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
Answers provided by Prof Simon Bartlett AM

1. Has TransGrid already signed up a contractor to build HumeLink, as is rumoured to be the case?

To the best of my knowledge, TransGrid has entered into two contracts to construct East Humelink and West Humelink respectively. East Humelink has been awarded to GenusPlus Group LTD a Joint Venture between Acciona Construction Australia Pty Ltd, Kalpataru Power Transmission Limited – proof as per link below. Humelink East comprises the new transmission line between Barnaby and the Interface Point and the augmentation of the current Barnaby substation.

Manufacturing This contractor has never built transmission lines in Australia before, which is likely to increase the risks due to the shortage of skilled line construction workers in Australia. Acciona Construction Australia is also in another Joint Venture called ACE Energy sponsored by Acciona, Cobra and Endeavour Energy) that has been selected by the Energy Corporation of NSW to build, finance, own and operate the West Orana REZ transmission grid, which is comparable in size to Humelink. Cobra is a Brazilian Transmission Construction company that has never worked in Australia.

The contract for Humelink West has presumably been awarded to UGL Engineering Pty Ltd an experience Australian transmission line construction company. They were one of the two other contractors on TransGrid's shortlist to construct Humelink. Presumably the scope of work for Humelink West is the remainder of Humelink being the Managle substation, the Gugga substation, extensions to Wagga Wagga substation and the 500kV overhead lines from the Interface Point to these substations, including a short length of 330 kV overhead line from Gugga to Wagga Wagga substation. I expect that the Interface Point is where the three 500kV lines meet each coming from Barnaby, Managle and Gugga.

It is telling that TransGrid has signed up two contractors. This will put TransGrid in a very strong position to build all of VNI West as overhead 500kV transmission line

2. What commitments beyond the $633 million for early works have been made?

TransGrid shave entered into contacts for reactors and transformers with Hyosung (Korea) and Hitachi (Japan) for both Humelink and VNI West and intend to enter into contracts for conductor and transmission tower steel to build both Humelink and the NSW part of VNI West as 500 kV AC overhead transmission line. TransGrid have an underwriting with the Federal government for $385million to secure supplies under the Rewiring the Nation Fund.

https://www.transgrid.com.au/media-publications/news-articles/federal-underwrite-of-385-million-to-accelerate-the-energy-transition-and-secure-critical-supplies

https://www.australianresources.com.au/transgrid-and-hitachi-energy-sign-supply-contract-for-transmission-projects/#:~:text=Transgrid%20has%20signed%20a%20supply%20contract%20with%20Hitachi,reactors%20for%20the%20VNI%20West%20and%20HumeLink%20projects.

3. Should all expenditure on HumeLink be paused till the Inquiry has concluded and the government made a decision on future undergrounding of transmission? Neither Humelink nor VNI West has been approved.

It appears that TransGrid has taken on the commercial risk on entering into contracts for both unapproved Humelink and VNI West projects of a total value of possibly up to $4bn being 80% of the $5bn costs advised by TransGrid to the Inquiry. I cannot comment on whether these contracts permit delivery to be paused or cancelled or whether the NSW Government has the power to direct TransGrid to pause expenditure on Humelink.

4. Are there any proposals for additional connections along the route of HumeLink?

There are no additional connections along the Humelink route and unlikely to ever be. That would not be economic compared with connecting to an existing 330kV line that runs to Barnaby or Wagga Wagga. The standard practice in NSW is to connect renewables to the 330kV or 220 kV network. There are no renewable generation connections using 500 kV lines anywhere in Australia. There are three in Victoria (Macarthur, Dundonnell and Stockyard Hill) that run 132kv or 220kv lines from the wind farms to the 500kv substation but they do not run 500 kV lines. It is much cheaper and better to run 330 kV lines and connect to the 330kV network. A 500 kV connection would cost around $m120 for the connecting substation and two transformers at the renewables site, plus $m6/km for a double circuit 500 kV line to the site. Connecting to the 330kV network in NSW would cost $m18 for the connecting substation, no transformers needed and $m2.8/km for the 330 kV transmission line to the site. The total cost of a 30 km connection would be $m300m at 500 kV triple the $m102 at 330 kV. There are many more 330 kV lines to connect to and there are power system security implications of connecting to the 500 kV grid.

4 (b) If so:

- why weren't they included in the PACR, and its benefit-cost analysis? N/A
- how much spare capacity does HumeLink have when Snowy 2.0 is operating?

In the Humelink PACR, TransGrid claimed that Humelink has a transmission capacity of 2,560 MW. TransGrid has just advised AEMO that the transmission capacity is 2,200 MW in both directions. I believe that Humelink's transmission capacity will also depend on whether the Snowy 2.0 scheme is pumping or generating as pumps are inherently unstable electrically for a power system. I expect a lower Humelink transmission limit when Snowy 2.0 is pumping. Snowy 2.0 is claimed to be rated at a maximum capacity of 2,040MW generating or 2,040 MW power usage when pumping. This alone indicates that there would only be only 160 MW of spare capacity on Humelink when Snowy 2,0 is running at full load either generating or pumping. AEMO are claiming that Snowy 2.0 will operate for the equivalent of 25% of the

year at full generation. This would require it to also operate for 37% of the time at full load pumping (assuming a 68% cycle efficiency as advised by Snowy Hydro for operating at full load). That totals 62% of the year with Snowy 2.0 operating at its full 2040MW either pumping or generating. This implies that there will only be 160MW of spare capacity on Humelink for most of the time, especially those times when Snowy 2.0 will be generating at full power because it is needed to "keep the lights on in Sydney

5 What consideration was given to upgrading existing AC lines or replacing with/adding DC circuits for proposed new transmission in NSW?
In the Humelink PADR and PACR, these options were not considered. Neither were they considered in the AEMO Integrated System Plan for 2018, 2020 and 2022. However, the 2024 Integrated System Plan is proposing to use transmission options as listed below supposedly to reinforce Humelink due the lack of sufficient capacity beyond that required for Snowy 2.0

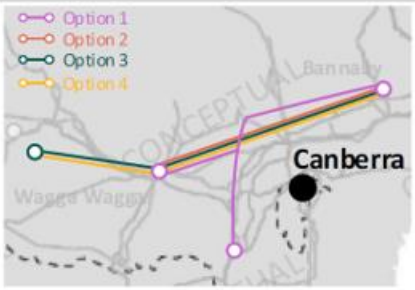
3.8 Southern New South Wales to Central New South Wales

Summary

The transmission network between Southern New South Wales (SNSW) and Central New South Wales (CNSW) provides access for the hydroelectric generation in the Snowy mountains, renewable generation in SNSW, and import from Victoria and South Australia to New South Wales major load centres.

HumeLink is a proposed transmission network augmentation that reinforces the New South Wales southern shared network to increase transfer capacity to New South Wales load centres. This was identified as an actionable ISP project in the 2022 ISP. Transgrid has completed the RIT-T process for this project and early works funding has been approved by the AER.

Subsequent to HumeLink, three options are proposed to increase the maximum network transfer capability between SNSW and CNSW to access increased import from Victoria and South Australia with increased generation in SNSW to NSW major load centres.



Existing network capability

The maximum transfer capability from SNSW to CNSW is 2,700 MW at peak demand and summer typical and 2,950 winter reference periods. The maximum transfer capability is limited by thermal capacity of Yass– Marulan or Crookwell-Bannaby 330 kV lines following a credible contingency.

The maximum transfer capability from CNSW to SNSW is 2,320 MW at peak demand and summer typical and, 2,590 MW at winter reference periods. The maximum transfer capability is limited by thermal capacity of Yass–Canberra or Marulan–Yass[62] or Gullen Range–Bannaby 330 kV lines following a credible contingency

Augmentation options

Description	Additional network capacity (MW)	Expected cost ($ million)	New easement length (km)	Lead time
Option 1 (HumeLink): • New Wagga Wagga 500/330 kV substation and 330 kV double-circuit connection to the existing Wagga Wagga 330 kV substation. • Three new 500 kV transmission lines: - Between Maragle and Bannaby 500 kV substations. - Between Maragle and new Wagga Wagga 500 kV substations. - Between new Wagga Wagga and Bannaby 500 kV substations. • Three 500/330 kV 1,500 MVA transformers at Maragle. • Two 500/330 kV 1,500 MVA transformers at new Wagga Wagga. • 500 kV Line shunt reactors at the ends of Maragle – Bannaby, Maragle – new Wagga Wagga and new Wagga Wagga – Bannaby 500 kV lines. *Provided by Transgrid – see Section 1.2.*	2,200[63] N6+N7: 2,200 (N6: 1,500), N5: 800	4,892[64] (June 2023 dollars) Class 5 (± 50%)	630	Short
Option 2: • A 2,000 MW bi-pole overhead transmission line from locality of Bannaby to locality of Wagga Wagga. • A new 2,000 MW bipole converter station in locality of Bannaby.	2,000 (both directions SNSW to CNSW) N6: 2,000	2,450 Class 5b (± 50%)	260	Long

• A new 2,000 MW bipole converter station in locality of Wagga.
• AC network connection between new HVDC converter the locality of Bannaby and the existing Bannaby 500 substation.
• AC network connection between HVDC converter stati locality of Wagga Wagga and a future Wagga Wagga substation.
Pre-requisite: HumeLink

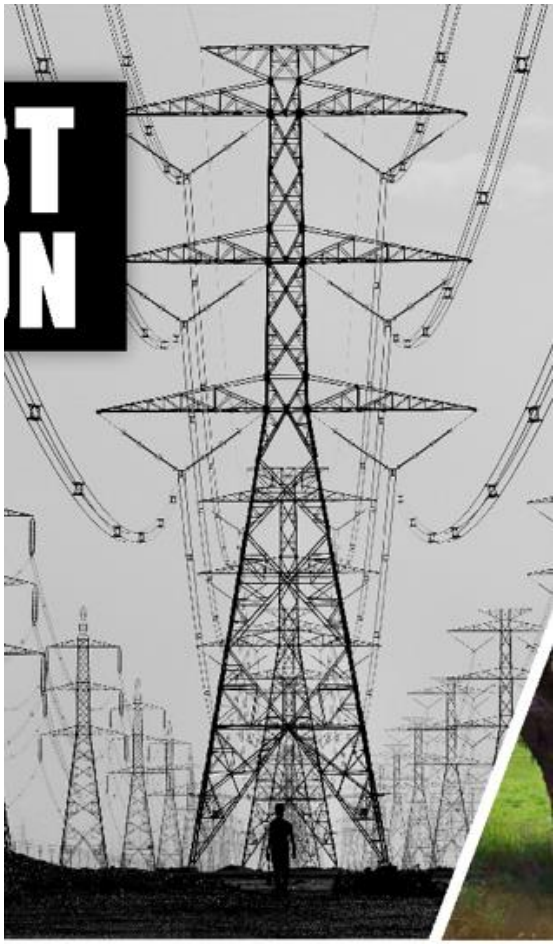
Option 3:
• An additional new 500 kV double-circuit line from Dina Wagga Wagga.
• An additional new 500 kV double-circuit line from Near Wagga to Bannaby.
• 4 additional new 500/330/33 kV 1,500 MVA transforme Dinawan.
Pre-requisite: HumeLink, VNI West, SNW Southern 500

Option 4:
• An additional new 500 kV single-circuit line from Dina Wagga Wagga.
• An additional new 500 kV single-circuit line from Near Wagga to Bannaby.
• 2 additional new 500/330/33 kV 1,500 MVA transforme Dinawan.
Pre-requisite: HumeLink, VNI West, SNW Southern 500

Adjustment factors and risk

Option	Adjustment factors applied
Option 1	• Cost estimate provided by Transgrid
Option 2	• Land Use: Developed area/Grazing • Jurisdiction: NSW – Southern • Project network element size: # of to 31/applicable for HVDC converter st project/Above 200 km • Location (regional/distance factors): • Delivery timetable: Long
Option 3	As per Option 2 except: • Project network element size: # of to 10/Above 200 km
Option 4	As per Option 2 except: • Project network element size: # of to 5/Above 200 km

While AEMO says that these options are subsequent to Humelink, it shows that a 2,000 MW overhead HVDC line from Barnaby to Wagga Wagga would be half the cost of Humelink. Given that Snowy 2.0 is delayed until at least end 2029, the overhead HVDC option to Wagga Wagga seems a better option as overhead HVDC overhead is far less visually intrusive that 500 kV HVAC and can be easily undergrounded through prime agricultural land of other sensitive locations at only 2 to 3 times the cost of that section of line.



HVDC Overhead Bi-pole transmission line 500kV HVAC double circuit line

6 What consideration has been given to locating underground cables within, or near, existing overhead line easements?

Whilst this is common practice overseas, the only consideration given to it in Australia was for the Directlink, Murraylink, Basslink and Marinus projects by TransEnergie and Tasnetworks.

7 What are the requirements for HumeLink to be 'a collector line'?

There is no requirement for Humelink to be a collector line. Humelink's role is high capacity, long distance transmission of bulk electrical energy, exactly the same role as HVDC used overseas

8 What is the basis for claiming that HumeLink would be delayed up to five years if undergrounded?

Undergrounding Humelink using HVDC cable is likely to take around 6 years, comprising 4 years to obtain the right of way, design, tender, manufacture and deliver the cable and AC/DC converters (by say mid 2027), and 2 ½ years to install, test and commission (by end 2029). Humelink is unlikely to obtain the right of way for many years, if at all. That alone could take another 5 years to mid-2028. Whilst TransGrid has let the contracts for the equipment and construction, no field work can commence until they have the right-of way. It would then take a

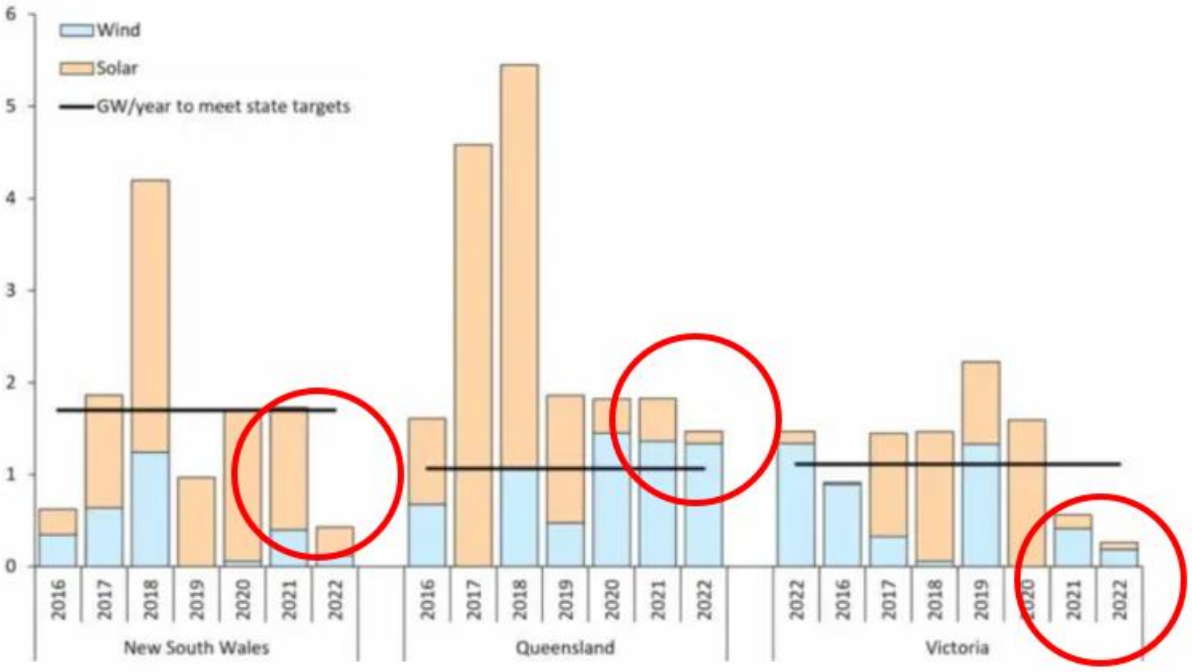
similar 2 ½ years of field work, possibly longer than the DC option, with completion by end 2030. Based on that timing the HVDC underground option may be completed earlier than the 500kV overhead option. Given the national groundswell against overhead 500kV transmission, Humelink may never be completed.

9 What renewable energy will not be able to be connected if HumeLink is not completed by 2026

As illustrated below, approvals for new renewable generation in NSW virtually ceased in 2022 when 1,320MW of new solar farms came on-line in south-west NSW, severely congesting the 330kv and 220kV lines back to Marallan substation (near Barnaby substation) resulting in the solar farms being constrained off-line wasting half of their potential energy generation and a further 10% being wasted in transmission losses.

Figure 3: Annual capacity approved vs capacity required to meet 2030 state targets

Gigawatts (GW)



https://reneweconomy.com.au/wind-and-solar-face-planning-brick-wall-that-threatens-to-derail-switch-from-coal/?fbclid=IwAR3xqY

There is now severe congestion on sunny days on the existing 330kv transmission line between Marallan (near Barnaby) to Yass to Wagga-Wagga to Darlington Point and on the 220kv line from Darlington Point to causing curtailment of existing solar farms and excessive transmission losses as high as 50% making it unviable for solar farms in south-west NSW and wagga Wagga REZs. The drastic fall-off in new solar farms has happened in every state because their weak rural transmissions lines have become severely congested by the flood of solar farms in the preceding years. New wind farm approval has also stopped for the same reason except for Queensland with its strong 275kV/330kV network in Southern Queensland. Building the 500kV Humelink and VNI West will partially address the congestion on the 330 kV lines as it would act like a freeway, carrying large volumes of traffic direct from Dinawan to Wagga to Barnaby, relieving the traffic on the 330 kV lines. However, upgrading the 330kV lines is a faster option, and is required anyway as they will act as collector lines feeding traffic to and from the freeway. The answer to the question is

none, as new solar farms have already stopped because of severe congestion on the 220kV/330kV lines.

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?

The only interconnector to NSW before 2030 is Project Energy Connect. PEC was justified connecting to Wagga Wagga without Humelink but at the time, experienced power engineers knew that it needed stronger transmission from Wagga Wagga to Barnaby as the existing 330kV lines had insufficient capacity, as noted above. PEC could not justify that cost of the required upgrade beyond Wagga Wagga compared with the option of HVDC from Queensland to South Australia. PEC was supposed to be operational by 2023/24 but has now been deferred to 2026, coinciding with the date for Humelink. However, Humelink cannot possibly carry the 800MW from PEC plus the 1,500MW of solar power plus the 2,000MW from Snowy 2.0. In truth, PEC will not be able to transmit anything close to its claimed 800 MW capacity because the 220kV networks between Darlington Point and Buronga and in north-west Victoria are already fully loaded by new solar farms. PEC will have to be constrained to well below 800MW to avoid making the situation even worse

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11 Is it realistic to expect that HumeLink could be built by 2026?

No – Completion by 2026 would require the EIS to be finalised and approved by both governments, the easement to be agreed, surveyed and gazetted and compensation to be agreed or compulsory acquisition. The community/landowner opposition to Humelink is much stronger than the opposition to Eastlink back in 1996 which culminated in the sacking of the Goss labour government in Queensland and the abandonment of the Project. I expect a similar outcome for Humelink.

12 Could an underground HumeLink be completed by the time Snowy 2.0 is completed (2029+)?

Yes, provided work commences now and trust in TransGrid by the community can be restored.

13 TransGrid has said that the delay in Snowy 2.0 is a 'potential delay'. Is it potential or actual?

The Snowy 2.0 project was approved in February 2019, has hardly progressed with only 150m of its 27,000 m water tunnel bored and not yet started the power station excavation. Wivenhoe, a vastly easier pumped storage scheme that I planned took 9 years from approval to completion. The Snowy 2.0 project will not be completed before the next decade and most likely will be abandoned.

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)?

It doesn't. Not only is the electrical connection of Humelink to the Snowy scheme very weak, but the existing 330kV transmission already provides ample capacity for all of the stored Snowy energy to be used and transmitted to Sydney and NSW. What TransGrid is referring to is that there may be insufficient transmission capacity for the Snowy Scheme to run at full capacity. However, that is not required to access its full energy storage. Every year, that already happens, in fact in 2022 the Snowy reservoirs were drawn down far lower than normal. On average the Snowy Scheme runs at only a 10% annual capacity factor meaning if it can only generate at full output for 10% of the year. If additional transmission capacity is provided to enable the scheme

to run at full capacity, the reservoirs would discharge their average annual energy capability in just over one month. Should there be a benefit in increasing the existing transmission capacity for the Snowy Scheme, that could be achieved by working the existing 330kV network harder by dynamic, real-time ratings of the existing transmission lines or installing FACT's devices if there is a stability limit. There is no need to provide additional transmission capacity by building Humelink earlier than it is really needed.

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 Energy Connect will be connected to the existing 330kV network at multiple locations? This is a repeat of question 10.

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?

There is only 1,500MW of South West REZ generation, all solar farms, comprising Colleambally (150MW), Darlington Point (336MW), Limondale (249MW), Sunraysia (200MW), Hillston (120MW), Wagga (30MW), Bomen (100MW), Junee(30MW), Sebastol (90MW), Griffith (30MW), Wyalong (75MW) and West Wyalong (90MW). No more are likely to be installed until the very high curtailments are drastically reduced.

17 What additional power is estimated to be transmitted to Sydney by HumeLink over the next decade, in addition to Snowy 2.0?

The 1,500MW of existing South-west REZ solar farms, the 636 MW of Wagga-Wagga REZ solar farms, the 1,800MW import from VNI West. Please note that AEMO has made the Sydney Ring 500kV project an Actionable Project for completion by 2027 running 500kV from Barnaby to Sydney. Overhead 500 kV lines will never be approved in that area. A much better option would be to continue the HVDC beyond Barnaby to say South Sydney substation.

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18 Is there any reason why priority should not be given for undergrounding transmission lines in NSW, as is the case in many overseas countries?

It may be unnecessary to underground transmission lines through many less sensitive areas or to underground 220 kV and 330 kV lines. The priority should be to underground very high-capacity transmission lines in sensitive areas such as high-quality cultivated land, places of high scenic amenity and more densely populated areas, such as within 50 kms of Sydney. 220 kV, 330 kV, single circuit 500 kV and HVDC overhead lines have much lower socio-environmental-economic impacts than 500 kV double circuit lines. 500 kV overhead double circuit lines are a direct competitor to HVDC overhead lines/underground cables and are unlikely to be a better option.

19 Are underground cables designed to cope with the heat generated? If so, how? Refer to Ken Barber

20 Are fibre optic monitoring cables installed to prevent overheating? If so, how? Refer to Ken Barber

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

21 Can't underground cables be designed to equal the capacity of overhead lines? Refer to Ken Barber

22 In what ways is maintaining underground lines more challenging than overhead lines? Refer to Len Brand I believe that maintaining overhead lines and their easements is more challenging than maintain underground cables.
23 What 'regular inspection and maintenance' is required for underground cables other than occasional 'driving or droning of the route' to ensure no building activities? Refer to Ken Barber and Les Brand
24 Aren't monitoring systems installed with underground cables, providing real-time information on cable conditions and warnings of potential problems? Refer to Ken Barber and Les Brand
25 Doesn't modern fault detection technology usually locate underground faults within hours? I would expect that to take much less time than hours. Refer to Ken Barber and Les Brand
26 What is the typical fault history of underground cables – it is understood to be far superior to overhead lines? Refer to Hen barber. CIGRE has excellent fault history data.
27 Are underground cables designed to withstand moisture seepage (e.g., subsea cables)? Explain. Of course, refer to Ken Barber
28 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? Refer to Ken Barber
29 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? Overhead transmission lines have much higher ongoing maintenance costs and refurbishment costs, including their easements
30 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? Overhead easements are required to be inspected every 6 months to measure and remove potential bush-fire material, tree regrowth, structures build on the easement. This is not required for underground cables.
31 Aren't there substantial restrictions on farming activities for overhead lines (tall machinery, cropping planes, drones, interference of GPS machinery etc)? yes, all of the above.
32 Do the much wider easements for overhead lines result in greater biosecurity risks? A major concern for farmers is that construction and maintenance vehicles will bring weeds onto the farming property.
33 Where are there examples of a 50-metre-wide trench being required? I have never encountered this in my 52 years working in 5 countries
    - what is the width of trenches for underground cables in Australia and overseas? Several 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.
34 Where are there examples of trenches a 'minimum two metres deep, typically more'? sorry I can't provide any examples
35 Can underground cables be routed to avoid land that is unsuitable or of particular construction difficulty or having high economic/environmental value? Yes, however it is best to run the cables in a straight continuous direction
36 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'? yes
37 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)?
38 Can most forms of farming be continued on an underground easement (cropping, pastures etc)? yes, an exception would be growing trees above the cables

39 Do access roads (tracks) for overhead lines usually extend along the entire line? Access tracks must go to every tower but not necessarily along each span

40 Is an access track always required along underground cables? No, but normally to joint boxes

41 Is the identification of aboriginal heritage essential for both overhead lines and underground cables? Yes – Above ground such as scar trees, stone tools and scatters, usually by walking and inspecting the preferred alignment. Below ground i.e., burial sites. Usually by a monitor for underground excavations only – boring tower footings, earthing trenches, cable trench. But not for erecting new lines or cable installation.

    a. Can underground cables be routed to avoid such sites, even when discovered during construction? Overhead lines have been routed to avoid significant sites. So can cables, but usually scar trees are not removed and avoided. Stone tool scatters may be relocated by the indigenous monitors. I've never encountered an underground burial remains in constructing thousands of kms of overhead lines and cables