CENTRAL PARK – WILTON B RECONDUCTORING

Attachment B
OPTIONS AND COSTING REPORT

Keeping the energy flowing




TRANSPOWER

Transpower New Zealand Limited The National Grid

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1 Introduction

This document provides the long list of options we considered for this project, and how we evaluated these options in order to determine our short list. It is one of the supporting attachments for our main report ("Central Park – Wilton B reconductoring listed project application").

2 Long List options

We initially compiled a long-list of options which fell into 4 broad categories:

- dismantling
- do nothing (maintain existing assets and patch as required)
- piecemeal replacement (maintain existing assets and replace entire spans over time)
- non-transmission solutions
    - new generation
    - demand side alternatives
- transmission solutions
    - "like for like" conductor replacement
    - different capacity conductors (ranging from 165MVA to 313MVA)
    - enhancing the A line (and dismantling the B line)
    - a new line and/or duplexing
    - underground cable instead of overhead lines

A public long list consultation and non-transmission solution request was issued in April 2015 and received one response, from Wellington Electricity, which was generally supportive of reconductoring. Their short term load forecast projections are lower than those of ours, but they noted that a conservative approach is prudent over the asset lifespan.

2.1 Key requirements and assessment criteria

The long list was evaluated using the following key requirements and assessment criteria:

1. Fit for purpose
    - The design will meet current and forecast energy demand
2. Technically feasible
    - Complexity of solution
    - Reliability, availability and maintainability of the solution
    - Future flexibility – fit with long term strategy for the Grid
    - Ideally the design can be staged and / or have flexibility to preserve options for future changes
3. Practical to implement
    - It must be possible to implement the solution by the required dates
    - Implementation risks, including potential delays due to property and environmental issues
4. Good electricity industry practice (GEIP)
    - Consistent with good international practice
    - Ensure safety and environmental protection
    - Accounts for relative size, duty, age and technological status
    - Technology risks

5. Provide system security (additional benefit resulting from an economic investment)
    - Improved system security
    - System operator benefits (controllability)
    - Dynamic benefits (modulation features and improved system stability)
6. Indicative cost
    - whether an option will clearly be more expensive than another option with similar or greater benefits

2.2 Evaluation of the longlist options

The appendices contain a complete list of all the long list options we evaluated. The results of our analysis are summarised below.

- × **Dismantling** the line was considered in the full long list to demonstrate the benefit of keeping the line. The limited capacity of the existing A line as an alternative supply to Central Park would result in lost load which is valued well in excess of the reconductoring cost. We have estimated the value of this lost load to be in excess of $30m (depending on the demand scenario). Customers would also be exposed to "N" security conditions which is not consistent with the Grid Reliability Standards. So this option was not taken forward to the short list.
- × **Do nothing** is not a viable option. Our asset condition assessment has determined that the Zebra section of the line has reached replacement criteria. There would be numerable patches required and in some areas, patching would not be possible as cranes could not reach.
- ✓ **Piecemeal replacement** is plausible. This would involve close condition monitoring and replacing entire spans, either singly, or in small groups, over time. It would defer some cost, but would be more expensive than reconductoring the whole line because there are set-up costs each time reconductoring is undertaken.
- × **Non-transmission solutions** are not plausible. We are not aware of any new (large scale) generation planned in the area nor of any large enough demand side options (our consultation process raised no alternative options).
- ✓ **Transmission solutions** considered reconductoring options. We evaluated a range of potential conductors for the B line as well as enhancing the A line (and dismantling the B line).

3 Options evaluated for the short list

The B line is currently duplex Zebra with excess transfer capacity for the foreseeable future (using our latest demand forecasts).

As demand will be adequately supplied by a simplex configuration we have only considered simplex further. An advantage of replacing duplex conductor with simplex is that tower loadings are lower and so no tower strengthening is required for these options.

To determine which conductors to evaluate in the short list we started by considering the cost of a wide variety of conductors. Our cost estimates for the full list of options considered the following:

- Transpower Enterprise Estimating System (TEES) costings for construction using specific conductor types, and
- Transpower Business Case (BC1+) estimates prepared for the RCP2 application for access costs, property and regulatory costs, foundation strengthening and tower strengthening.
- Maintenance costs are assumed to be zero due to the installation of a new conductor

A more accurate "Solution Study Report Plus" (SSR+) was subsequently undertaken for the preferred option (Sulphur). We have adjusted the "old" costs for the other conductor options to reflect this new cost information[1]. The new SSR+ Sulphur cost (present value) was approximately $1million lower than the "old" cost estimate, and in our view the relative cost differences between the options will not have changed materially in light of the SSR+ study.

In addition to the capital costs we have also considered the potential benefits resulting from lower electrical losses. Larger conductors that run at lower temperatures will result in lower electrical losses. We have considered potential losses over 40 years using our "P50" expected demand forecast. These have been valued at $100/MWh and discounted using a 7% discount rate to determine the present value of losses associated with each option.

Table 3-1: Conductor cost comparisons (P50 estimates)

Option	Winter MVA	Capital cost PV ($mill)	Losses PV ($mill)	Total present value cost ($mill)
ACSR Chukar (@75°C)	313	10.8	1.5	12.3
ACSR Zebra (@90°C)	217	9.0	2.1	11.1
ACSR Goat (@75°C)	168	8.9	2.5	11.3
AAAC Sulphur (@70°C)	238	9.1	1.7	10.8
AAAC Selenium (@90°C)	229	8.9	2.0	10.9
AAAC Phosphorous (@90°C)	199	8.8	2.3	11.1
AAAC Nobelium (@90°C)	165	8.7	2.7	11.5

As can be seen, with the exception of Chukar, all the conductor options have similar costs.

We have further assessed the suitability of the conductors against each other using a variety of other considerations to refine the list of options to be considered in the short-list. A concept design study was undertaken considering the loads on structures, modelling the clearances and swing distances, but not foundation strengths or construction access requirements. This is shown in the following table.

[1] New cost option A = New cost Sulphur * (Old cost option A / Old cost Sulphur).
Except for Zebra (one of our other shortlisted options) where we have conducted a desktop estimate of the new vs old cost differences.

Table 3-2: Conductors evaluated

Simplex Conductor	Type	Meets future load scenarios?	Future TTU upgrade possible?	Conductor weight and tower load	Swing impacting on property rights	Suitability to environment	Spare conductor stock	Short list?
Chukar (@75°C)	ACSR	Yes	Yes	Greatest applied tower load which requires greatest quantum of foundation strengthening	No	Yes	Yes	✘
Zebra (@90°C)	ACSR	Yes	No	Lower tower load than existing duplex Zebra	No	Yes - three layers	Yes	✓
Goat (@75°C)	ACSR	No	Yes	Greater swing than Zebra	No	OK- 2 layers	Yes	✘
Sulphur (@70°C)	AAAC	Yes	Yes	Lower tower load than existing duplex Zebra	No. Effects contained within existing corridor – no apparent injurious affect	All Aluminium construction has longer lifespan than ACSR	Yes	✓
Selenium (@90°C)	AAAC	Yes	No	Lower tower load than existing duplex Zebra	Yes. Encroachment outside existing corridor on some spans – Injurious affect risk assessed in relation to land use. ~$680k	All Aluminium construction has longer lifespan than ACSR	No	✘
Phosphorous (@90°C)	AAAC	Yes	No	Lower tower load than existing duplex Zebra	Encroachment outside existing corridor on some spans – Injurious affect risk assessed in relation to land use. ~$590k	All Aluminium construction has longer lifespan than ACSR	No	✘
Nobelium (@90°C)	AAAC	No	No	Lower tower load than existing duplex Zebra	Encroachment outside existing corridor on some spans – Injurious affect risk assessed in relation to land use. ~$670k	All Aluminium construction has longer lifespan than ACSR	Yes	✘

Higher levels of conductor swing are a risk for Transpower as a wider corridor is likely to fall outside our statutory right to operate the existing lines under the Electricity Act. This would necessitate the acquisition of easements to enable the additional corridor. This will add significant time and cost to the project, particularly given that the cost to acquire easements would include compensation to remove commercial forestry that adjourns the existing line.

For these reasons, the smaller conductors including Selenium, Phosphorous and Nobelium were not included on the short list.

Goat was removed because it doesn't meet future load growth scenarios, and has a greater swing range than Zebra.

Chukar was excluded because it has a greater tower load requiring foundation strengthening.

Both Sulphur and Zebra conductors meet all of our requirements – hence they have been short-listed for further analysis.

- Simplex Sulphur AAAC @ 70^{o}C has a rating of 238 MVA, so use of this conductor in simplex configuration will not reduce the overall line rating and this conductor could also be thermally upgraded at some later stage, if required.
- Simplex Zebra ACSR @ 90^{o}C has a rating of 217 MVA and would also meet our prudent demand forecast to 2040, although this conductor has no flexibility to be further thermally upgraded.

In addition to these options we have retained a Base case option where it is assumed that the existing line is maintained with the worst sections progressively replaced over a longer period of time (piecemeal replacement). Each section (conductors between strain towers) would be replaced with Sulphur Conductor.

The Base case maintenance costs are based on annual inspections and replacement of 3 tower spans (36 wire spans) every two years with minor repairs undertaken during the intervening year.

In practice, piecemeal replacement may be effective where the corrosion is concentrated in a smaller number of line sections, however in the CPK-WIL B line the corroded sections are spread throughout the line which would increase the failure risk. Despite this, we retain this option in the analysis as our point of comparison- Base case.

4 The short list

The short list to be evaluated using cost-benefit analysis is therefore:

Table 4-1: Short list options

Base Case (piecemeal replacement)
Reconductor (simplex Sulphur 70°C)
Reconductor (simplex Zebra 90°C)

A.1 Long list of options

Non transmission options

Option	Description	Shortlisted?	
Demand side			
Load shedding SPS	Install a Special Protection Scheme (SPS) that sheds load at Central Park.	X	This option was rejected it does not meet the need. The quantum of load shedding required would be in excess of 120 MVA of site capacity.
Load Shifting	Load shifting via distribution network.	X	This option was rejected it does not meet the need. The distribution network does not have the capacity to shift 120 MVA of site capacity
Demand Side Response (DSR)	Contract consumers to participate in a demand side response program that will reduce load at Central Park during peak load times.	X	This option was rejected it does not meet the need. The RFI consultation paper did not receive any demand side interest. The time frame for calling DSR is currently 2 hours. This is not fast enough to prevent overloading during unplanned circuit outages and therefore the DSR would have to be called pre contingency. This option may be more practical for a short period of time to cover construction or consenting delays.
Supply side			
New market generation	New generation connection at Central Park	X	This option was rejected it does not meet the required timeframe. We are also not aware of any generation proposals.
Embedded Generation	New generation embedded within the Wellington Electricity network behind Central Park	X	This option was rejected it does not meet the required timeframe. We are also not aware of any generation proposals.
Generation Redispatch	Entering into a contract with a generator, or generators, to procure generation services to defer transmission investments	X	Not available. Westwind is reliant on weather conditions for generation.
New distributed generation at Central Park	While we are not aware of any proposals large scale adoption of distributed generation technologies may reduce the load at Central Park.	X	This option was rejected it does not meet the required timeframe. It is unlikely to be developed in sufficient time to meet the timing of the need for investment. Solar may not have sufficient contribution at peak load times to provide an appropriate level of security.
Increased sub-transmission capacity	Increased Wellington Electricity sub-transmission capacity between Wilton and Central-Park distribution areas	X	This option was rejected. It does not meet the required timeframe. A new 33kV cable or O/H line would be required and would need to transfer ~120 MVA of load.

Transmission Options – enhance existing assets

Option	Description	Shortlisted?	
Maintain capacity of Central Park–Wilton B line			
Do nothing	Keep existing conductor and patch as required	X	Condition assessment indicates that we will soon be removing more and more sections of the line, such that replacement is likely to be more economic. There are some sections of this line where patching would be infeasible due crane access
Piecemeal replacement	Replace spans of existing conductor over time	✓	In this option we continually monitor condition of the conductor and replace as required. Eventually the entire line would be replaced. Effectively, this option weighs the reconductoring set-up costs with capital deferral costs
Reconductor with like-for-like or modern equivalent conductor	Replace existing conductor with like-for-like or modern equivalent conductor	X	Aluminium coated core is preferred for ACSR conductors
Increase capacity of Central Park–Wilton B line			
Variable line rating	Implement variable line rating methodology to gain a higher capacity rating particularly during peak load times.	X	Does not address the conductor condition
Dynamic line rating	Implement dynamic line rating to allow greater flow during cold, wet or windy weather.	X	Does not address the conductor condition
110 kV reconductoring	Re-conductor the existing line to a higher rated conductor.	X	Demand forecast doesn't justify additional capacity. Towers may need strengthening. Other assets may need replacing with greater capacity versions. Value limited by transformer capacity
Decrease capacity of Central Park–Wilton B line			
110 kV reconductoring	Re-conductor the existing line to a lower rated conductor.	✓	This option was included in the short list because it meets all requirements. Conductor options have been considered as sub options.

Transmission Options – reconfigure existing assets

Option	Description	Shortlisted?	
Reconfigure Central Park–Wilton B line			
Reconstruct line for 110 kV operation (not 220 kV as at present)	If conductor is replaced use 110 kV insulators rather than 220 kV as at present	X	This option was not included in the short list. It incurs extra costs compared to 110kV reconductoring and removes any future flexibility to move Central Park to 220kV
Convert line to 220 kV operation	This would double the (power) capacity of the circuits.	X	Demand forecast doesn't justify additional capacity. Would require considerable associated works at Central Park, Wilton and West Wind
Convert some or all sections of line to buried cable	Much of the terrain does not make this realistic.	X	Very expensive. Undergrounding is not economically justified when compared to reconductoring costs and there are no other justifications for the added costs.
Bond the two circuits	Connect Central – Park Wilton 1 & 2 together, creating one circuit of double capacity	X	Does not address the conductor condition n-1 no longer maintained because if new circuit fails the A line may overload
Reconfigure Central Park–Wilton A line			
Operate one CPK-WIL A line circuit at 33kV	Would provide a link between the WIL 33 kV and CPK 33 kV	X	Does not address the B line condition and 33 kV transfer capability is not sufficient to supply current CPK load of ~190 MVA . We would still need to reconductor the B line
Reconductor CPK-WIL A line at higher capacity	The Central Park – Wilton A line has lower rating than the B line, and will overload first	X	Does not address the issue of the B line condition. This option was rejected because of the cost (>$40m) and lengthy implementation timeframe to acquire property rights(5-10 yrs) Towers on the A line are at maximum load now and would need to be upgraded. The A line has significant underbuild.
Dismantle Central Park – Wilton A line	Would require uprating of Central Park Wilton B line to keep n-1 and possibly a 110 kV bus at Central Park	X	This option was rejected because it does not meet the need. Dismantling the A line necessitates the added cost of a 110 kV bus at CPK (>$18m) and we would have to reconductor the B line.
Dismantle Central Park–Wilton B line			
Dismantle Central Park–Wilton B line	Cental Park would be supplied through only one circuit. No West Wind connection.	X	This option was rejected as the supply to CPK using only the CPK-WIL A line would result in lost load valued at >$30m. The capacity of the A line (limited by the transformer capacity) is currently 120MVA with no alternative supply to meet CPK demand. Central Park would not have sufficient supply, even at n security. Would require additional investments.
Dismantle Central Park–Wilton B line and upgrade A line.	Cental Park would be supplied through only one circuit. No West Wind connection.	X	This option was rejected because of the cost (>$40m) and lengthy implementation timeframe to acquire property rights (5-10 yrs) Towers on the A line are at maximum load now and would need to be upgraded. There is also significant underbuild that would complicate obtaining property rights.
Dismantle part of Central	Dismantle part of Central Park–Wilton B line, leaving West Wind connected to	X	This option was rejected because it cannot meet current capacity requirements without load reduction or costly (>$40m) upgrade of the A line. We would

Park–Wilton B line	Wilton or Central Park by the remainder but not both.	still need to reconductor 50% of existing B line to WWD. Cental Park would be supplied through only one circuit.

Transmission Options – new assets

Option	Description	Shortlisted?	
New circuits			
New Overhead circuit(s)	New overhead circuit(s) between some combination of Central Park, West Wind and Wilton.	X	This option was rejected because of the cost (>$30m) and lengthy implementation timeframe (5-10 yrs) The designation for a new route would require consideration of alternatives, probably making it unachievable, unless the existing routes' capabilities were exhausted. A 110 kV bus or transformer rearrangement would be required at Central Park
New cable circuit(s)	New underground cable circuit between some combination of Central Park, West Wind and Wilton	X	This option was rejected because of the cost (>$40m) and lengthy implementation timeframe (5-10 yrs) Likely to be prohibitively expensive
New work at existing substations			
110 KV bus at Wilton	Would allow greater capacity in event of circuit outage	X	This option was rejected because it is too costly (>$18m) and does not address the conductor replacement.
Convert West Wind and/or Central Park to 220 kV	In association with operating Central Park–Wilton B at 220 kV	X	Uneconomic. This option was rejected because it is too costly to convert CPK and WWD to 220kV and does not address the conductor replacement. New 220/33 kV transformers would be required as well as 220 kV bus work
New Grid exit point			
New GXP to offload Central Park	Would require transmission and distribution connections	X	This option was rejected because of the significant cost(>$25M) and long implementation time (> 5 yrs) Obtaining designation would be difficult.
Grid reconfiguration			
New Grid Reconfiguration SPS	Reconfiguring the network automatically to remove post-contingency constraints	X	This option was rejected because it would require reduced load at CPK or alternative supply such as A line capacity upgrade or new cable