# Comparative Review

## of AusNet Services WVTNP Underground Construction Summary Report


Energy Grid
ALLIANCE

Murraylink underground HVDC project

Maximising the opportunities and benefits of feasible transmission systems will require bold and visionary leadership to re-imagine our future grid.

# The Transition to a Renewable Energy Future

Our electricity system is transforming at a rapid rate and more Australians want a reliable power system that keeps the lights on around the clock, especially during extreme weather events when we need it most.

We need to invest in transmission networks that are reliable, resilient, secure, robust and efficient to support the connection of new wind, solar and hydro generation and smart storage solutions that are waiting to be commissioned.

We should be using existing rights-of-way, and augmenting existing assets with smart high voltage direct current (HVDC) technology. Not only does this keep lifetime costs down, but it speeds up the time for renewable connections, powering new and exciting industries.

Where there is a need for new transmission, we should underground infrastructure to minimise risks from extreme weather and bushfire related events and significantly reduce our impact on the environment and regional communities. This will modernise Australia's electricity grid in alignment with global trends.

According to analysis by world-leading transmission cable manufacturers, ABB[1], we can cut hundreds of millions of tonnes of carbon emissions by optimising design solutions that minimise the number of overhead transmission links needed.

Network planners and energy companies should listen to the needs of Australians; keeping the power on, while protecting our lives, environment and livelihoods by optimising our legacy infrastructure footprint to meet our future electricity needs.

By working together, with smart thinking and technology, we can engineer resilience, safeguard reliability, reduce carbon emissions, encourage renewable generation investment, create new and exciting jobs and avoid unnecessary impacts on our economy and environment.

***REFERENCE***

1. *ABB Underground transmission with HVDC Light*
   *https://library.e.abb.com/public/15896c343f126852c1257488003ee14e/ABB%20Review%20April%202005%20-%20Underground%20transmissin%20with%20HVDC%20Light.pdf*

Victoria's future Renewable Energy Zones (REZs)

# Purpose of this paper

**The purpose of this paper is to provide a high-level comparative review of the undergrounding concepts and relative design information to understand how AusNet Services (AusNet) has estimated the underground costs of HVAC to be 16 times greater than overhead transmission and subsequently dismissed underground alternatives.**

# Background

On 26 November 2021, AusNet announced the final preferred transmission path for the Western Victoria Transmission Network Project (WVTNP). A proposed 190-kilometre high voltage transmission line between Sydenham and Bulgana in Western Victoria.

AusNet also released the preliminary findings[2] of its investigation into undergrounding the transmission line as required by the Environmental Effect Statement (EES) process.

Assessing the viability of feasible project alternatives, such as undergrounding transmission lines and refining the project by identifying areas of significance and sensitivity, is an important part of the Environment Effects Statement (EES) process and determining the final location of the transmission line.

While AusNet's findings are preliminary and are still subject to peer review, their investigation finds that undergrounding the HVAC transmission line along their proposed routes would cost approximately 16 times more. As a result AusNet have dismissed undergrounding and have recommend overhead construction.

Earlier this year, June 2021, the Moorabool Shire Council released a *High-Level HVDC Alternative Scoping Report*[3] for the WVTNP. This report was independently prepared by Amplitude Consultants, an Australian-based engineering consulting company that provides specialist consulting services to clients involved in the transmission and distribution of electricity. The Amplitude report has been referenced in AusNet's underground construction summary.

Dismissal of an underground HVDC solution and announcement of a final preferred transmission path at this stage of the EES process has prompted a review of AusNet's *Underground construction summary*[1].

# Contents



## Recommendations

**AusNet's preliminary findings require further scrutiny.**

**Misconceptions may have inadvertently led to overhead HVAC construction being recommended as the preferred solution by the investigation and underground solutions prematurely dismissed.**

To satisfy the requirements of the EES, Energy Grid Alliance recommends that proportionate and robust investigations be conducted on feasible technologies and alternate corridors by a suitably qualified independent expert before the final transmission corridor, path and technology can be determined.

The EES process seeks the project option that delivers superior environmental outcomes. This process does not seek the cheapest option. Underground HVDC is proven to deliver these outcomes.


***REFERENCES***

2. *Western Victoria Transmission Network Project Underground construction summary - AusNet Services (November 2021) https://www.westvictnp.com.au/assets/resources/Underground-construction-summary-November-2021.pdf*
3. *Western Victoria Transmission Network Project High-Level HVDC Alternative Scoping Report - Amplitude Consultants (June 2021) https://www.energygridalliance.com.au/wp-content/uploads/2021/12/wvtnp-high-level-hvdc-alternative-scoping-report.pdf*

# Understanding the costs of undergrounding

## Best practice transmission planning

Route selection should try to avoid, minimise, or offset impacts on important environmental, social, cultural, landscape values and strategic land use conflict by utilising existing rights-of-way as a priority.

Replacing overhead High Voltage Alternating Current (HVAC) with High Voltage Direct Current (HVDC) on existing infrastructure and deployment of underground HVDC technology should be considered as preferred transmission options to avoid community and environmental impacts.

While HVDC solutions may increase initial project cost due underground construction requirements and the need for converter stations, they would deliver greater lifetime benefits, including increased electricity throughput, less energy losses, improved reliability, less exposure to weather events, increased bushfire resilience, lower operating costs, less environmental impact and considerably less opposition.


Shetland Interconnector - Underground HVDC

AusNet's summary report suggests that in comparison to underground construction, overhead transmission lines result in less ground disturbance and provide more cost-effective connections for renewable energy generators, achieve the electricity system availability and reliability requirements and are a proven solution over the distance and at the capacity of this project.

AusNets's preliminary estimates undertaken indicate that underground construction of the WVTNP using HVAC technology could cost at least 16 times more than the equivalent overhead transmission line.

However, the summary report provides only a qualitative discussion around the intricacies of undergrounding HVDC, it does not include AusNet's costs for overhead HVAC, or their comparable underground HVAC or underground HVDC solutions. There is reference to the Amplitude cost estimate that states implementing the proposed HVDC solution would cost 5.7 times the cost of AusNet's proposed overhead transmission lines. AusNet's summary does not validate how this multiple was determined.

The Amplitude report provides detailed cost breakdowns of three technically feasible and environmentally sensitive underground HVDC options at $2.6, $1.75 and $1.49 billion.

The final transmission path has not yet been determined by AusNet. Therefore, the costs of construction, easement acquisition, compensation, community benefit programs, biodiversity offsets, the EES process, and ongoing maintenance are also unknown at this time.

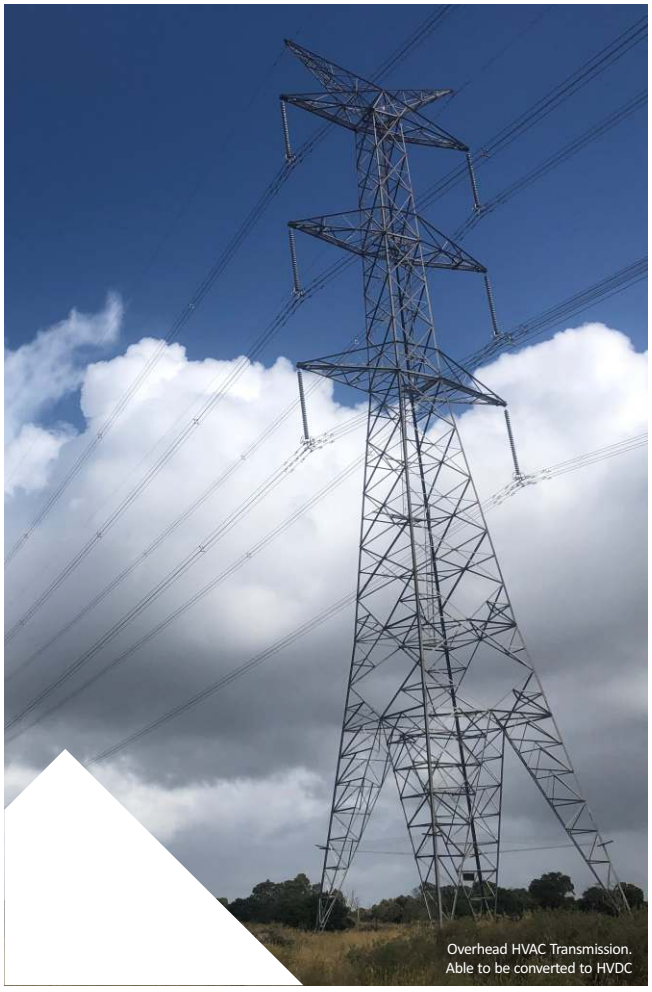
AusNet have not provided a comparative underground HVDC estimate in its summary so it is unclear how this feasible solution can be dismissed.

# Is the capital cost important?

The Regulatory Investment Test for Transmission (RIT-T) identifies the transmission investment option which maximises net economic benefits and, where applicable, meets the relevant jurisdictional or Electricity Rule based reliability standards. So yes, for the RIT-T, capital cost is extremely important.

While the RIT-T is not allowed to consider socioeconomic or environmental costs, the EES on the other hand is not interested in the cheapest option at all.

The EES is only concerned with the cumulative environmental effects of a project. Environment in this context is not limited to our natural environment. Environment considers agriculture, farming, air quality, aviation and aerial firefighting, biodiversity, bushfire risk, electronic interference, historic heritage, human health, landscape and visual, noise and vibration, project alternatives, socioeconomic, surface water and groundwater, traffic, and transport.



Overhead HVAC Transmission.
Able to be converted to HVDC

**The EES is only interested in the transmission investment option which delivers superior environmental outcomes while remaining technical feasible.**

To realise the true net benefit over the life of a project, a Triple Bottom Line (TBL) analysis is required to consider profit, people and the planet. Not just profit.

The EES process should provide this analysis through robust and proportionate investigations of all technically, socially and environmentally feasible alternatives.

It is encouraging to hear leaders in the energy sector considering more than just project costs by advocating the importance of people, planet and innovative thinking.

> *"The solution is to create the critical social and community licence for the infrastructure by working with communities, early on, in a collaborative way; to listen to and address their concerns and to support a smooth energy transition that truly delivers for all Australians."*
> Quote attributable to Mr Daniel Westerman, CEO and Managing Director of the Australian Energy Market Operator (AEMO)
> CEDA Luncheon July 2021.

> *"The efficiency of the underground cable is better, because, yes, there are some issues around the fact that it's buried. So, maintenance can be a bit harder, but the operating costs are lower. So, the capex is a little bit higher, but we think that the offsets with bushfire risk, environmental offsets, and actually, the engagement with the community is pretty critical."*
> Quote attributable to Mr Ben Bolot, Executive General Manager of ATCO Australia
> Renew Economy Podcast November 2021.

> *"No one has been able to explain why this asset can't go down the highway, I think we'll hear that as part of the EES process, and the community deserves to hear that."*
> Quote attributable to Mr Stuart Benjamin, Chair of the Grampians New Energy Taskforce
> The Courier November 2021.

# Impact of an underground HVDC solution on the environment

Network planners are under increased pressure to meet consumer and regulatory demands for a high quality, competitively priced power supply that has low environmental impact. The expansion of AC transmission capacity is often limited by local planning regulations and the concerns of local residents who object to the installation of new overhead lines.

It is economically feasible to expand transmission capacity using underground HVDC cables. This approach not only minimises environmental impact, it also improves the quality of the power supply.

The Murraylink[4] underground HVDC project in Western Victoria earned several Australian state and national awards for both environmental and engineering excellence.

At the time Murraylink was the world's longest underground high-voltage interconnection at 177 kilometers. The project won the 2002 Case EARTH Award for Environmental Excellence for best practice and innovation in the environmental management of civil construction projects.

This national award shows that a high level of environmental sensitivity is possible in large scale transmission infrastructure projects when an underground HVDC solution is selected.

**Comparative Analysis Ranking**

Superior Outcome | Moderate Outcome | Inferior Outcome

| Project Considerations | Overhead HVAC Proposed Corridor | Underground HVDC Amplitude Report |
|---|---|---|
| Capital cost | Moderate | Inferior |
| Ongoing operating cost | Moderate | Superior |
| Lifetime Project Costs (30 years)[5] | Moderate | Moderate |
| Triple bottom line[6] | Inferior | Superior |
| Fault finding/maintenance | Superior | Moderate |
| Electricity throughput | Moderate | Superior |
| Transmission losses | Moderate | Superior |
| Reliability and Security | Moderate | Moderate |
| Resilience to climate change[7] | Moderate | Superior |
| Environmental impact | Inferior | Superior |
| Biodiversity impact | Inferior | Superior |
| Visual amenity impact | Inferior | Superior |
| Cultural impact | Moderate | Superior |
| Land use conflict[8] | Moderate | Superior |
| Social impact | Inferior | Superior |
| Community opposition | Inferior | Superior |

**HVDC provides a superior environmental outcome**

HVDC solutions may increase the initial project cost (depending on length of the line).

Compared to overhead HVAC, HVDC can deliver greater lifetime benefits, including increased generation flow, less energy losses, improved reliability, increased resilience to weather events, increased bushfire resilience, lower operating costs, less environmental impact and considerably less opposition.

*Ranking has been determined following analysis of independent reports and technical studies*

***REFERENCES***

*4. ABB power transmission project wins national environmental award in Australia https://new.abb.com/news/detail/13669/abb-power-transmission-project-wins-national-environmental-award-in-australia*
*5. Lifetime Project Costs (30 years): Includes construction, ongoing operation, maintenance, economic impact due to power outages. (Western Victorian RIT-T AEMO)*
*6. Triple bottom line: The triple bottom line is a sustainability-based accounting method that focuses on people (social), profit (economic) and planet (environment).*
*7. Resilience to climate change: Resilience from bushfire to communities and infrastructure, resilience to increased extreme weather events.*
*8. Land use conflict: Strategic agricultural land, urban growth, significant landscape, materially populated towns.*

# HVDC Transmission systems

AusNet's underground construction summary states that HVDC transmission lines are installed as either a Monopolar link (two cables comprising a power cable and a metallic return cable) or Bipolar link (three cables comprising two power cables and a metallic return cable) with additional links necessary for increased power.

According to Ausnet, **up to five links**, **each with three cables**, may be required to achieve the capacity of the WVTNP high-capacity double circuit 500kV transmission lines.

Amplitude's Base Case concept design[3] for the 500kV cables shows detailed design considerations and cost estimates for a double symmetric monopole configuration with **four underground cables, in a single 3m wide trench**. This is a robust option that is equivalent to the AEMO preferred RIT-T Option, in terms of power transfer capacity and full system redundancy.

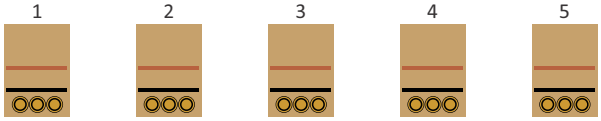
Built in redundancy is a key advantage of a double symmetric monopole configuration HVDC transmission system. This means that for a fault on either one cable or one converter, the second system can continue operating at its maximum system rated capacity. i.e. instead of splitting 2.26 GW across two systems, one “healthy” system will take the full load.


Underground HVDC Cable Splicing

**AusNet Services Concept (500kV Transmission)**

Five trenches, each with three cables

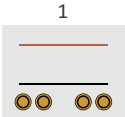
Thermal backfill is required




**Amplitude Concept (500kV Transmission)**

One trench, with four cables

No thermal backfill is required





Underground HVDC Transmission.
Laying 600kV cable (Europcable)

# HVDC Trench profile

According to AusNet, each of the five trenches will be approximately **2.5m wide and 1.5m deep and at least 3m apart**. This brings the underground HVDC cable trench width to approximately **24.5m for five HVDC links**. *See figure 1.*

In contrast, Amplitude specifies the HVDC cable trench width from Bulgana to North Ballarat will be **2m wide** and from North Ballarat to Sydenham **3m wide**. *See figure 2.*

**The difference in design is quite significant with AusNet's approach requiring 4 additional trenches, 11 additional cables and a 21.5m increase in overall trench width for 500kV underground HVDC transmission.**

AusNet claims the 24.5 metre trench width and subsequent 35m easement means underground HVDC cannot be installed in road reserves, existing transmission easements, limited workspace near subdivisions, presents less opportunity for trenches to avoid native grasslands and associated habitat, less opportunity for trenches to avoid heritage sites and artefacts compared to overhead transmission lines.

Amplitude on the other hand have reported that undergrounding HVDC is practically feasible as a cable trench of approximately 3 meters wide should be able to fit in the fire break zone of the existing roadways and easements and would not require a significant extension of the transmission line corridors.

**Figure 1 – AusNet Services Concept WVTNP HVDC Underground Cable Design**

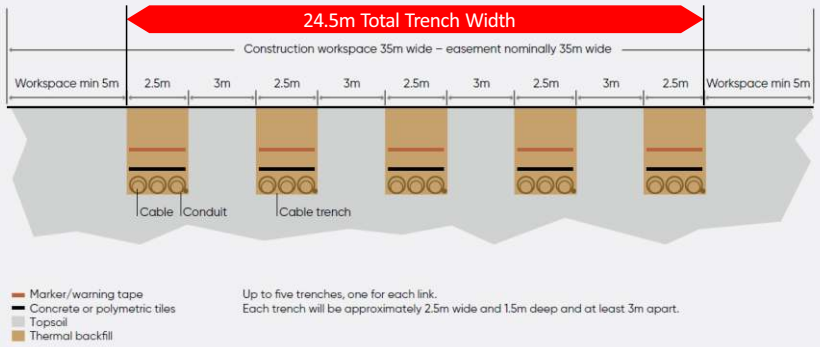
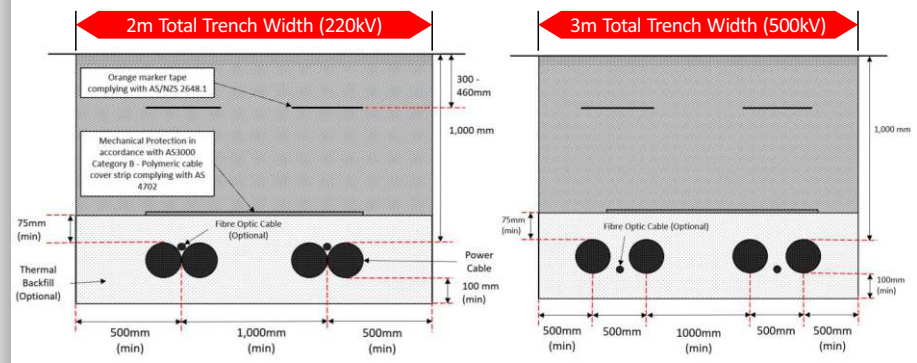



**Figure 2 – Amplitude Base Concept HVDC Cable Trench Profiles**




*Bulgana to North Ballarat (220kV)* *North Ballarat to Sydenham (500kV)*

**It's critical to understand the transmission system and trench profile.**

AusNet's summary concludes that ground disturbance and easement restrictions of underground construction will adversely impact vegetation, biodiversity, Aboriginal cultural heritage, agriculture and other land uses along the length of the transmission line.

AusNet's summary indicates that an independent peer review will be conducted of the investigation into underground construction done to date.

This should help clarify any uncertainty around HVDC transmission systems and trench profiles.

# Findings of review

As a side-by-side comparison, AusNet's *Underground construction summary* is what it claims to be. A broad overview of HVAC, HVDC, underground construction, potential routes and key differences in environmental impacts.

However the absence of design and cost detail for both the underground HVAC and HVDC options referenced make it difficult to verify and substantiate the conclusion.

When compared to the Amplitude *High-Level HVDC Alternative Scoping Report* it becomes evident there is conflicting information that needs to be clarified by an independent HVDC expert.

A single pair of 640 kV extruded high-voltage DC cables could transmit enough renewable energy to supply around 3 million households.

## Key findings of this review

AusNet's summary indicates these are 'preliminary findings' that have not been peer reviewed.

Technical specialists who compiled the information are not identified or credentialled, nor is any information referenced to allow independent verification.

AusNet's summary does not provide costs for its overhead HVAC, underground HVAC or underground HVDC solutions.

AusNet estimates underground HVAC is likely to cost 16 times more than an overhead HVAC solution. However, AusNet's estimate is not supported by a detailed cost breakdown.

Amplitude's report estimates the cost of underground HVDC to range between 3.15 and 5.7 times the cost of an overhead HVAC solution.

AusNet's HVDC concept design appears to have overestimated the sets of parallel cables, number of trenches and width of easements required for underground HVDC transmission. This requires further scrutiny as AusNet's assessment results in a notable increase in the number of cables and trenches and easement width required which impacts route selection, ease of construction and the environment.

- AusNet estimate 24.5m total trench width
- Amplitude estimate 2-3m total trench width

AusNet have said the environmental impact is greater for underground HVDC. This is based on assumptions around the number of cables required, sets of parallel cables, trench and easement widths.

## Recommendations

**AusNet's preliminary findings require further scrutiny.**

**Misconceptions may have inadvertently led to overhead HVAC construction being recommended as the preferred solution by the investigation and underground solutions prematurely dismissed.**

To satisfy the requirements of the EES, Energy Grid Alliance recommends that proportionate and robust investigations be conducted on feasible technologies and alternate corridors by a suitably qualified independent expert before the final transmission corridor, path and technology can be determined.

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Energy Grid
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Energy Grid Alliance was established with the purpose of engaging with energy transmission companies, industry regulators, market operators, relevant peak bodies, government and communities to establish best planning practices for new energy transmission infrastructure and to inform on the benefits of working with communities to acquire and maintain social license.

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