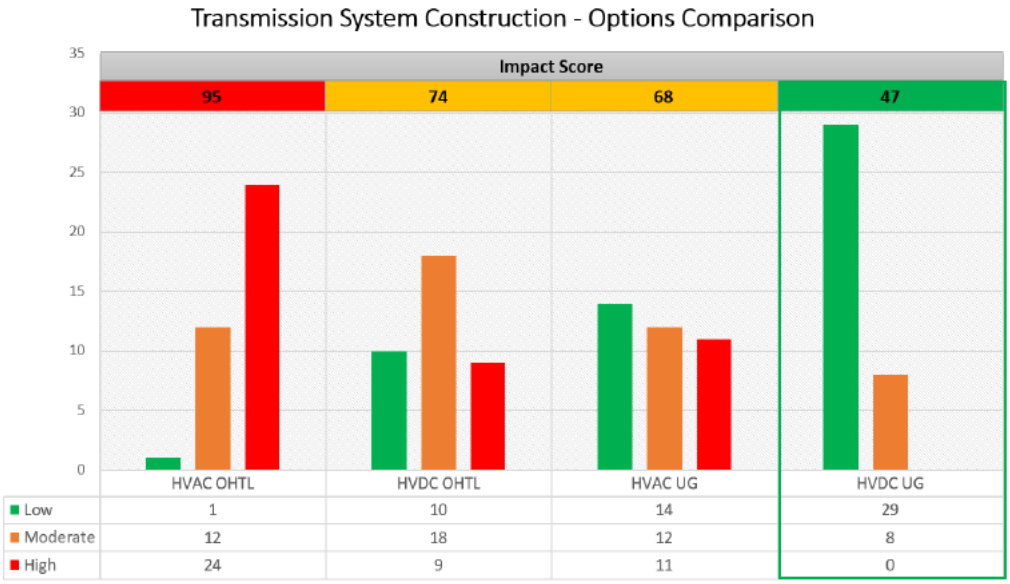
- 23 June 2021

HIGH-LEVEL HVDC ALTERNATIVE SCOPING REPORT – KEY POINTS

- The Moorabool Council's Expert report confirms that underground HVDC cables are a viable, safer, more reliable and more efficient alternative to overhead AC for the Western Victoria Transmission Network Project.
- This is the Council's second expert report, the first in Sep 20 debunked AusNet's claim that undergrounding could not be done.
- This report, the **High-Level HVDC Alternative Scoping Report**, finds that underground HVDC cables are likely to be more reliable and more efficient with significantly less impact to the community, land use, agriculture and the environment.
- The report presents a Base Case Concept HVDC System, and two cheaper alternatives, which could replace the proposed AC overhead transmission lines between Bulgana and Sydenham with an entirely underground HVDC transmission system utilising existing easements, roadsides and property boundaries, avoiding sensitive areas.
- The three equally capable underground HVDC options, all present far less risk than overhead options assessed against eight risk criteria.
- The report was prepared by **Amplitude Consultants**, an award winning, world leading Brisbane-based Australian HVDC industry consultancy, the lead author pioneered underground HVDC in Australia as the project engineer for Directlink and the award winning 170 km Murraylink interconnector, still serving Victoria and SA today.
- The report finds that an underground HVDC solution for the WVTNP would provide:
    - Negligible risk of causing fires.
    - Negligible risk of interruption to transmission, or to power supply being affected during bush fires as occurred in Feb 2020 or severe weather events as at Cressy in Jan 2020 and recently in the Dandenongs in Jun 2021.
    - Negligible impact to access for emergency services or aviation operations.
    - Minimal impact to private land and land use once construction is completed as the easement could be designed to fit within existing road reserves or run along property boundaries.
    - Negligible impact to flora and wildlife (such as wedge-tailed eagles) due to the cables being underground and sited along roadways.
    - No visual impact as the cables are buried underground.
    - Reduced visual impact from HVDC converter stations as much of the DC equipment would be housed indoors.
    - Negligible electromagnetic field impacts
    - No electrical or audible noise from corona effect.

- The high-level cost estimate demonstrates that it is much less than the "10 times greater" claimed by the AEMO, and publicly stated many times by AusNet.
- The base option is currently costed at $2.7Bn, only 5.7 times more that the RIT-T cost estimate for the current WVTNP overhead option, however, this option is considered 'in excess' of the required power transfer capacity as it is based on the reliability and capacity requirements of the current 500 kV AC overhead line option proposed by AEMO. This is overstated, i.e. more than required, and drives large capital expenditure which would leave the significantly more reliable HVDC system underutilised.
- The two additional underground HVDC options offer lower capital costs for a capable "redundant bipole" of lower capacity ($1.75Bn) and a "non-redundant single symmetric monopole" ($1.49 Bn).
- If options to uprate the 220kV line to Bulgana to 500kV were pursued, this would negate the need for a convertor station at north Ballarat, thereby reducing the HVDC system costs by between $350m to $709m.
- The report indicates that further optimisation may be able to reduce underground HVDC costs even more.
- Of significance, the report identifies that the cost of an overhead AC solution does not include the cost of mitigating risk anywhere near the extent that is inherently mitigated by the HVDC underground options. For the AC overhead solution to be engineered to achieve the same level of risk mitigation as the HVDC underground solutions, significant additional costs may need to be factored in. If the costs of these mitigations were to be fully addressed in the AC overhead solution, then the total AC overhead cost would be much more expensive than is currently estimated.
- Applying a 40 year 'whole-of-system-life' perspective the cost difference between the current overhead proposal and the worst case HVDC underground solution amounts to around the price of one six-pack of beer, or one adult-price movie ticket, per year, for all Victorian electricity customers. The MCHPA thinks this is good value when you consider the risk that is avoided.
- The report notes that a more wholistic approach, such as combining the WVTNP and the VNI West project would deliver even more benefits, and potentially even more cost competitive and technically superior, rather than the piecemeal approach to strategic transmission investment proposed by the AEMO.
- The report validates the many objections and submissions that the Moorabool and Central Highlands Power Alliance Inc. (MCHPA) has made on behalf of the affected communities under since the WVTNP announcement in June last year.
- The report independently substantiates the MCHPA's claims that other more cost-effective, efficient, technologically suitable and socially acceptable options are available to meet the renewable transmission requirements in Western Victoria.
- Underground HVDC options reduce community risk rather than adding to it.
- Cost comparisons in the report are based on the estimated cost for the C2 option in the PACR of $473.2m – this cost is considered vastly understated particularly considering the opposition to land acquisition amongst the community.

KEY FIGURES



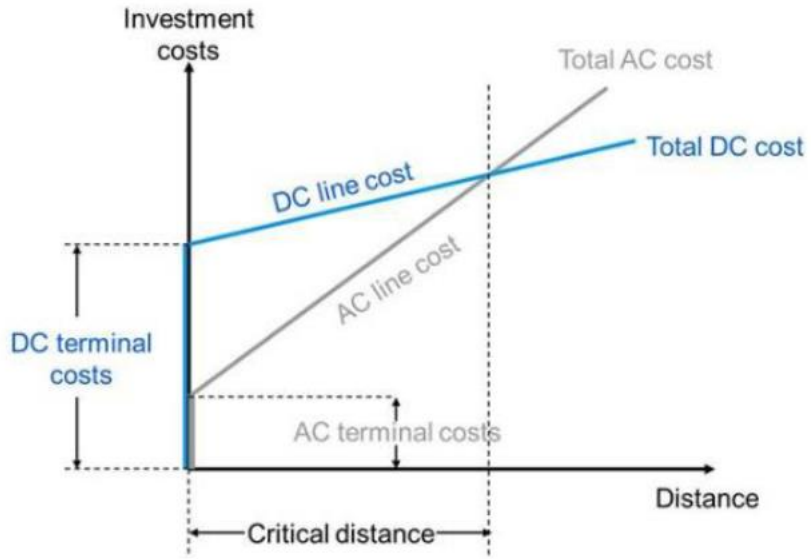
Comparison of Impact scores – land disturbance, environment, land use, technical & risks.

Table 7-1 – Pros and Cons of AC and VSC HVDC Technology for Power Transmission

Parameter	AC	VSC HVDC
Controllability	No	High
Losses – Substation/Converters	Lower	Higher
Losses – Lines/Cables	Higher	Lower
Inherent Voltage Support Capability	Not Available	Available
Inherent Damping Control Capability	Not Available	Available
Overhead Line	Larger Conductors, More Conductors, Larger Towers	Smaller Conductors, Fewer Conductors, Smaller Towers
Underground Cable Capability	At a distance >50km and at higher voltage, requires substantial reactive compensation	No Practical Limit on Distance, Fewer Cables
Tap Off Points Along Route	Unlimited, relatively low cost	Limited to a few and preferably known in advance, high cost
Substation/Converter Station Footprint	Smaller	Larger
Easement Width for Overhead Lines	Larger	Smaller
Visual Impact of Overhead Lines	Greater	Lesser

Once past the initial cost of convertor stations, lower underground cable costs mean that for longer distances, past the break even point, HVDC becomes cheaper than AC

Figure 7-1 – Comparison of AC and HVDC cost vs Distance[1]



Common Parameters of the HVDC Underground Alternative Solution

- VSC Convertor Technology – same as Murraylink –
- MMC Convertor Topology – less filtering equipment and land required, lower losses
- 525 kV – allows optimal cable sizing
- Route length – 167 km - most direct using 'prudence avoidance' using existing rights of way of existing transmission lines and along roadways and the Western Highway
- Horizontal direct drilling to avoid impacting infrastructure and sensitive areas
- Polymeric cable – ease of installation
- 3 – 6 Convertor stations depending on option, approx. 5 – 6.5 ha footprints
- Trench Depth – 1.25m deep, 2 – 3m wide respectively for 220 kV and 500 kV sections
- Depth to top of cable 1m

Comparison of AC versus HVDC system losses

Underground HVDC losses – estimated 2.49% of total Max capacity

Overhead AC losses – estimated 7.5% of total Max capacity

An even larger difference in losses would be expected if the transmission route were longer than that of the WVTNP.

The Cost Estimate:

- **Includes** capital costs limited to costs directly related to the engineering, procurement, manufacture, construction, installation, testing and commissioning of the proposed HVDC transmission system.
- **Excludes**:
  - **Land or easement purchase and associated ongoing costs**;
  - Environmental planning, permitting, or cultural heritage and associated mitigations (if required);
  - Site preparation or demolition works and civil engineering risk items such as rock or soil contamination risk;
  - Internal project management and overheads;
  - Local taxes, import and other taxes or duties;
  - Insurances, interest during construction (IDC), or contingency costs or allowances; and
  - Exchange rate or commodity price fluctuations, inflation or future market supply and demand-based risks or adjustments.
- Transmission line/cable costs based on publicly available professional transmission industry data

Cost Analysis includes:

Discussion of:

- **Capital construction costs**
- **Operation and maintenance costs** – HVDC system ~ $6.5m per year
- **Risk Mitigation Costs** – AC – the cost of the proposed AC overhead solution does not capture the cost of mitigating risks outlined to the same extent as what could be considered to have been inherently incorporated or mitigated against by the HVDC underground options. Costs to engineer the AC solution to provide the same level of risk mitigation would be very significant.

Schedule

HVDC underground project estimated to have similar duration to AC project, ~4 – 4.5 years from inception to start of commercial operation, however significant delays are anticipated for AC due to social and environmental approvals and potentially protracted land purchase disputes.

Redundancy Options

Overhead AC lines are typically designed to N-1 level redundancy, i.e. if one circuit goes down the other can carry full load.

This is appropriate for overhead which face significant risk from fire, weather, impact or malicious action – most, if not all of these risks are avoided by putting HVDC underground, less redundancy can be acceptable, allowing “as-capable, but lesser redundant” systems.

Hence the report offers:

- a three-terminal bipole with a metallic return system ~$1.73 Bn
- single symmetric monopole ~$1.49Bn

Staging Options

Staging of the HVDC base case is possible and allows infrastructure to be included as needed.

Reliability and Availability

Overseas trends in Transmission design