UPPER NORTH ISLAND GENERATION DECOMMISSIONING REPORT

SUMMARY OF INVESTIGATIONS STAGE 1

Transpower New Zealand Limited
March 2016

Keeping the energy flowing
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1 Executive Summary

This is the third in a series of reports by Transpower to help inform the electricity industry of the potential implications of thermal generation decommissioning, following recent and planned closures of a number of generation plants in the North Island.

The findings in this report indicate that New Zealand’s power system may struggle to supply peak loads for the Upper North Island from winter 2020 (under a prudent load forecast) if no new generation were commissioned.

However, it is the view of Transpower that the current energy markets in New Zealand operate well and will provide sufficient investment signals such that sufficient new or refurbished generation will likely be made available in 2019 as required.

The issues identified within this report have been outlined without consideration of how difficult or expensive it may be to resolve them: our next priority is to investigate at a high level the range of potential solutions to these issues so we can provide industry with an understanding of the transmission costs and benefits of a range of new generation locations.

This situation will continue to be monitored closely and updates will be provided as further detailed analysis is completed.

1.1 Background

In 2015, the decommissioning of major generation plants in the Upper North Island (UNI) was announced, including:

- 380 MW Otahuhu combined cycle unit (ceased generation in September 2015)
- 175 MW Southdown generation station (ceased generation at the end of December 2015)
- 500 MW Huntly units 1 and 2 (announced, to be withdrawn from the market in 2018).

This is a significant change to the New Zealand power system and comes on top of the 500 MW already decommissioned at Huntly (units 3 and 4). Consequently, Transpower is undertaking a project to investigate the effects of this decommissioning.

1.2 Process

Transpower has two overall areas of responsibility relating to this power system change. These are:

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1 The region defined as the Upper North Island is defined in Section 1.5 below.
1. short-term (to 2020) – understanding the effects on operability of the existing (and committed) system, and operational procedures that may be required to manage potential constraints, and
2. longer-term (2018 onwards) – investigating system constraints that may arise, and potential investments to ensure that the system meets regulatory and statutory requirements.

The investigations concerning system operability (short-term) are being undertaken by Transpower in its role as System Operator. The System Operator is responsible for day-to-day operation of the transmission system and have Principal Performance Obligations, as defined in the Electricity Industry Participation Code (the Code), which they must meet.

Transpower’s Grid Development team is investigating the longer-term constraints. It is the investigations into the longer-term constraints that are the topic of this report.

The first phase of Grid Development’s investigations will define the issues. This involves computer-modelling the North Island transmission system, taking the recent and proposed Upper North Island generation decommissioning into account. Projected load growth is modelled, along with a range of new generation scenarios.

The system is tested by modelling a range of credible contingencies (failures of equipment such as circuit outages). This testing is looking for scenarios where the transmission system cannot supply the forecast load without constraints such as overloaded circuits, over or under-voltage and dynamic voltage instability.

Following the announced decommissioning, the largest remaining single generator in the upper North Island region will be Huntly unit 5, at 400 MW. This unit cannot be expected to have 100 per cent availability, so the system was tested for both a single credible contingency (N-1) as well as a single contingency with unit 5 out of service (N-G-1).

There are some precedents\(^2\) for justifying investment based on N-G-1 security, particularly in major load areas such as the Upper North Island.

### 1.3 Summary of results

The results are broken down into six sub-investigations for this report.

1. Upper North Island reactive support - dynamic analysis
2. Upper North Island reactive support – load flow analysis
3. Thermal constraints between Whakamaru and Auckland
4. Review of existing constraints south of Whakamaru
5. Waikato 110 kV issues
6. High voltage management in the Upper North Island.

Each area is covered comprehensively in separate documents. These are attached as appendices to this report. The following is a summary of findings from the Needs

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\(^2\) For example the North Island Grid Upgrade project (2006). See Transpower North Island Supply Upgrade Application.
investigations. We have not considered solutions, so issues are reported without consideration of how difficult or expensive it may be to resolve them.

1. Dynamic voltage stability limits are reduced by the removal of generation in the upper North Island. The investigation found that post-decommissioning, the upper North Island winter N-1 and N-G-1 stability limits will be 2534 MW and 2219 MW respectively. This compares to the actual winter 2015 peak of 2150 MW, and the 2020 Prudent³ load forecast of 2550 MW. This indicates that the power system will not be able to supply the peak Upper North Island load from 2020 if the last two Rankine units at Huntly are decommissioned.

An investigation into options to resolve this constraint will be started immediately, and will follow a Major Capex Proposal (MCP) process. In addition, the results of this investigation indicate a possible stability issue in the wider Hamilton area. This will be investigated as part of the next stage of studies.

2. Upper North Island static voltage stability limits may be exceeded when the announced Huntly generation decommissioning goes ahead, unless the existing operating procedures are changed. An investigation into options to resolve this will be undertaken immediately, in conjunction with the dynamic voltage stability investigation. Insufficient dynamic voltage support (rather than static support) is expected to be the first constraint.

3. The timing of thermal constraints between Whakamaru and Auckland depends on the timing and location of replacement generation. For example, new generation in the Wairakei Ring area could create N-G-1 constraints immediately, however new generation in Taranaki will not create constraints between Whakamaru and Auckland in the short term (although it may create constraints outside this area).

4. The 110 kV Bunnythorpe–Mataroa circuit already limits the ability to supply the upper North Island with existing generation from the Wellington and Taranaki regions. There is an investigation underway looking at solutions to this constraint. Even with the Bunnythorpe-Mataroa constraint resolved, thermal N-1 constraints south of Whakamaru will occur as soon as new generation is commissioned in Taranaki or the lower North Island, or HVDC capacity is increased, to replace generation being decommissioned.

5. The Arapuni bus split will remain open, which is a reversal of our previous intention to close this split in 2017. This investigation has gone beyond the Needs stage because it was already an issue we were managing with a development plan⁴ in place prior to the generation decommissioning being announced. Further industry consultation on this issue will be initiated in 2016.

³ Using the Prudent forecast provides a conservative approach to investment timing. The introduction of technologies such as photovoltaics may reduce the load forecast, potentially resulting in deferred investment timing.

⁴ See Transpower’s website for background information.
6. The management of high voltages in the Upper North Island is not greatly affected by the announcement of the generation decommissioning. This is because it is a light-load issue, which occurs when most generation is turned off anyway. However, our review of this issue has indicated that there may be an economic case for investment and we intend to investigate this in 2016/17.

1.4 Next steps

1.4.1 Upper North Island Voltage Investments

The uncertainty regarding future generation closures and new generation locations creates difficulties in framing grid investment proposals in the absence of clear commitment by industry participants. However, the upper North Island voltage issues are common to the majority of thermal exit scenarios; an investigation to resolve these issues will be started immediately.

We will follow a Major Capex Proposal (MCP) process and will discuss with the Commerce Commission options for compressing the process timeframe.

To progress the MCP process Transpower follows an Investment Approval Process (IAP) which includes four stages:

1. identifying the need
2. identifying options
3. analysing options
4. proposing a preferred solution.

Where transmission investment options are expected to be greater than $20 million, Transpower will submit a MCP to the Commerce Commission for approval.

The process is intended to be transparent to industry participants and includes consultation on the options (at the ‘long list’ stage) and prior to submitting a proposal. It also includes a request for proposals (RFP) for non-transmission solutions, where appropriate.

This report describes the identified needs (constraints) from step 1. The next stage includes identifying options (long-listing), and will include industry consultation.

Detailed schedules for the project will be determined when the project group is formed.

If an MCP is approved, investments can be delayed or cancelled if the need changes.

1.4.2 Generation located outside of upper North Island

Further investigations on the impact of new generation located in regions outside of the upper North Island, i.e. Whakamaru and south including central North Island, Taranaki, Wellington and the South Island, will be initiated when there is more certainty on future generation investment location, size and timing.
1.4.2 Ongoing investigations

Investigations are already underway to assess options for resolving thermal constraints on Bunnythorpe—Mataroa, retaining the Arapuni bus split and central North Island 110 kV network constraints. These are not expected to require MCP approval.

An investigation into management of high voltages in the upper North Island is expected to commence in late 2016.
1.5 Definition of Upper North Island

Transpower generally uses the description Upper North Island to describe the power system north of Waikato. This includes Glenbrook, Drury and Bombay, and excludes Huntly and Hamilton. However, in this case Huntly generation is integral to the issue. Therefore, for the purpose of this investigation and report, we are including Huntly when referring to the Upper North Island. This is shown in Figure 1 below.

Figure 1: Illustration of Upper North Island transmission system
2 Introduction

Who is Transpower and what is our role in the industry with respect to future developments? Why are we producing this work?

Transpower is the owner and operator of the national grid. We are also the System Operator, responsible for coordinating and managing the transmission of electricity across the national grid.

As the System Operator, Transpower must meet Principal Performance Obligations, as set out in the Electricity Industry Participation Code (the Code).

As the Grid Owner, Transpower has obligations under the Electricity Industry Participation Code with respect to publishing information on grid reliability. Specifically, we must report on whether the grid is reasonably expected to meet the N-1 criterion over the next ten years, and whether we consider there are economic investments that could be made in respect of interconnection assets.

If there is a material change in forecast demand or supply of electricity, Transpower must publish revised information as soon as reasonably practicable.

Under normal circumstances, Transpower meets these obligations via publication of the Transmission Planning Report. The recently-announced generation decommissioning in the Upper North Island results in a material change of electricity supply at Southdown, Otahuhu and Huntly. This has driven the need to undertake the investigations described in this report.

What are the future developments we are investigating?

At the start of 2015, Auckland and Northland installed generation amounted to about 740 MW. Huntly was an additional 940 MW.

There were three major generation decommissioning announcements in 2015.

Mighty River Power’s Southdown generation station is a 175 MW gas-fired generation station located in Auckland. In March 2015, the closure of this station was announced and generation ceased on 31 December 2015.

Contact Energy announced in August 2015 that the 400 MW Otahuhu B power station, located adjacent to Transpower’s Otahuhu substation in Auckland, was to be closed. Generation ceased on 21 September 2015.

In August 2015, Genesis Energy announced its intention to permanently withdraw from the market the last two Rankine coal-burning generation units (units 1 and 2) at Huntly. This followed earlier announcements of the long-term storage and then
permanent retirement of units 3 and 4. Each of these units had a nominal output of 250 MW.

The present plan is for withdrawal of units 1 and 2 by December 2018 (unless market conditions change).

The result of these planned and completed closures is that Upper North Island generation reduces from approximately 1680 MW to approximately 610 MW by 2019. The 610 MW includes generation at Huntly, Glenbrook and Ngawha (Kaikohe).

**What historical work from the 2015 Transmission Planning Report is relevant to this issue?**

Transpower regularly reviews the capacity of the grid to meet future demand and generation scenarios. As part of this work, scenarios that consider very low generation in the Auckland region have been considered, and these are summarised in our [2015 Transmission Planning Report](#) (2015 TPR). The 2015 TPR does not consider generation levels low enough to simulate the announced reduction in generating capacity.

The work in this report builds on the work already done, in particular the existing constraints south of Whakamaru and the Arapuni 110 kV bus split sections.
3 Approach

How is the investigation being staged and what stage are we reporting here?

The approach we are taking to this investigation is based on our major capital investment process. The first stage is identifying and defining any issues (or ‘needs’).

At this stage we are looking to define a ‘need,’ which could be a need for capital investment or some alternative such as a non-transmission solution. The aim of this stage is to determine whether an investigation into solutions is justified. This is the stage covered in this report.

The second stage is to investigate solutions to any need that is defined in stage one. This stage generally begins with a long list, followed by a short list, from which a preferred option is selected. It includes a detailed economic assessment of the issue and the short-listed solutions.

For major investigations there will often be industry consultation and feedback at each stage. This aims to ensure general agreement on the credibility of the assumptions used and to get a wide view of potential solutions.

How did we decide what to study?

Through previous planning work, as reported in Transpower’s 2015 TPR, we are aware of the general effects of reducing generation in the Upper North Island area.

The areas investigated are a mix of existing issues that may be exacerbated by the generation change (e.g. existing constraints, high voltage management) and issues that we have anticipated for future consideration that may be brought forward (e.g. static and dynamic voltage limits, thermal limits into Auckland).

The approach to generation replacement is the critical assumption.

With the removal of more than 1000 MW of Upper North Island generation, the critical assumption for these studies is the location of replacement generation. If significant new generation appears in, or north of, Auckland then the issues are trivial. However, we are unaware of significant generation investment planned in the Upper North Island area.

There are a range of credible generation development areas, and potential transmission constraints vary depending on which of these is or are developed. To account for this, each study is repeated for a number of generation scenarios. Examples of additional generation, or ‘slack bus’, locations include Whakamaru, Wairakei, Stratford and Haywards (representing HVDC and/or Lower North Island generation).

Details are provided in each individual report found in the appendices.
Chapter 4: Results

Details of the following results are provided as appendices to this report.

1. Upper North Island reactive support - dynamic analysis

See Appendix 1 for the full report. The dynamic reactive support investigation identified that, following decommissioning of the last two Huntly Rankine units:

- the N-G-1 stability limit for the Upper North Island will be 2219 MW, and
- the N-1 stability limit for the Upper North Island will be 2534 MW.

This compares to the actual 2015 winter peak load of 2150 MW.

Under Transpower’s Prudent load growth forecast as used for our 2015 Transmission Planning Report, and assuming the Huntly Rankine units are decommissioned at the end of 2018:

- the N-G-1 limit will first be exceeded in winter 2019, and
- the N-1 limit will first be exceeded in winter 2020.

Therefore, without investment in the grid, or an alternative solution, there will be a risk of load management in the Upper North Island once the last Rankine units are decommissioned.

The study also noted low voltages occurring in the Waikato region. A separate study is needed to determine whether these low voltages are an indicator of voltage stability issues in the Waikato region. This study is currently underway.

2. Upper North Island reactive support – load flow analysis

See Appendix 2 for the full report. The static voltage support investigation identified the first issue as being a risk of voltage collapse, under N-1 and N-G-1 scenarios, centred around Hamilton. The following table summarises results.

<table>
<thead>
<tr>
<th>Case</th>
<th>Outage</th>
<th>UNI load limit</th>
<th>Forecast year (prudent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying existing operating procedures</td>
<td>N-G-1 (Pakuranga-Whakamaru-1 and Huntly unit 5)</td>
<td>2075 MW</td>
<td>exceeded in 2015</td>
</tr>
<tr>
<td></td>
<td>N-1 (Huntly unit 5)</td>
<td>2195 MW</td>
<td>2016</td>
</tr>
<tr>
<td>Altering operating procedures including increased bus voltages</td>
<td>N-G-1 (Pakuranga-Whakamaru-1 and Huntly unit 5)</td>
<td>2330 MW</td>
<td>2016</td>
</tr>
<tr>
<td></td>
<td>N-1 (Huntly unit 5)</td>
<td>2555 MW</td>
<td>2020</td>
</tr>
</tbody>
</table>

With the decommissioning of Huntly generation in 2018, the transmission system will not have N-1 security if peak load coincides with an outage of Huntly unit 5.

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5 This assumes the last two Huntly Rankine units are available until the end of 2018
If operating procedures can be changed, this may be pushed out until 2020. The viability of altering operating procedures will be considered in the next stage of this project. Results from this and the dynamic investigation indicate that there will be a need for additional dynamic voltage support before static voltage support.

Transpower as System Operator has published a report, dated 3 November 2015, indicating a voltage stability limit of 2250 MW for the Upper North Island. That limit is consistent with the range found by this investigation.

3. Thermal constraints between Whakamaru and Auckland

See Appendix 3 for the full report. This investigation considered the capacity of the 220 kV transmission system between Whakamaru and Otahuhu/Pakuranga.

The following table provides a sample of the results. These assume Huntly units 1 and 2 have been decommissioned.

<table>
<thead>
<tr>
<th>Generation development scenario</th>
<th>Outage</th>
<th>UNI load limit</th>
<th>Forecast year (prudent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wairakei Ring - new geothermal</td>
<td>N-1 (Ohinewai–Whakamaru–1)</td>
<td>2666 MW</td>
<td>2024</td>
</tr>
<tr>
<td>Wairakei Ring - new geothermal</td>
<td>N-G-1 (Ohinewai–Whakamaru–1 and Huntly Unit 5)</td>
<td>2370 MW</td>
<td>2016</td>
</tr>
<tr>
<td>Haywards - increased HVDC</td>
<td>N-1 (Ohinewai–Whakamaru–1)</td>
<td></td>
<td>Beyond 2030</td>
</tr>
<tr>
<td>Haywards - increased HVDC</td>
<td>N-G-1 (Ohinewai–Whakamaru–1 and Huntly Unit 5)</td>
<td>2608 MW</td>
<td>2022</td>
</tr>
</tbody>
</table>

In summary, following the decommissioning of Huntly units 1 and 2 the transmission system between Whakamaru and Auckland will not have N-G-1 security (it will be unable to supply peak load if it coincides with an outage of Huntly unit 5). The year that N-G-1 capacity is exceeded depends on the location of any replacement generation.

If replacement generation is located in the Wairakei Ring area, N-G-1 transmission capacity could be exceeded as soon as decommissioning occurs. If replacement generation is located in the southern North Island, South Island or Taranaki, there will be no N-G-1 constraints between Whakamaru and Auckland until at least 2022.

However, generation located in Taranaki, the southern North Island or the South Island, will create other constraints, as described in the following section.
4. **Review of existing constraints south of Whakamaru**

See Appendix 4 for the full report. This investigation identified transmission constraints that may occur if the decommissioned Huntly and Auckland generation is replaced by generation from other generation-rich areas. These include Taranaki and the South Island (i.e. the HVDC/Wellington), Wairakei and the Bay of Plenty. The report covers only the transmission network from these regions through to Huntly and Whakamaru.

The constraints described are already known and previously described in Transpower’s Transmission Planning Report. They are not changed by the generation decommissioning, but they may be more likely to bind due to the increased need for existing generation from regions south of Whakamaru or any replacement generation (constraints that bind will depend on the location of replacement generation).

The first binding constraint is the 110 kV Bunnythorpe–Mataroa–1 circuit, for generation export from the Wellington and Taranaki regions. This constraint has already been observed, particularly during some maintenance outages. There is a project underway to investigate options to resolve this, with the resulting preferred solution expected to be implemented prior to 2018. Therefore, subsequent constraints are of more interest in the medium-term.

In summary, increased generation in Taranaki and Wellington (including HVDC) is limited by the capacity of the 220 kV Tokaanu–Whakamaru circuits, followed by the Huntly–Stratford circuits. These constraints already exist so additional generation will mean they are more likely to bind.

Increased generation in the Wairakei or Bay of Plenty areas is limited by the Atiamuri–Ohakuri circuit followed by the Atiamuri–Whakamaru circuit. The 220 kV Kawerau–Ohakuri and Edgecumbe–Kawerau circuits may constrain generation export from the Bay of Plenty region. Approximately 100 MW of new generation can be added in either (but not both) of these regions before constraints are likely to occur.

There is no single area south of the Upper North Island in which replacement generation equivalent to the decommissioned generation at Huntly, Otahuhu and Southdown can be connected without creating transmission constraints during normal operation.

5. **Waikato 110 kV issues**

See Appendix 5 for the full report. This investigation considered the impact of the recent and proposed generation decommissioning on the Waikato 110 kV transmission network. A specific focus was the impact on our intention to permanently close the existing Arapuni 110 kV bus split in 2017, to enable the connection of a new substation in the South Waikato.

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6 The investigation only considered constraints in the North Island transmission network.
The outcome of the investigation indicates that the split should not be closed in 2017, as there will be insufficient generation to prevent circuit overloading.

This outcome will be followed by a net benefit test, industry consultation on our revised intention to retain the Arapuni bus split indefinitely and our recommended option to manage localised thermal capacity issues in the South Waikato.

6. High voltage management in the Upper North Island
See Appendix 6 for the full report. This investigation looked at the ability of the System Operator to manage voltage levels in the Upper North Island, following the recent and proposed generation decommissioning.

At times of light load, such as overnight during summer, System Operator action is usually required to prevent transmission system voltages exceeding their prescribed upper limits. In recent years this has often included removing one or two transmission circuits from service overnight.

This investigation found that the system voltages will still be manageable following the generator decommissioning. However, it is noted that there is likely to be an economic case for investment to assist in managing high voltages, and this will be investigated at the next stage.
A.1 Appendices

Appendix 1:
UNI generation decommissioning – UNI dynamic reactive support need analysis

Appendix 2:
UNI generation decommissioning – UNI reactive support need, load flow analysis

Appendix 3:
UNI Generation Decommissioning – Thermal constraints between Whakamaru and Auckland

Appendix 4:
UNI Generation Decommissioning – Transmission constraints south of Whakamaru

Appendix 5:
UNI Generation Decommissioning – Waikato 110 kV issues

Appendix 6:
UNI generation decommissioning – High Voltage Management