TRANSPOWER

# NORTH ISLAND GRID UPGRADE PROJECT

# AMENDED PROPOSAL

# ATTACHMENT B

# TREATMENT OF THE ARAPUNI – PAKURANGA LINE

## Analysis of the Effects of Removing the 110kV Arapuni – Pakuranga Line from Service

October 2006

# Contents



  

# 1 Introduction

Transpower's proposal for the construction of a new line from Whakamaru to Auckland utilises a large proportion of the existing 110 kV Arapuni Pakuranga Line (ARI-PAK).

There is extensive physical overlap between the new transmission line and the existing Arapuni-Pakuranga 110kV line, which has led Transpower to plan for the line to be decommissioned at least 18 months before construction of the transmission line commences.

Transpower analysis to date has assumed the ARI-PAK-A line would be removed from service to allow the safe and efficient construction of the proposed transmission line.

The proposed terminal point in Auckland for the cable sections of the Proposal and alternatives is now Pakuranga substation.

The amended proposal and the 220 kV alternative are currently intended to use the existing 2.3 km cable tunnel at Pakuranga.

The existing 110 kV cable would be removed 6-12 months prior to the new cables being commissioned.

In the Electricity Commission's draft decision it was suggested that the Arapuni-Pakuranga 110kV line could be kept in service until the commissioning of the proposal or 220 kV alternative.

The Commission analysis suggests that keeping the Arapuni-Pakuranga 110kV line in service allows the deferral of the construction of the 400kV by two years.

Transpower's submission on the draft decision to the Commission in June detailed a number of reasons why Transpower considered that the "clean build" option was the most appropriate, and for clarity these have been included here also.

# 2 Transmission Options to keep the ARI-PAK Line in service

There are two transmission approaches to keep the existing line in service until the new line is commissioned;

- relocation of the new line; or
- staging the construction of the new line.

With the relocation option the new line would be relocated to an alternative alignment that is clear of the existing line, either parallel and close to the proposed alignment or on a new alignment away form the proposed alignment enabling the ARI-PAK to remain in-service.

With the staged construction option the sections of the existing line would be bypassed using a temporary line, dismantled, the new line constructed, and the new line would be connected into the existing line to keep the ARI-PAK line in service.

Because of the low reactance of the new line compared with the existing 110 kV line the original 110 kV constructed sections and cable section will overload unless the current is limited using a tapped series reactor or phase shifting transformer.

The last section of the circuit is cabled and the risks and costs associated with keeping the cable section in service while installing the new cables is addressed in a separate section on cables.

# 3 Relocation of the line

To allow the existing ARI-PAK line to remain in service, the new transmission line could be relocated by either realigning the new line within the existing preferred route to achieve at least 45 metre separation to the existing ARI-PAK line route line, or by identifying and utilising another route, and defining an alignment within this new route.

# 4 Use of another route

The existing transmission route has been identified as the optimal route and is the preferred route. Using an alternate route is likely to cause cost increases, and if for instance the proposed eastern transmission route was used, the easement costs would increase and the line construction would also increase as this route is longer.

However, an equally material issue is the increased risk of the designation failing caused by both the increase in environmental, social and cultural effects associated with a less than optimal route, and the potential for an already saturated community to refuse to engage with Transpower in any consultation efforts. Transpower's relationship and reputation with local government will also be significantly damaged.

To find and designate an alternative route, Transpower would need to re-start its ACRE[1] process at the point at which it defined the route options within the preferred corridor.

Previously, two route options were defined and consulted upon to determine the preferred route. These route options were defined on the basis that the ARI-PAK line was to be removed, and therefore wasn't a constraint. Given that the ARI-PAK

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1 *The final route was determined by way of a process of identification and analysis of constraints at a broad level, narrowing down to corridors, routes within a preferred corridor, and identification of an alignment within a route. This is commonly referred to as the "ACRE" process, with the following stages:*

- *A Area (identification of study area, constraints and opportunities mapping)*
- *C Corridor (identification and confirmation of alternative corridors, ranking and selection of preferred corridor)*
- *Ri Route (selection and evaluation of alternative routes within the confirmed corridor, and present publicly for consultation)*
- *Rii Route (confirm the preferred route within the confirmed corridor, after public consultation)*
- *E Easement designation (identification and confirmation of the easement centreline and designation boundaries)*
- *D Documentation (prepare full documentation for lodgement with Councils)*
- *S Statutory Process (Lodge Notice of Requirement, Council Hearings, Environment Court appeal process (if required) and mediation, leading to confirmation of designation.)*

line would remain, a new route option within the corridor would need to be defined at a desk top level, taking the existing ARI-PAK line into account as a constraint within the corridor.

A preferred route would need to be identified through consultation, an alignment within that route identified, and the documentation for the notice of requirement and statutory processes completed. The total time required to complete this process is up to 4½ years. This will delay the commissioning of the new line and is a significant project risk.

The current transmission line route, and the alignment of the line within that route is the best solution with the least environmental and social impact. While Transpower is not required to choose the best route or alignment, any route/alignment it does choose will be assessed on the basis of its environmental impact, and Transpower will need to demonstrate that it has avoided, remedied or mitigated environmental effects adequately.

Inevitably, where the best route/alignment is not chosen, any other routes will present additional adverse environmental effects that may not be as adequately mitigated (for example, an alternative route may have more houses directly beneath, or may pass over more sites of importance to iwi). This presents additional risks that the designation may not be successful in the RMA process, on the basis that the effects cannot be appropriately mitigated.

In addition, the presence of an alternative and better route, which, while not relevant as a direct comparison, will complicate the assessment process and provide additional opportunity for the public to challenge Transpower's proposal.

Transpower will need to go back into the Waikato community to repeat a consultation process that recently created significant community upheaval. This will strain relationships with local authority staff and politicians, and most likely will destroy relationships with many landowners.

It is unlikely that any consultation efforts on another route will be successful with an already saturated community and tangata whenua. As the information gained through consultation is vitally important in informing Transpower's choice of route, this presents additional risks to the successful designation process in that key environmental, social and cultural effects may not be identified and therefore not appropriately mitigated.

# 5 Realigning the new transmission line section from Arapuni-Pakuranga within the existing route

An alternative to finding and utilising a new route is to realign the proposed NI transmission line within the existing preferred route to ensure a minimum of 45 metre separation between the existing ARI-PAK line and the proposed new transmission line.

To ensure this separation and manage crossings, the realignment is likely to involve over 50% of the towers on the existing alignment. This is a substantial change and would result in a cost increase, primarily as many more houses, places of work, and sites of significance would be affected by the line movement, and the property costs will be increased.

However, as noted above, the material risk is the increased risk of the designation failing caused by both the increase in environmental, social and cultural effects associated with a less than optimal alignment, and the potential for landowners to refuse to engage with Transpower in any consultation efforts to define tower locations. In addition, moving the alignment from that already agreed with many landowners is likely to adversely affect Transpower's credibility with the community and local government.

The existing alignment within the route has been carefully defined, in consultation with landowners, and threads a path through the constraints. Moving the alignment, but retaining it within the route, will greatly increase the number of violations of constraints, more so than the current alignment.

Once again, a less than optimal alignment presents increased risks to the success of the designation process. There will be additional adverse environmental effects that may not be as adequately mitigated - for example, an alternative route may have more houses directly beneath, may pass over more sites of importance to iwi. In addition, the presence of an alternative and better alignment, which, while not relevant as a direct comparison, will complicate the assessment process and provide additional opportunity for the public to challenge Transpower's proposal.

It will also increase the property acquisition risk as with increased constraints on tower locations, it will be harder to move towers to meet the individual request of landowners.

# 6 Staging of transmission line construction

A third option is to construct a by-pass for the ARI-PAK line where it follows the same path as the new transmission line, to allow the transmission line to be constructed while keeping the ARI-PAK line in service.
The overlaps in between the proposed transmission route and the Arapuni-Pakuranga line are extensive[2]:

There are 17 different sections of transmission line that conflict with the ARI-PAK line. Each section is an average length of 4.2km.
There are 10 crossings of the transmission alignment with the existing alignment.
228 towers on the ARI-PAK line (52%) conflict with proposed alignment.
71.1km the ARI-PAK line (49%) conflicts with the proposed new alignment.

The final alignment of the transmission line has been located to minimise crossing of constraints such as dwellings, places of work, archaeological sites, and ecological sites of significance.

Because of the extensive overlap between the proposed transmission line and the Arapuni-Pakuranga line, to retain the line in service during the construction of the transmission will in Transpower's view require the construction of a temporary bypass for the ARI-PAK which will need to be sited, where possible, to avoid these constraints as well.

[2] A conceptual design for a potential bypass has been undertaken, with all poles spotted, and the width and extent of any necessary temporary easement defined.

To achieve this, a bypass would have numerous sections of pole line, built parallel to the line route.

The cost estimate for the bypass could be up to $9.6 million with a possible property and consent cost of up to $11 million. There will be an additional but at present un-estimated cost associated with out of sequence work on the transmission line.

These costs are significant, but the material risks again are in the consenting processes under the Resource Management Act, and in the ability to purchase property rights.

Despite the by-pass being temporary, Transpower still has to meet its obligations under the RMA to avoid, remedy or mitigate adverse effects, and to examine alternatives, and the final by-pass alignment will still require authorisations under the RMA – resource consents and potentially a designation. The by-pass could be located either within or outside the exiting preferred route.

Where it is within the route, a constraints analysis exercise would need to be undertaken to define a temporary by-pass alignment. The existing ARI-PAK line would be a key constraint in this process, as would other environmental, social, cultural and physical factors.

Consultation with landowners would also be required to determine final alignment and tower positions. Once the centreline and easement was confirmed, resource consent applications or a notice of requirement for a designation would be prepared and lodged with the Council. This is likely to take approximately two years to complete, assuming appeals to the Environment Court.

Where it is outside the existing route, the boundaries of the route (study area) would need to be redefined, and alternative indicative alignment options defined and consulted upon to identify a preferred alignment. Once confirmed, detailed consultation with directly affected landowners would be required to determine final alignment and tower locations. Resource consents or a Notice of Requirement would be prepared and lodged with the Councils. This could take up to three years, assuming appeals to the Environment Court.

Once again, in either case, the current transmission alignment is the optimal alignment within the route. It has the least environmental impact and therefore the best chance of being successfully consented. A less than optimal alignment presents increased risks to the success of the resource consent/designation process. There will be additional adverse environmental effects that may not be as adequately mitigated. The presence of an alternative and better alignment, which, while not relevant as a direct comparison, will complicate the assessment process and provide additional opportunity for the public to challenge Transpower's proposal. In addition, defining an alignment outside the preferred route will increase the need for further public consultation, and introduce landowners into the process that were previously not affected by the route. This in turn presents more risks to the resource consent/designation processes.

Despite the by-pass being temporary, it will also require property rights. These have been estimated to be up to $11 million, but the temporary nature of the bypass make this difficult to estimate. This cost has not been considered in the Commission analysis, but the more significant point is that introducing a by-pass means Transpower may have to buy numerous additional property rights. These property rights must be obtained before construction on the substantive project, the North Island transmission line, can commence. The whole of this program can be put at risk through the refusal of a single landowner to have a pole on their property. When taken through the compulsory acquisition process, Transpower will be forced to justify the need for these structures, and this will inevitably be influenced by the existence of an alternative construction strategy that does not need poles, nor associated properly rights.

# 7 Staged dismantle of the ARI-PAK Line- Engineering Perspective

The preceding text was largely focussing on the environmental and property aspects of retaining the line. There are a number of construction issues with the staged dismantling of the ARI-PAK line. The following issues relate to lacing interfering segments of the ARI-PAK-A line with segments of the new line during off peak periods, then operating the segments of the new line at 110kV during peak periods.

It is assumed that peak periods pertain to both Winter and Summer peaks. For the purposes of this analysis it is assumed the ARI-PAK 110kV circuit would be required for operation in the periods of June-July-August and January-February (total of 5 months per year).

Given the above, construction periods through the overlapping sections of line are limited to March to May (3 months) and September to December (4 months). September and October are historically periods when both the weather and farming operations limit access, therefore in the majority of cases the second window for construction is reduced to November and December (2 months).

During the available construction periods identified above complete sections of line would need to have the ARI-PAK line dismantled, foundations installed (including curing time), towers erected, stringing of at least one circuit completed, connection to the ARI-PAK line and commissioning at 110kV completed. This is practical for short sections of line, however not for large sections of line.

As previously noted, there are 17 overlapping sections of line that would need to be considered for staged replacement. These sections are based on safe working clearances for construction. These vary in length between 0.5 to 12.4 kilometres in length.

Each of the above 17 segments require the insertion of a heavy strain tower at each connection point to facilitate the transition between to transmission conductor configuration/tensions and the existing ARI-PAK-A conductors. These are additional to Transpower's proposed design, and may be challenged through the RMA process as they would be a heavy interim solution remaining in place for the life of the line.

Staged replacement of the interfering segments of the ARI-PAK-A line brings with it a significant loss of construction efficiency. Construction becomes a juggle between available resource, availability of access to land, and available outage windows.

The loss of efficiency, and the limited outage windows (non-peak periods) are likely to add a further year to the construction programme, therefore construction would need to begin a year earlier to meet the same commissioning dates.

The staged replacement of the interfering segments would cost approximately $22 million for the transmission line portion. This includes additional towers, construction costs, strengthening or replacement of ARI-PAK-A terminal towers, construction efficiency losses, and additional direct Contractor project overhead costs due to an extension of the programme.

A larger risk however is the possibility of delay in returning the ARI-PAK line to service once removed to meet the peak periods, especially on the long sections. Construction timeframes through the overlapping portions would be very tight, and the lock-out or delay by one or more landowners is a very real possibility.

Progressively replacing the existing double circuit simplex line with a double circuit triplex will progressively decrease the reactance of the line and the current flow will increase. Phase shifting transformers or large tapped reactors would need to be installed to limit the current on the line at a cost of $7-10 M.

# 8 Cable route into Pakuranga

The original Transpower proposal had the initial cables terminating at Otahuhu (OTA) substation. A change to the original proposal is that it is now proposed that the initial cables will now take an eastern route and be terminated at Pakuranga (PAK). This is common for all four major options involve 220 kV cables into PAK.

There is an existing cable tunnel for the last 2.3 km of the route into PAK that contains a single 110 kV cable

Utilising the existing cable tunnel into PAK is the most cost effective approach. Providing separate cable routes down roads etc is more costly because of
distance; and
installation costs.

Initial estimates for alternative routes are at least 1 km longer than the tunnel route. This translates to about $20M (2 cables* 1km*$10M/km).

Transpower's cable installation experts have inspected the tunnel and have provided advice as indicated below. If the tunnel is not used and an alternative is to lay one cable directly above the existing tunnel and one on the longer route via roads as described above. This would reduce the cost difference to about $10 M.

The install time is estimated to be one year for two cables and about 6 months if only one cable is installed in the tunnel, the time includes the civil works required to modify the tunnel and additional jointing bays to accommodate the 220 kV cable. This would potentially impact the summer and possibly the winter preceding the commissioning of a major augmentation into Auckland. The tunnel would have to be modified. Detailed comments of the use of the cable tunnel have been provided separately to the Commission.

## 8.1 Detailed comments on existing ARI PAK cable tunnel for 220 kV cables

The existing ARI-PAK cable tunnel has an internal diameter of 1.8m with three jointing chambers (nominally 8 x 4m) at approximate chainages of 470m, 1,250m & 1,735m and is currently occupied by a single 110 kV circuit comprising 500mm$^2$ Aluminium conductor XLPE insulated power cable (approximate mass 10kg/m). The rating of the cables is limited to 735 A by the direct buried sections at each end of the tunnel. At these positions the cables are flat spaced with a separation of 650 mm at a depth of 1 m. The rating in the tunnel is 786 A based on still air temperature of 30 deg C. The circuit is single point bonded at the Pakuranga end with one set of joints in joint chamber no 2.

Because of the extremely limited space and the assumption that to achieve the required rating a 2,500mm$^2$ copper conductor XLPE insulated power cable (approximate mass 28kg/m) will be needed. Preliminary investigations indicate that the existing 110kV cables and support steelwork would have to be removed prior to the installation of the heavier 220kV cables. However, we do believe that this being the case it would be possible, but difficult, to install a double circuit.

As previously stated space is extremely limited, particularly when installing the second circuit and this will probably limit the level of mechanisation that can be employed and the use of extensive manpower would appear to be the only feasible installation technique. Further complicating matters no provision was made for this process when the tunnel was originally specified, i.e. there is no overhead I beam running track.

The tunnel is clearly a confined space and therefore significant OSH issues will have to be addressed. By way of comparison the National Grid Tunnel between Elstree and St. Johns Wood in London (which was designed to accommodate two circuits) has an internal diameter of 3.05m.

Assuming that it will not be possible to (a) transport cable drums containing more than 700m of cable and (b) physically install a single length through from one end of the tunnel to the other it will be necessary to introduce one additional jointing chamber in the section between current chambers 2 & 3 and excavate down and open the exiting ones to facilitate cable pulling.

All the existing jointing chambers would probably have to be extended in length to accommodate 220kV joints (these require at least 7.5m straight length) and support structures as well as provide adequate segregation, i.e. the joints would not share the same space.

To achieve diversity between cables, they will be installed in separate trenches, but putting the cables in one tunnel increases the risk of multiple failures, and could well be an issue. However, installing multiple cables in larger tunnels is common overseas.

Should any fault occur in either a cable or joint repair options would be severely limited because the lack of space in the existing tunnel. This would probably preclude the introduction of repair joints. It would therefore be necessary to remove the damaged cable section in its entirety and re-jointing within the chambers. This would be a long and involved process that could require re-excavation, etc.

Policies for access to the cable tunnel will have to be established. National Grid in the UK have recently decided that they will not allow access to their cable tunnel whilst the circuits are operating, this may well be overly conservative but does give an indication of the practices being implemented in other jurisdictions.

The above discussion indicates the implications in terms of costs for a risk-free environment. Allowance for risk and the ability to actually get sufficient capacity out of Arapuni further reduces the desirability of trying to keep these circuits in service up to the commissioning date of a major augmentation into Auckland. We will comment on this further in the technical report and the amended proposal.

# 9 Arapuni-Pakuranga Conclusion

Relocating the North Island transmission line to allow the Arapuni-Pakuranga 110kV line to remain in service, either through an offset within the exiting route or through use of the Eastern Route, increases project costs but just as importantly it increases project delivery risk significantly. A less than optimal route presents increased risks to the success of the designation process. There will be additional adverse environmental effects that may not be adequately mitigated, and the presence of an alternative and better alignment, which, while not relevant as a direct comparison, will complicate the assessment process and provide additional opportunity for the public to challenge Transpower's proposal.

Both options will incur additional costs. The additional costs are of the order of $20M for bypass (excluding project delivery risk) and circa $26M for re-alignment of the easement (excluding project delivery risk). Phase shifting transformers or large tapped reactors would need to be installed with the bypass options to limit the current on the line at a cost of up to $10M.

The staged replacement of the interfering segments is a theoretical possibility however has a number of draw backs that include substantial costs implementing the options, and substantial risks to both the project and the overall objective - security of supply to Auckland.

In addition to the transmission lines costs and risks there is also the potential increase in cable costs at the Pakuranga end that could increase the overall project cost between $10 and $20M.

# 10 Temporary Generation as a Deferment Option

An alternative to keeping the line in service is the installation of temporary generation in the Auckland area that would supply the 60 MW of transmission that was previously supplied via the ARI-PAK line. This alternative would require the installation of temporary generation to cover the winter and extreme summer periods; 16 weeks in the winter and 8 weeks in the summer.

There would be one off costs setting up the connections at substations, and these costs are additional to the generation estimates shown below. The one off costs include enabling costs such as new bus connection, circuit breakers, auto synchronisation equipment, circuit breaker protection, SCADA connections etc, and are likely to cost up to 200K per generator.

The costs for the generator can be split into the fixed and variable component. The fixed costs include costs such as the generator, transformer, and cable daily hire, standby technical support, and the establishment and disestablishment costs such as transport and commissioning/decommissioning the generators. The variable costs include fuel cost and the generator running costs.

As a minimum, the generators would need to be test run approximately 4 hours per week, but would only be run continuously if the Otahuhu CCGT or another large plant item is unavailable at peak load periods when there would be a supply shortfall. The optimistic case assumes that the generators run 4 hours per week and the pessimistic case assumes that the generators would operate for 30 hours per week in the winter and 20 hours per week in the summer.

The fixed and variable costs for the generation are shown in the table below. It is assumed that the generation will be installed on a temporary basis only for the periods shown below. The costs are based on quotes Transpower received early this year for the generators that were installed at Blenheim this winter to enable the 2nd BLN-STK circuit to be strung.

| Components | Winter (no contingency) | Summer (no contingency) | Winter (contingency) | Summer (contingency) |
|---|---|---|---|---|
| MW | 10 | 10 | 10 | 10 |
| Generator (daily rate) | $10,000 | $10,000 | $10,000 | $10,000 |
| Transformer (daily rate) | $2,000 | $2,000 | $2,000 | $2,000 |
| Cable (daily rate) | $1,200 | $1,200 | $1,200 | $1,200 |
| Generator Hire | $2,032,800 | $2,032,800 | $2,236,080 | $2,236,080 |
| generator setup | $320 | $320 | $320 | $320 |
| generator shutdown | $240 | $240 | $240 | $240 |
| Transport | $0 | $0 | $0 | $0 |
| *Total Fixed Cost per generator* | $2,033,360 | $2,033,360 | $2,236,640 | $2,236,640 |
| | | | | |
| Onsite tech | $64,000 | $64,000 | $64,000 | $64,000 |
| Accommodation - (onsite tech) | $16,000 | $16,000 | $16,000 | $16,000 |
| | $80,000 | $80,000 | $80,000 | $80,000 |
| | | | | |
| *Cost for 6 X 10 MW generators* | **$12,280,160** | **$12,280,160** | **$13,499,840** | **$13,499,840** |
| | | | | |
| Fuel cost per generation time | $200,326 | $75,122 | $1,502,448 | $375,612 |
| Running cost per generation time | $51,200 | $19,200 | $384,000 | $96,000 |
| *Total variable* | $251,526 | $94,322 | $1,886,448 | $471,612 |
| | | | | |
| *Running Cost for 6 X 10 MW generators* | **$1,509,158** | **$565,934** | **$11,318,688** | **$2,829,672** |
| | | | | |
| **Total cost for temporary generation per year** | **$13,789,318** | **$12,846,094** | **$24,818,528** | **$16,329,512** |
| | | | | |
| Generation time (weeks) | 16 | 6 | 16 | 6 |
| operation time per week | 4 | 4 | 30 | 20 |
| Generation operation time | 64 | 24 | 480 | 120 |
| Onsite support (days) | 80 | 30 | 80 | 30 |

# 11 Summary

The cost of keeping the ARI-PAK line in service by means of diversion is of the order of:

| | |
|---|---|
| Diversion costs | $9.6M |
| Property costs | $11M |
| Cable costs | $10-$20M |
| Phase shifting transformer(s) | $7-10M |

An optimistic assumption of $37M is representative of the direct costs but excludes the delivery risks. These could present reliability risks to supplies as the timetable would be critical and any one of many affected land owners would have the potential to cause construction delays.

The use of emergency diesels is estimated to cost between $26-40M, depending on the extent to which they are required to operate. While the lower end of this range is much more likely, the overall benefit of adopting this approach is likely to be relatively small in terms of the deferral benefits than can be achieved.

Transpower does not favour the use of emergency diesels to mitigate a known issue that can be avoided by prudent planning. The perception of Upper North Island loads being dependent on emergency generation carries, in Transpower's opinion, reputational risk for both the country and Transpower. Transpower notes that emergency diesels would be required around a major international event in Auckland.