Submission
No 102

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

Organisation: Transgrid

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Friday, 14 July 2023

The Hon Emily Suvaal MLC
Committee Chair
Standing Committee on State Development
Legislative Council
NSW Parliament House,
Macquarie Street
SYDNEY NSW 2000

Dear Ms Suvaal

Thank you for the opportunity to provide a submission in response to the New South Wales (NSW) Legislative Council Standing Committee on State Development inquiry on the feasibility of undergrounding the transmission infrastructure for renewable energy projects.

Transgrid is the operator and manager of the high voltage transmission network connecting electricity generators, distributors, and major end users in New South Wales (NSW) and the Australian Capital Territory.

Our responsibility is to operate and manage the transmission network safely, securely, and efficiently in the long-term interests of consumers.

Transgrid's projects form the future energy superhighway - at the centre of the nation's rapid renewable transition. It will supply clean, affordable, and reliable energy to millions of Australians.

This submission sets out our views in relation to the feasibility of undergrounding the transmission infrastructure for renewable energy projects in relation to the inquiry's terms of reference.

We look forward to continuing to support the NSW Government to build the grid to successfully transition to renewable energy. If you would like to discuss this submission, please contact Emma Ashton on

Yours sincerely

Marie Jordan
Executive General Manager - Network

Transgrid

People. Power. Possibilities.

Legislative Council Standing Committee for State Development inquiry into the feasibility of undergrounding transmission for renewable energy projects

Submission

14 July 2023

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Executive Summary

Australia is currently undergoing a once in a generation transformation of the energy sector, where traditional fossil fuels are being replaced by renewable energy.

Transgrid is actively working with a broad range of stakeholders to plan for this future including Governments, supporting the NSW Electricity Infrastructure Roadmap and the Australian Energy Market Operator's Integrated System Plan - which is a comprehensive roadmap for the National Electricity market.

Transgrid's nation-critical transmission forms the energy superhighways that play a vital role in facilitating the movement and sharing of clean energy across NSW and neighbouring states. The energy superhighways will support the transition to a sustainable energy future by enabling the integration of renewable sources, improving energy affordability, and ensuring a secure and reliable electricity supply for millions of Australians.

The next decade is critical to the expansion of our grid, and the timely delivery of projects is essential to underwrite energy security. The June 2022 energy market crisis demonstrated the current system's lack of resilience and the high consumer cost of disruption.

Australia also has an opportunity to capitalise on our abundant natural resources to drive economic growth, create new industries and jobs and become a renewable energy superpower. Many of these jobs will be located in regional Australia supporting the infrastructure construction and operation of generation, storage, and transmission.

As this decarbonisation of the sector occurs, local communities are raising concerns about the impacts of transmission infrastructure in their areas. As such this inquiry is examining the feasibility of undergrounding the transmission infrastructure for renewable energy projects.

Undergrounding transmission infrastructure can minimise visual impacts however, there are technical challenges relating to long-distance transmission lines, which collect and transport renewable energy along the route. Other limitations to undergrounding include significant cost increases, delivery timeframes and environmental and construction impacts.

Under the regulatory framework, Transmission Network Service Providers (TNSPs) are responsible for planning and proposing infrastructure projects for the transmission of electricity. When undertaking such projects, TNSPs are required to consider the long-term interests of electricity consumers in terms of price, quality, safety, reliability, and security of electricity supply. This ensures that the proposed transmission route is designed to meet the needs of consumers in an efficient and sustainable manner.

Transgrid recognises the significance of meaningful community engagement. Transgrid involves local communities in the decision-making process, allowing their concerns to be raised and addressed. By engaging early and regularly with various stakeholders, including landowners, residents, first nations representatives, local councils, and government agencies, Transgrid remains committed to understanding and considering the perspectives and needs of the communities impacted by major infrastructure projects. Transgrid will provide a significant and lasting positive social legacy to people living and working near transmission assets whilst delivering critical energy transition infrastructure projects which will bring enduring benefits to the Australian community.

About Transgrid

Transgrid operates and manages the high voltage electricity transmission network in NSW and the ACT. The network connects more than three million homes, businesses and communities to a safe, reliable and affordable electricity supply. The transmission network transports electricity from generation sources such as wind, solar, hydro, gas and coal power plants to large directly connected industrial customers and the distribution networks that deliver it to homes and businesses.

Transgrid's NSW and ACT network consists of 126 substations and switching stations, 13,045 kilometres of high voltage transmission lines and five interconnections to QLD and VIC, the network is instrumental to the electricity system and economy and facilitates energy trading between Australia's largest states.

Australia's transition to renewable energy

Transmission infrastructure is critical for the energy network as we transition from fossil fuel generation to new renewable energy sources are being built in locations that have not been connected to the electricity grid before.

Australian Energy Market Operator's (AEMO's) 2022 Integrated System Plan (ISP)[1] outlines the investment in new transmission required to transition Australia to a renewable energy-based power system and highlights the need to begin 'as urgently as possible'.

This is a comprehensive roadmap for the National Electricity Market (NEM) identifies committed and actionable transmission projects with a required delivery date for supplying affordable and reliable electricity to homes while supporting Australia's net zero ambitions.

Transgrid's strategy is aligned with AEMO's roadmap to build the critical infrastructure which will reshape the National Electricity Market and will continue to drive innovation and efficiencies. This will enable greater sharing of energy between NSW, ACT, Victoria, Queensland and South Australia.

There is no transition without transmission. An expanded and strengthened transmission backbone is essential to connecting geographically spread-out renewable generators and identified Renewable Energy Zones (REZs), which will support the energy sharing between the States. This will enable cheaper, renewable electricity to flow to consumers, and importantly this supply will help lower high wholesale energy prices.

As coal-fired generation withdraws from the market, Australia will transition towards cleaner energy alternatives, such as renewable sources, to meet the demand for electricity. Electrification of homes, vehicles and industries will therefore occur in the coming decades with a forecasted increase in demand of 70% by 2050. If Australia capitalises on the potential to become a renewable energy superpower producing and exporting green hydrogen and metals, the demand for electricity could increase six times by 2050.

The Integrated System Plan (ISP)[2] outlines the new transmission that is required to deliver renewable energy to the NEM. These include committed and anticipated projects, like QNI Minor and VNI Minor, which Transgrid has completed along with Project Energy Connect, which is currently under construction.

[1] https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp
[2] https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp p

This plan also identifies actionable projects which should progress just as urgently where possible, this includes HumeLink which has a committed latest delivery date of July 2026. Other actionable projects are VNI West (Via Kerang) to be delivered by 2031 or earlier with additional support, the Sydney Ring (the Northern part is Hunter Transmission Project) and the New England REZ Transmission project.

Benefits of accelerating the delivery of transmission projects

The June 2022 energy market crisis highlighted the high costs and system risks that can occur when there is a high number of generator outages – both planned and unplanned. This risk is increasing as ageing coal units run less frequently, therefore becoming less reliable over time.

Recent media commentary has identified the transition to renewable energy is not occurring quickly enough and delays in transmission construction have left the grid vulnerable to the sudden exit of coal-fired power stations[3].

A delay of even one year in delivering new transmission projects will result in higher bills for consumers[4]. Regional interconnection supports diversity of generation fuel, technology and geography, and the sharing of energy and system services between states. This will build greater resilience in the system and help insulate from market and system shocks.

Transgrid's obligation as the NSW Jurisdictional Planner is to maintain a secure and reliable transmission system as the Australian power system transforms. The delivery of priority ISP projects is vital to ensure the power system can continue to operate stably and reliably as coal generators leave the system and as new renewables connect.

We are responding to and supporting the NSW Electricity Infrastructure Roadmap and the Australian Government's Rewiring the Nation policy which support Government's emission reduction and renewable energy targets as well as working with AEMO, the NSW Government and EnergyCo to accelerate the grid's successful transition.

Australia also has a once in a lifetime opportunity to capitalise on our abundant natural resources to drive economic growth, create new industries and jobs and become a renewable energy superpower.

Supporting domestic and global decarbonisation is good for the nation, the economy and power bills and creates an export which allows the offset of other countries emissions. A deep decarbonisation of the economy supports 41,000 electricity sector jobs across the National Energy Market this decade.

Regulatory Framework - Transmission

The National Electricity Law (NEL) establishes the overarching legal framework for the National Electricity Market and sets out the roles of governing bodies. These include the Australian Energy Regulator (AER) who is responsible for economic regulation of transmission in Australia. Under their rules, Transgrid, like all other Transmission Network Service Providers, must propose the most efficient route for transmission that is in the long-term interests of consumers of electricity with respect to price, quality, safety, reliability and security of supply of electricity.

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[3] https://www.afr.com/companies/energy/the-energy-transition-is-far-too-slow-aemo-warns-20230619-p5dhmq

[4] https://reneweconomy.com.au/even-a-one-year-delay-in-new-transmission-links-will-hurt-homes-and-businesses/

The AER holds Transmission Network Service Providers (TNSP) to these principles through the Regulatory Investment Test for Transmission (RIT-T) and regulatory submissions. As such, Transgrid's assessment of options considers relevant costs and benefits for supply of electricity to consumers including the capital cost of the solution, the ongoing operational costs, the market benefits, the expected reliability, and the costs associated with the impact on landowners, the community, and the environment.

Transgrid follows a rigorous route selection process that analyses technical, environmental, social and economic factors, including using current easements to minimise impacting new landowners. Consultation with landholders also occurs and the local community plays a key role in our route selection process. We are committed to seeking feedback to help inform our decision-making. The key steps are outlined in Appendix A.

The NSW Government is currently developing transmission infrastructure guidelines, which are expected to be placed on public exhibition in September and finalised by the early 2024. Transgrid is supportive of these guidelines as it will allow for a consistent approach on the development of transmission infrastructure across the State.

The Energy Charter, which Transgrid is a signatory to, is also examining the issue of transmission undergrounding for projects. Through the development of the Better Practice Social Licence Guideline[5], they have identified an opportunity to improve the experience of landholders and communities impacted by new transmission infrastructure. The Energy charter conducting a deep-dive exploration of how overhead compared to underground transmission designs are evaluated.

Their new #BetterTogether initiative will:

- Validate community concerns, considerations and expectations for how the viability of underground compared to overhead transmission designs should be considered.
- Co-develop a shared knowledge and evidence-base, including Better Practice approaches to assessing and evaluating social costs and mitigating impact.
- Identify and address public information and evidence gaps, sources of disinformation and practice inconsistencies.

Transgrid is participating in the development of this paper financially and with resources. Transgrid's Landowner Advocate from the HumeLink project, Rod Stowe will be working with the Energy Charter and the community.

Transgrid's role in the energy transition

Major Projects Overview

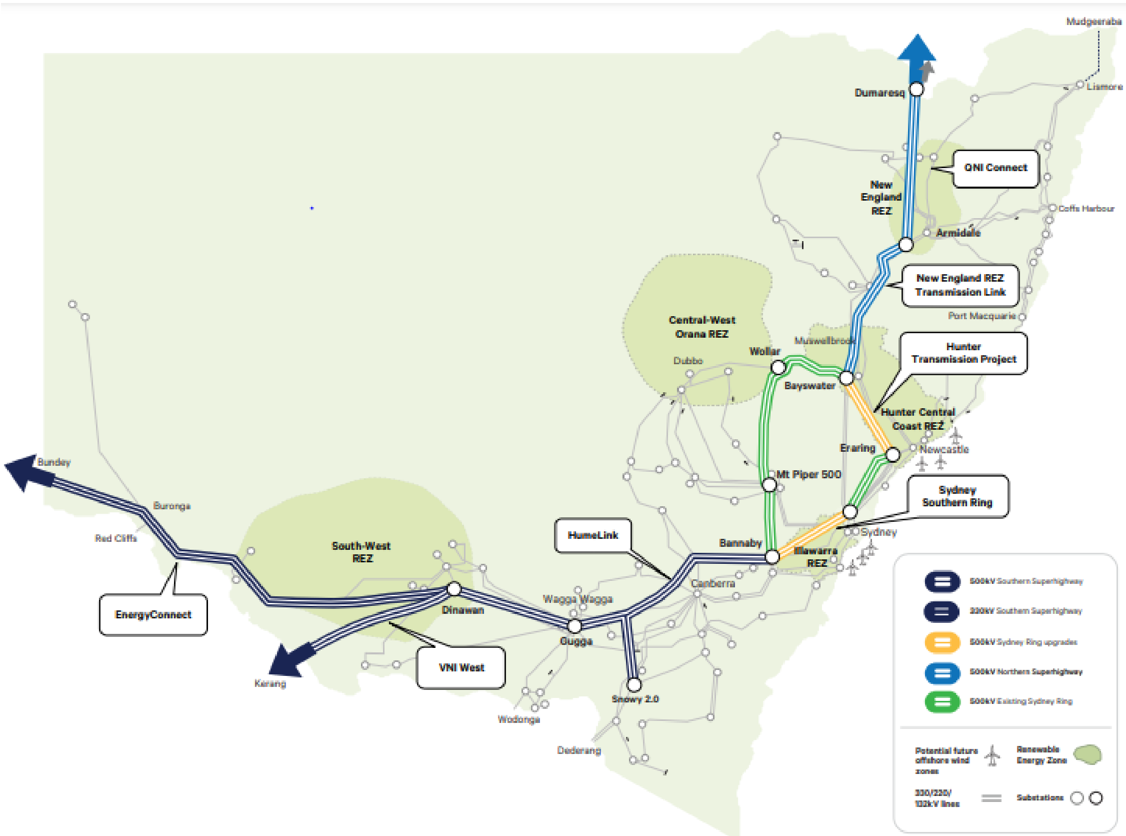
Transgrid is investing $16.5 billion in transmission infrastructure in NSW over the next decade. Our major projects will create an energy superhighway, connecting new renewable generation to a strong and flexible network.

These projects will:

[5] https://www.theenergycharter.com.au/better-practice-social-licence-guideline/#:~:text=The%20Better%20Practice%20Guide%20sets,in%20the%20management%20of%20impacts

- increase the capacity to share electricity between states.
- improve the reliability and security of electricity supply across the NEM.
- increase access to renewable energy sources.
- create an economic boost for regional communities through the provision of jobs, training and local supply opportunities.
- help achieve renewable energy targets and the overall decarbonisation of the National Electricity Market (NEM), while continuing to deliver safe, reliable and affordable electricity to consumers.

Transgrid's successful delivery of three projects, with a total value of $516 million, has played a significant role in enhancing the electricity network in key locations. These projects include the QNI (Queensland-New South Wales Interconnector), VNI Minor (Victoria-New South Wales Interconnector Minor), and Powering Sydney's Future.



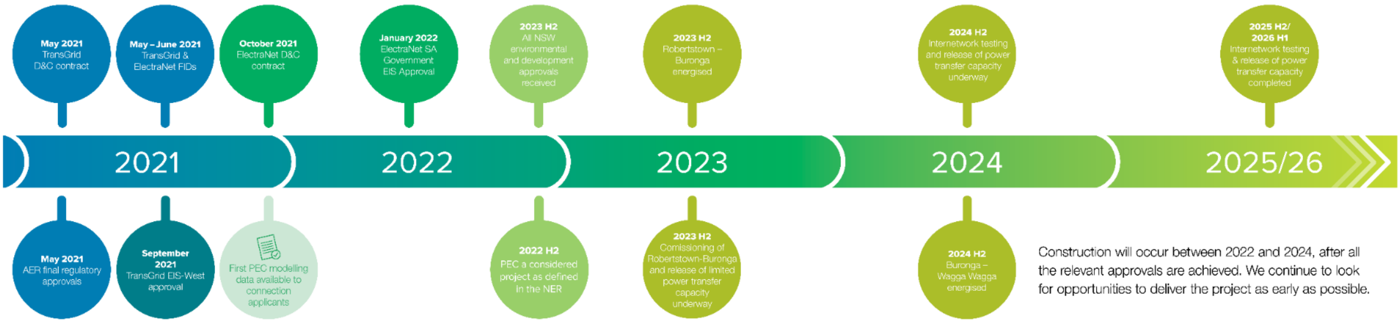
Projects Under Construction

EnergyConnect

Transgrid and its construction delivery partner SecureEnergy are progressing EnergyConnect – a 700-kilometre section of the 900-kilometre project from the South Australian border to the regional energy hub of Wagga Wagga. The project is a key element of the Australian Energy Market Operator's Integrated

System Plan. As a result, the NSW Government has declared it Critical State Significant Infrastructure (CSSI).

The new interconnector will enable the sharing of electricity between New South Wales, South Australia and Victoria; and when fully commissioned will allow for 800MW of energy shared between the State(s). The project will also save NSW energy customers $180 million a year; generate up to 1500 new jobs and will provide approximately $4 billion in economic benefits for NSW.



Projects in Development

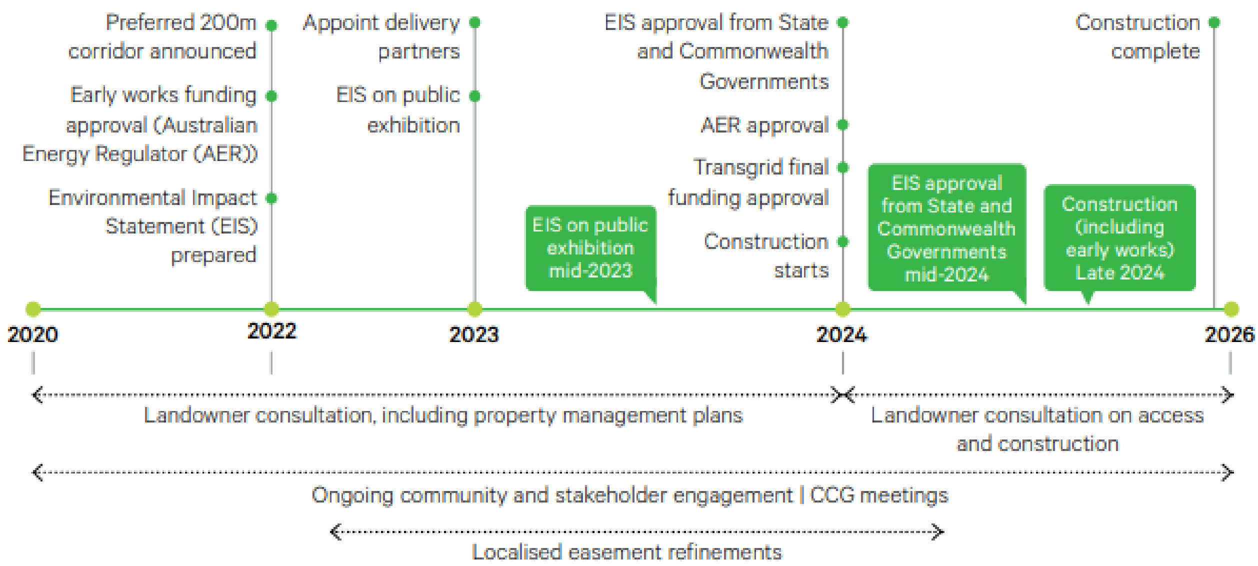
HumeLink

HumeLink is a significant investment in Australia's energy capability, increasing the amount of renewable energy that can be delivered to consumers and helping Australia to move towards a net zero future. HumeLink allows the connection of 3GW of renewables through PEC and SW REZ which includes the capacity of Snowy 2.0 (2GW).

This proposed 500 kilovolt (kV) transmission line will connect Wagga Wagga, Bannaby and Maragle and will be one of the nation's largest energy infrastructure projects, with about 360 km of proposed new transmission lines and new or upgraded infrastructure at four substations. HumeLink is critical to release of more affordable, reliable and renewable energy to the grid and is a priority project for the Australian Energy Market Operator (AEMO) and the Commonwealth and NSW Governments.

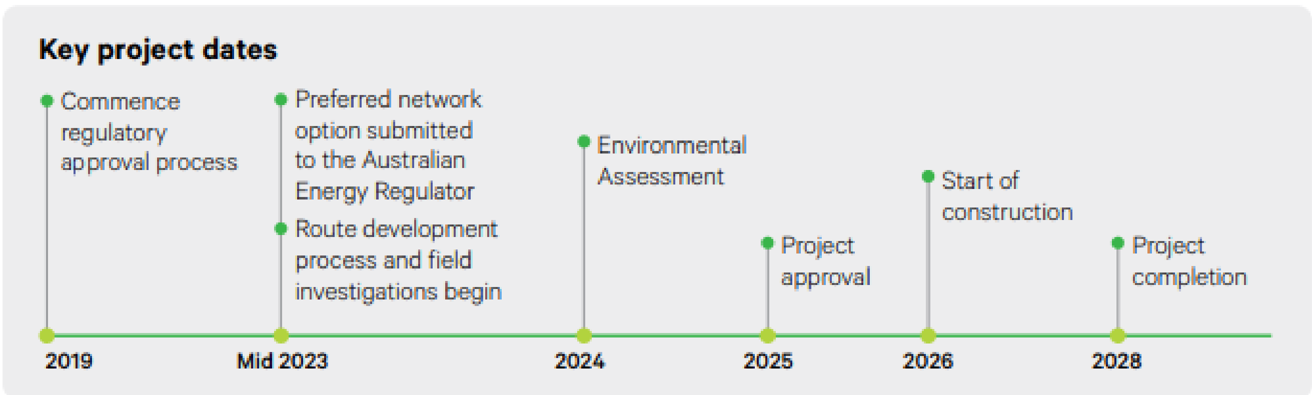
This nationally significant project will create over 1000 construction jobs, contribute to economic activity in regional NSW.

HumeLink project key dates



VNI West

The Victoria to New South Wales Interconnector West (VNI West) project is a proposed new high capacity 500 kilovolt (kV) double circuit overhead transmission line, connecting Western Renewables Link (WRL) in Victoria to EnergyConnect in New South Wales. The project will provide a vital new transmission line to link renewable generators and ensure reliable, affordable power as Australia transitions to clean, low-cost renewables, delivering an additional network capacity of 1935MW from Victoria and NSW and 1669 MW from NSW to Victoria.



*The above dates are indicative only and subject to change. Transgrid is working to achieve the objectives of the Federal Government's Rewiring the Nation plan and deliver the benefits of this project to the National Electricity Market (NEM) by 2028.

Community Engagement

Transgrid is committed to continuously improving our engagement with local communities to support our decision making. Transgrid's aim is to deliver tangible and lasting community benefits, while progressing our construction projects and meeting the infrastructure deadlines. Our community engagement policy[6] outlines our ambition to listen, respond and work with communities to ensure their views are embedded into our decision making.

We also seek to understand, and act on what matters most to communities, working with them to identify opportunities that benefit them, while striving to minimise the impacts of our operations. Our aim is to build trusted and beneficial relationships with the communities where we work. For the HumeLink project, Transgrid established Community Consultation Groups (CCGs) to encourage and facilitate community participation. Each CCG is made up of representatives of local councils, community groups and organisations as well as individual community members. A summary of community consultation can be seen at Appendix C.

Transgrid successfully advocated and worked with the NSW Government to introduce a strategic benefit payment for landowners impacted by infrastructure of critical state significance. We are now in discussion with the Government about how we may account for neighbour and visual amenity impacts, as we are aware other domestic (QLD) and international jurisdictions having such schemes as do energy generation mechanisms such as wind farms.

We are working with the community, local councils, and the potential construction partners on providing more benefits to communities and landowners through our Community Investment and Benefits strategy. This is in addition to the Community Partnership Program that aims to provide a significant and lasting positive social legacy to people living and working near our assets.

Recent initiatives include:

- Transgrid's MOU with Charles Sturt University.
- Transgrid investing $2 million in Engineering Scholarships.
- Partnering to develop a Clean Energy Training Centre.
- Legacy 100 which is a partnership with Secure Energy to train 100 workers in the regions.

[6] https://www.transgrid.com.au/media/g4abraei/d2022-01686-transgrid-engagement-policy-final.pdf

Transgrid response to the Inquires Terms of Reference

The costs and benefits of undergrounding

Undergrounding high voltage electricity lines refers to the installation of electrical cables in underground conduits, as opposed to the traditional method of installing overhead power lines supported by poles or towers.

There are various types of cables that can be used for underground installations, including high voltage power cables, extra-high voltage power cables, and submarine power cables. Each type of cable has its own technical specifications and installation requirements.

There are also different methods for installing underground cables, including trenching, directional drilling, and deep tunnelling. Underground installation is made up of several components, including the cable itself, conduits to house and protect the cable, and jointing kits to connect the cables together. Other components may include cable termination kits (underground to above ground transitions), grounding systems, and insulation materials.

While undergrounding has some advantages, such as reducing the visual impact of power lines there are a number of factors determining the suitability of undergrounding of transmission lines that need to be considered. These factors Include delivery timeframe, cost considerations, route selection, social considerations, and environmental issues. When considering the benefits of undergrounding, these considerations are evaluated alongside regulatory constraints.

There are also technical aspects to consider when designing and constructing transmission infrastructure including voltage levels to be transmitted, the distance of the line being installed and the terrain and environment that is crossed.

Long distance underground transmission lines of most often HVDC and are designed to deliver areas of high concentrations of generation to load points. There are good examples both in Australia and around the world that demonstrate the benefits of underground transmission lines.

HVDC is commonly used to connect offshore wind farms to the onshore grid. The long distances involved and the need to transmit large amounts of power from offshore installations make HVDC an efficient and reliable solution. HVDC transmission plays a role in its ability to transmit power efficiently over long distances, connecting remote generation sources to areas requiring the generation.

HVDC lines do have limitations. Transmission projects, including HumeLink, which form part of the National Electricity Market's energy 'superhighway' require, High Voltage Alternating Current (HVAC) transmission lines that will act as collector lines. These lines are designed to collect large volumes of renewable energy across their routes rather than a point-to-point delivery.

When connecting renewable energy sources to underground cables along a route, transition stations are often required to facilitate the conversion from underground to overhead transmission and vice versa. These transition sites, similar in area to traditional substations, play a crucial role in integrating renewable generation into the grid. (Appendix B) However, they can present challenges in terms of site placement, costs, and potential project delays.

HVAC underground cable is suited to lengths below approximately 50 km. Beyond 50 km length, AC lines at high voltage level will be subject to very large charging currents, requiring significant reactive compensation and design considerations.

For HVDC options, a long length of underground cable is feasible. Both underground HVDC and underground HVAC have their specific applications and considerations. The choice between them depends on factors such as the distance of transmission, power requirements, environmental considerations, and cost-effectiveness.

Other technical limitations of underground transmission lines are the heat generated. Specialised materials are required to ensure the insulation can withstand the very high voltages. If heat is not effectively removed from the cables, the insulating materials can suffer from accelerated degradation leading to cable failures or a shortening of the cable operational life.

This intense heat generated by underground lines also means they do not have the same capacity as overhead lines therefore will limit the ability to transport renewable generation sources along the route.

Another technical consideration is monitoring and maintenance of the line. Maintenance of the condition of underground transmission lines can be more challenging than with overhead lines. Regular inspection and maintenance require specialised equipment and techniques. Detecting and locating faults in buried cables can be time-consuming, increasing the time required to restore the power supply.

Underground cables are more susceptible to deterioration over time, primarily due to moisture seepage. This deterioration poses a significant risk to the reliability of the network and leads to increased ongoing maintenance expenses. In contrast, overhead lines are more exposed to weather and external events, but these events are typically temporary and transient in nature.

Costs

The cost of undergrounding transmission infrastructure is recognised as being significantly more expensive than overhead transmission line construction. Increased costs are related to:

- Materials required for underground infrastructure.
- Installation methodology (trenching, specialised backfill material, specialised cable jointing).
- Increased construction time frames.
- Additional circuits to meet equivalent overhead capacity.
- Cost of transition stations (Underground to overhead conversion sites).
- Need for reactive plant along the line to manage stability.

A benchmarking study for the Australian Energy Market Operator [7] specifically addresses underground versus overhead cost and states, “The costs of underground cables are approximately four to 25 times higher than overhead lines. Direct buried cables are at the lower end of this range, while tunnel installed cables are at the upper end.”

[7] AEMO 2021 Transmission Cost Report

Also, In the UK, an independent organisation oversaw a publicly available study to compare underground and overhead transmission cost. The study was commissioned by the UK National Grid and UK Department of Energy and Climate Change[8] and finds build cost of 75km underground transmission lines ranging from 10.1 to 14.4 times the overhead line cost.

Existing case studies and current projects regarding similar undergrounding of transmission lines in both domestic and international context

Marinus Link

Tasmania's Marinus Link involves approximately 255 kilometres of undersea High Voltage Direct Current (HVDC) cable and approximately 90 kilometres of underground HVDC cable in Victoria. It also includes converter stations in Tasmania and Victoria, and approximately 240 kilometres of supporting High Voltage Alternating Current (HVAC) transmission developments in North West Tasmania.

Submarine and underground crossings: HVDC is often chosen for submarine or underground power transmission crossings, such as under rivers, lakes, or straits. HVDC submarine cables can efficiently transmit electricity over long distances beneath bodies of water, avoiding the challenges and limitations of AC submarine cables. Similarly, when it is necessary to route power transmission through tunnels or underground corridors, HVDC lines can be installed to minimize environmental disruption.

SuedLink

SuedLink, which will be built in Germany in the next few years, will deliver a new underground cable connection to transport wind power from northern Germany to Bavaria and Baden-Württemberg. At a length of 700 kilometres, SuedLink will be the longest underground power cable in the world.

The SuedOstLink Line is a 525kV underground line with a length of 250km from Wolmirstedt, Magdeburg, Saxony-Anhalt, Germany, to Isar, Landshut, Bavaria, Germany. The project, which is currently in the planning stage, is expected to be commissioned in 2026.

The SuedLink and SuedOstLink projects were ultimately determined to be undergrounded due to public opposition to overhead lines. The opposition to the projects culminated in a law being adopted in 2015 that required all DC transmission lines to be planned and delivered as underground cables. One of the primary causes of the increased costliness of undergrounding was the need for trenching.

A federal sectoral planning submission for SuedLink by Tennet and Transnet BW[9] estimated that the trenching forms a significant proportion of the costs of construction, which would not be required for overhead construction. While the expected initial costs were not officially stated, a 2013 report in Munich-based Sueddeutsche Zeitung quoted a tripling of the initially estimated costs of $4.4B for the project.

SOO Green (USA, 2GW, symmetric monopole, 563km)

The Rock Island Clean Line project, the predecessor to SOO Green, was a proposed 500-mile, 3.5GW HVDC overhead line between Illinois to Iowa. The line secured approval from the Illinois Commerce Commission as a $2B (US) project; however, the project was withdrawn in 2017 due to public opposition to

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[8] Parsons Brinckerhoff in association with Cable Consulting International Ltd, Electricity Transmission Costing Study https://www.theiet.org/media/9376/electricity-transmission-costing-study.pdf
[9] SuedLink by Tennet and Transnet BW (VII Overall Review and Alternatives Comparison)

the proposed overhead line, and a decision of the Illinois Supreme Court which held that the company did not meet the ownership requirements to be a public utility in Illinois.

SOO Green is a proposed 350-mile, 2.1GW HVDC underground cable between Illinois and Iowa. It is forecast cost $2.5B (US)[10] but is 30% shorter and has 30% less capacity than the Rock Island Clean Line proposal.

Disregarding all other factors, on a per unit of length basis, the cost of the undergrounded SOO Green project is ~1.8 times the cost of the overhead Rock Island Clean Line Project. It is difficult to compare the two proposals however, due to their differences, and it is also difficult to compare the cost differential of SOO Green to that of other projects as the majority of the cable route runs along railroads, thereby dramatically simplifying the process of trenching, which is highly dependent on the terrain.

This finding is supported by construction cost estimates from 2019 in a federal sectoral planning submission by Tennet and Transnet BW[11] (VII Overall Review and Alternatives Comparison) for the SuedLink project that indicated that terrain has a significant impact on the cost of undergrounding, doubling the costs of construction on slopes greater than 30 degrees and tripling to quadrupling the construction costs for tunnelling.

It should also be reiterated, that the decisions to underground each of the three international projects mentioned above, were ultimately legal decisions, and not the result of cost-benefit analyses.

Western Victoria Renewable Integration Project

A report commissioned by the Moorabul Shire Council in response to the Western Victoria Renewable Integration Project[12] – “Comparison of 500kV Overhead Lines with 500kV Underground Cables” found that a 500 KV double circuit underground cable would be approximately ten times more expensive than an equivalent overhead line. It also found that the overall cost impact could be reduced by placing only the most sensitive sections underground but did not estimate to what extent.

Powering Sydney’s Future

Following the identification of the network solution being the Powering Sydney's Future project, a detailed route selection study was completed in 2017 with consideration given to environmental, land use and engineering constraints, infrastructure mode options, cost, avoidance, of sensitive areas, community impact, and feedback from key stakeholders.

The preferred macro route option was selected between Potts Hill and Alexandria and subsequently refined to comprise a 20 km, underground 330 kV transmission cable circuit between Rookwood Road and Beaconsfield West substations. The 20 km distance fits well with the typical underground line length of less than 50 km for underground HVAC.

The NSW Department of Planning, Industry and Environment in 2020 accepted that the preferred option was a logical and reasonable solution for the transmission cable network, given that it:

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[10] SOO Green’s latest estimate
[11] Tennet and Transnet BW (VII Overall Review and Alternatives Comparison)
[12] Moorabul Shire Council in response to the Western Victoria Renewable Integration Project – “Comparison of 500kV Overhead Lines with 500kV Underground Cables”

- was assessed as the most feasible option in terms of relative benefit to the environment, community and cost.
- provides the shortest connection option between existing substations that could support a new 330 kV transmission cable circuit.
- avoids connections (from the east and north) through the heavily constrained Sydney CBD area.
- utilises previously upgraded / constructed sections of transmission cables, connections and infrastructure, providing a secure long-term solution.

Costing estimates from international source

The estimated the cost of undergrounding transmission lines are similar around the world. The below two examples illustrate findings from different reports.

- T&D World[13] Part one in a two-part series examines the challenges of using underground high-voltage alternating current lines to transmit bulk electrical power. The extensive research found cost of overhead compared to underground were 4 to 10 time expensive to underground transmission.
- A 2006 Report of the Joint Legislative Audit and Review Commission to the Governor and the General Assembly of Virginia[14] "Evaluation of Underground Electric Transmission Lines in Virginia" found that underground lines typically appear to cost four to ten times more than overhead lines.

HumeLink - Underground Feasibility Study

In late 2021, Transgrid was requested by the community and landowners (through the CCGs) to investigate options which explore the feasibility of building the HumeLink project via underground cable instead of overhead transmission lines. Transgrid agreed to form a collaborative, Steering Committee, which developed an underground feasibility study scope of works. GHD and sub-consultants Stantec were appointed due to their High-Voltage Direct-Current (HVDC) expertise[15] to undertake the analysis.

Notwithstanding the technical requirements of HumeLink as a collector line and the limitations of undergrounding for this purpose, as outlined above, the findings of the Study also found that undergrounding increased the cost and significantly delayed completion, up to five years.

This delay would threaten the timely connection of the new renewable energy and the related essential new interstate connections to the grid. It is essential that the infrastructure is completed by 2026 to secure the network before the ageing power stations are decommissioned.

Any impact on delivery timeframes of undergrounding

The Australian Energy Market Operator has named HumeLink among "actionable" transmission projects that must be "progressed urgently" to help prevent blackouts in the fast-transitioning National Electricity

[13] https://www.tdworld.com/intelligent-undergrounding/article/21215620/overhead-or-underground-transmission-that-is-still-the-question

[14] 2006 Report of the Joint Legislative Audit and Review Commission to the Governor and the General Assembly of Virginia "Evaluation of Underground Electric Transmission Lines in Virginia"

[15] Final report August 2022 - https://www.transgrid.com.au/media/y0mpqzvw/humelink-project-underground-report-august-2022-final.pdf

Market. It has stated July 2026 as the "latest construction delivery date". "If HumeLink is not delivered on time, more long-duration storage than is anticipated under the NSW Electricity Infrastructure Roadmap and/or additional gas-fired generation would be needed to maintain power system reliability in New South Wales," AEMO ISP June 2022 report[16].

In support of this AEMO assessment, the NSW Government's Network Infrastructure Strategy's (NIS) Transmission Delay scenario showed how delays to all major NSW projects would have a similar impact and likely increase costs for NSW consumers. The NIS concluded that "a delay in major network projects leads to greater reliance on more expensive firming and long-duration storage capacity. This would take the form of higher cost technologies such as gas generation, potentially increasing electricity prices for NSW consumers. Instead, the timely delivery of network infrastructure would protect against this by allowing low-cost renewable energy to connect."[17]

The potential delay of Snowy 2.0 places even more importance on the timely completion of HumeLink. HumeLink will reduce the risk of supply scarcity for NSW consumers by reinforcing the southern network. The project will improve access to stored energy from across the entire Snowy scheme, renewable energy from southern NSW and energy from South Australia (via EnergyConnect) and Victoria (via VNI and VNI West), even in the absence of Snowy 2.0. It will also provide greater network resilience if other generation, storage and transmission projects are delayed.

The timely delivery of HumeLink is also linked to the success of the NSW Government's South West REZ as it increases transfer capacity between Southern NSW and Sydney. The South West REZ is indicatively planned to enable up to an additional 3200MW of renewable generation to connect in the south west of NSW. These renewable projects curtailment risks between Wagga Wagga and Sydney, and thus revenue risks, are reduced with the delivery of HumeLink unlocking network capacity towards Sydney. If HumeLink is delayed, this would likely delay many of the new renewable projects expected to connect in the South West REZ, increasing costs and reliability risks for NSW consumers.

It should be noted HumeLink is the only actionable ISP project that could be delivered in the critical period that directly addresses the risk of limited dispatchable capacity – if it is not delivered on time in 2026, it will jeopardise network reliability.

Any environmental impacts of undergrounding

While underground transmission lines are often chosen to reduce visual impact, their installation can still have environmental implications. Excavation and trenching can disrupt natural habitats, disturb ecosystems, and impact groundwater resources. Mitigation measures need to be implemented to minimise environmental impacts during installation and ensure proper reclamation after.

Trenching, which is the most common and generally lowest cost method of constructing underground transmission infrastructure, requires removal of all above-ground vegetation as well as 1-2 m of the ground surface. This creates impacts for biodiversity above the ground and sub-surface fauna and fauna habitat, soils and water resources.

Additionally, because heat from the underground cables is dissipated through the soil), as well as the ongoing requirement to provide access for excavation in the event of a fault, the land above underground

[16] https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf
[17] EnergyCo - NSW Network Infrastructure Strategy

lines must be kept clear of certain types of vegetation, for example, taller shrubs and trees with deep root systems. As such, easements above underground cables may be sterilised for other productive purposes. Also, due to the much larger quantities of soil disturbance and vehicle movement with underground cables there are also greater biosecurity risks.

An additional environmental impact related to the trenching of the easement is that an access road for the entire route is required, whereas with overhead transmission access roads are only required for individual tower locations. Excavated materials are not suitable for backfill and these need to be transported and disposed at other locations across regional and rural areas. This is a high cost and will heavily impact road networks in the local communities. The importation of the select fill around the cables will also require intensive use of road networks and the addition of more access roads, which will need to be built to safety specifications.

Farming activities can also be impacted as undergrounding is more invasive during construction. Also, some ongoing operational limitations will be placed on land use, which can include restrictions on farming activities and types of crops planted over the cables.

Australia's cultural heritage also needs to be considered when considering route and construction methodology. There is a higher potential for disturbance of aboriginal heritage with underground cables as the whole route is required to be excavated. Discovering heritage items during construction would have a greater impact than during the earlier detailed design phases where alignment changes can be captured. With overhead lines the proposed tower locations themselves can be surveyed, with the option of moving locations along the alignment for the final design should heritage items be discovered.

Bushfires are a significant concern for the communities where electrical assets are located. For all major projects, our planning, design, construction and operation takes bushfire risk into consideration every step of the way. Our work includes risk assessments, constraints mapping and engagement with emergency services as well as local communities.

Transgrid's role in bushfire management is preventative first. We focus on operating and maintaining our network to minimise the risk of bushfires through proactive and regular vegetation management, regular reviews and inspections of our assets (to ensure they are fit for purpose), and inspection and management of the easement that supports the infrastructure.

Electricity being carried by powerlines can start bushfires when infrastructure is damaged or foreign objects contact powerlines. This can cause arcing and generate sparks that can ignite dry vegetation. Recent figures stated that only 2.7% of bushfires are started by electrical infrastructure[18]. Analysis of the major bushfires in Australia caused by electricity infrastructure highlighted that it was ignited by distribution powerlines or equipment typically below 66kV, rather than transmission equipment in voltage ranges of 110kV and above[19].

[18] CIGRE Working Group B2.45, TB 767, Vegetation Fire Characteristics and Potential Impacts on Overhead Line Performance, June 2019

[19] https://www.climatechangeinaustralia.gov.au/media/ccia/2.2/cms_page_media/732/ESCI%20Case%20Study%205_Bushfire%20risk%20to%20distribution%20120721.pdf

Thank you for the opportunity to provide a submission in relation to this inquiry. Transgrid will continue to work collaboratively with local communities, the NSW and Commonwealth Government, local councils, and construction partners to mitigate the impacts of transmission infrastructure. We will continue to look at long-term benefits to the local communities, whilst delivering major transmission that support the energy transition in Australia.

Appendix A – Transgrid's route selection process

The key steps in Transgrid's route selection process are outlined below:

1

Stage 1: Options development and initial evaluation

a. Our team of specialists undertake a comprehensive desktop assessment of the project area to understand local conditions, constraints and opportunities and develop possible routes for the new transmission line.

b. A comparative evaluation is undertaken to assess all identified routes against our key selection criteria and measure how well each performs against a range of factors including:
   - proximity to residences
   - number of landowners affected
   - distance on private land
   - impacts to land use
   - areas of Aboriginal significance
   - bushfire risk
   - potential impacts to the environment
   - impacts to visual amenity
   - impacts to public amenities
   - design efficiency and constructability
   - use of existing corridor and/or infrastructure
   - cost to consumers (the total cost of the project is recouped from electricity consumers through their bills)

2

Stage 2: Route Selection

a. Ground-truthing and preliminary ecological studies are undertaken to build on our desktop assessment and gather additional information.

b. We consult key stakeholders to fully understand the constraints to further assess their viability.

c. Based on the previous steps a proposed route option is identified.

d. Further consultation on the proposed route option is undertaken to seek community feedback and understand any additional considerations.

e. Where possible, community feedback is taken into consideration and a preferred route option is selected for further investigation.

3

Stage 3: Route Refinement

With a preferred route option identified, additional site investigation work, including field studies and stakeholder consultation is undertaken.

4

Next steps: Environmental and planning approvals

a. Further stakeholder and community consultation

b. Ongoing field studies and corridor refinement

c. Property negotiations if required

d. Environmental and planning approvals process

Appendix B – Undergrounding Infrastructure and Trenching Works

Figure 1Transition Station (DC to AC) - NordLink

Figure 2 Underground Cable Installation During Construction

Figure 3 Haymarket Substation tunnel - 330kV cables on the right

Appendix C – Overview of HumeLink community consultation