STANDING COMMITTEE ON STATE DEVELOPMENT

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

Supplementary questions: Professor Bartlett, Mr Brand and Mr Barber

Answers are to be returned to the Committee secretariat by 8 August 2023

Questions 1-18 – Refer to Simon Bartlett's response.

1. Has TransGrid already signed up a contractor to build HumeLink, as is rumoured to be the case?
2. What commitments beyond the $633 million for early works have been made?
3. Should all expenditure on HumeLink be paused till the Inquiry has concluded and the government made a decision on future undergrounding of transmission?
4. Are there any proposals for additional connections along the route of HumeLink?
    a. If so:
        - why weren't they included in the PACR, and its benefit-cost analysis?
        - how much spare capacity does HumeLink have when Snowy 2.0 is operating?
5. What consideration was given to upgrading existing AC lines or replacing with/adding DC circuits for proposed new transmission in NSW?
6. What consideration has been given to locating underground cables within, or near, existing overhead line easements?
7. What are the requirements for HumeLink to be 'a collector line'?
8. What is the basis for claiming that HumeLink would be delayed up to five years if undergrounded?
9. What renewable energy will not be able to be connected if HumeLink is not completed by 2026?
10. What new interstate connections will not be able to be connected if HumeLink is not completed by 2026, noting that VNI West will not be completed till well after that date?
11. Is it realistic to expect that HumeLink could be built by 2026?
12. Could an underground HumeLink be completed by the time Snowy 2.0 is completed (2029+)?
13. Transgrid has said that the delay in Snowy 2.0 is a 'potential delay'. Is it potential or actual?
14. How does HumeLink improve 'access to stored energy from across the entire Snowy scheme' as HumeLink does not connect into the existing Snowy Scheme 330kV network (except the UTSS to LTSS line)?
15. What new interstate connections will not be able to be connected if HumeLink is not completed by 2026, noting that VNI-West will not be completed till well after that date and Project EnergyConnect will be connected to the existing 330kV network at multiple locations?
16. How is HumeLink expected to transmit 3,200 MW of South West REZ generation when its capacity is almost fully taken up when Snowy 2.0 is operating?
17. What is the amount of renewable generation planned to be added in the South West REZ prior to 2030?

18. What additional power is estimated to be transmitted to Sydney by HumeLink over the next decade, in addition to Snowy 2.0?
19. Is there any reason why priority should not be given for undergrounding transmission lines in NSW, as is the case in many overseas countries?

Not necessarily priority, however undergrounding should be considered at the very early stages of project development. This would necessarily mean a comparison of HVDC and AC options as well as overhead and undergrounding.

Whether it is AC or HVDC, undergrounding of transmission is expensive, so the additional cost would need to be justified. This leads to the idea that there are certain locations and situations where undergrounding could provide more benefits than the additional cost, which can be assessed via means such as the triple-bottom line assessments described in my submission.

For cases where the requirement is to shunt large amounts of renewable energy from remote areas (relative to the loads) to major load areas, the selection of HVDC transmission makes it easier to transition between overhead and underground where required, and the overhead elements are significantly less intrusive than the 500kV AC equivalent.

20. Are underground cables designed to cope with the heat generated? If so, how?

When selecting the size of an underground cable, the maximum loads are determined and then the amount of heat generated is calculated for each size of cable. Each cable type has a maximum conductor temperature that is allowed – this differs depending on insulation and manufacturer – but lets say 70 - 80 degrees for a HVDC polymer type cable as an example, depending on manufacturer. The cable size is then selected to make sure this is not exceeded even at maximum power, ambient and thermal resistivity conditions (i.e. how well the heat can be dissipated into the ground). Note this heat impact has no effect at ground level.

This is standard underground cable design. In a similar way that overhead transmission conductors are designed to avoid exceeding conductor temperature limits and creating sag, and how transmission towers are designed to hold the weight of the conductor and hardware and be resilient to design wind loadings – this is just how cables are selected and designed and is in no way a "negative" or disadvantage of underground cables.

21. Are fibre optic monitoring cables installed to prevent overheating? If so, how?

Modern underground cables can be installed with fibre optic cables that are used to monitor the outside temperature of the cable using Distributed Temperature Sensing (DTS) technology. These systems are not readily available as off the shelf products and will identify any hot spot areas.

A properly designed underground cable should not experience hot spots, within the design parameters – however if there are unknown conditions (such as previously undetected areas of high thermal resistivity) or if conditions change (i.e. cables are exposed or buried further by movement of soils) – these can be picked up and the asset operator can investigate and rectify the situation immediately.

a. Can examples be provided where this has not been the case and hence why it has been highlighted in Transgrid's submission?

The technology has been around a while, but I have noticed has significantly improved (in accuracy and distance of measurement) and become more commonplace over the past decade or so. Older systems (say cables installed more than 10 years ago) may not necessarily have these installed, and if that's the case then likely because of previous concerns over accuracy and distance measured. Australia has not built many (if any) long distance underground cables in that period, and I expect every future long distance underground cable project in Australia will have these installed.

22. Can't underground cables be designed to equal the capacity of overhead lines?

Yes they can, based on the design principles explained in the answers to question 20, and within the limitations of the maximum conductor sizes available and the thermal properties of the surrounding soil.

23. In what ways is maintaining underground lines more challenging than overhead lines?

Having set up and managed operations for Australia's two long distance underground cable projects I can say that aside from preparedness for a cable failure and repair, ongoing maintenance of HVDC cables is significantly less onerous and challenging than overhead lines.

For example, these underground cables typically only require an inspection of the route, at most monthly (but may be less frequent) – and that inspection is simply to observe no activity on the route, no sudden change in cable exposure (e.g. subsidence) and to make sure cable markers are in place. In the event of a cable fault (significantly less frequent than overhead line failures) – there will be a requirement to mobilise fault crews, locate the fault, excavate, repair the cable and reinstate. This activity may take a few weeks, but depending on length may be once per 10-20 years. There may be some need to respond to and investigate any alarms from DTS or DAS (distributed acoustic sensing) systems.

I do not support any statement that maintaining HVDC underground cables is more challenging than maintaining overhead lines.

24. What 'regular inspection and maintenance' is required for underground cables other than occasional 'driving or droning of the route' to ensure no building activities?

See answer to question 23.

25. Aren't monitoring systems installed with underground cables, providing real-time information on cable conditions and warnings of potential problems?

Yes. See response to question 21.

26. Doesn't modern fault detection technology usually locate underground faults within hours?

Yes. A lot has been said about cable fault detection, which I believe is influenced by subsea cable fault finding experience not necessarily underground cables. I have personally been involved in the location of underground cable faults, and "older" techniques such as Time Domain Reflectometry (TDR), cable thumping and using headphones/probes to "listen" for the fault are very effective. However modern cable systems can now utilise DAS (distributed acoustic sensing) that can very accurately detect the location of a fault through "hearing" the original failure and/or subsequent "thumps" of the cable using a HV pulse. These systems can provide indication of proximity within hours, with more accurate "pin pointing" occurring over the remainder of the day.

27. What is the typical fault history of underground cables – it is understood to be far superior to overhead lines?

Overhead lines can experience intermittent faults/failures (failures that clear themselves quickly, such as lightning, vegetation clashing, wildlife etc) – or permanent failures (for example, damage to insulators that require repair). This means failures occur more frequently, but as many of them are intermittent, can be relatively short duration.

For underground cables, any failure of the cable would be a permanent fault. However, these can be very rare. How often one should expect a fault will depend on the length of the cable and how many cables (statistically) – but could be one every 10-20 years. Murraylink, 2 cables at 180km long, has had only one in-service failure in over 20 years. Fault location and repair times depend on the level of preparedness of the operator, however I am of the view that a prudent operator with appropriate level of preparedness, with local jointers qualified with the new cable joints, should take no more than two weeks to repair.

28. Are underground cables designed to withstand moisture seepage (e.g. subsea cables)? Explain.

Cables can be specified and designed to have water barrier layers to prevent water seeping into the cable core, causing a fault. Water blocking in the conductors and water "swellable" tape can also be included to minimise the impact of water penetration if it does occur.

29. What is the prevalence of this 'moisture seepage problem'? Can examples be provided where this has not been the case and hence why it has been highlighted in Transgrid's submission?

I am unaware of this being an issue with modern DC polymer cables.

30. How is it that underground cables require 'increased ongoing maintenance expenses' when they are not subject to weather impacts (lightning, wind, ice, heat etc) and are considerably more reliable than overhead lines?

This may be referring to underground cables in built up areas, older cables or different designs. I do not agree that long distance HVDC underground cables have 'increased ongoing maintenance expenses' when compared to AC overhead lines.

31. What is the difference between overhead and underground easements with respect to being 'kept clear of certain types of vegetation' and sterilisation for other productive purposes?

Refer to pages 8 and 9 of my submission. The "no deeply rooted trees" limited is widely accepted as the only limitation. I have not encountered any sterilisation of vegetation above underground cables.

Having been O&M Manager for two of Australia's long distance underground HVDC cables, I can say based on experience that it is very difficult to find the location of an installed underground cable without the use of cable fault detectors. The vegetation grows just as healthily above the cables as on either side of it. A quick site visit to these locations will verify this.

Overhead lines however must be kept clear of vegetation, directly under and to the side of overhead transmission lines. Interestingly this seems to be an argument for why EHV AC transmission lines do not start bushfires – that the area below them is clear of any vegetation.

Below is a photo taken by my hiking group during a hike in during a hike in the Mt Coot-tha Forest just outside of Brisbane. This clearly shows ground cleared immediately below, as well as to the sides, of a transmission line.

32. Aren't there substantial restrictions on farming activities for overhead lines (tall machinery, cropping planes, drones, interference of GPS machinery etc)?

Refer to Ken Barber's response.

33. Do the much wider easements for overhead lines result in greater biosecurity risks?

Refer to Ken Barber's response.

34. Where are there examples of a 50 metre wide trench being required?

None that I am aware of. I have never heard of a HVDC underground project with a trench greater than 2.5 metres.

- what is the width of trenches for underground cables in Australia and overseas?

This depends on the number of cables, size of the cables and method of construction.

The trench width for Murraylink was less than 1 metre, because they applied a direct trenching and burial method. For Directlink, and from memory, the six cables were installed in less than 1.5 metres.

- the GHD report, commissioned by TransGrid, shows trenches 2.1 metres wide, spaced 3 metres apart (7.2 metres combined width) for the largest HVDC option.

I have reviewed this design and agree with this approach. The 3 metres apart could be less or more (for example to incorporate construction) – or possibly one trench on one side of a road and the other trench on another.

35. Where are there examples of trenches a 'minimum two metres deep, typically more'?

The Australian requirements are for 1.2 metres. For long distance HVDC transmission, deeper trenches may be used for certain areas such as road crossings etc.

Deeper trenches are generally avoided for the majority of the cable route as the deeper the trench, the thermal resistivity increases creating design/rating issues.

But the vast majority of the depth of a long distance HVDC underground cable would be expected to meet that 1.2m requirement. I am unaware of any long distance HVDC underground project in the region with a depth of 2 metres or more.

36. Can underground cables be routed to avoid land that is unsuitable or of particular construction difficulty or having high economic/environmental value?

Yes. For Murraylink the route literally "weaved" around trees to avoid them. We used routes in existing road reserves, along fencelines – through the Murray Sunset national park. For Directlink, we utilised an existing decommissioned rail reserve through the Burringbar range. Ares of high environmental value (e.g. the Murray River) can have cables installed under through horizontal directional drilling (HDD).

37. Can underground cables be routed to be beside existing roads, tracks, fences, fire breaks etc to minimise the impact and the need for additional access tracks or 'sterilisation'?

See answer to Question 31. I do not agree with the claims of "sterilisation" of the land above underground HVDC cables.

See answer to Question 36 on routing options.

Note, installing cables in the road reserve will avoid the need for new access tracks (the road is the track).

There will be no more access tracks required than for an overhead AC transmission line.

38. In some circumstances can't farmers reorient paddocks to 'fit' with the underground trench location (e.g. beside new fence lines and under new fire breaks)?

Yes.

39. Can most forms of farming be continued on an underground easement (cropping, pastures etc)?

Refer to Ken Barber's response.

40. Do access roads (tracks) for overhead lines usually extend along the entire line?

Not always. Certainly to each tower.

41. Is an access track always required along underground cables?

Not always. As visual inspection only is required, just the capability to be able to access areas is enough. HVDC underground cable faults are rare, and access can be established as part of the fault finding/repair process.

See my previous comment on placing all or part of the route in a road reserve, parallel to existing roads – which eliminates the need for specific access tracks.

42. Is the identification of aboriginal heritage essential for both overhead lines and underground cables?

I cannot comment, this is not my area of speciality.

    a. Can underground cables be routed to avoid such sites, even when discovered during construction?

Yes.

<u>Further Clarification:</u>
During the hearing testimony of TransGrid on 7 August 2023, they claimed that I stated that our cost did not include the HVDC converter stations. I will clarify now and confirm that this statement is incorrect and that the final reference to overall cost that I stated in the testimony (total cost) <u>did</u> include the HVDC converter stations, plus ALL indirect cost assumptions from the GHD/Transgrid.
An extract from the transcript of what I had said "There is still the cost of the converter stations and all the other costs that go around it, so our estimates come to about 80 per cent of

it." So, it is less than two times, including the cost of the HVDC converter stations and all indirect costs.