

**Open Letter  
18 January 2021**

The Hon Rob Stokes MP  
Minister for Planning and Public Spaces

The Hon Matt Kean MP  
Minister for Energy and Environment

**Snowy 2.0 transmission must be underground**

Dear Ministers,

You will soon be presented with an Environmental Impact Statement (EIS) proposing high-voltage overhead transmission lines through Kosciuszko National Park for the Snowy 2.0 pumped hydro station. We believe overhead transmission lines would cause extensive, unnecessary, and entirely unacceptable damage to the Park.

We urge you to insist on a comprehensive analysis of underground alternatives prior to the submission of the EIS, in accordance with regulatory requirements. The proposed option in the EIS must be for underground cables, not overhead lines. Overhead lines would cause environmental impacts that are totally incompatible with the national and international significance of Kosciuszko National Park.

In the absence of your intervention, we understand that four 330 kV overhead transmission lines will be proposed, suspended on two sets of steel lattice towers (up to 75 metres high). The lines would traverse eight kilometres of Park within an easement up to 200 metres wide. One square kilometre of National Park would be permanently cleared. The lines would be visible over a vast area, totally destroying the ambience and integrity of this remote and largely pristine region. This proposal is far more intrusive than any of the single tower lines constructed in Kosciuszko before the Park was established in 1967.

Underground cables may be more expensive, but they have several offsetting benefits including minimal environmental impact, higher reliability, reduced maintenance, and less vulnerability to outages from lightning, storms and bushfires.

Kosciuszko National Park is a special and irreplaceable place on our National Heritage List. Despite the damage of the past and present, it is one of the most majestic areas in Australia and one of our planet's natural icons. It has fundamental cultural significance for Indigenous peoples and is very much loved and enjoyed by all Australians.

The unique character and values of Kosciuszko must not be sacrificed for the cheapest transmission option, overhead lines, when viable and far less damaging underground alternatives are available, as outlined in the accompanying Paper.



Photomontage (TransGrid)  
Lobs Hole, Kosciuszko National Park



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# **Going underground with the transmission connection for Snowy 2.0**

**18 January 2021**



Figure 1 - Photomontage of proposed overhead transmission lines at Lobs Hole, Kosciuszko National Park (TransGrid)

# Going underground with the transmission connection for Snowy 2.0

## 1 Introduction

The Snowy 2.0 Transmission Connection Project (the 'Project') is to be built, owned and maintained by TransGrid, at Snowy Hydro's behest, and is the final component of the Snowy 2.0 pumped hydro development. The Environmental Impact Statement (EIS) is to be placed on public exhibition shortly.<sup>11</sup>

Advice from TransGrid indicates the EIS will propose the construction of two double-circuit 330 kV overhead transmission lines. The lines will traverse nine kilometres of Kosciuszko National Park (KNP) and the neighbouring Bago State Forest (BSF) along an easement up to 200m wide. The lines will be visible over vast distances and permanently raze 1.5 square kilometres of native vegetation and fauna habitat across a largely intact and pristine alpine region.

It appears that TransGrid has assumed approval will be granted and has already secured finance for the Project and awarded the design/construct contract.

This Paper argues that minimising environmental impacts on KNP, not minimising the cost, should be the primary consideration in selecting the most appropriate transmission option. This rules out overhead lines. The EIS must analyse alternatives and propose the best underground solution.

The previous Main Works stage of Snowy 2.0 had numerous serious environmental impacts that were unavoidable if Snowy 2.0 was to proceed. However, this is not the case with the Transmission Connection Project - there are several viable underground cable alternatives that would significantly reduce the adverse impacts on KNP. Underground cables would be more expensive than traditional overhead lines, but with offsetting benefits, including much lower environmental impact, higher reliability, lower losses, less maintenance, and reduced vulnerability to lightning and bushfires.

Overhead transmission lines are incompatible with our obligations for the protection of Kosciuszko National Park, the Australian Alps National Heritage Place, the UNESCO Kosciuszko International Biosphere Reserve, Aboriginal cultural heritage, head-water catchments for south-east Australia's major rivers, unrivalled natural landscapes, and unique biodiversity.

NPA opposes the Snowy 2.0 project, as it doesn't stack up economically, technically, or environmentally ([NPA Website](#)). There are cheaper, more efficient, and less environmentally damaging energy storage alternatives. Notwithstanding our opposition to Snowy 2.0, this Paper focuses on minimising the environmental impact of the transmission component of the project on Kosciuszko National Park.

The Paper is based on information provided by TransGrid in November 2020. TransGrid was asked for additional information and clarification on several issues but has yet to respond. Accordingly, it is possible that the way the Project has been described in the Paper may not completely reflect the latest design by TransGrid.

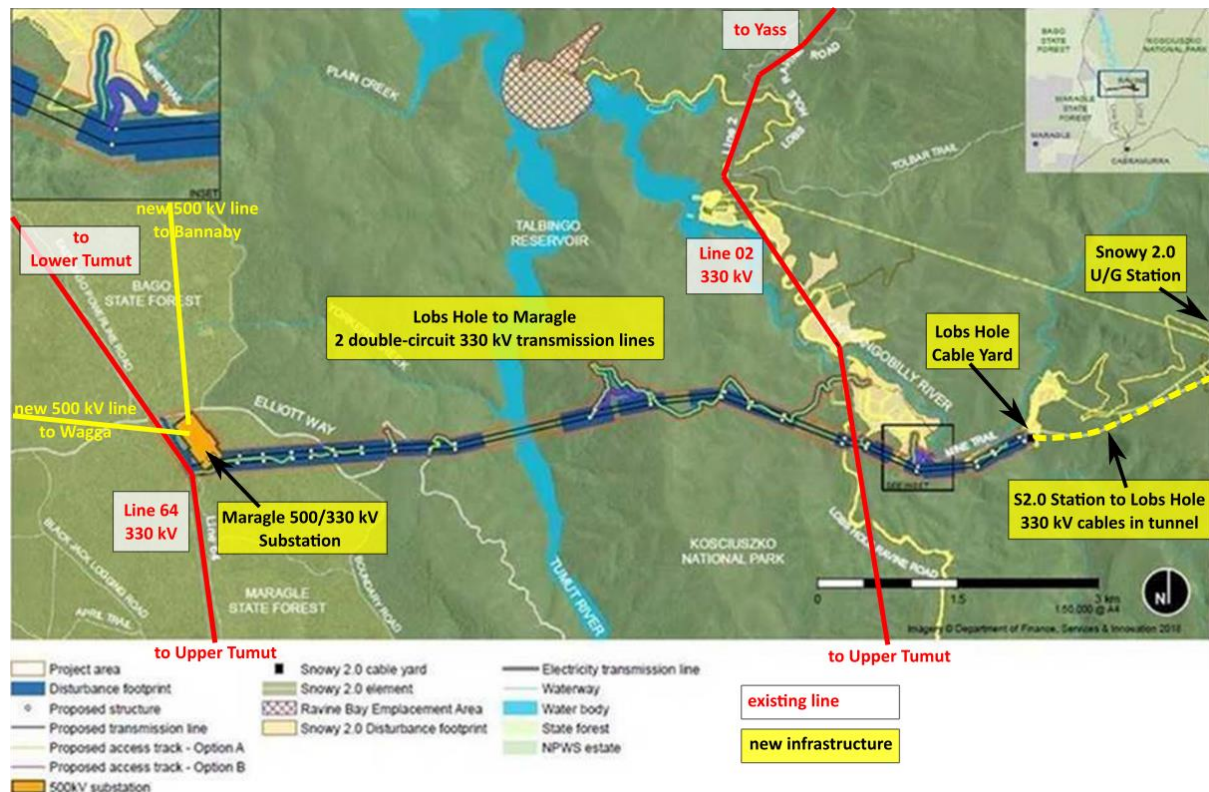
The Paper provides background to an Open Letter to the NSW Ministers for Planning and the Environment from 24 environmental organisations and 50 expert engineers, scientists, environmentalists, academics and economists, calling for a comprehensive analysis of alternatives and the adoption of an underground solution. Many of the signatories to the Letter, and others, have made significant contributions to the Paper.



## 2 The Project

Information provided by TransGrid indicates the Transmission Connection Project to be proposed in the EIS involves:

- two double-circuit 330 kV overhead transmission lines (on two sets of side-by-side towers<sup>1</sup>)
- traversing about eight km of KNP and one km of BSF, connecting the Lobs Hole Cable Yard (near the entrance to the Snowy 2.0 underground Station) with a new Substation (Maragle) in BSF (see the two parallel black lines and dark blue 'disturbance footprint' in Figure 2)
- twenty-one sets of steel lattice towers, each up to 75m high
- an easement varying from 120m to 200m in width
- a series of new access tracks (the green lines in Figure 2)



**Figure 2 – Layout of Snowy 2.0 Transmission Connection Project**

(TransGrid diagram – labels, existing transmission lines and Snowy 2.0 Main Works cables added)

## 3 Overhead transmission lines

Overhead transmission lines would cause significant environmental impacts, in addition to those from the Snowy 2.0 Main Works<sup>2</sup>, including:

- permanent 'disturbance' to 100 hectares (1 square kilometre) of KNP and a further 44 hectares of BSF, which is also an area of high environmental value and sensitivity
- habitat fragmentation and barriers for animal movement
- wide easements requiring regular clearing and introducing sources of erosion, landscape instability and weeds. Easements also provide avenues for feral pests such as foxes and pigs

<sup>1</sup> There are proposed to be four 330 kV circuits in total, one circuit on each side of two sets of towers. Each circuit consists of three bundled conductors (for each of the three phases of alternating current), with each bundle consisting of two to four individual conductors. Each of the bundled conductors are suspended from one of three tower cross-arms. Each tower carries six bundled conductors. Also, two earth wires are strung from either end of a top cross-arm to attract and safely ground lightning strikes.

<sup>2</sup> ["Snowy 2.0 doesn't stack up"](#) NPA

- loss of native flora, including threatened species in currently undisturbed vegetation communities
- loss of native fauna, including threatened species such as the Yellow-bellied Glider, Eastern Pygmy Possum, Squirrel Glider, Gang Cockatoo, Greater Glider, Scarlet Robin, Flame Robin, Powerful Owl, Masked Owl and Booroolong Frog
- carbon emissions from vegetation clearance, ending sequestration across the permanently cleared areas
- jarring visual impacts of towers, wires, easements and access tracks, across the spectacular Yarrangobilly and Tumut River valleys and surrounding country for tens of kilometres



**Figure 3 – Photomontage – Tumut River/Talbingo Reservoir Crossing (TransGrid)**

- a web of criss-crossing overhead lines at Lobs Hole from the four new lines in addition to an existing 330 kV transmission line (Line 02), which traverses a 3km stretch of the Yarrangobilly River
- an intense buzzing from corona loss, particularly audible at night and in foggy weather
- increased risk of starting bushfires, with substantial consequences - human, environmental, animal, property and financial
- dumping of excavated spoil from the tower footings and access tracks in KNP and BSF
- weed transfer and erosion from the access tracks along the easement corridor
- the destruction of the amenity and attractiveness of this outstanding remote alpine region, with few visitors choosing to recreate in such a degraded area

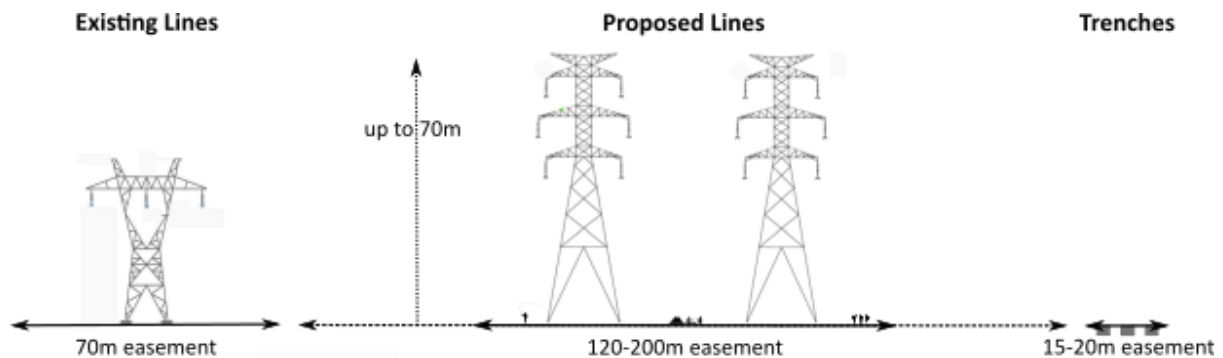
Whilst the existing transmission lines in KNP, built before the National Park was established in 1967, are an eyesore and environmentally damaging, they are far less imposing and intrusive than the proposed lines (see Figure 4 – the campers and bushwalkers at the base of the towers indicate the scale). Compared to the existing lines, the proposed transmission lines will have:

- two sets of side-by-side towers, compared to one set of towers for the existing lines
- two circuits per tower (of three phases), compared to one circuit
- 28 individual wires strung between towers, compared to 8
- much higher towers (conductors strung vertically), compared to shorter towers (conductors



- strung horizontally)
- easements of 120 – 200m wide, compared to 70m

For comparison, Figure 4 includes a depiction of the most environmentally impactful underground technique, being trenching, with a cleared easement of around 15-20m. Other underground techniques (tunnels and directional drilling) are less impactful, involving no above ground structures and no, or minimal, cleared easement (Section 4.2).



**Figure 4 – Comparison of Existing KNP Transmission Lines, Proposed Lines and Trench**

These environmental impacts compound an array of pressures on the ecological integrity and resilience of KNP. The alpine habitats have been subjected to historic damage, including clearing, grazing and unrehabilitated construction sites of the original Snowy Hydro-Electric Scheme<sup>3</sup>. They are now further challenged by global heating, rainfall variability, higher intensity storms, more frequent and greater intensity fires, feral horses, high impact recreational activities and the Snowy 2.0 project.

The January 2020 bushfires burnt one-third of KNP, including the entire route of the proposed lines. The burnt landscape is clearly visible in Figures 1 & 9. See the contrast with the pre-fire landscape in Figure 3. Recovery will take decades, leaving the area exposed to further damage from easement clearing and transmission line construction.

The cumulative impacts of these pressures risk large scale ecological collapse, and it is therefore imperative that every opportunity be taken to minimise any source of additional environmental damage.

## **4 Underground transmission cables**

### **4.1 A common technology**

High voltage underground cables are a viable alternative to overhead lines and are installed widely, particularly in cities and areas with high conservation value. NPA has been advised that almost all new transmission links are underground throughout Europe, in fact are mandated in some countries, and much of Asia. For instance, in 2010 the Netherlands capped the total length of overhead transmission and distribution – every new kilometre of overhead line must be compensated by undergrounding an equivalent length.

Underground cables can be installed in trenches, or tunnels or by under-boring (usually Horizontal Directional Drilling (HDD)). One or more of these techniques can be applied over a cable route,

<sup>3</sup> "Rehabilitation of former Snowy Scheme Sites in Kosciuszko National Park" Gabriel Wilks, 18 October 2019 <https://site.emrprojectsummaries.org/2019/10/18/rehabilitation-of-former-snowy-scheme-sites-in-kosciuszko-national-park-update-of-emr-feature-2019/>

depending on the circumstances.

#### 4.1.1 Underground example - urban

TransGrid recently obtained approval for a 20 km, 330 kV underground circuit between Potts Hill and Alexandria in Sydney<sup>4</sup>, at a cost of \$285 million. The project involves the installation of two sets of three conduits, using a combination of trenches, HDD and cable bridges.

When installed in a trench the six conduits are to be arranged either flat or layered (triangular or stacked). A flat configuration trench is around 3m wide and 1.2m deep, whilst a triangular configuration trench is around 1.6m wide and 1.6m deep (Figure 5).



Figure 5 – Trench for Two 330 kV 750 MVA Circuits – flat and triangular configurations (TransGrid)

#### 4.1.2 Underground examples - environmental

Transmission lines are often undergrounded partly or purely for environmental reasons, such as:

- the 'Directlink Interconnector' between Mullumbimby and Terranora in northern NSW; 63 km long, 180 MW rating and costing \$100 million
- 'Murraylink', between Red Cliffs in Victoria and Berri in South Australia; 180 km long, 220 MW rating and costing \$177 million
- the 87 km, 220 kV cable along the edge of Western Port Bay to connect the Victorian desalination plant
- undergrounding 132 kV transmission lines at Olympic Park prior to the Sydney 2000 Olympics, mainly for aesthetic reasons for world-wide TV audiences, at a cost of \$37 million
- the 'Hinkley Connection Project' in the UK<sup>5</sup>; 57 km long, consisting of 48.5 km of 400 kV overhead line and 8.5 km of underground cable "through the Mendip Hills Area of Outstanding Natural Beauty (AONB<sup>6</sup>)" [akin to a National Park]
- the 140 km, 400 kV Aalborg to Aarhus line/cable in Denmark<sup>7</sup> is another example of using cables to protect areas of natural beauty along a portion of the route, albeit at a higher cost. Fourteen km (10%) of the circuit was installed underground, across the Mariager Fjord and through the Gudenaa Valley, costing €35 million (25% of the €140 million total cost)

<sup>4</sup> "Powering Sydney's Future: Potts Hill to Alexandria transmission cable project EIS" TransGrid, October 2019 <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSI-8583%2120191010T060146.019%20GMT>

<sup>5</sup> "Hinkley Connection Project" <https://hinkleyconnection.co.uk/category/ourproject/>

<sup>6</sup> An AONB is an area of countryside in Britain that has been designated for conservation due to its significant landscape value. AONBs enjoy levels of protection from development similar to those of National Parks. .

<sup>7</sup> "Underground High Voltage Cables: Wiring Europe for the Future" <https://www.stjornarradid.is/library/01--Frettatengt---myndir-og-skrar/ANR/ANR---Raflinur-i-jord/33-Underground-high-voltage-cables-Leonardo.pdf>

- Fifty underground cable projects are listed by Barber<sup>8</sup> and Moorabool Shire Council<sup>9</sup>

#### 4.1.3 Snowy 2.0

Indeed, the Snowy 2.0 project will be installing six sets of 330 kV, 450 MVA cables (i.e. 2,700 MVA capacity in total) from the Snowy 2.0 underground Station to Lobs Hole Cable Yard (on the surface) in a multi-purpose tunnel used for emergency egress, cables, and ventilation. These cable sets (18 individual cables in total) will each be three km long – already covering one quarter the distance to Maragle Substation.

#### 4.2 Underground alternatives for Snowy 2.0

This Paper contends that the cables to be installed from the Snowy 2.0 Station to Lobs Hole should continue all the way to Maragle Substation or the Lower Tumut Switching Station (SS). Five potential alternative options are described below (Section 4.2.1).

Underground cables could be installed in trenches, tunnels or HDD, or in combinations of the three:

- for those sections to be trenched, a flat cable configuration could entail three trenches (two circuits per trench, as per Figure 5), each about three metres wide, with two access ways between, resulting in a partially cleared easement of around 15 - 20m wide. Such an easement width is around 10% that proposed for overhead lines (see Figure 4). The easement could be narrower if the cables were layered, as illustrated in Figure 5.
- a tunnel for six sets of cables would typically be 3 - 4m diameter. No above ground clearing is required, just two portals at either end, resulting in minimal environmental impact. Tunnel spoil could be extracted from the Maragle end (or the Lower Tumut SS end for Alternatives C/D/E(2)) to avoid dumping in KNP.
- sections with HDD would require six bore holes. No clearing is required, except for cable jointing pits about every 1 – 1.2 km, though these would be installed below ground

##### 4.2.1 Underground cable alternatives

Five underground alternatives for the transmission connection from the Snowy 2.0 Station are described below, with the indicative routes and lengths of the first four depicted in Figure 6.

- A. extending the three km of underground cables from the Snowy 2.0 Station to Lobs Hole Cable Yard, generally following the direct route of the proposed overhead lines, for the remaining nine km to Maragle. The cables could be in a trench, tunnel or HDD conduit, or combination.**
- B. laying cables in a trench from Lobs Hole along, or near, the road to the Snowy 2.0 excavated spoil dump in Talbingo Reservoir, at the junction of the Yarrangobilly and Tumut Rivers, and then via a trench/ tunnel/ HDD to Maragle (about 13 km). Approximately half the route is under the road and therefore of straightforward construction, with no additional clearing or environmental impact.**
- C. as per Alternative B to the junction of the Yarrangobilly and Tumut Rivers, and then in, or adjacent to, Talbingo Reservoir to the existing Lower Tumut SS, located next to Tumut 3**

<sup>8</sup> "Achievement and experience in service of long length High Voltage AC electrical links by insulated power cables" CIGRE Latin American Workshop 2013, Ken Barber

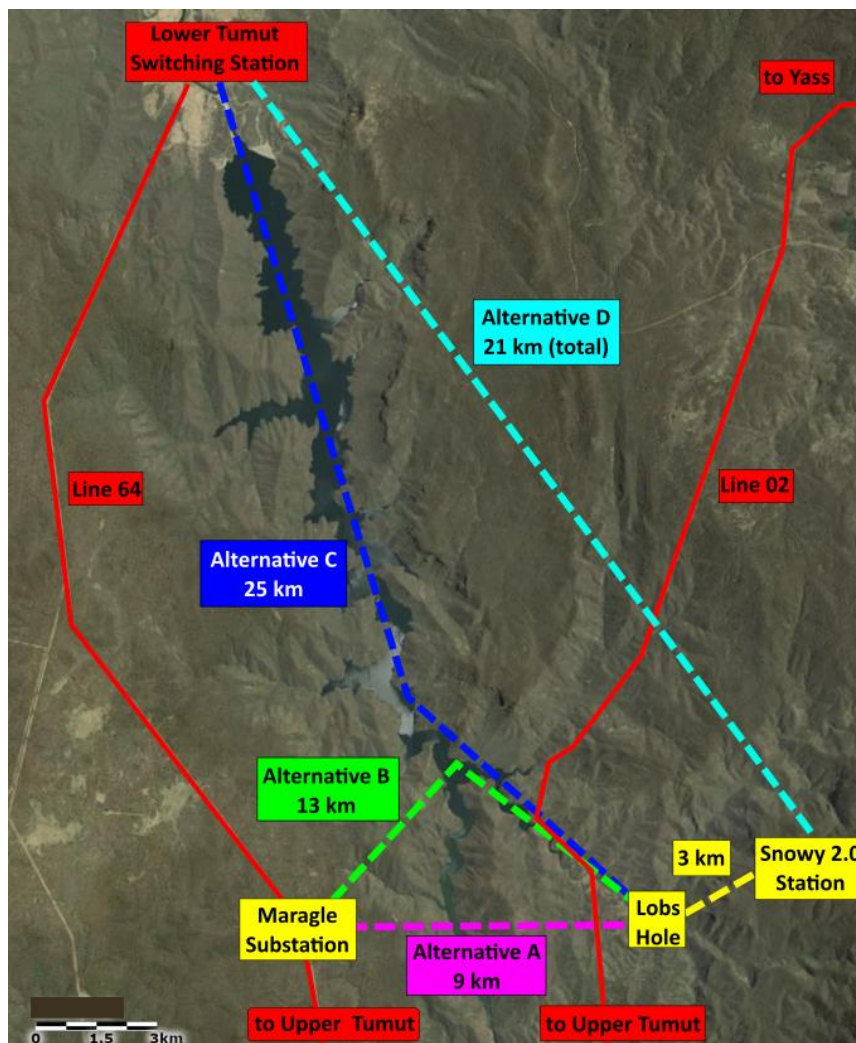
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<sup>9</sup> "Comparison of 500 kV Overhead Lines with 500 kV Underground Cables" Moorabool Shire Council, September 2020

<https://www.moorabool.vic.gov.au/sites/default/files/largefiles/20200924%20MSC%20Transmission%20Comparison%20Overhead%20with%20Underground.pdf>

Pumped Hydro Station at Talbingo (about 25 km). This alternative effectively relocates Maragle Substation to Lower Tumut SS, with ongoing new connections to the main grid being constructed from Lower Tumut SS, rather than from Maragle (see Figure 8).

- D. laying cables in a tunnel from the Station directly to Lower Tumut SS (avoiding the need for cables from the Station to Lobs Hole).
- E. laying cables in the tailrace tunnel from the Station to its inlet at Talbingo Reservoir, and then via a trench/ tunnel/ HDD to Maragle (E1), or via the Reservoir to Lower Tumut SS (E2).



**Figure 6– Four Alternative Routes for Underground Cables**

A permutation on the first three alternatives would be to also connect the circuits to the existing 330 kV Line 02 running through Lob's Hole, to provide back-up transmission capacity in the event of an outage.

This Paper recommends that the above alternatives be comprehensively analysed by TransGrid. TransGrid should also use the full resources at its disposal to identify any additional underground options that warrant consideration. A preferred underground option should then be adopted and proposed for formal assessment through the EIS.



## 5 Obligation to analyse alternatives

The *Environmental Planning and Assessment Regulation 2000* (Clause 7(1)(c) of Schedule 2) requires all EISs to include ‘an analysis of any feasible alternatives’ for a proposed project:

*“7 Content of environmental impact statement*

*(1) An environmental impact statement must also include ...*

*(c) an analysis of any feasible alternatives to the carrying out of the development, activity or infrastructure, having regard to its objectives, including the consequences of not carrying out the development, activity or infrastructure”*

This requirement is repeated in the Secretary’s Environmental Assessment Requirements for the Transmission Connection Project, which state *“In particular, the EIS must include a summary of the background to the project, including alternatives that were considered to the project”*.

It would appear that TransGrid has dismissed underground cable transmission options without any analysis, possibly as the higher construction costs would not be agreed by Snowy Hydro. Recent actions by TransGrid bear this out, with financing arranged and the design/construct contract having been awarded (Section 7).

Failure to assess viable and lower impact alternatives is not consistent with TransGrid’s statutory obligations nor the community’s expectations that all reasonable steps will be taken to minimise the impacts on KNP.

## 6 Project cost and context

### 6.1 Indicative cost of Project

At this stage TransGrid has not provided information on the cost of the Project.

However, an indication can be gleaned from the announcement by the Clean Energy Finance Corporation (CEFC) of a \$125 million corporate debt facility with TransGrid<sup>10</sup>, *“to design, construct, operate and maintain a new 330 kV switching station and associated transmission lines as part of its agreement with Snowy Hydro Limited to provide connection services for 30 years”*. This debt facility of \$125 million appears to encompass the cost of the Project, covering three components - transmission lines, a switching station (possibly Lobs Hole Cable Yard), and operations & maintenance (O&M) for 30 years.

A further indication of the cost of the Project is provided by the announcement by the CIMIC Group (UGL)<sup>11</sup> of being awarded five electricity utility sector contracts *“for more than \$112 million ... including the design and construction of a 330kV switchyard at Maragle in the Snowy Mountains, NSW for TransGrid. The contract includes building 10 kilometres of 330kV transmission lines to connect the switchyard and the Snowy 2.0 pumped-hydro project cable yard.”* The value of the Snowy 2.0/TransGrid contract was not disclosed but is likely to constitute the majority of the \$112 million.

A ‘ball-park’ figure for double circuit 330 kV overhead lines, provided to NPA by transmission

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<sup>10</sup> “CEFC and TransGrid Services in landmark investment to support Snowy 2.0 grid development” 27 Nov 2020 <https://www.cefc.com.au/media/media-release/cefc-and-transgrid-services-in-landmark-investment-to-support-snowy-2-0-grid-development/>

<sup>11</sup> “UGL awarded more than \$112M in utilities contracts”, CIMIC, 4 December 2020 <https://www.cimic.com.au/en/news-and-media/latest-news/ugl/2020/ugl-awarded-more-than-112m-in-utilities-contracts>

engineers, is \$3.5 million per kilometre. This would imply a cost for the lines from Lobs Hole to Maragle of around \$60 million, and is the figure assumed in this Paper.

This Paper also assumes the total cost of the Project to be \$125 million, in line with the CEFC debt facility. This implies a cost for the 10-bay Lobs Hole Cable Yard (switching station) of around \$40 million, with O&M and financing costs making up the balance of the \$125 million.



**Figure 7 – Photomontage - Lobs Hole (TransGrid)**

## **6.2 Cost and benefits of underground cables**

According to NPA's expert advisors, underground cables typically cost between three to ten times more than traditional overhead lines and involve different design and construction challenges. The wide range is due to the vastly different circumstances and installation techniques that can apply.

This 'rule-of-thumb' suggests that Option A has an indicative cost of \$200 million to \$500 million. Detailed information is needed before a more definitive estimate could be determined, but estimates for all alternatives should be produced by TransGrid in its EIS analysis.

Cable prices are currently dropping whilst the cost for constructing overhead lines is increasing, as evidenced by the Australian Energy Market Operator's (AEMO) recent adjustments to overhead transmission costs of +30% and recent higher tender prices. Tender prices are influenced by construction demand, so the forthcoming increase in transmission projects throughout eastern Australia (mostly overhead lines) may result in a further narrowing of the price gap between overhead and underground circuits.

### **6.2.1 General benefits of underground cables**

Countering the higher cost of installing underground cables are several offsetting benefits, many with significant financial savings, including:

- less prone to physical damage
- no exposure to weather events – lightning, bushfires, storms, extreme winds etc.  
Such events are expected to become more frequent and intense with climate change, causing more outages, physical damage, more repair costs and lost revenue, sometimes costing tens of \$millions from a single event (as was the case with the January 2020

bushfires<sup>12</sup>).

- higher reliability, though taking longer to repair. (The longer repair time should rarely be a concern, as if one cable is out of service the remaining five generators/pumps can still operate up to a combined capacity of 1,670 MW).
- the loss of one cable circuit due to a fault should not result in the need to back off Snowy 2.0 output/load to cover a subsequent cable loss. Whereas the loss of a double-circuit overhead line from a fault (or lightning strike or bushfire) would result in backing off output/load to cover for a subsequent loss of the second double-circuit. Also, the proximity of the two overhead double-circuit lines pose a system stability risk that is not applicable for underground cables<sup>13</sup>.
- ready physical access for repairs and maintenance if in a tunnel
- lower operating costs (potentially one-tenth that of overhead lines<sup>14</sup>), though higher repair costs
- lower electrical losses (reputed to be around 30% lower)
- far less or zero easement clearing and maintenance cost
- little or no release of greenhouse gasses from vegetation clearing
- no potential to start bushfires, as can occur from overhead lines through fallen towers, conductor clashing or breaks, and subsequent insurance claims<sup>15</sup>
- and, most importantly, underground cables have substantially less environmental impact and no visual blight<sup>16</sup>, other than a relatively narrow easement if trenches are used.

In addition to the above benefits all underground cabling alternatives in Section 4.2 avoid the need for the Cable Yard and overhead transmission lines, thereby saving the Project cost of \$125 million.

## 6.2.2 Additional benefits of the proposed Alternatives connecting to Lower Tumut SS

**Alternatives C, D and E(2)** involve longer routes than the other alternatives as they connect to Lower Tumut SS rather than Maragle (see Figure 6). Alternatives C and E(2) are 28 km, including the leg from the Station to Lobs Hole. Alternative D is shorter, at about 21 km, and does not require the 3 km leg from the Station to Lobs Hole, so only entails an extra 18 km of cabling.

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<sup>12</sup> The January 2020 bushfires resulted in outages for some days in the Snowy, and separation of the NSW/Victoria transmission networks. Damage to TransGrid's assets in the Snowy region was *"north of \$15 million to \$20 million, which was not insurable"* [TransGrid CEO]. Snowy Hydro lost supply capability *"costing the company millions"* [Snowy Hydro CEO].

<sup>13</sup> "Queensland and South Australia system separation on 25 August 2018" AEMO, 10 January 2019 [https://www.aemo.com.au/-/media/files/electricity/nem/market\\_notices\\_and\\_events/power\\_system\\_incident\\_reports/2018/qld---sa-separation-25-august-2018-incident-report.pdf](https://www.aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2018/qld---sa-separation-25-august-2018-incident-report.pdf)

<sup>14</sup> "Overview of the Potential for Undergrounding the Electricity Networks in Europe" prepared for the European Commission, 28 February 2003 [https://ec.europa.eu/energy/sites/ener/files/documents/2003\\_02\\_underground\\_cables\\_icf.pdf](https://ec.europa.eu/energy/sites/ener/files/documents/2003_02_underground_cables_icf.pdf)

<sup>15</sup> "Black Saturday bushfire survivors secure \$500 million in Australia's largest class action payout" ABC News, 15 July 2014 <https://www.abc.net.au/news/2014-07-15/black-saturday-bushfire-survivors-secure-record-payout/5597062>

<sup>16</sup> "Valuing the social benefits of avoiding landscape degradation from overhead power transmission lines: Do underground cables pass the benefit–cost test? Ståle Navrud ,Richard C. Ready,Kristin Magnussen &Olvar Bergland, 12 May 2008 *"the social benefits of avoiding negative impacts [from overhead transmission lines] on the landscape exceed the costs of burying the lines as underground cables ... based only on an assessment of the aesthetic impacts [urban setting]. Impacts of overhead power lines on wildlife and human health would likely make burial of power lines even more attractive."* <https://www.tandfonline.com/doi/abs/10.1080/01426390802045921>

Although these alternatives involve longer routes, they offer a number of significant advantages to those through Maragle substation, as outlined below.

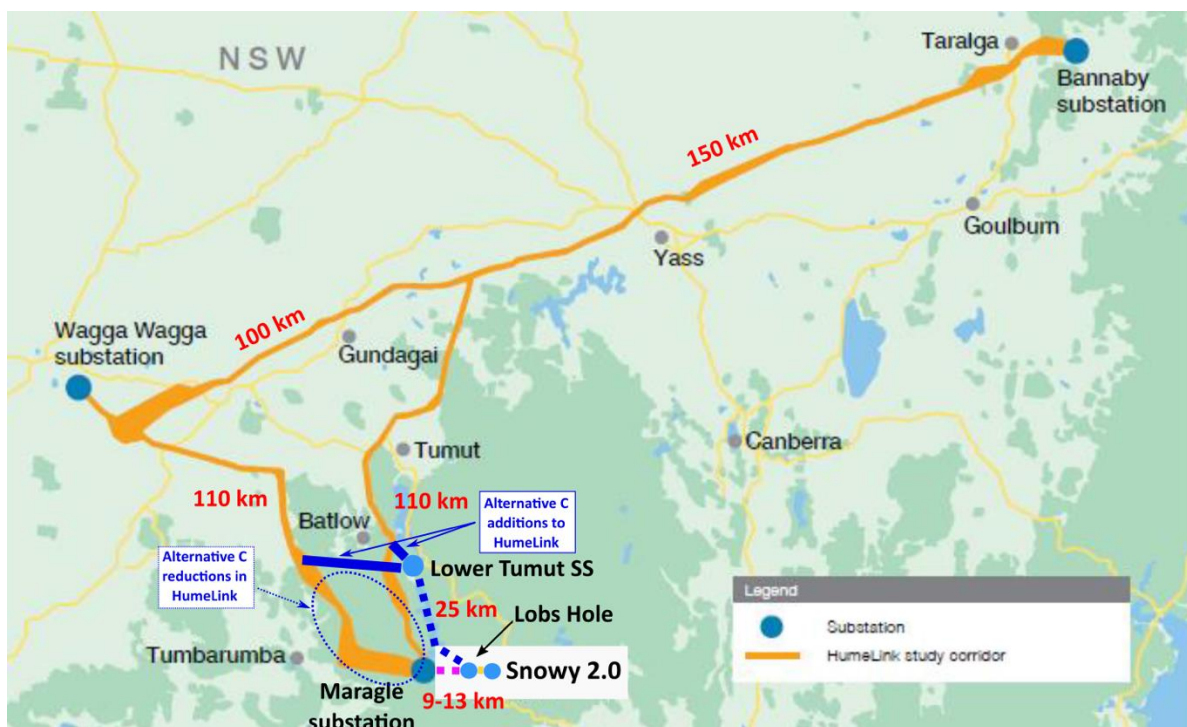
#### 6.2.2.1 *Augmenting an existing substation rather than building a new substation*

These Alternatives circumvent the need for Maragle Substation by using the site of the existing Lower Tumut SS. Augmentation of existing substation infrastructure at a more accessible, well serviced location should result in savings in construction and ongoing maintenance, compared to a 'greenfield site' in the middle of a State Forest.

#### 6.2.2.2 *Shortens HumeLink, with significant financial savings*

The proposed HumeLink project aims to reinforce the southern NSW network by connecting Wagga Wagga and Bannaby with two 500 kV circuits. It is expected to cost up to \$2 billion. One circuit goes direct and the second takes a substantial 'dog-leg' deviation via Maragle to connect Snowy 2.0 to the main grid backbone. In Figure 8 the two HumeLink circuits are depicted by the ochre-coloured lines showing the land corridor within which the lines are proposed to be constructed.

The routes for Alternatives C/D/E(2) run parallel with the proposed HumeLink lines to Maragle for about 20 km. Hence, terminating the two Snowy 2.0 connections at Lower Tumut SS (blue lines in Figure 8), rather than Maragle Substation, shortens their combined length by approximately 40 km. This would save about \$140 - \$200 million, depending on whether the lines are single or double circuit and are suspended from one or two sets of towers.



**Figure 8 – HumeLink (TransGrid diagram, with distances and Snowy 2.0 Alternatives added)**

Snowy Hydro would not be the beneficiary of a reduction in the cost of HumeLink if the Australian Energy Regulator (AER) agrees with Snowy Hydro's view that HumeLink should be paid for entirely by electricity consumers<sup>17</sup>. However, many energy experts contend that Snowy Hydro should be

<sup>17</sup> "We've said this 150,000 times. Transmission is for the common good. Everyone benefits from it. We use it about 10 per cent of the time and the other 90 per cent it's used by everybody else, particularly on the renewable side." Mr Paul Broad, Snowy Hydro CEO [Behind Snowy's Battery Bet, Australian Business Review](#).



required to contribute to HumeLink due to the extra 120 km of deviated lines that are needed to connect Snowy 2.0 to the main grid. Also the transmission capacity needed is substantial, as Snowy 2.0 will be the largest load (for pumping) to ever be added to the National Energy Market (NEM) and the largest generator for a quarter of a century.

Irrespective of how the AER adjudicates, either consumers or taxpayers will benefit from constructing less HumeLink transmission lines. This public benefit is therefore a significant offset to the additional cost of Alternatives C/D/E(2). When added to the avoidance of the Project cost, the total saving is around \$265 - \$325 million.

#### *6.2.2.3 Improved reliability from reduced exposure to lightning and bushfires*

The 40 km of overhead lines not needed are in BSF, a high-risk area for lightning strikes and bushfires. 'Removing' those lines would improve the reliability of both HumeLink and Snowy 2.0's connection to the grid.

Avoiding the construction of new transmission lines in fire prone areas is consistent with the Snowy Hydro's CEO<sup>18</sup> assertion that new interstate interconnectors should only be constructed in non-forested areas west of the Great Dividing Range.

#### *6.2.2.4 Potential network and financial benefits for Snowy Hydro*

Linking Lower Tumut SS to HumeLink and the main grid would increase the transmission capacity from Lower Tumut SS, both to the north and the west. This may alleviate occasional transmission constraints to Sydney experienced by the existing Snowy generators<sup>19</sup>, which have been claimed to cost \$millions in lost revenue.

TransGrid's proposal to deviate HumeLink through Maragle provides no additional transmission capacity for the existing Snowy Scheme, except possibly partly through the tie-in to Line 64.

#### *6.2.2.5 Potential to further reduce HumeLink and address local opposition*

There is significant community opposition to the HumeLink connections to Maragle, particularly in the Tumut/Batlow/Adelong region. The issue has been raised in State Parliament and spurred TransGrid to engage a specialist negotiator. Terminating the two lines at Lower Tumut SS may provide an opportunity to re-route the lines through less contentious areas.

It may be possible to eliminate one of the HumeLink connections altogether. A double-circuit 500 kV line between Lower Tumut SS and Wagga would have ample capacity (6,000 MVA) to transmit Snowy 2.0's full output/load. This new line would be in addition to the three existing 330 kV lines from Lower Tumut SS to Wagga, Yass, and Canberra, providing further transmission and back-up capacity. Cutting back to one 500 kV connection would address much of the opposition to the HumeLink proposal and reduce the length of the HumeLink deviations to connect Snowy 2.0 by a further 85 km.

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14 Sep 2019

<sup>18</sup> "The head of the nation's giant Snowy Hydro power scheme has warned rising bushfire risk along the east coast has spurred the need for critical electricity transmission lines to be built connecting Victoria and NSW, but through the west of the states in non-forested areas that are less prone to fires". The Australian Business Review, "Fire sparks Snowy Hydro call to link NSW, Victoria power", 9 January 2020  
<https://www.theaustralian.com.au/business/fire-sparks-call-to-link-nsw-victoria-power/news-story/4543f7131e74e960691182020c73c609>

<sup>19</sup> "No; the transmission today is not enough for existing [Snowy output], so it obviously won't be enough for 2.0." Mr Broad, Snowy Hydro CEO, Senate Environment and Communications Legislation Committee, 21 October 2019

A related possibility could be to use the existing 330 kV overhead transmission line and/or easement between Lower Tumut SS and Wagga (Line 051). This line could either be replaced by the double-circuit 500 kV HumeLink connection between Lower Tumut SS and Wagga or the new HumeLink line could be built beside it by widening the easement. Replacing the line seems the preferable option as then the only environmental impact of HumeLink would be taller towers, though possibly a few less towers, in place of an existing 330 kV line, but resulting in a three-fold increase in transmission capacity.

#### *6.2.2.6 Environmental benefits*

Finally, these Alternatives avoid the clearing of about 400 hectares (4 square kilometres) of BSF for the HumeLink lines, Maragle Substation, and the lines from Lobs Hole. Both the construction damage and ongoing easement and infrastructure maintenance impacts would be avoided.

**Alternative D** could provide drainage from the Station. The cable tunnel from the Station to Lower Tumut SS could be designed to also act as a gravity drain for seepage water that will accumulate at the base of the Station, saving pumping equipment and piping. It would be particularly valuable in the event of a Station flooding incident.

### **6.3 Context**

The latest Snowy Hydro forecast for the 'construction cost' of Snowy 2.0 is around \$5 billion (Snowy Hydro's initial forecast for the project was \$2 billion). Many independent experts consider the latest forecast to also be optimistic, with a more realistic total project cost of around \$10 billion, when all components and related grid augmentations are included.

This massive public expenditure is meaningless without the infrastructure to transmit power through and beyond KNP. The overhead transmission line Project option represents just over 1% of the total cost of Snowy 2.0.

The Project must be assessed in relation to the financial cost and environmental impacts of the Snowy 2.0 project in its entirety. In that context, NPA considers that a low impact underground transmission option would justify expenditures many times higher than the \$125 million for overhead lines.

The Snowy 2.0 project is already costing considerably more because of its location within KNP than if it were not in a National Park. The environmental conditions imposed, such as minimising construction footprints (e.g. using more expensive compact equipment for substations), avoiding sensitive areas, offset payments (\$100 million), waste management, monitoring etc have added many hundreds of \$millions to the cost. Insisting on the transmission connection being underground should be another 'standard' condition for developments within National Parks.

Simply, if a developer wishes to build an electricity transmission circuit or pipeline, road or any other infrastructure through a National Park then such a proposal should normally be rejected out of hand and only considered in exceptional cases, and then only if it were demonstrated that the installation resulted in the minimal possible environmental damage. Snowy Hydro/ TransGrid should not receive special treatment compared to any other developer or NEM participant.

It is notable that \$285 million has recently been allocated for a single 330 kV underground circuit in Sydney (Section 4.1.1). A similar willingness to invest in a low impact underground option to ensure that further damage is not inflicted on KNP is entirely appropriate.

Undergrounding transmission lines along portions of the route in areas of outstanding natural beauty

is common practice (see the UK and Denmark examples in Section 4.1.2). The Project should be considered within the wider context of HumeLink, and the entire length for the Snowy 2.0 connection to the main grid backbone.

For Alternative A, the connection from Lobs Hole to Maragle is just nine km out of the total 220 km of lines to Wagga and the Wagga-Bannaby corridor (see Figure 8). That is, only 4% of the total length of circuits needed to link Snowy 2.0 to the main grid backbone would be undergrounded, leaving the remaining 96% as overhead lines. For Alternatives C/D/E(2) the percentage that would be undergrounded is higher but still relatively minor, at 12%.

Surely such a small percentage for the connection of Snowy 2.0 to the main grid being underground is reasonable - Kosciuszko National Park is unquestionably an area of outstanding natural beauty.

## 7 Snowy 2.0 staging

Consideration of the Transmission Connection Project EIS, and its alternatives, should have occurred concurrently with the Main Works EIS, enabling the impacts of the two major components of Snowy 2.0 to be assessed together<sup>20</sup>. In fact, well before the release of the Main Works EIS, Snowy Hydro executives advised that a concurrent assessment of both components was intended.

However, there will be at least a 15-month gap between the release of the Main Works EIS in September 2019 and the EIS for the Transmission Connection Project. NPA is not aware of any technical reason for this extended staging and delay in the exhibition of the Transmission Project EIS.

Approval of the Main Works in June 2020 effectively guarantees that the Connection Project will also be approved. However, this presumption of approval must not mean automatic authorisation of whatever is proposed, especially the cheapest and most environmentally damaging option.

TransGrid is clearly assuming approval, as Project financing has been arranged<sup>10</sup> (November 2020) and a construction contract awarded<sup>11</sup> (December 2020). (It is noted that TransGrid has followed a similar presumptive path as did Snowy Hydro, which awarded the \$5.1 billion Main Works contract in April 2019, six months before the EIS was exhibited and 15 months before it was approved).

Revising the design to an underground option will take some time, delaying the start of construction, but this should not hinder Snowy 2.0's commissioning.

The latest Snowy 2.0 forecast is *"to start up in the June half of 2025, ahead of an 18-month ramp-up"*, resulting in full commissioning of the Station in 2027 and 'landscape rehabilitation' thereafter. When announced in March 2017, Snowy 2.0 was to be completed in 4 years after the Feasibility Study – i.e. by December 2021. Many industry experts consider this latest Snowy 2.0 forecast also to be overly optimistic.

It is notable that AEMO acknowledged the possibility of construction delays and assessed that Snowy 2.0 is not needed until at least 2029-30<sup>21</sup>. Independent experts have further examined the AEMO

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<sup>20</sup> "Kosciuszko: A Great National Park", Slattery & Worboys, May 2020. *"The impacts of the transmission lines will be huge but are not considered in the [Main Works] EIS. This fractured assessment process invites 'death by a thousand cuts' and obscures the true scale and impact of the project on Kosciuszko National Park."*

<sup>21</sup> The 2020 AEMO Integrated System Plan (ISP) included a sensitivity analysis of a four-year delay in the commissioning of Snowy 2.0 till 2029-30, concluding that *"the power system is relatively resilient to a delay, with minimal impact to the overall market benefits of the network development, as shown in Table 16 [Appendix 2]"*.

forecast and determined that the existing 1,800 MW Tumut 3 pumped hydro station can accommodate the demand for Snowy Hydro storage until 2033<sup>22</sup>.

Nevertheless, if Snowy 2.0's latest construction forecast is achieved and the transmission connection needs to be completed by the start of 2025 for commissioning of the first unit, four years is ample time to design and construct underground cable circuits over such a short distance.

## 8 Conclusion

Kosciuszko National Park is a landscape of exceptional natural and cultural significance, protected for future generations.

Infrastructure development should not be permitted within KNP, but if genuinely unavoidable, it must be designed with the overriding objective of minimising environmental damage.

New overhead transmission lines have no place in any National Park, especially when there are practical alternatives with far less impacts.

The Snowy 2.0 Transmission Project EIS should adopt an underground connection.



**Figure 9 – Photomontage - Lobs Hole (TransGrid)**

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<sup>22</sup> [AEMO's Integrated System Plan: Does it leave Snowy 2.0 high and dry?](#) Victoria Energy Policy Centre, 10 August 2020



# Going underground in Kosciuszko National Park with the transmission connection for Snowy 2.0

## Addendum A:

Further assessment of connecting Snowy 2.0 to the grid via  
Lower Tumut Switching Station - Alternative D

4 February 2021



Figure 1 - Photomontage of proposed overhead transmission lines at Lobs Hole,  
Kosciuszko National Park (TransGrid)

# Connecting Snowy 2.0 to the grid via Lower Tumut Switching Station Alternative D

## 1 Introduction

The Snowy 2.0 Transmission Connection Project (the 'Project') is to be built, owned, and maintained by TransGrid, at Snowy Hydro's behest and expense. It is an integral component of the pumped hydro development, comprising that section of Snowy 2.0's electrical connection to the grid that traverses Kosciuszko National Park (KNP). An Environmental Impact Statement (EIS) is expected in mid-February and is understood to propose overhead transmission lines.

On 18 January 2021 an [Open Letter and Background Paper](#) to NSW Planning Minister Stokes and Energy & Environment Minister Kean, signed by two dozen environmental organisations and fifty experts, called for alternatives to overhead lines to be comprehensively analysed and for an underground solution to be adopted.

The Background Paper identified five example underground alternatives, as depicted in Figure 2 (Appendix A provides a brief description).

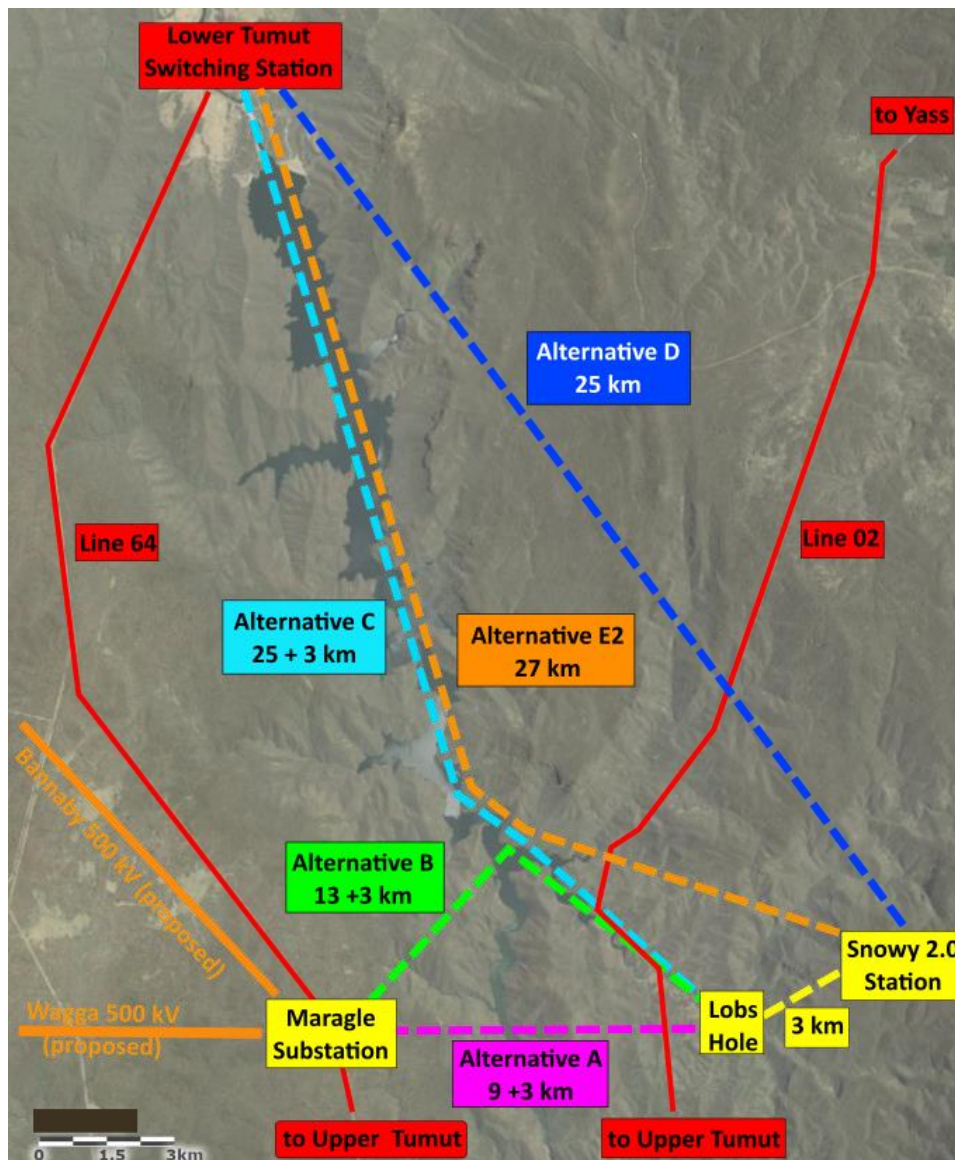


Figure 2 – Alternative Routes for Underground Cables from Snowy 2.0 to Maragle or LTSS

- Alternatives A & B connect Snowy 2.0 to a proposed substation at Maragle, just outside KNP, 'replacing' the overhead lines. From Maragle, 500 kV lines to Wagga and to Bannaby complete the connection of Snowy 2.0 to the grid (as part of HumeLink).
- Alternatives C, D & E2 connect Snowy 2.0 to the existing 330 kV Lower Tumut Switching Station (LTSS) instead, via different routes and underground techniques. From LTSS, 500 kV lines to Wagga (and possibly Bannaby) connect Snowy 2.0 to the 500 kV grid.

**This Addendum further examines Alternative D, that is the installation of 330 kV cables in a tunnel from the Snowy 2.0 underground Station ('Station') to LTSS.** Most of the commentary also applies to the other two LTSS alternatives (C & E2).

The advantages of Alternative D extend beyond the Project, which only covers the first nine kilometres of Snowy 2.0's connection to the main grid, totalling 382 km. Connecting to LTSS, rather than Maragle, provides opportunities to shorten, rationalise and improve the utilisation of the HumeLink legs of Snowy 2.0's connection to the 500 kV grid. It improves the capacity and reliability of transmission to/from LTSS. Environmental damage is substantially reduced in KNP, Bago State Forest (BSF) and across hundreds of kilometres of proposed 500 kV transmission lines. Adverse impacts on communities, including Tumut, Adelong and Batlow, are significantly mitigated.

Connecting to LTSS and having the opportunity to re-route the \$2 billion HumeLink proposal would deliver financial, operational, and environmental benefits - for the National Electricity Market (NEM), the Australian Energy Market Operator (AEMO), Snowy Hydro, TransGrid, electricity consumers, the environment (KNP and beyond), and landholders and communities along the routes of the proposed lines.

NPA and its expert advisors were taken aback by TransGrid's response to the Open Letter<sup>1</sup>:

*"Tunnelling, trenching and directional drilling were considered but ruled out following consideration of environmental impacts, safety and future disturbance for maintenance in mind. TransGrid always takes safety and environmental impact into consideration as a priority when planning its projects".*

Paradoxically, the stated 'reasons' for preferring overhead lines are three of the primary advantages of underground cables. Compared with overhead lines, undergrounding has less environmental impacts, is safer, and incurs little or no future disturbance.

This Addendum has been quickly prepared in light of TransGrid's response and sustained support for overhead lines through KNP. Its purpose is to encourage a broader exploration of the various means of connecting Snowy 2.0 to the main grid by highlighting the potential advantages of one alternative. The Addendum is not comprehensive and some of its assumptions and statements may not be entirely accurate. Many of the issues raised are only on a superficial level. A detailed assessment, including load flow and stability studies, is necessary to determine the full implications.

A comprehensive *"analysis of any feasible alternative"*, covering technical, financial, environmental, and social issues, is essential for the integrity of the EIS process<sup>2</sup> and to ensure the best underground alternative is adopted for the benefit of all.

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<sup>1</sup> ["Snowy project to cut 'massive swath' through national park, NPA says"](#), Sydney Morning Herald 20 January 2021

<sup>2</sup> An *"analysis of any feasible alternative"* in an EIS is a requirement of the *Environmental Planning and Assessment Regulation 2000* (Clause 7(1)(c) of Schedule 2)



## 2 Current TransGrid Proposal

### 2.1 The Project - overhead line connection to Maragle

Preliminary information from TransGrid indicates that the EIS for the Transmission Connection Project will propose two double-circuit 330 kV overhead transmission lines traversing eight km of KNP and one km of BSF. The lines will connect the Lobs Hole Cable Yard (near the entrance to the Snowy 2.0 Station) to a new Substation (Maragle, in BSF).

At the two 'ends' of the Project are connections:

- from Lobs Hole Cable Yard to the Snowy 2.0 Station, via six 330 kV cable sets installed in a multi-purpose tunnel. The cable sets (18 individual cables) will each be three km long. Alternative D circumvents the installation of these cables.
- from the new Maragle 500/330 kV Substation to both Wagga (110 km) and Bannaby (260 km), via 500 kV overhead lines as part of the HumeLink project (see Figure 3). Alternative D 'shifts' Maragle Substation to LTSS and rationalises the HumeLink connections.



Figure 3 – HumeLink (TransGrid diagram, with distances and Alternative D1 added)

The Project cost is expected to be approximately \$125 million for the overhead lines, Cable Yard, and operation & maintenance ('O&M') for 30 years. Underground alternatives avoid this expenditure, together with some HumeLink costs, but incur other costs.

### 2.2 Proposed HumeLink deviation to Maragle Substation

The proposed HumeLink project aims to reinforce the southern NSW network by connecting Wagga Wagga ('Wagga') and Bannaby with two 500 kV circuits. TransGrid's preliminary cost estimate is \$1.35 billion (Option 3C in the PADR<sup>3</sup>), though this seems low. Recent tender prices suggest the cost

<sup>3</sup> "Reinforcing the NSW Southern Shared Network to increase transfer capacity to demand centres (HumeLink), Project Assessment Draft Report, TransGrid 10 January 2020 [https://www.transgrid.com.au/what-we-do/projects/current-projects/Reinforcing%20the%20NSW%20Southern%20Shared%20Network/Documents/TransGrid\\_HumeLink%](https://www.transgrid.com.au/what-we-do/projects/current-projects/Reinforcing%20the%20NSW%20Southern%20Shared%20Network/Documents/TransGrid_HumeLink%20Project%20Assessment%20Draft%20Report.pdf)



of 500 kV lines is around \$3.5 million/km, indicating a total HumeLink cost of well over \$2 billion, after including new substations at Wagga and Maragle, and extensions to Bannaby Substation.

One HumeLink circuit goes direct between Wagga and Bannaby (250 km) and the second takes a substantial 'dog-leg' deviation via Maragle Substation (370 km) to enable Snowy 2.0 to be connected to the 500 kV grid backbone. In Figure 3 the HumeLink circuits are depicted by the ochre-coloured lines showing the land corridors within which TransGrid proposes to construct the lines.

The dog-leg deviation consists of two 500 kV lines connecting Maragle Substation, and thence Snowy 2.0, to the 500 kV grid:

Leg a Maragle to Wagga, about 110 km long

Leg b Maragle to the Wagga-Bannaby corridor just east of Gundagai, also about 110 km, and thence to Bannaby (a further 150 km, for a total distance of 260 km)

Were it not for Snowy 2.0, both 500 kV circuits would go direct between Wagga and Bannaby (250 km). Deviating to Snowy 2.0 adds a further 120 km [ $2 \times 110 - 100$ ] to HumeLink (24% extra length).

### **3 Alternative D proposal - underground connection to LTSS and re-routing HumeLink**

#### **3.1 Alternative D**

Alternative D in the Background Paper entails:

- boring a tunnel from LTSS to the Station, approximately 25 km in length and around four metres in diameter. Boring from the LTSS end enables the excavated spoil to be extracted at Lower Tumut and disposed of outside KNP
- installing six sets of 330 kV, 450 MVA cables (total capacity of 2,700 MVA) - this is the same specification for the proposed cables from the Station to Lobs Hole Cable Yard
- terminating the two proposed HumeLink legs to Snowy 2.0 at LTSS, rather than at Maragle, thereby shortening the deviation
- further rationalising HumeLink for Alternatives D2 & D3 (below)
- potential use of the tunnel for drainage, communications, access to Snowy 2.0 from LTSS (Talbingo), and an emergency exit
- additional works at LTSS may be necessary to address higher fault levels and load sharing between the 330 kV and 500 kV networks

'Moving' Maragle Substation 20 km north to LTSS opens up a number of route options for the two deviated legs. Three Alternatives (D1, D2 & D3) are examined, but there are many others.

#### **3.2 Alternative D1 (Figure 3)**

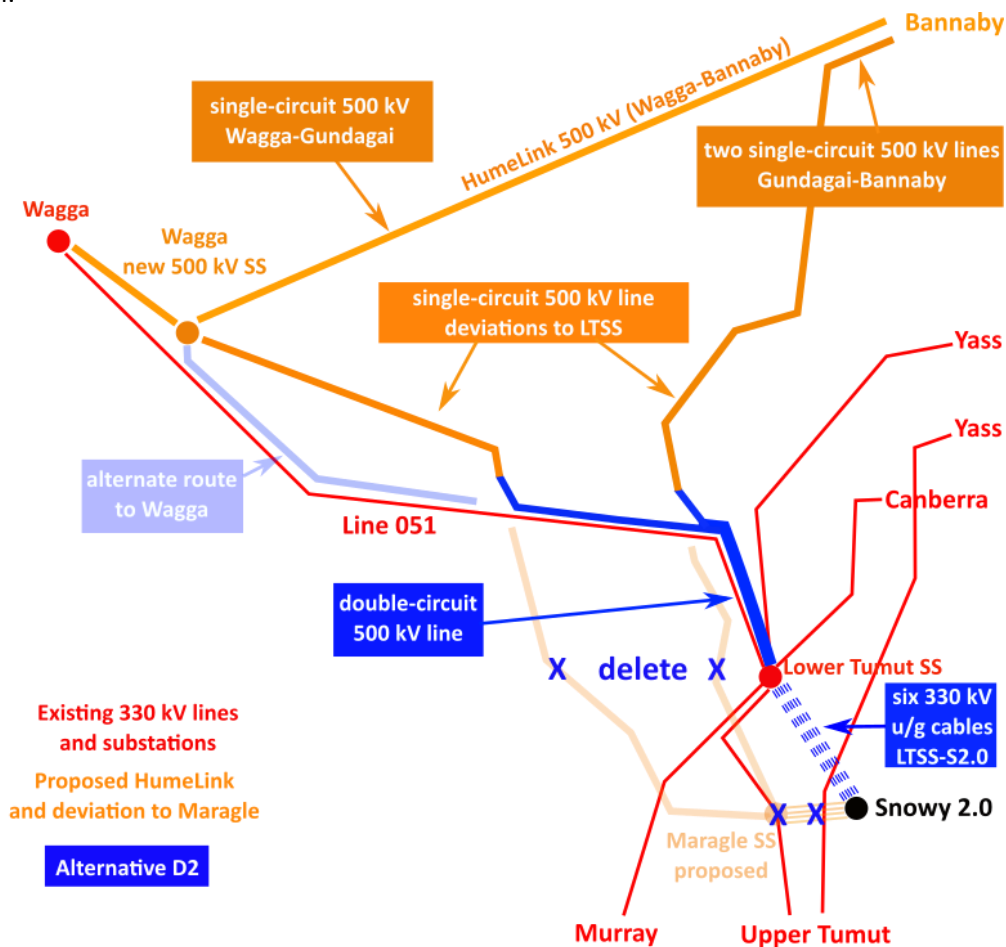
Retain the routes of the proposed HumeLink deviation legs as far south as LTSS, where they are redirected east and terminated at LTSS.

The length of the two legs is reduced by about 20 km, to 90 km each, thereby shortening the HumeLink deviation by 40 km (20%).

#### **3.3 Alternative D2 (Figure 4)**

Instead of two single-circuit 500 kV lines, construct a double-circuit line from LTSS beside the existing 330 kV Line 051 for the first 20 km. At each of the crossings with the proposed legs to Bannaby and to Wagga, branch into those legs and then continue for the remainder of those routes.

This Alternative branches into the two legs about 20 km north of LTSS, ‘moving’ about 40 km of new lines in the Batlow/Adelong/Tumut area to the existing Line 051 corridor. As with D1, the length of the two deviated legs is reduced by about 40 km, but with the added advantage of replacing 40 km of single-circuit lines with 20 km of double-circuit, and removing all lines through BSF, totalling about 70 route-km.



**Figure 4 – HumeLink deviation to LTSS Alternative D2**

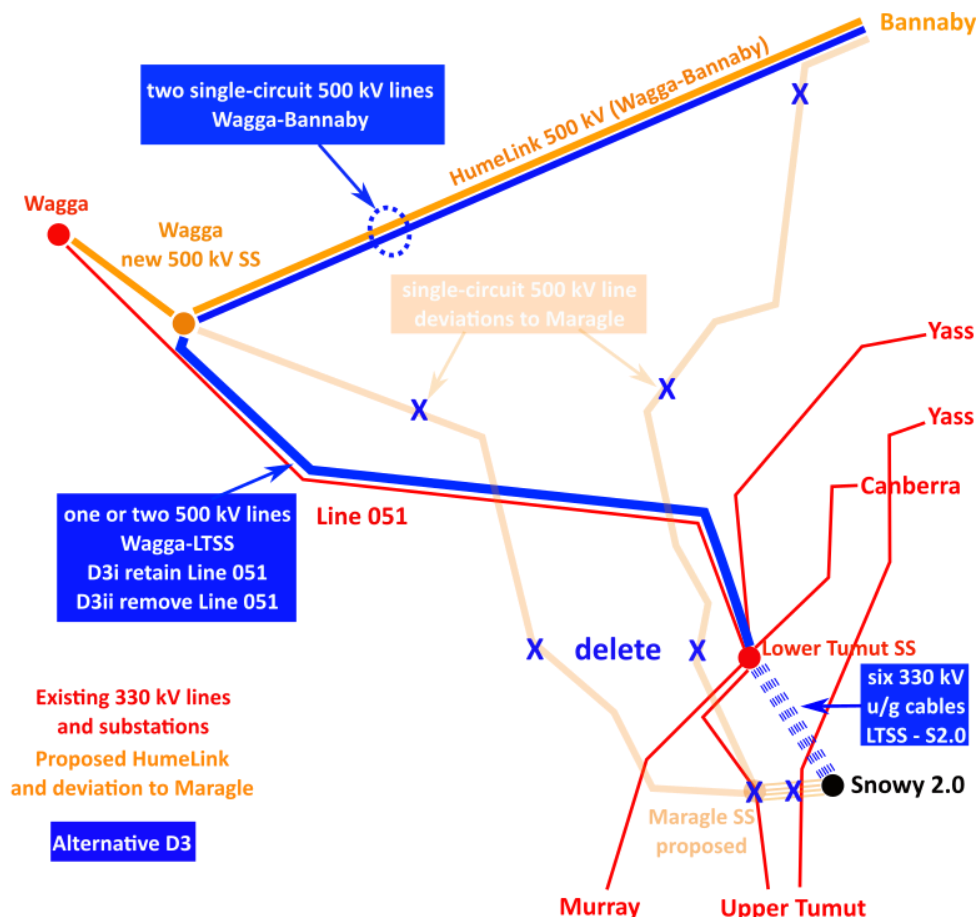
A sub-Alternative is to continue the second 500 kV line all the way to Wagga beside Line 051, avoiding the need for a new easement for the remainder of Leg a.

### 3.4 Alternative D3 (Figure 5)

**(D3i)** Construct two 500 kV HumeLink lines directly between Wagga and Bannaby (250 km), with no deviations (as would have been the situation without Snowy 2.0 being built). Connect Snowy 2.0 by one or two legs from Wagga to LTSS (90 km) beside Line 051. The total length of 500 kV lines is 590 km (one leg from Wagga to LTSS) or 680 km (two legs).

This Alternative is analogous to TransGrid’s Option 2C in its PADR<sup>3</sup>, which was ranked ‘equal-first’ with the chosen Option 3C (Figure 3), at a similar cost (\$1.38 million versus \$1.35 million) and net benefit.

Alternative D3 has the least environmental and community impact of all three alternatives, by deleting both deviated legs entirely (220 km). No new easements are required, other than a widening of the existing easement of Line 051 to accommodate one or two 500 kV lines and a widening of the proposed easement between Wagga and Gundagai to accommodate a second 500 kV line.



**Figure 5 – HumeLink deviation to LTSS Alternative D3**

**(D3ii)** A sub-Alternative would be to replace Line 051. If replaced by a single or a double-circuit 500 kV line, the additional environmental impact is limited to taller towers, with no new easements required for the deviation. Two single-circuit lines would require a wider easement and two sets of towers. This sub-Alternative would deliver an increase in transmission capacity of 2,000 – 5,000 MVA.

### 3.5 One or two legs LTSS-Wagga

A single 500 kV line from LTSS to Wagga has sufficient thermal capacity (3,000 MVA) to transmit Snowy 2.0's maximum generation/pumping load (2,000 MW). (It is noted that the stability rating would be less than the thermal rating).

A second line is required for the Maragle proposal to provide for redundancy and system stability, but may not be necessary for Alternative D.

One 500 kV line would increase the combined thermal capacity of LTSS from 5,000 MVA to 8,000 MVA, which is higher than the generating capacity of the existing Snowy Scheme plus Snowy 2.0 (6,000 MW). Though LTSS would not need to accommodate that full output, as a significant portion 'goes south' via the Murray Switching Station. Even if the 500 kV line were out of service, LTSS should be able to transmit the bulk of the Snowy Scheme's output, including Snowy 2.0, in most circumstances.

These suppositions would need to be tested by power system analysis and an assessment of load sharing between the 500 kV and 330 kV networks.

It would be extremely rare for the Snowy Scheme to be operating at full output. Pumped hydro will make up 3,800 MW of the 6,000 MW Snowy maximum output and typically operates for a few hours a day, occasionally. The chances of the 500 kV line being out of service at the very same time that the Snowy Scheme was generating 6,000 MW is exceedingly small.

Is a second 500 kV line from LTSS to Wagga, costing around \$300 million, justifiable? If the Wagga-LTSS connection is classified by the Australian Energy Regulator (AER) as a Connection Asset, as contended above, then the decision on one or two lines would be for Snowy Hydro to make, as it would be paying for it.

### **3.6 Consideration of Alternatives**

Consideration of these Alternatives and other permutations needs to take into account many factors, including network analysis, costs and savings, redundancy, topographies, land use, impacts on local landholders and communities, bushfire and lightning vulnerability, construction and maintenance, and of course environmental impacts.

This Addendum offers only preliminary comments on their respective merits though, as contended in the Background Paper, the reduction of environmental impacts on KNP alone is sufficient justification to choose an underground alternative.

### **3.7 Additional works at LTSS**

Alternative D involves ‘moving’ the proposed Maragle 330/500 kV Substation to Lower Tumut. There would appear to be sufficient area adjacent to the existing Switching Station for the new Substation and connection of six 330 kV pump/generator cable sets and one or two 500 kV lines (Figure 6).

It may be necessary to install shunt reactors at the new Substation to compensate for the cable connections, but that should not be an issue.

Other considerations include whether the existing switchgear and equipment can handle the higher fault level resulting from the additional circuits and the load sharing between the 500 kV and 330 kV networks. It is noted that the proposed Humelink connection to Maragle requires equipment upgrades at both LTSS and Upper Tumut SS. If the existing equipment at LTSS is not sufficiently rated there are several options.

At one extreme it may be economical to immediately upgrade the existing LTSS switchgear to enable integration with the new Substation and realise the network benefits outlined below. Or the installation of fault limiting devices between the 330 kV busbars may resolve any issues.

At the other extreme the new substation could be electrically isolated from the existing Switching Station for the time being and simply connect to the 500 kV grid at Wagga and Bannaby, with the same (serial) connection arrangement proposed for Maragle. Over time the existing Switching Station could be integrated with the new Substation as equipment came due for replacement. It is noted the existing LTSS is 50 years old, though some equipment has been replaced recently. This approach would deliver some immediate benefits and realise the remainder over time.

## **4 Benefits of Alternative D**

Contrary to TransGrid’s rebuttal of the Open Letter, undergrounding, whether by tunnelling, trenching or directional drilling, inflicts less environmental impact, is safer, and incurs little or no

future disturbance, compared to overhead lines.

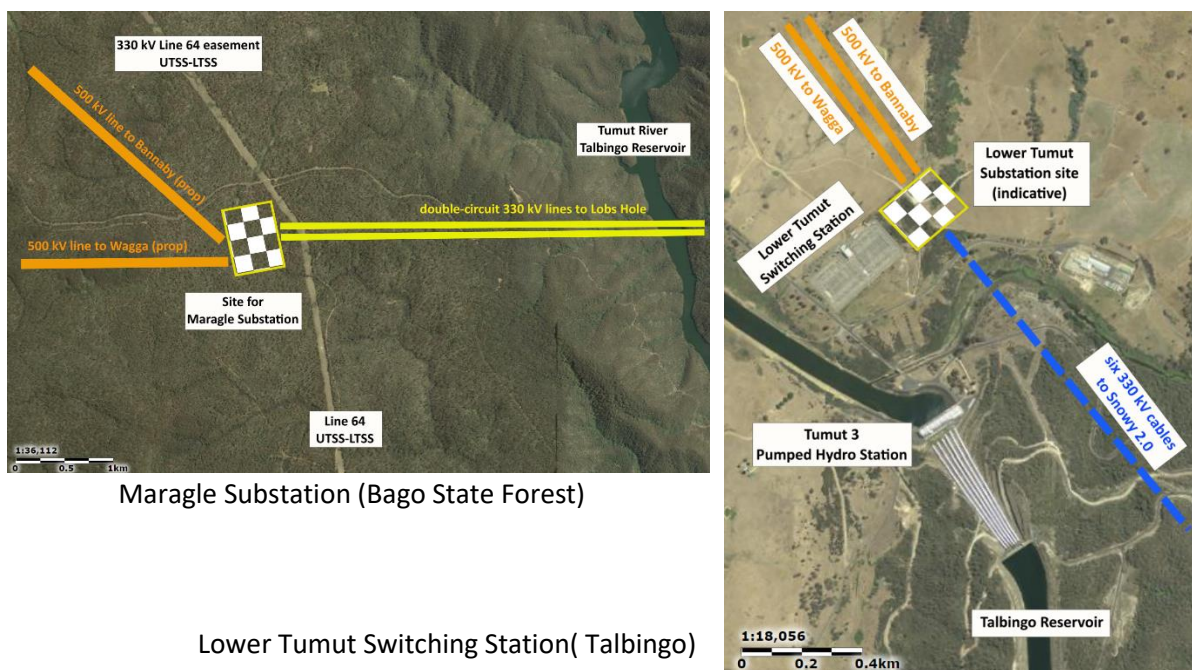
As stated in the Letter *“Overhead lines cause environmental impacts that are totally incompatible with the national and international significance of Kosciuszko National Park”*. Undergrounding in important natural areas is standard practice throughout Australia and overseas (see Section 4.1 of the Background Paper). The Background Paper also highlighted the inherent benefits of underground cables compared to overhead lines (see Appendix B).

It is also relevant to note that almost fifty kilometres of tunnels are being bored for Snowy 2.0, with just under half for purposes other than water transfer.

Alternative D is the shortest of the underground alternatives to LTSS (25 km), but longer than the routes to Maragle (12 - 17 km). Offsetting the extra 8 – 13 km of cables to connect to LTSS rather than Maragle are several advantages, outlined below.

#### 4.1 Augmenting an existing substation rather than building a ‘greenfield’ substation

Alternative D circumvents the need for Maragle Substation by augmenting the existing LTSS to a 500/330 kV Substation. LTSS is next to Tumut 3 pumped hydro station and Talbingo township (Figure 6). Talbingo is a base for Snowy Hydro and TransGrid personnel and is readily accessible from the Snowy Mountains Highway.



**Figure 6 – Maragle and LTSS Sites for 500/330 kV Substation**

Augmentation of existing substation infrastructure at a more accessible, well serviced location should result in savings in construction and ongoing maintenance, compared to a ‘greenfield site’ in the middle of a State Forest. There should be ongoing efficiency savings for TransGrid and hence a lower ‘pass-through’ charge for consumers.

#### 4.2 Network benefits

Diverting Humelink to Maragle provides no benefit to the NEM, other than an intermediate point for connecting Snowy 2.0 to the 500 kV grid and a link to the existing 330 kV Line 64 between Upper Tumut Switching Station and LTSS. In fact, the dog-leg deviation introduces drawbacks for the NEM by increasing the length of one of the two circuits between Wagga and Bannaby, reducing the overall



capacity of the Wagga-Bannaby link, incurring additional transmission losses and increasing the susceptibility to outages from lightning and bushfires.

On the other hand, connecting Snowy 2.0 and HumeLink to LTSS provides significant additional benefits for the NEM, AEMO, Snowy 2.0, the existing Snowy Scheme and TransGrid.

Linking LTSS to HumeLink would increase the transmission capacity to/from LTSS, to the north, west and south. LTSS would become a more substantial electrical hub through a connection to the 500 kV network. The addition of one or two 500 kV connections (thermal capacity 3,000 - 6,000 MVA) adds to the existing five 330 kV lines (capacity 5,000 MVA) to Canberra, Yass, Wagga, Murray, and Upper Tumut (see Figures 4 and 5).

LTSS's flexibility and reliability would be improved through a doubling of its transmission capacity (if two 500 kV connections) and an increase from five to seven connections.

Connection of Snowy 2.0 to both the 330 kV and 500 kV grids through LTSS would be shorter than through Maragle:

- LTSS: Snowy 2.0's connection to the existing 330 kV grid would be 25 km. Connection to the to-be extended 500 kV grid is a further 90 km to Wagga (one or two lines – see Section 3.5)
- Maragle: Snowy 2.0's connections to the 500 kV grid total 382 km - six cables for 3 km, plus four 330 kV lines for 9 km, and then 110 km to Wagga and 260 km to Bannaby. Connection to the 330 kV main grid is the same distance (connection to Line 64 at Maragle does not constitute a connection to the 330 kV grid, as it is just a single, often heavily loaded, line)

LTSS provides Snowy 2.0 with a more reliable and redundant connection:

- LTSS: underground cables are more reliable than overhead lines and not subject to interruptions from weather events and bushfires.  
Also, if one of the six cables is out of service the Station's capacity is only reduced by 17% (to 1,670 MW). From LTSS there are six/seven transmission lines with a total capacity of 8,000 - 11,000 MVA, providing substantial redundancy.
- Maragle: connection to the grid by four, then two overhead lines for 379 km, through lighting and bushfire prone areas, would be considerably less reliable.  
Also, two circuits provide far less redundancy. When one of the 500 kV lines is out of service, Snowy 2.0's pumping/ generation would need to be scaled back, possibly to 700 MW or lower when pumping, to avoid system stability issues if the second line tripped.

Finally, augmenting LTSS should alleviate occasional transmission constraints to Sydney (and to a lesser extent, Melbourne) experienced by the existing Snowy generators. Snowy Hydro has referred to these constraints many times, claiming they cost \$millions in lost revenue and sometimes result in unnecessary load shedding.

Deviating HumeLink through Maragle provides no relief for existing transmission constraints, except possibly marginally through the tie-in to Line 64.

### **4.3 A shorter HumeLink, with significant financial savings**

#### **4.3.1 Alternative D1**

Simply 'moving' the termination point of the two deviated legs by 20 km north of Maragle shortens their combined length by approximately 40 km, saving around \$140 million.

As discussed in the Background Paper, the AER has yet to decide whether Snowy Hydro will be required to contribute to the cost of HumeLink. Snowy Hydro contends it need not, whilst many

experts contend it should, especially due to the two extra 110 km legs needed to connect Snowy 2.0 to the grid. Irrespective of how the AER adjudicates, either consumers or taxpayers (as the ‘owners’ of Snowy Hydro) will benefit from shorter HumeLink legs to connect Snowy 2.0.

When this public benefit is added to the avoidance of both the Project and the cables from the Station to Lobs Hole, the total saving is over \$300 million (available to offset the additional works for Alternative D).

#### 4.3.2 Alternative D2

Alternative D2 reduces the length of new easements by a further 20 km (net) in the Batlow/Tumut area.

#### 4.3.3 Alternative D3

Alternative D3 adds a second 500 kV line directly between Wagga and Bannaby (+250 km). Also, it replaces both deviations to Maragle (220 km) by a 500 kV line, or two single-circuits or a double-circuit, from LTSS to Wagga (90 km) beside Line 051. Or Line 051 could be replaced altogether.

Conceptually, Alternative D3 is the simplest and would deliver cost savings additional to the \$300 million if a single line from LTSS to Wagga was sufficient.

It also simplifies the decision on apportioning HumeLink’s costs, with consumers paying for the two Wagga-Bannaby lines (Shared Asset) and Snowy Hydro paying for the Wagga-LTSS line(s) and LTSS Substation (Connection Asset).



**Figure 7 – HumeLink Current Proposal (ochre) compared with Alternative D3 (dark blue)**

Figure 7 illustrates the very much reduced easements required for Alternative D3 compared to the current HumeLink proposal.

#### 4.4 Snowy 2.0 commissioning not contingent on HumeLink

Snowy 2.0 is now forecast to start commissioning in 2025 and continue over the following 18

months. As outlined in Section 7 of the Background Paper, this latest forecast represents a further delay and is also viewed by experts to be overly optimistic.

Nevertheless, if Snowy 2.0's latest construction forecast is achieved, the transmission connection needs to be completed by early 2025.

Whilst this provides ample time to design and construct the underground cable connections to LTSS (or Maragle), there are doubts that the HumeLink legs from Wagga and Bannaby would also be completed. HumeLink is a massive project with considerable hurdles and exposure to delays, including finalising the routes, obtaining the necessary regulatory approvals, and then constructing 250 km of 500 kV line direct between Wagga and Bannaby and another 370 km via Maragle. Even if HumeLink were staged to place the Maragle legs as first priority the timing is tight.

If the HumeLink legs to Maragle are delayed till after 2025, then Snowy 2.0 units could be progressively commissioned by the tie-in to Line 64. Though, its output would be restricted to well below full capacity. However, if Snowy 2.0 were connected to LTSS Snowy 2.0's commissioning would not be reliant on the HumeLink legs being constructed, and it could attain full output, though probably at the expense of Tumut 3.

#### **4.5 Lower transmission losses**

Alternative D should result in lower transmission heating losses from:

- lower line loadings at LTSS and hence lower losses from adding one or two 500 kV connections (losses increase by the square of the current)
- shortening and rationalising the HumeLink deviation legs
- constructing both HumeLink connections by the most direct route along the Wagga-Bannaby "highway", maximising the transmission capacity and avoiding the extra transmission losses from the deviated legs

Such lower losses would result in considerable savings to electricity consumers over the 100-year lifetime of the proposed infrastructure.

#### **4.6 Improved reliability from reduced exposure to lightning and bushfires**

Bago State Forest is a high-risk area for lightning strikes and bushfires. Alternative D1 results in 40 km of 500 kV overhead lines not needed in BSF. Alternatives D2 and D3 remove all lines from BSF, totalling about 70 route-km.

'Removing' those lines from BSF would significantly improve the reliability of both HumeLink and Snowy 2.0's connection to the 500 kV grid.

#### **4.7 Reduces impacts on local communities and landholders**

There is significant community opposition to the HumeLink legs to Maragle, particularly in the Tumut/Batlow/Adelong region. The issue has been raised in State Parliament and spurred TransGrid to engage a specialist negotiator.

500 kV lines are the tallest, bulkiest, and most imposing of all transmission lines in Australia, completely dominating the landscape for tens of kilometres.

There is little that can be done to address community concern if the lines must be built. The only changes would be minor alterations to line routes and tower placements, and cosmetic extras like tower painting. 'Community consultation' becomes a divisive process as landholders attempt to

move the lines to someone else's property – an intractable and traumatic situation, especially for those whose lives are being so dramatically affected.

Terminating the two HumeLink legs at LTSS will shorten the lines and provide opportunities to re-route through less contentious areas.

Alternatives D2 and D3 offer significantly less impacts on landholders and local communities. Alternative D3 results in no new easements or lines, except for either a widened easement and 500 kV line beside Line 051 or no new easement if Line 051 is replaced.

#### **4.8 Substantially less environmental impacts**

Overhead lines should not even be contemplated in a National Park or area of natural beauty and environmental value. And only in the most extraordinary circumstance should underground cables be considered.

Connecting Snowy 2.0 to LTSS rather than Maragle will result in substantially less environmental impact in KNP, BSF and across hundreds of kilometres of other public and private lands. HumeLink can be shortened and rerouted.

The Project involves the clearing of 1.5 square kilometres (km<sup>2</sup>) of KNP and BSF. Additionally, HumeLink involves easements over 15 km<sup>2</sup> for the 220 km of deviated legs.

Alternative D avoids the Project clearing. Alternative D1 avoids a further three km<sup>2</sup> of clearing in BSF, and Alternatives D2 and D3 avoid almost double that amount in BSF.

Alternative D3i avoids approximately 110 km of new lines and easement (eight km<sup>2</sup>). Alternative D3ii, replacing Line 051, avoids nearly twenty square kilometres of easement.

#### **4.9 Multiple use of cable tunnel**

A cable tunnel running downhill from Snowy 2.0 Station to Upper Tumut SS can provide for other uses beyond housing transmission cables.

##### **4.9.1 Communications cables**

The tunnel provides for the installation of communication and control cables in a protected environment, not subject to external interference or weather.

##### **4.9.2 Drainage**

Underground stations are subject to water seepage, which is collected in pits and pumped away, usually into the tailrace tunnel. Such collection and extraction is critical for keeping the station operational and requires significant equipment, redundancy, and operational cost.

A gravity drainage system via the tunnel to LTSS negates the need for such equipment. It would also be particularly useful in the catastrophic event of a station flood that put all electrical equipment (including water pumps) out of action.

##### **4.9.3 All-weather access to Snowy 2.0**

Snowy 2.0 is in a very remote location. The main access is by the circuitous and steep 15 km long Ravine Track from near Three-Mile Dam on the Kiandra-Cabramurra Road. Lobs Hole is about 110 km from Cooma, the closest major town. The road is tortuous in sections and subject to closure by snow, fallen trees and landslips.

The cable tunnel could provide all-weather access from LTSS and Talbingo, if of sufficient width.

Snowy Hydro's current operating and maintenance personnel at Tumut 3 could be augmented by the staff needed to operate and maintain Snowy 2.0. They could be based and live at Talbingo or nearby (Tumut is only 40 km away). Minor equipment for repairs and maintenance could be transported from Talbingo.



**Figure 8 – Sydney City East Cable Tunnel (3.5m diameter)<sup>4</sup>**

#### **4.9.4 Emergency exit**

Snowy 2.0 will have a Main Access Tunnel (MAT) and an Emergency, Cable and Ventilation Tunnel (ECVT). A third access tunnel is not needed, but a cable tunnel to LTSS would provide another exit. This could be useful in the event of a Station fire, with fumes and smoke flowing up the MAT and ECVT, or if access to those exits was blocked.

## **5 Conclusion**

This Addendum highlights numerous benefits of connecting Snowy 2.0 by underground cables to LTSS compared to Maragle - financial, operational, environmental, social, and community - to all stakeholders (see Figure 9).

Alternative D, along with other underground alternatives, must be comprehensively analysed by TransGrid and Snowy Hydro in the EIS process and, as stated in the Open Letter, an underground alternative must be proposed.

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<sup>4</sup> "Cable tunnels under Sydney" Utility Magazine, 22 April 2014 <https://utilitymagazine.com.au/cable-tunnels-under-sydney/> 3.2 km, 3.5 m diameter, \$141 million, 132 kV cables

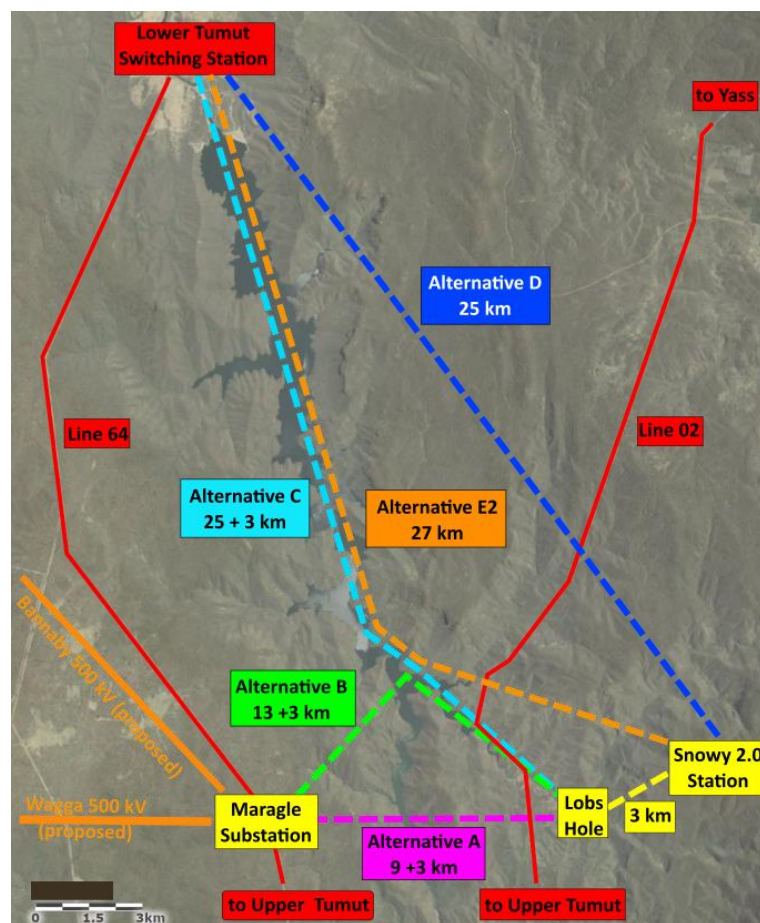


<b>NEM and AEMO</b>	<ul style="list-style-type: none"> <li>• LTSS becomes a more substantial electrical hub, with improved flexibility, reliability, and transmission capacity</li> <li>• the number of connections to LTSS increases from five to six/seven, and its transmission capacity increases from 5,000 MVA to 8,000 - 11,000 MVA</li> <li>• less transmission heating losses</li> <li>• a shorter, direct, more robust HumeLink connection between Wagga and Bannaby</li> <li>• reduced exposure to outages from lightning strikes and bushfires</li> </ul>
<b>Electricity consumers</b>	<ul style="list-style-type: none"> <li>• cost savings from: <ul style="list-style-type: none"> <li>○ a shorter HumeLink – savings on construction and O&amp;M</li> <li>○ less transmission losses</li> </ul> </li> <li>• a marginally more reliable service from Snowy generators</li> </ul>
<b>The environment</b>	<ul style="list-style-type: none"> <li>• fewer and shorter overhead lines</li> <li>• no overhead transmission lines, easements, or access tracks in KNP or BSF</li> <li>• no substation in BSF (Maragle)</li> <li>• up to 20 square kilometres less clearing for easements and access tracks</li> <li>• substantially less new overhead transmission lines blighting the countryside</li> </ul>
<b>Local communities</b>	<ul style="list-style-type: none"> <li>• fewer transmission lines will result in less impacts on the local communities and people's livelihoods and wellbeing</li> <li>• opportunities to re-route some lines</li> <li>• ultimate opportunity (Alternative D3ii) of only replacing an existing 330 kV line with a new 500 kV line(s), limiting the impact to landholders along the existing line (not ideal, but better than other options and considerably better than the current proposal)</li> </ul>
<b>Snowy Hydro (taxpayers)</b>	<ul style="list-style-type: none"> <li>• improved transmission capacity to/from the entire Snowy Scheme, reducing constraints and occasional loss of revenue</li> <li>• far shorter and more reliable connection of Snowy 2.0 to the main grid</li> <li>• avoids scaling back Snowy 2.0's generation/pumping when one 500 kV line is out of service</li> <li>• reduced contribution to the cost of HumeLink (if AER deems that Snowy Hydro ought to contribute)</li> <li>• Snowy 2.0's commissioning/operation is not reliant on the HumeLink legs being completed in time</li> <li>• possible reduced costs for Station drainage and access</li> </ul>
<b>TransGrid</b>	<ul style="list-style-type: none"> <li>• augmentation of an existing substation (LTSS) rather than constructing a new substation in a remote location, with cost and operational benefits</li> <li>• less construction of new lines and less ongoing maintenance</li> <li>• less opposition to HumeLink from local communities</li> </ul> <p>It is noted that as TransGrid is a regulated monopoly, all costs and savings for shared assets are passed on to the consumer. Costs and savings for connection assets, such as the cables to LTSS, are paid for by the client, in this case Snowy Hydro. Hence, cost savings to TransGrid will be passed through to consumers and taxpayers.</p>

**Figure 9 – Benefits of Alternative D**

## Appendix A – Underground Alternative Examples (extracted from Section 4.2.2 of Paper)

- Alternative A extending the three km of underground cables from the Snowy 2.0 Station to Lobs Hole Cable Yard, generally following the direct route of the proposed overhead lines, for the remaining nine km to Maragle. The cables could be in a trench, tunnel or HDD conduit, or combination.
- Alternative B laying cables in a trench from Lobs Hole along, or near, the road to the Snowy 2.0 excavated spoil dump in Talbingo Reservoir, at the junction of the Yarrangobilly and Tumut Rivers, and then via a trench/ tunnel/ HDD to Maragle (about 13 km). Approximately half the route is under the road and therefore of straightforward construction, with no additional clearing or environmental impact.
- Alternative C as per Alternative B to the junction of the Yarrangobilly and Tumut Rivers, and then in, or adjacent to, Talbingo Reservoir to the existing LTSS, located next to Tumut 3 Pumped Hydro Station at Talbingo (about 25 km). This alternative effectively relocates Maragle Substation to LTSS, with ongoing new connections to the 500 kV grid being constructed from LTSS, rather than from Maragle.
- Alternative D laying cables in a tunnel from the Station directly to LTSS (avoiding the need for cables from the Station to Lobs Hole).
- Alternative E laying cables in the tailrace tunnel from the Station to its inlet at Talbingo Reservoir, and then via a trench/ tunnel/ HDD to Maragle (E1), or via the Reservoir to LTSS (E2).



Alternative Routes for Underground Cables

## Appendix B – General benefits of underground cables (extracted from Section 6.2.1 of Paper)

Countering the higher cost of installing underground cables are several offsetting benefits, many with significant financial savings, including:

- less prone to physical damage
- no exposure to weather events – lightning, bushfires, storms, extreme winds etc. Such events are expected to become more frequent and intense with climate change, causing more outages, physical damage, more repair costs and lost revenue, sometimes costing tens of \$millions from a single event (as was the case with the January 2020 bushfires<sup>5</sup>).
- higher reliability, though taking longer to repair. (The longer repair time should rarely be a concern, as if one cable is out of service the remaining five generators/pumps can still operate up to a combined capacity of 1,670 MW).
- the loss of one cable circuit due to a fault should not result in the need to back off Snowy 2.0 output/load to cover a subsequent cable loss. Whereas the loss of a double-circuit overhead line from a fault (or lightning strike or bushfire) would result in backing off output/load to cover for a subsequent loss of the second double-circuit. Also, the proximity of the two overhead double-circuit lines pose a system stability risk to a lightning strike that is not applicable for underground cables<sup>6</sup>.
- ready physical access for repairs and maintenance if in a tunnel
- lower operating costs (potentially one-tenth that of overhead lines<sup>7</sup>), though higher repair costs
- lower electrical losses (reputed to be around 30% lower)
- far less or zero easement clearing and maintenance cost
- little or no release of greenhouse gasses from vegetation clearing
- no potential to start bushfires, as can occur from overhead lines through fallen towers, conductor clashing or breaks, and subsequent insurance claims<sup>8</sup>
- and, most importantly, underground cables have substantially less environmental impact and no visual blight<sup>9</sup>, other than a relatively narrow easement if trenches are used.

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<sup>5</sup> The January 2020 bushfires resulted in outages for some days in the Snowy, and separation of the NSW/Victoria transmission networks. Damage to TransGrid's assets in the Snowy region was *"north of \$15 million to \$20 million, which was not insurable"* [TransGrid CEO]. Snowy Hydro lost supply capability *"costing the company millions"* [Snowy Hydro CEO].

<sup>6</sup> "Queensland and South Australia system separation on 25 August 2018" AEMO, 10 January 2019 [https://www.aemo.com.au/-/media/files/electricity/nem/market\\_notices\\_and\\_events/power\\_system\\_incident\\_reports/2018/qld---sa-separation-25-august-2018-incident-report.pdf](https://www.aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2018/qld---sa-separation-25-august-2018-incident-report.pdf)

<sup>7</sup> "Overview of the Potential for Undergrounding the Electricity Networks in Europe" prepared for the European Commission, 28 February 2003 [https://ec.europa.eu/energy/sites/ener/files/documents/2003\\_02\\_underground\\_cables\\_icf.pdf](https://ec.europa.eu/energy/sites/ener/files/documents/2003_02_underground_cables_icf.pdf)

<sup>8</sup> "Black Saturday bushfire survivors secure \$500 million in Australia's largest class action payout" ABC News, 15 July 2014 <https://www.abc.net.au/news/2014-07-15/black-saturday-bushfire-survivors-secure-record-payout/5597062>

<sup>9</sup> "Valuing the social benefits of avoiding landscape degradation from overhead power transmission lines: Do underground cables pass the benefit–cost test? Ståle Navrud, Richard C. Ready, Kristin Magnussen & Olvar Bergland, 12 May 2008 *"the social benefits of avoiding negative impacts [from overhead transmission lines] on the landscape exceed the costs of burying the lines as underground cables ... based only on an assessment of the aesthetic impacts [urban setting]. Impacts of overhead power lines on wildlife and human health would likely make burial of power lines even more attractive."* <https://www.tandfonline.com/doi/abs/10.1080/01426390802045921>