Submission No 81

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

Organisation: Monash Energy Institute, Monash University

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MONASH University

MONASH ENERGY INSTITUTE

Feasibility of Undergrounding the Transmission Infrastructure for Renewable Energy

Parliament of New South Wales

via email to: undergrounding.infrastructure@parliament.nsw.gov.au

From: Monash Energy Institute, Monash University

27 November

Dear Committee Members,

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

The Monash Energy Institute is pleased to present the diversity of Monash University's specialised expert insights on the Inquiry concerning the feasibility of undergrounding the transmission infrastructure for renewable energy projects. The core activities of the authors of this response include conducting rigorous research on energy transition topics and educating students comprising both future and current industry professionals.

This paper includes preliminary results from a capacity expansion model developed to identify the optimal combination of electricity generation, transmission, and storage systems. We welcome the opportunity to conduct a more rigorous study.

The effective implementation of transmission projects while addressing the potential repercussions on communities, is critical. We thank this Select Committee for the opportunity to provide input based on our academic experience.

Community participation/ involvement
Prof. Yolande Strengers

Decades of research with consumers and households on energy transition issues indicates that people are keenly interested in contributing to the energy transition but do not understand many of the current decisions being made. Critical to any energy transition project is clearly communicating the vision and purpose and canvassing the options and potential solutions with communities[1]. In general, our research suggests that households are more supportive of placing distribution and transmission infrastructure underground than aboveground for a range of reasons, such as to reduce bushfire and storm risks or minimise aesthetic impacts on the landscape. However, they are unlikely to be aware of the costs associated with this preference. They may also be unaware of the disruption and potential impact on local places and communities during the construction process of undergrounding transmission infrastructure. Engaging in an open dialogue with affected communities will be essential to ensuring positive social outcomes that support the broader energy transition.

Additionally, Indigenous communities will have their own views and rights on the location, process and impact of undergrounding transmission lines as traditional custodians of the land.

[1] Engaging households towards the future grid - an engagement strategy for the energy sector.

Monash University capacity expansion modelling

A/Prof Roger Dargaville and Dr Changlong Wang

Monash has developed a capacity expansion model that finds the optimal electricity generation, transmission, and storage systems for a given set of demand projections and carbon constraints. Using the AEMO Integrated System Plan technology cost projections and government emission targets, we ran the model for a standard overhead transmission scenario and compared it with a scenario where all new transmission capacity was assumed to be underground. Undergrounding transmission typically costs more than overhead lines. Estimates suggest it can range from 4-10 times as expensive, depending on region and project specifics. If we conservatively assume four times higher costs for undergrounding, our preliminary modelling results show:

- It can disincentivise wind adoption as the best resources tend to be in more remote locations.
- It may shift the optimal mix of investments more heavily toward solar generation closer to load centres (cities) and require additional storage solutions.
- It increases the average wholesale plus transmission costs of electricity by 18% (30-year average system long-run margin costs).

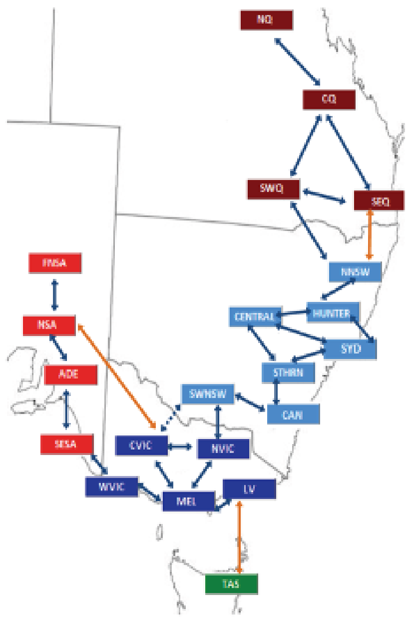

Figure 1: Map of the 21-node NEM transmission network simulated in the MUREIL scenarios. Orange lines represent HVDC links, while blue represents conventional HVAC. Dashed lines are under planning/construction.

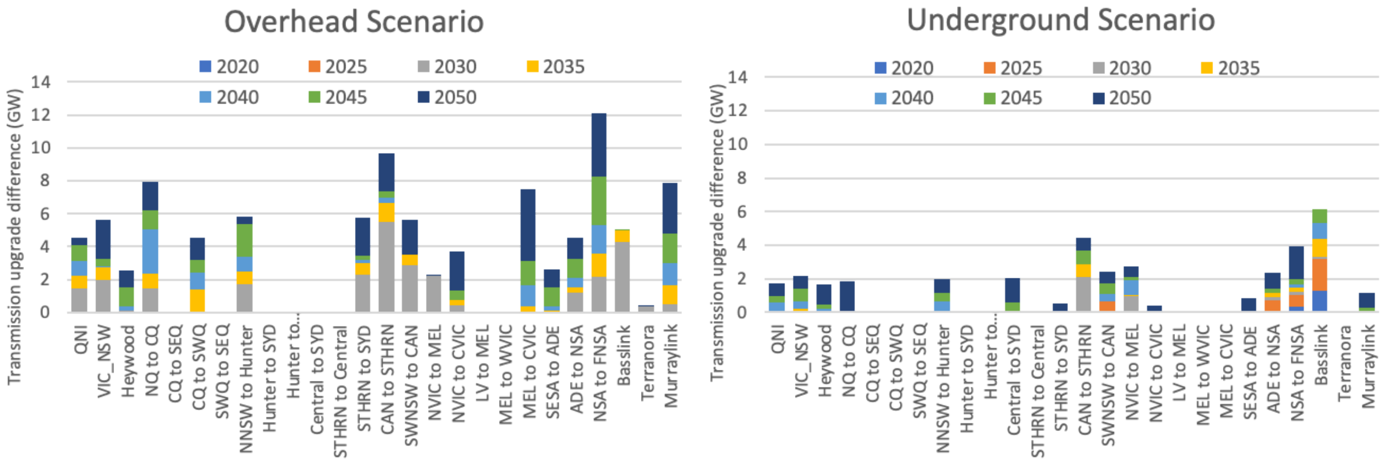

Figure 2: New transmission capacity required in the conventional overhead scenario (left) and the underground transmission scenario (right). In the overhead scenario, massive increases in transmission capacity are built, for example, 8 GW to connect Northern Queensland to Central Queensland (NQ to CQ) and 12 GW in South Australia (NSA to FNSA). Considerably less transmission infrastructure is built when the underground transmission costs are significantly higher than aboveground lines. This results in more generation capacity being built close to load centres, and higher reliance on energy storage.

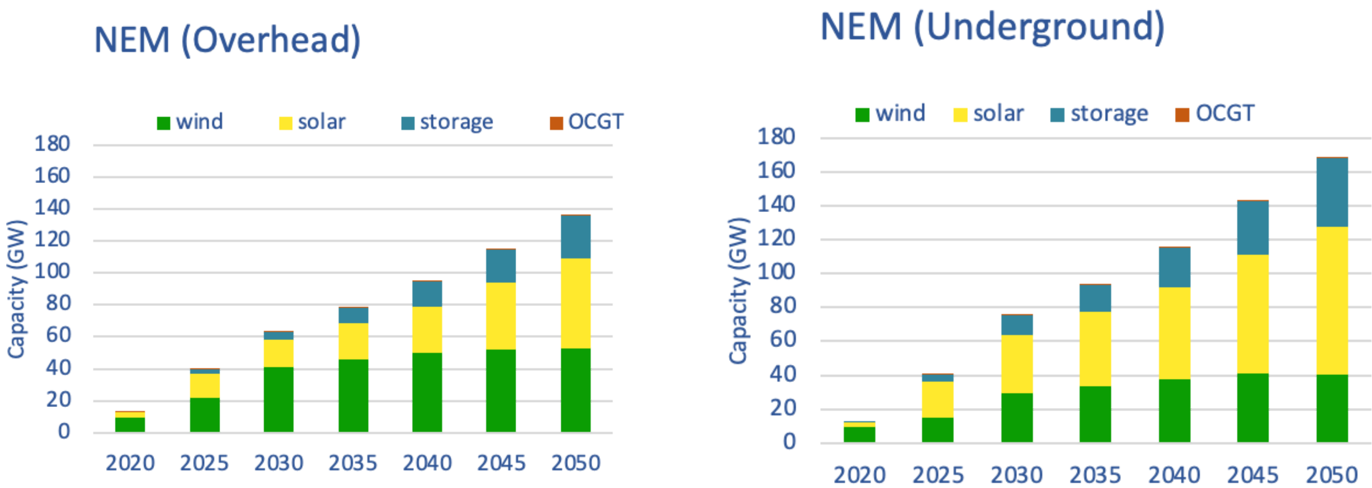

Figure 3: Total new renewable energy generation capacity for the standard overhead transmission scenario (left) and the generation capacity with underground transmission (right). In the underground scenario, significantly more generation capacity is required (~28 GW), partly as lower quality resources are economically accessible and partly due to the reduction in geographic diversity that leads to a higher storage requirement with inherent inefficiencies.

Engineering and construction considerations

Dr Ross Gawler and Mr Shreejan Pandey

- Engineering designers commonly use a risk matrix to assess considerations, favouring underground cables in high bushfire risk areas for risk mitigation. The decision between overhead and underground is influenced by comparing costs with benefits and risks, including potential damage to life and property.
- Significant underground excavation in forested areas to prevent bushfires impacts wildlife habitat and native bushland, requiring case-by-case assessment.
- Geographical and geological conditions notably impact deployment costs. E.g. overhead transmission in rolling hill country requires less access infrastructure than undergrounding.
- Underground cables have higher capacitive reactive power generation per km than overhead transmission lines, requiring expensive segmentation and compensation with shunt reactors for long distances.
- Considering DC undergrounding for long-distance transmission is an option, but costs must be weighed against those related to AC-DC conversion at each end.
- Cable joints in underground transmission have a higher failure rate than those in overhead lines. Fault finding and restoration in underground transmission is more complex and challenging than in overhead lines, leading to a higher risk of extended power outages.
- The geology of the underground can vary significantly along the cable's length, requiring the design to account for worst-case scenarios, leading to potentially significant cost escalation for the cable.
- Lack of information on existing buried services (gas, water, fibre etc.) can delay design and construction timelines.
- While undergrounding, the discovery of buried artifacts will require alteration in design to preserve history and/or significant cultural heritage.

Case studies

Dr Ross Gawler and Mr Shreejan Pandey

Richmond-Brunswick 220kV

The Richmond-Brunswick 220kV underground powerline is a valuable case study into underground power lines' engineering and social aspects. It was planned in the 1980s as an overhead line built along roadway easements. Subsequent objections by the local community led to a lower-rated, much higher-cost underground cable. The higher cost was eventually accepted and justified because of the visual amenities in a built-up area of the inner city. The cable was essential to maintain the security of supply to the central business district in Melbourne. Information is available at the State Library of Victoria[2].

California Utility Pacific Gas and Electric Co.

In 2021, PG&E announced plans to underground 10,000 miles of its power lines to reduce bushfire risk. The announcement responded to several years of significant damage to life, property, and the environment from electrical transmission lines ignited bushfires. The project is expected to cost between $15 and $30 billion and expects to deliver a safe and resilient system to be paid for by customers. California Public Utilities Commission’s assessment states aesthetics, enhanced safety

[2] Proposed 220 kV transmission line Brunswick-Richmond environment effects statement (vgls.vic.gov.au)

and reliability to be the main benefits of undergrounding and that converting overhead infrastructure to underground is up to 10 times more expensive than installing new overhead lines[3].

Other related matters

A hybrid solution could be feasible, weighing factors such as safety, risks, economics, and community considerations.

Expert bios

Prof. Yolande Strengers

Yolande Strengers is a digital sociologist and human-computer interaction professor investigating the sustainability and inclusion impacts of digital and smart technologies, including emerging forms of AI. At Monash University, she Co-leads the Consumers theme at Monash Energy Institute and leads the Energy Futures research program in the Emerging Technologies Research Lab, which undertakes critical interdisciplinary and international research into the social, cultural and experiential dimensions of the design, use and futures of new and emerging technologies.

A/Prof. Roger Dargaville

Roger Dargaville, Acting Director of the Monash Energy Institute, works on energy system integration, understanding the optimal combination of different technologies to achieve a low-carbon, affordable and reliable electricity system.

Dr Changlong Wang

Changlong is a postdoctoral research fellow at Monash University. In his PhD, he developed a capacity expansion model to optimise the electricity generation, transmission, and storage systems simultaneously. Changlong is one of the key developers of the Hydrogen and Green Steel Economic Fairways Mapper, for which his team won the 2023 Australian Museum Eureka Prize for Innovative Research in Sustainability.

Dr Ross Gawler

Ross Gawler's professional experience has spanned the technical and economic factors in developing and operating electricity generation and transmission. His professional goals have mainly centred on conducting realistic economic and risk analysis, leading to effective investments in generation and transmission assets.

Mr Shreejan Pandey

Shreejan Pandey has a power systems engineering background and considerable experience designing overhead and underground high-voltage transmission systems. He is the Director of Strategic Initiatives and Partnerships at Monash Energy Institute

Attachment

- *Preliminary MUREIL modelling results, Overhead vs. underground transmission by Dr Changlong Wang and A/Prof. Roger Darvaille, 27 November 2023*

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[3] CPUC Undergrounding Programs Description