45 Stuart Street
Monee Ponds
Victoria 3039
Australia

To assist the Tribunal, the report of an expert witness should contain a cover page that

(a) the file number given by the Tribunal for the relevant proceeding:

VCAT Reference Number: P768/2014

(b) the date of the report:

12 August 2014

(c) if the report relates to a person, the name of that person:

Not applicable

(d) if the report relates to a property, the address of that property and the date(s) of any inspection:

WAVERLEY PARK

(e) the party for whom the report has been prepared: and

CITY OF MONASH

(f) the person from whom the expert received his/her instructions:

BEST HOOPER SOLICITORS

(a) The full name and address of the expert witness:

AKHTAR KALAM
45 STUART STREET
MOONEE PONDS
VICTORIA 3039

(b) The expert's qualifications, experience and area of expertise:

BSc, BScEng, MS, PhD, FEA, CPEng, FIET, CEng, FAIE, MCIGRE, MIEEE

Professor Akhtar Kalam has been at Victoria University, Melbourne since 1985 and a former Deputy Dean of the Faculty of Health, Engineering and Science for 7 years. He is currently the Discipline Group Leader of Electrical, Electronic and Sports Engineering. He is the Chair of the Smart Energy Research Unit at Victoria University. He is also the CEO and Director of Al-Kalam Educational Solutions Pty Ltd.

Professor Kalam is regularly invited to deliver lectures, work on industrial projects and examine external thesis overseas. His major areas of interests are power system analysis, communication, control, protection, renewable energy, smart grid, IEC61850 implementation and cogeneration systems. He has been actively engaged in the teaching of Energy Systems to undergraduates, postgraduates and providing professional courses to the industry both in Australia and overseas. He regularly offers Continuing Professional Development and Master Class courses on Power System Protection, Renewable Energy, IEC61850, Cogeneration & Gas Turbine Operation and PBL in engineering education to practising engineers, the Energy Supply Association of Australia (ESAA) and Australian Power Institute (API). He also runs postgraduate distance education programme on Power System Protection for the ESAA. He has conducted research, provided industrial consultancy and published over four hundred and seventy publications on his area of expertise and written over 29 books in the area. He provides consultancy for major

electrical utilities, manufacturers and other industry bodies in his field of expertise. Professor Kalam is a Fellow of EA, IET, AIE, a member of IEEE and CIGRE AP B5.

(c) A statement setting out the expert's expertise to make the report:

Akhtar is a very active participating member in various professional associations. His relationship with Scienceworks and getting support from the electricity supply industries for around half million dollars to start the High Voltage Theatre is acknowledged. He has contributed and held number of responsible positions in ACPE, AUPEC, IEEE, IET, EA, E4G, Scienceworks, etc. He has received funds of over $5.0M from the industry for doing innovative works for the electricity supply industries. He is extremely supportive of increasing research activities within universities. He is also known to have strong teaching skills and has written numerous technical papers and reports. He has been known to have good working relationship with the academic and support staff of the Faculty and an extremely good relationship with the industry personnel. He is regularly asked to conduct research, consultancy and provide expert advice on electricity issues. He has substantial experience in Australia and internationally in:

- **Teaching both at undergraduate and postgraduate levels;**
- **Senior management of a large faculty;**
- **External Examiner and Visiting/Distinguished Professor in University of New South Wales and four Malaysian universities: University Malaysia Perlis; University Technology Malaysia, University of Technology, MARA and University Malaysia Sabah;**
- **Establishing links with the engineering industry; and**
- **Research and consultancy, with considerable published work in mathematical modelling and computer simulation of energy systems networks.**

(d) Reference to any private or business relationship between the expert witness and the party for whom the report is prepared:

No private or business relationship.

(e) All instructions that define the scope of the report (original and supplementary and whether in writing or oral):

Written instructions were provided to me by Best Hooper Solicitors.

45 Stuart Street
Monee Ponds
Victoria 3039
Australia

(f) the facts, matters and all assumptions upon which the report proceeds:

The accuracy of the application materials provided.

(g) reference to those documents and other materials the expert has been instructed to consider or take into account in preparing his or her report and the literature or other material used in making the report:

Various documents provided for in my brief includes:

- **the planning permit;**
- **the endorsed plans;**
- **the amended plans;**
- **Other materials referenced in Section 5.0 of this statement.**

(h) the identity and qualifications of the person who carried out any tests or experiments upon which the expert relied in making the report;

All statements have been made from my own qualification, experience and research.

(i) a statement:

- summarising the opinion of the expert

  The undergrounding of the overhead line can be achieved. It is viable. It is not cost-prohibitive.

- identifying any provisional opinions that are not fully researched for any reason (including the reasons why such opinions have not been or cannot be fully researched)

  Full scale cost benefit analysis needs to be done.

- setting out any questions falling outside the expert's expertise; and

  Legal considerations and complying with various electricity, council and state regulations and which are not under my expertise.

45 Stuart Street
Monee Ponds
Victoria 3039
Australia

- indicating whether the report is incomplete or inaccurate in any respect.

The report is complete. The complete report is as follows:

1.0 What technology is available to put the existing power lines underground.

The technology that is currently available is:

- **Cross-inked Polyethylene (XLPE) Cable**
- **Gas Insulated Lines (GIL)**
- **High Temperature Superconducting (HTS) Cable**

There is ongoing demand for reliable electricity in terms of supply and distribution. Underground cables using XLPE have the potential to reduce outages, maintenance cost and transmission losses in the best and most effective environment-friendly way possible. In general transmission losses are lower with underground cables compared to overhead lines. Modern technology makes underground cables a more practical solution to improve power network reliability where they were not an option in the past. GIL and HTS Cable technology enables the massive increase in power transmission capacity, with its unique characteristics of the low impedance and low ohmic losses; HTS Cable has the potential of becoming a feasible new solution to power transmission problems. This incorporates environmental benefits of no thermal or magnetic field emission and no visual impact on the surroundings.

Economic benefits can also be achieved in situations where civil works are reduced by avoiding unnecessary digging. Underground cables can deliver big savings in tree pruning which reduce the risk of bush fires.

2.0 Transitions

At the end of an underground cable a termination is applied to control the electric field. Factors influencing the design, installation and testing of terminations are very similar to those of joints. The technology required to join cables tends to becomes increasingly complex (and costly) with increasing voltage. The electric field (stress) in the insulation of a 60 kV cable is a few kV/mm. In order to reduce the size and weight of 400 kV XLPE cables, these operate at a much higher stress (about 12 kV/mm). The increased stress results in a cable that is more expensive to manufacture, requires a more sophisticated joint design and much greater care during installation.

45 Stuart Street
Monee Ponds
Victoria 3039
Australia

Joints are more complex than the cable itself and are made on-site rather than in the factory. In consequence the joints tend to be less reliable than the cable. The higher voltage cables tend to be heavier and less flexible than lower voltage cables. This leads to shorter drum lengths (delivery lengths) for the higher voltage cables and hence more joints per kilometre. To maintain reliability extreme care is required in the installation and testing of 400 and 500 kV cable joints.

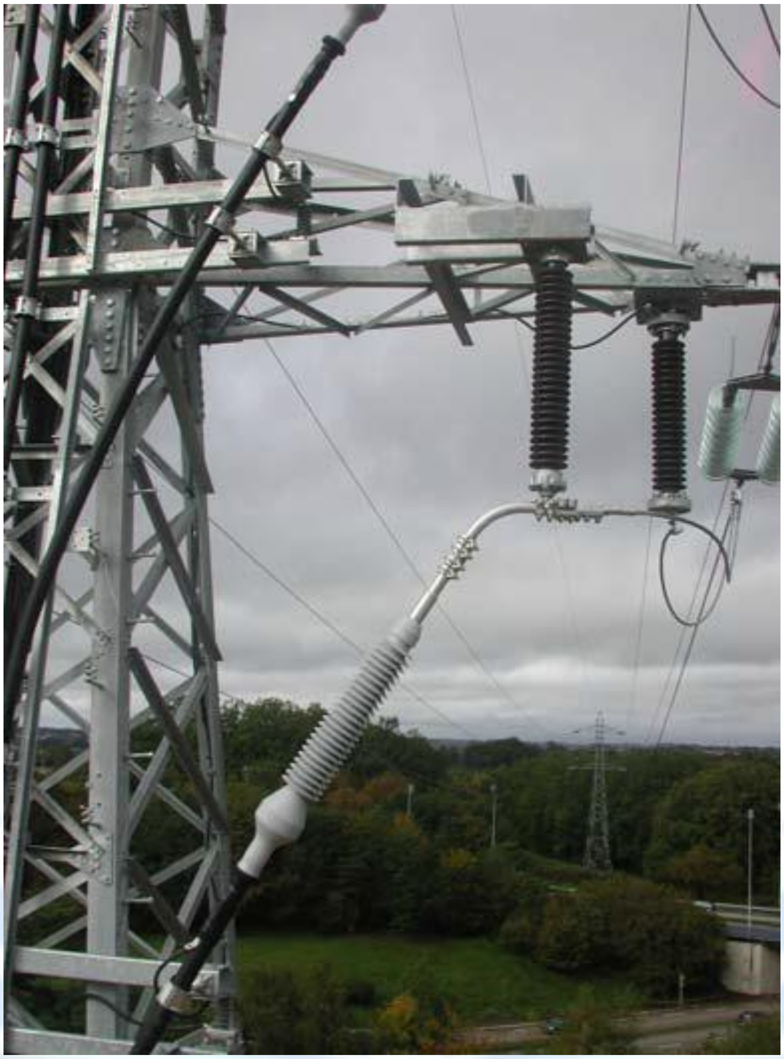
After jointing, the cable is usually subjected to a high voltage test to prove the quality of the joint. At 400 and 500 kV the equipment required for this test is very large and special provisions are often required to get the test equipment to site.

For an overhead line only the conductor needs to be jointed and this is usually achieved with a simple compression fitting.

When a section of underground cable is incorporated in an overhead transmission line, the connection from a fully insulated cable to a bare overhead conductor is by means of a termination, but how this is implemented depends on the voltage of the circuit. At lower voltages the terminations can normally be located and supported within the overhead line tower structure (Figure 1). The following Figures 1 (a & b) illustrates a overhead transmission line and the associated tower-mounted terminations on a 90kV line.

45 Stuart Street
Monee Ponds
Victoria 3039
Australia

(a)



(b)

Figure 1 (a &b): Tower-mounted terminations on a 90kV line

At intermediate voltages (220/275 kV) the terminations can be mounted on the tower by installing a platform on the tower (Figure 2).

45 Stuart Street
Monee Ponds
Victoria 3039
Australia

Figure 2: Terminations mounted on a platform on a 110kV overhead line tower

45 Stuart Street
Monee Ponds
Victoria 3039
Australia

At 400 and 500kV, the size and weight of terminations and the necessary clearances dictate the use of a separate, high security transition compound on the ground (Figure 3). The compound can require an area of 2,500 m^2 depending on the power level and the amount of equipment installed. The overhead line tower at this location is more substantial because the line terminates at this point and hence the mechanical forces on the tower are unbalanced.

Figure 3: 400kV Transition compound

45 Stuart Street
Monee Ponds
Victoria 3039
Australia

3.0 Estimate order of costs for doing so

Detailed cost requires in-depth calculation, (including cables, accessories and civil cost); however a rough/approximate cost based on the following:

- Current cost of XLPE cables at $500.00 per meter (12 cables each 800m length of this size will be available and joints will not be required);
- 18 terminations at $30,000 each, with 3 circuits (9 length of cables of 800m)
- Civil, Construction, Design, Project costs

I believe this cost to be around $15.0M.

4.0 Comparable examples of where this has been done

The best example of 220kV underground in Melbourne is the Brunswick to Wonthaggi, Berwick.

Other 220kV underground lines are in CBD Auckland and Sydney.

5.0 References

1. Karlstrand, J., Bergman, G., and Jonsson, H.-A. “Cost-efficient XLPE cable system solutions”, AC-DC Power Transmission, Seventh International Conference, 2001.
2. Putting Cables Underground Working Group, “Putting Cables Underground Report”, 1998.
3. ICF Consulting Ltd, “Overview of the Potential for Undergrounding the Electricity Networks in Europe”, London, 2003.
4. Koch, H. and Hopkins, M. “Overview of gas insulated lines (GIL)”, Power Engineering Society General Meeting, IEEE, 2005.
5. Benato, R., Di Mario, C., and Koch, H. “High Capability Applications of Long Gas Insulated Lines in Structures”, PES TD, 2006.
6. Kalam, A., Al-Khalidi, H., and Willen, D. “HTS cable and its anticipated effects on power transmission networks”, AC and DC Power Transmission, ACDC, 2006.
7. Marazzato, H. and Barber, K.W., “The Challenge for Undergrounding Electricity Supply”, Australian Power Transmission & Distribution magazine.
8. Ausnet, SP, “SP AusNet Electricity Distribution Price Review 2006”, 2005.
9. Sauers, I., et al, 2006, “High Voltage Testing of a 5-meter Prototype Tri-Axial HTS Cable”, Presented at 2006 Applied Superconductivity Conference, 27 Aug 2006, Seattle, WA, USA. IEEE Transactions on Superconductivity.

45 Stuart Street
Monee Ponds
Victoria 3039
Australia

10. N. Lynch, N., et al, 2006, "Cryogenic Supply System for the Bixby Road Superconducting Cable Project", Presented at 2006 Applied Superconductivity Conference, 27 Aug 2006, Seattle, WA, USA. IEEE Transactions on Superconductivity.
11. Lindsay, D., Roden, M., Demon, R., Willen, D., Mehraban, B. and Keri, A., 2007, "Installation and Commissioning of Triax Superconducting cable", Jicable'07.
12. Kalam, A. "Conversion of Overhead Lines to Underground Power Cables", The Power Cables & Switchgear Conference 2008, IDC Technologies.

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Tribunal.

Akhtar

Professor Akhtar Kalam