Grid Upgrade Plan 2008
Instalment 3

Part VII: Bombay 110 kV Bus Security Investment Proposal
Executive Summary

Transpower’s Bombay 110 kV Bus Security Investment Proposal

The purpose of this Bombay Bus Security Investment Proposal is to obtain Electricity Commission (the Commission) approval to recover the full costs (up to $4.7 million) associated with a programme of work to install a bus coupler circuit breaker, full local backup protection and bus zone protection measures on the 110 kV busbar at Bombay substation.

Proposal at a Glance

<table>
<thead>
<tr>
<th>What:</th>
<th>Upgrade the bus security on the Bombay 110 kV bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>When:</td>
<td>Commissioning in 2011</td>
</tr>
<tr>
<td>How much:</td>
<td>Transpower is seeking approval for up to $4.7 million (2011 dollars)</td>
</tr>
</tbody>
</table>

Background to the Proposal

This is a resubmission of the Bombay Bus Security Investment Proposal submitted in March 2009 (the Original Proposal), which sought approval for $4.9 million (2010 dollars).

Why the Proposal is necessary

At present, the Auckland region is vulnerable to a loss of supply in the event of a fault on the 110 kV Bombay substation bus. Such an event would result in a loss of supply at the Bombay substation.

The Grid Reliability Standards (GRS) are not currently met for those assets.

Clarification of the Original Proposal

The Original Proposal included a number of works in addition to the installation of a bus coupler. These works included the replacement of nine 110 kV circuit breakers on the Bombay site. Four of these circuit breakers (262, 272, 282 and 292) need to be replaced with dead tank circuit breakers and moved out from the busbar to provide sufficient maintenance clearances in line with Transpower Standard TP.DS.62.01 (Clearances and Conductor Spacings and safe access for AC switchyards) – refer section 3.4.

In addition, it was proposed to replace the remaining five circuit breakers (212, 222, 232, 242, and 252) with relatively new used spare SF6 Circuit Breakers from other sites thus allowing removal of the compressor house and the installation of a high impedance bus zone scheme.

In a letter dated 4 May 2009, the Commission raised concerns that this additional work had not been adequately described, resulting in a lack of transparency in the Original Proposal. In addition, it pointed to Vector’s submission as part of the consultation process which questioned why the cost of the Original Proposal was considerably more than the similar Redclyffe Bus Security Investment Proposal.

1 Refer the attached 110/33 kV single line diagram.
2 Attached.
3 Refer the attached 110/33 kV single line diagram.
4 Submitted for approval 12 March 2009.
Transpower acknowledged that the Original Proposal was not as clearly described as it might have been and indicated to the Commission, in a letter dated 8 May 2009, its intention to withdraw the Original Proposal and review it in light of the Commission’s concerns.

How this proposal differs from the Original Proposal

Transpower has reviewed the Original Proposal in light of concerns raised by Commission staff, namely:

- the potentially misleading description of the components of the proposal;
- the lack of transparency of the additional works; and
- the adequacy of the consultation process.

The following table shows the breakdown of components associated with the Original Proposal compared to this Proposal.

Table 0-1: Comparison with Original Proposal

<table>
<thead>
<tr>
<th>Original Proposal – Components</th>
<th>This Proposal - Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of a bus coupler on the Bombay 110 kV bus.</td>
<td>Installation of a bus coupler on the Bombay 110 kV bus.</td>
</tr>
<tr>
<td>Replacement of the four circuit breakers adjacent to the new bus coupler circuit breaker and moving them out from the busbar to maintain sufficient clearances.</td>
<td>Replacement of the four circuit breakers adjacent to the new bus coupler circuit breaker and moving them out from the busbar to maintain sufficient clearances.</td>
</tr>
<tr>
<td>Replacement of five remaining circuit breakers 212, 222, 232, 242, 252 with relatively new used spare SF6 circuit breakers from other sites.</td>
<td>-</td>
</tr>
<tr>
<td>Removal of the compressor house and relocation of Voltage Transformer No. 2.</td>
<td>Relocation of the compressor house and Voltage Transformer No. 2 to enable the new bus coupler circuit breaker to be installed.</td>
</tr>
<tr>
<td>Addition of backup line protection to five circuits and replacement of the main line protection on another four circuits to give full local backup protection on all circuits compatible with the new bus zone protection.</td>
<td>Addition of backup line protection to five circuits and replacement of the main line protection on another four circuits to give full local backup protection on all circuits compatible with the new bus zone protection.</td>
</tr>
<tr>
<td>Installation of a high impedance bus zone scheme.</td>
<td>Installation of a low impedance bus zone scheme.</td>
</tr>
</tbody>
</table>

As shown in the above table, the key differences between the Original Proposal and this Proposal are that Transpower no longer proposes to replace five of the circuit breakers, and as such, the compressor house needs to be retained and relocated.

Given that the Bombay site is particularly constrained for space, the compressor house and 110 kV Voltage Transformer No. 2 need to be relocated in order to install the new bus coupler.

5 Refer to the attached 110/33 kV single line diagram.

6 Sites include Maungatapere and Halfway Bush. Since the submission of the Original Proposal, an investigation into the installation of a bus coupler at the Halfway Bush site has shown it to be uneconomical so one spare is no longer available.
The current transformers in the remaining five oil circuit breakers which Transpower does not propose to replace at the present time (due to the additional associated cost) are not suitable for implementing a high impedance bus zone protection scheme. Consequently, a slightly more expensive low impedance scheme is required.\(^7\)

Given that there are now only four spare SF6 circuit breakers available as well as additional secondary systems works required to accommodate the new equipment configuration, the Estimated Cost of the Original Proposal is now $4.6 million (compared to the original estimate of $4 million). Transpower will refer to this revised Original Proposal of $4.6 million, (updated to include the costs for one new circuit breaker and additional secondary systems work) as the Reference Case.

The approval cost of the Proposal is $200,000 less than the Original Proposal. The reduction in cost is essentially due to retaining the remaining five oil circuit breakers which means that less site work is required, although that cost reduction is partially offset by the more expensive low impedance bus zone scheme and the requirement to relocate the compressor house.

The options Transpower has considered

Transpower considered the following options for the purposes of upgrading the Bombay 110 kV bus to meet the Grid Reliability Standards (GRS):

1. The Reference Case, which comprises the Original Proposal but updated to include costs for one new circuit breaker (as there are now only four spare circuit breakers available), and additional secondary systems work.

2. As per option 1, but using five new dead tank circuit breakers rather than four spare circuit breakers and one new circuit breaker.

3. The Proposal, which involves retaining the remaining five oil circuit breakers (212, 222, 232, 242, and 252), relocating the compressor house, and installing a low impedance bus zone scheme.

Option costs

The costs have been estimated at a level of accuracy commensurate with the estimated capital expenditure for these investment options. Costs in 2009 dollars are estimated at $4.6 million for the Reference Case (the high impedance bus zone option) and $3.8 million for the Proposal (the low impedance bus zone option).\(^9\)

In response to Vector’s query about costs in its submission on the Original Proposal,\(^10\) Transpower acknowledges that the costs for both the Reference Case and the Proposal are higher than other recent bus security investment proposals, including the Redclyffe Bus Security Investment Proposal. The variation in costs is due to the significant scope difference between the two projects. There is considerably less work required at Redclyffe to implement the bus security upgrade, in particular:

- the Redclyffe bus security project only requires the replacement of two circuit breakers in the two adjacent bays with dead tank circuit breakers to enable the bus section circuit breaker to be installed;
- there are fewer circuits at Redclyffe so the costs for the bus zone protection scheme are lower;

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\(^7\) Circuit breakers 212, 222, 232, 242, and 252. Refer the attached 110/33 kV single line diagram.

\(^8\) This is slightly more expensive than a high impedance bus zone scheme due to the type of relay required.

\(^9\) These costs exclude provision for price contingency, interest during construction and inflation.

• no other primary equipment needs to be relocated at Redclyffe, and modern local backup protection is already in place.

Application of the GIT

Transpower considers that there is no difference between the options when assessed by reference to expected market benefits.

Therefore, in testing the Reference Case and the Proposal against the GIT, the assessment becomes a cost comparison, with the option that minimises the expected net market cost satisfying the GIT.

The GIT results are shown in Table 0-2:

Table 0-2: Grid Investment Test Results

<table>
<thead>
<tr>
<th>Present Value 2009 $NZ million</th>
<th>Expected Net Market Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposal – low impedance scheme</td>
<td>$3.4</td>
</tr>
<tr>
<td>Reference Case – high impedance scheme</td>
<td>$4.2</td>
</tr>
<tr>
<td>Option 2 – all new CBs, high impedance scheme</td>
<td>$4.8</td>
</tr>
</tbody>
</table>

The Proposal – installing a bus coupler and low impedance bus zone protection at Bombay – is the option that minimises the expected net market cost compared with the other alternative project, the Reference Case, and therefore passes the GIT.

Accuracy of the GIT analysis

Transpower recognises there is inherent uncertainty in the cost assumptions used in the GIT analysis. However, Transpower considers the rigour and comprehensiveness of the analysis undertaken is commensurate with the estimated capital expenditure required for the proposed investment.

Timing

As the configuration of the Bombay substation does not currently meet the GRS, the timing for the Proposal is to implement the upgrade as soon as possible. It is expected that the Proposal could be installed and commissioned in 2011 with the construction programme for the Proposal scheduled to start in the first half of 2010 and a completion target of March 2011.

Maximum Approval Cost

For the purposes of the GIT, the costs used are the Expected Cost, being the Estimated Cost, plus a scope allowance, in current year dollars.

For approval purposes, a Maximum Approval Cost (MAC) is calculated, being a reasonable maximum Expected Cost for the project, in commissioning year dollars. The MAC is similar, but not the same, as previous proposals which included the use of a P90 figure (being the figure for which there is a 90% probability of the actual costs falling within the figures quoted).

The MAC, being the amount for which approval is sought from the Commission, is shown below in comparison to the Expected Cost and an Expected End Cost, which is the cost Transpower expects the Proposal to cost in commissioning year dollars. The Expected End Cost is similar to the old P50 figure.
### Table 0-3: Approval Cost

<table>
<thead>
<tr>
<th></th>
<th>$NZ million</th>
<th>Estimated Cost</th>
<th>Expected Cost</th>
<th>Price contingency</th>
<th>Exchange rate variability</th>
<th>Inflation</th>
<th>IDC</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Cost</td>
<td></td>
<td>3.1</td>
<td>3.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.8</td>
</tr>
<tr>
<td>Expected End Cost</td>
<td></td>
<td>3.1</td>
<td>3.8</td>
<td>0.2</td>
<td>–</td>
<td>0.3</td>
<td>0.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Maximum Approved Cost</td>
<td></td>
<td>3.1</td>
<td>3.8</td>
<td>0.3</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>4.7</td>
</tr>
</tbody>
</table>
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Part A - Proposal

This part describes Transpower’s Bombay Bus Security Investment Proposal (the Proposal).

Transpower is seeking Commission approval to recover the full costs associated with implementing the following programme of works:

Components of the Proposal
- Installation of a bus coupler on the Bombay 110 kV bus.
- Replacement of the four circuit breakers adjacent to the new bus coupler circuit breaker and moving them out from the busbar to maintain sufficient clearances.
- Relocation of the compressor house and Voltage Transformer No. 2 to enable the new bus coupler circuit breaker to be installed.
- Addition of backup line protection to five circuits and replacement of the main line protection on another four circuits to give full local backup protection on all circuits compatible with the new bus zone protection.
- Installation of a low impedance bus zone scheme.

Timing
As the configuration of the Bombay substation does not currently meet the GRS, the timing for the Proposal is to implement the upgrade as soon as possible. It is expected that the Proposal could be installed and commissioned in 2011 with the construction programme for the Proposal scheduled to start in the first half of 2010 and targeted for completion in March 2011.

Costs
On commissioning of the Proposal, Transpower seeks approval to recover the full costs associated with implementing the Proposal up to a total amount of $4.7 million. This amount is the estimated MAC to implement the Proposal, based on the timing above, expressed in New Zealand dollars exclusive of GST.

Appendix C describes how the MAC has been derived.
Part B – Justification

1 Introduction

1.1 Purpose of the Proposal

The purpose of the Proposal is to obtain Commission approval to recover the costs associated with implementing a solution to ensure reliable electricity supply to the substation served by the Bombay 110 kV bus.

1.2 Purpose of Part B

Part B describes the processes followed and information analysed by Transpower in reaching its decision to seek approval from the Commission to recover the costs associated with implementing the Proposal set out in Part A. Part B is not therefore part of the Proposal as such, but contains the justification for it.

Part B is designed to lead readers through the process Transpower has followed in applying the GIT and to present the conclusions of the GIT analysis.

1.3 Attachments

There are 2 attachments to the Proposal:

1. the 110/33 kV Single Line Diagram of the Bombay Substation;
2. Transpower’s Standard TP.DS 62.01, Clearances and conductor spacings and a safe access for a.c switchyards.

In line with international practice Transpower’s standards around spacings have been revised to reflect new equipment, maintenance practices and safety requirements. In accordance with the revised standard, historical installations are to comply with the revised clearances as far as practicable, while not only taking into account existing equipment and practices but also the future equipment that may be installed.

1.4 The Proposal is part of the 2008 Grid Upgrade Plan (GUP)

This document is a resubmission of Part VII of the 2008 GUP\textsuperscript{11}.

Transpower has submitted the following parts of the 2008 GUP to the Commission:

- Part I: Comprehensive Plan for Asset Management and Operation of the Grid;
- Part II: Investment Contracts;
- Part III: Wairakei Ring Investment Proposal;
- Part IV: Maungatapere Bus Security Investment Proposal;
- Part VI: Woodville–Mangamaire–Masterton Transmission Investment Proposal;
- Part VII: Bombay Bus Security Investment Proposal;
- Part VIII: Redclyffe Bus Security Investment Proposal; and
- Part IX: Marsden Substation Investment Proposal.

\textsuperscript{11} For ease of reference this resubmission is now part of Instalment 3.
1.5 Compliance with the Grid Upgrade and Review Policy (GUIRP)

Transpower notes that the development of the investment proposal and alternative option, and the analysis of those options, does not follow in a number of respects the processes and policies set out in the GUIRP.

However, for smaller projects, Transpower has abbreviated the process consistent with the principles that the analysis undertaken in applying the GIT be commensurate with the estimated capital expenditure required for the proposed investment. This approach reflects one of the key principles of the GUIRP.

1.6 Glossary/terminology

A glossary of terms and acronyms used in the Investment Proposal is included in Appendix A.

All references to Rules in this document refer to those in Section III of Part F of the Electricity Governance Rules 2003 unless otherwise specified.

12 Clause 12, Schedule F4 of the Rules.
13 Grid Upgrade Investment and Review Policy, June 2008, para 2.1.1(h).
2 Transmission Need and Type of Investment

2.1 Background to the Proposal

The Bombay 110 kV bus is considered part of the core grid as the Wiri–Bombay line is listed in the Core Grid Determination, set out in Schedule F3A of the Rules.

The Bombay substation is connected from the north by two 110 kV circuits from Otahuhu (Wiri is supplied by a tee connection on these circuits).

From the south, Bombay is connected to Hamilton to the south by two 110 kV circuits.

Counties Power takes supply at Bombay at 33 kV via two supply transformers and at 110 kV via four 110 kV feeders. There is a capacitor connected to the 110 kV bus.

A fault on the 110 kV bus at Bombay will result in the loss of the 110 kV and 33 kV supplies to Counties Power at Bombay.

Therefore the Bombay 110 kV bus does not currently meet the “n-1” security standard on the core grid required by clause 4.2 of the GRS. As such, an immediate solution must be found to ensure reliable electricity supply to the potentially affected area.

Figure 2-1: Auckland Area
2.2 Components of the Proposal
This Proposal covers the works set out below:
- installation of a bus coupler circuit breaker on the Bombay 110 kV bus;
- relocation of the compressor house and Voltage Transformer No. 2 to enable the new bus coupler circuit breaker to be installed;
- replacement of the four adjacent circuit breakers and moving them out from the busbar to maintain sufficient clearances;
- addition of backup line protection to five circuits and replacement of the main line protection on another four circuits to give full local backup protection on all circuits compatible with the new bus zone protection; and
- installation of a low impedance bus zone scheme.

2.3 Type of investment
Transpower considers that the Proposal is a “reliability investment” under the Rules as:
- the Proposal is an investment by Transpower in the grid;
- the primary effect of the Proposal is to reduce expected unserved energy on the grid; and
- the expected unserved energy will result from likely planned or unplanned outages of primary transmission equipment.

2.4 Project Costs
The project costs given below exclude contingencies and interest during construction.

<table>
<thead>
<tr>
<th>Bombay Substation Upgrade Costs</th>
<th>$000's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Equipment</td>
<td>1053</td>
</tr>
<tr>
<td>Secondary Equipment</td>
<td>421</td>
</tr>
<tr>
<td>Consenting</td>
<td>9</td>
</tr>
<tr>
<td>Project management</td>
<td>871</td>
</tr>
<tr>
<td>Site works</td>
<td>1,426</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,779</strong></td>
</tr>
</tbody>
</table>

Although a key aspect of this Proposal is the installation of a bus coupler circuit breaker, the cost of this Proposal is higher than other bus security investment proposals, such as the Redclyffe Bus Security Investment Proposal. This is due to the significant scope difference between the two projects. For example, considerably less work is required at Redclyffe to implement the bus security upgrade, in particular:
- the Redclyffe bus security project only requires the replacement of two circuit breakers in the two adjacent bays with dead tank circuit breakers to enable the bus section circuit breaker to be installed;
- there are fewer circuits at Redclyffe so the costs for the bus zone scheme are cheaper; and
• no other primary equipment needed to be relocated at Redcliffes, and modern local backup protection is already in place.

3 Identification and Consideration of Options

3.1 Requirements under the Rules

The application of the GIT requires an analysis and comparison of the expected net market benefits and costs of the proposed investment and those of a number of alternative projects.

Therefore, Transpower must first identify those options that fall within the definition of “alternative projects” under the Rules.

3.2 Short-list options

Under the Rules, the GIT requires that a reliability investment proposed by Transpower, that is necessary to meet the reliability standard set out in clause 4.2 of the GRS, must maximise the expected net market benefits or minimise the expected net market costs compared with a number of alternative projects.¹⁴

Accordingly, Transpower must identify a number of options in addition to the Proposal that fall within the definition of “alternative projects” under the Rules.

To identify options for consideration, Transpower has undertaken a process which included the following stages:

• confirming the need for the investment;
• identifying all options to address the identified need;
• assessing all the options to identify a short-list of options that in the circumstances can reasonably be considered as alternative projects; and
• confirming the short-list of options.

This process resulted in the selection of the Proposal and the alternative projects described below.

3.3 Alternative projects

Under the Rules,¹⁵ “alternative projects” are defined as:

"Alternative projects" means any alternative transmission augmentation projects and transmission alternatives to the proposed investment, including any variant of the proposed investment that involves a non-negligible change in the timing of that proposed investment, that are:

19.1. technically feasible;

19.2. reasonably practicable having regard to the matters set out in clauses 8.1 to 8.4;

¹⁴ Clause 4.1, Schedule F4
¹⁵ Clause 19, Schedule F4.
19.3. reasonably likely to proceed if neither the proposed investment nor any other alternative project proceeds and unlikely to proceed if the proposed investment does proceed;

19.4. reasonably expected to provide similar benefits, in type but not necessarily in magnitude, to relevant nodes, as the proposed investment; and

19.5. reasonably expected to enable the deferment of investment of the type contemplated by the proposed investment for a period of 12 months or more."

In addition,\(^{16}\) the alternative projects to be considered in the GIT must be limited to:

“…those appropriate in number and technology given the cost magnitude of the proposed investment, the complexity of the required modelling and the urgency of the proposed investment.”

3.4 The short-list of options

Bombay substation is a physically constrained site with a 110kV outdoor switchyard designed to accommodate air insulated switchgear mounted under and on a lattice gantry. The original design clearances and spacings allowed for the equipment to be maintained from ladders and platforms placed beside or against the equipment and gantry.

The existing switchyard was modelled utilising the new clearances and existing constraints identified and the bus coupler equipment was added and mitigations applied to comply with the required spacings and clearances of the Transpower standard\(^{17}\). Considered mitigations included reductions in minimum approach distances for maintenance access, relocation of equipment and replacement of equipment. The solutions that were considered enable the bus coupler to be installed while allowing for the future replacement and maintenance of remaining legacy equipment. This results in a design that does not permit unconstrained mobile elevated work platform access but does allow access without infringing the Minimum Approach Distance (MAD).

In developing a short-list of options, Transpower considered two potential alternative solutions.

All options considered involve installing a bus coupler circuit breaker on the Bombay 110 kV bus, replacing the adjacent four circuit breakers, relocating Voltage Transformer No. 2, and either relocating or removing the compressor house. This is the minimum work required to maintain sufficient clearances at the site. In addition, full local backup protection will be provided by adding backup line protection to five circuits while four circuits will have main line protection replaced compatible with the new bus zone protection.

Should the remaining five oil circuit breakers (212, 222, 232, 242, and 252) on site be retained (and this requires the compressor house to be relocated), a low impedance bus zone scheme will be installed. Alternatively these circuit breakers can be replaced (which will enable the compressor house to be removed rather than relocated), in which case a cheaper high impedance bus zone scheme can be installed.\(^{18}\)

In addition, Transpower also gave preliminary consideration to permanently splitting the Bombay 110 kV busbar but did not continue with this approach as it would mean that

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\(^{16}\) Clause 11, ibid.

\(^{17}\) Refer Attachment - Transpower’s Standard TP.DS 62.01, Clearances and conductor spacings and a safe access for a.c switchyards.

\(^{18}\) Please see the attached 110/33 kV single line diagram.
• the distribution network served by the bus would require augmenting; and
• overall system security would be reduced.

The two options that have therefore been considered are as follows:

Option 1 (Reference case):
• Install a bus coupler,\(^\text{19}\) replace the circuit breakers in the four adjacent bays (262, 272, 282, and 292) with dead tank circuit breakers and move them out from the busbar.
• Replace the remaining five oil circuit breakers (212, 222, 232, 242, and 252) with four spare live tank SF6 circuit breakers and current transformers from Maungatapere, and one new dead tank SF6 circuit breaker.
• Remove the compressor house and relocate 110 kV Voltage Transformer No. 2.
• Install a high impedance bus zone scheme.
• Install backup line protection to five circuits.
• Replace the main line protection on four circuits.

Option 2:
• As per option 1 above except use five new dead tank circuit breakers rather than four spare circuit breakers and one new circuit breaker.

Table 3-1: Estimated Option Costs ($ ’000)

<table>
<thead>
<tr>
<th></th>
<th>Option 1</th>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Equipment</td>
<td>1,240</td>
<td>1,989</td>
</tr>
<tr>
<td>Secondary Equipment</td>
<td>365</td>
<td>365</td>
</tr>
<tr>
<td>Consenting</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Project management</td>
<td>1,112</td>
<td>1,180</td>
</tr>
<tr>
<td>Site works</td>
<td>1,898</td>
<td>1,729</td>
</tr>
<tr>
<td>Total</td>
<td>4,624</td>
<td>5,271</td>
</tr>
</tbody>
</table>

3.5 The short-list options must reflect Good Electricity Industry Practice (GEIP)

In order for the Commission to approve a reliability investment, the proposed investment must reflect GEIP in meeting the GRS.

The Rules define GEIP in relation to transmission as:

"The exercise of that degree of skill, diligence, prudence, foresight and economic management, as determined by reference to good international practice, which would reasonably be expected from a skilled and experienced asset owner engaged in the management of a transmission network under conditions comparable to those applicable to the grid consistent with applicable law, safety and environmental protection. The determination is to take into account factors such as the relative size, duty, age and technological status of the relevant transmission network and the applicable law."

Accordingly, comparable international practice should be considered in assessing what is GEIP in terms of grid investment planning. Transpower, as a prudent planner, owner and operator of a transmission network, must adopt solutions consistent with good international practice.

\(^\text{19}\) The location of bus coupler 278 was selected following customer consultation.
Transpower considers that all the short-list options reflect GEIP. Specifically, the approach taken for the Proposal is consistent with international practice as being a prudent investment given the size, nature and importance of the Auckland area load.

3.6 The short-list options must also meet the GRS

The GRS are contained in Schedule F3 of the Rules. These state that the grid satisfies the grid reliability standards if:

"4.1 the power system is reasonably expected to achieve a level of reliability at or above the level that would be achieved if all economic reliability investments were to be implemented; and

4.2 with all assets that are reasonably expected to be in service, the power system would remain in a satisfactory state during and following any single credible contingency event occurring on the core grid."

As the Bombay substation concerns the core grid, any reliability investment must meet both clauses 4.1 and 4.2 of the GRS.

Transpower considers that both short-list options meet the GRS as required by Rule 13.4.1.1.

3.7 Base case

For the purposes of the GIT, the Rules also require that the Proposal and the alternative projects be assessed against a base case, which is defined as follows:

"Base case" means the market development scenarios developed for the reasonable future state of the electricity industry without the proposed investment or any alternative project.

As noted by both the Commission and Transpower in analysis of the North Island Grid Upgrade Proposal, and more recently in the Maungatapere Bus Security Investment Proposal, it is difficult to identify a suitable base case for the analysis when an investment proposal is required to meet the GRS, and more particularly Rule 4.2 of the GRS because the base case must meet the GRS, but not be an alternative project.

The Commission has previously resolved this issue by using one of the “alternative projects” as a reference case. Transpower has adopted this approach.

4 Application of the GIT

4.1 Compliance with the GIT

As the Proposal concerns the core grid and must therefore meet the grid reliability standard set out in clause 4.2 of Schedule F3, the Proposal will satisfy the GIT under clause 4.1 of Schedule F4 if:

- the proposed investment maximises the expected net market benefit or minimises the expected net market cost compared with a number of alternative projects; and

20 Clause 20 of Part F Section III Schedule F4.
• if sensitivity analysis is conducted, the conclusion (on net market benefits or net market costs) that a proposed investment satisfies clause 4.1.1 is sufficiently robust having regard to the results of that sensitivity analysis.

4.2 Analytical approach and market development scenarios

The economic analysis presented in this report differs in form, but less so in substance, from that used for analysis of major transmission investment proposals such as the HVDC Grid Upgrade Investment Proposal. The difference in substance arises because the scale of the Bombay Bus Security project is much smaller in terms of both cost and complexity. The Rules require that:

“The rigour and comprehensiveness of the analysis undertaken in applying this grid investment test must be commensurate with the estimated capital expenditure required for the proposed investment.” 21

Transpower’s economic analysis for the Proposal focuses on the capital cost effects of the short-list options, as these areas are the principal sources of market benefits and costs. Transpower considers that this approach is commensurate with the Rules given the estimated capital expenditure for the Proposal.

This approach is also consistent with the analytical approach adopted for the Wellington 110 kV interconnection upgrade.

Given that there is no new generation in any of the market development scenarios detailed in the Commission’s 2008 Statement of Opportunities, or in any other reasonable future state of the electricity industry, that would materially impact on the GIT analysis, Transpower considers that an analysis of the net market benefits of the short list options under multiple market development scenarios would yield the same results for each scenario. Therefore Transpower has assessed the net market benefits of the short list options on the basis of one generation scenario, in which there is no new generation built in the region. This scenario is assigned a 100% probability. Transpower notes that this approach is broadly similar to the approach adopted by the Commission in assessing previous grid upgrade proposals.

4.3 Application of the GIT

Table 4-1: GIT Results

<table>
<thead>
<tr>
<th>Present Value</th>
<th>Expected Net Market Cost</th>
<th>Difference with Reference Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009 $NZ million</td>
<td>Proposal – low impedance scheme</td>
<td>$3.4</td>
</tr>
<tr>
<td></td>
<td>Reference Case – high impedance scheme</td>
<td>$4.2</td>
</tr>
<tr>
<td></td>
<td>Option 2 – all new CBs, high impedance scheme</td>
<td>$4.8</td>
</tr>
</tbody>
</table>

The results show that the Proposal – installing a bus coupler and bus zone protection with a low impedance bus zone scheme – has the lower expected net market cost and therefore satisfies the GIT.

21 Clause 12, Schedule F4.
4.4 Timing of the Proposal
As the configuration of the Bombay substation does not currently meet the GRS, the timing for the Proposal is to implement the upgrade as soon as possible. It is expected that the Proposal could be installed and commissioned in 2011, with the construction programme for the Proposal scheduled to start in the first half of 2010 and targeted for completion in March 2011.

5 Compliance with the Processes set out in the Rules
The Commission may approve a proposed reliability investment where the proposed investment complies with the processes set out in the Rules. Transpower notes that the Commission interprets this rule as requiring that Transpower must comply with the processes required by the Rules in relation to the proposed investment under consideration.

The processes in the Rules require Transpower to:
• submit a grid upgrade plan in accordance with Rule 12.2;
• comply with any requests from the Commission prescribed in writing to provide information it considers is reasonably required to enable it and interested persons to evaluate the proposed investment – Rule 12.3.4;
• comply with the timetable for consultation and approval of reliability investments proposed in Transpower’s grid upgrade plan, agreed between Transpower and the Commission, or as stipulated by the Electricity Commission, in accordance with Rule 13.2; and
• respond to any requests for further investigation or further information in accordance with Rule 13.3.3.

The processes under the Rules that Transpower follows in respect of potential investments are project-specific and accordingly do not assist in differentiating between the short-list options.

5.1 Submission of a Grid Upgrade Plan
Rule 12.2.1 provides that either:
• Transpower must submit a grid upgrade plan to the Commission within 3 months of receiving a written request from the Commission, or such other date as the Commission agrees; or
• Transpower may submit a grid upgrade plan for the Commission's consideration at any other time.

Transpower has not received a written request for submission of a grid upgrade plan (GUP). Transpower is submitting this document, as part of its 2008 GUP to the Commission.

5.2 Provision of information
Rule 12.3.4 requires a grid upgrade plan to, amongst other things, include:

"such other content as prescribed in writing by the Board, to ensure that grid upgrade plans includes such information that the Board considers is reasonably required to enable the Board and interested parties to evaluate proposed transmission investments, such as indicative pricing impacts of investment proposals."

The Commission has not requested any information under Rule 12.3.4. No further requests for information under Rule 12.3.4 or otherwise were made.
Accordingly, Transpower has complied with the requirements of Rule 12.3.4.

5.3 Compliance with the timetable and process

Rule 13.2.1 requires the Commission and Transpower to agree a timetable for consultation and approval of reliability investments. In the absence of agreement, the Commission may stipulate such a timetable.

Additionally, the Commission must consult with Transpower on the process for consultation and persons who the Commission will consult with.

Transpower and the Commission have agreed on a timetable for consultation and approval of the Proposal, including persons who the Commission will consult with.

Transpower considers that, to date, it has complied with the timetable and process agreed with the Commission.

5.4 Requests for further investigation and further information

Under rule 13.3.3, the Board may:
- direct Transpower to undertake further investigations into its proposed reliability investment;
- ask questions of Transpower or require further information or consultation on part or all of Transpower’s Proposal;
- ask Transpower to evaluate alternative reliability investments; and
- where Transpower possesses relevant expertise, ask Transpower to evaluate transmission alternatives.

The Commission has not requested any information under rule 13.3.3. Transpower will endeavour to continue to comply with any reasonable requests the Commission may have in accordance with the above requirements.

6 The Proposal meets the Rule Requirements

As the Proposal is a “reliability investment”, the Commission can approve the Proposal under rule 13.4.1, if the Proposal:
- reflects GEIP in meeting the GRS;
- complies with the processes set out in the Rules; and
- meets the requirements of the GIT.

Transpower considers the Commission may approve the Proposal on the grounds that it satisfies the criteria under rule 13.4.1.

7 Approval Amount for the Proposal

7.1 Approval amount sought

This application seeks Commission approval to recover the lesser of actual costs or the estimated MAC of the Proposal.

The Expected Cost of the Proposal, as used in the GIT, is estimated to be $3.8 million and the MAC of the Proposal is estimated to be $4.7 million.
7.2 Approval amount methodology

Previously, Transpower has used what is known as a P90 methodology to calculate the approval amount. For this Proposal, Transpower has used a simplified methodology to determine a formulaic MAC. This allows for variations in such items as financing costs, exchange rates and commodity prices, i.e. costs typically beyond the control of Transpower. Transpower considers the use of a MAC aids transparency and makes tracking of project costs against the approved amount much simpler.

The amount for which approval is sought from the Commission is shown below in comparison to the Expected Cost, as used in the GIT analysis, and the Expected End Cost which is the cost that Transpower expects for the Proposal. The Expected End Cost is similar to the old P50 figure.

<table>
<thead>
<tr>
<th>$NZ million</th>
<th>Estimated Cost</th>
<th>Expected Cost</th>
<th>Price contingency</th>
<th>Exchange rate variability</th>
<th>Inflation</th>
<th>IDC</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Cost</td>
<td>3.1</td>
<td>3.8</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3.8</td>
</tr>
<tr>
<td>Expected End Cost</td>
<td>3.1</td>
<td>3.8</td>
<td>0.2</td>
<td>—</td>
<td>0.3</td>
<td>0.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Maximum Approved Cost</td>
<td>3.1</td>
<td>3.8</td>
<td>0.3</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Appendix C describes further how the MAC has been derived. It is based on a cost estimate calculated in June 2009.

For comparison, Transpower has calculated a P90 figure for the Proposal, using the same approach as used in previous GUPs. The MAC and P90 are shown in Table 7-2 below:

<table>
<thead>
<tr>
<th>MAC</th>
<th>P90</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.7</td>
<td>4.7</td>
</tr>
</tbody>
</table>
### Appendix A Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alternative Project</strong></td>
<td>Projects that are reasonable to consider as alternatives to the proposed investment in applying the Grid Investment Test, in accordance with rule 19, Schedule F4, Part F Section III, Electricity Governance Rules.</td>
</tr>
<tr>
<td><strong>Expected costs</strong></td>
<td>Expected costs represent the estimated cost plus a contingency for scope accuracy. Scope accuracy allows for unexpected variations in the design scope and a standard allowance, based on experience, for items not considered in the design. Expected costs are in current dollars and do not allow for cost uncertainty related to price variations, inflation, or financing costs.</td>
</tr>
<tr>
<td><strong>expected unserved energy</strong></td>
<td>A forecast of the aggregate amount by which the demand for electricity exceeds the supply of electricity at each grid exit point as a result of likely planned or unplanned outages of primary transmission equipment.</td>
</tr>
<tr>
<td><strong>GEIP</strong></td>
<td>Good Electricity Industry Practice.</td>
</tr>
<tr>
<td><strong>GIT</strong></td>
<td>Grid Investment Test. A cost-benefit analysis for both reliability and economic investments. The specific rules defining the Grid Investment Test, as developed according to the process in rule 6 of section III, are set out in Schedule F4 of section III of Part F.</td>
</tr>
<tr>
<td><strong>GUIRP</strong></td>
<td>Grid Upgrade and Investment and Review Policy</td>
</tr>
<tr>
<td><strong>MAC</strong></td>
<td>Maximum Approval Cost</td>
</tr>
<tr>
<td><strong>modelled projects</strong></td>
<td>Transmission augmentation projects and non-transmission projects, other than the proposed investment and alternative projects, which are likely to occur in a market scenario, are reasonably expected to occur in that market development scenario within the time horizon for assessment of the market benefits and costs of the proposed investment and alternative projects, and the likelihood, nature and timing of which will be affected by whether the proposed investment or any alternative project proceeds.</td>
</tr>
<tr>
<td><strong>Monte Carlo</strong></td>
<td>Monte Carlo simulation is a method for iteratively evaluating a deterministic model using sets of numbers randomly generated within certain ranges as inputs. It creates a distribution of possible outcomes on which descriptive statistics can then be run.</td>
</tr>
<tr>
<td><strong>P90 cost</strong></td>
<td>Estimated 90\textsuperscript{th} percentile of project costs.</td>
</tr>
<tr>
<td><strong>reliability investment</strong></td>
<td>Investments by Transpower in the grid, or alternative arrangements by Transpower, the primary effect of which is, or would be, to reduce expected unserved energy.</td>
</tr>
<tr>
<td>Rules</td>
<td>The Electricity Governance Rules 2003. In the context of this document, it generally refers to Part F Transport, Section III Grid Upgrade and Investments.</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Transpower</td>
<td>Transpower New Zealand Limited, owner and operator of New Zealand’s high-voltage electricity network (the National Grid).</td>
</tr>
</tbody>
</table>
Appendix B Bus Configuration with Bus coupler

The figure below shows the network schematic of the Bombay 110 kV bus with the bus coupler. Counties Power are supplied at both 33 kV and 110 kV (Opaheke West and East, Pukekohe North and South 110 kV feeders). Transpower has consulted with Counties Power regarding the position of the bus coupler and they have elected the position shown. Although both Bombay 33 kV transformers are on the same bus section, this position for the bus coupler was chosen as it aligns with both customer and Transpower future developments.

Appendix Figure 1: Bus connection configuration with bus coupler, Bombay 110 kV bus
Appendix C  Maximum Approved Cost Methodology

This application seeks Commission approval to recover the lesser of actual costs or the estimated MAC of the Proposal.

The Expected Cost of the Proposal, as used in the GIT, is estimated to be $3.8 million and the MAC of the Proposal is estimated to be $4.7 million. This section sets out how Transpower has estimated the MAC and describes the difference between the Expected Cost and the MAC.

In previous investment proposals submitted to the Commission, Transpower has sought approval to recover up to a P90 cost. It is expected there is only a 10% probability that the P90 figure would be exceeded once the Proposal was commissioned. The P90 figure was derived from a probabilistic analysis of the expected cost of the Proposal using a Monte Carlo approach.

However, experience has shown that the development of a P90 figure lacks transparency and in particular it is difficult to relate the P90 cost back to actual, trackable, project specific costs.

Transpower has therefore applied a different method for the Bombay Bus Security Investment Proposal and has determined a MAC. The methodology for determining a MAC is described below.

For comparison, Transpower has also calculated and reported a P90 figure in order to assist the Commission understand how the new approach for calculating a maximum approval amount relates to the previous approach.

The relationship between the Expected Cost used in the GIT and the MAC is represented in Appendix Figure 2.
Appendix Figure 2: – Relationship between Expected Cost and MAC\textsuperscript{22}

The approval amount is higher than the Expected Cost used in the GIT because:

- The Expected Cost comprises an estimated cost plus an allowance for scope variations. It does not include an allowance for all uncertainties present in a construction project of the type proposed.
- The Expected Cost is in current (today’s) dollars, whereas the approval amount is an estimate of the end cost of the project in future (commissioning year) dollars.
- The approval amount is required to cover the full cost of the project including financing costs, price variations on materials, exchange rate variations and foreign exchange hedging, etc.

Importantly, at the approval stage the actual costs are known at a high level only as such things as transformer suppliers are yet to be determined and there is also a reasonable time gap between approvals and when the majority of actual costs are incurred.

Appendix Figure 2 shows that the Expected Cost used in the GIT is the Estimated Cost plus Scope Allowance only, in current year dollars.

The Maximum Approved Cost is higher than the Expected Cost because it includes an allowance for price contingencies and all other variables. Estimates are used to produce an overall MAC similar in magnitude to the previously calculated P90.

\textsuperscript{22} Exchange rate variations are based on historical volatility and estimated on a 90\textsuperscript{th} percentile likely over the period between the Reference Date (used for calculating costs used in the GIT) and when tenders might be accepted.
Method of calculating Maximum Approval Cost

The following inputs and variables are considered in deriving the Expect Cost and MAC:

- **Estimated Cost.** The Estimated Cost is the estimated cost of designing, procuring, constructing and commissioning the components which make up the Proposal. These costs can include decommissioning costs and the costs of obtaining designations, easements, resource consents and property purchases for these works if applicable. The Estimated Cost does not include contingencies. The Estimated Cost is in current dollars, as calculated on the Reference Date.

- **Reference Date.** Transpower prepared estimated capital costs as at 10 December 2008. A reference date is used to ensure consistency between the estimated capital costs of components within each option considered in the GIT and between options. For calculating costs at commissioning time, Transpower has assumed a commissioning date of 31 March 2011. These commissioning dates are assumed to be the dates at which accumulated costs for the project would be included in Transpower's regulated asset base and from which costs would start to be recovered through the Transmission Pricing Methodology.

- **Scope allowance.** Transpower also estimates a scope allowance, which is added to the Estimated Cost, to cover two distinct categories of costs:
  a) costs for works which are planned, but which have not been included in the estimated capital costs except through this general allowance, and
  b) costs for works not anticipated at the time costs were estimated. The Estimated Cost plus Scope Allowance equals the Expected Cost of the project or various components of it and this is the cost used in GIT analyses. The Scope Allowance is treated as a fixed percentage of Estimated Costs which are added to the Estimated Cost.

- **Price Contingency.** As regulatory approval occurs prior to the issuing of tenders, there is uncertainty over the price of equipment to be installed. In particular, this includes the risks that:
  - market pressures may affect the cost of capital items, e.g. if worldwide demand for transformers is high at the time Transpower seeks tenders, the prices offered may reflect a tighter supply situation and therefore be higher than at other times; and
  - commodity price movements. Tender prices for some capital items include escalators linked to market price variations in significant elements of that item e.g. metals such as steel and copper. As with exchange rate variations, Transpower would not, typically, consider hedging anticipated commitments until a contract is awarded/signed. This is because of the somewhat speculative nature of entering commodity futures contracts in advance of commitment and the costs involved, which may or may not be required, depending upon the terms of the eventual contract. Hence, Transpower is exposed to commodity price movements up until contracts are signed and so an estimate is made of the potential cost variation this might cause.

  Price movements could be downward as well as upward and for this reason the price contingency is estimated as the minimum and maximum variations expected. A price contingency of -5% to +20%, would be typical. The MAC costs are based on a cost estimate derived in June 2009.

  For the purposes of calculating the Expected End Cost, the mean of this range is taken i.e. 5% for the example above.

  For the purposes of calculating the MAC, the 62nd percentile of this range is taken i.e. 6.3% for the example above.

- **Exchange rate variations.** Transpower’s current practice is to enter foreign exchange contracts to hedge foreign exchange movements, once contractual commitments are
made. This provides NZ dollar cost certainty from the point that tenders are awarded/contracts signed.

- Transpower does not, typically, hedge anticipated commitments. This is because of the somewhat speculative nature of entering foreign exchange contracts in advance of commitment and the added costs of having to pay option premiums for hedging a range of possible currencies and execution dates, most of which would not be exercised. Hence the requirement to estimate the effect on costs of exchange rates moving in the interim period before signing contracts.

- The Estimated Costs were based on average exchange rates around the Reference Date. For the purposes of calculating the MAC, the Proposal cost reflected a USD exchange rate of 0.4732.

- The exchange rate variations are based on historical volatility and are estimated on either a 90th or 50th percentile likely over the period between the Reference Date and when tenders might be accepted. The methodology used to calculate the 90th and 50th percentile volatility variations is as developed by Bancorp and as used for the HVDC Proposal.

**Exchange rate hedge.** As mentioned above, Transpower’s current practice is to enter foreign exchange contracts to hedge foreign exchange movements, once contractual commitments are made. However, for smaller projects Transpower may elect not to hedge these risks. This is the case for the Proposal. As a result, hedging costs for both the Expected End Cost and MAC are zero.

- **Real interest rates.** Real interest rates are used in the calculation of Interest During Construction costs and are assumed to vary between 3.3% and 5.3%, as 10th and 90th percentiles respectively, with a mean of 4.3%. The nominal interest rate is the real interest rate plus the inflation rate, equating to a mean nominal interest rate of 7.3% in this instance. This is approximately Transpower’s current cost of debt.

  For the purposes of calculating the Expected End Cost and MAC, the mean of 4.3% is used.

- **Inflation.** Transpower assumes inflation will vary between 2% to 4% per annum, as 10th and 90th percentiles respectively, with a mean of 3%.

  For the purposes of calculating the Expected End Cost and MAC, the mean of 3% per annum is used.

### Results of Expected Cost, Expected End Cost and MAC calculations

The Expected Cost of the Proposal, as estimated in May 2009, is $3.8 million.

This cost includes a scope allowance and represents Transpower’s estimate of the cost of designing, purchasing, constructing and commissioning the Proposal, in current dollars. Transpower will not start recovering the costs of a stage of this Proposal until it is commissioned, i.e. March 2011. The cost Transpower will look to recover at that time is higher, due to potential cost uncertainties, financing costs incurred throughout the construction period and inflation.

The Expected End Cost of the Proposal includes a price contingency, exchange rate variability allowance, the expected cost of foreign exchange hedging, inflation and Interest During Construction costs. For the purposes of calculating an Expected End Cost, all parameters (e.g. inflation) are assumed at their 50th percentile levels. This gives an Expected End Cost akin to a P50. The Expected End Cost for the Proposal is $4.5 million.

The MAC for the Proposal is calculated using upper percentile estimates for the various parameters and results in a MAC of $4.7 million. Transpower is seeking approval to recover the lesser of actual costs or the MAC.

There is a probability of exceeding the MAC (and in fact as shown below, the MAC is close to a P90 figure). If there are changes which are materially different to those assumptions
used in deriving the MAC then this cost may be exceeded. In such a case, Transpower would apply for approval for the revised costs of the project in accordance with Rule 17.2.

Appendix Table 1 shows the break down of the MAC.

**Appendix Table 1: Maximum Approval Cost for the Proposal, $ million**

<table>
<thead>
<tr>
<th>$NZ million</th>
<th>Estimated Cost</th>
<th>Expected Cost</th>
<th>Price contingency</th>
<th>Exchange rate variability</th>
<th>Inflation</th>
<th>IDC</th>
<th>TOTAL</th>
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</thead>
<tbody>
<tr>
<td>Expected Cost</td>
<td>3.1</td>
<td>3.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.8</td>
</tr>
<tr>
<td>Expected End Cost</td>
<td>3.1</td>
<td>3.8</td>
<td>0.2</td>
<td>–</td>
<td>0.3</td>
<td>0.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Maximum Approved Cost</td>
<td>3.1</td>
<td>3.8</td>
<td>0.3</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
<td>4.7</td>
</tr>
</tbody>
</table>

For comparison, Transpower has calculated a P90 figure for the Proposal, using the same approach as use for past GUPs. The MAC and P90 are shown in Appendix Table 2 below:

**Appendix Table 2: Maximum Approval and P90 Costs, $million**

<table>
<thead>
<tr>
<th></th>
<th>MAC</th>
<th>P90</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.7</td>
<td>4.7</td>
</tr>
</tbody>
</table>

**Summary of estimated Expected End Cost and Maximum Approval Cost**

Transpower estimates the Expected End Cost, with variations accounted for, to be $4.5 million and the Maximum Approval Cost of the Proposal is $4.7 million in $2011.