconnector fails due to equipment breakdown, sabotage, or a natural disaster, it can black-out the connected regions, unless it is lightly loaded or adequately duplicated. There can be a cascading collapse of the power system or instantaneous instability that may blackout large parts of the state(s) with widespread and long-lasting power outages. This is increasingly likely to occur in the transition to large, remote sources of renewable generation via the long-distance, high-capacity Super-grid. Investing in the necessary infrastructure to avoid SPoF's in the Super-grid is justified despite adding ~20% to the capital cost as it prevents massive disruptions in the long run. Transmission planners must prioritise security, reliability, resilience, and redundancy in planning Australia's Super-grid.

3. Federal Legislation on Critical Infrastructure Security

The Federal government's Critical Infrastructure Centre was established in January 2017 to safeguard Australia's critical infrastructure from the increasingly complex national security risks of sabotage, espionage and coercion. A disruption to critical infrastructure could have serious implications for business, governments and the community. The Security of Critical Infrastructure Act 2018 (the SOCI Act) places obligations on entities in the electricity sector. *SOCI Act Section 10* states that a critical electricity asset is a network, system, or interconnector, for the transmission or distribution of electricity to ultimately service at least 100,000 customers. The Security Legislation Amendment (Critical Infrastructure Protection) Act 2022 (SLACIP Act) uplifted the security and resilience of Australia's critical infrastructure and introduced new obligations for responsible entities to create and maintain a critical infrastructure risk management program for operators of systems of national significance (Australia's most important critical infrastructure assets – SoNS). It aims to make risk management, preparedness, prevention and resilience, business as usual for the owners and operators of critical infrastructure assets.

On 12 August 2022, Energy Ministers agreed to identify and declare transmission of national significance which included the actionable projects in the Integrated System Plan and specifically identified VNI West (via Kerang) and Humelink. The proponents and designers of these projects, AEMO and TransGrid now have these legal responsibilities. A single point of failure (SPoF) is a flaw in the design, configuration, or implementation of a system, circuit, or component where just one malfunction or fault causes the whole system to stop working. According to the Australian Energy Market Commission (AEMC), increasing the degree of interconnection means that there are fewer SPoF which is important for both system security, resilience and reliability. According to Appendix 8 of AEMO's 2020 Integrated System Plan (ISP) energy systems are normally designed to avoid SPoF's. AEMO claims that transmission lines are separated over multiple, diverse corridors using meshed

**Threat to the Security of Electricity Supplies to Victoria and NSW
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designs. The AEMC and AEMO requirement to avoid SPoF's in transmission network design has not been applied to Humelink and WRL-VNI West or the remainder of the Super-grid being developed and designed by AEMO in the Integrated System Plan (ISP).

4. Design of WRL – VNI West Project and Humelink

AEMO, together with TransGrid have designed and are implementing the WRL – VNI West project that stretches ~800 km from Melbourne to Wagga Wagga, NSW via Bulgana, New Kerang and Dinawan substations. It then connects to TransGrid's Humelink Project which runs 360km to Bannaby substation (130km from Sydney) via Snowy 2.0 power station. AEMO's ISP predicts that ~11,000MW of existing and new power generation will depend on that Super-grid to reliably transmit their electricity to Melbourne and Sydney just 8 years from now. This will comprise 6,500MW connected to WRL-VNI West and 4,500MW connected to on Humelink.

As illustrated in TransGrid's figure alongside, the design has a single tower on a single easement, with each tower supporting two transmission circuits, on each side of the tower. This is called a double-circuit (D/C) transmission line. Each circuit is rated at ~ 3,000MW of electricity which is ~60% of the total average electricity demand of Victoria and 40% of NSW. There will be approximately 1,750 D/C transmission towers supporting the 800 km of WRL-VNI West, and 800 supporting Humelink, each tower being a SPoF should that tower fail. Australia's uses an N-1 security criteria for planning and operating its power system so that the failure of any single part of the grid will not cause load-shedding, however this does not include the failure of a single tower causing both D/C transmission circuits to fail. Other countries invariably consider a D/C transmission line failure as N-1. Should both circuits fail (as occurs from time to time with a D/C line), there will be no transmission capacity across that part of WRL-VNI West or Humelink. The power will immediately transfer to the parallel 220 kV or 330 kV transmission network, causing it to overload and trip resulting in a cascading collapse of the southern Victorian or southern NSW power systems. Given the large power flow on WRL-VNI West, the cascading collapse is likely to black-out greater Melbourne and the Portland smelter and the rest of southern Victoria. In the case of NSW, Humelink is rated at 2,200MW, the loss of which will immediately cause the Queensland – NSW interconnection to overload and trip, which combined with the loss of Humelink, is almost certain to result most of NSW being blacked-out including greater Sydney and the Hunter Valley aluminium smelters. If aluminium smelters are without electricity for more than about 8 hours, they are abandoned.



5. AEMO, and TransGrid were formally advised of the severe risk to power system security

AEMO, TransGrid and the AEMC Reliability Panel have been formally advised of this severe risk to Victoria's electricity supply in the Mountain/Bartlett submission to the VNI West Consultation report in April 2023; and in the Mountain/Bartlett Plan B submission in August 2023, and in two emails to the Chairman of the AEMC Reliability Panel in March and April 2023. The later were not even acknowledged and the responses from AEMO/TransGrid were technically incorrect and included:

- (a) towers will not fail, despite actual failures proving otherwise, the increasing intensity of natural disasters (e.g., severe lightning, wildfires, extreme winds, floods, sabotage). AEMO publicly accused Mountain/Bartlett of being "reckless" in mentioning this serious risk in a public submission, in an apparent attempt to discredit their reputation and their submission

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- (b) “Special control schemes” will prevent this from happening, however protection schemes will instantaneously switch-out both circuits to protect life and property well before any control scheme can possibly operate. AEMO/TransGrid’s response demonstrates ignorance of the difference between protection and control of the power system, and flippantly rejects the certainty that the Victorian power system will collapse
- (c) Stating that the parallel 220kv and 330 kV lines would be able to carry the power transferred from both tripped 500 kV lines. This ignores the certainty that the parallel lines would overload and be automatically switched out or that voltage and transient instability of the power systems would occur even before the protection schemes can operate.
- (d) The power will instead be carried by the existing Victoria NSW Interconnection (VNI), which is incorrect as that line does not connect to any of the 6,500MW of generation to be serviced by WRL-VNI West
- (e) TransGrid’s Humelink proposal to eliminate severe lightning failures using surge arrestors and improved tower footing resistance is invalid for severe, “steep-fronted” lightning strikes that will result in simultaneous “double back flashovers” occurring on both 500 kV circuits regardless
- (f) TransGrid’s proposal to de-load Humelink whenever bush-fires approach the power line will still mean that both 500 kV circuits will be held to low power transfers whereas locating the 500 kV circuits on geographically separate easements will avoid this happening.

AEMO and TransGrid have consistently failed to acknowledge the outcome is almost certainly to be the collapse of the Southern Victorian power system, followed by a lengthy manual system-restart taking days, noting that AEMO has no plan or experience in restarting a primarily renewable power system.

5. What could bring down any of the 2,550 D/C transmission towers?

Severe lightning: AEMO issues market notices, sometimes, many times a day for severe lightning tripping both circuits of a D/C transmission lines. A positive-voltage lightning strike often occurs with no prior storm warning, so it is impractical to take prior precautions

Wildfires: have caused multiple transmission lines on the same easement to trip, one resulting in ~ 250,000 Victorian electricity users having their electricity supply automatically interrupted without warning. Transmission lines must be switched off when fire-fighters are near transmission lines, yet AEMO and TransGrid have not considered this in locating the D/C line on a single easement in fire-prone areas.

Flood damage: has and will undermine the foundations of transmission towers causing them to collapse or flood debris can bring down transmission towers. VNI West is being routed through flood-land in many places, yet this risk does not appear to have been considered in planning the route for VNI-West.

Sabotage: has and will occur, as recently as May 2023 when bolts were removed from a tower base causing it to collapse near Perth. There have been similar instances in the past in other states, including using high explosives to blow the legs off transmission towers. The UK Government Register now rates the likelihood of an attack on its energy network 5% to 25% likely during the next two years.

Destructive Winds: have collapse 233 transmission towers in Australia and NZ in the last 65 years, including seven 500kV D/C towers in Victoria in 2020 that nearly resulted in permanent damage and closure of the Portland aluminium smelter. Transmission towers are not built to withstand extreme winds and the intensity of destructive winds are increasing with climate change.

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These risks are real and cannot be ignored, as being done at present by AEMO and TransGrid in planning WRL – VNI West and Humelink. This appears to be reckless disregard for known risks with extreme consequences.

6. AEMO and TransGrid acknowledge this power system security risk

Section 4.1 of TransGrid's 2023 Annual Planning Report acknowledges that TransGrid is planning the NSW Super-grid for "cascading outages with system-wide impacts", potentially resulting in a state-wide blackout, and foreshadows adopting a new "N-1 Secure planning criteria". This will be too-little, too late, as the D/C design will be locked-in. No amount of N-1 secure planning/operation can change the certainty of state-wide, blackouts, unless the Super-grid is then duplicated which is impractical. AEMO's July 2022 Power System Frequency Risk Review acknowledges in Recommendation 10 that a non-credible outage of the Western Renewables Link would cause a cascading collapse of the transmission network supplying Southern Victoria including greater Melbourne and the Portland aluminium smelter. Despite undertaking to consider that serious risk in the planning process, AEMO has since committed to VNI West which will vastly increase the amount of electricity to be transmitted across WRL and virtually ensure that a D/C fault on WRL must result in blacking out southern Victoria.

7. Learning from the past

A review of the historical development of the Victorian, NSW and other state's transmission networks shows that never before, has a higher voltage, higher capacity super-grid, been built using D/C transmission lines located on a single transmission easement. All have adopted secure and resilient transmission network designs by building single circuit transmission lines (not double circuit lines) located on geographically separated easements (not a single easement) to avoid these unacceptably high power system security risks. Only when the network had developed to the stage it had sufficient resilience and redundancy, were lower-cost D/C lines used along lower risk routes. D/C lines are ~ 20% lower-cost but have been rejected by the planners of Australia's transmission networks in the past, and this is even more justified with the increased climate risks and Australia's growing dependency on long distance transmission. TransGrid adopted D/C lines for Humelink in their July 2021 PACR, even though the saving was only 5% to build the highest-risk 228kms of the route as D/C and only 22% savings for the entire route. TransGrid only considered lightning and bushfire risks and even then, their justification for adopting D/C lines was invalid as demonstrated in (e) and (f) above. TransGrid did not consider the risks of extreme winds, flooding or sabotage and gave no benefit for the much higher security of single-circuit 500kV transmission lines located on separated transmission easements.

8. Conclusion

Through its ongoing development and defence of both the WRL and VNI West projects, AEMO appears to have blatantly neglected its responsibilities under the SOCI Act, the SLACIP Act and its own Resilience and Climate Change report. A loss of the WRL – VNI West interconnector would result in the majority of generation in western Victoria and imports from NSW being instantly separated from southern Victoria resulting in a cascading collapse of the southern Victorian power system, blacking out greater Melbourne and the Portland smelter. A similar risk to electricity supplies to most of NSW including greater Sydney and the Hunter Valley smelters is created by the design of Humelink. Is this not 'reckless' by design?

Investing in the necessary infrastructure and technology to avoid single points of failure in electricity transmission can cost an additional 20% in the short term but can save a significant amount of money and prevent massive disruptions in the long run. It is, therefore, essential for transmission planners to prioritise security, reliability, resilience, and redundancy in their electricity transmission systems. This is something that has not occurred in planning and developing WRL – VNI West, Humelink and the rest of the 500 kV Super-grid for eastern Australia.