NSW Parliamentary Inquiry – Undergrounding

Questions on Notice

Questions taken on Notice from the 16 February hearing.

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<tr><th>Question</th><th>Answer</th></tr>
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<td>The Hon. WES FANG: How many long distance HVDC transmission lines does Australia have?
MARIE JORDAN: The one that I'm familiar with—and I'll take on notice if I've missed some, but I do know you have Marinus Link, which is an underground cable. And underground cable—you'll see that a lot in HVDC solutions. As a matter of fact, when I was here last time there was discussion about the most recent HVDC line that is headed into New York City. The majority of that is in the Hudson River. It's very common. The other one is Murraylink. Murraylink is not comparable in distance. It used to be one of the longest in the globe for HVDC but it's a much lower voltage and it carries much less megawatts across that line so there's a very different heating factor on that conductor.</td>
<td>We have 3 operational (and one in development) HVDC lines across Australia (outside of any smaller voltage internal connections for SF and/or WF developments)
<table>
<tr><th>Name</th><th>Voltage</th><th>Power</th><th>Start Location</th><th>End Location</th><th>Length</th><th>In-Service Year</th></tr>
<tr><td>Terranora Interconnector (Directlink)</td><td>80kV</td><td>180MW</td><td>Mullumbimby, NSW</td><td>Bungalora, NSW</td><td>63km Cable</td><td>2000</td></tr>
<tr><td>Murraylink</td><td>150kV</td><td>220MW</td><td>Red Cliffs, VIC</td><td>Berri, SA</td><td>176km Cable</td><td>2002</td></tr>
<tr><td>Basslink</td><td>400kV</td><td>500MW</td><td>Loy Yang, VIC</td><td>George Town, TAS</td><td>298km Cable
72km Pole (shore sections)</td><td>2006</td></tr>
<tr><td>Marinus Link (in development/delivery)</td><td>320kV</td><td>1500MW</td><td>Burnie, TAS</td><td>Latrobe Valley, VIC</td><td>345km Cable (250km subsea cable and 95km land cable)</td><td>2028/29 Stage 1
2030/31 Stage 2</td></tr>
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<td>1. The CHAIR: In relation to the resilience plan you just mentioned that you put into IPART, is it possible
at all for the Committee to have a look at any of that work?
MARIE JORDAN: They did an audit of our processes. I'll take it on notice and have our asset management organisation provide information on their resiliency plan.</td>
<td>For contextual clarification, Transgrid presented to IPART in a closed forum about how we have assessed climate change risk to the transmission network, and what plans we have to manage these risks into the future. Subsequent to this IPART issued a request for information on the same topic. Please see the relevant excerpt below from our response back to IPART on this matter.

Transgrid has undertaken a range of modelling exercises to better understand the key impacts that extreme weather events can have on the transmission network, and based on this these can broadly be categorised into:

Increased demand - extreme weather giving rise to steep increases in electricity demand and altered network utilisation.
Reduced generation - reduction in the output from large scale generation changing network utilisation.
Network derating - dynamic reduction in the rating of transmission network assets during periods of high ambient temperatures to avoid loading the assets to levels that can cause damage.
Asset damage – potential direct damage to infrastructure, such as transmission lines, from events such as high winds, storms, floods, and bushfires.

These impacts are driven by the following change in climate hazards:
<table>
<tr><th>Changing Climate Hazard</th><th>Electricity System Vulnerability</th></tr>
<tr><td>Rising temperatures and increasing duration of heatwaves</td><td>Reduced generator and network capacity at time of peak demand.</td></tr>
<tr><td>Increased frequency, severity, and extent of bushfires</td><td>Bushfires have potential to impact all electricity networks including both transmission and distribution assets. The degree of impact varies significantly but is typically higher across distribution networks. The smoke and particulates can also significantly reduce the generation from large scale and embedded solar generating systems.</td></tr>
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<tr><td>Increasing frequency of extreme winds</td><td>Extreme weather and wind events are a key consideration in the network design specifications. Wind generation is sensitive to a reduction in average wind speed as well as to the frequency and magnitude of destructive gusts</td></tr>
<tr><td>Increased variability or reduction in rainfall, and dam inflows</td><td>Reduces the water available for hydro generation. Increases the requirement for desalination and associated energy demand. Reduced soil moisture may increase damage from lightning and reduce thermal conductivity of underground power lines</td></tr>
<tr><td>Compound extreme events</td><td>Extremes in multiple climate variables occurring simultaneously or in close sequence can cause substantial disruption. These events can be exacerbated by associated non-climatic factors such as infrastructure or staff fatigue</td></tr>
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Detailed modelling scenarios were completed across the following spaces:

Climatic impacts of high intensity winds, lighting strikes and ice accumulation on all critical transmission lines on Transgrid’s network.
Changes in bushfire intensity forecast using Electricity Sector Climate Information (ESCI) data.
Substation future flood impacts.
Forecast transmission line rating impacts using ESCI data.

Results from these models were then used to develop options that seek to selectively address vulnerabilities to maintain acceptable levels of network risk and resilience for critical assets in the face of increasing climate change-related hazards. From this the following initiatives are being progressed as they meet either As Low as Reasonably Practicable (ALARP) or economic benefit investment tests when the costs required to implement versus overall benefits are evaluated:

Expansion of dynamic rating systems
Expanding dynamic line rating as a part of regular operations at Transgrid offers numerous benefits. When conditions are favourable, the rating of a transmission line can be increased. This has the potential to reduce congestion and allows more flexible

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Question	Answer
	network operation. Conversely, when conditions are unfavourable, such as on extremely hot days, lines may be derated, preventing overheating and maintaining the service life of the asset. Implementing this initiative has a resilience benefit in that it may reduce asset damage, but it also has significant market advantages as unnecessary constraints may be avoided. 2. Wood Pole Replacement program Replacement of wood poles with composite structures such as concrete or steel is a reasonably simple like-for-like substitution and one that Transgrid is progressing over multiple regulatory periods as the investment on each pole can be justified. While this program of work is focused on addressing asset condition issues, it also offers a network resilience benefit particularly from fires. 3. Replacement of Polymer insulators with toughened glass insulators Polymer insulators are less resilient to the extreme heat that occurs during bushfires. As such design standards have been updated and polymer insulators are being changed out with toughened glass insulators during replacement programs, these have much higher bushfire resistance. As bushfire has been a theme throughout the Inquiry, we feel it's important to note extensive modelling has been undertaken by Transgrid to understand risk profiles across the NSW transmission system. In addition, we have also completed specific resilience modelling to understand the nature of bushfire risk when forecast climate change is applied across the 2020-2050 and 2050-2090 epochs. Results from these modelling exercises have then been used as key inputs as we determine: • Asset maintenance programs • Forecast capital replacement programs (like the aforementioned) • Locations requiring prioritised investment • New technology pilot programs • The bushfire risk management plan Regarding forecast climate change scenarios modelled across those epochs, this was completed by Melbourne University with results indicating minimal impacts on overall annualised bushfire risks either to or from Transgrid's network. This suggests our current understanding of bushfire risks will remain accurate over time (until model input parameters are no longer valid), and therefore we are

Question	Answer
	confident our current combination of risk mitigation practices and resilience-based investments are fit for purpose. Through continuous improvement we also ensure these models are routinely updated with current data and revalidate input parameters/assumptions. Our processes and practices within this space are subject to routine external auditing by IPART, and are supported by an ISO55001 certified and industry mature asset management system. A number of other identified initiatives will continue to be assessed for optimal timing as the climatic conditions change. We are also continuing to investigate other opportunities to maintain a highly resilient New South Wales transmission network in response to the projected impacts of climate change. As part of these investigations, future resilience works have been identified which can be grouped into the following themes: • Developing and refining compound event analysis • Ongoing assessment of vulnerability and mitigations options • Development of and reporting against key resilience metrics
2. Jeremy Roberts - Based on our information, that is not changing the Australian standards. We must apply the Australian standards and use ALARP—which is "as low as reasonably practical" to design—to ensure that we are not over-designing. We will be heavily scrutinised for over-designing above what the standards are. The CHAIR: When did those standards change? For example, a steel transmission tower—when did those standards last change? Have they been updated in the past few years? MARIE JORDAN: We'll take that on notice for the exact timing,	The last revision date for the Australian Standard AS7000 was 2016.

Commented [E1]: [redacted] you advised it was 2016 is this the correct answer for Q3. looping in [redacted] for his information

Commented [IG2R1]: 2016 was the last revision date for the Australian Standard AS7000 that is often referred to for designing transmission lines. There hasn't been any further changes to the AS7000 since then. There has been updates to our internal manuals relating to transmission line designs and construction, but not to the AS7000.

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3. The CHAIR: That's your evidence? I have the report in front of me; that is the report from Transgrid

Overview of *2019-20 Bushfire Damage to TransGrid's Network* as a result of the Black Summer fire. The executive summary has 2,681 transmission line structures were within the bushfire zone and there were 1,822 steel lattice tower and pole structures within the burn area and 596 wood pole structures. How many of those were damaged, for example?
MARIE JORDAN: We can take on notice the exact number, but the steel tower structures fared well.

We were able to re-energise. Actually, some of the wood pole structures, I do know, had some fire damage. Many of it could be re-energised, and that's at the 132 level, and they had work done post being re-energised. We took clearances and took care of those. But we can take on notice more exact figures.
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Per the referenced report *2019-20 Bushfire Damage to TransGrid's Network* submitted to the Australian Energy Regulator, see the below table summarising asset damage suffered to Transgrid's network. Of particular note no material damage was suffered to our steel and concrete tower asset fleets, demonstrating the high levels of fire hazard resilience achieved through these asset types and design.
<table>
<tr><th colspan="2">Asset type</th><th>Assets within bushfire impacted zone</th><th>Asset damage</th></tr>
<tr><td colspan="2">Overhead Conductor</td><td>999 km</td><td>47 km</td></tr>
<tr><td rowspan="3">Structures (pole/towers)</td><td>Wood Pole</td><td>596</td><td>86*</td></tr>
<tr><td>Steel Tower</td><td>1822</td><td>0</td></tr>
<tr><td>Concrete Pole</td><td>263</td><td>0</td></tr>
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*Only 13 from the 86 wood pole required immediate replacement
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4. **The CHAIR:** It's an important line of inquiry for this Committee. The report states:
… the unprecedented scale and intensity of the 2019/20 bushfires has had a significant impact on TransGrid's transmission network and the condition of the assets.
That's your report. We're here today and I'm asking you about what the impact of those fires was, and it just seems as though the whole impact is not being conveyed to this Committee in a way that this report would suggest. Were you around then at that time, Mr Roberts?
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Per Q4 there were 86 wood poles damaged (13 requiring immediate replacement) as a result the 2019/20 bushfires.
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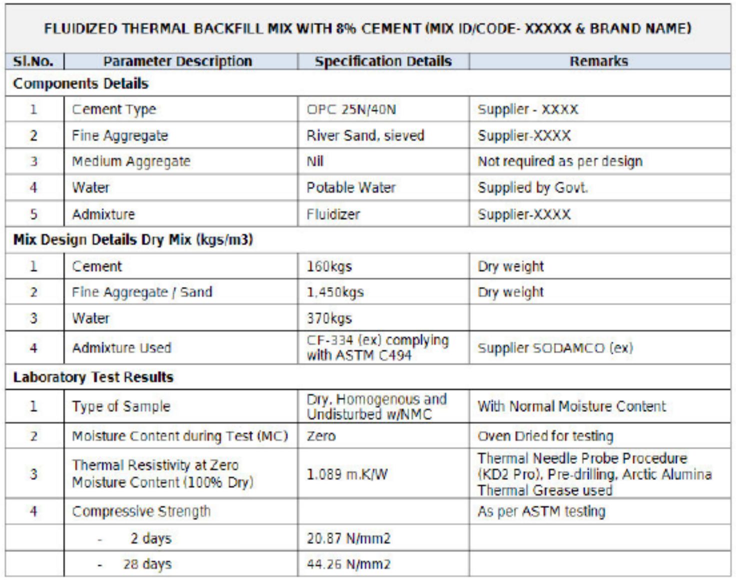
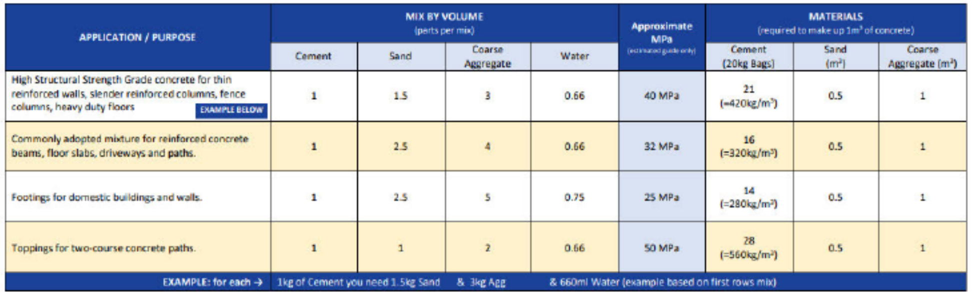
Question	Answer
The CHAIR: It had a significant impact on your infrastructure—on the network and the assets. JEREMY ROBERTS: On the wood pole structures, there were some damaged poles. I'll take it on notice as to the exact impacts of how many. But, as I stated before, that's the impact to the customers and the outages that occurred as a result of our network at the time. I can provide the exact numbers of wood poles that were damaged or replaced as a result. But, again, that is the 132 network, not the HV 500 kV tower network. The CHAIR: I've got here central New South Wales, not necessarily saying that the towers themselves were impacted. The report states: In total there were 12 trips of 500 kV transmission lines. This is significant as these are not only part of the main backbone of TransGrid's network but are also the tallest and largest structures on the network. The fact that so many trips occurred on these assets indicates the magnitude of the severity of the fires and the volume of smoke being produced at the time. As well as trips to Transgrid's 500 kV network there were also 129 outages caused by bushfires on the 330 kV network.	
5. The Hon. EMILY SUVAAL: Tell me, what is the emissions profile like of the slurry and the backfill and all of this sort of stuff that you're then having to put into the ground? MARIE JORDAN: We would look at it in different instances. I don't know currently what it is, because there are different ways of making slurry right now. I	Fluidised Thermally Stable Backfill (FTSB) key components are: - Cement - Crushed gravel - Coarse sand - Water Typically, the emissions profile of interest (or paraphrasing to CO2 emissions) would be constrained to the production of the Portland cement portion of the FTSB. Portland cement produces approx 800kg CO2/tonne. Comparing a typical FTSB design mix with that of a standard concrete of 32MPA

Question	Answer
don't know how readily available it is. But I'll definitely look to see if we can find a credible source for that information. The Hon. EMILY SUVAAL: Thank you. That will be interesting.	strength (suitable for footpaths, floor slabs, driveways etc), the FTSB has approx half the kg/m3 of Portland cement compared to the standard concrete mix. Therefore the emissions profile per cubic metre of the FTSB would be half that of typical concrete mix that is used for domestic and industrial uses. For completeness I've included the references below: Example mix design of FTSB (source: [(PDF) GENERAL MIX DESIGN OF FLUIDIZED THERMAL BACKFILL FOR UNDERGROUND EHV CABLES (researchgate.net)]()):



FLUIDIZED THERMAL BACKFILL MIX WITH 8% CEMENT (MIX ID/CODE- XXXXX & BRAND NAME)

Sl.No.	Parameter Description	Specification Details	Remarks
Components Details			
1	Cement Type	OPC 25N/40N	Supplier - XXXX
2	Fine Aggregate	River Sand, sieved	Supplier-XXXX
3	Medium Aggregate	Nil	Not required as per design
4	Water	Potable Water	Supplied by Govt.
5	Admixture	Fluidizer	Supplier-XXXX
Mix Design Details Dry Mix (kgs/m3)			
1	Cement	160kgs	Dry weight
2	Fine Aggregate / Sand	1,450kgs	Dry weight
3	Water	370kgs	
4	Admixture Used	CF-334 (ex) complying with ASTM C494	Supplier SODAMCO (ex)
Laboratory Test Results			
1	Type of Sample	Dry, Homogenous and Undisturbed w/NMC	With Normal Moisture Content
2	Moisture Content during Test (MC)	Zero	Oven Dried for testing
3	Thermal Resistivity at Zero Moisture Content (100% Dry)	1.089 m.K/W	Thermal Needle Probe Procedure (KD2 Pro), Pre-drilling, Arctic Alumina Thermal Grease used
4	Compressive Strength		As per ASTM testing
	- 2 days	20.87 N/mm2	
	- 28 days	44.26 N/mm2	

Question	Answer
	Example of Standard Concrete mix designs (source: bgccement.com.au/documents/2019/03/guide-concrete.pdf/): 

APPLICATION / PURPOSE	MIX BY VOLUME (parts per mix)				Approximate MPa (estimated guide only)	MATERIALS (required to make up 1m³ of concrete)		
	Cement	Sand	Coarse Aggregate	Water		Cement (20kg Bags)	Sand (m³)	Coarse Aggregate (m³)
High Structural Strength Grade concrete for thin reinforced walls, slender reinforced columns, fence columns, heavy duty floors EXAMPLE BELOW	1	1.5	3	0.66	40 MPa	21 (=420kg/m³)	0.5	1
Commonly adopted mixture for reinforced concrete beams, floor slabs, driveways and paths.	1	2.5	4	0.66	32 MPa	16 (=320kg/m³)	0.5	1
Footings for domestic buildings and walls.	1	2.5	5	0.75	25 MPa	14 (=280kg/m³)	0.5	1
Toppings for two-course concrete paths.	1	1	2	0.66	50 MPa	28 (=560kg/m³)	0.5	1
EXAMPLE: for each →	1kg of Cement you need 1.5kg Sand		& 3kg Agg	& 660ml Water (example based on first rows mix)				