Supplementary Question

NSW inquiry into the feasibility of undergrounding transmission infrastructure for renewable energy projects

Questions and Answers

Question	Answers
1. TransGrid has emphasised the primary objective being to provide the lowest cost service to electricity consumers. How are the costs and benefits to other stakeholders, such as local communities, landowners and neighbours, and the environment, taken into consideration?	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, any Transmission Network Service Provider (TNSP), 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. The AER holds Transmission Network Service Providers (TNSPs) to these principles through the Regulatory Investment Test for Transmission (RIT-T) and other additional regulatory submissions. The RIT-T is designed to ensure the benefits of investment outweigh the costs, ensuring consumers only pay for infrastructure that is needed. This is driven by the National Electricity Rules (clause 5.15A.1(C)) which state that the purpose of the RIT–T is to identify the network option that maximises the present value of net economic benefit to all those who produce, consume and transport electricity in the market. Transgrid's assessment of options includes 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, local businesses and stakeholders and the environment. Transgrid follows a rigorous route selection process that analyses technical, environmental, social and economic factors, including using current easements wherever feasible, to minimise impacts to landowners. In parallel to progressing a project through the RIT-T process, the project must also be assessed through the statutory framework for environmental and planning approval in NSW. This process includes considering impacts and benefits to local stakeholders and the environment. For example, TNSPs are required to prepare an Environmental Impact Statement in accordance with the NSW Planning Secretary's environmental assessment requirements (SEARs). Impacts considered include social, environmental, indigenous and non-indigenous heritage, economic and technical.

Question	Answers
2. Can the cost of a five-year delay to underground HumeLink be quantified, noting that Snowy 2.0 is unlikely to be completed during that period?	The potential delay of Snowy 2.0 places even more importance on the timely completion of HumeLink. AEMO's 2022 Integrated System Plan (ISP), identified HumeLink as an actionable project and states that it should be progressed as urgently as possible. 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. HumeLink will reduce the risk of supply scarcity for NSW consumers by improving access to stored energy from across the entire Snowy scheme, renewable energy from southern NSW and energy from South Australia (via Project 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. For every year that HumeLink is delayed it will cost consumers circa $450,650,000.
3. Where, and when, are connection points for new generators and loads envisaged for HumeLink?	Additional capacity must be ready to prepare for the expected retirement of large coal-fired power stations from the NSW power system. HumeLink is expected to unlock additional capacity for new generation (primarily renewable generation) in areas of southern NSW, which have recognised high-quality wind and solar resources. It will allow the additional transfer capacity between South Australia and NSW provided by Project EnergyConnect and the additional transfer capacity between Victoria and NSW, provided by the VNI West upgrade, to flow to major demand centres in NSW. There is a significant interest from renewable generation projects to connect in areas that will be unlocked by HumeLink. For example, EnergyCo NSW conducted a registration of interest process for the South West REZ in late 2021 and received 49 registrations of interest, totalling 34 GW, from potential generation and storage projects. EnergyCo noted within its Draft South West REZ Access Scheme position paper that HumeLink is required to alleviate constraints on other parts of the network to enable the full 2.5 GW intended network capacity of the South West REZ to be utilised. They also noted that the South West NSW region is likely to be subject to significant

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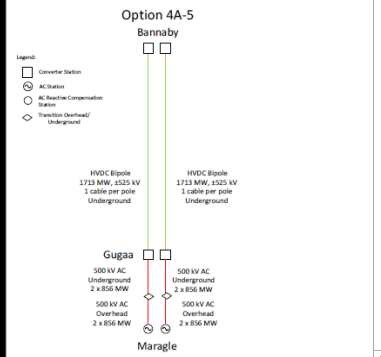
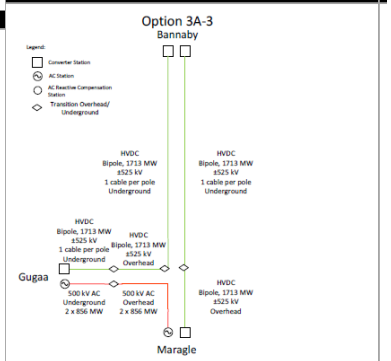
	constraints until the delivery of HumeLink with new connections likely to compete with existing and committed generation in proximity to Wagga Wagga. In addition, Transgrid is working on approximately 25 wind and solar projects in the South and South West regions of NSW totalling roughly 7100 MW. These projects range anywhere from the connection enquiry stage to application or committed, and all will benefit or have their investment decisions hinge on the extra capacity unlocked towards the greater Sydney load centre from HumeLink. Potential generator connection points to HumeLink include new and augmented substations near Wagga Wagga and Bannaby and augmentation at the. existing Wagga Wagga substation. Connection enquiries to connect directly to new transmission assets delivered as part of HumeLink are not accepted at this stage. We expect proponents interested in connecting directly to HumeLink to submit connection enquiries when the project reaches "Considered Project" status. This is the term under the National Electricity Rules (NER) which green-lights an infrastructure project as an approved addition to the National Electricity Market (NEM).
4. Can TransGrid refer to any electricity system component (e.g. transformers, lines, switchgear etc) that has a reliability of 99.998%?	Transgrid records reliability as a holistic performance measure across its transmission system and has a demonstrated long-term reliability of 99.9995% (which is above the NEM's. This is achieved through our existing network and substations, which are designed with redundancy across system elements and make use of HVAC equipment with proven very high levels of reliability. Within the electricity sector *Reliability* means that the power system has enough capacity to meet consumer demand. That being the system has sufficient capacity (including generation assets, demand response and inter-state transmission assets) to produce and transport electricity to meet consumer demand. The National Electricity Market's (NEM's) reliability standard defines a required level of reliability of 99.998% applicable to the entirety of the NEM and is imposed via the National Electricity Rules (NER) clause 3.9.3C. Transgrid's transmission system is a core component of the NEM and plays a central role in achieving this requirement. The reliability of an electrical High-Voltage Direct Current (HVDC) converter station and the connected DC transmission lines can vary depending on several factors including system design, quality of components, maintenance practices, and environmental conditions. HVDC converter stations are typically robust elements of a transmission system, however their inherent design and componentry means reliability values are generally around 98%, which is lower than system reliability measures across the NEM. This is seen in European Transmission Operator HVDC systems, where historical average

Question	Answers
	converter station reliability is quoted as being below transmission operator requirements (refer: CIGRE, 2020, *European Experiences in HVDC System Reliability and Availability).*
5. Please provide an example of a connection point being added to a 500 kV line in NSW.	During the past three years, Transgrid has provided several proponents seeking to connect renewable generation to the existing 500kV network with a pre-feasibility assessment, as well providing responses to formal connection enquiries in accordance with its NER obligations. These have included: • Two separately proposed Solar/BESS hybrid projects each connecting to existing line 5A4, with one project having a proposed generation capacity of 500MW and the other 550MW. • A proposed 290MW Wind Farm to existing line 5A7. • A proposed Wind/Solar/BESS energy hub with a connection point capacity of 500MW to existing line 5A3. • Numerous of these projects are now progressing through the connection application process, with one in an advanced stage. It is also noted that Central West Orana Renewable Energy Zone, being developed through EnergyCo, is currently proposed to connect to existing 500kV lines 5A3 and 5A4. The above are examples of proposed renewable generation projects connecting to a 500kV line and these are in addition to the thermal generation that is already connected to the 500kV network, such as Bayswater Power Station, Mount Piper Power Station and Eraring Power Station.
6. When was TransGrid advised of the updated AEMO estimate of $4.89 billion to build HumeLink?	As the projects progresses cost estimations are provided through the regulatory process and into the development/delivery phase. The preliminary cost estimate from the Project Assessment Conclusions Report (PACR) was presented in real dollars. As part of a submission on updated project costs and class of estimate, AEMO requested input into their 2023 Transmission Expansion Options Report (TEOR). On 17 July 2023, in accordance with regulatory process, the next stage of more detailed planning and estimation was provided to AEMO . This reflected the revised cost estimate in nominal 2023 dollars of $4.892 bn. This figure was incorporated into AEMO's 2023 TEOR and published on the 27 July 2023. Transgrid also advised the AER of this updated cost estimate which will be reflected in its Feedback Loop request to AEMO and its Contingent Project Application to the AER, in accordance with standard regulatory process.

Question	Answers
a. Has TransGrid formally advised the AER of this updated figure?	
7. Did the GHD underground study include options for part overhead and part underground lines? If so, why would they not be feasible for Humelink?	Of the eight preferred options identified in the GHD underground study the options which considered part overhead/ part underground where also a hybrid of AC and DC systems. Of these, the two options which met the MVA ratings were:(see images below): • Option 3A-3 Overhead in Public land, HVAC & HVDC Hybrid (via Blowering and Kosiusko) -$9.6Bn • Option 4A-5 HVAC and HVDC hybrid (via Hume Highway) - $11.5Bn

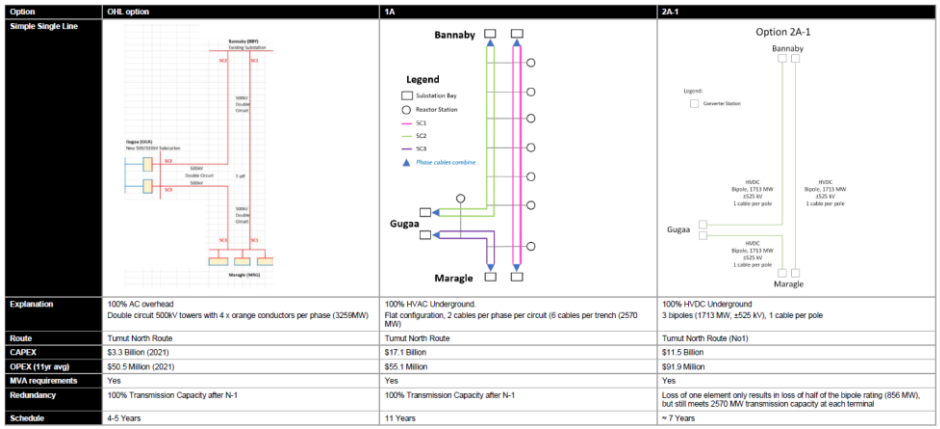
Question	Answers

Option	4A-5	3A-3
Simple Single Line		
Explanation	HVDC and HVAC Hybrid 2 symetrical monopoles (1713 MW, ±525 kV), 1 cable per pole. HVAC double circuit to match HVDC redundancy (856MW)	HVDC and HVAC Hybrid (Overhead in public land) 2 bipoles (1713 MW, ±525 kV), 1 cable per pole. HVAC double circuit to match HVDC redundancy (856MW)
Route	Hume Highway	Blowering Northeast and Kosciuszko Combination
CAPEX	$11.5 Billion	$9.6 Billion
OPEX (10yr avg)	$107.7 Million	$129.6 Million
MVA requirements	Yes	Yes
Redundancy	Loss of one element only results in loss of half of the bipole rating (856 MW), but still meets 2570 MW transmission capacity at each terminal	Loss of one element only results in loss of half of the bipole rating (856 MW), but still meets 2570 MW transmission capacity at each terminal
Schedule	≈ 6 Years	≈ 6 Years

Based on an average unit rate, sourced from the HumeLink undergrounding report, as shown below:

Construction type	Unit rate per km (excluDes offsets, converter stations, reactors and UGOHs)
Underground AC (single cct)	$23.5m
Underground HVDC	$11.35m
Overhead AC	$6m
Tunnelling AC^	$28.5m

Question	Answers
	The above estimates do not include the converter stations required at each switching point which cost approximately $500,000each and are required at each of the planned switchyards.
8. Given the capacity of HumeLink of 2200 MW and the capacity of Snowy 2.0 of 2000 MW and the proposed REZ and interstate transmission, when will HumeLink be operating at capacity and further augmentations be necessary?	HumeLink is designed as a 500kV overhead transmission line connecting Snowy 2.0 at Maragle and transferring power south and north between planned renewable zones in the south and load centres such as metropolitan Sydney. Connection points include new and augmented substations near Wagga Wagga and Bannaby and augmentation at existing Wagga Wagga substation at 330kV. Full transfer capacity of 2200 MW on HumeLink can be realised under several scenarios, including development of the South West REZ and upgrade of Project EnergyConnect (PEC) between Dinawan and Wagga Wagga to 500kV, as well as connection of Snowy 2.0. The upgrade of PEC to 500kV is planned to be accomplished as part of the VIC-NSW Interconnector (VNI) West project. Further increase in transfer capacity of HumeLink will be realised through Sydney Southern Ring, which is currently being evaluated by AEMO for the 2024 Integrated System Plan (ISP). AEMO's 2022(ISP) did not include any further additional network augmentations for HumeLink. AEMO's 2023 Transmission Expansion Report includes additional network augmentation options to further increase network capacity to cater for increased renewable generation in Southern NSW in the future and is subject to assessment in the 2024 ISP . It is to be noted that HumeLink is a pre-requisite for all the 3 additional network options under consideration. Transgrid will continue to engage and support AEMO, through joint network planning, in the development of the 2024 ISP.
9. Is the HumeLink augmentation	The GHD Report provides a comparison between the Humelink AC and DC Options as follows: HVAC OHL Option - $3.3Bn

Question	Answers
option for HVDC of comparable cost to HVAC, and wasn't it provided by TransGrid?	Option 1A - HVAC Underground Option - $17.1Bn Option 2A-1 - HVDC Underground Option - $11.5Bn The full HVAC underground option is significantly higher that the full HVDC underground option. See images below: 
10. If the distance has to be more than 800 km for a HVDC line to be economic, are there any examples of installed and proposed	HVDC is typically a point-to-point solution, meaning that new renewable energy sources would not be able to be connected to an HVDC HumeLink. The ability to connect future renewable energy sources in the future is, as it stands, a key component HumeLink's value proposition. While possible, multi-terminal DC systems are significantly more complex and expensive than multi-terminal AC systems, and it is difficult to expand existing AC systems to support multi-terminal DC. This is because power flow in a multi-terminal DC system must be actively regulated by the converter control system, rather than relying on the inherent impedance and phase angle properties of an AC transmission line. As a result, multi-terminal DC systems are rare.

Option	OHL option	1A	2A-1
Simple Single Line			
Explanation	100% AC overhead Double circuit 500kV towers with 4 x orange conductors per phase (3259MW)	100% HVAC Underground. Flat configuration, 2 cables per phase per circuit (6 cables per trench (2570 MW)	100% HVDC Underground 3 bipoles (1713 MW, ±525 kV), 1 cable per pole
Route	Tumut North Route	Tumut North Route	Tumut North Route (No1)
CAPEX	$3.3 Billion (2021)	$17.1 Billion	$11.5 Billion
OPEX (11yr avg)	$50.5 Million (2021)	$55.1 Million	$91.9 Million
MVA requirements	Yes	Yes	Yes
Redundancy	100% Transmission Capacity after N-1	100% Transmission Capacity after N-1	Loss of one element only results in loss of half of the bipole rating (856 MW), but still meets 2570 MW transmission capacity at each terminal
Schedule	4-5 Years	11 Years	~ 7 Years

Question	Answers
HVDC lines of shorter length?	<u>Australian examples:</u> The following HVDC underground/ undersea cables are installed in Australia (all are interconnectors between states): • Basslink (Georgetown, TAS to Loy Yang, VIC)– 70km HVDC overhead, 290km undersea cable. 400kV, 500MW • Directlink (Bungalora NSW to Mullumbimby NSW (QLD network)) – 65km HVDC Underground. 80kV, 180MW • Murraylink (Redcliffs VIC to Berri SA) - 176km HVDC Underground. 150kV, 220MW The proposed Marinus link between Tasmania and Victoria • Marinus Link (Heybridge TAS to Hazelwood VIC) – 255km undersea + 90km underground. 320kV, 1500MW <u>International examples:</u> Globally, only three multi-terminal HVDC systems are currently in service: 1. The Québec – New England transmission between Radisson, Sandy Pond, and Nicolet. 2. The Sardinia–mainland Italy link which was modified in 1989 to also provide power to the island of Corsica, 3. The NordLink - between Norway and Germany. • The Corsica and NordLink lines are both largely submarine lines. • The Quebec New England Transmission line had to be implemented using HVDC due to the American and Québec energy grids being asynchronous. It should also be noted that the Quebec-New England is overhead for the majority of its length.

Question	Answers
11. What is the process to be taken with property owners who refuse to allow TransGrid onto their land or refuse to agree to an easement – in detail please with timeframes?	Every effort Is made to each settlement with landowners before commencing any compulsory acquisition process. The NSW Land Acquisition (Just Terms Compensation) Act 1991 (Just Terms Act) provides a pathway for TNSPs to gain access to land, in circumstances where landowners refuse access or refuse to agree to grant a TNSP an easement. The Just Terms Act specifies the following: • At least six months of negotiations with the landholder prior to the commencement of the formal compulsory acquisition period (with some limited exceptions, eg. acquisitions of Crown Land); • Where agreement is not reached with a landholder within the 6-month pre-acquisition period, a Proposed Acquisition Notice (PAN) is served on the landholder; • A period of 90 days from service of the PAN applies, before the TNSP can proceed to seek gazettal of an acquisition notice; • The acquisition notice must be gazetted within 120 days of the PAN being given (unless the landowners agree to extend); • The easement is granted to the TNSP on gazettal of the acquisition notice; • Written notice of the acquisition, entitlement to compensation and the amount of compensation offered is given to the landholder in a compensation notice; • The amount of compensation offered in the compensation notice is determined by the Valuer-General – the statutory period is 45 days after gazettal (although, in practice, the Valuer-General often takes a longer period of time); • The amount of compensation offered is deemed to have been accepted within 90 days of giving the compensation notice unless landowner advises otherwise; • Payment of either all the compensation assessed or an advance payment of 90% of amount of compensation offered by the TNSP to the landholders or into trust must be made before the landholder is required to grant access to the easement land; • In addition, where residences are impacted by the acquisition landholders are entitled to remain in occupation of any building which is the person's principal place of residence or place of business for 3

Question	Answers
	months after acquisition, even if all or part of the compensation has been paid to the landowner or into trust. However, the Minister can approve immediate vacant possession if satisfied that the authority requires this. At specific stages, steps in the compulsory acquisition process are undertaken and controlled by parties, such as Ministerial decisions to issue PANs, and Transgrid has no control over the timeframes within which these steps are taken and completed. In the event, that a landholder locks out the TNSP from their property, notwithstanding the TNSP having a right of access via an easement obtained by compulsory acquisition process, the TNSP may be able to: a. Seek to enforce its rights under the easement in Court; b. Gain access under its powers in the Electricity Supply Act, 1995; or c. Seek the NSW Sheriff's Office assistance to enforce access. Transgrid's priority continues to be to engage with landowners to negotiate access.
12. Can TransGrid meet its 2026 target if compulsory acquisition is needed for a significant proportion of landholders?	Transgrid is on track to meet its 2026 target, even if compulsory acquisition is required for easements to gain access to a significant number of landholdings. Construction of the project will be undertaken in stages, which take account of availability of access to relevant landholdings.
13. What budget has TransGrid set for legal actions against	Transgrid Makes allowances related to legal support for property negotiations, compulsory acquisitions and access rights. While the numbers are still being finalised, the total allowance for legal support for compulsory acquisition and access issues constitutes less than 5% of the land and property acquisition budget.

Question	Answers
property owners? a. How will such actions impact the 2026 target?	A schedule risk analysis has also been undertaken and some level of contingency has been allowed should the impact affect activities on critical path, and the contractor is unable to reasonably mobilise to an alternate property while the access matter is being resolved. Every effort will be made to avoid compulsory acquisition, however,shoul a landowner objects to the compensation determined by the Valuer General, that dispute would be heard by the Land and Environment Court. However, this hearing would take place after the gazettal of the easement and has no impact on Transgrid's ability to access the easement whilst this dispute is ongoing.