Submission
No 29

INQUIRY INTO FEASIBILITY OF UNDERGROUNDING THE TRANSMISSION INFRASTRUCTURE FOR RENEWABLE ENERGY PROJECTS

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Legislative Council
Standing Committee on State Development
Via online submission

RE: Inquiry into the feasibility of undergrounding the transmission infrastructure for renewable energy projects

Dear Sir/Madam,

The Inquiry into the feasibility of undergrounding the transmission infrastructure for renewable
energy projects were established on 22 June 2023 to inquire into and report on the feasibility of
undergrounding the transmission infrastructure for renewable energy projects.

The Terms of Reference indicate that the Standing Committee on State Development inquire into
and report on the feasibility of undergrounding the transmission infrastructure for renewable energy
projects, with particular reference to:

a) the costs and benefits of undergrounding,
b) existing case studies and current projects regarding similar undergrounding of transmission
lines in both domestic and international contexts,
c) any impact on delivery timeframes of undergrounding, and
d) any environmental impacts of undergrounding.

About the author

Attached is a summary of my qualifications and professional experience in electricity transmission in Australia and overseas that demonstrates that I am one of Australia's most respected independent experts recognised by national and international awards including Member of The Order of Australia for services to the electric power industry. My 50 years' experience includes the planning, development, operation and maintenance of the electricity networks in Queensland and South Australia, and serving on international Cigre study committees and task forces, the global society for knowledge sharing in all aspects of electricity transmission. I recently served on Cigre Task Force B4.77 at the cutting edge of the integration of massive amounts of renewables into conventional power systems using HVDC VSC MMC technology.

Preamble on undergrounding

Traditionally global and Australian power systems have used overhead high-voltage-alternating-current (HVAC) technology due to its low cost and high-power characteristics. Undergrounding HVAC is feasible for distances up to ~ 30kms. Although costing around 5 to 10 times the cost of overhead lines, undergrounding HVAC has been justified on the main grid when land-use conflicts demanded undergrounding. In Australia, this has invariably been in urban areas except for the cable to the desalination plant in Victoria. I have been involved in 4 such projects (3 in Qld and 1 in South Australia) as well as investigating many more. There is now growing pressure for undergrounding new powerlines through sensitive environmental areas (e.g., Snowy Mountains National Park) and to reduce the adverse socio-economic impacts when traversing high value agricultural land, areas of scenic amenity or where strong opposition to overhead lines prevails (hence this inquiry). In more densely populated and affluent countries (e.g., Europe, UK and Japan and many more) undergrounding extensions to the main grid are now the standard practice along with the use of High Voltage Direct Current (HVDC) Voltage Source Converter (VSC) technology. These two technologies go hand-in-hand as HVDC VSC transmission lines are far more amenable to undergrounding than HVAC lines. Costs are typically only 2 to 3 times as much as overhead, and the line can be undergrounded as frequently along a route and for as far as needed in each case. The standard practice in the UK is now to use off-shore HVDC-VSC underseas cables due to the difficulties now being encountered on the land.

Australia is lagging well behind international best practice, knowledge and experience both in terms of undergrounding and especially the use and benefits of HVDC VSC technology. Other than TasNetworks and Amplitude Consultants, there is almost no knowledge of HVDC VSC in Australia. In fact, AEMO and the other TNSP's are unaware of the key role for this technology in the massive integration of renewables into Australia's power systems. Proof can be found in AEMO's Draft 2023 Transmission Expansions Options Report, issued 2 May 2023, that contained the most appalling assumptions on all their HVDC options every imaginable. The Inquiry needs to bear this in minds when considering submissions on undergrounding from these parties.

Despite the TOR for the Inquiry, not specifically mentioning HVDC, it goes without saying that this is an integral and key part of considering the partial or full undergrounding of the main grid in Australia.

Another dimension of HVDC that must be considered by the inquiry is the conversion of existing HVAC powerlines to HVDC VSC lines using the existing easement, transmission towers and wires. The only new equipment needed is to replace the insulators (attaching the wires to the towers) and to install converter stations at either end (or at the end of new underground cables connecting to the overhead line) to convert HVAC into HVDC. The 2000MW Ultra-Net project in Germany is a real-world example of this optuion, scheduled to be commissioned later in 2023. There is no apparent reason, that the same solution could not be used in Australia, in many applications – e.g., from Melbourne to Sydney using existing power lines to take the place of WRL, VNI West, Humelink and Sydney Ring 500kV new transmission projects.

This submission will provide further information of these broader aspects of undergrounding transmission in Australia.

The Case for Undergrounding in NSW and Victoria

The community opposition to overhead transmission lines in NSW and Victoria has already added some $m4bn to the cost of AEMO's proposed 500kV interconnector between Melbourne and Sydney (being planned in 4 sections WRL, VNI West, Humelink and Sydney Ring). This is seen by comparing the ~600km length of the most direct/shortest route in grey/mauve between Bannaby-Murray-Derdarang-South Morang with the 1,100km latest route in fine black Bannaby-Wagga Wagga-Darlington Point-Dinawan-Kerang-Bulgana-Melbourne. The extra 500+ kms at $8m/km has increased the cost by some $bn4. Doubling the route length has also halved its transmission capacity, making it almost useless.

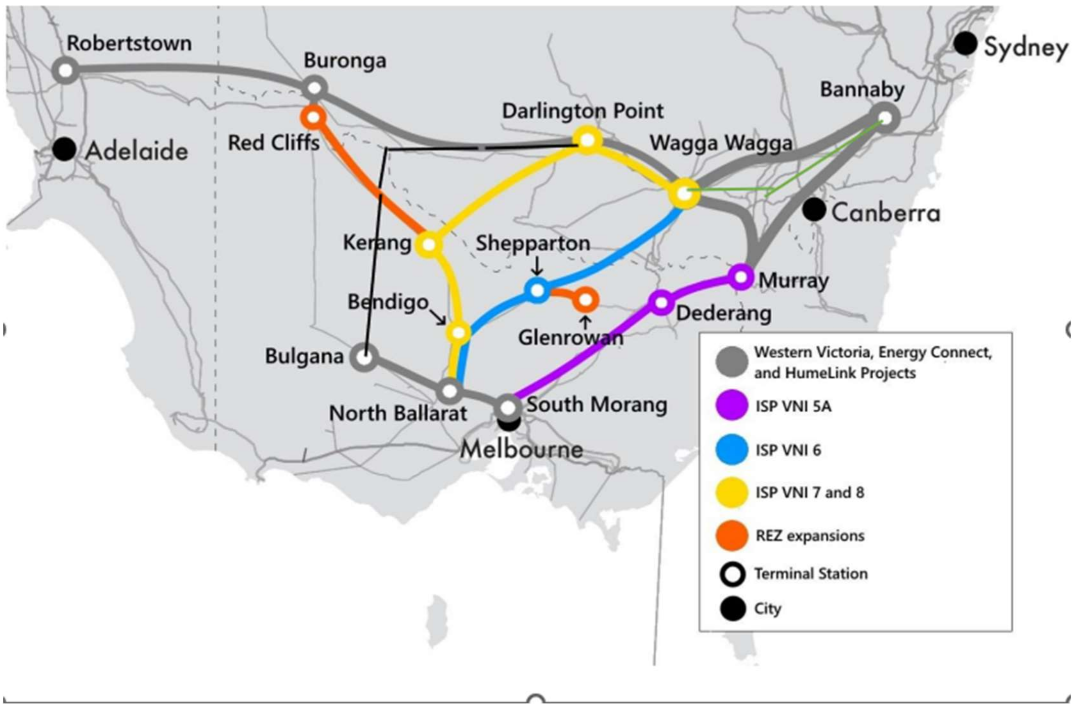
The mauve route is the existing 330kV VNI interconnection. Using the Ultra-Net approach, it could be converted to HVDC, extended to Sydney by undergrounding or converting another HVAC powerline to HVDC, delivering much more capacity. This would obviate the need to underground parts of Humelink, VNI West and WRL. Instead, the existing regional 220kV and 330KV HVAC radial lines could be rebuilt on their existing easements at a fraction of the cost and without resuming easements.

Other advantages of undergrounding with HVDC VSC technology or converting existing HVSC lines to HVDC VSC.

As demonstrated in Europe, UK, China, and India HVDC VSC is their proven technology for integrating large amounts of variable renewables into the conventional power system. Some of the many reasons include:

(a) HVDC VSC is controllable so the amount of power to be transmitted can be accurately set, adjusted and limited. This is a major advantage compared

Figure 1 Map of credible options



with HVAC, especially where there are parallel HVAC paths with uneven distribution of power, and a real risk of overloading, and tripping one patch when there are unexpected events on the power system. These are called loop-flows and in the case of Project Energy Connect, running in parallel with the Heyward interconnection and VNI, there are going to be very substantial issues that will prevent the achievement of their full planned interconnector capacities. Converting PEC to HVDC, even now, would eliminate these operational limitations

(b) HVDC VSC will not be part of cascading power system collapses. The NM and overseas interconnected HVAC power systems fail by a sequence of cascading overloading or under-voltages across the power system like a stack of dominoes. This does not occur with HVDC VSC interconnections

(c) HVDC VSC can black-start remote, weak power systems. In the event that the power system at one end of an HVDC VSC interconnection totally collapses with a total black-out, the HVDC interconnection can relatively quickly re-start that region using power from its other end. This will be more important in the future as the NEM's current back-start sources close down in the transition.

(d) Flexibility and low cost of undergrounding with HVDC. An HVDC powerline can be easily and cheaply undergrounded and for indefinite lengths, Typically the additional cost of undergrounding would be around doubler the cost of overhead lines depending on the circumstances

(e) Mush lower visual impacts of HVDC overhead lines. HVDC overhead lines have half the number of wires (i.e., conductors) of HVAC lines, and their transmission tower therefore much simpler and are less ugly. Depe4nding on the tower design, they can be erected much quicker

(f) No alternating w=electro-magnetic fields. The electro-magnetic fields generated by HVDC lines do not vary at 50 cycles a second, but are constant like the earth's magnetic field. This eliminates landowners' potential concerns about harmful health effects such as childhood leukemia

(g) Source of high frequency harmonics and sub-synchronous resonance. HVDC VSC inverters-converters can us Multi Modular Converter technology to become what is termed grid-forming inverters. This generates a perfect sinusoidal voltage wave form unlike the "chopped" wave-form of conventional inverters. This eliminates serious technical issues caused by the harmonics that have been plaguing weaker power systems including in growing parts of the NEM. There have also been reports of premature failures of power system equipment including transformers, reactors and cables from these harmonics.

(h) Deep connection issues frequently occur when a new HVAC network, with a higher voltage is built in parallel with a lower voltage HVAC network (e.g., 500kV in parallel with 330kV or 220 kV This can cause overloading and tripping of transmission lines and equipment deep within the lower voltage power system. An example of this will be as soon as PEC or VNI West are energised, that will constrain off-line generators and impose artificially low transmission limits.

Many of these technical issues can be avoided or mitigated by the undergrounding using HVDC VSC (MMC) technology of new powerlines.

Discussion and Clarification

Should the inquiry require clarification or desire to discussed any of the above or related material, I can be contacted on mobile or email Should I be required to present to the inquiry, I would be willing but would have to commute from Brisbane

Yours sincerely

Simon Bartlett