7 Northland Regional Plan

7.1 Regional overview and transmission system

7.2 Northland demand

7.3 Northland generation

7.4 Grid enhancement approach

7.5 Asset capability and management

7.1 Regional overview and transmission system

The Northland region load includes a major industrial load (oil refinery) at Bream Bay, and loads at smaller regional centres.

The existing transmission network for the Northland region is set out geographically in Figure 7-1 and schematically in Figure 7-2.

Figure 7-1: Northland region transmission

[Map of Northland region transmission showing key locations and network layout]
7.1.1 Transmission into the region

The Northland region is supplied by a 220 kV double-circuit line from Huapai and a 110 kV double-circuit line from Henderson, which is effectively in parallel with the 220 kV circuits.

As generation capacity in Northland is well short of that needed to meet local demand, most of the region’s electricity demand is imported from the central North Island, through the Auckland region.

7.1.2 Transmission within the region

Within Northland, the transmission system can be broken down to two sub-regions.

The high capacity 220 kV double-circuit line from Huapai to Marsden and Bream Bay defines one of the sub-regions. Voltage support is provided by two static synchronous compensators (STATCOMs) at Marsden, connected on the secondaries of the two 220/110 kV interconnecting transformers.

The second sub-region is around Maungatapere, supplied mainly through the 110 kV double-circuit Marsden–Maungatapere line. There is also a low capacity double-circuit Henderson–Maungatapere line, with substations at Wellsford and Maungaturoto. From Maungatapere there is a 110 kV double-circuit line to Kaikohe.

Voltage support for the sub-region is provided by capacitors within the distribution network at Kaiapitai and Kaikohe.
Two 220/110 kV interconnecting transformers at Marsden interconnect the 220 kV and 110 kV networks in the Northland region.

### 7.2 Northland demand

After diversity maximum demand for the Northland region is forecast to grow by an average 1.5 per cent per annum over the next 15 years, from 248 MW in 2017 to 313 MW by 2032. This exceeds the national average of 1.4 per cent per annum.

Table 7-1 sets out forecast peak demand (prudent growth\(^1\)) at each grid exit point over the forecast period.

**Table 7-1: Forecast annual peak demand (MW) at Northland grid exit points to 2032**

<table>
<thead>
<tr>
<th>Grid exit point</th>
<th>Power factor</th>
<th>Peak demand (MW)</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2032</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bream Bay</td>
<td>0.98</td>
<td></td>
<td>55</td>
<td>55</td>
<td>56</td>
<td>56</td>
<td>57</td>
<td>57</td>
<td>57</td>
<td>57</td>
<td>58</td>
<td>58</td>
<td>58</td>
<td>60</td>
</tr>
<tr>
<td>Kaikohe</td>
<td>0.921</td>
<td></td>
<td>63</td>
<td>64</td>
<td>65</td>
<td>66</td>
<td>66</td>
<td>67</td>
<td>67</td>
<td>68</td>
<td>69</td>
<td>69</td>
<td>70</td>
<td>74</td>
</tr>
<tr>
<td>Maungatapere</td>
<td>0.98</td>
<td></td>
<td>123</td>
<td>125</td>
<td>127</td>
<td>129</td>
<td>131</td>
<td>133</td>
<td>135</td>
<td>137</td>
<td>139</td>
<td>140</td>
<td>142</td>
<td>152</td>
</tr>
<tr>
<td>Maungaturoto</td>
<td>1.00</td>
<td></td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>22</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>Wellsford</td>
<td>0.991</td>
<td></td>
<td>37</td>
<td>38</td>
<td>39</td>
<td>40</td>
<td>40</td>
<td>41</td>
<td>42</td>
<td>43</td>
<td>44</td>
<td>44</td>
<td>45</td>
<td>49</td>
</tr>
</tbody>
</table>

This is a leading power factor.

### 7.3 Northland generation

The Northland region’s current generation capacity is approximately 39 MW. As this is less than is required to meet local demand the deficit is imported through the National Grid.

Table 7-2 lists the generation forecast for each grid injection point for the forecast period. This includes all known and committed generation stations including those embedded within the relevant local lines company’s network (Vector, Northpower or Top Energy).\(^2\)

Further generation may be developed during the period but is not sufficiently advanced to be included in our forecasts. (Refer to section 7.5.7 for more information on potential new generation).

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1 Our prudent peak forecast has a 10 per cent probability of exceedance forecast for the first seven years of the forecast period. For the rest of the forecast period we assume an expected (or mean) rate of growth. Refer to Chapter 3 for further information on demand forecasting.

2 Only generators with a capacity greater than 1 MW are listed. Generation capacity is rounded to the nearest megawatt.
Table 7-2: Forecast annual generation capacity (MW) at Northland grid injection points to 2032 (existing and committed generation)

<table>
<thead>
<tr>
<th>Grid injection point (location/name if embedded)</th>
<th>Generation capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bream Bay (Marsden Diesel)</td>
<td>9</td>
</tr>
<tr>
<td>Maungatapere (Wairua)</td>
<td>5</td>
</tr>
</tbody>
</table>
7.4 Grid enhancement approach

7.4.1 Possible future Northland transmission configuration

Figure 7-3 shows the possible configuration of Northland transmission in 2032. New assets, upgraded assets, and assets scheduled for replacement within the forecast period (based on potential enhancement approaches set out in the following sections) are shown.

Figure 7-3: Possible Northland transmission configuration in 2032

7.4.2 Enhancement approach

We ensure secure transmission into and within the Northland region into the future. Through the E&D process we assess transmission capacity and reactive support requirements in the region over the next 15 years (while remaining cognisant of longer-term development opportunities). In developing Grid Enhancement Approaches to address identified issues and opportunities we take into account uncertainty in future demand, generation and technological developments.

The Northland region, together with the Auckland and Waikato regions share the transmission network to the Central North Island. Due to the decommissioning of thermal generation in the Auckland and Waikato regions, there is a need to invest in voltage support to ensure voltage stability is maintained on the grid backbone. The Waikato and Upper North Island (WUNI) project is looking at investment options to maintaining voltage stability in these regions (see Chapter 6). The outcome of the WUNI project may result in some reactive support equipment being installed in the
Northland region to support the grid backbone and provide other benefits such as maintaining voltages during extended contingencies.

Transmission issues likely requiring E&D or Customer funded investments in Northland over the next 10-15 years include:

<table>
<thead>
<tr>
<th>Section number</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.4.2.1</td>
<td>Wellsford supply capacity</td>
</tr>
</tbody>
</table>

**7.4.2.1 Wellsford supply capacity**

Peak load at Wellsford is forecasted to exceed the n-1 capacity of the supply transformers from 2019.

Enhancement approach:

- In the short term, the overload can be managed operationally within Vector’s network.
- We will discuss longer term upgrade options with Vector, when the lack of n-1 capacity can no longer be managed operationally. One option is to install larger transformers at Wellsford. Alternatively, a possible new grid exit point between Henderson and Wellsford may offer more economic benefit. Either of these options will ensure sufficient capacity is available for the forecast period.
- An upgrade of the Wellsford supply transformers and/or a new grid exit point will also require an upgrade of the Henderson–Maungatapere line protection and/or the installation of line circuit breakers at Wellsford or Maungaturoto.

**Customer investments**

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Wellsford supply capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project description:</td>
<td>Replace Wellsford–T1 and T2 with larger units</td>
</tr>
<tr>
<td>Project’s state of completion</td>
<td>Possible</td>
</tr>
<tr>
<td>OAA level completed:</td>
<td>None</td>
</tr>
<tr>
<td>Grid need date:</td>
<td>2024</td>
</tr>
<tr>
<td>Indicative cost [$ million]:</td>
<td>9</td>
</tr>
<tr>
<td>Part of the GEIR?</td>
<td>No</td>
</tr>
</tbody>
</table>

**Base E&D Capex investments**

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Upgrade protection scheme Henderson–Wellsford–Maungaturoto–Maungatapere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project description:</td>
<td>Protection scheme upgrade (may require switchgear upgrade)</td>
</tr>
<tr>
<td>Project’s state of completion</td>
<td>Possible</td>
</tr>
<tr>
<td>OAA level completed:</td>
<td>None</td>
</tr>
<tr>
<td>Grid need date:</td>
<td>2024</td>
</tr>
<tr>
<td>Indicative cost [$ million]:</td>
<td>3</td>
</tr>
<tr>
<td>Part of the GEIR?</td>
<td>No</td>
</tr>
</tbody>
</table>
7.5 Asset capability and management

We assessed the transmission capacity and reactive support requirements in the region for the next 15 years. When an issue or opportunity exists, we have examined initial options and actions that may be taken to address it. Grid Enhancement Approaches (refer to section 7.4.2) have been developed to address issues or opportunities that require action within the forecast period and where investment is justified.

This section discusses the main inputs to the E&D process. These are:

- transmission capability (taking into account forecast demand and generation and possible technological changes)
- customer requests
- generation proposals and opportunities
- risk-based asset replacements
- significant upcoming work planned over the period
- asset feedback (information on assets or issues submitted through the asset feedback process).

7.5.1 Northland significant upcoming work

We integrate our capital project and maintenance works to enable system issues to be resolved, if possible, when assets are replaced or refurbished. Table 7-3 lists the significant upcoming work\(^3\) proposed for the Northland region during the next 15 years that may significantly impact related system issues or connected parties.

<table>
<thead>
<tr>
<th>Description</th>
<th>Tentative year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maungaturoto 33 kV outdoor to indoor conversion</td>
<td>2023-2025</td>
</tr>
<tr>
<td>Wellsford 33 kV outdoor to indoor conversion</td>
<td>2023-2025</td>
</tr>
<tr>
<td>Wellsford T1 and T2 refurbishment</td>
<td>2018–2019</td>
</tr>
</tbody>
</table>

7.5.2 Northland asset feedback

The Asset Feedback Register includes the following entry related to E&D that is specific to the Northland region:

- Future of Kaitaia 33 kV binary switched capacitor.

7.5.2.1 Future of Kaitaia 33 kV binary switched capacitor

Issue

We have divested the Kaitaia substation and the 110 kV Kaikohe–Kaitaia transmission line to Top Energy but retained ownership of the 33 kV binary switched capacitors to provide reactive support to the Northland region. The maintenance and operations of these capacitors is relatively expensive as the site is far from our

\(^3\) Condition-based replacement of the asset is included in this list.
northern-most substation. In addition, the capacitors are sited on Top Energy’s property which requires its cooperation to facilitate maintenance and servicing.

What next?

We are currently studying the reactive support requirements for the upper North Island under the WUNI project (see Chapter 6). This work will give us a better understanding of future reactive power requirements in the region, so we can determine future need for the Kaitaia 33 kV capacitors.

7.5.3 Changes since the 2015 Transmission Planning Report

Table 7-4 lists the specific issues that are either new or no longer relevant within the forecast period (relative to our previous Transmission Planning Report).

Table 7-4: Changes since the 2015 TPR

<table>
<thead>
<tr>
<th>Issues</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maungaturoto supply transformer</td>
<td>Removed, increased protection and metering capacity</td>
</tr>
</tbody>
</table>

7.5.4 Northland transmission capability

Table 7-5 summarises the transmission capability issues identified for the Northland region for the next 15 years. In each case we have detected a condition that would constrain the network capacity if action were not taken. Each issue is discussed in more detail below.

This transmission capability section reports whether the Grid can be reasonably expected to meet (n-1) security requirements over the next 15 years. This section, together with the demand and generation sections, forms part of the Grid Reliability Report (GRR).

Table 7-5: Northland region transmission issues – regional/site by grid exit point

<table>
<thead>
<tr>
<th>Section number</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional</td>
<td></td>
</tr>
<tr>
<td>7.5.4.1</td>
<td>Upper North Island voltage instability for grid backbone contingencies</td>
</tr>
<tr>
<td>Site by grid exit point</td>
<td></td>
</tr>
<tr>
<td>7.5.4.2</td>
<td>Kaikohe–Maungatapere 110 kV transmission capacity</td>
</tr>
<tr>
<td>7.5.4.3</td>
<td>Wellsford supply transformer capacity</td>
</tr>
</tbody>
</table>

7.5.4.1 Upper North Island voltage instability for grid backbone contingencies

Issue

As demand in the Auckland and Northland regions grows, voltage stability margins will deteriorate to the point where several generators and circuit contingencies on the grid backbone can cause voltage problems within the Northland region.

What next?

We are currently investigating additional reactive power support requirements in the Waikato and Auckland regions to maintain voltage stability margins (see Chapter 6,
WUNI project). Any investments made under the WUNI project will also resolve voltage stability issues in the Northland region.

7.5.4.2 Kaikohe–Maungatapere 110 kV transmission capacity

Issue

Two 110 kV Kaikohe–Maungatapere circuits supply Kaikohe providing:

- total nominal installed capacity of 129/158 MVA (summer/winter)
- n-1 capacity of 63/77 MVA (summer/winter).

The 25 MW Ngawha (geothermal) generation station is embedded behind the Kaikohe supply bus.

Peak load at Kaikohe will exceed the n-1 capacity of the Kaikohe–Maungatapere circuits when Ngawha is not generating, as shown on Table 7-6.

Table 7-6: Kaikohe–Maungatapere 110 kV transmission line overload forecast

<table>
<thead>
<tr>
<th>Circuit/grid exit point</th>
<th>Transmission line overload (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaikohe</td>
<td>4</td>
</tr>
</tbody>
</table>

What next?

The existing capacity of the Ngawha generation is sufficient to ensure the Kaikohe–Maungatapere circuits remain within their n-1 capacity over the forecast period. Top Energy is also looking at expanding its Ngawha generation in the near future, adding to the amount of generation that can be used to prevent overloading on the circuit.

We have no plans to upgrade the capacity on the Kaikohe–Maungatapere circuit at present. We will investigate investment options when the customer (Top Energy) requests a capacity increase.

7.5.4.3 Wellsford supply transformer capacity

Issue

Two 110/33 kV transformers supply Wellsford's load, providing:

- total nominal installed capacity of 60 MVA
- n-1 capacity of 37/39 MVA (summer/winter).

Peak load at Wellsford is forecast to exceed the n-1 winter capacity of the transformers by 1 MW in 2019, increasing to approximately 12 MW in 2032 (see Table 7-7). Both existing transformers comprise three single-phase units. There is no spare unit on site.

Table 7-7: Wellsford supply transformer overload forecast

<table>
<thead>
<tr>
<th>Circuit/grid exit point</th>
<th>Transformer overload (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellsford</td>
<td>0</td>
</tr>
</tbody>
</table>
What next?

In the short term, the overload can be managed operationally within Vector’s network. Refer to section 7.4.2.1 for our proposed approach.

7.5.5 Northland bus security

This section presents issues arising from the outage of a single bus section rated at 66 kV and above for the next 15 years.

Bus outages disconnect more than one power system component (for example, other circuits, transformers, reactive support or generators). Therefore, bus outages may cause greater issues than a single circuit or transformer outage (although the risk of a bus fault is low, being less common than a circuit or transformer outage).

7.5.5.1 Transmission bus security

All 220 kV and 110 kV buses in the Northland region have bus section circuit breakers and bus zone protection. Therefore, a bus fault will trip only half a bus (and connected circuits and transformers). Supply will be maintained through the circuits and transformers connected to the other half bus that did not trip.

7.5.6 Other regional items of interest

7.5.6.1 North of Huapai transmission security

Issue

The Huapai switching station comprises three circuit breakers:

• one on each of the 220 kV circuits connecting Marsden and Bream Bay
• a shared circuit breaker for the two incoming 220 kV circuits from Albany and Henderson.

If the shared circuit breaker fails to trip following an incoming 220 kV circuit fault, both the outgoing circuits will trip, leaving the entire load north of Huapai supplied by the low capacity 110 kV Henderson–Maungatapere circuits. This may result in a loss of supply to the Northland region, depending on the region’s load at the time.

What next?

We have investigated this issue and found that investments to increase the security level are not economically justified. We will continue to monitor this issue and will consider enhancing the Huapai bus security if there are synergies with other future developments.

7.5.6.2 Regional transmission security during maintenance of a 220 kV circuit

Issue

During maintenance of one of the 220 kV Huapai–Bream Bay circuits, system operations splits the 110 kV network, by opening the Henderson–Maungatapere circuits at Maungatapere. This is done to cover against the possible contingency of the other 220 kV circuit, which could cause voltage collapse in the Northland region. The 110 kV split puts the region on n security.
NorthPower and Vector have indicated that they would like us to study other possible options that could help to maintain n-1 security during this type of maintenance operation.

What next?

We will schedule an investigation to look at possible options based on the criticality of the need.

7.5.6.3 Supply security during maintenance of a 110 kV Henderson–Maungatapere circuit

Issue

The Henderson–Maungatapere double circuit line supplies Wellsford and Maungaturoto. There are no line breakers at either of the two substations, therefore if a circuit is out for maintenance and the other trips, there will be loss of supply at these two sites.

As the line is relatively long, maintenance outages occur relatively frequently which results in the load being on n security for long periods of time.

What next?

From experience on other similar parts of the transmission system, investments to increase security to Wellsford and Maungaturoto are unlikely to be economic. The customers (NorthPower or Vector) have not requested a higher security level.

7.5.7 Northland generation proposals and opportunities

This section details relevant regional issues that may affect generation proposals under investigation by developers and in the public domain, or other generation opportunities. The impact of committed generation projects on the grid backbone is discussed separately in Chapter 6.

The maximum generation that can be connected depends on several factors and is usually expressed as a range. Generation developers should consult with us at an early stage of their investigations to discuss connection issues.

7.5.7.1 Maximum regional generation

The following maximum generation estimates assume a light North Island load profile and high output from existing generation in the region (Ngawha generating 25 MW).

For generation connected at the Maungatapere 110 kV bus, the maximum generation that can be injected under n-1 conditions is approximately 300 MW. Generation would be constrained by one Marsden interconnector when the other interconnector is out of service.

For generation connected at the Huapai 220 kV bus, the maximum generation that can be injected under n-1 conditions is approximately 560 MW. This constraint is due to the Henderson–Huapai–1 circuit overloading when Albany–Huapai–1 is out of service. This may increase to 750 MW if a substation equipment constraint on this circuit is removed.
7.5.7.2 Generation injection at Maungatapere

Generation of approximately 300 MW can be connected directly or indirectly to the Maungatapere 110 kV bus. This includes generation at Kaikohe, and for some system configurations, generation connected to the 110 kV Henderson–Maungatapere line. It may be possible to install more generation if some equipment at substations were replaced, the Marsden interconnection capacity was upgraded, and the Henderson–Maungatapere line was thermally upgraded.

7.5.7.3 Generation connected to the 110 kV Henderson–Maungatapere line

There is a 110 kV double-circuit line from Henderson to Wellsford, Maungaturoto, and Maungatapere. Each circuit is rated at 56/68 MVA (summer/winter). Generation up to a total of approximately 200 MW can be connected, provided a system split is put in place with half the generation transmitted towards Maungatapere and half towards Henderson. If one circuit were out of service, the generation would need to be automatically reduced to match the capacity of the remaining circuit.

The two circuits can be thermally upgraded to allow approximately 300 MW of generation, or have replacement conductors to allow greater capacity. Generation transmitted towards Maungatapere forms part of the generation injection limit into Maungatapere.

7.5.7.4 Generation connected to the 220 kV Huapai–Marsden line

The 220 kV double-circuit line from Huapai (north of Auckland) to Marsden and Bream Bay (in Northland) is the main connection to the Northland region. One circuit is predominantly a simplex conductor (rated at 333/370 MVA) while the other is a duplex conductor (rated 666/740 MVA).

Generation can be connected along this line, not just at existing substations. Maximum generation of between 300 MW and 500 MW may be possible depending on which circuit generation was connected into, with the simplex Bream Bay–Huapai conductor being the limiting component. New generation elsewhere in the Northland region will reduce this limit.

7.5.7.5 Generation connected to the 220 kV bus at Marsden

For generation connected at the Marsden 220 kV bus, the maximum generation that can be injected under n-1 conditions is approximately 600 MW. The constraint is due to the Bream Bay–Huapai–1 circuit overloading for an outage of the Albany–Huapai–Marsden line.

7.5.7.6 Generation connected to the 110 kV bus at Marsden

For generation connected at the Marsden 110 kV bus, the maximum generation that can be injected under n-1 conditions is approximately 275 MW. The constraint is due to one Marsden interconnecting transformer overloading for an outage of the parallel transformer.

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4 The actual circuit rating is limited to 457 MVA at present due to some substation equipment. As this is relatively easy and inexpensive to replace in the context of generation connection this limit is ignored for the purposes of this discussion.