REACTIVE POWER NEEDS ASSESSMENT FOR UPPER NORTH ISLAND

SUMMARY

This document sets out the System Operator's assessment of the reactive power needs for the Upper North Island. This document should be read in conjunction with the 2006 ancillary services Procurement Plan.

The System Operator published a reactive power needs assessment for the Upper North Island in mid 2005. This document concluded that additional reactive support (200 Mvars) should be contracted. The System Operator has since procured (under the 2005 procurement plan) additional reactive support.

The current voltage support contracts in the Upper North Island are shown in Table 1.

Plant	Comment
Otahuhu A G1 and G2	These units will provide continuous voltage support from April 2007 to April 2010.
Otahuhu A (two of G4, G5 and G6)	Contracts for these units expire on 31 March 2007.
Otahuhu A third unit	The contract for this unit expires on 31 March 2007
Marsden condenser	The contract for this unit expires on 31 October 2008

Table 1 - Voltage support contracts in Upper North Island

The System Operator has carried out this updated review of reactive power needs for the Upper North Island. The review has considered:

- Revised load forecasts and power factor forecasts in light of Upper North Island peak winter demand in 2007.
- New voltage support contracts from G1 and G2 at Otahuhu A power station.
- The condition and continuing availability of certain older capacitors in the Auckland region.
- New capacitors installed at Penrose and Hepburn Road substations.
- The planned commissioning of the new Southdown generating unit including a consideration of its availability during commissioning and early operation.
- The planned commissioning of the new Huntly E3P unit including a consideration of its availability during commissioning and early operation.
- The proposed Albany SVC and capacitors and the Kaitaia capacitors
- The value of flexibility in contract period.

Load forecasts for the period 2007 to 2012 have been prepared. These forecasts are based on a similar methodology to that of the Short Term System Security Forecast published in May 2006. Historic demand is analysed to determine expected and prudent demands taking account of temperature effects. Trends in power factor are also considered.

The reactive power need analysis considers only new investment that is committed (e.g. that meets the requirements of the System Security Forecast committed investment test) and voltage support that is currently contracted (e.g. the contracts for two Otahuhu A units expires in October 2006 and is not considered to be renewed).

The historic experience with gas and steam turbine units (including Southdown units) is that the availability in the immediate period following commissioning does not reflect that typically expected over the life of the plant.

The review has concluded that with the assets currently available:

- Summer 2007 prudent demand can be met with all plant in service. Summer 2007 prudent demand can not be met with the Otahuhu B generating unit out of service during summer 2007 without additional (such as from the new Southdown unit).

- Summer 2007 expected demand can be met with Otahuhu B generating unit out of service.

- Winter 2007 prudent demand can be met with Otahuhu B out of service if reactive support equivalent to 2 of the three Otahuhu A units 4, 5 and 6 is available.

- Winter 2007 prudent demand can be met with the Otahuhu B generating unit out of service provided that reactive support equivalent to that provided by two of the Otahuhu 4, 5 and 6 units are available and regional power factor is close to 0.99.

- Prudent demand in 2010 can be met if an additional voltage support of 100 Mvars is procured to be available at times of peak demand.

The implications for the 2006 procurement plan are:

- An additional 100 Mvar of reactive support should be procured for the period October 2006 to October 2011. It is preferable that this amount of reactive support is provided by active compensation plant. The voltage support contract can be either on an availability basis or continuous basis.

1 ASSUMPTIONS

1.1 Procurement Plan

Voltage support (and other ancillary services) are procured by the System Operator using the annual Procurement Plan process. The current contracting position for voltage support is described in Table 1. Further voltage support to meet identified needs can be contracted through Part C processes or by investment in transmission assets (reactive plant such as capacitors and SVCs) or new generation.

Much of the equipment currently used for providing voltage support through contracted ancillary services is near end of life. The relevant providers have made clear to the System Operator the difficulties they face in maintaining such equipment to ensure reasonable availability levels. The System Operator has contracted with some service providers for three year contracts to provide certainty both for the service provider and the industry.

The System Operator intends to contract services for the next 3 to 5 year period to:

- ensure current providers have certainty of revenue to commercially justify their continued commitment to end of life plant and the required capital and maintenance spending

- the needs identified for winter 2008 can reliably be provided.

Contracting for these periods is complementary to investment being considered under Part F processes. Firstly, the planning assumptions used in the Annual Planning Report are that reactive support equivalent to the capability of all the current Otahuhu A generating units is available for the future. Contracting for some additional voltage support in the Auckland region for three to five years is consistent with the planning assumptions.

This approach will allow appropriate time for new plant investments to be considered, approved and come into operation (thereby replacing existing time-expired plant and increasing total available support) without acting as a disincentive to such new investment.

1.2 Existing voltage support contracts

The current voltage support contracts in the Upper North Island are shown in Table 2.

Plant	Comment
Otahuhu A G1 and G2	These units will provide continuous voltage support from April 2007 to April 2010.
Otahuhu A (two of G4, G5 and G6)	Contracts for these units expire on 31 March 2007.
Otahuhu A third unit	The contract for this unit expires on 31 March 2007.
Marsden condenser	The contract for this unit expires on 31 October 2008.

Table 2 - Voltage support contracts in Upper North Island

1.3 Availability of new generation

Two new generating units will be commissioned in 2007 in the Upper North Island. These are Huntly unit 5 (e3p) and Southdown unit 5. Both of these units are gas fired. The availability of these units during commissioning and in the months immediately following commissioning is not expected (based on experience from the commissioning of Otahuhu B and TCC units) to be representative of the availability expected over the life of the asset.

The new Southdown unit is expected to be commissioned in December 2006. It is assumed that that with six months operation post commissioning the new unit will be available for the 2007 winter period. The effect of the new unit not being in service is a reduction in power system transfer limits due to voltage stability into the Upper North Island of around 55-60 MW.

Huntly unit 5 is expected to be commissioned around April 2007. Given the historical availability of large CCGT plant post commissioning, it is considered prudent to identify power system limits both with and without Huntly unit 5 in service in winter 2007. The effect of Huntly unit 5 not being in service is a reduction in power system transfer limits due to voltage stability into the Upper North Island of around 150 MW.

1.4 Power Factor

Figure 1 shows historic summer power factor for the Upper North Island for 2004 to 2006 (note that only the top 10% of demand for each year is shown for clarity). While the power factor varies between 0.99 and 0.965, there seems to be no significant downwards trend.

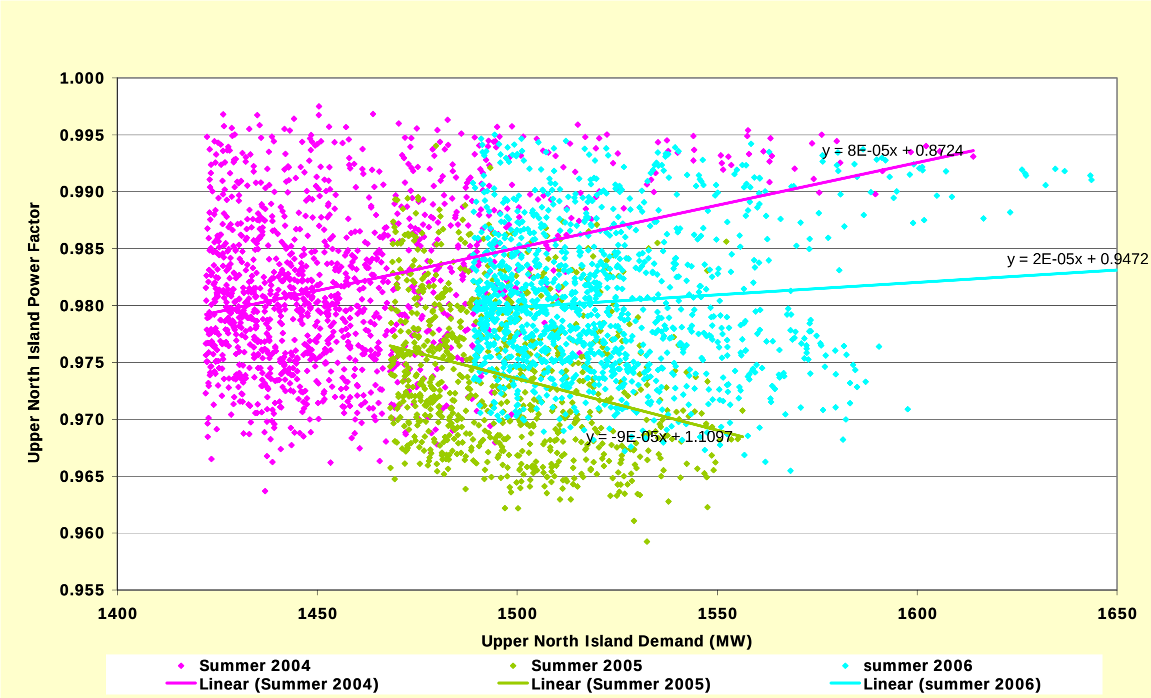

Figure 1 - Summer power factor for Upper North Island

Figure 2 shows the historic winter power factor for the Upper North Island for 2004 to 2006 (note that only the top 10% of demand is shown). While the power factor is quite high, there is a definite downwards trend over time.

Figure 2 - Winter power factor for Upper North Island

Forecast power factor assumptions for period 2007 to 2012:

- The power factor in summer is 0.97. This is not expected to change over the period.
- The power factor in winter will reduce to 0.98 over the period. A conservative estimate of 0.98 will be used for the 2007 to 2012 period. Note that a 0.01 pf change in winter power factor equates to a change in power system voltage stability limits of 100 MW.

1.5 Grid Capacitors

The Grid Owner has installed new capacitors (200 Mvars) in 2006 at Penrose and Hepburn Road substations. The Grid Owner plans to decommission around 100 Mvar of capacitors in the Auckland region as the capacitors reach end of life. It is assumed that none of the 100 Mvars of capacitors will be available from 2007 onwards.

1.6 Proposed grid investment

The Grid Owner has proposed the following investments in reactive plant in the Upper North Island as part of the Interim Grid Expenditure application in October 2005:

- Albany Static Var Compensator (+/- 100 Mvar range)
- Albany capacitor bank (100 Mvar)
- Kaitaia capacitor bank (24 Mvar)

The Electricity Commission approved these projects in March 2006. These projects are considered in this analysis.

1.7 Forecast load in Upper North Island

These forecasts are based on a similar methodology to that of the Short Term System Security Forecast published in May 2006.

Winter

Figure 1 shows the forecast demand (half-hour) for the Auckland and North Isthmus regions.

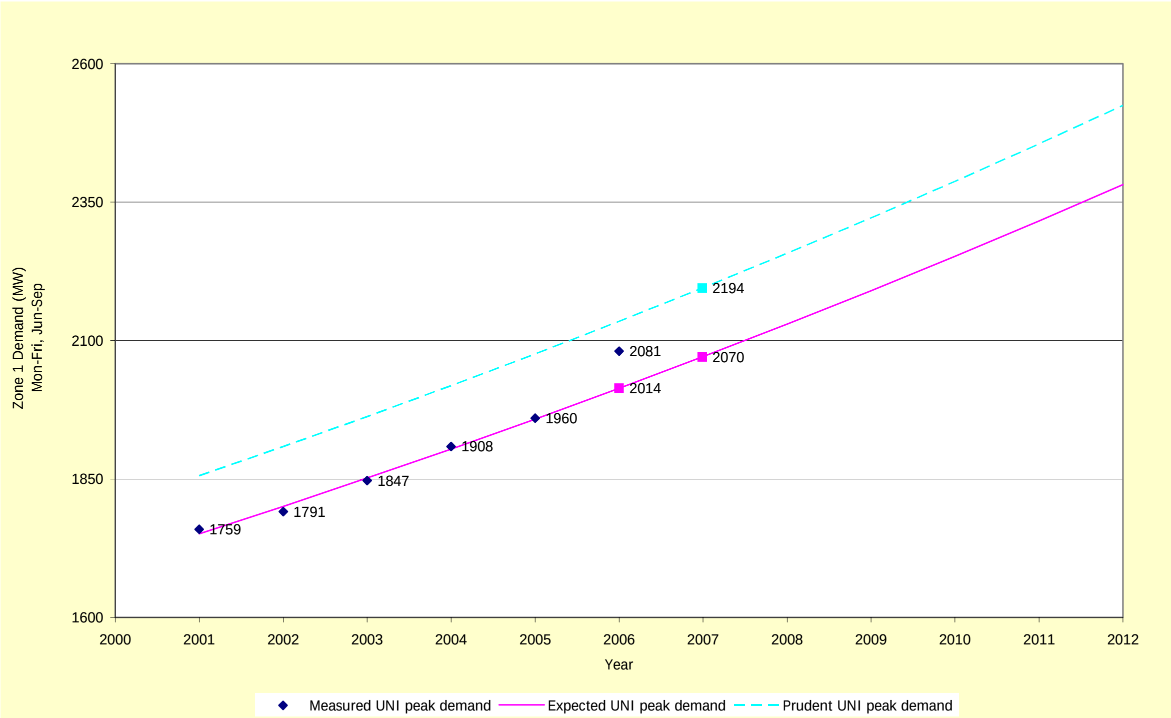

Figure 3 - Forecast prudent and expected winter peak demand for Auckland and North Isthmus Regions

The highest evening peak demand observed to date in 2006 is 2081 MW (note this is demand experienced on 19 June 2006). This evening peak is expected to be reflective of system and distribution network conditions similar to evening peaks in previous years for the Upper North Island load.

A morning peak demand that occurred on 23 June 2006 was marginally higher but does not appear to be typical. This peak has been ignored for the purposes of forecasting expected and prudent peak demand for the period 2007 to 2012. The expected and prudent peak demands in 2007 are 2070 and 2194 MW respectively.

Summer

Figure 4 shows the forecast demand (half-hour) for the Auckland and North Isthmus regions.

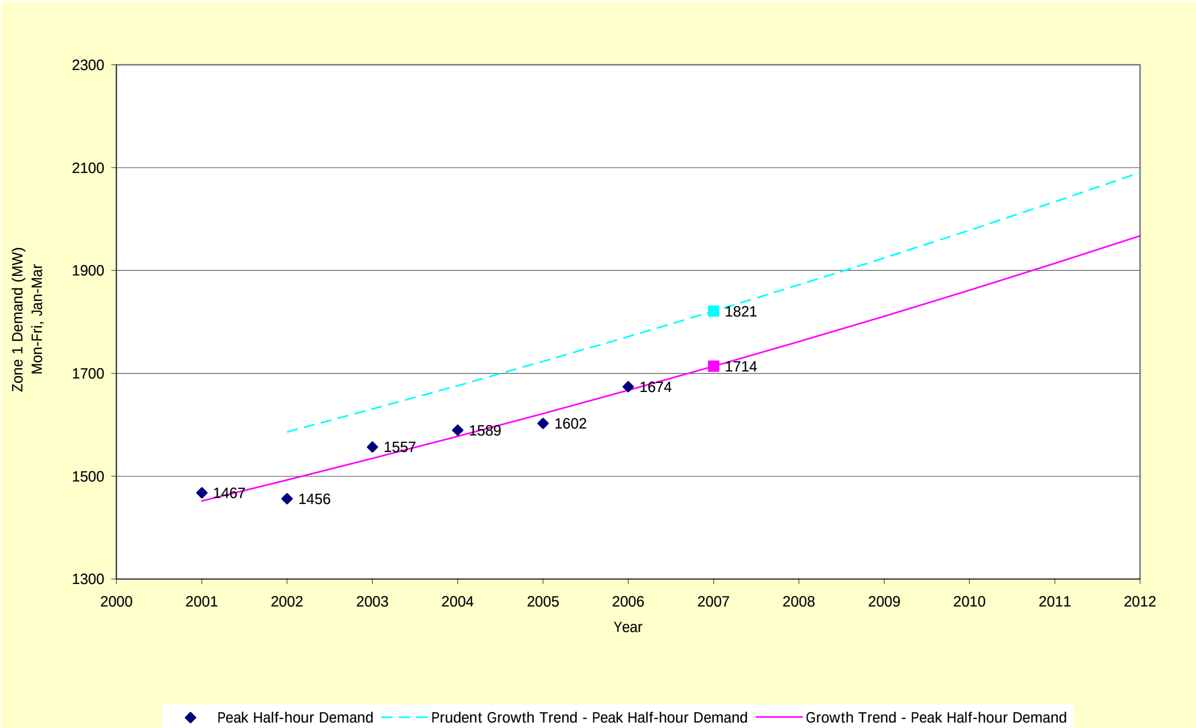

Figure 4 - Forecast prudent and expected summer peak demand for Auckland and North Isthmus Regions

The expected and prudent peak summer demands in 2007 are 1704 and 1810 MW respectively.

1.8 Power system capability limits

Table 3 shows the assumed contributions of new generation and contracted voltage support to power system limits in the Upper North Island.

Asset	Availability/Reliability – Indicative effect on voltage stability limits								
	Summer 07	Winter 07	Summer 08	Winter 08	Summer 09	Winter 09	Summer 10	Winter 10 to 12	Summer 11 and 12
Huntly E3P			+175 MW	+150 MW	+175 MW	+150 MW	+175 MW	+150 MW	+175 MW
Southdown new unit		+58 MW	+54 MW	+58 MW	+54 MW	+58 MW	+54 MW	+58 MW	+54 MW
OTA 1 and 2		+40 MW	+60 MW	+40 MW	+60 MW	+40 MW	+40 MW		
Two of OTA 4, 5 and 6	+36 MW								
Third unit OTA 4, 5 and 6	+18 MW								
Marsden 2	+24 MW	+36 MW	+24 MW	+36 MW					
Proposed grid investments			+165 MW	+185 MW	+165 MW	+185 MW	+165 MW	+185 MW	+165 MW

Table 3 - Assumed availability and reliability of generation and reactive resources in the Upper North Island for 2007 to 2012

Power system capability limits for the Upper North Island for the next five years are shown in Table 4. These limits take into account the assumptions in Table 3 around the availability for certain plant (especially the new generating units). The N-1 limit is the case where all plant is in service prior to the contingency. The N-G-1 is the case where the largest generating unit in the region (Otahuhu B) is not in service prior to the contingency.

Case	Assumptions	Power system limits	
		N-1	N-G-1
Summer 07	• Power factor 0.97	1880	1720
Winter 07	• Power factor 0.98	2140	2050
Summer 08	• Power factor 0.97	2070	1910
Winter 08	• Power factor 0.98	2480	2380
Summer 09	• Power factor 0.97	2210	2050
Winter 09	• Power factor 0.98	2440	2350
Summer 10	• Power factor 0.97	2210	2050
Winter 10	• Power factor 0.98	2440	2350
Summer 11	• Power factor 0.97	2170	2010
Winter 11	• Power factor 0.98	2380	2290

Table 4 – Indicative Upper North Island power system capability limits for the next five years

It should be stressed that the limits in Table 4 can only be considered as indicative and are likely to be revised by the System Operator periodically taking into account the prevailing power system conditions.

1.9 Dynamic and static voltage support

Reactive support plant can be categorized as two types:

- Passive compensation plant, such as capacitors, which provides reactive power that is largely fixed (i.e. the capacitor is switched in and provides a steady amount of reactive power which will vary as system voltage varies).

- Active compensation plant, such as synchronous condensers and static var compensators, has control systems which will change its reactive power output rapidly in response to changes in system voltage (e.g. during a fault where voltage on one or more phases is depressed).

This reactive power needs assessment considers how much passive and active compensation plant should be procured.

The total amount of reactive support is calculated by steady state load flow analysis. This is the amount of reactive support required to ensure that voltages in the power system will remain stable for small disturbances.

The amount of active compensation plant required for a given load to keep transient voltages within safe limits can be determined through transient analysis. This type of analysis requires accurate models of generating unit dynamics and load characteristics. The existing models available for the Upper North Island load do not have sufficient information to use in determining active compensation voltage support requirements.

An alternative approach is to consider the performance of the Upper North Island power system during recent faults. On 15th February 2006 at 09:34 hrs, a series of phase-to-phase faults occurred at Otahuhu substation end of the Otahuhu-Whakamaru 3 circuit. Voltage recovery during the 15 February faults was good. Voltages were back to normal within seconds. The generating and synchronous condenser units in service at the time (Otahuhu B, Southdown, Glenbrook and two Otahuhu A units) were sufficient to ensure satisfactory voltage recovery.

Contracts for Otahuhu A units 4, 5 and 6 to provide voltage support expire in March 2007. It is desirable to procure active compensation voltage support at least the equivalent of these units.

1.10 Voltage Quality Targets

This report identifies any additional voltage support required to meet the voltage quality targets in the Policy Statement. These targets are summarized in Table 5.

Event	Quality Target
Contingent Event: • *Loss of transmission circuit* • *Loss of HVDC pole* • *Loss of a single generating unit* • *Loss of both transmission circuits of a double circuit line, where the system operator has determined a high level of likelihood of occurrence based on historical information.*	• Grid voltage is within advised asset capability. • Grid voltage will be within the range set out in rule 3.1.1 of section III of Part C. • Voltage stability of the power system is maintained. • No demand is interrupted (other than contracted reserves).
Extended Contingent Event • *Loss of both HVDC poles*	• Grid voltage is within advised asset capability. • Grid voltage will be within the range set out in rule 3.1.1 of section III of Part C. • Voltage stability of the power system is maintained. • AUFLS operation may be used.
Stability Event (severe power system faults that may lead to): • *Contingent Event* • *Extended Contingent Event* • *Loss of bus section* • *Loss of interconnecting transformer*	• Transient and dynamic stability of the power system is maintained.

Table 5 - Voltage quality targets

Voltage support needs in the Upper North Island are primarily assessed against maintaining normal and post contingency steady state voltages within the target ranges and to ensure no demand is interrupted during a contingent event.

The System Operator does not intend to procure voltage support to meet other quality targets (e.g. to maintain transient voltages within certain limits and to avoid demand interruption during stability events).

2 ASSESSMENT

2.1 Summer 2007

Figure 5 shows the N-1 and N-G-1 power system capability limits for the Upper North Island compared to prudent and expected peak demand forecast for the summer of 2006/2007 (i.e. the period from January 2007 to April 2007). During this period:

- Regional power factor is assumed to be 0.97
- Total generation from Huntly powerstation (excluding unit 5) is assumed to be restricted to 500 MW in summer reflecting the likely impact of river heating constraints based on the performance of the new cooling tower at Huntly.

This assumption was based on experience of the summer of 2006:

- Huntly generation was greater than 520 MW for the top 10% of load in the Upper North Island
- Huntly generation averaged 690 MW for the period.

It is possible that summer 2007 will be hotter than average which could result in lower Huntly generation due to resource consent constraints. This scenario is considered by the Upper North Island Summer Security working group.

The shaded and dotted blocks indicate contributions from assets that can not be considered firm. These contributions may be present in summer 2007 but can not be relied upon.

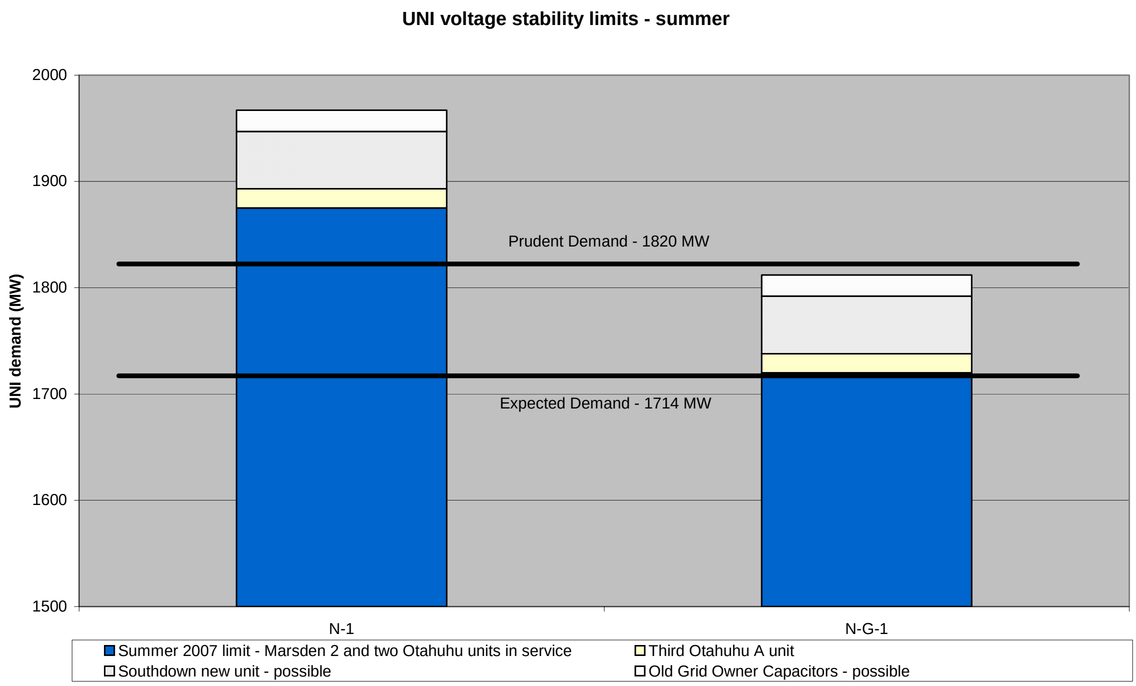

Figure 5 - Power system limits for summer 2007

For the scenario above, the power system is capable of meeting prudent demand with all plant in service. The power system is not capable of meeting prudent demand with the Otahuhu B generating unit out of service during summer 2007 without support from the new Southdown unit and some additional plant.

The UNI Summer group's contingency arrangements for summer 2007 include consideration of a further four scenarios.

2.2 Winter 2007

Figure 6 shows the N-1 and N-G-1 power system capability limits for the Upper North Island compared to prudent and expected peak demand forecast for the winter of 2007 (i.e. the period from June 2007 to September 2007). During this period:

- Regional power factor is assumed to be 0.98

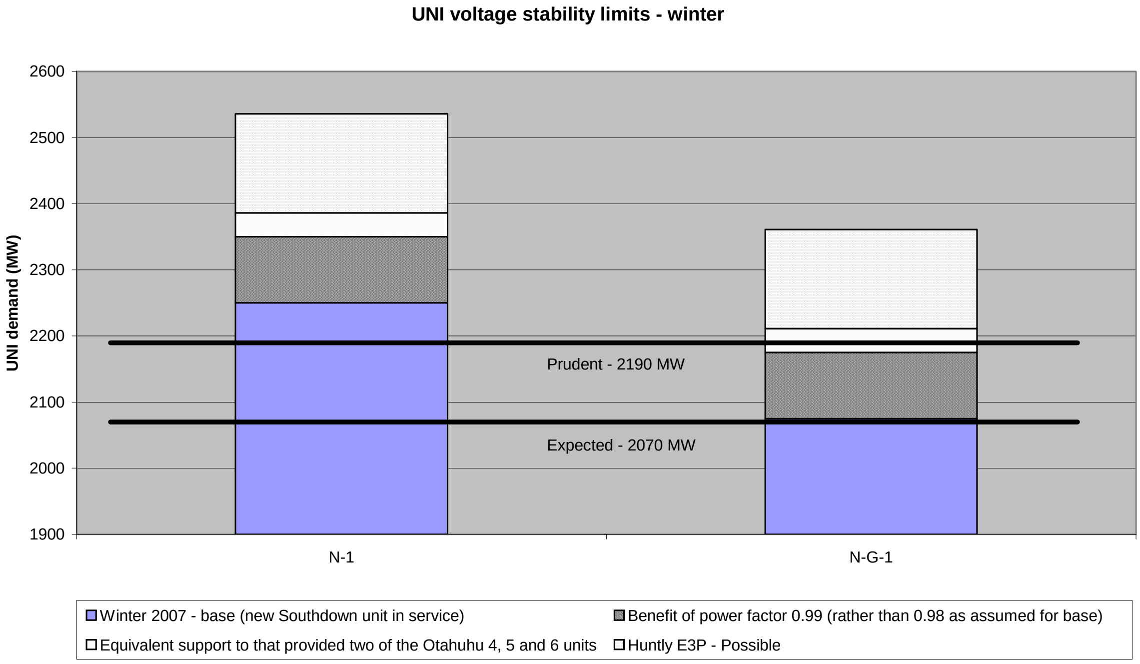

Figure 6 - Power system limits for winter 2007

The power system is capable of meeting prudent demand with the Otahuhu B generating unit out of service during winter 2007 provided that reactive support equivalent to that provided by two of the Otahuhu 4, 5 and 6 units are available and regional power factor is close to 0.99. Note that winter power factor has been assumed to be 0.98 pf over the period from 2007 to 2012 to reflect the observed trend of declining peak winter power factor.

2.3 Reactive needs 2007 to 2012

Figure 7 shows the N-1 and N-G-1 power system capability limits for the Upper North Island compared to prudent and expected peak demand forecast for the period from 2006 to 2012. The following assumptions are made:

Summer (January to March):

- Regional power factor is assumed to be 0.97
- Generation from Huntly units 1 to 4 and 6 is assumed to be restricted to 500 MW.

Winter (June to September)

- Regional power factor is 0.98 reflecting the progressive declining trend in winter power factor.

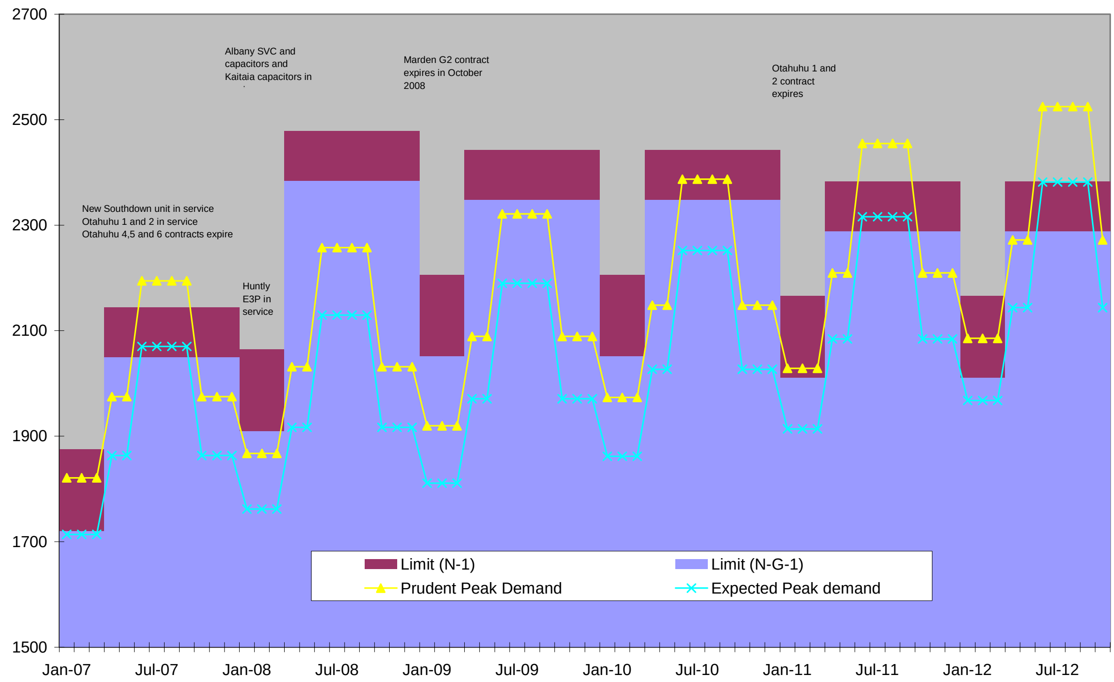

Figure 7 - Power system limits and forecast peak demand for 2007 to 2012

In Figure 7, the shaded areas represent the N-1 and N-G-1 limits at different stages during the years. The limits are lower in the summer period which reflects summer power factor and the availability of Huntly generation during summer which can be constrained to avoid breaching resource consent conditions on river heating. The lines present the expected and prudent peak demand across the years. Note that the summer peak period (January to March) reflects summer peak demand and the winter peak period (June to September) reflects winter peak demand.

From Figure 7:

- The prudent demand forecast can not be met in summer or winter 2007 with the Otahuhu B generating unit out of service. The expected demand in 2007 can be met.
- The prudent demand forecast for 2008 and 2009 can be met with Otahuhu B generating unit out of service. This assumes Huntly unit 5 is available for service.
- Additional voltage support of 100 Mvar will be required for 2010 to meet prudent demand with Otahuhu B generating unit out of service.

The reactive power needs assessment indicates that

- Additional reactive support of 100 Mvar should be procured for winter 2010.

3 RECOMMENDATIONS

An additional 100 Mvar of reactive support should be procured for the period October 2006 to October 2011.

It is preferable that this amount of reactive support is provided by active compensation plant.

The voltage support contract can be either on an availability basis or continuous basis.