IMPORTANT

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1. **Executive Summary**

The purpose of this study is to assess any voltage stability (VS) issues that may arise from low generation scenarios in the Upper South Island (USI or Zone 3) area in the winter from May to September 2015 inclusive.

Voltage stability is primarily affected, in Zone 3, when one of the four 220 kV circuits into Islington has tripped and the load is high. This limiting contingent plant is usually one of the two Ashburton – Timaru – Twizel circuits or the Islington Tekapo B circuit.

The following scenarios were studied for low Zone 3 generation, during peak load periods to identify the corresponding load limit. These scenarios represent 'reasonable' and a 'worst case' system conditions under which to assess voltage stability in the region.

**Table 1: Zone 3 load limits**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Tekapo B</th>
<th>Tekapo A</th>
<th>Islington SVC 9</th>
<th>Limiting Contingency</th>
<th>Expected Forecast Load</th>
<th>VS Load Limit</th>
<th>Margin</th>
<th>Margin %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IN</td>
<td>IN</td>
<td>OUT</td>
<td>Islington Tekapo B</td>
<td>1096</td>
<td>1170</td>
<td>74</td>
<td>6.75</td>
</tr>
<tr>
<td>2</td>
<td>OUT</td>
<td>OUT</td>
<td>IN</td>
<td>Ashburton Timaru Twizel 1 or 2</td>
<td>1096</td>
<td>1200</td>
<td>104</td>
<td>9.49</td>
</tr>
</tbody>
</table>

The results of the studies show that the USI peak winter demand can be met with all available plant in service as there is adequate margin (>5%) even in the worst case scenario 1 above.

Therefore, there are no requirements this winter for:

- A NIWA report to assess expected extreme weather conditions with accompanying high Zone 3 loads
- An UNI Contingency plan whereby Christchurch load is managed pre or post contingently to mitigate potential voltage collapse when the contingent plant trips
2. **INTRODUCTION**

The purpose of this document is to provide market participants with an indication of what the limiting load limits are for the USI based on perceived generation scenarios. The limiting contingent loss of plant causing voltage collapse in Zone 3 is generally a transmission line as opposed to a generator. This study cannot be used to infer system transfer limits at a glance but will give indicative load limits based on these generation scenarios. In real time VS is managed based on system conditions at the time.

2.1 **UPPER SOUTH ISLAND NETWORK OVERVIEW**

The USI is the area that encompasses Grid Zones 9, 10, 11, and 12, which are the Nelson and Marlborough, Christchurch, Canterbury, and West Coast regions. The region is supplied by 220 kV transmission circuits from the lower South Island. The 220 kV circuits originate from Twizel and Livingstone buses in Grid Zone 13.

Capacitor banks are available at Bromley, Islington, Southbrook, Kikiwa, Stoke, Blenheim, Greymouth and Hokitika substations. Two Static Var compensators (SVC) are installed at Islington and two STATCOMS are installed at Kikiwa substations.

The USI region is shown geographically in Figure 1.
Figure 2: Geographic Representation of Upper South Island
2.2 **UPPER SOUTH ISLAND SCHEMATIC OVERVIEW**

![Diagram of the Transmission network of Upper South Island](image)

*Figure 2: Schematic Representation of the Transmission network of Upper South Island*
3. **Assumptions & Methodology**

The following assumptions and methodology are applied in the assessment of voltage stability in the USI.

3.1 **Grid Configuration**

It is assumed that there are no transmission outages unless otherwise stated. There are four circuits supplying the Christchurch region including Islington Tekapo B, Islington Timaru Twizel 1 & 2 and Islington Livingstone. There is also some local generation.

3.2 **Generation Scenarios**

Maintenance is generally not carried out on generators over winter so the following generation scenarios are used for the study. These scenarios represent ‘reasonable’ and a ‘worst case’ system conditions under which to assess voltage stability in the region.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Tekapo B</th>
<th>Tekapo A</th>
<th>Islington SVC 9</th>
<th>Islington SVC 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IN</td>
<td>IN</td>
<td>OUT</td>
<td>IN</td>
</tr>
<tr>
<td>2</td>
<td>OUT</td>
<td>OUT</td>
<td>IN</td>
<td>IN</td>
</tr>
</tbody>
</table>

**Table 2: Generation Scenarios**

<table>
<thead>
<tr>
<th>Plant</th>
<th>Rating (MW)</th>
<th>Rating (MVAr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tekapo A</td>
<td>25</td>
<td>-15 / 28</td>
</tr>
<tr>
<td>Tekapo B</td>
<td>2 * 65</td>
<td>-50 / 70</td>
</tr>
</tbody>
</table>

**Table 3: Generation Ratings**
3.3 **Other Generation Assumptions**

The following are assumed values for other generating stations. These are typical historical values for a low generation scenario.

**Table 4: Other Generation Assumptions**

<table>
<thead>
<tr>
<th>Station</th>
<th>Generation (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnold</td>
<td>1.5</td>
</tr>
<tr>
<td>Argyle</td>
<td>5</td>
</tr>
<tr>
<td>Cobb</td>
<td>23</td>
</tr>
<tr>
<td>Coleridge</td>
<td>28</td>
</tr>
<tr>
<td>Kumara</td>
<td>9</td>
</tr>
<tr>
<td>Highbank</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>90.5</td>
</tr>
</tbody>
</table>

3.4 **Dynamic Reactive Plant Capability**

The following dynamic reactive plant are used in Zone 3

**Table 5: Dynamic Reactive Plant Status**

<table>
<thead>
<tr>
<th>Plant</th>
<th>Rating (MVAr)</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Islington SVC 3</td>
<td>-50/+59 MVAr</td>
<td>IN</td>
<td>IN</td>
</tr>
<tr>
<td>Islington SVC 9</td>
<td>-75/+150 MVAr</td>
<td>OUT</td>
<td>IN</td>
</tr>
<tr>
<td>Kikiwa Statcoms</td>
<td>2 x -40/+40 MVAr</td>
<td>IN</td>
<td>IN</td>
</tr>
</tbody>
</table>
3.5 **LOAD FORECAST**

Loads used in this study are based on a morning peak scenario. These load values were provided by the lines companies.

<table>
<thead>
<tr>
<th>Table 6: Zone 1 Load Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1 Load Assumptions</td>
</tr>
<tr>
<td>2014 Actual Peak (MW)</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Alpine Energy</td>
</tr>
<tr>
<td>Buller Networks</td>
</tr>
<tr>
<td>Electricity Ash</td>
</tr>
<tr>
<td>Mainpower</td>
</tr>
<tr>
<td>Marlborough Lines</td>
</tr>
<tr>
<td>Network Tasman</td>
</tr>
<tr>
<td>Orion Group</td>
</tr>
<tr>
<td>Westpower</td>
</tr>
<tr>
<td><strong>Total Zone 3</strong></td>
</tr>
</tbody>
</table>

Zone 3 peak power factor = 0.99. This is the worst case value for the last year.

### 3.5.1 Definitions

- **Expected forecast**
  - this forecast is the peak demand that each lines company would expect to see in the average winter, MW
- **Actual Peak**
  - this is the actual system peak demand from SCADA, MW
- **Margin**
  - difference between Actual and expected load, %

### 3.6 GENERAL METHODOLOGY

Voltage stability studies are carried out for each scenario using the expected 2015 load. The study is iterated by scaling up the load until the voltage collapse point is reached. The load limit is then determined as being 95% of the voltage collapse point. This value represents the highest load that can be attained in Zone 3, for that particular scenario, before any load management is required.

---

1 The lower Westpower load is attributed to the new embedded generation in their network.
4. **RESULTS**

4.1 **RESULTS VOLTAGE STABILITY**

The table below shows load limits and the respective margins available for the scenario studied.

*Table 7: Generation Results*

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Tekapo B</th>
<th>Tekapo A</th>
<th>Islington SVC 9</th>
<th>Limiting Contingency</th>
<th>Expected Forecast Load</th>
<th>VS Load Limit</th>
<th>Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IN</td>
<td>IN</td>
<td>OUT</td>
<td>Islington Tekapo B</td>
<td>1096</td>
<td>1170</td>
<td>74</td>
</tr>
<tr>
<td>2</td>
<td>OUT</td>
<td>OUT</td>
<td>IN</td>
<td>Ashburton Timaru</td>
<td>1096</td>
<td>1200</td>
<td>104</td>
</tr>
</tbody>
</table>

In the above scenarios the expected 2015 forecast load of 1096 MW can be met adequately without any load management mitigation.

A margin over 5% or 55 MW is considered adequate for the USI to allow for variations due to adverse weather conditions and concurrent single transmission outages.
5. **APPLICATION OF LOAD LIMIT**

5.1 **CONSTRAINTS**

The load limit is enforced in the forward looking schedules and in real-time using market stability constraints.

The stability constraint is applied normally using an equation with a high RHS (default value). The high RHS value is used to allow for variations in power factor, load, generation and reactive support. In real-time the RHS is adjusted to match system conditions at the time.

The constraint used is

**Constraint Name:** UPPER_SOUTH_ISLAND_STABILITY_P_1B

**Constraint Equation:**

\[
-1 \times \text{ASB_TIM_TWZ2.3} + -1 \times \text{ISL_TKB.1} + -1 \times \text{ISL_LIV.1} + -1 \times \text{ASB_TIM_TWZ1.3} \leq \text{RHS}
\]

The following table show the indicative RHS that could be applicable for the scenarios studied.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>VS Eqn. RHS (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Default value</td>
<td>1330</td>
</tr>
<tr>
<td>1</td>
<td>1085</td>
</tr>
<tr>
<td>2</td>
<td>1140</td>
</tr>
</tbody>
</table>

Note: RHS is the transfer into the region (zone) and not the load limit.
6. **Summary**

The results indicate that the expected 2015 forecast can be met with adequate voltage stability margins in the USI.

Therefore, there are no requirements this winter for:

- A NIWA report to assess expected extreme weather conditions with accompanying high Zone 3 loads
- An USI Contingency plan whereby Christchurch load is managed pre or post contingently to mitigate potential voltage collapse when the contingent plant trips

If system conditions significantly change during winter such as:

- Unexpected outages on generators
- Unexpected outages on transmission plant
- Unexpected higher loads

Then new studies will be carried out and the industry notified accordingly.
7. **APPENDIX**

7.1 **REVIEW LAST WINTER**

The actual peak last year was about the same as expected forecast load 1078 MW as shown in the bar chart below.

*Figure 3: Last Winter Review*

Upper South Island winter peak 2014 demand was supplied without any system security issues.

*Figure 4: Comparison of Previous Years Load*