BEFORE THE BOARD OF INQUIRY

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of applications for resource consent and notices of requirement by Transpower New Zealand Limited for the North Island Grid Upgrade Project

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STATEMENT OF EVIDENCE OF MILIND VISHNU KHOT IN REBUTTAL FOR TRANSPOWER NEW ZEALAND LIMITED
(Line rating, conductor selection, EMF, insulation design, lightning performance, RFI/NZECP)

SIMPSON GRIERSON
D J S LAING / J G A WINCHESTER
TELEPHONE: +64-4-499 4599
FACSIMILE: +64-4-472 6986
DX SX11174: PO BOX 2402
SOLICITORS
WELLINGTON

J S KÓS QC
STOUT STREET CHAMBERS
TELEPHONE: +64-4-472 9026
FACSIMILE: +64-4-472 9027
PO BOX 117
WELLINGTON

Introduction

1. **MY** name is Milind Vishnu Khot. I wish to present rebuttal evidence to the statements of evidence of:

   (a) Mr Martin Gledhill on behalf of the Ministry of Health (**MOH**);

   (b) Mr Gary Orbell on behalf of Matamata-Piako District Council;

   (c) Mr Murray Parrish on behalf of Carter Holt Harvey Limited **(CHH)**; and

   (d) Mr Doug Parker on behalf of Hunua and Paparimu Valley Residents' Association Incorporated.

2. I address the evidence of each submitter below.

Mr Martin Gledhill on behalf of MoH (Submission number 0823)

3. **AT** paragraph 3.14 of his evidence, Mr Gledhill requests specific details on the live line maintenance clearances provided in the proposed design and how these would limit the use of compact tower designs.

4. **AS** stated in my first statement of evidence, the extent of compacting (bringing the circuits and phases closer together) that could be achieved depends on the desired maintainability of the line. In the case of the proposed line, for system reliability and availability reasons it is imperative that the line be capable of being maintained in its "live" state. Therefore providing safe live line clearance distances is of paramount importance.

5. **LIVE** line maintenance, as the name suggests, is the ability to perform maintenance activities with the line in its energised state. These activities may include changing of insulators, replacement of associated hardware, conductor inspection etc. Live line work can be done either by bare hand directly accessing the live conductors, or hot stick from the tower structure, or from an external working platform, e.g. insulated bucket truck. Live line maintenance requires special intensive training and extremely stringent work procedures.

6. **STANDARD** NZECP 46 is the applicable Code of Practice for live line work in New Zealand. This code of practice is due for review this year. I also understand that a new comprehensive standard is being developed by the Energy Networks Association Australia in conjunction with Standards Australia (Committee EL-052-01 - High Voltage Live Line Work), which might be adopted in future by New Zealand.

7. **A** self-explanatory clearance diagram is attached in **Appendix A**. This is a preliminary draft drawing that shows the various clearances to which the width of the cross-arm (and hence the distance of the conductors from the body of the tower) must be designed to prevent flash-overs. It also shows the minimum phase to phase clearance for the same circuit based on these flash-over distances.

8. **AS** explained in my first statement of evidence, the length of the insulator itself is designed to withstand lightning impulse voltages, and to provide sufficient creepage length (defined in my evidence) to prevent flashovers due to pollution. This lightning flashover length is approximately 3.35 m for the proposed line. The creepage length is decided by the expanded profile length of the sheds of the insulator. The total length of the insulator string including the swivel fittings, clamps and associated hardware would be about 4.7 m.

9. **IT** is important to note that specific clearances to the structure need to be achieved under various conditions of insulator swing due to wind. For instance, under conditions of normal everyday wind, the insulator is expected to typically swing by an angle of about 20°. Under these conditions, the conductors must be far enough away from the structure to withstand impulse surges such as lightning. This clearance distance at this swing angle therefore must be at least the same as the lightning arc length of the insulator, which is about 3.35 m.

10. **UNDER** conditions of high wind gusts (typically 3 second gusts), the insulator will swing more (assumed to be about 65° angle) and closer to the structure, but this swing is a transient state. When the gust passes, the insulator will return back to its pre-gust state or position of equilibrium. Because this high wind swing time is relatively short, the clearance distance to the structure must be sufficient to withstand the peak power frequency phase to earth voltage. This power frequency voltage withstand distance is estimated to be 1.2 m.

11. **INSULATOR** swing can be restricted by the use of a V-string configuration that prevents the free lateral swing of insulators. Therefore, theoretically, the circuits could be brought closer to the structure body. However, bringing the circuits closer infringes on live line working distances and capability which are absolutely essential for the proposed line. This is discussed in the rebuttal evidence of Mr Lake.

12. **IN** addition to the above, the drawing shows the following distances that must be maintained:

- 3.4 m - The minimum approach distance for a 400 kV line. In comparison, for a 220 kV line it is 2.2 m, as defined in the safety rules.
- 2.65 m - The minimum live line approach distance for a 400 kV line. For a 220 kV line it is 1.65 m.
- 0.7 m - Climbing corridor distance for routine maintenance activities.
- 0.26 m and 0.2 m respectively - Clearances for the swing of the swivel fittings that suspend the insulator and the widths of the step bolts for climbing.
- 0.1 m – Steel clearance allowance.

13. **THE** width of the super-structure (preliminary only) of the tower is expected to be about 2.8 m (1.4 m on either side of the centre line).

14. **IT** can be observed that the live line bare hand working zone clearance distance of 2.65 m is the governing distance that decides the width of the cross-arm. Any reduction of the cross-arm width results in the violation of this distance, and hence severely constrains live line maintenance capability.

15. **THE** minimum width of the top cross-arm from the centre-line that would satisfy all the above safe clearance distances would be about 7.55 m. However, the super-structure of the tower becomes wider at the middle cross-arm level (as can be seen from the drawing), and therefore the cross-arm width required is greater. The width of the middle cross-arm is about 8.05 m. Similarly, for the bottom cross-arm, it is no longer the super-structure, but the waist of the tower that the conductors must maintain their clearance to, which is wider. Hence the bottom crossarms need to be about 8.55 m on either side of the centreline.

16. **A** similar analysis of the phase to phase clearances on the diagram would show that a distance of approximately 9.8 m is required between phases.

17. **TO** check against the requirements of the ICNIRP public exposure reference level of 5 kV/m, it is clear that the field levels must be calculated for these crossarm widths. The height of the conductors above the ground therefore must be designed so as to meet these field levels for these minimum circuit to circuit and phase to phase clearances.

18. **IT** is now clear that further compacting of the phases or circuits would compromise these clearances, and particularly live line capability.

19. **LASTLY,** the above dimensions and clearances (as shown in the diagram in **Appendix A**) are representative only for a standard average suspension tower. The actual dimensions may vary depending on, by way of example, the terrain or the line angle.

Mr Gary Orbell on behalf of Matamata-Piako District Council (Submission number 0558)

20. **MR** Orbell, at paragraph 5.5 of his evidence, discusses effects on electric and standard fences and possible realignment of such structures.

21. **INDIRECT** effects of electric fields such as micro-shocks may be felt only when unearthed objects are touched and the accumulated charge discharges to earth through the body of a person or animal. Solidly earthed objects or even partially earthed objects do not accumulate charge. Fences are generally considered as earthed objects. Wooden fence posts provide quite good earthing even though wood itself is an insulator. This is because of the moisture within the wood. Also, because of the spacing of the fence posts at periodic intervals (about 3 – 4 m), fences may be treated as "frequently earthed" objects. Any charge induced in fences would inevitably discharge to earth in such fences.

22. **IN** electric fences, constructed to discourage farm animals from transgressing outside farm territory, the wires carry a voltage and are insulated from the fence posts. However, the current that an electric fence discharges through the body of the animal is quite minimal ("deterrent" level) since the power that drives it is very low. The additional charge induced by the proposed line's electric field would be