BEFORE THE HEARING PANEL

Under the Resource Management Act 1991

In the matter of

The Proposed Waikato District Plan Hearing 22: Infrastructure

Between

Waikato District Council

And

Transpower New Zealand Limited (Submitter S576 and Further Submitter FS1350)

Statement of Evidence in Chief of Andrew Renton for Transpower New Zealand Limited dated 29 September 2020

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PRIMARY STATEMENT OF EVIDENCE OF ANDREW CHARLES RENTON ON BEHALF OF TRANSPOWER NEW ZEALAND LIMITED

SUMMARY OF EVIDENCE

A. Transpower manages and maintains its existing transmission line fleet to have a perpetual life. It is vital that Transpower is able to operate, maintain, develop and upgrade the National Grid lines in order to deliver a reliable, secure supply of electricity nationally and to the Waikato District.

B. Transmission line components corrode and wear as any similar steel infrastructure does in the New Zealand environment. This corrosion and wear comes about by the constant exposure of the line to the elements, such as wind, rain and various pollutants. Transmission line aging, corrosion and wear all mean that ongoing inspection and routine maintenance work is constantly required.

C. Routine maintenance in the Waikato District mainly includes inspections and patrols, foundation repair and replacement, insulator and steel replacement, and conductor repairs – these are generally works associated with aging, wear and tear, environment or willful damage.

D. Physical access to transmission lines is required for all routine and urgent maintenance and project work. Maintenance work involves staff, vehicles and, at times, drones and helicopters, as well as large earthmoving or crane equipment on work sites. The very nature of the works can significantly inconvenience people if they work or live near the lines when the works are being carried out.

E. I consider that a regulated transmission corridor is essential for providing adequate access and working space at the towers and mid-span. Prudently designing buildings or activities with the transmission line in mind (including beneath conductors) ensures vital Grid infrastructure is protected and can be maintained and upgraded when needed. Underbuild may delay, or in some instances severely restrict and compromise, Transpower's ability to undertake maintenance or project work. Transpower would need to consider other options that may not always be acceptable to the wider community (such as building a new line), if existing lines cannot be operated, maintained or upgraded when necessary.

F. In the event of a system fault (for example, as a result of very high winds), the Grid needs to be restored quickly and efficiently. A system outage can have a substantial impact on businesses and communities throughout the Waikato District, and beyond. Restoring faults quickly becomes challenging if transmission lines are difficult to access due to intensive developments that may be constructed under and around them.

G. Transpower operates its assets as safely as possible, but there are residual risks due to the high voltages being carried on the lines. Electric shocks can be caused by earth potential rise, step and touch voltages, induced voltages, conductor drop and flashovers. Hazards can also be caused by trees coming into contact with or close proximity to overhead lines.

H. Transmission lines can also cause concern or annoyance, because of how they look, their mechanical or electrical noise, electrical interference, and perceived health effects. These effects can lead to requests for Transpower to underground lines, or move lines away, or to raise or lower conductors.

I. The 10m or 12m National Grid Yard is the general area beneath the conductors in "everyday" wind conditions, being the conditions when line maintenance can be carried out. A 12m setback around each tower or support structure is also sought for access, maintenance and safety purposes. A wider area is sought for subdivision which extends to the width defined by the swing of the conductors in high wind conditions. These areas are a bare minimum to ensure that Transpower's maintenance, repair, upgrade and operation activities are not compromised.

J. In my view, there are certain activities, primarily sensitive activities, commercial buildings and intensive development (including some farm buildings) which should be avoided beneath transmission lines because of electrical risk, annoyance caused by the transmission lines, and the difficulties these activities can cause when Transpower needs to access, maintain, upgrade and develop the lines.

K. I consider that Transpower should be given the opportunity to comment on applications for subdivision in the vicinity of the corridor and lines, as these issues can be addressed best at an early stage.

L. Land disturbance activities also need to be managed to take the lines into account, in all areas. Land disturbance can undermine transmission line support structures or reduce conductor to ground clearances to unsafe levels.

M. While NZECP34:2001 may adequately provide for the minimum safe electrical distances for smaller buildings and structures and some activities around transmission lines, it does not prevent underbuild and does not ensure the operation, maintenance, upgrade and development of the Grid is not compromised. I consider that the construction and location of new intensive development and buildings for sensitive activities should always be sited to complement the operational or maintenance activities of existing transmission lines.

INTRODUCTION

Qualifications and Experience

1 My full name is Andrew Charles Renton.

2 I am employed by Transpower New Zealand Limited (Transpower) as the Senior Principal Engineer. I have a New Zealand Certificate of Engineering and Bachelor of Engineering (Electrical).

3 I have over 26 years' experience in transmission engineering work. I am a professional engineer with a degree in electrical and electronic engineering (UC 1999). I am a member of Engineering New Zealand, the Electrical Engineers Association of New Zealand, and CIGRE (The International Committee for Large Electrical Systems). I currently work in the Grid Development Division of Transpower. My role involves investigating and providing holistic, pragmatic and strategic advice to developers and the infrastructure divisions of councils, on suitable and cost-effective transmission solutions as well as new developments and technologies. My previous roles at Transpower have included the Asset Development Engineering Manager responsible for all substation and transmission line engineering development work. I have also been involved with work for the International Energy Agency.

4 I am familiar with the National Grid assets within the Waikato District Council's jurisdiction.

5 I have read the statements of evidence of **Ms Pauline Whitney** and **Mr Dougall Campbell** and have taken these statements into account in preparing this statement of evidence.

CODE OF CONDUCT

6 I have read the Environment Court's Code of Conduct for Expert Witnesses. As I am employed by Transpower, I acknowledge that I am not independent; however I have sought to comply with the Code of Conduct. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

SCOPE OF EVIDENCE

7 I have been asked to provide primary evidence in relation to the infrastructure provisions of the Proposed Waikato District Plan (**the Proposed Plan**). I explain in further detail the nature and location of Transpower's current and future overhead transmission lines and the works Transpower undertakes to operate, maintain, upgrade and develop the National Grid.

8 Specifically, in this brief of evidence I will outline:

8.1 The location of existing lines in the Waikato District and the role these play;

8.2 The types of works that are generally required to ensure the ongoing operation, maintenance, upgrading and development of the National Grid. I also cover the need for, and requirements of, emergency works, as well as planning for electricity outages;

8.3 The risks to people and property undertaking activities and land disturbance near transmission lines, including the different types of electric shock that can occur. I identify some of the many examples of where problems have occurred;

8.4 Potential impacts of other third-party activities on Transpower's assets, including direct effects and reverse sensitivity effects; and

8.5 How Transpower manages the risks associated with the National Grid and expects others to manage their risks.

THE LOCATION OF EXISTING LINES

9 Transpower has 18 existing overhead transmission lines in the Waikato District consisting of approximately 4,000 structures and 1,360 kilometres of line length. The evidence of **Mr Campbell** includes a map showing the location of these existing lines. Specific details of the assets are provided in the evidence of **Mr Campbell**, with a geographic summary of the assets concerned shown in the image below. In a normal year these assets move approximately 25% (11,000,000MWh)

of New Zealand's annual electricity consumption through the region. The region itself consumes approximately 1,200,000MWh in an average year, peaking at approximately 250MW during a winter evening.

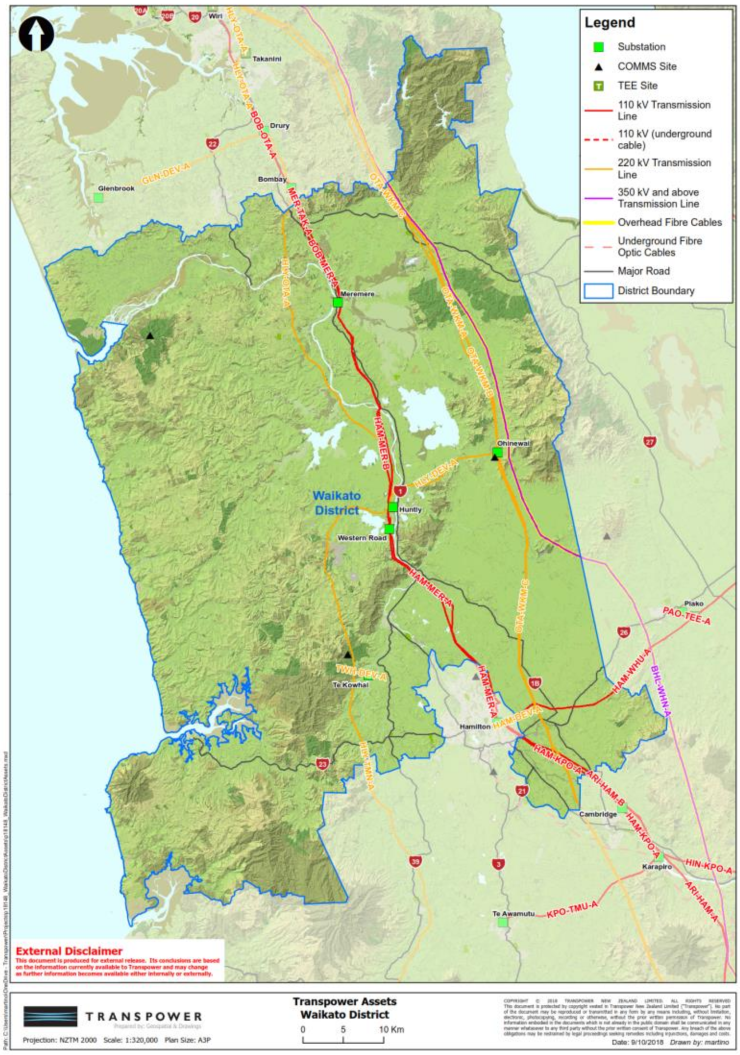

Figure 1: Transpower assets in the Waikato District

10 The vast majority of Transpower's overhead line infrastructure is on private land. Despite this location, most of this infrastructure is not designated (the exception being Transpower's substations, and the more recent Brownhill – Whakamaru North A transmission line that was designed and built to operate at 400 kV but is currently operating at 220kV, and Te Kowhai Deviation A 220kV line), nor is it protected by an easement. Instead, Transpower relies on "deemed easements" under the Electricity Act 1992. While Transpower has rights to lawfully occupy,

and (subject to certain processes and notice requirements) access its infrastructure, this state creates challenges for Transpower.

11 Transpower continues to invest in the National Grid both in terms of maintenance and enhancement of its asset base. Transpower's development and investment strategy is centred on maximising the use of existing infrastructure, therefore maintaining the environmental footprint for as long as possible before the introduction of new infrastructure. The focus for the next 10 years will generally be on maintaining and enhancing the assets we have in the Waikato District.

12 Mr Campbell has covered in his evidence the most significant upgrade project proposed in the Waikato District, being the installation of series capacitors at a new substation site on the 400kV capable Brownhill-Whakamaru A transmission line. Transpower has no plans in the next 10 years to build new lines for its own needs but will investigate upgrade options on existing assets that include:

12.1 Duplexing of Ōtāhuhu – Whakamaru A and B lines (replacing each single conductor with a group of two conductors); and

12.2 Deviating the Brownhill-Whakamaru A transmission line into Ōhinewai for additional capacity to service the northern Waikato area.

13 As the needs of the network change over time, Transpower will consider removing assets that are under capacity and no longer required. An example of this is the reconfiguration of the supply around Pokeno and Bombay. Due to growth within the region Transpower has a project to reinforce the supply into Bombay from the 220kV network. If approved, this will remove the need for the lower capacity 110kV Hamilton-Mercer A and Hamilton-Mercer B transmission lines, and they would consequently be dismantled.

14 Other likely new build works are for a number of solar and windfarms connections should they proceed. Each would need a short connecting transmission line to an existing substation or the establishment of a new

substation. Mr Campbell’s evidence describes the multi-disciplinary process that Transpower follows to establish new transmission assets.

BASIC COMPONENTS OF AN OVERHEAD TRANSMISSION LINE

15 Overhead transmission lines consist of five basic components:

15.1 Conductors (wires);

15.2 Structures;

15.3 Insulator sets;

15.4 Foundations; and

15.5 Earthwires.

16 These components are described in greater detail in **Appendix A** to my evidence.

OPERATION, MAINTENANCE AND UPGRADE OF TRANSMISSION LINES

17 Transpower's asset strategy for its transmission line fleet is that all lines have a perpetual life. Transmission line structures can be maintained almost indefinitely by practices such as painting of towers, concrete encasement of existing grillage foundations and replacement of insulators. Conductors are replaced and increased in size and, at times, in the number of conductors per phase to meet the existing and future electrical demand.

18 Maintaining the National Grid is a core part of Transpower's business. To ensure the Grid delivers a safe, secure and reliable electricity supply, all assets need to be patrolled and inspected on a regular cycle reflecting the asset's age and type, its environment and geographic location, and high risk areas (such as where lines are over major roads, rail and urban areas).

19 It is important that appropriate access to the National Grid is retained in order to allow maintenance and upgrade activities to take place. This is particularly relevant to changing land use and subdivisions. As outlined

in the evidence of **Ms Whitney**, Transpower seeks to manage the network through a National Grid Corridor approach which is comprised of a smaller National Grid Yard and a wider National Grid Subdivision Corridor.

20 Within the Waikato District, Transpower has regular maintenance scheduled including replacing hardwood poles with concrete poles, insulator replacement, EPR mitigations, steel and bolt replacement, tower painting, tower-foundation interface refurbishment, grillage encasement and vegetation.

Inspections of our assets

21 Transpower carries out two main types of inspection activities in order to determine maintenance, refurbishment or upgrade requirements – routine patrols and condition assessments.

Routine patrols

22 A routine patrol involves viewing every asset annually, as a minimum, to identify any short-term defects or situations that may affect the operation or safety of the National Grid in the shorter term. Items identified on patrols include damaged or broken insulators, impediments on the conductors, broken climb guards, faded signs, vegetation growth, access issues, land subsidence, and developments or activities under or near the line that may affect its safe and reliable operation.

23 I emphasise in particular that developments or activities under or near the lines, which are unsafe, will potentially only be identified by Transpower once per year (assuming that the activity occurs on the day of the patrol and is identified by the patrol team). This is a further reason why Transpower seeks provisions in the Proposed Plan that will assist in land users adopting safe operations and practices. I will come back to third party activities in more detail below.

Condition assessments

24 A full condition assessment involves every line component being inspected and, in some cases, tested on a time-based schedule (mainly three to seven yearly depending on the asset type and environment). Condition assessments require access to all transmission line structures

and conductors. From these detailed inspections, a work programme is developed to ensure components are replaced or refurbished well in advance of their failure point.

25 Routine patrols and condition assessments of towers are carried out by field staff or contractors using a 4x4 ute or all-terrain vehicle to get as close as possible to the base of each structure.

26 Transpower's conductor condition assessment inspections also include the use of drones and helicopters for location and closer observation of developing defects by taking thermal images, and high-resolution photos. More detailed mid-span inspections of conductors, conductor joints and hardware as part of the condition assessment programme. Conductor tests are also carried out by a remote-controlled conductor robot that travels down the span taking images and data and relaying this to a computer on the ground. Alternatively, it can be done by line mechanics accessing the conductor via a conductor trolley or by being suspended under a helicopter, mid-span to measure joint resistance by testing.

Maintenance activities

27 From these routine patrols and condition assessment inspections, a wide range of maintenance work is identified and incorporated into a consolidated work programme. Transpower has an ongoing programme of planned maintenance work to be undertaken in the Waikato District. Most of this work will occur on private land.

28 The maintenance activities that occur most frequently are:

28.1 Foundation refurbishment;

28.2 Tower refurbishment including abrasive blasting and painting;

28.3 All aspects of tower conductor and insulator (and associated hardware) maintenance or replacement; and

28.4 Vegetation and tree control.

29 Some of these activities also involve related land disturbances.

Foundation refurbishment

30 Tower foundations include grillage foundations, i.e. directly buried steel. Inspecting these foundations requires the whole foundation to be dug out on all four legs using earth moving machinery such as excavators. If the foundation needs to be excavated, the tower must at times first be supported via props or guy wires before excavation. Figure 2 on the next page gives an indication of the amount of spoil and land disturbance required for a typical grillage foundation strengthening project.

Figure 2: Grillage foundation replacement

Figure 3: Foundation replacement

Tower refurbishment

31 Tower painting is a significant on-going maintenance project for Transpower. Painted transmission towers have a coating life of approximately 14-18 years. Once the galvanising on a tower reaches its end life (depending on the environment) the bare steel shows a combination of alloying with rust breakout in more corrosive areas (see Figure 4). The longer a tower is left to corrode the more extensive the secondary preparation is, therefore increasing the cost of the painting work (additional steel and bolt replacement may also increase with time).

32 Tower painting can range from $50,000-$150,000 per tower, depending on its condition, location, size and type.

Figure 4: Tower corrosion

33 Tower painting can disrupt people who live and work near towers. Abrasive blasting of towers prior to painting can cause material to be airborne. People and property located near this operation need to be protected from this material. Figures 5 and 6 below show houses and cars being draped with polythene sheets as protection during abrasive blasting. As seen from these photos, all effects (such as debris and emissions of airborne particles) cannot be eliminated or fully mitigated through the use of the polythene sheets.

Figure 5: Tower painting in an urban setting

Figure 6: Tower painting in an industrial setting showing garnet debris falling onto cars

34 By comparison, in areas where there is no under-build, methods such as geotextile matting laid under the structures, can more easily capture debris from tower painting, as Figure 7 below shows.

Figure 7: Abrasive blasting in area with no under-build — Auckland area

35 In underbuilt areas, Transpower's resource consents often require that less intensive blasting or painting processes are used. Not only does this increase costs (by $15,000-$20,000 per structure), it also reduces the quality and life of the paint system. As a result, towers need to be painted more frequently (every 7-10 years, instead of every 14-18 years), leading to more frequent disruption of people living or working under the lines.

Conductor and insulator (and associated hardware) maintenance or replacement

Conductor repair and replacement

36 Conductor repair and replacement is a significant and key part of transmission lines management. Conductors corrode or wear as they age, until reconductoring either all or part of the line is required. Repair and replacement work involve:

36.1 Building, stringing and tensioning work sites to locate pullers and tensioners, laying down sites, storage, as well as an area for working;

36.2 Accessing each tower to remove the existing insulators and installing stringing equipment such as running blocks;

36.3 Tower and foundation strengthening where necessary;

36.4 Rewiring (using the old conductor to pull out the new conductor);

36.5 Sagging operations at each tower to ensure even and consistent sag profiles;

36.6 Reinstalling the insulators, including clipping in the conductor; and

36.7 Removal of plant and reinstatement of land.

37 Access for maintenance work on simplex conductors presents some additional challenges compared to working on a duplex conductor[1]. For example, access to simplex conductors is usually limited to ground base operation using elevated work platforms or cranes, or lowering the conductor to the ground. In some cases, it is possible to suspend line mechanics from helicopters, but this involves long periods of helicopter time while the work is being carried out below.

Figure 8: Maintenance work being carried out using helicopters

1 The difference between a simplex and duplex conductor is shown on the diagrams contained in Appendix A.

38 In the case of duplex conductors, access can be arranged using line mechanic conductor trolleys or helipods as shown in Figure 8 above. Conductor trolleys or helipods are suspended using both conductors of a duplex configuration to hold the trolley in place. The trolleys have four wheels which allows them to be moved along the spans between towers.

39 From time to time, Transpower needs to access the conductors at midspan for inspection purposes or to carry out repairs. Mid-span damage can be caused by lightning or corrosion damage or could be caused by third party activities under the line from smoke or fires, vehicle or mobile plant, or vegetation touching causing flashovers. I discuss these issues in more detail later in my evidence.

40 Conductor replacement or mid-span conductor repairs include inserting new sections of conductors, new joints, mid-span repair joints or sleeves. This work requires a relatively clear area under the line where the works are being carried out. In some cases, this may be the entire line.

41 Conductor repair methods include inserting new sections of conductors, new joints, mid-span repair joints or sleeves and removing impediments such as kites, balloons, and electric fence wires. In all cases access to the conductor is necessary.

42 Mid-span under-build, particularly dwellings and buildings for intensive development (where people are most inconvenienced) creates significant additional costs for Transpower in carrying out any reconductoring or mid-span repair works. There will be cases where this work could not be undertaken efficiently. Alternatives (such as a new or bypass line) may need to be considered. In some instances, it may be necessary to consider relocating people living and working under the line - at significant inconvenience and costs to all concerned.

43 In an urban or industrial environment, the reconductoring operation can cause inconvenience to the community by restricting vehicle, and walking access to public or commercial areas such as schools, businesses, and parks.

44 Some commercial and industrial activities may need to shut down during conductor repairs, and/or can be affected by helicopter use. Work sites, particularly in a span where there is potential for inadvertent loss of control of load or machinery failure, require the area to be closed off to provide a safe work site.

45 Intensively used buildings and commercial operations pose a risk during maintenance. This includes buildings such as high-level storage facilities, factories, large scale industrial buildings, commercial operations that emit dense smoke, dust or chemicals and high-density lifting operations involving forklifts, cranes, tip trucks and similar vehicles. These buildings and activities either are at greater risk of effects from the transmission lines or put the line itself at greater risk.

46 If allowed to be constructed, these intensively used buildings and commercial operations would need to be either vacated during reconductoring operations or protected by the construction of high cost scaffolding and nets as shown in Figure 9 below (this is based on the assumption that the development allowed room for the construction of such structures). The scaffolding and netting constructed below to protect an undercrossing line cost in excess of $350,000 to construct and dismantle. Intensively used buildings and commercial operations also have higher risks of compromising Transpower's ability to maintain the line and are at risk from electrical hazards (which I discuss below).

Figure 9: Scaffolding protection structure for stringing

47 Reconductoring a typical existing line section would likely take 2-3 weeks. Even smaller maintenance work typically takes 8-12 hours. So it is practically very difficult, for Transpower to work around intensive industry operations without incurring large time or cost impacts to both parties.

Scheduling of maintenance works

48 Transpower seeks to schedule its works, including any outages, to cause the least inconvenience to landowners and the public. However, this is not always possible.

49 Live line work is sometimes possible, but there are restrictions on the types of activities that Transpower's workers can undertake while a line is live. Mid-span jointing, removing jumpers or conductors, lowering conductors to the ground for repairs, and some insulator replacements cannot be carried out while lines are live, either due to the nature of the work or due to restricted worker distances from live equipment. Live line work involves a highly trained work crew and requires the same access, work areas and crew numbers as the traditional de-energised work methods.

Vegetation and tree control

50 Trees and vegetation need to be monitored to ensure they are not growing too close to the lines. Transpower undertakes vegetation clearance in accordance with the Electricity (Hazards from Trees) Regulations. I comment on the safety risks of trees and vegetation later in my evidence.

Maintenance work equipment

51 Depending on the type of maintenance work, the use of lifting machinery, stringing equipment, elevated work platforms or helicopters may be involved. Earth moving machinery, such as excavators or diggers, are required to expose or extract tower foundations or carry out tower refurbishment works.

52 For substantial works, a wide range of plant and equipment is sometimes necessary as seen in Figures 10 and 11 below.

Figure 10: Removal of copper conductor on Pakuranga-Penrose A line, Auckland

Figure 11: Crane being used for re-stringing – Central Otago

Maintenance work space and access

53 Clear working space and good access is required particularly around the base of the towers and in some cases under conductors, to move the plant and equipment in and set it up correctly. Cordons must be installed around the work site to minimise hazards and restrict access to everyone other than the trained work party. When work is carried out on a tower, the effective work area for health and safety purposes includes the spans either side of that structure. Accordingly, cordons are important and may cover a large area.

54 For some projects, such as wiring or where alterations are being made to structures hurdles may be required, or properties may need to be evacuated to protect against potential conductor drop hazards. Figures 12 and 13 below show hurdles established at a work site. Hurdles are installed to protect traffic on access roads from risks associated with dropped conductors (mainly during re-stringing). Similar projects in urban and industrial developments have required the evacuation of inhabitants or workers for periods of up to a week.

Figure 12: Typical hurdles installed to mitigate potential conductor drop during wiring

Figure 13: More substantial hurdles installed to mitigate potential conductor drop during wiring

55 The area at the base of a tower must allow sufficient work site space for plant and equipment.

Time necessary for maintenance work

56 Depending on the location and type of maintenance work proposed, the time taken to travel to a site, establish and set up equipment and prepare and secure the site ready for the maintenance work can be significant. It can take several hours simply to transport and establish cranes or excavators on site and set them up on a suitable platform (see Figure 14 below). It also takes time to apply safety devices and hold work briefings.

There may be delays during the planned work periods because weather or environmental conditions may restrict crane or excavator operations due to safety concerns.

57 Once the work has been carried out, the above measures need to be reversed (for example, the equipment and cranes have to be removed from the site) which can also take considerable time. It is therefore most efficient to carry out the work during reasonable daylight hours on consecutive days. It is simply not efficient to carry out maintenance in short disruptive periods (for example, between arrivals of containers to the port, between milking times, or around working hours). In addition, maintenance is generally discouraged at night because of the greater safety and health risks to line mechanics, particularly if they are working at height in the dark.

Figure 14: Reconductoring in an urban setting

Emergency Works

58 The works described above are those Transpower has planned or are typical of the works expected to be necessary. In addition, Transpower needs to be able to quickly access its lines at all times in order to find and fix faults. Businesses and communities are heavily reliant on electricity, so it is crucial that faults are identified and fixed as soon as possible. While Transpower's assets perform extremely well in storm events or

natural disasters, excessive winds and rivers changing course do at times break or collapse National Grid infrastructure and emergency repairs need to be carried out to get these back into production. During these times there is often a heightened requirement for electricity (the National Grid is a part of lifelines infrastructure).

Access

59 Transpower has statutory rights to access its assets on private land under the provisions set out in the Electricity Act 1992 (*Electricity Act*). The Electricity Act provides for access to maintain, inspect and operate the National Grid. In some cases, Transpower has contractual or property rights to access new assets that are located on private land.

60 An ideal outcome would be to have unimpeded physical access to all transmission line structures. However, in a practical sense this is not always possible. Physical barriers and natural obstacles such as waterways, valleys, and undulating ground require Transpower to use alternative access options depending on the type and nature of the work required on the asset. Further intensive or sensitive development will add additional physical barriers, and thereby increase the costs and difficulties associated with access. For example, dismantling fences and other structures, temporary bridging of waterways, excavation and vegetation removal, all add to the effort and cost of completing works which if adequately allowed for as part of the local planning regime could be avoided. **Mr Campbell**'s evidence includes an example of residential development preventing access to a tower for maintenance work.

Figure 15: Pole replacement works, equipment and space required

Figure 16: Example crane access required for cross arm and insulator works as part of re-conductoring

ELECTRICITY OUTAGES DURING MAINTENANCE

Frequency of outages

61 Transpower typically plans to carry out 2,000 to 3,000 outages each year on lines and equipment in substations. The majority of these are scheduled more than 12 months in advance and most 18-24 months in advance so as to co-ordinate with generators, and electricity distribution companies to minimise disruption to end use consumers. Limited outage windows make it difficult to maintain certain parts of the Grid, and therefore make it more likely that costly upgrades will be brought forward.

62 We can in some cases, maintain a live circuit on one side of a tower, while outages and work take place on the other side. Undertaking maintenance in this manner means additional new lines are not required but does make the supply to end consumers more vulnerable to interruptions where there only one circuit left supplying electricity. A fault on the remaining in-service circuit during maintenance will result in a loss of supply to consumers as there is no additional back-up.

63 Momentary faults on the remaining circuit during maintenance, for whatever reason, will result in an interruption to supply for a minimum of 1-2 hours until it is established that it is safe to reenergise the circuit with consequential economic and social consequences to the district. A fault that damages the circuit may result in an outage of up to eight hours or more if the circuit being maintained has to be restored instead.

Co-ordinating outages with landowners

64 When Transpower needs to gain access to its lines, it works with landowners to minimise the impact of work on their operations. This normally requires us to co-ordinate with multiple landowners along the length of a transmission line for a single outage.

65 Landowner access requirements vary, as activities under the length of a line are not the same. For instance, access restrictions for certain types of farming or industry may be at different times to access restrictions for busy port activities, or residential activities.

66 The greater work on the line is fragmented to accommodate individual landowner access requirements, the more outages at different times are required to complete the work. Mostly a suitable compromise can be found. However due to all the competing needs of generation, distribution, system security, demand and access it is not always possible to accommodate the specific needs of every landowner in every situation.

67 A more optimised solution that meets all parties' needs and enables work on transmission lines to proceed is to allow provisions in the planning rules to locate away from the lines activities that cannot be easily shut down, or which are likely to have reverse sensitivity effects. This would mean their operations would not be impacted by the need for Transpower to undertake maintenance or scheduled upgrade and development work.

Co-ordinating outages within the electricity industry

68 The Grid is a network of lines, with most substations having two or more lines connecting them. If one line is turned off, then the electricity has to flow via other lines, without overloading, to still supply the consumers or generation that rely on that substation.

69 Arranging outages is a complex process to ensure the needs of our maintenance contractors and affected landowners are addressed. However, we also need to consider the generators, major electricity users and local lines companies' requirements with regards to capacity, and security, so they can manage electricity demand within the remaining available Grid capacity while work is being undertaken.

70 We also consider the impact outages have on the operation of the wholesale electricity market. Removing lines can result in more expensive electricity generation being required to run or hydro storage being spilled. The Electricity Industry Participation Code 2010 set by the Electricity Authority incorporates an Outage Protocol which sets out the process Transpower must follow for arranging planned outages of the Grid. The process includes preparing and consulting on an annual plan. The consultation must include conducting regional forums with interested electricity industry participants. Affected electricity industry participants may require Transpower to carry out a net benefits test to demonstrate

that the benefits of a planned outage outweigh the costs to electricity market participants for a planned outage in the outage plan.

71 Subject to limited exceptions, Transpower must notify (at least 40 business days in advance) and consult on any variations (cancellations or rescheduling) of the planned outages in the outage plan.

72 Planned outages may be cancelled at short notice by the System Operator (a separate division of Transpower that operates the power in a real time system under contract to the Electricity Authority). Cancellation of planned outages is likely if the overall configuration of the power system prior to the outage creates a heightened risk that full electricity supply may not be maintained. This cancellation can be either due to other coincident outages of lines or generation, or forecast weather conditions. Cancelled outages are rescheduled; again requiring co-ordination with contractors, landowners, local electricity distribution companies, and generators.

RISKS FROM TRANSMISSION LINES

Electric shocks

73 The main hazard associated with high voltage transmission lines is receiving an electric shock. The risk and severity of electric shocks varies depending on the transmission voltage and type of exposure (e.g. direct human contact, mobile plant, or vegetation). Risks are most likely to be highest within 12m of the centreline of a line. However, some associated effects can be transferred beyond 12m.

74 Lethal electric shocks can be caused by:

74.1 Earth potential rise (***EPR***);

74.2 Conductor drop;

74.3 Flashovers (coming into contact with the line conductors or where the electricity arcs from a conductor onto an object such as a structure, fence or vegetation that is too close to a line);

74.4 Step and touch voltages; and

74.5 Induction voltages.

75 These hazards can occur as a result of third-party activities (such as mobile plant or machinery) coming into contact with conductors, or excavations occurring too close to structures or mid-span thereby reducing clearance distances. All of these things can endanger safety and compromise the operation of the Grid. **Mr Campbell**'s evidence includes an example of mobile plant striking the line and the consequences of this incident.

Earth potential rise

76 EPR is usually caused by an earth fault at a tower. An earth fault occurs when an energised conductor comes into contact with, or flashes over to, the tower or any earthed object. This can occur through an insulation failure as a result of lightning, pollution or foreign objects.

77 During an earth fault, there is a significant current (5-40 times normal) flowing in the faulted line from the power source into the fault point. These fault currents are highest either near the electricity source (generator) or substation as the current returns through the ground. The return current causes momentarily high voltages to appear on both the tower and the ground around the base of the tower. The voltages are highest on the faulted tower and decrease on the ground as you move further away from the faulted tower.

78 The risks of EPR lessen with distance from the support structures. Voltages can appear on any conductive object on the ground (such as a fence) that bridges the voltage contours. The earth fault current causes EPR around the faulted tower, which in turn results in "step and touch" voltage hazards and transferred voltage hazards as discussed below.

79 Step and touch voltages can arise due to a fault at a tower and, as explained above, momentarily raise the voltage at the tower base and the surrounding ground. A step voltage hazard can occur when a step is taken in this area. A step or touch voltage can occur when a person or animal is in contact with the tower and standing on the ground thus causing a voltage difference between the feet or between the feet and

hands. Where conductive horticulture structures or fences, for example, are located close to the tower, high current and voltage may transfer from the tower, via the ground and travel some distances down these structures causing an electrical hazard some distance from the faulted tower and causing the same effect.

80 Step and touch and transferred potential hazards from transmission tower structures are low probability events, but are significant because of the possible consequences.

Conductor drop

81 The conductor can drop to the ground should a mechanical failure occur to the support structures, supporting insulators and hardware, or the failure of pressed mid-span joints. In addition, electrical failure can lead to the mechanical failure of the conductor or the pressed mid-span joints.

82 While it is rare for a support structure, conductor, or the conductor hardware to fail causing the conductor to drop to the ground, it can happen. Historically, the majority of line drops have occurred in rural areas, but there have been rare occasions where a line drop has occurred in an urban setting (where the generally more intensive and sensitive development places more people and property at risk).

83 When a line drop does occur, the consequences can be wide ranging for activities under the line. Figure 17 below shows impacts within a dwelling, following a line drop. The internal electrical switchboard and appliances have been damaged by the significant transfer of voltages to earth from an adjacent transmission line.

Figure 17: Electrical damage following a conductor drop

Figure 18: A conductor drop

84 As well as the electrical risks of a conductor drop, there is also a mechanical risk of a large load dropping. Conductors on a typical duplex 220kV line weigh approximately 3.0kg/m. Therefore, for a typical span the weight of the conductor at the point of impact could be as high as 750kg. That weight could cause substantial property damage and risk to human health and safety.

Flashovers

85 A flashover is a major electrical discharge, usually in the form of an electric arc, which leaps or arcs from the conductor across the insulator string to the tower (or from the conductor to another object) resulting in a short circuit. Flashovers can occur from lightning strike, contamination of the insulator or when a person/object is too close to, or comes into contact with, the conductors.

86 Third party activities involving mobile plant or machinery such as excavators, hi-abs and cranes have the potential to reach up to, or above, the height of the conductors. It is essential that the use and location of this machinery is carefully considered to avoid close proximity or contact with the conductor. Coming into close proximity to a live conductor and causing a flashover (i.e. the flashover will occur prior to contact) can:

86.1 Compromise the safety of the machinery operators or workers or members of the public in or near the machinery and result in electric shock;

86.2 Damage the machinery or the line itself; and

86.3 Affect the operation of the Grid and the security of supply.

87 The risks of incidents such as these occurring increases if incompatible activities are intensified under or near lines.

88 From an engineering and risk management perspective, the longer the amount of time that a person is working or living close to high voltage electricity, the greater the risk of injury or damage to their property from a fault on the line (triggered for example, by a lightning strike, a tree fall or activity under the line).

Equipment or structure failure

89 Transmission lines, similar to buildings, are designed to withstand specified levels of climatic conditions (e.g. wind speed, snow thickness). If these levels are exceeded, it is more likely that failure will occur. Failure events include broken or fallen conductors, collapsed towers (see Figure

19 below), or any other substantial component failure which results in high risk of property damage, injury and electricity disruption.

90 Transpower designs all components of the National Grid to withstand extreme events in accordance with international best practice, having higher design specifications than lower criticality and consequence assets such as distribution lines in keeping with Transpower's civil defence responsibilities. In particular, during an emergency event, Transpower is required to continue functioning, to the greatest extent possible, both during and after the event.

91 Although the probability of a failure event is low, there is the possibility that injury or damage could occur if a person, animal or item of equipment is in the wrong place at the wrong time.

Figure 19: Failed tower on the Benmore-Haywards A line

92 Land disturbance activities adjacent to towers or poles can undermine the stability of the structure foundations, causing the structure to lean or, worse, collapse. Excavations or mounding mid-span can also increase

risks by reducing the clearance between the ground and conductors. **Mr Campbell**'s evidence includes some examples of land disturbance activities that have created unstable batters, causing significant safety risks, as well as risks to security of supply.

93 One of the reasons Transpower seeks to manage land disturbance activities is to mitigate or at least significantly reduce the safety risks I have described above. Physical separation from transmission infrastructure greatly reduces the likelihood of harm or damage occurring to people or property. However, Transpower is comfortable with provisions that closely align with NZECP34:2001 (albeit that the restriction is sought in the plan for broader reasons than safe electrical separation distances).

Vegetation

94 Trees growing close to a line, and which cause a flashover from a conductor to the tree, may cause:

94.1 A circuit fault that affects the operation and supply of the Grid;

94.2 Injury or death to anyone who may be near the tree at the time of the fault; or

94.3 Damage to the tree, land or property.

95 I understand that vegetation clearances are not part of Transpower's request for rules in the Proposed Plan. A note has been sought instead and I understand from **Ms Whitney**, has been recommended for inclusion in the Proposed Plan by the s42A reporting officer.

96 The effects of failing to comply with the Electricity (Hazards from Trees) Regulations 2003 provides a similar context to that of buildings and other activities.

97 If a tree touches or comes close to touching the conductors and causes a flashover, dangerous voltages may arise on the tree itself or in the ground area around the tree. These voltages have the potential to cause serious injury or death. Flashover to a tree where high voltages are

involved can cause the tree to ignite and cause a wider fire hazard if the tree is near buildings or forests.

Figure 20: Tree damage from fire caused by a flash-over

98 It is therefore vital that trees and all other vegetation are trimmed before they grow within 5m of a conductor (in any location). Trimming or cutting vegetation in this manner will ensure that the Trees Regulations are complied with. [2]

THE POTENTIAL IMPACTS OF OTHER ACTIVITIES ON TRANSMISSION LINES

99 In addition to potentially exposing people and property to the risks outlined above, third party development and activities in close proximity to overhead transmission lines can impact upon Transpower's ability to operate, maintain, upgrade and develop its infrastructure. Such activities can also give rise to reverse sensitivity effects.

Direct effects

100 Despite the NPSET being gazetted over 12 years ago, underbuild and inappropriate development continues to occur under and around National

[2] For voltages of 110kV or higher, vegetation is considered a hazard once it is 4m from the conductor. A notice to trim or remove the vegetation can be given once the vegetation grows to 5m from the conductor. In practice, Transpower would cut two years growth off vegetation, so that a distance of at least 5m from the conductors is maintained.

Grid assets and overhead transmission lines in particular. **Mr Campbell** describes some examples in his evidence. I discuss below some additional activities which can have direct effects on the National Grid, which should be avoided in close proximity to transmission lines.

Activities with particular sensitivities to National Grid activities

101 There are a range of activities which have particular sensitivities to Transpower's assets. For example:

101.1 Electrical interference could have serious implications for places such as hospitals or rest homes which rely on the proper functioning of electrical equipment 24 hours a day.

101.2 Radio controlled and global positioning systems are also known to be affected by the close proximity of transmission lines; such systems are being used more for communications and automated control systems in industrial processes.

101.3 Also of concern is any residential development or intensification under transmission lines or close to support structures. As outlined in the evidence of **Ms Whitney**, the NPSET provides specific reference to sensitive activities (which include residential activities). The main hazard associated with high voltage transmission lines is receiving an electric shock, a risk which cannot be mitigated from an engineering perspective, rather can only be avoided.

102 As noted earlier, people living or working in buildings under transmission lines also create significant difficulties when Transpower needs to do maintenance, upgrade and development work. A lot of work has to be done with the lines energised. Even when line mechanics carry out work with the line de-energised (i.e. during a scheduled outage), there are risks to the people and property under the line which sometimes requires people to vacate buildings or restrict the freedom to enter or exit buildings while the work is underway. Replacing a conductor is the time when the risk of conductor drop is greatest.

Hazardous substances

103 Certain activities that involve a large amount of hazardous substances are also a concern for Transpower. One example of this type of facility is the establishment, or extension, of a service station development under a line or adjacent to a substation. The establishment of a service station, with associated underground tanks causes concerns from a risk perspective. Further, practical issues arise about how construction and installation will occur in proximity to the lines.

Preventing access

104 Both land use and subdivision can prevent physical access to structures and the area of mid-span. As noted earlier, **Mr Campbell**'s evidence describes how a dwelling constructed in Auckland prevented Transpower accessing the tower for grillage refurbishment work.

Reverse sensitivity

105 Physical separation of third-party activities from transmission lines is also important from Transpower's perspective to reduce the incidence of people who live and work nearby complaining about the line and requesting changes (i.e. limits or restrictions) to its operation. Reverse sensitivity effects are caused by residential activities which locate near lines. They often relate to noise, visual, electrical interference, and perceived health and safety effects (humans and animals), as well as the limitations placed on land uses in close proximity to the lines.

106 The area or distance from the lines within which reverse sensitivity effects can arise may vary according to the type of issue raised, but they are most noticeable in the area to where the conductor swings out. Depending on asset type, this area can be out to 37m either side of the centreline.

Complaints

107 I have discussed above the importance of physical separation of third-party activities from transmission lines for safety, access, and sufficient working space. A further reason why physical separation is important from Transpower's perspective, is to reduce incidents of people who live

and work nearby complaining about the line and requesting changes (i.e. limits or restrictions) to its operation. I briefly discuss these issues below.

108 The presence of a transmission line can give rise to perceived health concerns and visual amenity issues, even some distance from the line. Furthermore, sometimes people complain of electrical interference (such as a fuzzy television pictures and electronic devices not working properly). These complaints have historically been associated with the electromagnetic interference associated with Cathode Ray Tube displays (televisions and monitors) and AM radios. As the technology has developed and these early technologies have been replaced with modern equivalents such as flat panel displays, smart TVs, and FM radios these issues have significantly reduced and almost disappeared.

109 In addition to general complaints arising from the presence of transmission infrastructure, Transpower also receives requests from landowners to underground existing overhead lines, raise conductors, or restrict future Grid works, particularly if they involve changes in visual appearance. Although the distances that these types of effects are experienced at vary according to the type of effect, I expect they are most noticeable within 12m of the centrelines.

110 At the North Island Grid Upgrade Project (**NIGUP**) Board of Inquiry into the then proposed 400kV capable Brownhill Road – Whakamaru North A line, a number of submitters raised concerns about both potential mechanical and electrical noise, and the potential effect on milking dairy herds in close proximity to the lines, as well as on the operation of sensitive electronic equipment such as radio controlled systems. In most cases, these concerns were addressed by Transpower moving existing buildings away from the proposed line. These complaints are much more difficult to address where new activities locate close to an existing line, perhaps without understanding the effects that lines can have.

111 Noise can also give rise to complaints. Noise from a transmission line usually comes in two forms: mechanical noise and electrical noise:

111.1 Mechanical noise can come from vibration which causes a rattle of the line hardware (insulator attachments, steel members) or from environmental events such as high winds (wind whistling through conductors or over steel works).

111.2 Electrical noise usually comes from some form of electrical discharge, or leakage. This generally can be heard discharging down insulators when it starts raining after a long spell of fine weather. In some cases this corona discharge may be seen at night when insulators are polluted and electricity is seen discharging down from the conductor to the tower steel.

112 In some areas of New Zealand, landowners/occupiers have also raised concerns about electric and magnetic fields (**EMF**) from transmission lines. I note that Transpower's assets operate well within the limits in the International Commission on Non-ionising Radiation Protection Guidelines for limiting exposure to time varying electric magnetic fields (1Hz – 100kHz) (Health Physics, 99(6): 818-836, 2010 (known as the ICNIRP Guidelines). These Guidelines are recognised by the Ministry of Health and the World Health Organisation. However, that fact does not prevent people from making misguided complaints and lobbying in opposition to Transpower’s activities.

MANAGEMENT OF RISKS

113 Transpower manages risks when designing and constructing new assets and through continuous assessments and maintenance of the existing assets. When earth faults occur (rare though they are), the current is interrupted by protective devices at each end of the line to clear the fault in a fraction of a second.

114 However, engineering solutions such as this are only part of the answer. It is also vital that third parties do not interfere with proper operation of the line and appropriate maintenance and upgrade work can be carried out when required.

115 This risk can be minimised by ensuring development is either avoided or is compatible with the lines. Where large scale development (such as

subdivision) is proposed it can (and should in my opinion) be designed to ensure that only appropriate activities occur under the lines (such as carparks, roads, stormwater infrastructure, or open space that does not involve buildings and structures).

116 Proper design of any underlying activities, including consultation with Transpower, is essential to manage risk, and I address this in more detail later.

117 I consider that development by third parties should take into consideration the "safety by design" concept when planning and designing a development (such as a structure or land disturbance) near a Grid asset. "Safety by design" involves understanding and managing the risk throughout the lifecycle of an asset, appreciating when you create a risk it is your responsibility to manage it. Risk should be assessed and designed out of processes, equipment and environments. Where the decision is still to develop in the vicinity of transmission line the following considerations would be made:

117.1 The safety of workers during any construction or build stages of the development (e.g. builders, earth movers, and electricians);

117.2 The safety of residents, workers and the public who may be working, living or recreating in the area after the development is competed;

117.3 The safety of the line maintenance workers who are required to access the Grid assets both during the development's construction and after completion;

117.4 Whether the proposed development follows construction industry best practice; and

117.5 Access to structures and lines by emergency vehicles.

118 The planning, installation and use of buildings, structures as well as heavy lifting plant operations must take into consideration a number of key elements:

118.1 The location and configuration of the transmission line support structures;

118.2 The inductive voltages that may be present and possible mitigation measures that may need to be applied;

118.3 The vehicle movements, location of construction materials and height restrictions of both vehicles and workers necessary to avoid entering the conductor flashover zone;

118.4 The transferred voltage hazards; and

118.5 The EPR issues associated with workers in and around transmission line structures.

119 However, as discussed earlier, notwithstanding these measures, I do not consider that it is appropriate for activities where groups of people are present for extended periods to establish under the line. It is better to avoid such activities too close to lines in order to minimise risks to people and property and potential disconnection of electricity to end consumers.

NATIONAL GRID CORRIDOR

120 The importance of transmission corridors has been recognised by Government policy makers. The NPSET, introduced in 2008, requires Councils to give effect to its provisions in their RMA plans.

121 As explained by **Ms Whitney**, Transpower is seeking a National Grid Corridor for undesignated overhead transmission lines, to provide for:

121.1 A 10m or 12m corridor either side of the centreline, where specified activities are restricted (referred to as the "National Grid Yard")[3];

121.2 A wider corridor (out to 14, 32 or 37m either side of the centreline depending on the line voltage and the nature of the line's support

[3] A 10m corridor either side of the centreline is sought for 110kV transmission lines on single poles. A 12m corridor either side of the centreline is sought for 110kV transmission lines on towers, and 220kV transmission lines.

structures) where subdivision is managed (referred to in my evidence as the "National Grid Subdivision Corridor"); and

121.3 A 12m setback around structures.

122 The National Grid Corridor approach has several important purposes:

122.1 To enable uncompromised access and maintenance.

122.2 To avoid reverse sensitivity effects.

122.3 To reduce risks of damage to structures and their foundations as a result of adjacent structures and land disturbance.

122.4 To avoid safety hazards.

123 The National Grid Corridor is also important for the following reasons:

123.1 To protect the infrastructure corridor itself. As land uses become more intense, it is increasingly more difficult to identify routes for new assets. If a transmission line is compromised by encroaching land uses, it can sometimes be impossible to optimise the capability of existing lines (which defers the need to build new lines). If new lines are required, it can be difficult to identify an alternative route which would disrupt landowners less.

123.2 To alert landowners to the constraints the National Grid lines impose on land use. It also clearly indicates how they can manage their own activities.

124 The corridors Transpower seeks reflect the minimum areas considered necessary for the protection and operation/maintenance of the National Grid. The corridors have not been sized to provide for major rebuilds or new lines. The proposed areas do not *fully* address such matters as amenity and reverse sensitivity.

NZECP34:2001 - PURPOSE AND LIMITATIONS

125 In this part of my evidence I briefly comment on NZECP34:2001 as many parties purport NZECP34:2001 is sufficient to address corridor

management issues for the National Grid and the above corridor approach outlined above is not required. I do not support this assertion.

126 NZECP34:2001 serves an important purpose in prescribing minimum safe distances for the construction of buildings and structures, for the use of mobile plant, and for excavation near transmission line support structures and overhead lines. It does not address the wider third party activities effects that compromise the National Grid, which are managed by the NPSET (discussed in detail above).

NZECP34:2001 overview

127 Compliance with NZECP34:2001 is mandatory. Regulation 17(1)(a) of the Electricity (Safety) Regulations 2010 provide that:

> A person who carries out any construction, building, excavation or other work on or near an electric line must maintain safe distances … in accordance with ECP34.

128 Clause 2.4.1 of NZECP34:2001 states that:

> Except with the prior written consent of the overhead electric line owner, no building or similar structure shall be erected closer to a high voltage overhead electric line support structure than the distances specified in Table 1"

129 Table 1 states:

Minimum safe distances between buildings and overhead electric line support structures

Circuit Voltage	Pole	Tower (Pylon)
11kV to 33kV	2m	6m
Exceeding 33kV to 66kV	6m	9m
Exceeding 66kV	8m	12m

Table 1 NZECP34 Distance between buildings and the line support structures

130 Therefore, in respect of circuits exceeding 66kV (i.e. Transpower's 110kV and 220kV lines), NZECP34:2001 requires that buildings must be at least 8m from a pole and 12m from a tower.

131 The distances in Table 1 are measured from the "closest visible edge" of the overhead electric line support foundation, and the nearest part of the outermost part of the building.

132 NZECP34:2001 also specifies minimum safe distances between conductors and buildings and other structures. These distances differ depending on the voltage of the line, and the length of the span between support structures. The tables within NZECP34:2001 are firstly based on generic and conservative span length envelopes. More detailed calculations can be undertaken to remove the conservatism. These detailed calculations require specialist engineering expertise. For spans longer than 350m, NZECP34:2001 would generally prevent the construction of buildings outside of the 12m Yard we propose.

133 Regulation 17(3) of the Electricity (Safety) Regulations 2010 states that various people commit a criminal offence if they fail to maintain the safe distances specified in NZECP34:2001, including a person who carries out or controls the construction, building, excavation, or other work and a person who owns or controls any line, works, fittings, building, structures, equipment, or machinery that is the subject of, or involved in, the infringing work.

Where NZECP34:2001 falls short

134 Minimum safety requirements in NZECP34:2001 neither seek to protect the integrity of the National Grid from the effects of third parties, nor prevent development (including sensitive and intensive development) from occurring directly underneath transmission lines. As discussed above, such development can constrain operational and maintenance activities on lines.

135 Further, NZECP34:2001 does not adequately account for EPR hazard contours.

136 Clause 5 of NZECP34 specifies four metres as the minimum distance that must be kept between live overhead lines and any part of any mobile plant or load carried by that plant (without Transpower's prior written approval). In my experience, the four-metre distance is very difficult to monitor and enforce. Mobile plant operators such as forklift drivers, concentrating on the load they are carrying, may not look up and be aware of live conductors as low as 7 metres above the ground.

137 While NZECP34:2001 is a good base document for the determination of safe clearances, experience has found that the document is not well understood by the public. Even relatively sophisticated commercial entities often do not understand compliance requirements, let alone lay people.

138 NZECP34:2001 requires a building to be no less than 8m from a pole and 12m from a tower. However, it is questionable whether this Code applies to temporary structures such as stacked containers, stored materials or structures such as railway sidings. In other words, NZECP34:2001 does not provide for all access, workspace, step and touch hazards, and other matters I have discussed above. A greater separation distance is required to address those many issues.

139 Usually Transpower's contractors will patrol every line and structure once a year. If an NZECP34:2001 violation is discovered, then the Transpower contractor will discuss this with the landowner and come back to check the problem has been rectified. If a regular patrol does not discover any minimum distance violations, a breach could occur the following week but may not be picked up until the next patrol (which could be a year later) or perhaps earlier if maintenance work occurs on the line in the meantime. This means that it can be very difficult to enforce the minimum distances in NZECP34:2001.

140 Provided the minimum vertical clearances are not breached NZECP34:2001 does not prevent mid-span underbuild. When considering the minimum vertical clearances, most people only consider the building in its finished form and do not consider the Health and Safety at Work implications of how the building is constructed or maintained.

CONCLUSIONS

141 The National Grid is enduring critical infrastructure, both locally and nationally. It is critical that there is a planning framework in place that will enable development and other asset maintenance to occur efficiently.

142 Preventing sensitive and incompatible activities from establishing under the transmission lines, along with controls on activities that will occur near lines will assist the National Grid to be reliable, and to have a managed environmental footprint while serving future generations.

143 It is critical that a preventative approach is taken to the management of the transmission corridors and a proactive approach is taken to ensure safety for high risk activities regularly occurring under National Grid lines.

Andrew Renton

29 September 2020

APPENDIX A – BASIC COMPONENTS OF AN OVERHEAD TRANSMISSION LINE

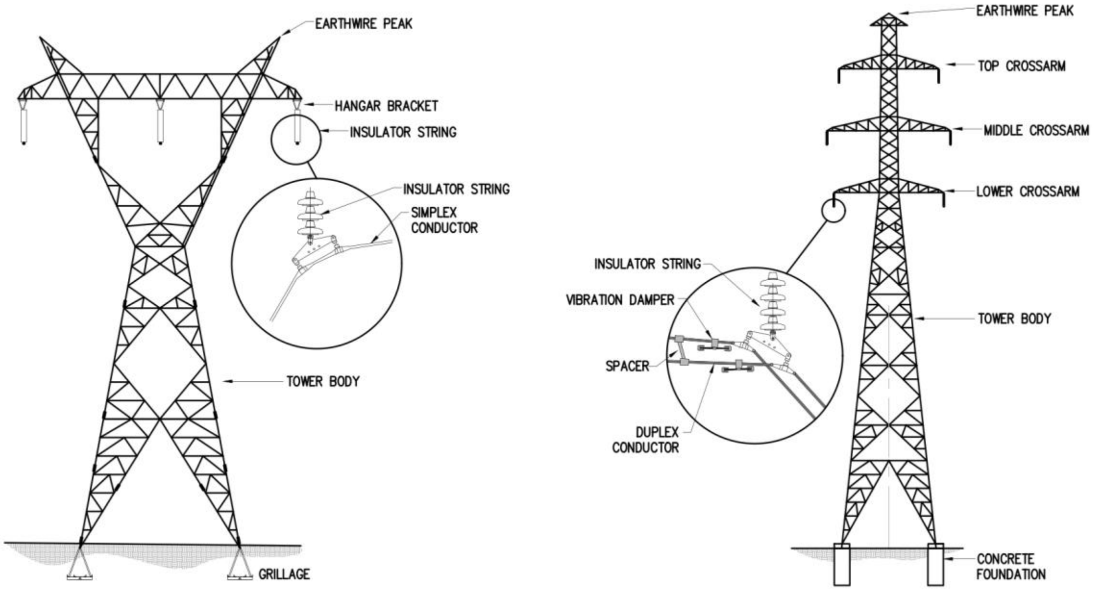

Figure 1: Tower component diagram

Conductors

1 Conductors (wires) are the physical conductive connections that transport live electrical energy at high voltages between substations (that is, between generators and substation supply points). Conductors usually consist of a number of aluminium stranded wires wrapped around an internal stranded steel support wire. In some cases aluminium or hard drawn copper alone is used, the latter being phased out as they age.

2 Conductors are arranged in different configurations and with different spacing between them depending on the structure types and circuit voltage. 220kV lines typically have a 5.5m, and 110kV lines a 3.25m, vertical conductor separation. Where conductors are duplexed (two conductors per phase), sub-conductor spacers are installed to separate the two wires to prevent the two parallel wires twisting and clashing, particularly in windy conditions.

Structures

3 Structures support the conductors and earth wires above the ground or other obstacles to maintain safe electrical clearances. Structures take many forms; for example, self-supporting lattice steel towers, concrete and wood poles, and steel tubular poles (monopoles). In the Waikato, the structures are predominantly steel lattice towers.

4 Transmission line structures are designed for specific line characteristics, including voltage, conductor size, conductor tension, climatic conditions (wind and snow) and topographic criteria (span length, line angle and tower height). Upgrading of line capacity or replacement of conductors typically requires the strengthening of towers (addition of steel members), raising of towers (insertion of complete tower sections), and in some cases complete replacement of the structure to ensure modern design standards are met.

Insulator sets

5 Insulators electrically insulate the live conductors from the earthed structures and prevent loss of energy to earth. Each phase on each structure requires an insulator set. The sets consist of insulators that may be manufactured from glass, ceramic porcelain or a composite material, and the steel hardware assemblies which attach the insulators to the structure and the conductors. In most cases the insulators are suspended from the pole or tower crossarms.

Foundations

6 Foundations form the base on which each tower sits. Foundations for steel lattice towers typically consist of three main designs:

6.1 Directly buried lattice steel (grillages), where a lattice steel configuration sits on a formed platform below the ground and the entire configuration is directly backfilled and buried;

6.2 Concrete encased buried lattice steel (grillages), where a corroded or understrength buried steel grillage is retrofitted with a buried concrete foundation; and

6.3 Formed concrete foundations that connect the tower by either a bolted base plate arrangement or a concrete encased steel connection.

7 Poles are generally directly buried.

Earth wires

8 Earthwires are used to bond all conductive structures together and form a protective shield to help mitigate lightning strikes on the conductors. In some parts of the Transpower network, fibre optics are encased in the earthwire and serve as a communication system by utilising an internal fibre capability and providing signalling for protection systems and a communication link between substations.

9 Not all assets have full length earthwires installed. They are, however, typically installed in at least the first 5 structures out from all substations and generating sites.