Submission
No 7

# INQUIRY INTO FEASIBILITY OF UNDERGROUNDING THE TRANSMISSION INFRASTRUCTURE FOR RENEWABLE ENERGY PROJECTS

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# The Safe and Cost-Effective Transmission of Power from Renewable Energy sources by underground cables in Australia

Ken Barber SMIEEE

# Background

- **Australia lags behind Europe in accepting the need to be transferring power from renewable energy sources to the grid using underground cables rather than bare overhead lines.**
- **Why Underground cables (UGC) versus Overhead Lines (OHL)**
    - **Today most countries consider OHL environmentally unacceptable except for remote areas.**
    - **They require many years planning. Have high energy losses, are subject to high maintenance costs, limit farming activities, lower property values, and provide more risks with climate change.**
    - **The implementation of UGC avoids all these issues.**
    - **It can be relatively quick to get community acceptance.**
- **AC versus DC - Depends on the route length and the power transfer required.**

# Transmission of power

The earliest form of transfer of power was by bare conductor overhead lines using air as the insulation and with glass or porcelain insulators.

Then oil impregnated paper was used as the insulation which enabled transfer of electrical power by means of underground or undersea cables.

In more recent years, new types polymeric insulation have been developed and now cables carrying AC and DC power at 500 – 535 kV are common.

The cost of these cables and methods of installation are rapidly reducing, whilst the costs of building and maintaining overhead transmission is increasing.

**In the future these cables and all overhead lines may be replaced by underground pipelines carrying hydrogen in the same way as water, gas and oil.**

# OVERHEAD LINES

## DISADVANTAGES

- High maintenance costs
- Climate change vulnerability
- Visual impact
- Extensive land use
- Community health and safety concerns - EMF
- Devaluation of property
- Hazard for birds and wild-life
- Can cause bush fires
- Impedes control of bush fires
- Imposes limits on farming
  - Drones, GIS and RTK
- Safety hazards with irrigation equipment & grain elevators
- Inductive coupling with fence lines

## ADVANTAGES

- Transmission line conductors transfer their heat to the air.
- They are very suitable for remote and desert areas.
- Lower construction costs.

# Other significant disadvantages with OVERHEAD LINES

## Transmission Losses

- When a conductor carries current (Power) heat is developed due to the ohmic resistance. For an OHL this heat is removed by the air around the conductor. This is very efficient, so smaller, higher resistance conductors are possible.
- In VIC and NSW, the old type of steel reinforced conductors are used on transmission lines. QLD promoted the use of low loss alloy conductors on all new lines.
- All these energy losses are paid for directly by consumers.
- In some countries, the renewable energy supplier is responsible for the transmission connection. As such they do not want to lose revenue from these wasted energy losses.

## Makes modern farming technology impossible

### NEW FARMING TECHNOLOGY

RTK (Real Time Kinematics) disruption

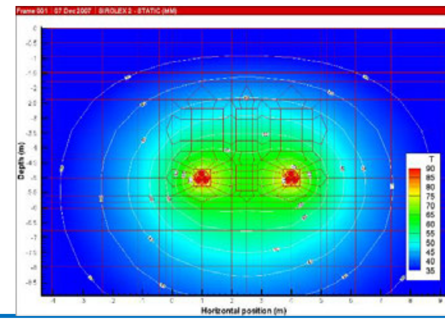
- RTK (Real Time Kinematics) is a Global Positioning Technique that is used to enhance the precision of positional data.
- The frequency used is affected by the low frequency EMF generated by high voltage powerlines.
- This technology is utilised in current and emerging farming practices, these are including but not limited to:-
- Machine and Implement Guidance, Yield Mapping, Animal Welfare Collars, Virtual Fencing, Controlled Traffic Farming, Variable Rate Applications, Inter-Row Planting, Land forming Solutions, Animal Behaviour Monitoring

**High Voltage overhead Power lines make it impossible to use this modern technology**

# UNDERGROUND CABLES

- No Visal impact
- Reliability & Security
- Community acceptance
- Quicker to construct
- Less land use
- Does not affect the agricultural use of land
- Allows use of modern farming technology – Spraying & GPS
- No RIV interference
- Lower – EMF
- Lower transmission losses
- Rating - thermal capacity
- Real time monitoring for temperature and fault location
- AC cables may require capacitive compensation

500 kV and 525 kV DC cables



Underground cables need to transfer the heat from the cable though the ground. Hence the conductors are quite large and have a lower resistance i.e., lower losses.
The temperature at ground surface is not significantly increased because of the good heat dispersion through the surrounding soil.

# Cost comparison Overhead to Underground

## Old technology

- Twenty years ago, the cost RATIO of Underground (UG) to Overhead line (OHL) was 6 to10 times.
- The reason was that OHL were quite cheap to build.
- UG costs were quite high.
- The cost to build an OHL today is very expensive because whilst the cost of the conductors has not changed, civil engineering costs have sky rocketed.

## New technology

- The current cost RATIO of UG to OHL is 1.5 to 2.5.
- The cost to build UG cable links are now much cheaper because
  - We have better, cheaper insulation material.
  - Modern manufacturing.
  - Better installation methods and equipment.
  - It can be done with DC which is more efficient.
- Soon the cost for UG links will be lower than the cost of OHL.

# SOME KEY ISSUES TO BE CONSIDERED WITH UNDERGROUND

- AC or DC
- Cable design
- Cable rating
- Drum size
- Sea Freight
- Land Transportation
- HDD boring
- Method of installation
- Circuit monitoring (DTS)
- GPS mapping of circuit
- Land ownership
- Private or Public
- Security, fencing, biosecurity
- Direct buried or in Conduit
- Areas of native vegetation
- Roads and farm tracks
- Streams and Rivers
- Steep slopes
- Upgrading access tracks
- Community consultation

# Comparison AC or DC

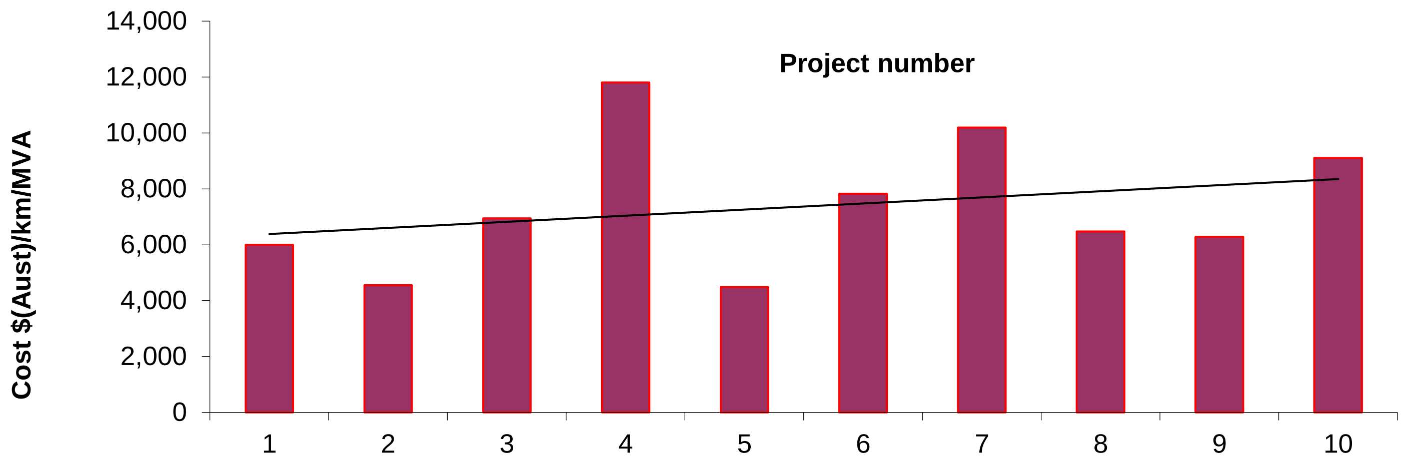
## AC

- Circuits have 3 cables
- Voltages in Australia - 66, 132, 220, 275, 330 & 500 kV
- Length of circuit typically
  - <20 - 200 km
- Rating typically
  - < 100 – 2000 MW
  - For ratings greater than 300 MW, lengths are usually less than 80 km (Refer page 158 Cigre TB 680)
- Cost of cable and installation typically
  - $5000 – $10,000/Km/MW
- Longer lengths require reactive compensation.

## DC

- Circuits have 2 or 3 cables
- Voltages are 200, 320, 400 & 525 kV
- Length of circuit typically
  - > 100 km
- Rating typically
  - > 500 MW
- Cost of cable and installation typically
  - $3000 – $6000/Km/MW
- We need to add the cost of convertor stations, but there is no requirement for reactive compensation.

# Summary of AC cable system Costs
# 1990 – 2012



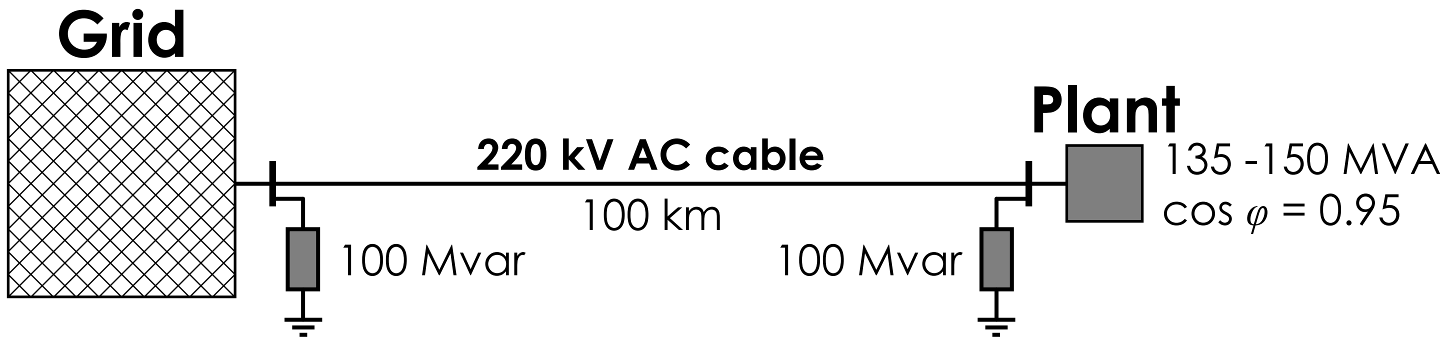

**Examples:-**

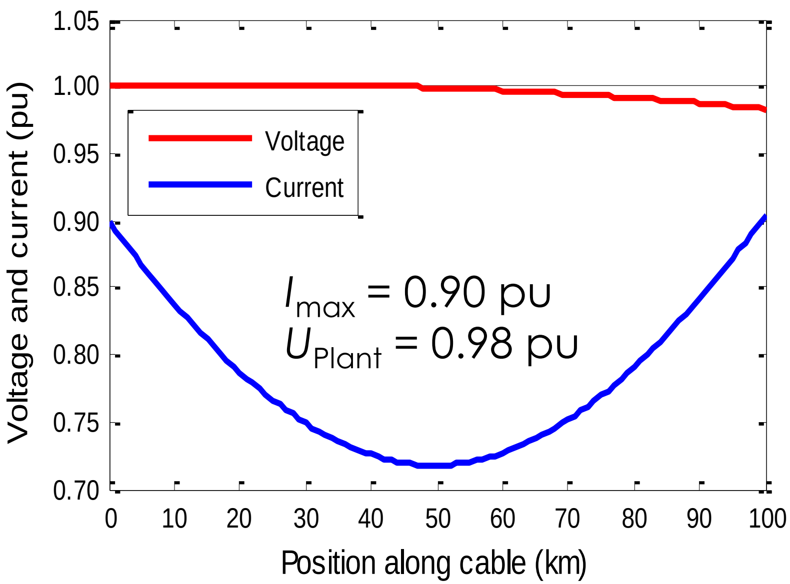
Project 1(1990) 9km 220kV @ 400MVA for $21.5mill = $5972/km/MVA

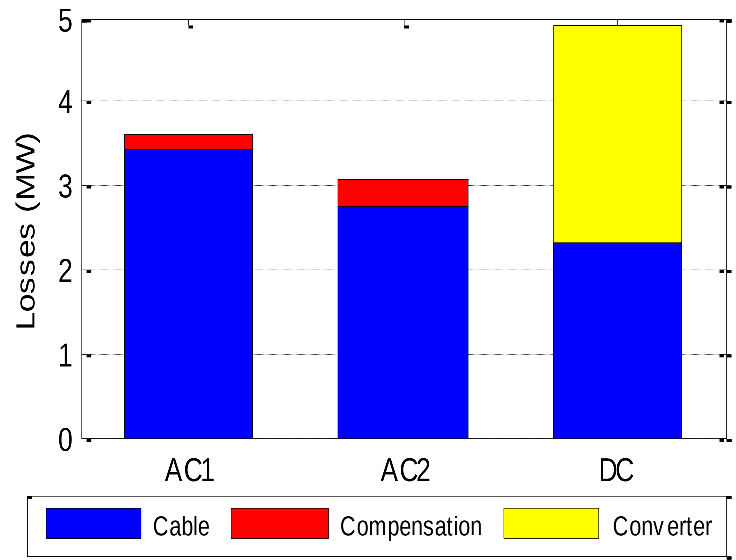
Project 10(2012) 42km 220kV @ 400MVA for $153 mill = $9107/km/MVA

**The GHD report on HUMELINK suggests $17.2 billion, for approx. 700 km of Underground AC cable rated at 2570 MW this relates to $9,560/km/MVA**

# Example of a 220 kV AC cable link of 100km




**It is possible to have lengths longer than 100 km and with greater capacity than 150 MVA**

# Long AC Transmission links

## Offshore windfarms

- Many use 3 core AC submarine cables because there are difficulties in maintaining a DC convertor station on an offshore platform.
- Some links are up to 200Km from shore and ratings are up to 400MVA

## Cable Tunnels

- In Japan, Singapore and China there are now many long lengths of 220kV, 400kV and 500kV cables in tunnels.

## Underground

- In many countries all the important grid connections are with underground cables.
- In some counties AC at 16 Hz is now being considered as this reduces the need for reactive compensation


220kV Submarine cable

Cable tunnel in Beijing

# DC Transmission systems

**DC Systems**

**Symmetrical Monopole (SM)**

- **Here there are two HV cables. One pole positive and the other pole negative.**
- **This is a very economical system but if one HV cable fails then the complete circuit provides no power until the faulty cable is repaired.**
- **Hence it is often preferred to have at least two SM circuits in the corridor.**

**Bipole (BP)**

- **Here there are two HV cables and an earth return conductor.**
- **Normally the earth conductor carries very little current.**
- **If one of the HV cables fails, then the earth cable can be used to complete the circuit and provide 50% of the capacity.**

**Asymmetrical Monopole (AM)**

- **This is the lowest cost DC system. Here there is only one HV cable and one earth conductor. This carries half the capacity of either an SM or BP system. The 400kV Bass Link system is an AM system.**

# Examples of published costs of long DC transmission links

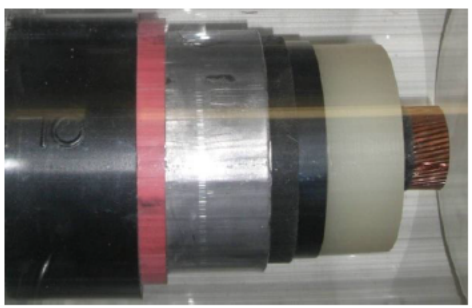
- One of the first XLPE HV DC links was the “inelfe 2 x1000 MW link” between France and Spain. This was planned in 2007 and service by 2014. It is a 65 km route and the total cost inclusive of convertor stations was Euro 700 mill.(A$1,150 mill).
  - This very high cost was due to the fact that at the time this was very new technology, and the route included making an 8.5 Km tunnel through the Pyrenees Alps.
  - From the ECC Inc presentation it is clear that cost of the cable and installation, less the tunnel costs, was A$560 mill so the net cost is $4,270/km/MW.

# Recent Long Transmission links

1. In Europe there are now many 250 – 600 Km DC UG projects in construction and many more planned.
2. Currently there are no published costs for these new links.
3. In the Europacable report on HVDC Underground Cables published in 2011, it is stated that the cost of installing underground DC cable is 2-3 times higher than the cost of installing a DC overhead line.
4. The technology for the manufacturing of DC cables is advancing very rapidly. New insulating materials have recently been developed in China & Italy. This means that DC cables with these new materials do not need to be made on continuous vulcanisation (CV & VCV) lines, so costs should reduce further.

# Cable design

- This is very important when considering long lengths of either AC or DC underground cable.
- A compromise has to be made between lowest cost and robust design, enabling ease of installation with long service life.
- In Australia this is even more significant because we now have no manufacturer of Extra High Voltage cables, so all cable need to be imported on drums.



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Issues such as :-Copper or aluminum conductors. Cost, weight, supply lengths, installation, joints, repairs and maintenance

CAS

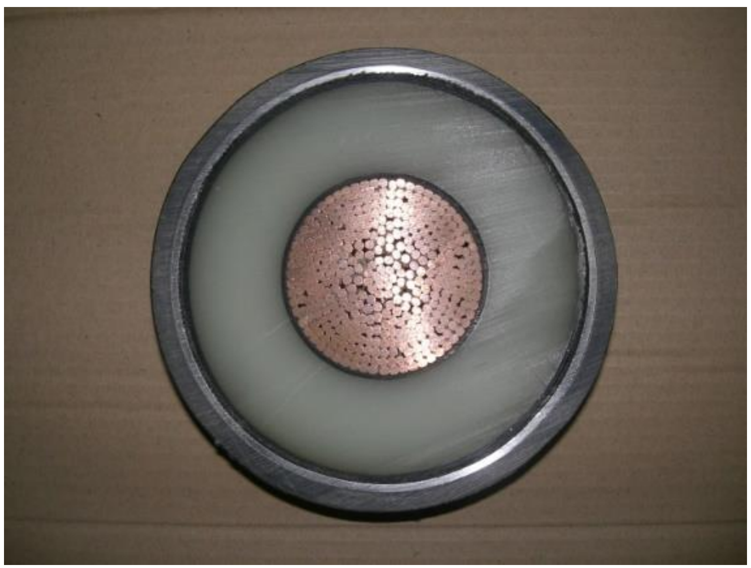
# CABLE DESIGN - Conductor

COPPER or ALUMINIUM

- 95mm2 to 3500mm2

Stranded or Milliken

- Skin effect (Only applicable for AC)
  - •Copper > 1000mm2
  - •Aluminum >1200mm2



# CABLE DESIGN - Insulation

## XLPE

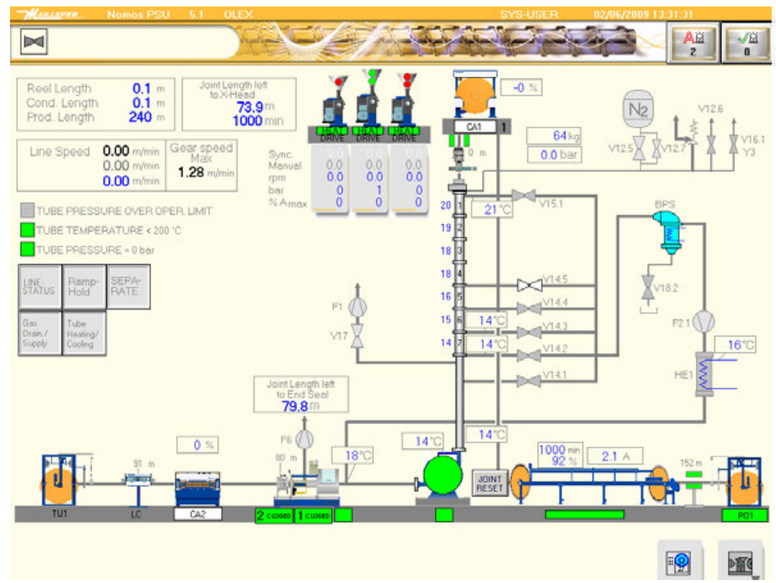
- Requires Triple Extrusion and Cross linking, under pressure, to limit formation of voids
- **Continuous Vulcanisation (CV) lines**

  **Catenary CV - CCV**

  - Long run – faster production - Specific machine for specific range – CDC or with water cooling.

  **Vertical CV - VCV**

  - High Capital Cost – lower output – greater concentricity for large wall thicknesses - greater range capability
- **Special grades of XLPE**
  - Required for DC cables



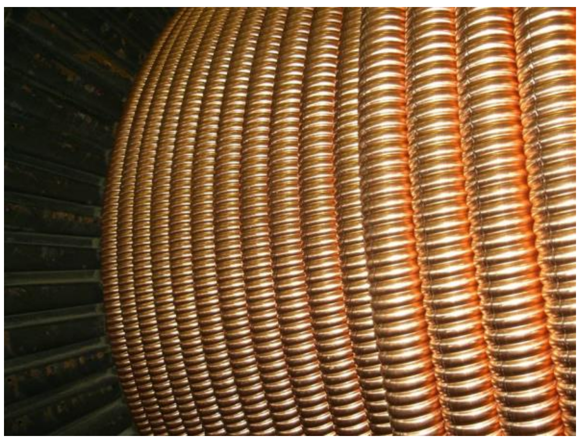

## PP

- This is a new, modified Polypropylene (PP) based material, that has been developed in Italy and China.
- Requires Triple Extrusion but not crosslinking
- Can be made on the same or lower cost plant.
- More flexible than ordinary Polypropylene
- Lower cost than XLPE

# CABLE DESIGN - Metallic Screen

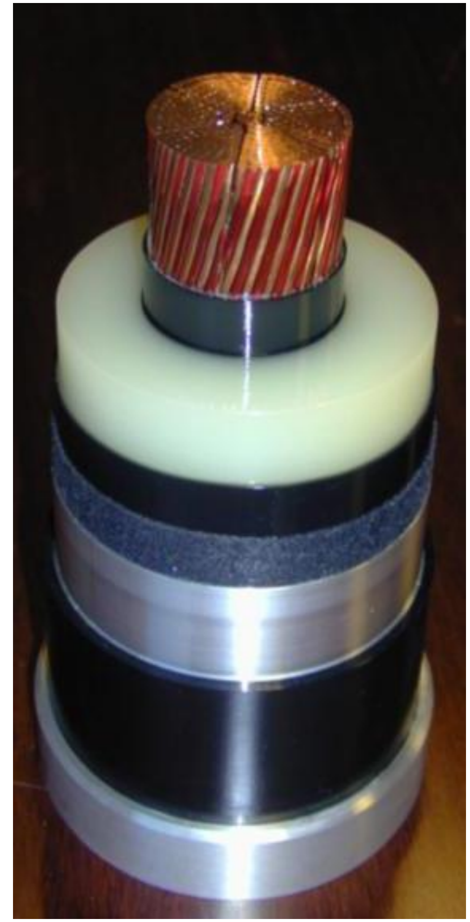
**TYPES**

- Lead Alloy – Extruded
- APL – Aluminum Poly Laminate – “Moisture Barrier”
- CAS –Extruded - Corrugated Aluminum
- CAS – Welded - Corrugated Aluminum
- CCS – Welded - Corrugated Copper
- CSS – Welded - Corrugated Stainless Steel
- SAS – Welded – Smooth ”swaged & bonded” Aluminum



CCS

Welding & Corrugating



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# CABLE DESIGN- Outer sheath Protection

**MATERIALS**

- PVC
- MDPE
- HDPE
- Semi Cond PE

- **INSTALLATION**

  **- Abrasion, bending and pulling**

- **APPLICATION**

  **- Buried or exposed**

- **ENVIRONMENT**

  **- Water, Chemicals, Corrosion.**

  **- Animals, Rodents, Termites.**

  **- Tropical, Vibration, Sunlight,**

  **- Tidal forces, Seismic**

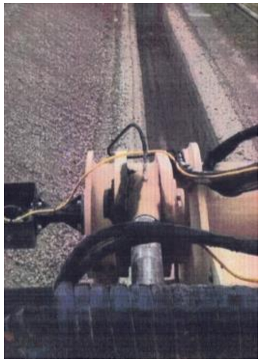
- **SERVICE LIFE 40 - 80 years**

  **- Operational management**

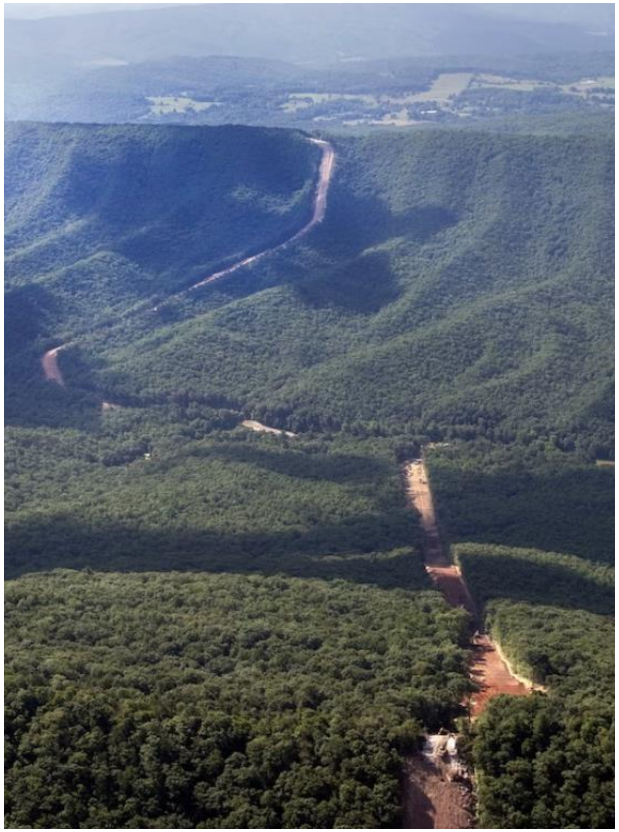
  **- External damage**

  **- Changes to infrastructure**

# Cable installation



- Long cable length is a key factor
  - Reducing number of joints and jointing cost,
  - Reducing transportation and installation costs
- Cable laying
  - Trench excavated by conventional means
  - Trench excavated by trenching machines with rock saws
  - Direct ploughing
  - In HDPE conduits placed in the trench
  - HDD Boring with HDPE conduits



# Design and Construction of Underground HV links

As mentioned, long lengths of cables are important because that reduces the number of joints, transport costs etc. etc.

In Europe there are cable factories, so long lengths of cable can be put onto large drums and transported directly to the site.

As we have no HV Cable manufacturing plants in Australia all cable need to imported.

This means it is most important to select the most suitable cable type and drum length to optimise the cost of transportation

## DRUM SIZES and Cable supply on site

- In Australia we often use drums with a maximum flange diameter of 4.3m, a maximum overall width of 2.4m
  - These these can be shipped economically on container ships on flat racks.
  - They can be transported on most roads in Australia without the need for special "over width" permits.
- For longer lengths, and particularly with for cables with Aluminium conductors special drums are used.
  - These drums are up to 8m long and have flanges of up to 4.4m.

# Cable design and installation - Key Criteria for Asset Managers

**PERFORMANCE / FEATURES**

- Low Overall Cost
- Long length of cable
- Easy Installation
- Ease of fixing
- Low Life Cycle Assessment (LCA)

**RELIABILITY**

- Environment
  - Direct buried
  - In Conduit
  - In Tunnels
- Long life in service
- Compatibility with system and accessories
- Overload capability due to thermal capacity
- Monitoring in service
- Easy to repair

**COST / DRUM LENGHTS**

- Many of the long DC cables are submarine cables. These are expensive because of the protection and weight. Land cables are much lower cost, but the transport cost is a consideration.
- A compromise also has to be made between the lowest cost and a robust design, which will enable ease of installation with long service life.
- For the conductor we can select copper or aluminium, the latter is often preferred but when you consider maximum drum lengths then the choice is often Copper.

**AVAILABILITY**

- Because there is no cable manufacturing facility in Australia all HV AC cables are now supplied from China, Korea or Japan.
- Until recently all the demand for DC Land and Submarine cables has been in Europe. Japan was the only local source of supply.
- Now both Korea and China are making DC land and Submarine cables up to 535 kV.
- The cable factories in China have very modern plant and often have more capacity than plants in Europe.
- Cable factories in India are also developing DC cables.
- Australia is now well placed for the supply of DC cables.

# Practical design and of Underground HV links

## SPECIAL BACKFILL

It should be noted that in order to get the longest length on a drum, for a specific rating, we need to keep the cable size as small as possible.

- Unless the native soil resistivity is exceptional low, rather than select a larger size conductor, it may be more cost effective to put a Low Thermal Resistivity(TR) Backfill around the conduits, or cable to meet the rating requirements.
- It should also be noted that any backfill, either native soil or a low thermal resistivity mixture of crushed rock, sand, cement and fly ash, needs to compacted to eliminate voids. In the past this was done using manual compaction tools and then the degree of compaction was measured before any further material was put in the trench.
- Nowadays that manual process is too expensive, so in many cases a cement truck is used to bring the backfill mixture, with some water, to the site. This called “Fluidised Thermal Backfill” (FTB), which is poured in around the cables or conduits. The water evaporates and we are left with relative strong, low thermal resistivity backfill, to more easily dissipate the heat from the cable.

# CONSTRUCTION METHODS for UNDERGROUND CABLE

In rural and farming areas it may be better to install HDPE conduits in the trenches between joint bays. This is because even though the easement will be fenced:-

- Leaving hundreds of metres of trench open while cable is delivered to the trench is a safety and security risk.
- It is often better to do this civil work well before any cable arrives on site.
- Cables will be pulled into these conduits from alternate joint bays, so it limits the access roads required.
- If there is a cable fault in service, then only access is required to the joint bay location.
- A fault will often be at a joint bay. However, if it is in a location between two joint bays then a new length of cable will be installed rather than build a new joint bay at the fault location.
- Because the cables will be fitted with Optical fibres for remote temperature monitoring, location of any hot spot or cable failure will be very easy.
- This means access is only required at joint bay locations for repairs and maintenance.
- Using conduit decreases the rating capacity of the cables. However, this can partly be compensated for by putting low thermal resistivity (FBT) around the conduit. This also provides additional protection for the cables in these locations.

Note the precast concrete joint bay and cable drum

HDPE conduits in Trench


Examples of cable installation

**Evidence obtained from the NSW "Inquiry into the feasibility of undergrounding the transmission infrastructure for renewable energy projects"**

**Information from the public that was obtained during the hearings of this inquiry revealed some very important facts**

**Bushfires.** There was clear evidence that HV Overhead Transmission lines can cause bush fires. Also, that the presence of the towers and lines very seriously hamper the fighting of bushfires. There needs to be a system where the RFS is given mandatory authority to have the power switched off HV lines, just as they have with MV lines.

**Easements.** One import fact is that depending on the wind direction the easement under the transmission lines can act as a funnel to rapidly spread a fire. Easements for underground cables are not a problem as they are typically limited to about 20m width and the deviations in the route are very helpful.

# NSW Legislative Council Inquiry

## Feasibility of Undergrounding transmission for renewable energy

## July – October 2023

### Hearings

At the second hearing in Tumut there where presentation by local councils, Australian transmission experts, members of the community and the local fire services

### Outcomes from the Meeting in Tumut 6th August 2023

- **Three of Australia's Transmission experts gave evidence.**
  - **Supporting the need to use HVDC cables for transmission.**
  - **They explained that this was now the standard practice in Europe as the public do not want overhead lines.**
  - **That whilst the actual capital cost was about twice the current costs for OHL, the real cost after consider energy losses and maintenance costs was less than for OHL.**
- **Representatives from the Rural Fire Services gave solid evidence:-**
  - **That Transmission lines can start bushfires.**
  - **The easements under transmission lines accelerate the fire path**
  - **Transmission lines must be switched off before any bushfire control can take place.**
  - **Transgrid failed to switch off power during the 2020 bush fire which destroyed more than $2 Billion of plantation assets.**

**The nett outcome is that the NSW Govt. have still not introduced any legislation restricting the construction of new Overhead lines in rural areas or demanding that transmission lines be switched off during days of extreme fire danger.**

# Responsibilities for the effects of contact with bare overhead lines or their impact on Bush fires

- It should be noted that unlike other countries the management and boards of Utilities in Australia are not directly responsible for the lives of people effected by contact with a bare overhead line, or the impact of a Bush fire if it is caused by distribution or transmission lines.
  - Naturally they are responsible for the:-
    - repair to the power line infrastructure, and
    - the insurance premiums will be increased,
  - However, both of these effects are be passed onto consumers with increased tariffs.
- Hence there is NO INCENTIVE TO PROVIDE SAFER Transmission and Distribution, which was clearly identified in the discussions landholders had with TransGrid representatives during the NSW inquiry.
- On the other hand under Australian law the management are directly responsible for the safety of their staff.
- This is very different from many other countries for example, in Malaysia if a member of the general public is killed by contact with a power line, then the Utility management are directly accountable.
- Hence, they will not allow bare overhead distribution lines.
- On the other hand, if a worker is killed by contact with an electric line, it is considered an employment risk and the employee is made directly responsible for their own safety.

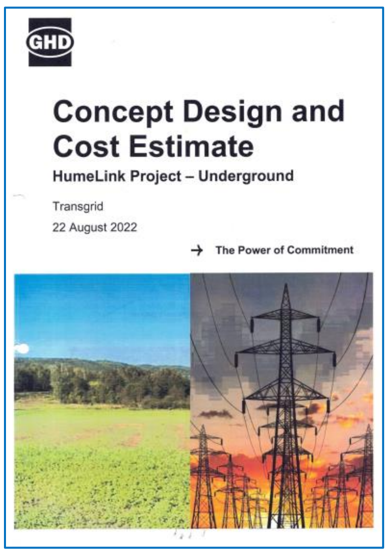
# Information on the cost of Transmission line failures

## California USA

Line 11 runs through coastal areas, where towers, conductors, insulators and attachment fittings are at greater risk of corrosion. It only takes one failing component to cause a disaster. In 2018, in California, a failed transmission attachment fitting sparked a fire that destroyed 18,804 structures and resulted in 85 fatalities. Damages attributed to the network operator ran into billions of dollars.

**HumeLink is a proposed transmission network augmentation, with the object of reinforcing the NSW southern network and increase transfer capacity between Snowy Mountains and the Greater Sydney area,**

**TransGrid is proposing an overhead line transmission link. They commissioned GHD to investigate concept designs for transmission network options which use underground cables**

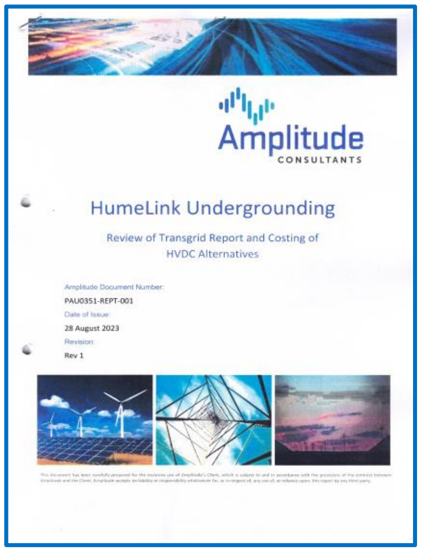



**The AEMO 2020 I.S.P. had a modelled cost for this link at $2.1 Billion. The cost in the GHD report issued in August 2022 was $3.3 Billion based on 2021 estimates. Transgrid has recently advised the NSW inquiry that the current cost estimate is $4.89 Billion.**

- **The GHD report confirmed that proposed overhead line would be with Double circuit 500kV towers and each phase would have four ACSR conductors.**
- **Three circuits are proposed Bannaby to Maragle, Bannaby to Gugaa and Maragle to Gugaa, making a total length of approx. 700km.**
- **The report indicates that a 100% HVAC Underground Cable option would cost $17.1 Billion – e.g. about 3.5 times the cost of the OHL.**
- **The report suggests a 525 kV DC option for the three circuits would as above would be a total cost $11.5 Billion – e.g. about 2.35 times the cost of the OHL.**
- **The report also provided other options for a DC underground cable solution.**

**Landowners and community members along the proposed route for HumeLink engaged an Australian company, well experienced in Extra HV AC and DC transmission, to review the GHD report.**

**The Amplitude team included people with a first-hand knowledge of all of the Underground AC and DC links installed in Australia and the region.**



Amplitude
CONSULTANTS

HumeLink Undergrounding

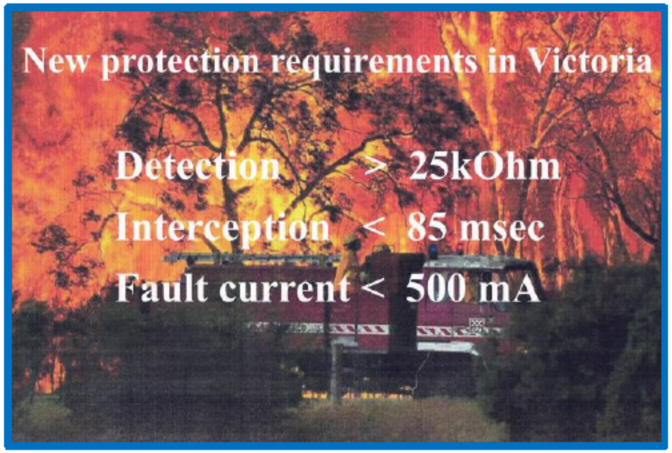
Review of Transgrid Report and Costing of HVDC Alternatives

Amplitude Document Number:
PAU0351-REPT-001
Date of Issue:
28 August 2023
Revision:
Rev 1

**This report was presented to the NSW Government and the Federal Minister for Energy on 9th October 2023. It highlights that using HVDC cable technology is a cost-effective solution, which resolves the related to Bush Fire risks and subsequent liabilities**

- **This report highlights that a 525 kV DC option for the three circuits as detailed in the GHD report could be built for a total cost $7.32 Billion – e.g. 36.3% lower that the GHD estimate, and only 1.5 times the cost of the overhead line.**
- **It further suggests that the cost for an alternative DC underground link from Maragle to Bannaby could be constructed for $5.46 Billion or virtually the same cost as the overhead line.**
- **It is also shown that the electrical losses on these proposed DC underground options are 13.5 - 21.3% lower than the AC overhead line. This means that any increase in capital cost will be recovered during the life of the DC connection.**

# BUSH FIRE Legislation




STATUTORY RES 2016 S.R. No. 32/2016 Electricity Safety Act 1998 Electricity Safety (Bushfire Mitigation).
Amendment Regulations 2016UL

**It should be noted that this type of protection is not applicable for HV or EHV transmission**

## Legislation in Victoria

- After the serious bush fires in 2009, which were caused by arcing on a medium voltage overhead line, the Victoria Bushfire Royal Commission initiated the Powerline Bushfire Safety Task Force in 2011.
- The task was to explore the most cost effective and fastest way to minimize the risk of bushfires started by power lines.
- Replacing all bare overhead lines by using underground or overhead cables was considered desirable, but too expensive.
- A Rapid Earth Fault Current Limiter can eliminate fault currents in a very short time. Such a device known as a GFN was developed in Sweden. It was tested in Australia from 2014 – 2015 and in May 2016 it was legislated to be required on circuits, where there were bare conductors, which might be subject to bushfires and where replacing the lines with cable was not considered appropriate.
- So far Victoria is the only state that has this requirement for GFN protection.
- At that time of the Task Force enquiry there were no examples of Transmission lines causing Bush Fires and it was expected that all new Transmission in Victoria would be with Underground cables.

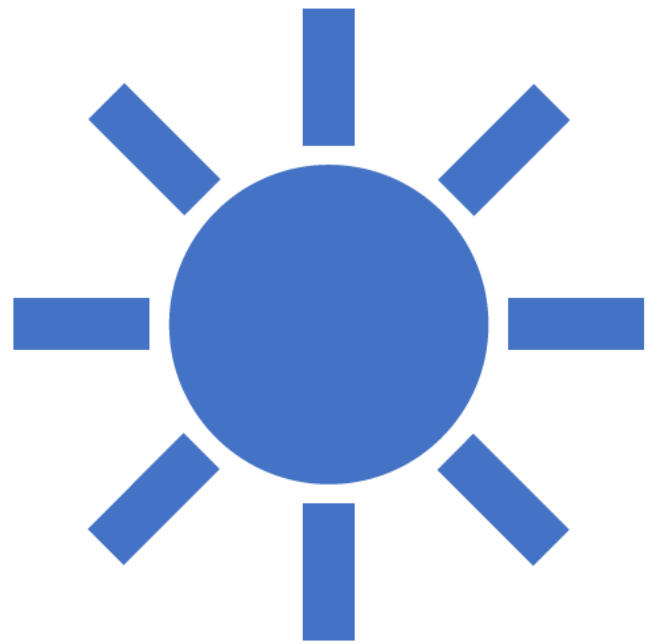
# Conclusion

**Australia unlike our neighbouring countries is rich in energy resources.**

**We have sunlight and wind which are FREE energy resources that only need harvesting and sending to our cities.**

**Today we have the technology to transport the electricity from these resources by underground cables.**

**We owe it to our future generation not to continue to pollute our rural landscape with overhead transmission lines which also have high energy losses and serious risks with the changing climate.**



# THANK YOU
# for letting me address you today

Ken Barber -

# Ken Barber SMIEEE

Ken has been employed in the Electric Cable industry since 1961. He has worked for Cable plants in UK, India, Malaysia, and Australia. For 34 years commencing in 1976 he was responsible for OLEX Australia's R&D and HV cable systems.

Has been Chairman of the Australia Standards committee for Insulated cables, on standards committees for Overhead Line conductors and the Australia Wiring rules. Became Group Technical Manager and later General Manager High Voltage, Engineering and International Sales.

After NEXANS took over OLEX he became Sales Director HV cable Asia Pacific based in Singapore.
Has been involved in supply and installation of 2000 km of HV and EHV underground cable for more than two hundred projects in the Asia Pacific region. As an example, in 1990 was responsible for OLEX winning the 9 km, 220 kV cable link in Melbourne and in 2010 the 88 km, 220 kV cable link to the Victorian Desalination plant which is still the longest underground AC cable transmission link in Australia.

In 2013 took on the role of Convenor of a CIGRE B1 Working Group, which developed the Technical Brochure TB 680 "Implementation Issues relative to Long Length AC cable systems" published in 2017. This an international recognised publication which highlights the international growth in the demand for underground transmission.

Is an individual member of the Association of the Electricity Supply Industry of East Asia and the Western Pacific (AESIEAP). Has his own consultancy company "Istana Park Pty Ltd," registered in Australia for more than 20 years and through this company works now for organisations in Australia and S.E. Asia who are looking to connect renewable energy plants with underground or undersea cables.

For 5 years was working with Hydro Tasmania and TasNetworks providing cable designs and cost estimates for the Marinus Link project, the proposed 350 km.,1500 MW DC link from Tasmania to Victoria.