Supplementary Submission No 3a

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**

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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 very 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 installations 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.**

OVERHEAD LINES

- High maintenance costs
- Vulnerability to climate change
- Visual impact
- Extensive land use
- Environmental – EMF
- Noise & RIV interference
- Community concerns
- Devaluation of property
- Hazard for birds
- Affected by Bush fires
- Imposes limits on farming
- Safety hazards with irrigation equipment
- Inductive coupling with fence lines

- Transmission line conductors transfer their heat to the air
- High Transmission losses

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 Victoria and NSW, the old type of steel reinforced conductors are used on transmission lines. Only QLD has promoted the use of low loss alloy conductors.
- The published transmission line losses in Australia are 5 – 6%, this energy loss is 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

EXAMPLE of NEW FARMING TECHNOLOGY

RTK (Real Time Kinematics) disruption

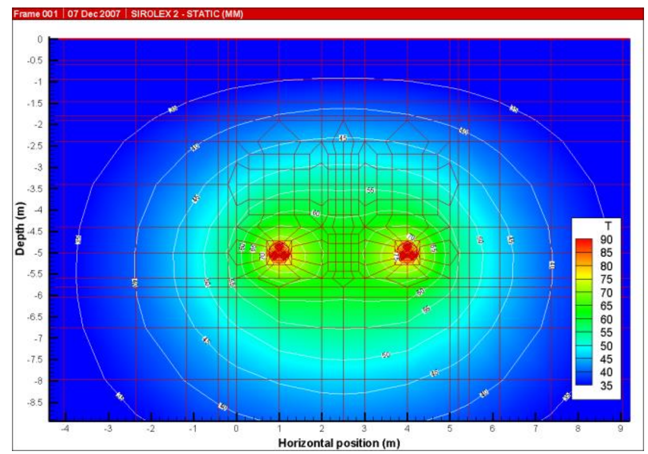
- RTK (Real Time Kinematics) is a Global Positioning Technique that is used to enhance the precision of positional data.
- The frequency used is heavily affected by the low frequency EMF generated by high voltage powerlines. This technology is utilised in current and emerging farming practices, these 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

A High Voltage Power line will render this modern technology and other future farming techniques completely disadvantaged.

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

525 kV DC cables



Underground cables need to transfer the heat from the cable though the ground to the surface. Hence the conductors are quite large and have a lower resistance i.e., lower losses.

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

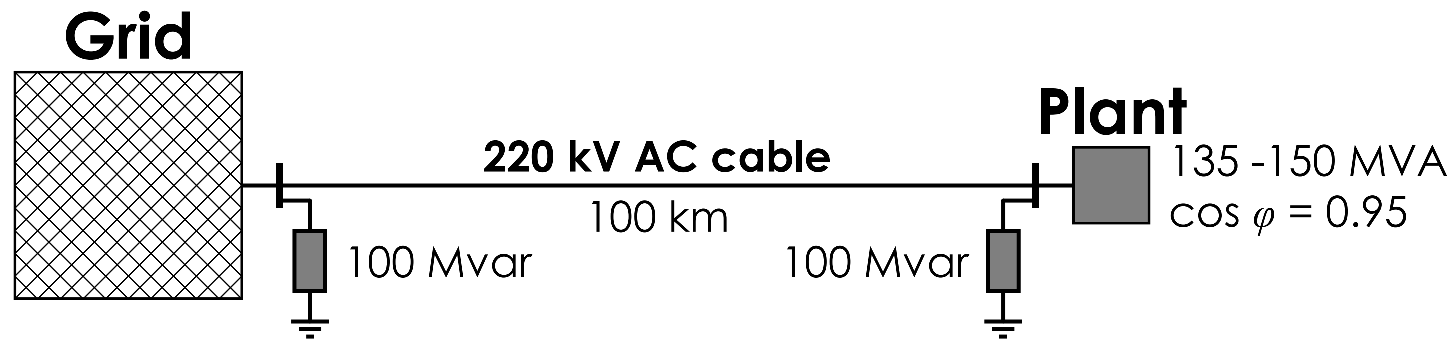
AC

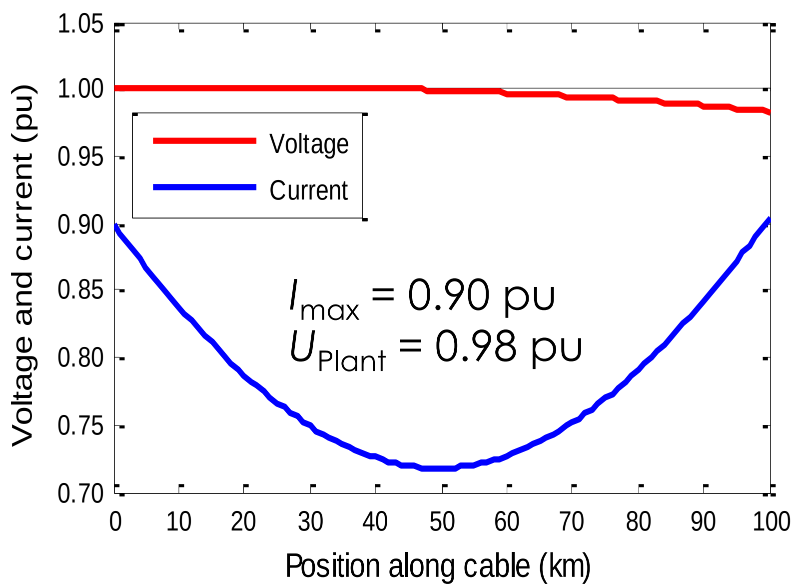
- Circuits have 3 cables
- Voltages in Australia - 66, 132, 220, 275, 330 & 500 kV
- Length of circuit typically
  - <20 - 200 km
- Rating typically
  - < 100 – 2000 MW
  - For ratings greater than 300 MW, lengths are usually less than 80 km (Refer page 158 Cigre TB 680)
- Cost of cable and installation typically
  - $3000 – $9,000/Km/MW
- Longer lengths require reactive compensation.

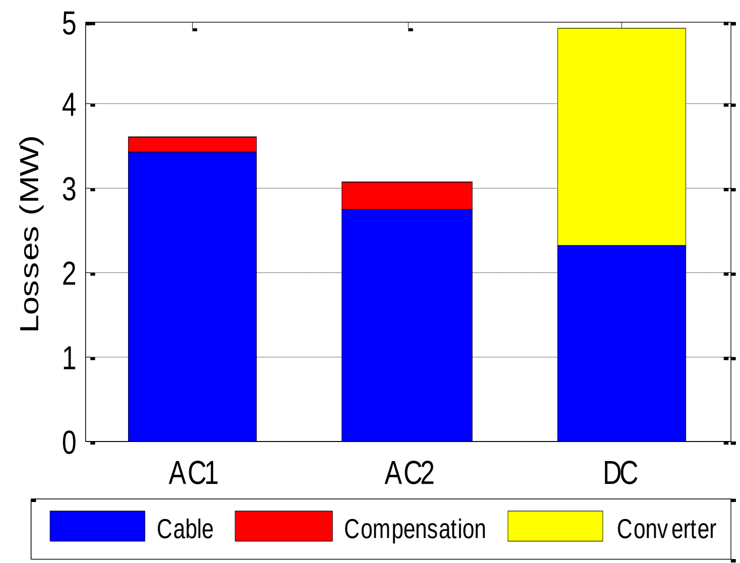
DC

- 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
  - $2000 – $6000/Km/MW
- Need to add cost of convertor stations but there is no requirement for reactive compensation.

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 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

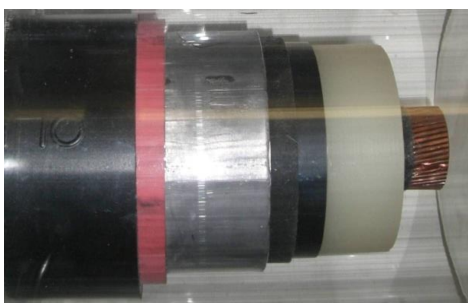
- From an ECC Inc. presentation in 2007 the budgeted cost for a 500kV, MIND Cable, for a 2000 MW link in Alberta was (US$4.35 –US$5.00/km) this relates to A$6.5-7.5/km or A$3250-3750/km/MW.
- One of the first XLPE HV DC links was the “inelfe 2 x1000 MW link” between France and Spain. This was planned in 2007 and service in 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 also due to the fact that 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 270 – 580 Km 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. In the past 12 years the costs manufacture, and installation of DC cables appear to have decreased.
5. 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.**



SAS

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

CAS

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

- Drums with a maximum flange diameter of 4.3m, a maximum overall width of 2.4m between flanges and a total weight not exceeding 35Tons.
- They can be shipped economically on flat racks
- These drums can be transported on most roads in Australia without the need for special permits

Practical design and of Underground HV links

Examples of HV DC cable lengths that can be put on drums with a flange of 4.3m and width of 2.4m

- **1200m of 1400mm2 copper conductor cable for a 750 MW 320 kV SM circuit.**
- **900m of 1400mm2 copper conductor cable for a 1250 MW 525 kV SM circuit**
- **700m of 2000mm2 copper conductor cable for a 1750MW 525 kV BP circuit.**

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. Therefore, unless the native soil resistivity is exceptional low, it is more cost effective to put a Low Thermal Resistivity(TR) Backfill (FTB) around the conduits (or cable) to meet the rating requirements.

Cable installation

- **Long cable length is 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 on private land**
  - **HDD Boring**

CONSTRUCTION METHODS for UNDERGROUND CABLE

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

1. Leaving hundreds of metres of trench open while cable is delivered to the trench is a safety and security risk.
2. Cables will be pulled into these conduits from alternate joint bays, so it limits the access roads required.
3. If there is a cable fault in service, then only access is required to the joint bay location.
4. Normally a fault will 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.
5. 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.
6. This means access is only required at joint bay locations for repairs and maintenance.
7. Using conduit decreases the rating capacity of the cables but this can compensated, by putting fluidised backfill with a low thermal resistivity (FBT) around the conduit. This also provides additional protection.

Note the precast concrete joint bay and cable drum





Examples of cable installation

Rules on how to design an Underground Cable Transmission link in Australia

- The route needs to be surveyed (Using a pipe-line laying contractor, is excellent, because they are used to going through the country, whereas cable experts typically just use roads).
- Google maps are used and special features such as native vegetation etc. need to be avoided where possible.
- A geologist is needed to check on seismic fault lines, rock and soil types.
- A cable expert is needed to review the route and make recommendations for the various types of installation techniques e.g. trenching, HDD bores, etc. Also, how to address land contour installation, to calculate and reduce pulling tensions.
- Land use needs to be carefully considered, access roads, stock movement etc. Good consultation with landowners.

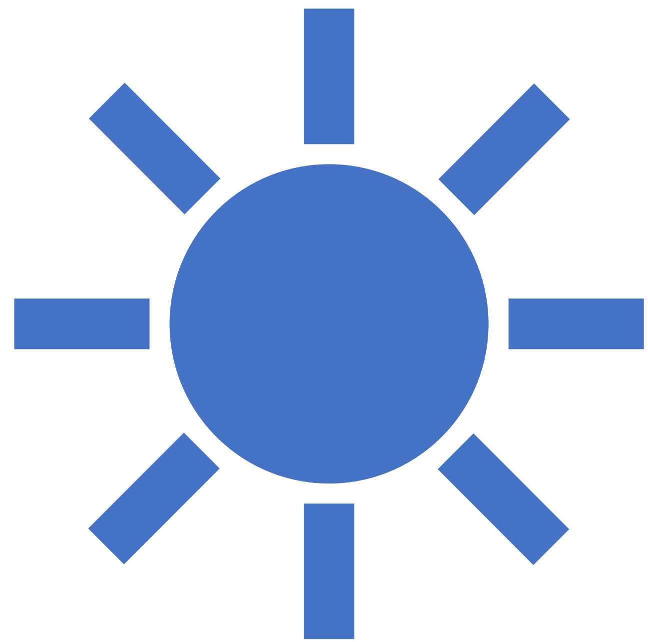
Conclusion

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 -