From: Andrew Kingsmill
Sent: Monday, 8 January 2024 11:25 PM
To: Undergrounding Infrastructure
Subject: RE: Inquiry into the feasibility of undergrounding the transmission infrastructure for renewable energy projects - Post-hearing responses - 27 November 2023
Attachments: Transcript - Undergrounding Transmission Infrastructure - 27 Nov 2023 - CORRECTIONS REQUESTED - Hay Kingsmill.pdf

Daniel,

Thank you for the transcript and questions on notice. I have attached the transcript with corrections requested.

We are currently finalising our response to questions on notice, could I please request an extension to Tuesday, 9 January to provide this response?

Regards,
Andrew.

REPORT ON PROCEEDINGS BEFORE

SELECT COMMITTEE ON THE FEASIBILITY OF UNDERGROUNDING THE TRANSMISSION INFRASTRUCTURE FOR RENEWABLE ENERGY PROJECTS

UNCORRECTED

At Preston Stanley Room, Parliament House, Sydney, on Monday 27 November 2023

The Committee met at 11:00.

PRESENT

Ms Cate Faehrmann (Chair)

The Hon. Mark Buttigieg
The Hon. Susan Carter
The Hon. Wes Fang (Deputy Chair)
The Hon. Stephen Lawrence
The Hon. Rod Roberts
The Hon. Emily Suvaal

* Please note:
[inaudible] is used when audio words cannot be deciphered.
[audio malfunction] is used when words are lost due to a technical malfunction.
[disorder] is used when members or witnesses speak over one another.

The CHAIR: Welcome to the first hearing of the Select Committee's inquiry into the feasibility of undergrounding the transmission infrastructure for renewable energy projects. I acknowledge the Gadigal people of the Eora nation, the traditional custodians of the lands on which we are meeting today. I pay respects to Elders past and present, and celebrate the diversity of Aboriginal people and their ongoing cultures and connections to the lands and waters in New South Wales. I also acknowledge and pay my respects to any Aboriginal or Torres Strait Islander people who are joining us here today.

My name is Cate Faehrmann, and I am the Chair of the Committee. I ask everyone in the room to please turn their mobile phones to silent. Parliamentary privilege applies to witnesses in relation to the evidence they give today. However, it does not apply to what witnesses say outside of the hearing. I urge witnesses to be careful about making comments to the media or others after completing their evidence. In addition, the Legislative Council has adopted rules to provide procedural fairness for inquiry participants. I encourage committee members and witnesses to be mindful of these procedures.

Mr JAMES HAY, Chief Executive Officer, Energy Corporation of NSW (EnergyCo), affirmed and examined

Mr ANDREW KINGSMILL, Executive Director, Network Planning and Technical Advisory, Energy Corporation of NSW (EnergyCo), affirmed and examined

The CHAIR: I welcome our next witnesses. Would either of you have a short opening statement for the Committee?

JAMES HAY: Just a little bit about Energy Corporation of NSW for the Committee's benefit. We are a statutory authority. We were originally created under the 1987 Energy Utilities and Administration Act, and our role was to advise the State on the energy resources of the State. Under the Electricity Infrastructure Investment Act 2020, often referred to as the electricity road map, Energy Corporation was added and had a function—Energy Corporation actually didn't do anything for 30 years, but we were re-enlivened under the road map legislation to be the infrastructure planner. The role of the infrastructure planner is to act in the public interest. We are a not-for-profit. We don't—we are a government entity. Ultimately, we won't have a balance sheet; we are not going to operate electricity infrastructure.

Our role is to act in the place of coordinating the investment and transmission generation and storage, principally in the renewable energy zones [REZs] but also what we call priority transmission investment projects, which are transition investment projects that are needed for reliability to keep the lights on. We look at those as a whole. As you know, the transition from the current fleet of coal-fired generators is in progress and happening rapidly. We have an obsolescence issue with that fleet. The existing transmission lines were built to the existing fuel sources, which are the coalfields and the water areas where the coal plants are based. The challenge for New South Wales is to replace over 75 per cent of its base load energy within 10 to 15 years. The CSIRO advice, which is the basis for most policy work in the national electricity market of which New South Wales is a part, is that firmed renewables are the cheapest alternative, particularly in New South Wales. Firmed renewables consist of wind, solar and thermal elements such as short- and long-duration batteries, pumped hydro and gas.

Our role is to recommend the network solutions for the renewable energy zones, in particular, and the coordination of those with the generation that is going to come into those areas and the storage that will be in those areas and elsewhere. The renewable energy zones are like the new power stations in that sense—in an electrical sense. One of the things that the Act really recognised—two things: The State no longer has control in the way it did when the transition to coal-fired generation was done 40, 50 years ago. In those days, the State owned generation, transmission, distribution, retail and set the prices, and it also owned the coalfields. Now it doesn't have those interests. The coordination is a much more informed—different way; you don't have the ownership interest, so most of the investment would be private sector investment.

Our role is to recognise the roles of the community, and the objects of the Act stress that obtaining the support and fostering the support of local communities, which is the way that the Act refers to social licence, is a key objective of the Act and the key objective of Energy Corporation in recommending what the right network solutions are to deliver the energy transition. These renewable energy zones are so large that we have to take a view across the whole of the network of New South Wales. Many of you may be familiar with the network infrastructure strategy that we published earlier this year, which looks at the REZs in the context of the network and the wider network in New South Wales and the priority investment projects and how they fit as part of the national electricity market. They are interconnectors with Queensland, with Victoria and with South Australia, in particular.

Just a little bit about myself and Andrew. I have spent most of my career tunnelling or digging holes in grounds in one way, shape or form. I have worked on infrastructure as broadly as hospitals, prisons and tunnels for electricity and for road purposes. I have also been involved in rebuilding major cities and looking at other things like that—in particular, in Christchurch in New Zealand. I have been in the electricity sector for nigh on 30 years in different capacities. Andrew Kingsmill is a very experienced transmission power systems engineer and has worked in both network planning and network operations for all of his career. He leads our technical advisory group at EnergyCo, which assembles the network infrastructure strategy and then informs the scope and scale of the projects that we are tasked with advancing for the people of New South Wales.

Just a couple of other quick things I would make in that opening statement, if I may, Chair. We look at all projects on their merits, and all projects are different. Perhaps one of the things I would like to stress to the Committee: Transmission is not just poles and wires. One of our signature projects at the moment is the Waratah Super Battery project, which is a transmission project and will be for a substantial part of that asset's life. What that project does—and it's based at the old coal-fired power station site at Lake Munmorah. It enables the existing transmission network to be used at a much higher level of utilisation. It avoids the need for build.

Summary of Comments on Transcript - Undergrounding Transmission Infrastructure - 27 Nov 2023 - CORRECTIONS REQUESTED - Hay Kingsmill.pdf

Page: 4

Number: 1 Author: kingsma Subject: Highlight Date: 8/01/2024 11:00:19 PM
Replace with "infrastructure"

Number: 2 Author: kingsma Subject: Highlight Date: 8/01/2024 11:01:15 PM
Replace with "transmission infrastructure"

Number: 3 Author: kingsma Subject: Highlight Date: 8/01/2024 11:02:01 PM
Replace with "firming"

Number: 4 Author: kingsma Subject: Highlight Date: 8/01/2024 11:03:05 PM
Capitalise i.e. "Network Infrastructure Strategy"

Number: 5 Author: kingsma Subject: Highlight Date: 8/01/2024 11:04:19 PM
Replace with "much"

Number: 6 Author: kingsma Subject: Highlight Date: 8/01/2024 11:04:01 PM
Capitalise i.e. "Network Infrastructure Strategy"

In this case, it's actually buying time for the need for some build to allow proper community engagement, which we have just commenced on what we called the Hunter Transmission Project, and proper planning with Transgrid and with AEMO. AEMO is the Australian Energy Market Operator, who sets the overall plan for the network in the national electricity market, which is called the integrated system plan. So we look at those things—in and around. The Waratah Super Battery, which by megawatts is one of the largest batteries in the world, will be completed in August 2025, having been commenced as a project in 2022. That enables the existing network to perform at a much higher level than it was currently performing at to keep the lights on whilst other initiatives are planned and other investments occur.

We also look at conventional investments and lines. So the renewable energy zones act like collector systems. They are there to collect generation and aggregate it and bring it to the points where electricity is used on a utility scale. They complement the New South Wales electricity strategy, which is an end-to-end strategy about rooftop solar, energy efficiency and peak demand response schemes. It goes from the very point of production, whether that's on the rooftop or on a utility scale, wind or solar farm or a coal generator, and it looks at the system as a whole.

What we do with other projects like the Hunter Transmission Project—it's about the back haul. It's about the backbone of the network to transport bulk energy. We cover the ambit of that, and we're happy to go through how we look at these projects and the specifics. We look at each community as we find it. We look at the landowners as we find them. We look at the electricity needs and the anticipated demand and use of electricity over time and how it serves affordability, reliability and sustainability for the community over time.

The Hon. SUSAN CARTER: Thank you, gentlemen, for being here today. I am just interested what the relationship between Energy Corporation and the Clean Energy Investor Group is.

JAMES HAY: The Clean Energy Investor Group is a peak body that works with other entities. We work with everyone in the industry, whether they be market bodies—

The Hon. SUSAN CARTER: You are members with them, and you use them as consultants?

JAMES HAY: We are not a member. We don't use them as consultants, to my knowledge.

The Hon. SUSAN CARTER: And who prepared your submission today?

JAMES HAY: We prepared our own submission.

The Hon. SUSAN CARTER: You might care to look afterwards at striking similarities between the way you discuss underground transmission in your submission and pages 3 and 4 of the Clean Energy Investor Group's submission. I am wondering what the sources are, because the sources you have disclosed as your footnotes don't appear to give the source for your information about underground transmission in New South Wales.

JAMES HAY: We can certainly look into that for the Committee. What I would stress—and one of the other parts I should mention about Energy Corporation—is that we have an advisory committee that consists of members very specialist in both communities and the sector as a whole. Our submission was prepared by my own team of experts, with advice from external parties, our consultants and others, and also with the review our EnergyCo advisory committee, which consists—the key members of that, for this purpose, are Dr Keith Turner, who is an international expert in transmission engineering, and Dr Alex Wonhas, who is AEMO's system planner for many years.

The Hon. SUSAN CARTER: So perhaps there is a lot of crossover between your advisers and Clean Energy Investor Group, which is just a matter of interest. Is there any formal connection with the RE-Alliance?

JAMES HAY: No.

The Hon. SUSAN CARTER: They appear to be very closely linked with Clean Energy Investor Group in terms of using each other's submissions and, by extension, with what we have in front of us to day.

JAMES HAY: We work with all bodies, and there's a lot of common material. Our website is the source of many people's information as well. Our job is to put information out there. You'll see quite a lot on our website, so it may well be that others have seen what we've put out there.

The Hon. SUSAN CARTER: I notice in your submission, at page 4, you talk about undergrounding and you talk about a bending radius. What's the bending radius of overhead transmission lines?

JAMES HAY: That might be a good opportunity for Andrew to come in with the more technical side, and we probably have some exhibits here that might help demonstrate that point, with the permission of the Committee.

Page: 5

Number: 1 Author: kingsma Subject: Highlight Date: 8/01/2024 11:05:19 PM
Capitalise i.e. "Integrated System Plan".

The Hon. SUSAN CARTER: What's the bending radius of overhead transmission lines?

ANDREW KINGSMILL: Overhead transmission lines can actually turn corners quite sharply with the right civil design, so we don't talk about—

The Hon. SUSAN CARTER: Is it a bend or is it a corner with an overhead transmission line?

ANDREW KINGSMILL: With overhead transmission lines, we don't talk about bending radii, typically.

The Hon. SUSAN CARTER: Is that because they can't bend around natural features like trees in the way that underground cables can?

ANDREW KINGSMILL: No, they can bend around natural features, absolutely.

The Hon. SUSAN CARTER: So the alignment that is proposed bends around natural features to accommodate natural features?

ANDREW KINGSMILL: It can. When we—

The Hon. SUSAN CARTER: It can, but does it?

ANDREW KINGSMILL: That would be specific to each location along the line routes.

The Hon. SUSAN CARTER: Your recommendation is that, if it is overhead powerlines, it should be bent to accommodate the natural features so as to have minimal impact on stakeholders?

ANDREW KINGSMILL: We consider a range of considerations when we set a route. That includes biodiversity-type impacts. That includes the topology of the land, the constructability, the physical impacts and the impacts on land use. All of those are considerations.

The Hon. SUSAN CARTER: Does it include bushfire risk?

ANDREW KINGSMILL: Yes, it includes bushfire risk.

The Hon. SUSAN CARTER: What's the bushfire risk of overhead transmission lines compared to underground cables?

ANDREW KINGSMILL: The bushfire risk—and we're talking here about extra high voltage overhead transmission lines. I would define that as voltages over 330 kilovolts and above—so 330 and 500 kilovolts.

The Hon. SUSAN CARTER: And the risk?

ANDREW KINGSMILL: A 500 kilovolt line has never started a bushfire in Australia, and I note the evidence provided by—

The Hon. SUSAN CARTER: Could I just stop you there? How many 500 kilovolts are currently in Australia?

ANDREW KINGSMILL: There are a number in New South Wales. I would have to get the quantity, but off the top of my head it is in the order of seven or eight. And there are a number in Victoria.

The Hon. SUSAN CARTER: You wouldn't know the kilovolts of the wires that started the bushfires in Maui, would you?

ANDREW KINGSMILL: I don't. I am not familiar with Maui.

The Hon. SUSAN CARTER: And the risk for underground cables?

ANDREW KINGSMILL: I'll just finish talking to the bushfire risk for overhead lines. We noted in our submission the evidence provided by Andrew Dyer to the previous inquiry where he used the term "virtually zero", and that came from some work he did with Energy Safe Victoria. What I would also note is that where bushfires have started previously—for example, the tragic Black Saturday bushfires in Victoria—they were on far lower voltage assets and, particularly in the case of the Kinglake Fire in Victoria, that was around a particular technology called single-wire earth return. A lot of those issues are less of an issue at higher voltages where the easements are wider, where the lines are higher off the ground and where there isn't as much encroachment from trees on the line—very, very low risk. In terms of underground cables, the bushfire risk, as I understand it, is also virtually zero.

The Hon. WES FANG: Thank you very much, gentlemen, for coming today. Looking at some of the projects that have been flagged by EnergyCo recently, and looking at something like Central-West Orana, where you have a REZ and then you have to get power from that Central-West Orana REZ to somewhere like Sydney

or other major metropolitan areas, to a major population base, you've said that you are in charge of the network design and, Mr Kingsmill, you're effectively the person that does that design. Have you looked at undergrounding those lines? If you have, what is it that precludes undergrounding for you?

ANDREW KINGSMILL: "Precludes" is a very strong word. As Mr Hay said, we take each project on its merits. But, Chair, if I may, now might be a good time to table some samples, and I can talk about some of the physical characteristics of underground and overhead.

The CHAIR: Yes, go ahead.

ANDREW KINGSMILL: This is a sample of underground transmission cable at extra high voltage at 330 and 500 kilovolts. It is quite a large asset. It's very specifically manufactured. The interior of the cable is a copper core. It can be an aluminium core, but this one is copper. Outside of that, there's a very specialist cross-linked polyethylene plastic layer, which provides insulation. Then there is an earth and a sheath around that. These cables weigh approximately 40 kilograms per metre, so the installation of them is quite a significant civil undertaking.

They involve excavations, and I recognise that the inquiry has received a number of opinions on how big those excavations are and how wide that corridor is, but I will come to that in a moment. They also have handling requirements so as not to damage the cables, which can be quite expensive to replace. In contrast, an overhead conductor, which this is a sample of, is much smaller. It is much easier to install with a traditional winch-type system. Certainly, the construction of the towers is different between the two, but hopefully this gives a bit of a visual. Committee members are welcome to inspect these if they wish, after the inquiry.

The Hon. WES FANG: We might do that a little bit later. I have some more questions I need to get through, and my time has almost expired. Where you have the need to move energy, have you looked at undergrounding from, say, Central-West Orana into the bigger metropolitan areas?

ANDREW KINGSMILL: We have, and we've done some calculations on that around the size of the trenches, the number of cables, the distances they would need to run, the volume of spoil that would need to be removed and the cement slurry backfill that would need to be poured in that. They are summarised in our submission, but we can provide more information on that if we need to.

The Hon. WES FANG: Is it only a matter of cost that precludes the undergrounding from being an option, or are there other things that preclude your adoption of undergrounding over an overhead system?

ANDREW KINGSMILL: There are a number of other factors. For example, particularly in environmentally or culturally sensitive areas, with overhead lines, the towers are spaced 400 to 500 metres apart. So it is possible to route lines around those areas or to minimise impact through those areas, even such that, if the topology is right, it's possible to route them so that there is no need to clear the vegetation under the lines—for example, if they are routed on two sides of the valley. We've considered things like truck movements on local roads with the amount of spoil that would need to be removed.

JAMES HAY: It's also important, Andrew, to stress that you can't just replace the soil around this thing. They have to be spaced at a certain minimum. One of these conducts much less electricity than one of these, so you have to space them further. You have more of them. They have to be deep, and they have to be encased in heat-resistant material, on which nothing will grow.

ANDREW KINGSMILL: I realise that time is short but, very briefly, the other consideration we have is that the capacity of an underground cable is less than that of an overhead line at extra high voltages. The transmission lines that we are looking at running overhead in Central-West Orana and New England are good for four gigawatts per line. With an HVAC cable, the highest at 500 kV today is 1.8 gigawatts per line and an HVDC 525 kilovolts is 2.6 gigawatts per line. So you end up with more cables to get the same capacity.

The Hon. WES FANG: Unfortunately, my time has run out. I have so many more questions. We may have to ask you to come back at another time because we're not going to get to all the questions today.

The CHAIR: Just to check with that cable, what would be an HVAC or HVDC, did you say?

ANDREW KINGSMILL: This particular cable is an HVAC. An HVDC is not dissimilar. It is marginally smaller—maybe 10 per cent smaller in terms of diameter—but a lot of the properties are very similar.

The CHAIR: Firstly, let me talk about bushfire. Particularly in the State Development Committee inquiry into this issue, we largely covered where the overhead transmission lines can cause fire, and we didn't really talk about the impact on transmission network infrastructure. I think that's an important aspect, given that we will be facing more intense and severe bushfires and fires as the years pass. What has EnergyCo done to futureproof, if

you like, potential overhead transmission lines? The Black Summer bushfires absolutely tore through the overhead transmission network, both in Victoria and New South Wales. The impacted transmission infrastructure in lots of parts of the State was down for quite a few days. Are you aware of that? What is EnergyCo doing to ensure that overhead transmission lines can withstand the types of fires that we know we are going to experience again and again?

ANDREW KINGSMILL: In the previous fires, there was certainly a small amount of infrastructure that might have been down from that time, pending repairs. But the large backbone, if you like, of the New South Wales electricity system was returned to service and continued in service. I realise there were some repairs to be made after that, but the backbone lines themselves were serviceable. In terms of the measures that EnergyCo takes, we look at easement width, we look at how we route the lines in terms of proximity to bushfires, and we engage contractors to do natural hazard assessment, which actually looks at the bushfire intensity along the line route. That will involve consideration of vegetation, and it involves consideration of topology, and how fires move through the area. That is one of the considerations that we use when we develop our corridor. Where possible, we would try to avoid forested areas, in some respects. In other respects, there are advantages to going through them. But the easement widths, the access and those natural hazard assessments are the measures that we take.

JAMES HAY: We can provide further details of just how little interruption there was to the major transmission lines during the fire season. It might be worth the Committee seeing that.

The CHAIR: That would be very useful because I don't want to get the sense that the importance of this is being downplayed in any way. It wasn't mentioned by Transgrid at all during the last inquiry, despite numerous questions about bushfires. But there is a whole report that the regulator has done into what happened to the energy transmission network during the Black Summer fires. There is whole report into Transgrid's network and how severely it was impacted at that time. You would be aware of that report, I take it?

JAMES HAY: Just confirming you are referring to the Australian Energy Regulator?

The CHAIR: Yes.

JAMES HAY: We do have a few regulators. We will have a look at that. We will come back with the details.

The CHAIR: In terms of bushfires, am I correct in saying that, if we are looking at trying to ensure that the network is able to continue providing electricity for residents during emergencies, there is less risk in undergrounding than there is in overhead transmission, at the height of something like the Black Summer bushfires?

ANDREW KINGSMILL: It's probably a question that depends on the definition of "less risk". I wouldn't have said there is materially less risk from undergrounding. The modern power systems are set up with, effectively, as a system, a self-healing type function. If there is a disturbance to a line—and that could be a lightning strike or it could be a fire passing under the line—the system will try to self-heal. If the hazard has passed, then the system would self-heal. I realise that a number of submissions have made the point that overhead lines are more susceptible to those natural hazards. What I would add to that is that, for most of those natural hazards, they do self-heal.

The CHAIR: When you say self-heal, Transgrid's transmission line network within the burnt area—for example, there were 596 wood pole structures. When you are saying self-heal, do they withstand the fire?

ANDREW KINGSMILL: If the line is physically intact and capable of conducting electricity, the power system will switch it back on after the hazard has passed. If there's physical damage to infrastructure to the extent that it's no longer capable of conducting electricity, then obviously that would be unsuccessful. What I would like to investigate—and I'm happy to revert to the Committee on this—is the extent to which those statistics were purely about transmission infrastructure or the extent to which they were about sub-transmission or indeed distribution infrastructure because I am aware of much bigger impacts at the distribution level.

The CHAIR: It really is around making sure as much as possible that the electricity stays on. During the Black Summer fires there were 12 trips of 500 kV transmission lines. The report states:

> 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.

Again, that's a positive for underground transmission, is it not, and should be factored in?

JAMES HAY: I think there are a couple of things we might tease out here. One is the continuity. We talked a lot about continuity of service, which is different from damage. A line may have impacts that are later needing to be repaired because a fire has passed through it, but did it lose service? For the trips you are talking about, what you would need to look at is the duration of them. They may be momentary. Many of them would be of a relatively short duration. There is quite a nuance to this. I would point out that one of the things with these cables is that they can't follow terrain. Often we are talking here about quite undulating terrain where these kinds of fire risks are pretty high. Much of this, where it's not following the terrain, may be effectively on bridges because these are too heavy to hang on pylons. They will be lower and closer to the height of the fire if they are bridging a gap.

The CHAIR: I will go to my colleague now but I can ask you more on notice, if I wish.

The Hon. ROD ROBERTS: Thank you, Chair. You and I have obviously been reading from the same document because I, too, have questions in relation to it. Page 15 in the last paragraph of your own submission states:

> Underground transmission lines are typically unaffected by aboveground fires – grass and scrub fires move quickly enough that the temperature of the ground surrounding the cable is not raised significantly.

I go to Transgrid's own document—and I'm sure you have probably seen this and are aware of this—which the Chair has quoted from. These are Transgrid's own words:

> In total there were 12 trips of the 500 kV transmission line. This is significant …

The Chair has already alluded to that. These were trips of the system. If it was underground, it's highly unlikely the system would be tripped at any time at all, according to your own submission.

ANDREW KINGSMILL: That would be correct.

JAMES HAY: Where it's underground, what we are trying to say is sometimes—

The Hon. ROD ROBERTS: I heard what you said. I just asked my question, that's all. I don't want you to take that as being rude but I am on the clock and I have to get it finished. Mr Hay, you said a short period ago in your own evidence here today that nothing will grow above underground high voltage lines.

JAMES HAY: Very little of any merit.

The Hon. ROD ROBERTS: You said nothing before. Now we have something or do we have nothing? You also said that you need special fill.

JAMES HAY: Yes.

The Hon. ROD ROBERTS: Did you listen to any of the expert witnesses this morning at all?

JAMES HAY: No.

ANDREW KINGSMILL: I did, and I can take that question, Mr Roberts, if you would like me to.

The Hon. ROD ROBERTS: Would you suggest that those witnesses this morning intentionally misled the Committee? Their evidence is directly contradictory to Mr Hay's evidence.

ANDREW KINGSMILL: I think it would be worth correcting the record here. It depends on the capacity and the size of the cables and the amount of power to be transferred through them. We are quite aware that with HVDC cables—and particularly traditional HVDC cables that aren't as large as the ones that we would be talking about in the renewable energy zones—it is possible to use engineered fill of local soil and retrench that. Those cables typically operate up to a temperature of 50 degrees Celsius and so that's appropriate to dissipate the heat. For cables of this size and the 525 kV HVDC high capacity, they operate at temperatures of up to 85 degrees Celsius, and so that requires a different thermal treatment. I think what you heard from the experts earlier in the day—and we would agree with this—is that it really is a case-by-case basis, where you need to run the thermal software on the cross-section of the cable. But, certainly, my experience with cables at higher capacity is that you would need thermal fill.

The Hon. ROD ROBERTS: I take it that you should read the transcript of their evidence from this morning.

ANDREW KINGSMILL: I was watching this morning. I heard the evidence.

The Hon. ROD ROBERTS: It's completely contradictory to what you said.

The Hon. EMILY SUVAAL: Thanks to you both for appearing today. My first question is to Mr Kingsmill. Could you tell us about your expertise in this area of undergrounding?

ANDREW KINGSMILL: My expertise is primarily in power system planning, operation and asset management. My background prior to working at EnergyCo was with the network business Transgrid in those capacities. During that time I managed a range of assets, including some underground cables. While I was at Transgrid we installed underground cables. We faced rating issues with underground cables where the spoil and the fill had deteriorated chemically. We faced end-of-life issues with cables, and we faced issues of movement in cables where they're joined to each other, which we had to remediate. So I've had some experience in cable maintenance.

The Hon. EMILY SUVAAL: Can you tell us about the transmission planning landscape in New South Wales? Who are the main players and, importantly, who has expertise when it comes to transmission planning and delivery?

ANDREW KINGSMILL: There are three planners for transmission and network infrastructure at extra high voltage in New South Wales. AEMO is the national transmission planner, and we see that most in the Integrated System Plan. Transgrid is the jurisdictional planning body, and we see that in their Transmission Annual Planning Report. EnergyCo is the infrastructure planner for renewable energy zones and priority transmission projects, and we see that in our Network Infrastructure Strategy. We joint plan with AEMO and Transgrid.

The Hon. EMILY SUVAAL: Who has the expertise when it comes to that planning into the grid?

ANDREW KINGSMILL: I'd say that all three organisations have the expertise in terms of planning. I would add that AEMO doesn't manage assets directly. That would be more network operators that have that expertise.

The Hon. EMILY SUVAAL: Is there any expertise about undergrounding transmission lines in Australia?

ANDREW KINGSMILL: Look, I think there is. There are a number of Australian engineers that are part of an international consortium called CIGRE, including one of your witnesses this morning and other engineers that work for engineering consultancies.

The Hon. EMILY SUVAAL: Some of the evidence to this Committee suggests that you could easily put transmission lines underground. Can you explain to us why things might be different when it comes to 500 kV lines?

ANDREW KINGSMILL: Absolutely. The size, weight and physical constructability issues would be the main things that I would cite there. At these sorts of sizes, capacities and voltages, the physical logistics and the sheer size of equipment to be able to trench and to bury and to backfill is significantly larger than the smaller cables that you might perhaps underground down a street or within a wind farm or solar farm. The manufacturing of these is specialist—it needs to be high quality to ensure that there are no impurities in there—but so is the installation of them.

These cables typically come on drums of between 500 metres and a kilometre, probably 500 metres for the higher capacity ones. They're joined at the end of those sections to the next section by joint boxes that are about the size of three of these tables. It's about the width, the height and the size of the side of the room that we are sitting on today. Typically at extra high voltage we don't have the capability in Australia to do that jointing, whether that's for installation or repair. Historically we've sourced that from overseas, typically from the same countries that manufacture the cables: Japan, Korea and the like. There is expertise in Australia at lower voltage and lower capacity cables at sub transmission and distribution voltages.

The Hon. EMILY SUVAAL: Thanks. Why is most of the new planned infrastructure in New South Wales proposed to be 500 kV and what are the benefits of this?

ANDREW KINGSMILL: There are two main benefits of going to a higher voltage, and 500 kV is the highest that we run. One is that the higher the voltage, the lower the loss for the same power transfer. Less energy is lost from the sending end of the line to the receiving end of the line. The second reason is that the capacity of those lines is higher. I cited earlier four gigawatts for a 500 kV overhead line. Typically it is about one gigawatt for a 330 kV line—perhaps slightly higher or slightly lower, depending on design. One of the things that we're conscious about EnergyCo is that if we go into a community to do these works, we want to disrupt the community as little as possible. That means making the best use and most efficient use with the highest capacity use of the corridors that we can secure.

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The Hon. EMILY SUVAAL: Thank you. Can you tell us more about the challenges of operating and maintaining underground lines?

ANDREW KINGSMILL: I do agree with the statements made earlier today. It probably varies a bit depending on whether they are HVAC or HVDC. But I alluded earlier to some of the physical characteristics. Cable movement can damage cables. It's possible for external interference. Horizontal direct drilling can actually drill into cables—that has happened before—and needs to be replaced. Some of the maintenance would be around testing. But if there is major damage to a cable, it would take similar construction to how the cable was laid in the first place to remove the section, to replace the section and to rejoin the section into the linear asset.

The Hon. EMILY SUVAAL: How long does it take to construct and procure transmission lines? Would undergrounding take longer?

ANDREW KINGSMILL: The advice that we have is that undergrounding would take longer, in the order of two to three years, than overhead. The full procurement process for an overhead line—are we talking once we have regulatory and environmental approvals or prior to that? Once we have regulatory and environmental approvals—this is generalising; it depends on the length and the topology and a range of things—there is probably a year to 18 months of design and site investigations and geotechnical work, and then, if I was to give you an average, maybe 18 months to two years of actual construction for overhead.

The Hon. EMILY SUVAAL: What are the environmental impacts of undergrounding transmission infrastructure?

ANDREW KINGSMILL: They're spelt out a little bit in our submission. Because undergrounding requires a trench and excavation for the full length of the asset, it's not impossible, but it becomes harder to route that around environmentally sensitive areas. Whereas with overhead transmission, where the ground disturbance is at the towers, it's more readily possible, in terms of directional changes of overhead towers, to minimise impacts through sensitive areas by doing that. I don't have a background in agriculture, but it has been reported that in Germany, where they are undergrounding a cable, farmers have raised concerns about the effects of heat from cable on the soil and the effects of heat from cable on their crops.

The Hon. EMILY SUVAAL: Interesting. In terms of the restrictions on farming, are there restrictions for underground transmission infrastructure on farming, noting what you've just said?

ANDREW KINGSMILL: There would be restrictions. To clarify the statement that was made earlier about what can grow over an underground cable, it would be things that don't have the potential to damage the cable. Anything that has deep root systems—there needs to be access to the cable at all times, in case repairs or maintenance are needed. There's probably a slight bit of latitude on this, but my answer would be that grasses typically would be permitted.

The Hon. EMILY SUVAAL: So not a rice paddy or anything like that—something requiring a lot of water?

ANDREW KINGSMILL: We would seek to completely avoid irrigated areas unless there was no other option.

The Hon. EMILY SUVAAL: Thank you. In terms of the size of the trench, there has been some varying evidence about what the size of a trench would be for a 500 kV line. What is your submission of the size of the trench and the easement?

ANDREW KINGSMILL: The easement for the cables would be in the order of 30 to 40 metres. It really depends on the capacity and how many cables. There are some examples in our submission. That doesn't include construction easement. Typically for construction, the advice that we've received is that you would add another 30 metres, roughly. But those estimates vary. Some are slightly less and some are slightly more.

The Hon. EMILY SUVAAL: Thank you. What are the cost implications of overhead versus underground transmission infrastructure?

ANDREW KINGSMILL: Most of our information on that comes from publicly available reports that we've researched. We would be saying in the order of three to 10 times. I'm aware that there are estimates that have been prepared that have been slightly less than that. What I would say is that those estimates are for lower capacity cables than what we would need to run to renewable energy zones. We've spelt that out in our submission—the difference between some of the lower estimates and some of the capacities that you'd get from the physical infrastructure that would be more commensurate with what we'd run to renewable energy zones.

The Hon. EMILY SUVAAL: And what would the impact on consumer bills be of underground transmission infrastructure?

ANDREW KINGSMILL: We haven't done a calculation at this point as to the impact on consumer bills, but we could do that and revert, if that was of interest to the panel.

The Hon. EMILY SUVAAL: It certainly would be. In terms of the HVAC and HVDC infrastructure, can you briefly explain the difference between these and why you're planning them for the REZ, in terms of the rationale?

ANDREW KINGSMILL: I can. I'll try and answer the question, then feel free to follow up. HVAC is how most of the power system operates today, with the exception of three DC interconnectors between States. The reason HVAC is used is typically because rotating machines naturally generate AC. Because our power system has historically been developed around rotating coal-fired generators and hydro generators, that's why HVAC is used. Traditional motors—not so much the modern motors—would typically use HVAC. HVDC is a different technology. Newer generators such as solar panels will generate at HVDC. I can fill that in more later, if you'd like.

The CHAIR: Thank you very much to you both for appearing. That's the end of our time today. I'm not sure whether anything was taken on notice. The secretariat will be in touch with you about that, if so, as well as any supplementary questions that members may have. Thank you.

(The witnesses withdrew.)

The Committee adjourned at 15:50.