Arapuni Bus Split Net Benefit Test – Supporting Information

The purpose of this document is to provide background information on the Net Benefit Test for the Arapuni bus split. This information will be referenced in an industry teleconference.

Why did we implement the Arapuni Bus Split?

The Waikato 110 kV network (see below regional schematic) operates in parallel to the 220 kV network. In 2010 it became increasingly difficult to manage a 220 kV circuit contingency. This situation was resolved in real time by splitting the system at Kinleith which reduced security there. To improve this situation a bus split was installed at Arapuni in 2010, using the bus coupler CB 48. This split meant the Arapuni:

- North bus connected the two circuits to Hamilton, two circuits to Hangatiki and one circuit to Bombay with generating units 1-4
- South bus connected the two circuits to Kinleith
- Generating units 5-8 were selectable between the north and south bus.

Minimum generation is required on the south bus to manage voltage and thermal issues post contingency. In addition, the configuration is temporary, requiring bus disconnectors to be bypassed.

With the recent commissioning of the Pakuranga-Whakamaru circuits the 220 kV circuit contingency was no longer unmanageable. However, there was still economic value in keeping the bus split open. The net benefit test indicated it was worthwhile prevailing with the split until the Wairakei-Whakamaru C line and Tarukenga interconnecting transformer replacement projects were completed.

With these upgrades now commissioned we are re-evaluating the future need for a bus split.

Why are we revisiting the Net Benefit Test?

We advised with the results published in October 2012 that we would review the net benefit test following the commissioning of the Wairakei-Whakamaru C line and the new Tarukenga interconnecting transformers. Both projects relax the constraints on Arapuni generation and are now commissioned.

In addition, the new Remedial Action Scheme (RAS) software has been implemented by the System Operator. This software has resulted in the reduction of pre-contingency constraints on Arapuni generation.

We have performed the test three times in the past:

1. To confirm the initial installation of the Arapuni bus split was economic
2. Following the commissioning of the North Island Grid Upgrade project to confirm the ongoing use of the Arapuni bus split
3. Following the outage of the Arapuni T1 transformer to confirm the temporary closure of the split until the transformer was returned to service.

November 2014
The documentation of those tests can be found at the following link:

https://www.transpower.co.nz/news/grid-configuration

What question is the Net Benefit Test answering?

We implemented the split in a temporary manner by bypassing three bus disconnectors making the isolation of equipment for maintenance or repairs difficult. In order to make the split permanent we would need to make it consistent with our substation design standards. This would cost $570k.

We have applied the net benefit test to see if spending this additional capital can be justified. Given that we will not continue with the existing configuration at Arapuni we have two options. Either we spend a:

- relatively small amount now to return the Arapuni bus to its pre-split configuration
- larger amount of money to make the split permanently operational and continue to benefit from reduced generation constraints at Arapuni and loss benefits for the next two years.

We have only considered the 2015-2017 period in our net benefit test as future developments will largely eliminate the benefits of the split.

Options considered

1. Close Arapuni bus split permanently, this option has a capital cost of $26,000
2. Invest to install Arapuni bus split permanently, this option has a capital cost of $570,000.

Assumptions

The assumptions used for the Net Benefit Test calculation are the same as for previous versions of the test.

- Losses and generation constraints have been valued based on marginal costs used in our evaluation of the Bunnythorpe-Haywards A and B conductor replacement Major Capex Proposal1.
- Value of lost load is $20,000/MWh.

Some assumptions are different from past tests to reflect changes to the system or ensure the change in conclusion is robust.

Previous tests have assumed a five minute off load time is required on the Arapuni-Hamilton circuits for the outage of a parallel circuit or 220 kV Hamilton-Whakamaru circuit. With the new RAS software this constraint has been relaxed. The analysis assumes that the Arapuni-Hamilton circuits may be loaded to 95% of their seasonal rating pre-contingency.

In the past, we have conservatively valued losses and generation constraints at $20/MWh and found the split was still justified. As these costs were considered lower-bounds on the benefit of the split, there was no need to refine these assumptions further.


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In order to confirm that the economically preferred option is to close the split, we have refined the cost assumptions further to be more generous to keeping the split open. We have valued generation constraints and losses based on the month and time of day we would expect them to occur. The costs are based on modelling undertaken for our Bunnythorpe-Haywards A and B Conductor Replacement Project.

For our analysis of this project we used data from the 2013 year on the grid to determine the constraints that would occur at Arapuni with the current grid configuration.

We then estimated the degree to which the constraints would reduce Arapuni generation using historical dispatch information from 2000-2009.

**Future Developments**

There are two future developments that have an impact on the constraints on the Arapuni-Hamilton circuits. That is the Hangatiki-Te Awamutu circuit and the Putaruru Grid Exit Point.

With these two developments commissioned operating with the Arapuni bus split open will be increasingly difficult. The split will also have a diminishing fuel cost benefit as constraints on Arapuni generation will be rare after the projects are commissioned.

For these reasons the Net Benefit Test is only performed over the three years until 2017 when these developments are expected to be commissioned.

The reduced unserved energy cost of having the Arapuni bus split closed is in two places:

- **Hangatiki** - which will no longer be exposed to a common bus fault at Arapuni North (around $26,000 per year)
- **Kinleith** - which will no longer be exposed to the loss of one Kinleith-Tarukenga circuit immediately followed by the other circuit (around $40,000 per year).

**High Level Results**

Table 1 and Table 2 show the results of the Net Benefit Test for each of the options.

**Table 1: Option 1 – Close Arapuni bus split permanently ($000)**

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<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>Total (NPV)</th>
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<td>Reduction in Fuel Costs</td>
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<tr>
<td>Reduction in Losses</td>
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**Table 2: Option 2 – Make Arapuni bus split permanent ($000)**

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<tr>
<td>Reduction in Fuel Costs</td>
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What are we proposing to do?

We are proposing to permanently close the Arapuni bus split at the end of the summer ratings period in early 2015.

Waikato Region Schematic