Procurement Plan Needs Assessment

Zone 1 Voltage Support Requirements to 2010

System Operator

July 2005

Purpose

The purpose of this Needs Assessment is to set out the System Operator's rationale for procuring additional dynamic voltage support in Voltage Support Zone 1 as part of the forthcoming 2005 ancillary services procurement round.

Background

In the context of voltage support, Zone 1 is all points of connection to the grid North of Huntly Power station excluding the Thames Valley spur. It is also colloquially referred to as the Upper North Island. It includes the major Auckland load centre as well as generation at Otahuhu, Southdown and Glenbrook.

Power transfer into Zone 1 is limited in most circumstances by the need to avoid voltage instability. A description of the power system limits applying in zone 1 can be found in the December 2004 System Security Forecast (http://www.transpower.co.nz/?id=4464).

Voltage support is an ancillary service comprising reactive power injection or absorption to boost or reduce voltage at the point of injection. Voltage support can be provided by generating units and reactive plant such as capacitors and reactors. The System Operator procures voltage support as an ancillary service on a zonal basis (e.g. in voltage support zone 1, there is an existing contract for Otahuhu A power station to provide voltage support). The costs of procuring voltage support in a zone are allocated to distributors and non-compliant generators in that zone according to the formulae set out in Part C of the rules.

Current Situation

Contracts for voltage support in zone 1

The System Operator has an existing contract for dynamic reactive support from Otahuhu A that expires in March 2007. This contract exists under the transitional provisions (Part I) of the EGR's, and as such can not be extended. If dynamic reactive support is required beyond this time the current contract would need to be replaced with a new contract.

In addition to the contracted Otahuhu A reactive support, additional dynamic reactive support resources exist at Otahuhu A and Marsden B. Some plant has recently been restored to service through short term procurement contracts. Other plant could be made serviceable to meet any need either as a base requirement or to be available for contingency response. Owners of this existing dynamic reactive plant have advised their plant cannot be retained indefinitely to meet short term ad hoc procurement needs and a longer term commitment is required to ensure plant is maintained and available for continued dynamic reactive support.

Winter and Summer 2005

With all generation, reactive support (including Otahuhu A) and transmission assets in service, and given expected demand in winter and summer 2005, the System Operator

believes it can meet its PPOs and the requirements of the Policy Statement (Schedule C4 of Part C of the rules) without recourse to demand shedding.

However, as part of prudent operational management and contingency planning with industry stakeholders in the region, the System Operator secured the availability of additional dynamic voltage support through short term procurement arrangements for the summer and winter of 2005. This additional dynamic reactive support (from Otahuhu A and Marsden A) was intended to ensure that for a sustained outage of key assets the System Operator PPOs could be met without demand shedding.

Details of the operational management and contingency plans for the Upper North Island in 2005 can be found at (http://www.transpower.co.nz/?id=5388).

Voltage Support needs beyond 2005

Power system capability into the Upper North Island will be enhanced (as voltage stability limits will be increased) by a number of committed projects:

- Huntly cooling tower (due early 2006)[1],
- Huntly e3p project (due late 2006) and
- 100 Mvar of additional static capacitors in 2006.

Even with the Huntly upgrades and addition of new grid capacitors, forecast demand in the Auckland and North Isthmus regions will be approaching voltage stability limits with all expected plant in service by 2008. Investment in power system capability or demand side initiatives will be required over the five years. Further investment in significant assets to increase power system limits into the upper North Island have been signalled, though none of these projects have yet been committed. The commissioning of additional, substantial new assets is considered unlikely to occur before 2008-2010.

The need to secure the availability of additional voltage support (as has been done in 2005) from 2005 to 2008 continues. This additional reactive support is intended to ensure that for a sustained outage of key assets, the unavailability of Huntly generation in summer (see footnote 1) or deterioration in regional power factor the System Operator PPOs could be met without demand shedding. This will also allow for asset outages to facilitate connection of new assets.

There is considerable benefit in the additional voltage support procured being dynamic support. There is no automated regional reactive power control scheme in the Upper North Island. Voltage management across the upper North island involves manually co-ordinating the operation of static and dynamic reactive resources, including capacitors, generators and plant operating as synchronous condensers across 10 busbars. Until an automated or partially automated reactive power control scheme is made available further reactive resources need to be dynamic to provide sufficient operational flexibility to aid the efficient management of voltages across the region in real time, throughout the day.

[1] The Huntly Cooling Tower reduces the likelihood of a reduction in Huntly generation in summer due to high temperature. The risk of Huntly generation having to be reduced is not eliminated. For the purposes of this assessment it is assumed that the cooling tower increases voltage stability limits by around 70 MW.

Assessment

The System Operator believes it is prudent to assess the voltage support requirements for the next three to five years for this year's ancillary services procurement round rather than for just one year. The reasons for doing this are:

- There is an ongoing need over the next three to five years for securing the availability of reactive support plant in zone 1.
- The costs of procuring such support on a short term basis are high and the future availability of the plant is not guaranteed by the potential service providers.
- Potential service providers have indicated that they will guarantee the longer term availability of reactive plant under an appropriate contractual arrangement.

In making this assessment the System Operator is not seeking to supplant or delay transmission investment or possible alternatives. The assessment is operationally focussed and based on conditions being experienced in 2005. It does not purport to be a power system planning analysis of future power system limits into Auckland.

It is acknowledged that other operational measures being employed for winter 2005 to cover contingency planning include distributors managing to a regional limit, grid reconfiguration and reliance on Automatic Under-Voltage Load Shedding as a back up measure. Such measures will still be required where prudent in some scenarios. Work by the options sub group of the Upper North Island industry response group indicates that there are few other options that can be readily secured within the existing EGR framework.

The assumptions and analysis supporting the assessment are set out in Appendix 1. For the expected load forecast, a further 100 Mvars of voltage support is required to avoid demand shedding during a sustained unplanned outage in 2007. This voltage support should be dynamic in nature to aid in operational voltage management.

Proposal to contract additional reactive support

Ancillary services contracts under Part C of the EGR's are typically taken annually. The System operator has determined that under the Rules there is no impediment to a longer contract term.

The System Operator therefore proposes to invite tenders from the providers of dynamic reactive support for services on one or both of the following bases:

- Tender 1 for 200 Mvars for a three year period from November 2005. This tender will be for dynamic reactive support to cover contingency planning requirements additional to the dynamic support presently contracted. This will not be for continuous operation but for response to a contingency. Contract terms will focus on availability with dispatch as and when required.

- Tender 2 for 60 Mvars for a three year period from April 2007. This tender for dynamic reactive support will replace that currently procured under Part I of the Rules from Otahuhu A. Contract terms will be on the basis of continuous operation.

It is proposed that reactive support needs to replace those procured under tender 1 beyond November 2008 would be re-evaluated in late 2006 against any further committed investments to enhance power system capability in the upper North Island.

Appendix 1 – Zone 1 Voltage Needs Assessment

Assumptions

The analysis in this appendix has been synthesised from the December 2004 System Security Forecast and recent operational experience in zone 1. Additional more complicated analysis (e.g. full dynamic voltage stability assessment) has not been included. Load forecasts have been simplified, consistent with operational practice.

A static analysis method of determining voltage stability has been used in this paper. The point of collapse limit due to voltage instability is determined by the amount of load at which the point of collapse occurs. A margin of 5% is then applied to the load.

Voltage stability limits are sensitive to power system conditions and will vary significantly for different generation patterns, voltage profiles, load power factors etc. The System Operator assesses operational voltage stability limits in light of prevailing power system conditions and may revise the limits from time to time.

The results of the analysis presented should not be considered to be definitive. There is considerable uncertainty in the inputs (e.g. load forecast) used. The results should be interpreted as indicative rather than absolute.

Existing voltage support resources

Freely available voltage support resources in Zone 1 include grid capacitors and voltage support from generating units up to the amounts specified in the voltage support Asset Owner Performance Obligations. It is assumed that the amount of these resources will continue to be available over the next five years.

The Grid Owner has advised its intentions to install 200 Mvar of capacitor banks in the Auckland region in 2006. However, the Grid Owner has also advised that existing grid capacitors in the Auckland region are reaching end of life and could be removed from service in the near future and therefore only 100 MVar of new capability should be assumed. This 100 Mvar increase in fixed capacitors has been reflected in the needs assessment.

Additional existing voltage support resources in the Auckland and North Isthmus region are shown in Table 1.

	Increase in voltage stability limit into Auckland (MW)					
Plant	*2005*		*2006*		*2007*	
	Summer	*Winter*	*Summer*	*Winter*	*Summer*	*Winter*
Additional 100 Mvar caps				+60	+40	+60
Otahuhu G1 and G2 (re powered)	+105	+105	+105	+105	+105	+105
Otahuhu G3 Condenser	+15	+20	+15	+20	+15	+20
Marsden condenser	+24	+36	+24	+36	+24	+36
Otahuhu G4 and G5[2]	In use	In use	In use	In use	+30	+40
Potentially Available	*144*	*161*	*144*	*221*	*214*	*261*

Table 1 - Additional existing voltage support resources

[2] Otahuhu G4 and G5 are currently contracted to provide voltage support. This contract expires in 2007.

These resources can only be accessed if appropriate contracts for availability and or continuous operation are in place. Note that given the different reactive offtake within the region there are different implications for the voltage stability limit in summer and winter.

Summer and winter peak demand in the Auckland and North Isthmus region

The peak summer load in Auckland in 2004 was 1535 MW. The peak winter load in Auckland in 2004 was 1948 MW. Growth in peak demand for the Auckland region is assumed to be between 2% and 4%. Table 2 shows the increase in peak load in MW for 2% to 4% annual increases.

	Annual increase in load		
	2%	3%	4%
Summer	31 MW	46 MW	61 MW
Winter	39 MW	58 MW	78 MW

Table 2 - Annual load increases in Auckland region

Assuming no further investment in power system capacity occurs, the margins between voltage stability limits and peak load will reduce by between 30 to 60 MW per year in summer and by between 40 to 80 MW per year in winter.

Voltage Stability Limits

Voltage stability limits depend on the prevailing condition of the power system. Significantly different limits can apply for relatively small changes in power system conditions (e.g. load power factor, dispatched generation). The voltage stability limits in this section are indicative and based on a certain set of assumptions.

Improvements in voltage stability limits through the commissioning of the Huntly cooling tower and E3P vary with power system conditions and conservative figures (worst case) have been assumed for the purposes of this analysis.

Summer Voltage Stability Limits into Auckland

The summer voltage stability limits for power transfer in Auckland are shown in Table 3.

Voltage Stability Limit (MW)	2005/06	2006/07	2007/08
Current power system (as in 2004)	1500	1500	1500
Present Otahuhu VS contract (G4 and G5)	+30	+30	0
Huntly cooling tower[3]	+70	+70	+70
Huntly E3P		+90	+90
New Grid Capacitors			+40
Total	*1630*	*1690*	*1700*

Table 3 - Summer voltage stability limits

[3] See footnote 1. The Huntly cooling tower is assumed to increase voltage stability limits by 70 MW. Under high water and air temperatures, the cooling tower may provide no benefit with the effect that generation available from Huntly will be reduced.

The above limits assume a summer regional demand power factor of 0.97. A decrease in regional demand power factor from 0.97 to 0.96 will reduce voltage stability limits by approximately 80 MW. Actual demand power factor at summer peak in 2005 was slightly below 0.97. An additional 1 Mvar of voltage support will increase the voltage stability limit by 0.4 MW in summer.

Winter Voltage Stability Limits into Auckland

The winter voltage stability limits for power transfer in Auckland are shown in Table 4.

Voltage Stability Limit (MW)	2005	2006	2007
Current	2030	2030	2030
Present Otahuhu voltage support contract (G4 and G5)	+40	+40	0
Huntly E3P		+140	+140
New Grid Capacitors (100 Mvars)		+50	+50
Total	2070	2260	2220

Table 4 - Winter voltage stability limits

These limits are based on an observed demand power factor of 0.99 at winter peak in 2004. A decrease in power factor to 0.98 will reduce the limits by 100 MW. An additional 1 Mvar of voltage support will increase the voltage stability limit by 0.5 MW in winter.

Analysis

Summer 2007

From table 3 summer voltage stability limit into Auckland in 2007/08 is around 1700 MW. The summer peak load in 2007/08 is expected to be between 1600 and 1660 MW (assuming 2% to 4% load growth per year). The power system should be able to meet the expected summer peak demand in 2007 with all plant in service. If a major generating unit is unavailable at times of peak load or demand power factor declines to 0.96 then additional voltage support is required to avoid some demand shedding.

Figure 1 shows the expected and prudent summer load duration curves for the Auckland and North Isthmus load.

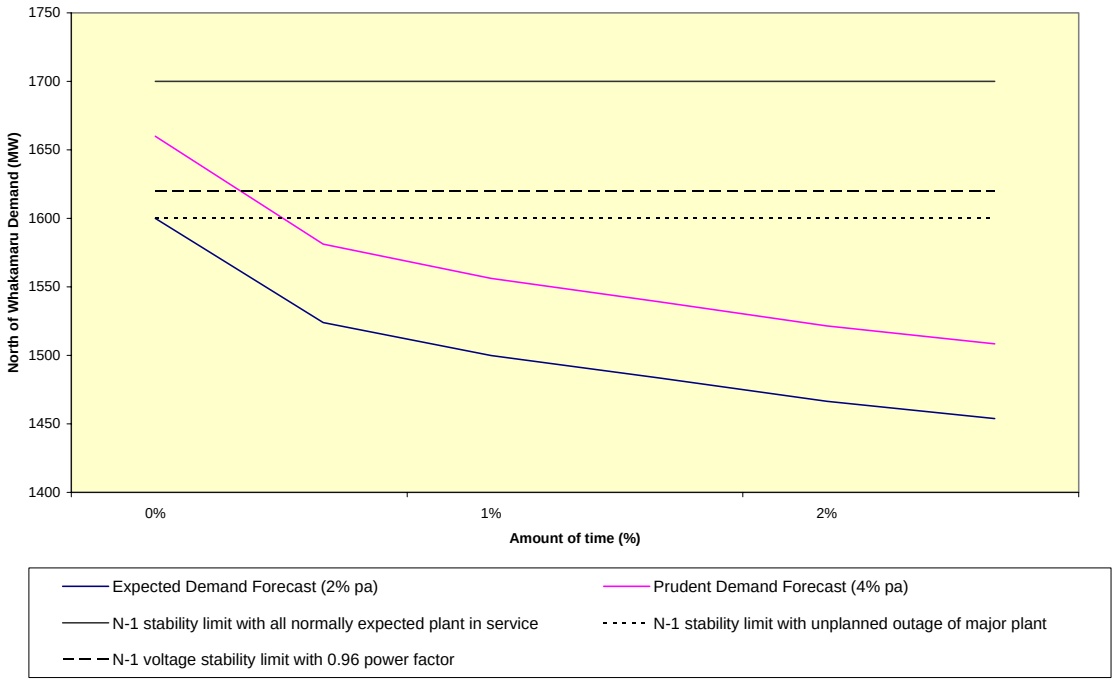

Figure 1 2007 Summer Voltage Stability Limits into Auckland and North Isthmus

Figure 1 suggests that without additional reactive support or investment in the power system:

- The power system should be able to meet prudent load forecast in summer 2007 with all plant in service
- Some demand shedding will be required for up to 0.5% of the time during a sustained unplanned outage.

Table 5 shows the amount of additional voltage support needed to be available under the different load forecasts and System scenarios to avoid demand shedding.

	Demand Forecast	
System Scenario	2% increase pa Mvar (MW of load)[4]	4% increase pa Mvar (MW of load)
All normally expected plant in service	None	None
Major plant outage	None	150 (60)
0.96 power Factor	None	100 (40)

Table 5 - Required amount of available voltage support to avoid demand shedding

The amount of additional voltage support contracted for availability to cover a sustained major plant outage should be up to 150 Mvar (to cover prudent load forecast).

Winter 2007

From table 4 the winter voltage stability limit into Auckland in 2007 is 2220 MW with all plant in service. The winter peak load in 2007 is expected to be between 2110 and 2290 MW (assuming 2% to 4% load growth per year).

[4] In summer, an additional 1 Mvar of voltage support increases the voltage stability limit by 0.4 MW.

Figure 2 shows the winter load duration curves for the Auckland and North Isthmus load.

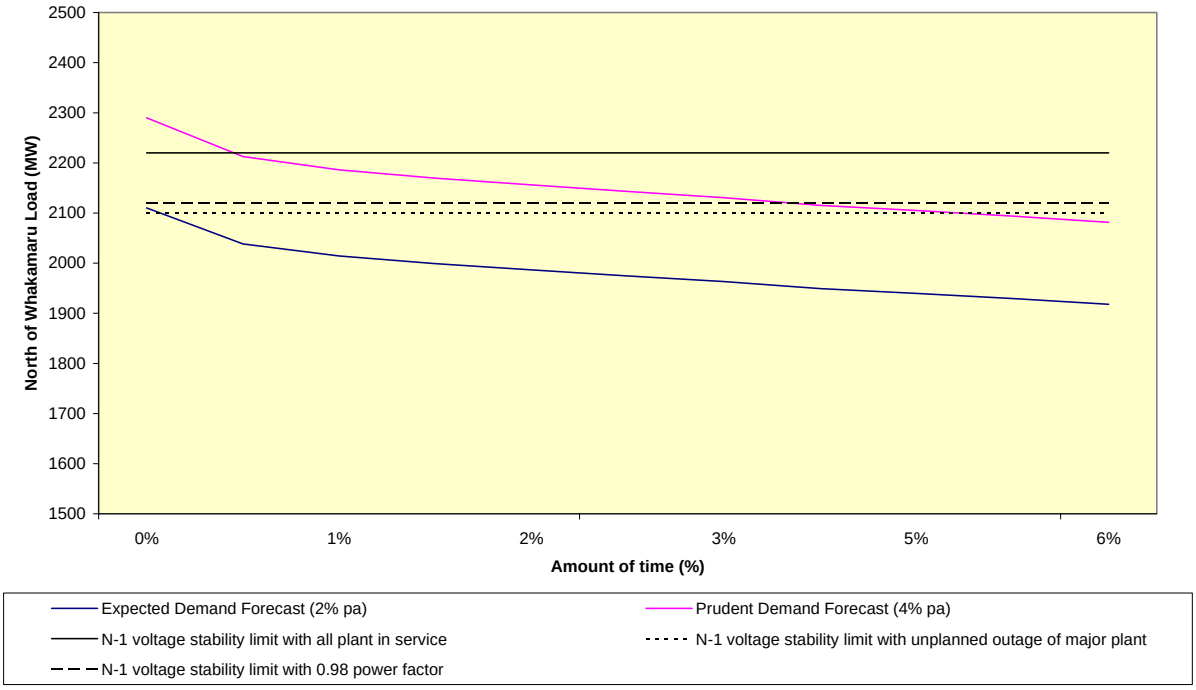

Figure 2 - 2007 Winter Voltage Stability Limits into Auckland and North Isthmus

Figure 2 suggests that without additional reactive support or investment in power system capability:

- The power system is capable of meeting expected load forecast with all plant in service in winter 2007.
- Some demand shedding could be required for up to 0.5% of the time for the prudent load forecast with all plant in service.
- Some demand shedding will be required for 0-4% of the time during a sustained unplanned outage.

Table 6 shows the amount of voltage support needed to be available under the different load forecasts and System scenarios.

	Demand Forecast	
System Scenario	2% increase pa Mvar (MW of load)[5]	4% increase pa Mvar (MW of load)
All normally expected plant in service	None	100 (50)
Major plant outage	20 (10)	380 (190)
0.98 power Factor	None	340 (170)

Table 6 - Required amount of available voltage support to avoid demand shedding

The amount of additional voltage support contracted for availability to cover a major plant outage should be at least 20 MVar (for expected load forecast) and as much as 380 Mvar (to cover prudent load forecast).

[5] In winter, an additional 1 Mvar of voltage support increases the voltage stability limit by 0.5 MW.

Additional voltage support requirements in 2007

Additional zone 1 voltage support of at least 20 Mvars is required in 2007 to avoid some demand shedding during the sustained outage of major plant for load growth of 2% per annum. As much as 380 Mvars would be required to avoid some demand shedding for a sustained outage if load growth was 4% per annum. This paper recommends procuring an intermediate amount of dynamic voltage support. If this amount is too small then there will be opportunities to procure additional voltage support in 2006 and 2007.

It is proposed that a further 200 Mvars of voltage support should be procured in 2005 for a period of three years to be available to avoid some demand shedding during a sustained unplanned outage.

Discussion

Risk and flexibility of operation

Operational experience in Auckland suggests it is not prudent to assume that all plant will be in service at times of peak demand.

Unplanned Outages

If a generating unit is damaged it may be weeks or months before the unit can be repaired and returned to service. The unplanned outage of Otahuhu B generating unit earlier this year and sustained outages at Huntly and Otahuhu B due to unit transformer failures are all examples. It is reasonable to expect that there will a significant period during the next five years when a major generating unit in the Auckland region will have an unplanned outage.

The Huntly cooling tower increases voltage stability limits in summer by allowing a higher level of Huntly generation at most times. There is still the risk that during periods of high river water temperature and high air temperature no generation will be available at Huntly.

Planned outages

Additional investment in power system capability to meet peak demand in the Auckland and North Isthmus regions will be required beyond 2007. Major investment in transmission capacity or generating plant in the Auckland region seems unlikely to occur before 2008. The commissioning of any new capacity is likely to require the outage of plant for extended periods.

Planned outages of generating plant can occur at times of peak demand. The planned outage for Huntly units in August 2005 for work essential to increasing station output in summer is a good example.

Contracting of additional voltage support resources

There are additional (non-contracted) voltage support resources in the Auckland region that can raise voltage stability limits into the region by 174 MW. These are the five generating units at Otahuhu A power station and the synchronous condenser at Marsden. Two of the Otahuhu A units are contracted to provide voltage support until March 2007. Both Contact and Mighty River Power as potential voltage support service providers have indicated that the Otahuhu A and Marsden units are likely to be decommissioned unless there are

contracts in place to secure their availability given the standing costs of retaining these assets.

Other options

An Automatic Under Voltage Load-shedding Scheme (AUVLS) has been installed for use over winter 2005 given all readily available voltage support has been contracted. AUVLS allows the margin applied to the voltage stability limit to be reduced from 5% (~100 MW) to 2.5% (~50 MW) during the winter period. The implications of relying on AUVLS as a back up are the risk of demand shedding and hence it is a measure that should only be applied when other options have been exhausted.

Operational voltage management in Auckland

Aside from providing reactive power, these dynamic voltage support resources will enhance operational flexibility in managing voltage in the Auckland region. It is expected that managing voltage in Auckland will become progressively more difficult as voltage stability limits are approached and further reactive support is added.

There is no Reactive Power Control system in Auckland. Management of voltage during manual switching of static capacitors is an intensive process. Dynamic voltage support resources such as the Otahuhu A and Marsden units will reduce the impact of capacitor switching and enhance the dynamic stability of the power system following disturbances.

Conclusions

A further 200 Mvars of voltage support should be procured in 2005 for a period of three years to be available to avoid some demand shedding during a sustained unplanned outage. This voltage support should be dynamic in nature to aid in operational voltage management.