VENCorp

APPLICATION NOTICE

NEW LARGE TRANSMISSON NETWORK ASSET

ADDITIONAL 500/220kV TRANSFORMATION TO
SUPPORT WESTERN METROPOLITAN MELBOURNE AND GEELONG
AREA LOAD GROWTH

AUGUST 2005

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DISCLAIMER

VENCorp's role in the Victorian electricity supply industry includes planning and directing augmentations of the electricity transmission network to provide, in an economic manner, a reliable and effective transmission network. This report describes development of a new large transmission network asset, involving the establishment of a 500/220kV transformer to support load growth in the western metropolitan Melbourne, Geelong and western Victoria areas.

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1. Executive Summary

This document forms the basis of VENCorp's regulatory test application and public consultation on a proposal to develop a new large transmission network asset to support load growth in the western metropolitan Melbourne, Geelong and western Victoria areas. The development involves the supply and installation of a new 500/220kV transformer and associated switchgears. This report follows from VENCorp's preliminary review conducted as part of its 2005 Electricity Annual Planning Report (Section 6.10).

VENCorp has now completed its detailed analysis and concluded the preferred network augmentation to avoid uneconomic network constraints is the installation of a second 500/220kV, 1000MVA transformer at the Moorabool Terminal Station available for service in September 2008. The estimated capital expenditure of the project is $17M ±25%.

Sensitivity studies over the 45 years of the asset life show the present value of the expected market benefits range from $80M to $142[1], delivering an expected net present value of the market benefit between $65 M and $135M, and averaging $98M.

VENCorp considers this project satisfies Part 1(b) of the Regulatory Test on the basis that it maximises the expected net present value of the market benefits compared with a number of alternative options and timings, in a majority of reasonable scenarios.

The preferred augmentation is a contestable project with some non-contestable interface works to integrate the new transformer with the existing assets, which SP AusNet owns, at the Moorabool terminal station. For the purposes of this assessment, VENCorp has not differentiated between these components.

VENCorp does not consider that the preferred augmentation will have a material inter-regional impact.

Submissions regarding this Application Notice close on Friday 23rd September 2005.

2. Process

This Application Notice addresses the requirements of Clause 5.6.6 of the National Electricity Rules. In respect of this clause, all Registered Participants and interested parties are invited to make relevant submissions to VENCorp. These written submissions or inquiries can be forwarded by email to:

Mr. Graeme Cook
General Manager, Development
VENCorp
PO Box 413
World Trade Centre, VIC 8005

[1] All present values are based on real dollars as at July 2005, unless explicitly stated.

Email: vencorp@vencorp.vic.gov.au
The closing date for submissions relating to this notice is 23rd September 2005.

In accordance with the requirements of the National Electricity Rules, VENCorp will consider all submissions and present a Final Report that summarises these plus VENCorp's responses.

3. VENCorp's Role and Background of the Constraint

VENCorp is the provider of shared electricity transmission network services in Victoria and has responsibilities under various legal and regulatory instruments to plan and direct the augmentation of the shared network within Victoria.

VENCorp executes its planning role in an independent manner, with the objective of undertaking effective planning and development of the shared transmission network so as to maximise net benefits to electricity participants (including end consumers) as a whole.

As the first step in the development of the network, VENCorp's Electricity Annual Planning Report identifies constraints associated with supply of electricity via the shared transmission network. Constraints imposed by the Keilor 500/220 kV transformers and the Keilor-Geelong 220 kV lines have been reported in previous Electricity Annual Planning Reports.

Since the 2003 Annual Planning Report, number of initiatives have been undertaken to reduce the severity of these constraints. These include,

- procurement of a spare single phase 500/220 kV transformer compatible with the existing Moorabool, Rowville and Cranbourne 500/220 kV transformer single phase units, to reduce the duration of a potential Moorabool single phase unit unplanned outage;
- installation of a fast load shedding scheme, removing the potential need for load shedding prior to a credible contingency following a Moorabool 500/220 kV transformer outage;
- installation of a real time wind monitoring scheme adjacent to the Keilor-Geelong lines, to utilise higher thermal ratings at times of high wind speed during high ambient temperature periods; and
- upgrade of the connections of the Moorabool transformer to allow higher transfer capability.

These recent developments have deferred the need for a large transmission network augmentation to remove the constraints imposed by the Keilor 500/220 kV transformers and Keilor-Geelong 220 kV lines. The 2005 Electricity Annual Planning Report identified that significant constraints were forecast to be imposed by these assets from summer 2008/09 onwards. These increased constraints are primarily driven by load growth in the western metropolitan Melbourne, Geelong and western Victoria areas.

The 2005 Annual Planning Report concluded that subject to the detailed application of the regulatory test, a network augmentation for the installation and switching of a new 1000 MVA 500/220kV transformer at Moorabool valued at around $17M ±25% could be justified with a tentative timing of September 2008. This Application Notice presents the results of the detailed application of the regulatory test.

4. VENCorp Shared Transmission Network Planning Criteria

VENCorp undertakes its shared network planning on the basis that any project must maximise the net present value of the market benefits, in accordance with limb 1(b) of the Regulatory Test. Implicit in this approach is the retention of customer supply reliability through economic means.

In its application of a probabilistic approach to shared network planning, VENCorp does not plan the network to provide 100% reliability after a single credible contingency, or any other event. Rather, VENCorp accounts for the probabilities (often very low) of the event occurring and determines an ‘Expected Value’ of the constraint using a Value of Customer Reliability (VCR) of $29,600 per MWh, which it then compares with the total cost of the network options. This ensures that the cost of the project is weighed against its expected benefits in determining whether it will proceed.

A project will only proceed if:

- the benefits of a project exceed the cost of the project; and
- it maximises the net market benefits compared with alternative options.

In its application of a probabilistic approach to shared network planning, VENCorp also considers the need to maintain the system in both a satisfactory and a secure operating state as referred to in the National Electricity Rules.

The term ‘satisfactory’ reflects operation of the network in a state such that all plant is operating at or below either its continuous rating or its applicable short term rating. That is, all plant is operating below its thermal capability. Typically, VENCorp planning adopts a short term rating of 15 minutes for critical transmission lines, based on the response time required after a contingency to facilitate manual intervention. Shorter time frames are allowable operationally, if automatic control schemes are designed and implemented to respond after a contingency.

The term ‘secure’ reflects the operation of the network such that following a credible contingency, the network will remain in a ‘satisfactory’ state.

As per general principles for maintaining power system security referred in Clause 4.2.6 of the National Electricity Rules, VENCorp plans the network such that following a credible contingency, the power system can be returned to a secure state within 30 minutes.

Reference can be made to VENCorp’s Transmission Network Planning Criteria (available at www.vencorp.com.au) for full details of the shared transmission network planning criteria.

5. Location of the Constraints

Western metropolitan Melbourne, Geelong and western Victoria areas, Point Henry smelter load and export to South Australia via Murraylink are mainly supplied from the 500 kV transmission network via a 500/220 kV transformer at Moorabool (A1), three 500/220 kV transformers (A2, A3 and A4) at Keilor and local generation in these areas.

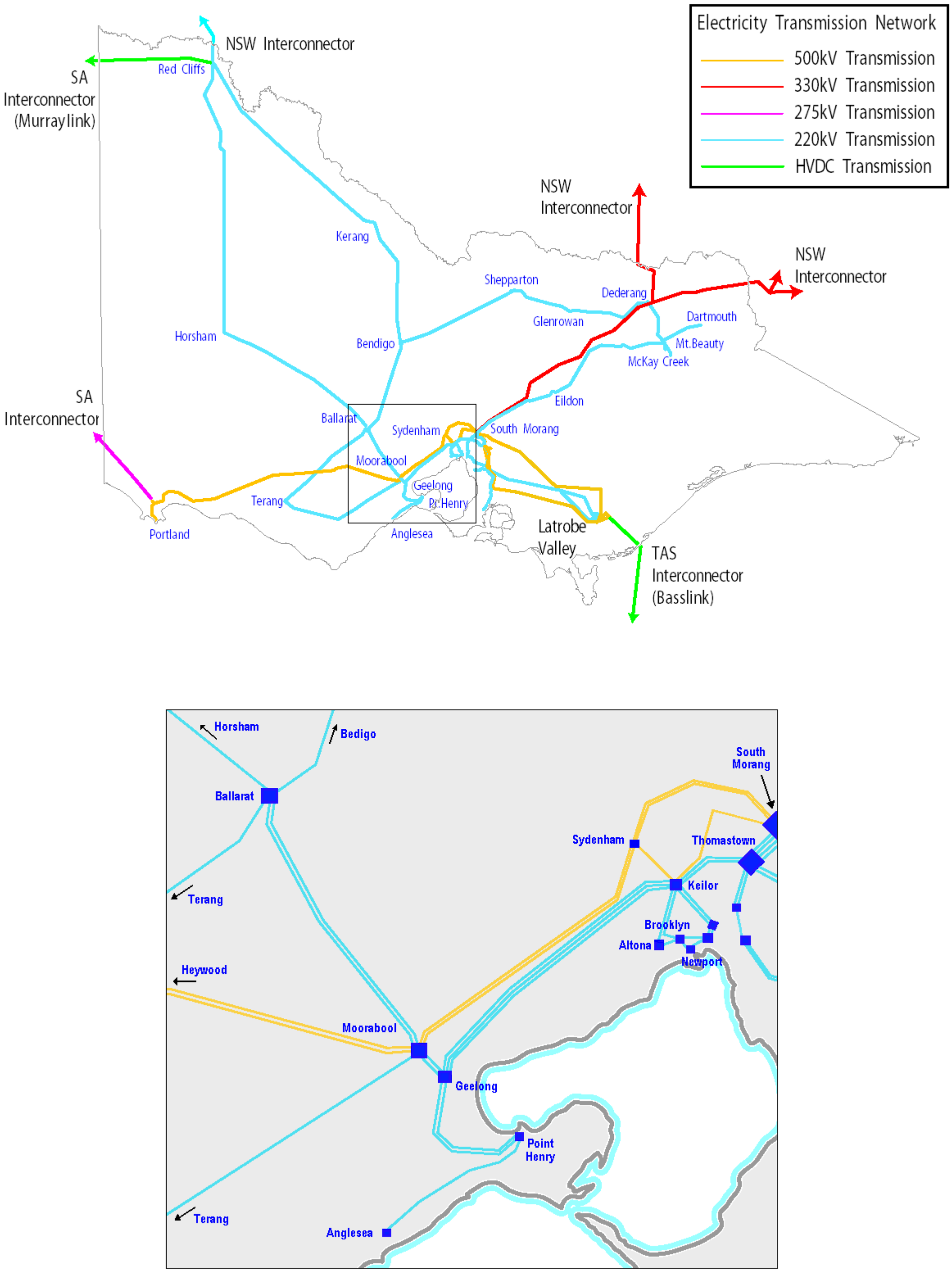
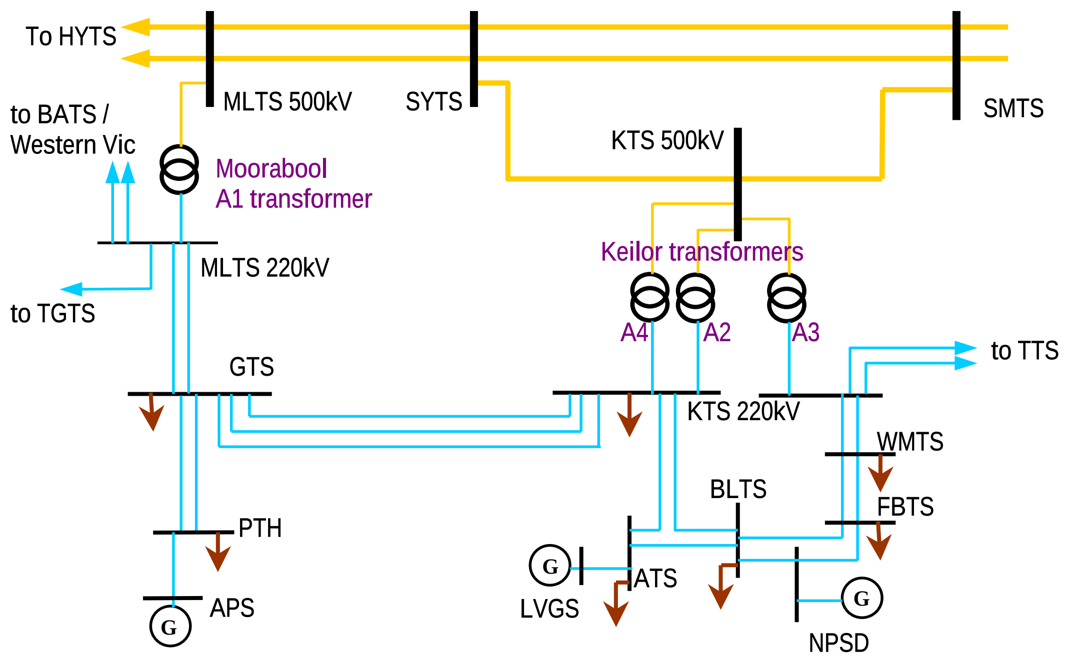


Figure 1: Geographical representation of the terminal stations affected by the forecast constraints



Abbreviations:

APS – Anglesea Power Station
ATS – Altona Terminal Station
BATS – Ballarat Terminal Station
BLTS – Brooklyn Terminal Station
FBTS – Fishermans Bend Terminal Station
GTS – Geelong Terminal Station
HYTS – Heywood Terminal Station
KTS – Keilor Terminal Station
LNGS – Laverton North Gas Station
MLTS – Moorabool Terminal Station
NPSD – Newport Power Station
PTH – Point Henry Customer Substation
SMTS – South Morang Terminal Station
SYTS – Sydenham Terminal Station
TGTS – Terang Terminal Station
TTS – Thomastown Terminal Station
WMTS – West Melbourne Terminal Station

500 kV transmission line
220 kV transmission line
Load

Figure 2: Electrical representation of the terminal stations affected by the forecast constraints

In addition, the western metropolitan Melbourne area is supplied from Thomastown to a lesser extent and, the western Victoria area and export to South Australia via Murraylink are supplied by the 220 kV lines at Dederang and NSW interconnector at Red Cliffs. These are shown in a geographical map in Figure 1 and an electrical single line schematic in
Figure 2.

The constraints, which create the need for augmentation occur on the Keilor 500/220 kV transformers in the western metropolitan Melbourne area and the Keilor to Geelong 220 kV lines in southwest Victoria as shown in the
Figure 2.
The affected terminal stations are Keilor, West Melbourne, Fisherman's Bend, Altona, Brooklyn, Geelong, Point Henry and part of western Victoria, which supply a wide area covering Melbourne's western central business district, western metropolitan, Geelong and western Victoria area and the Point Henry smelter load.

These terminal stations supply an aggregate demand amounting to about 33% of the Victorian peak summer demand, through three of the five Victorian distribution businesses and a major customer. In addition up to 220 MW export to South Australia via Murraylink is transferred through the network in this area.

6. Load Forecast

The VENCorp 2005 Annual Planning Report describes the aggregate Victorian summer peak demand and energy forecasts as presented in Table 1 and the process to establish them. These forecasts form the basis of this assessment.

Year	*Forecast Maximum Summer Demand [MW]*			*Forecast Annual Energy [GWh]*
	10% POE Medium	*50% POE Medium*	*90% POE Medium*	
2005/06	10,119	9,260	8,700	50,976
2006/07	10,367	9,471	8,886	51,343
2007/08	10,635	9,701	9,092	51,989
2008/09	10,850	9,876	9,241	52,255
2009/10	11,097	10,088	9,431	52,901
2014/15	12,218	11,056	10,299	56,247

Table 1: Victorian Aggregate Demand and Energy Forecasts Medium Economic Scenario

The 10%, 50% and 90% Probability of Exceedance (POE) peak demand levels relate to the long-term average daily temperature[2] (business days) in Melbourne of 32.9°C, 29.6°C and 27.1°C, respectively. Network constraints have been assessed based on these three POE peak demand scenarios and energy at risk from each scenario is weighted equally (i.e. 1/3 each).

Non-scheduled generation including wind power generation is projected to grow faster in the future[3]. Non-scheduled generation refers generators excluded from NEM dispatch schedules due to their small size and/or unpredictable available capacity. Most of these non-scheduled generators connect to a distribution network, however some are connected to the transmission grid. The demand and energy forecasts presented in the Table 1 include the projected non-scheduled generator entry as referred in the VENCorp 2005 Electricity Annual Planning Report.

[2] Average daily temperature represents the average of the daily maximum and minimum temperatures
[3] Reference: 2005 Electricity Annual Planning Report

Figure 3 presents the Victorian demand duration curve for the 2005/06 financial year based on the 10% POE conditions and the medium economic growth scenario. The shape of this curve is reflective of those used in the subsequent years. The medium economic growth scenario is used for the purposes of analysing the development of this transmission network augmentation.

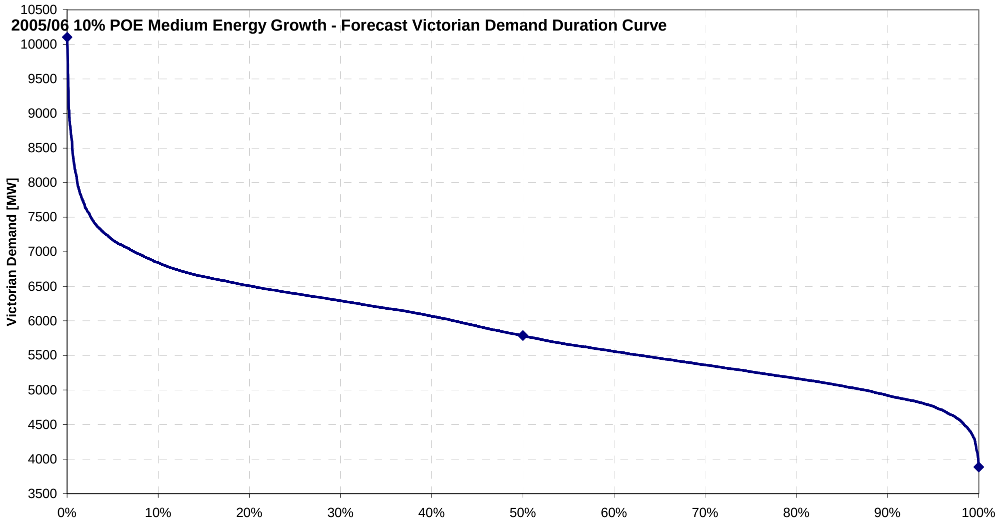


Figure 3: The Victorian 2005/06 10% POE Medium Energy demand duration curve

Table 2 and Table 3 present the 10% POE peak demand forecasts for the load supplied to the western metropolitan Melbourne, Geelong and western Victoria areas and export to South Australia via Murraylink. In addition Point Henry smelter load also supplied via Geelong area.

	2005/06	2006/07	2007/08	2008/09	2009/10	20013/14
ATS/BLTS	514	520	513	522	532	576
FBTS	260	273	284	292	300	332
KTS	497	523	540	556	571	634
WMTS	540	560	593	607	620	677
Total	1811	1876	1930	1977	2023	2219

Table 2: Western metropolitan load forecasts [in MW] for the 10% POE scenario

	2005/06	2006/07	2007/08	2008/09	2009/10	20013/14
BATS	159	163	168	173	177	190
BETS	188	191	195	199	202	219
GTS	358	363	370	373	379	393
HOTS	79	80	81	82	83	87
KGTS	66	69	72	74	76	84
RCTS	170	175	184	189	194	214
TGTS	169	174	177	181	184	198
Murraylink	220	220	220	220	220	220
Total	1409	1435	1467	1491	1515	1605

Table 3: Geelong and state grid west load forecasts [in MW] for the 10% POE scenario

At the time of system peak demand in 2005/06, the load in the affected terminal stations (as defined in Table 2 and Table 3 excluding export to South Australia via Murraylink) is 33% of the aggregate Victorian system demand. The total Victorian load growth from 2005/06 to 2006/07 is +248 MW. The affected terminal stations, as defined above, see an increase of 90 MW (37%). This trend is forecast to continue over the 10-year period.

These load forecast at the terminal stations and Distribution Companies proposed plan to meet increased load growth at these terminal station as published in their 2004 Transmission Connection Planning Report were used as a basis for the assessment of constraints.

7. Constraints on Keilor 500/220 kV transformers and Keilor-Geelong 220 kV lines

7.1. Reason for Constraints

An outage of the Moorabool A1 transformer results in constraints due to loading on:

- Keilor A2 and A4 transformers[4]; and
- Keilor-Geelong 220 kV transmission lines.

These constraints are primarily driven by load growth in the terminal stations referred in Table 2 and Table 3, and the thermal rating of the constraint elements, which is presented in the Table 4.

Plant	Thermal rating (continuous)	Thermal rating (Short term)
Keilor 500/220 kV transformer	750 MVA	810 MVA – 2 hours
Keilor to Geelong 220 kV lines	237 MVA at 40°C & 0.6 m/s wind speed 315 MVA at 40°C & 1.8 m/s wind speed	at 40°C & 1.8 m/s wind speed 380 MVA 15-minute short-term rating

Table 4: Thermal Ratings of Constrained Plants

Currently committed network and generation projects are included in the assessment of the constraints. In particular this includes a second 1,000 MVA 500/220 kV transformer at Rowville planned for service in September 2007.

7.2. Conditions of Constraint

7.2.1. Constraint due to Keilor 500/220 kV transformers

The loading on the Keilor 500/220 kV transformers depends on:

- Outage of the Moorabool A1 transformer, which causes an increase in loading of the Keilor 500/220 kV transformers;

[4] Throughout in this document Keilor transformer refers to 500/220 kV transformers at Keilor Terminal Station.

- Outage of a Keilor 500/220 kV transformer, which causes an increase in loading of remaining in-service transformers at Keilor;
- Western metropolitan Melbourne, Geelong and western Victoria area and Point Henry loads, which causes an increase in transformer loading, as these loads increase;
- Generation output from Newport, Anglesea and Laverton North[5], which causes an increase in transformer loading as generation is reduced;
- Southern Hydro generation output, which causes an increase in transformer loading as generation is reduced;
- The interchange between Victoria and NSW, which causes an increase in transformer loading as Victorian import decreases; and
- Murraylink transfer between Victoria and South Australia, which causes an increase in transformer loading as Murraylink export to South Australia increases.

The most critical of these factors are the western metropolitan Melbourne, Geelong and western Victoria area and Point Henry loads and generation output levels from Anglesea, Laverton North and Newport generators.

Table 5 presents the loading on each of the Keilor A3 and A4 transformers at 10% POE demand forecast, 1900 MW Victorian import from NSW and Anglesea, Newport, Laverton North and Southern Hydro generation at full output.

Year	System normal loading *[MVA]*	Loading following outage of Moorabool A1 transformer[6] *[MVA]*	Loading following outage of a Keilor 500/220 kV transformer with prior outage of Moorabool A1 transformer[6] *[MVA]*
2005/06	515	745	1185
2006/07	535	775	1245
2007/08	545	805	1330
2008/09	560	900	1370
2009/10	585	960	1525

Table 5: Keilor (A2 or A4) transformer loading

The third column of Table 5 represents the potential loading of Keilor transformers during system normal operation (i.e. with all plant in service). For a system normal secure operating state, the potential loading of the Keilor transformers should remain within their 2-hour short time rating of 810 MVA. This loading limitation will allow for satisfactory operating conditions following a Moorabool A1 transformer outage, providing the 15 minutes requried for operational staff to take appropriate action to reduce the Keilor transformer loading to within its continuous rating of 750 MVA and to maintain the secure operating state.

5 Target service date 1 December 2005

6 This excludes the export of South Australia via Murraylink. The impact of Murraylink on post-contingent flow is removed by an automatic runback scheme. If the Moorabool transformer were to be tripped while Murraylink is exporting to South Australia, then the runback scheme would rapidly reduce Murraylink transfer to zero.

The fourth column of Table 5 represents the potential loading of Keilor transformers with prior outage of the Moorabool transformer. With prior outage of the MLTS A1 transformer, to operate the system in a secure operating state,

- the loading of Keilor 500/220 kV transformers should remain within 750 MVA; and
- the potential loading of the KTS 500/220 kV transformers (column 4 of Table 5) should remain,
  - within the 2 hour short-term rating of 810 MVA of the Keilor transformers, or
  - within the 30 seconds rating of 1100 MVA of the Keilor transformers, provided that the Keilor transformer overload control scheme[7] is armed for load shedding to remove the overload on Keilor transformers within 30 seconds following the next contingency.

System normal secure operating condition

Prior to summer 2008/09, loading of the Keilor transformers is forecast to remain within the 2-hour short term rating following a Moorabool transformer outage (Table 5, column 3). Hence, there is no system normal constraint forecast to occur prior to summer 2008/09. From summer 2008/09, at times of peak demand with all transmission and generation plants in service, the potential loading of Keilor transformers would exceed their 2-hour short-term rating and, the network cannot be maintained in a secure operating state. Action would need to be taken to operate the system in a secure operating condition. Since all generation in this area is modelled at full output with maximum import from the NSW/Snowy regions, the most likely option is to reduce the load in the western metropolitan Melbourne/Geelong/Point Henry areas to maintain the secure operating state during system normal conditions (i.e. prior to outage of the Moorabool A1 transformer). Table 6 presents the required load shedding at times of 10% POE demand with full generation output under system normal condition.

Moorabool A1 transformer prior outage – secure operating state

With a prior outage of Moorabool A1 transformer, the loading of the Keilor transformers would exceed their 30-seconds short-term rating of 1100 MVA following an outage of a Keilor transformer. To operate the system in a secure operating state, load in the western metropolitan Melbourne and Geelong areas and Point Henry need to be reduced within 30 minutes of the Moorabool A1 transformer outage, such that potential loading of Keilor transformers should be up to 1100 MVA following a parallel Keilor transformer outage. In addition the Keilor fast load shedding control scheme should be armed for additional potential load shedding.

From summer 2005/06, at times of peak demand, with full generation output from generators at Anglesea, Laverton North and Newport, load needs to be shed to maintain a secure operating state following Moorabool A1 transformer outage. Table 6 presents the required load shedding at times of 10% POE demand with full generation output,

- with all transmission in service (column 2)
- following MLTS A1 transformer outage (column 3); and

[7] Keilor fast load shedding scheme is in place to shed load in order to remove the overload on the Keilor transformers following a low probability second contingency.

- following KTS A2 or A4 transformer outage with prior outage of MLTS A1 transformer outage (column 4).

The amount of load to be armed for potential shedding is about 600 MW for peak demand conditions with prior outage of the Moorabool A1 transformer. Probability of this additional load shedding is very much small, since it involves two contingencies during peak demand period.

Year	System normal load shedding Secure operating state	Additional load shedding following MLTS transformer outage Secure operating state	Additional load shedding following a KTS 500/220 kV transformer outage with MLTS transformer prior outage[8]
2005/06	0	120 MW	~600 MW
2006/07	0	220 MW	
2007/08	0	300 MW	
2008/09	60 MW	320 MW	
2009/10	170 MW	320 MW	

Table 6: Load shedding for peak demand conditions due to KTS 500/220 kV transformer ratings

7.2.2. Constraint due to Keilor to Geelong 220 kV Lines

Following an outage of the Moorabool transformer, loading on the Keilor-Geelong 220 kV line increases to support the load at Geelong, Point Henry, Ballarat, Terang, Bendigo, Kerang, Horsham and Red Cliffs and export to South Australia via Murraylink. The loading and rating of the three Keilor to Geelong 220 kV lines is dependent on:

- The number of Keilor to Geelong 220 kV lines in service;
- Point Henry, Geelong and western Victoria loads, which causes an increase in line loading as they are increased;
- Anglesea generation levels, which causes an increase in line loading as it is reduced;
- Ambient temperature, which lowers the line ratings as it is increased;
- Wind speed, which increases the line ratings as it is increased[9];
- Southern Hydro generation, which causes an increase in line loading as it is reduced;
- NSW/Snowy to Victoria transfer, which causes an increase in line loading as Victorian import decreased; and
- Murraylink transfer from Victoria to South Australia, which causes an increase in line loading as it is increased.

Table 7 presents the loading on a Keilor-Geelong 220 kV line for 10% POE demand summer 2005/06 forecast, 1900 MW import from NSW to Victoria and Anglesea generation at full output. Murraylink

[8] Potential load would be armed for automatic load shedding immediately following KTS transformer outage with prior outage of MLTS transformer.

[9] A dynamic wind monitoring scheme has been installed for Keilor-Geelong 220 kV lines, to determine the real-time rating based on ambient temperature and wind speed.

transfers from Victoria to South Australia are 220 MW for system normal conditions, i.e. with all plant in service (column 2) and 0 MW under MLTS A1 transformer outage conditions[10] (columns 3 and 4).

Year	System normal loading *[MVA]*	Loading following outage of Moorabool A1 transformer *[MVA]*	Loading following outage of a Keilor-Geelong line with prior outage of Moorabool A1 transformer *[MVA]*
2005/06	125	325	480
2006/07	130	335	500
2007/08	130	345	520
2008/09	130	360	530
2009/10	135	375	555

Table 7: KTS-GTS 220 kV line loading for an outage of Moorabool A1 transformer

System normal secure operating condition

High wind speeds are likely at times of high ambient temperature along the Keilor-Geelong 220 kV lines. The 15 minute short term rating is 380 MVA at 40°C ambient and 1.8 m/s wind speed. Based on this, these lines are forecast to cause no system normal constraint for the next 5 years (Table 7, column 3). While it is possible for low wind speeds to occur during high ambient temperature, the coincident occurrence of these conditions has a low probability.

Moorabool A1 transformer prior outage – secure operating state

With a prior outage of Moorabool A1 transformer, the loading of the Keilor-Geelong 220 kV lines would exceed their continuous rating on high ambient temperature days and the potential loading would exceed their short-term rating following a parallel Keilor-Geelong line. To operate the system in a secure operating state following the Moorabool transformer outage:

- load in the Geelong/Point Henry area would need to be reduced to maintain the line loading within the continuous rating; and
- load shedding control scheme should be armed for additional potential load shedding following a second contingency event (very low probability event).

Table 8 presents the required load shedding at times of 10% POE demand with full generation output following MLTS A1 transformer outage for 40°C ambient temperature and 1.8 m/s wind speed adjacent the Keilor-Geelong lines.

[10] Murraylink is designed with an automatic runback scheme, which will reduce the export to South Australia to zero if MLTS A1 transformer were to be tripped.

Year	System normal load shedding Secure operating state	Additional load shedding following Moorabool A1 outage Secure operating state	Additional load shedding following a Keilor-Geelong circuit outage with Moorabool A1 transformer prior outage
2005/06	0	40 MW	~360 MW
2006/07	0	70 MW	
2007/08	0	100 MW	
2008/09	0	120 MW	
2009/10	0	150 MW	

Table 8: Load shedding for hot day demand conditions due to KTS-GTS 220 kV line ratings

While these constraints are lower than those imposed by KTS A2 and A4 transformers, presented in Table 6, they relate to another contingency type (KTS-GTS line outages) and increase the probability weighted load at risk value, which is the benefit of the proposed MLTS transformer installation.

7.2.3. Other Subsequent Outages

There are number of other subsequent outages (2nd contingency) with prior outage of Moorabool A1 transformer would increase the loading on Keilor transformers above their 2-hour short-term rating. For summer 2008/09 10% POE demand levels with all generation at full output, 1900 MW import from NSW/Snowy to Victoria and zero transfer to South Australia via Murraylink, the loading levels of Keilor transformer following a second contingency with prior outage of the Moorabool A1 transformer are summarised in Table 9.

Subsequent outage with prior outage of the Moorabool A1 transformer	Loading of Keilor A2 or A4 transformer (% of 2-hour short-term rating of 810 MVA)
Outage of Keilor 500/220 kV A2 transformer	170%
Outage of Keilor 500/220 kV A2 transformer	170%
Outage of Keilor 500/220 kV A2 transformer	116%
Outage of South Morang 330/220 kV No.1 transformer	109%
Outage of South Morang 330/220 kV No.1 transformer	106%
Outage of South Morang 500/330 kV transformer	107%
Outage of Rowville 500/220 kV A1 transformer	105%
Outage of Rowville 500/220 kV A1 transformer	105%
Outage of Bendigo-Shepparton 220 kV line	117%
Outage of Buronga-Red Cliffs 220 kV line	110%

Table 9: Summary of critical subsequent outages with prior outage of Moorabool A1 transformer

7.3. Assessment of Constraint Energy

In the National Electricity Market, demand and generation changes continuously throughout each day. Hour-by-hour market modelling using Monte-Carlo simulation was used to determine the forecast flows on the constraining elements. These forecast flow conditions are then compared with the capability of critical plant, allowing the exposure to constraint energy to be quantified for each year. Constrained energy is assessed as re-dispatch of generation and/or unserved energy.

7.4. Probability of plant outages

The expected constrained energy is subjected to the probability of occurrence of outage of the plant, which causes the constraint. Table 10 provides the forced outage rates, which have been used for the assessment of the expected constrained energy, expected rescheduled generation and expected unserved energy at risk.

Plant	Forced outage rates
Moorabool 500/220 kV Transformer (A spare single phase unit is to be available at Moorabool by summer 2005/06)	Short term outage – 0.03% (based on historical data) Long term outage – 1 in 50 years (or 1 in 150 years per phase), with a duration of 2 weeks
Keilor 500/220 kV Transformers (A spare single phase unit is available at Keilor)	Short term outage – 0.055% (based on historical data) Long term outage – 1 in 50 years (or 1 in 150 years per phase), with a duration of 2 weeks
Keilor to Geelong 220 kV Lines	0.165% (based on historical data)

Table 10: Forced outage rates

8. Do Nothing – Expected Value of Constraint

Market modelling studies have been undertaken to quantify exposure to constraints due to Keilor 500/220 kV transformer and Keilor to Geelong 220 kV line ratings.

Table 11 provides the rescheduled generation and unserved energy due to all constraints. Expected unserved energy and expected generation rescheduling energy are estimated based on the probabilities derived from the Table 10. Figure 4 presents the value of expected constraint for secure operation under system normal conditions and with prior outage of the Moorabool A1 transformer.

		2005/06	2006/07	2007/08	2008/09	2009/10
System normal, Secure operation (i.e. to remain operating satisfactorily after Moorabool A1 transformer outage)						
Annual hours of constraint	Hours	2	5	5 (note[11])	10	33
Expected rescheduled generation	MWh	960	1,895	2,135	3,460	9,700
Expected unserved energy	MWh	3 (note[12])	11 (note[12])	15 (note[12])	114	355
Value of expected constraint energy	$k	120	382	496	3,465	10,768
Following Moorabool A1 outage, Secure operation (i.e. to remain operating satisfactorily after Moorabool A1 transformer outage and the next worst credible contingency)						
Annual hours of constraint	Hours	120	233	340	425	635
Expected rescheduled generation	MWh	505	1,355	1,460	2,670	2,535
Expected unserved energy	MWh	3	8	10	15	20
Value of expected constraint energy	$k	105	263	334	500	657
Total Expected constraint energy						
TOTAL VALUE OF EXPECTED CONSTRAINT ENERGY	$k	225	645	830	3,965	11,425

Table 11: Expected Value of Constraint[13]

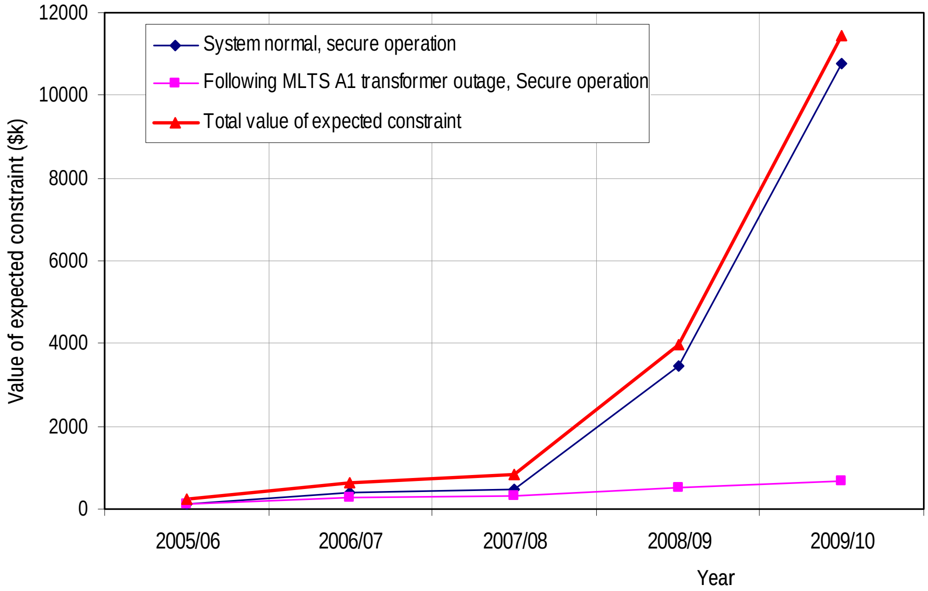


Figure 4: Value of expected constraint

[11] Constraint is reduced due to installation of the second 500/220 kV transformer at Rowville – target service date September 2007.
[12] There is no expected unserved energy with all generating plant in service at times of peak demand period. The values shown are based on probability of forced outage of critical generators.
[13] The values shown in Table 11 are different to the values published in the Electricity Annual Planning Report 2005. These revised values are based on detailed assessment including the proposed 2nd 500/220 kV transformer at Rowville with a service date of September 2007.

9. Network Options for Removal of Constraint

Part 1(b) of the regulatory test states that an option satisfies the regulatory test if the option maximises the expected net present value of the market benefit compared with a number of alternative options and timings, in a majority of reasonable scenarios.

A number of network options have been identified, which could address the constraints associated with flows on the Keilor 500/220kV transformers and the Keilor-Geelong 220 kV transmission lines. These are:

- Option A: installation of a second 500/220 kV transformer at Moorabool;
- Option B: installation of a fourth 500/220 kV transformer at Keilor and replacement of three 220 kV circuit breakers with high interruption capability at Keilor terminal station;
- Option C: rebuild of Keilor-Geelong 220 kV lines;
- Option D; installation of a third 330/220 kV transformer at South Morang. This requires re-configuration of the existing Rowville-Thomastown 220 kV line as Rowville-South Morang and South Morang-Thomastown with additional circuit breakers at South Morang to deliver power from the 330 kV to the 220 kV system;
- Option E: installation of a 500/220 kV transformer at South Morang. This also requires re-configuration of the existing Rowville-Thomastown 220 kV line as Rowville-South Morang and South Morang-Thomastown with additional circuit breakers at South Morang to deliver power from the 500 kV to the 220 kV system; and
- Option F: development of a new 500 kV terminal station near Mortlake with a 500/220 kV transformer. This involves connection of the existing Moorabool-Heywood 500 kV lines and connection of 220 kV side to a nearby 220 kV network.

Option A, installation of a second 500/220 kV transformer at Moorabool, removes the constraint due to the Keilor 500/220 kV transformers and the Keilor-Geelong lines completely.

Option B, installation of a fourth 500/220 kV transformer at Keilor, removes the constraint due to the Keilor 500/220 kV transformer but not on the Keilor-Geelong lines. Further this option increases the loading on the Keilor-Geelong lines and hence aggravates the line constraint.

Option C, rebuild of Keilor-Geelong 220 kV lines, removes the constraint on the Keilor-Geelong lines but not on the Keilor transformers.

Combined options B and C remove the constraint on the Keilor transformers and the Keilor-Geelong lines.

Options D and E do not relieve the system normal potential overload on the Keilor transformers from 2008/09 and do not remove the constraint on the Keilor-Geelong lines. These options also require additional transmission line works to deliver the power from the 500 kV or 330 kV systems to the 220 kV system. In addition, the planned development of 220/66 kV at South Morang[14] by distribution businesses is forecast to reduce the loading at Thomastown terminal station and, not at the Keilor and/or Geelong terminal stations. Overall, Options D and E are likely to result in higher costs than other options with little reduction of the constraints.

Option F involves development of a new 500/220 kV terminal station including installation of a new 1000 MVA 500/220 kV transformer near Mortlake or closer to the 500 kV and 220 kV transmission lines in the south-western Victoria. Depending on the location of the 500 kV station and connection point to the 220 kV existing transmission lines, a new transmission line may be required. Currently, neither a site for the new terminal station nor easement for a new 220 kV line is available. This transformer 220 kV connection is electrically remote from the Keilor 220 kV buses, hence this option does not relieve the Keilor transformer overload completely. Further, the capital cost of this option would be much higher than the cost of option A.

Following consideration of all the above options, two options have been short listed to address the constraints associated with flows on the Keilor 500/220kV transformers and the Keilor-Geelong 220 kV transmission lines. These are:

- Option 1: installation of a second 500/220 kV transformer at Moorabool; and
- Option 2: installation of a fourth 500/220 kV transformer at Keilor and rebuilding of the Keilor-Geelong 220 kV lines (combined Option B and C).

9.1. Option 1 – 2nd Moorabool Transformer

The proposed scope of works for Option 1 involves the development and switching of a new 1000 MVA 500/220 kV A2 transformer at the existing Moorabool Terminal Station, as shown schematically in Figure 5.

The capitalised cost estimate for Option 1 is $17M ± 25%. The asset life for Option 1 is assumed to be 45 years. Table 12 compares the annualised costs of this option for a given range of discount rates.

Total Capitalised Cost [$k]	*Discount Rate*	*Annualised Cost [$k]*
17,000	6%	1,100
	8%	1,404
	10%	1,724
Upper Tolerance (+25%): 21,250	6%	1,375
	8%	1,755
	10%	2,155
Lower Tolerance (-25%): 12,750	6%	825
	8%	1,053
	10%	1,293

Table 12: Cost for Option 1

[14] Reference – Transmission Connection Planning Report 2004, produced jointly by the Victorian Electricity Distribution Businesses

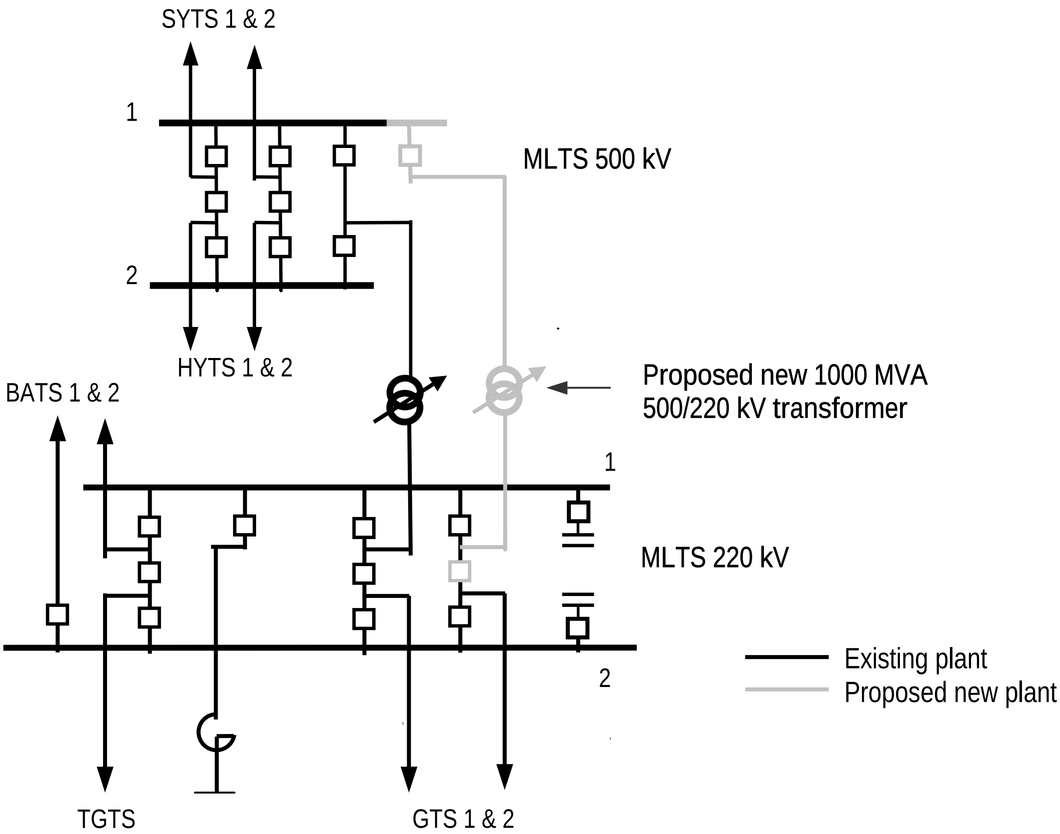


Figure 5: Proposed electrical representation of option 1, Moorabool transformer

The estimated lead time (i.e. for design, procurement and construction) for the proposed development of Option 1 is 24 months from the execution of all necessary contracts.

9.2. Option 2 – 4th Keilor 500/220 kV Transformer & uprate of Keilor-Geelong lines

The proposed scope of works for Option 2 involves,

- installation of a new 750 MVA 500/220 kV transformer with one 500 kV and one 220 kV circuit breakers;
- replacement of three 220 kV circuit breakers with high rupture capability at the existing Keilor Terminal Station; and
- rebuilding of the existing Keilor-Geelong 220 kV No.2 line.

The existing Keilor-Geelong lines consists of three 220 kV circuits, one on a single circuit tower line (No.2 line) and two on a double circuit tower line. At 40^{o}C ambient, each circuit is rated to 237 MVA and 315 MVA with wind speed of 0.6 m/s and 1.8 m/s respectively. Following the Moorabool transformer outage, each of these lines can be loaded to around 375 MVA at times of 10% POE summer demand in 2009/10. This loading level is forecast to increase in future years. A technically feasible option to remove the constraint on the Keilor-Geelong line is to rebuild the existing single circuit line with a high capacity double circuit line. The estimated capital cost of line rebuild is $60M ±25%.

The capitalised cost estimate for Option 2 is $80M ±25%. The asset life for Option 2 is assumed to be 45 years. Table 13 compares the annualised costs of this option for a given range of discount rates.

Total Capitalised Primary Cost [$k]	*Discount Rate*	*Annualised Cost [$k]*
78,000	6%	5,047
	8%	6,442
	10%	7,908
Upper Tolerance (+25%): 97,500	6%	6,308
	8%	8,052
	10%	9,886
Lower Tolerance (-25%): 58,500	6%	3,785
	8%	4,831
	10%	5,931

Table 13: Cost for Option 2

The estimated lead-time for the proposed development of Keilor transformer is 24 months from the execution of all necessary contracts, and rebuilding of the line could take more than 24 months.

10. Benefits Associated with Relieving Constraints for the Network Options

The regulatory test defines market benefits as the total benefits of an option to all those who produce, distribute and consume electricity in the NEM. That is, the change in consumers' plus producers' surplus or another measure that can be demonstrated to produce an equivalent ranking of options in a majority of reasonable scenarios.

This regulatory assessment predominantly considers the benefits of changes in involuntary load shedding caused through savings in reduction in lost load, using a reasonable forecast of the value of electricity to consumers. It also considers the changes in costs through the deferral and advancement of transmission investments.

The two network options considered have almost identical market benefits when assessing their ability to eliminate or minimise the expected constraints over the forthcoming years.

10.1. Annual Market Benefits

Options 1 and 2 alleviate all of the identified constraints and this is summarised in Table 14.

		Total value of expected market benefit				
		2005/06	2006/07	2007/08	2008/09	2009/10
Option 1, Moorabool transformer	$k	225	645	830	3,965	11,425
Option 2, Keilor transformer & Keilor-Geelong line rebuild	$k	225	645	830	3,965	11,425

Table 14: Annual Market Benefits

11. Longer Term Planning

To meet the increased demand growth in western metropolitan Melbourne, Geelong and western Victoria areas, longer term planning has identified that there is a need for additional 500/220 kV transformers in the western metropolitan Melbourne and/or Geelong area to deliver the power from the 500 kV transmission system.

Each of the network options considered to remove the forecast constraints will have long term benefits. While these long term benefits will be realised, they are difficult to quantify as the system will change for other reasons over the transformers asset life. The following considerations have been made to address the longer term impacts as part of this assessment

11.1. Ongoing Benefits

The development of either of the two network options under consideration will reduce the flows on both the existing Moorabool A1 and Keilor 500/220 kV transformers over their entire 45 year asset life. In addition a second Moorabool transformer reduces the flow on the Keilor-Geelong 220 kV lines.

For the purposes of representing these benefits, a conservative approach has been taken in the economic assessment where the annual benefits in the last year of the technical assessment (i.e. 2009/10) are carried through without any escalation for the remaining years of the asset life. This is taken to be a highly conservative approach as, in practice, it is expected the benefits of the transformer will increase in a linear or even quadratic nature as demand grows. This approach also allows for differentiation between each option based on the variation in benefits as quantified for 2009/10.

11.2. Deferral of the Subsequent Western Metropolitan Transformation

Table 15 presents forecasts of potential flows (as a percentage of short-term ratings) on critical 500/220kV transformers for the Do Nothing scenario and for each of the network options These loadings are following the critical transformer outage, hence these potential loadings should remain within the short-term (at least 15 minutes) of the monitored plant for secure operation prior to any outages.

	Monitored Transformer	*% of Loading of the monitored plant*			
		2008/09	*2009/10*	*2011/12*	*2014/15*
Do nothing	Moorabool A1	81%	84%	90%	100%
	Keilor A2	103%	109%	115%	125%
	Keilor A4	103%	109%	115%	125%
	Keilor A3	73%	76%	81%	88%
Option 1 Moorabool	Moorabool A1	69%	72%	77%	85%
	Keilor A2	86%	88%	93%	101%
	Keilor A4	86%	88%	93%	101%
	Keilor A3	68%	72%	77%	82%
Option 2 Keilor	Moorabool A1	69%	72%	77%	86%
	Keilor A2	81%	84%	89%	99%
	Keilor A4	81%	84%	89%	99%
	Keilor A3	66%	70%	76%	81%

Table 15: Loading of critical transformers with each options

This simplistic study indicates that, in both the options 1 and 2, a subsequent 500/220 kV transformer in the western metro area may be required around 20014/15.

12. Other Benefits

The Moorabool A1 transformer supplies about 40% of total load in Geelong, Point Henry (smelter) and state grid areas at times of peak demand. An outage of this transformer would increase the reactive losses significantly in the state grid area transmission lines and KTS-GTS 220 kV transmission lines. There are already two 150 MVAr 220 kV switched shunt capacitors installed at MLTS, and additional reactive support may be required in the form of dynamic (eg. Static Var compensator) reactive support to control the voltage continuously and avoid possible voltage collapse. A second transformer at MLTS would reduce the reactive power losses significantly, and defer the need for additional reactive support in this area. For the purpose of market benefit tests, a benefit of deferral of 150 MVAr shunt capacitor bank (a conservative value) is included in the option 1 of 2^{nd} Moorabool transformer.

The existing fast load shedding control scheme, when armed about 600-800 MW load in the western metropolitan Melbourne and Geelong areas are selected for potential load shedding. The probability of needing this load shedding is very low, since the control scheme is designed to be armed for a second contingency. However, inadvertent tripping of the control scheme could result in load shedding when it is not required. An augmentation to support the load in these areas will result in significantly reduced need for arming of the fast load shedding scheme.

13. Consideration of Non-Network Alternatives

The new large transmission network asset options considered as part of this analysis avoid considerable volumes of load shedding that may be required as a consequence of very low probability events occurring at times of moderate to high demand in Victoria.

Non-network options, such as new demand side participation or embedded generation, would require reliability commensurate with the network options considered. They would need to be available to the

Geelong and western metro areas supplied from the 220 kV network with a peak capacity growing from around 120 MW in 2005/06 to 600 MW in 2009/10 and at times of peak demand period and following plant outages, to be considered a technically and commercially feasible alternatives to the proposed network options. At least 40% of new demand side participation or generation should be available from Geelong area to remove the constraint on the Keilor-Geelong lines.

14. Economic Cost-Benefit Analysis

The net market benefit assessment carried out for Options 1 and 2 and is presented in Table 16.

Discount Rate	8.00%
Economic Life	45
VCR	$ 29,600
Ongoing Benefit Factor	1
Capital cost of Option 1	$17M
Capital cost of Option 2	$78M

		Present Value	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	PV Residual
Do Nothing	Exp. Energy at Risk	105,750	225	645	830	3,965	11,425	11,425	11,425	11,425	11,425	11,425	145,956
Option 1 2nd Moorabool transformer	Market Benefits	104,330				3,965	11,425	11,425	11,425	11,425	11,425	11,425	145,956
	Total Costs	- 13,500				- 1,404	- 1,404	- 1,404	- 1,404	- 1,404	- 1,404	- 1,404	- 17,936
	Deferral of capacitor bank	2,560				266	266	266	266	266	266	266	3,398
	Net Market Benefits	93,400				2,827	10,287	10,287	10,287	10,287	10,287	10,287	131,418
Option 2 4th Keilor transformer & rebuild of Keilor-Geelong line	Market Benefits	104,330				3,965	11,425	11,425	11,425	11,425	11,425	11,425	145,956
	Total Costs	- 61,920				- 6,442	- 6,442	- 6,442	- 6,442	- 6,442	- 6,442	- 6,442	- 82,295
	Deferral of capacitor bank												
	Net Market Benefits	42,420				- 2,477	4,983	4,983	4,983	4,983	4,983	4,983	63,661

Table 16: Net Market benefits for Options 1 and 2

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This scenario indicates that (Table 16) Option 1 maximises the expected net present value of the market benefits at $93.4, followed by Option 2 at $42.4M.

15. Sensitivity Analysis and Project Timing

The regulatory test requires that the calculation of market benefits encompass sensitivity testing on key input variables.

In accordance with this requirement, VENCorp has identified the following key variables to include in its sensitivity testing of the net present value of the market benefits:

- Base case discount rate of 8%, with sensitivity testing at 6% and 10%; and
- Capitalised cost estimates varying by ±25% with sensitivities to discount rate.

In total 9 sensitivity studies were conducted with the results presented are in the Table 17.

		Net present value of net market benefits [$M]	
Sensitivity variables		*Option 1 2nd Moorabool transformer*	*Option 2 4th Keilor transformer & rebuild of Keilor-Geelong line*
Discount Rate 8%	Base cost	93.4	42.4
	Costs up by 25%	90.0	26.9
	Costs down by 25%	96.8	57.9
Discount Rate 6%	Base cost	131.5	76.9
	Costs up by 25%	128.0	60.5
	Costs down by 25%	135.1	93.2
Discount Rate 10%	Base cost	68.8	21.0
	Costs up by 25%	65.6	6.3
	Costs down by 25%	72.0	35.6

Table 17: Sensitivities of net market benefits

All the sensitivity studies resulted in higher net market benefits for Option 1 than Option 2. This is as expected, since the cost of option 2 is much higher than the option 1.

The full cost-benefit analysis for each of these sensitivities is presented in Attachment 2.

Another set of sensitivity studies for the key variables were carried out for Option 1 to determine whether the optimal service date of the transformer was for summer 2007/08, 2008/09 or 2009/10 and the results presented in Table 18. 9 out of 9 sensitivity studies show that the optimal service date is maximise the net market benefit for the service date of summer 2008/09.

		Net present value of the market benefits [$M]		
Sensitivity variables		*Timing Summer 2007/08*	*Timing Summer 2008/09*	*Timing Summer 2009/10*
Discount Rate 8%	Base cost	92.7	93.4	91.6
	Costs up by 25%	89.0	90.0	88.4
	Costs down by 25%	96.3	96.8	94.7
Discount Rate 6%	Base cost	130.7	131.5	129.7
	Costs up by 25%	126.9	128.0	126.3
	Costs down by 25%	134.4	135.1	133.0
Discount Rate 10%	Base cost	68.0	68.8	67.1
	Costs up by 25%	64.5	65.6	64.2
	Costs down by 25%	71.5	72.0	70.1

Table 18: Sensitivities to the project timing

16. Ranking of Options

Table 19 presents the expected net present value of the market benefits for each option considered, and ranks them based on the number of scenarios the option maximises the net present value of market benefits and then from highest to lowest benefit.

Option	*Range of Net Present Value of the Market Benefit [$M]*	*Average Net Present Value of the Market Benefit [$M]*	*No of scenarios/ sensitivity studies that maximises the NPV of the Market Benefits*	*Ranking*
1, 2nd Moorabool transformer	65 to 135	98	9 out of 9	1
2, 4th Keilor transformer and KTS-GTS 220 kV line rebuild	6 to 93	47	0 out 9	2

Table 19: The ranking of Options to address constraints on Keilor 500/220 kV transformer and Keilor-Geelong 220 kV lines

Option 1 maximises the net present value of the market benefit.

Over the 45 years of the asset life, the expected present value of the market benefits ranges from $80M to $142M, delivering an expected net present value of the market benefit of between $65M and $135M, averaging over the sensitivity studies at $98M. Further the net market benefits for Option 1 are maximised over range of conditions when it is completed for summer 2008/09.

Therefore, VENCorp considers this project, implementing Option 1, satisfies Part 1(b) of the Regulatory Test on the basis it maximises the expected net present value of the market benefits in a majority of reasonable scenarios and considering a number of alternative options.

Option 1 maximises the net present value of the market benefit in all scenarios and sensitivity studies assessed. On this basis VENCorp considers Option 1 is the preferred network option.

17. Consideration of Material Inter-regional Network Impacts

In accordance with clause 5.6.6(b)(4) of the National Electricity Rules, the Inter-Regional Planning Committee must prepare an augmentation technical report if any augmentation is reasonably likely to have a material inter-network impact. VENCorp has assessed the preferred augmentation against the screening criteria published by the Material Inter Network Impact Working Group and has determined that:

(1) Power transfer capability criteria: no material impact, as the peak transfer capacity between inter-regional networks will not be reduced or increased by 3% or 50MW nor will the intra-regional peak transfer capacity within another TNSP's network reduce by 3% or 50MW.

(2) Fault level increase criterion: no material impact, as fault levels will not increase by more than 10MVA at any station in another TNSP's network.

(3) Series capacitor criteria: no material impact, as there is no proposal to install series capacitors.

Note that, VENCorp has identified that the installation of a 500/220kV transformer at Moorabool will have the impact of slightly reducing flows on the critical South Morang 500/330kV F2 transformer, marginally increasing the transfer capacity from Victoria to the NSW/Snowy regions, under some conditions. However, VENCorp considers that this augmentation has no material impact on peak transfer capacity between inter-regional network, as defined by screening criterion (1) above because:

- in cases where the augmentation causes any peak transfer capacity increase, the increase does not exceed 50 MW; and
- in numerous cases peak transfer capacity is determined by factors unaffected by this augmentation, which then has no peak transfer capacity impact.

Lastly, the preferred augmentation will slightly widen the range of system conditions under which the peak transfer capacity can be delivered and therefore have some beneficial market impacts. These market impacts have not been quantified as part of this assessment.

As the proposed project has no material inter-network impact, the Inter Regional Planning Committee has not been requested to prepare a technical report for this augmentation.

18. Recommendation

VENCorp considers Option 1, a new 1000MVA, 500/220kV transformer at Moorabool Terminal Station, for September 2008, satisfies Part 1(b) of the Regulatory Test on the basis that it maximises the expected net present value of the market benefits compared with a number of alternative options and timings, in a majority of reasonable scenarios. This option delivers an expected net present value of the market benefit of between $65M and $135M, averaging at $98M.

This project considerably improves the reliability of supply to customers in the western metropolitan Melbourne, western Melbourne CBD, Geelong and western Victoria areas and smelter load at Point Henry in an economic manner. The capitalised cost estimate of the project is $17M ± 25% and the recommended service date is September 2008.

Authorised by VENCorp Level 2 Yarra Tower, World Trade Centre, Melbourne 3005.