ROAM Consulting®
(A.B.N. 54 091 533 621)

FINAL REPORT (NGF00001) TO

NATIONAL GENERATORS FORUM

NATIONAL ELECTRICITY MARKET ASSESSMENT

Critique of NEM Reliability Assessment Processes

6 May 2004

A. EXECUTIVE SUMMARY

The National Generators Forum (NGF) has concerns that "*NEMMCO intervention triggers and long-term demand forecasts lead to an unrealistic view of NEM reliability thereby increasing the risk of unnecessary intervention and consequently producing distorted signals for timing of new investment*".

Therefore the NGF has engaged ROAM Consulting to provide a technical assessment and opinion of the validity of the view:

That NEM reliability is *being portrayed as unreasonably* poor

1) KEY FINDING

The results of our assessment conclude that NEM reliability is being portrayed as unreasonably poor compared with our appraisal of the real situation. This is primarily because the current methodology used to determine a 'Reserve Margin' for adequate future reliability is a poor approximation for maintaining the NECA Reliability Panel's requirement of an unserved energy (USE) level of less than 0.002%.

In the absence of the use of a probabilistic (and more accurate) model, the market has been left with the view that the forecast future Reserve Margin will need to be in excess of each region's Intervention Reserve Threshold out 10 years into the future (with the Intervention Reserve Threshold being set at the maximum forecast demand under extreme weather conditions plus an allowance for any single credible contingency). This methodology is materially flawed, specifically:

1) It does not consider important variables such as transmission and generator forced outage rates (FOR), and regional demand profiles. Because these variables are not currently considered:

    a) An incorrect view of the state of health of the market will be developed. This misperception will be greatest in regions that have the "peakiest" demand shapes (i.e. Victoria and South Australia); and

    b) Inconsistencies will be introduced between the different regions, which was not the intention in the creation of the NEM.

2) It is highly sensitive to forecast maximum demand (formally a one in ten year demand outcome), which is a very difficult forecast to estimate. By using a probabilistic methodology, the sensitivity to forecast maximum demand would be reduced by the effect of looking at all points in the demand curve, and not just the maximum point (which has been shown as difficult to forecast in the ROAM Consulting analysis).

A considerably more accurate picture of NEM Reliability can be gained through the use of a probabilistic methodology, which addresses these (and other) shortcomings. Such an approach is considered world's best practice, and has been used by NEMMCO on several occasions (just not in conjunction with the production of the Statement of Opportunities).

The use of a probabilistic methodology would ensure that NECA Reliability Panel reliability standards would still be met or exceeded whilst optimising asset utilisation and thereby minimising total costs paid by end consumers.

2) SUMMARY OF ANALYSIS

In order to perform this assessment, ROAM Consulting has determined that three different aspects of the issue needed to be assessed, as follows:

1) ***Methodology of Calculation:*** It has been necessary to analyse the methodology used for the quantification of forecast future reliability in the NEM. Specifically:

    a) It has been necessary to contrast the (conservative) indications delivered through the use of the more simplistic deterministic analysis of an extreme demand case to the (more realistic) indications delivered through the application of a more thorough probabilistic analysis of multiple plausible scenarios; and

    b) It has been necessary to clarify the timeframe over which reliability is being measured;

2) ***Input Data:*** ROAM Consulting has recognised the importance of ensuring the accuracy of key input data used in the modelling:

    a) A review has been performed of the levels of uncertainty that can be ascribed to assumptions made with respect to several key variables (forecast demand growth rates, and generator outage rates);

    b) This assessment has also provided an indication of the degree to which the calculated NEM Reliability is sensitive to changes in these and other factors;

3) ***Communication:*** ROAM Consulting has provided recommendations for ways in which the communication of NEM Reliability can be enhanced in order to deliver a greater level of understanding across a wider range of NEM participants and other stakeholders.

All three facets are integral to the perceptions held by stakeholders of the NEM with respect to its reliability. ROAM Consulting has considered all three aspects in this assessment.

3) METHODOLOGY OF CALCULATION

The NECA Reliability Panel established that the minimum level of reliability in the NEM should be no more than 0·002% of unserved energy in any region for a given year.

The correct technique for forecasting unserved energy in the market over any future time horizon entails the use of specialist software packages that can model numerous iterations of a given market development scenario. It is necessary to model multiple outcomes for a given market scenario in order to accurately reflect the probable impact of random events in the market, such as generator forced outages. This approach does provide an accurate reflection of the state of reliability in the market. However, such modelling does take some time to complete.

In order that NEM Stakeholders could have another tool that could be applied to provide a high-level overview of the supply/demand balance, NEMMCO introduced the *Reserve Margin* calculation for use as a general guide:

- The *Reserve Margin* calculation is formally used over the short and medium term (i.e. out to three years into the future) with respect to the *Intervention Reserve Threshold* defined for each region as a possible trigger for NEMMCO's intervention in the market;
- The *Reserve Margin* calculation has no formal application over a longer time-horizon.

Over the course of the last five years, the *Reserve Margin* calculation has become more frequently used (and more broadly applied) as NEM stakeholders have found its simplicity and ease of application to be beneficial. Correspondingly, there has been a reduced emphasis amongst some stakeholders on the more correct probabilistic standard.

Hence, the *Reserve Margin* measure has become misleadingly accepted as the defacto reliability standard for the NEM.

As shown in our analysis, the use of *Reserve Margin* in this manner provides a significantly inaccurate outlook on the future of the market[1]. This is a natural outcome of the fact that the Reserve Margin calculation places too great an emphasis on the (low-probability of occurrence) extreme events, such as extreme weather events. Such a bias has been increasingly overlooked in the application of this measure to situations for which it has not been defined.

[1] This view is internationally accepted, as illustrated by the following extract from the Republic of Ireland "Generation Adequacy Report 2003-2009" published by the Transmission System Operator Ireland:

> *LOLE (*Loss of load expectation, a probabilistic measure equivalent to USE*) is used to assess system adequacy because unlike other measures, such as capacity margin, it takes the following factors into account;*
>
> *1) The load at every hour of the year is considered to have an influence on system adequacy, not just the hours of peak demand.*
>
> *2) Plant availability performance is taken into account. High availability plant is of more benefit than low availability plant from the system adequacy perspective.*
>
> *3) The number and relative sizes of generating units impacts on the LOLE calculation. A large number of small units will provide more security than a small number of large units, other factors being equal.*

The following table shows a comparison of the following:

- The first column lists the required timing of the development of new generation plant implied by the application of the *Reserve Margin* calculations in comparison with the *Intervention Reserve Threshold*;

- The second column lists the (more correct) required timing of the development of new generation plant revealed by the correct application of probabilistic modelling in conjunction with the NECA Reliability Panel reliability standards.

In both cases, data has been referenced to the information provided in the NEMMCO 2003 *Statement of Opportunities* to aid in the comparability of the two cases.

Table Exec A: Comparison of Reserve Margin Shortfall and Probabilistic

	Source: ***SOO 2003***[2] **Deterministic** *Reserve Margin* referenced to *Intervention Reserve Threshold* (under the medium growth scenario**)**	**Source:** ***ROAM Modelling*** **Probabilistic Level of USE (under the Lower FOR case, incorporating the medium growth scenario)**[3] referenced to the 0.002% USE reliability standard
Queensland	Insufficient reserves forecast for summer 2005/06	Reliability standard breached in 2007/08 (i.e. **2 years later than implied in the SOO**)
NSW	Insufficient reserves forecast for summer 2005/06	Reliability standard breached in 2008/09 (i.e. **3 years later than implied in the SOO**)
Victoria	Insufficient reserves forecast for summer 2003/04	Reliability standard breached in 2009/10 (i.e. **6 years later than implied in the SOO**)
South Australia	Insufficient reserves forecast for summer 2003/04	Reliability standard breached in 2008/09 (i.e. **5 years later than implied in the SOO**)

[2] Since publication of the SOO 2003, the minimum reserve margin in the combined Victoria and South Australia regions has been reduced by NEMMCO to 530MW, delaying the timing of a reserve shortfall to 2006/07, according to the deterministic methodology.

[3] The case described here is the one calculated with assumed "lower" levels of plant forced outage rates (which is described in the report). The various potential weather-dependent load-shapes within the medium growth scenario have been weighted according to peak demand Probability of Exceedence (POE).

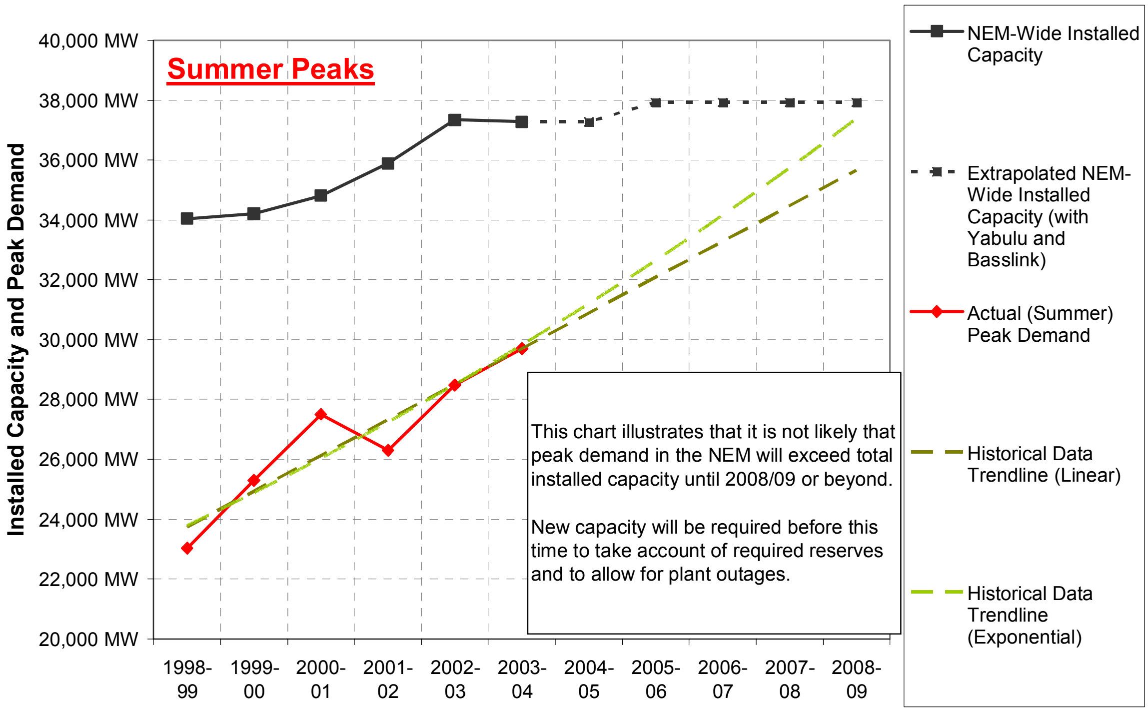
Here, the demand forecasts have been given weightings of 30.44% for the 10% POE and 69.56% for the 50% POE (with the implication that the 90% POE case would be even less severe than the 50% POE case). This is in accordance with the weighting factors used by NEMMCO as described in *Assessment of NEMMCO's 2001 Calculation of Reserve Margins* (MMA, 2002).

This greater level of conservatism in the calculation of *Reserve Margin* occurs as the calculation is deterministic, and hence places a disproportionate weighting on the likelihood of extreme events occurring.

Given that the two columns in Table Exec A imply two very different states of reliability for the NEM, ROAM Consulting considered it prudent to conduct an independent validity check of the results generated through the numerically-intensive modelling process completed for this study.

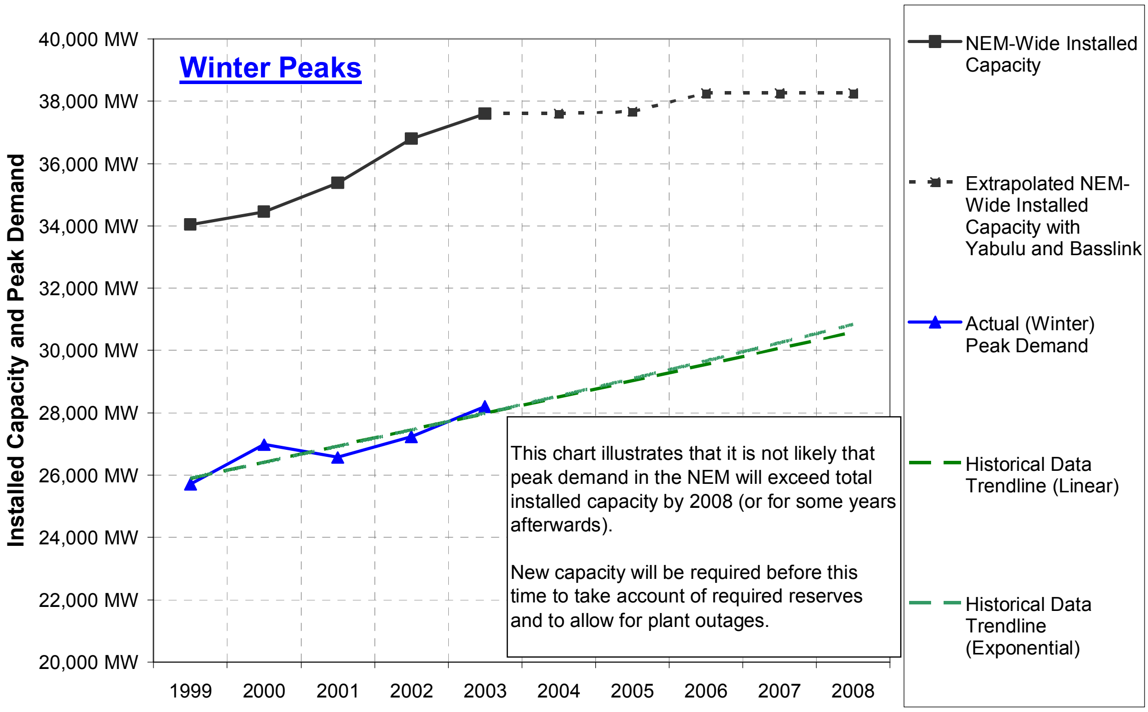
To do this, ROAM Consulting has graphed the cumulative NEM-wide peak demand experienced in successive summers (and winters) over the previous years since the NEM commenced and compared this with the total installed capacity across the NEM. The two charts shown below illustrate the extent to which there is (and will remain in the medium term) excess capacity in the mainland regions[4] of the NEM above the actual peak annual half hourly simultaneous demand.

Figure Exec A: Illustration of Excess Generation Capacity



[4] Mainland capacity in the NEM has been augmented by 600MW following the planned date of commissioning of Basslink in November 2005.

Figure Exec A: Illustration of Excess Generation Capacity



ROAM Consulting fully accepts that these pictures do not reveal the entire picture with respect to the forecast future reliability of the NEM, as they do not take into account a wide variety of issues (including plant outages and other constraints, operational reserve requirements, network constraints). Indeed, it is for this reason that the more complex probabilistic modelling must be performed.

However, the charts do confirm that the NEM is fundamentally operating, at present, with significant quantities of plant above system maximum demand available to meet its requirements from a reliability perspective. This excess capacity will not be absorbed by growth in peak demand until towards the end of the decade.

4) DATA

Given that both demand growth projections and also generator forced outage rates have been shown to have a significant impact on forecast NEM Reliability, ROAM Consulting has focused considerable effort on the analysis of both parameters.

It has been demonstrated that there is significant uncertainty attached to the production of the growth projections for annual energy consumption, and especially for peak summer demands (which have been shown to be especially critical to NEM Reliability). As a result, ROAM Consulting considers that the probabilistic market forecasting process should incorporate each of the three different economic growth scenarios (and within these the mild, medium and extreme weather patterns).

In addition, ROAM Consulting has proposed that a process be developed for the derivation of historical (planned and forced) outage rates on the basis of information released publicly to the market during each dispatch interval. This process would require a small change to the arrangements for disclosure of information provided in the ST PASA process.

5) COMMUNICATION

ROAM Consulting believes that the current confusion in the market with respect to the actual levels of forecast NEM Reliability has arisen by virtue of the methods used to communicate these calculations.

ROAM Consulting has identified that the market has developed in such a way that the Annual Report produced annually by the NECA Reliability Panel does not meet all of the objectives prescribed for such a report in the National Electricity Code. Specifically, it is essential that such a report provides a detailed assessment of likely future levels of NEM Reliability over several different load growth scenarios. Such an assessment would need to be completed using a probabilistic methodology similar to that applied in the completion of this study.

The issue of NEM Reliability is of such importance that this annual review should be incorporated in its own report (titled the *"Annual Reliability Review"*) that should be given the same prominence in the market as the *Statement of Opportunities*. The *Annual Reliability Review* should be published on or before 30 September each year, which would provide sufficient time following the release of the *Statement of Opportunities* to facilitate the latest updates of data provided in that document, and sufficient time before the coming summer to ensure its usefulness.

With the creation of the *Annual Reliability Review*, NEMMCO would have greater latitude to ensure that the *Statement of Opportunities* more effectively met its objectives, prescribed under the Code, eliminating the potentially confusing nature of the more recent issues of the *Statement of Opportunities*.

The imminent changes to the governance arrangements applicable to the NEM provide an ideal opportunity to implement these changes, to the benefit of all NEM Stakeholders.

B. CONTENTS

1) TABLE OF CONTENTS

2) LISTING OF FIGURES

3) LISTING OF TABLES

C. ANALYSIS AND DISCUSSION

1) BACKGROUND

1.1) The National Generators Forum

The Reliability Sub-Group (RSG) of the National Generators Forum (NGF) has been established to consider issues relating to the reliability standards used in the National Electricity Market (NEM), and their portrayal.

The RSG has formed a consensus view that NEM reliability is *being portrayed as unreasonably* poor. ROAM Consulting has been appointed by the NGF to provide the RSG an independent technical assessment of the validity of this view.

The RSG has expressed its concerns as follows:

- NEMMCO intervention triggers and long-term demand forecasts lead to an unreasonably conservative view of NEM reliability thereby increasing the risk of unnecessary intervention,
- Some jurisdictions and possibly some Jurisdictional Planning Bodies are currently resisting efforts by NEMMCO and the reliability panel to create slightly less conservative standards;
- Presentation of reliability information by various parties, especially NEMMCO in relation to the Statement of Opportunities, creates an unreasonably alarming picture.

We understand that these matters are of concern to generators as they can lead to unnecessary interventions, distortions, market disrepute and political interventions.

Thus, ROAM Consulting has been appointed as an independent consultant and tasked with assessing:

… whether NEM reliability is being portrayed as unreasonably poor.

1.2) Scope of Work

The RSG has specifically requested that the ROAM Consulting review include the following assessments:

Specific areas of interest to the NGF	**Is this concerned with the Methodology?**	**Is this concerned with the Data?**	**Is this concerned with the Presentation?**
An assessment of the current quality of long-term regional demand forecasting.		**YES**	
An assessment of the current NEMMCO approach regards the correlation of peak regional demands	**YES**	**YES**	
A discussion on the validity of deterministic trigger levels in medium and long-term reserve assessment	**YES**		
A technical assessment of NEMMCO's current intervention trigger levels in comparison with the reliability panel's 0.002% unserved energy criterion	**YES**		
Consideration of the accuracy of generator forced outage rates as used by NEMMCO		**YES**	
An assessment of the sensitivity of each of the reserve calculations to each of the input parameters (e.g. generator FOR etc.)		**YES**	
Given the above information, an opinion upon whether the nature and the content of the presentation of reserve levels of the 2003 Statement of Opportunities document presents a reasonable picture of NEM reliability in the context of the panel's criterion.			**YES**

2) INTRODUCTION

The NGF has requested ROAM Consulting to provide an answer to the question:

Is NEM Reliability being portrayed as unreasonably poor?

This is a complex question to answer, for reasons outlined below.

2·1) Perception is Important

Importantly, the essence of this question is such that it could be rephrased as follows:

Is NEM Reliability being perceived as unreasonably poor?

An important aspect to the answering of the question is to recognise that, to the wider community "NEM Reliability" is an intangible commodity.

This lack of familiarity with NEM Reliability has arisen because, until the start of the market, considerations of reliability in the wholesale electricity supply industry were made entirely within a small, specialised group of industry people within vertically integrated utilities.

With the advent of the marketplace, the number of people with a direct interest in NEM reliability (and the capability to directly impact on this reliability through their investment or operational decisions) has increased greatly. Hence, no matter the level of rigor that can be applied to the accurate measurement of NEM Reliability, these efforts will prove ineffective if effective communications are not used to raise (and broaden) the level of understanding of NEM Reliability.

It has principally fallen to NEMMCO, and the NECA Reliability Panel, to address this imbalance between requirement and understanding. Over the past 5 years since the inception of the NEM, efforts have been made to address this lack of understanding.

This assessment has highlighted areas of misunderstanding amongst NEM stakeholders about what is meant by "NEM Reliability". Some suggestions are provided with respect to ways in which these misunderstandings might be alleviated.

2·2) Measurement is Complex

Because of the nature of "NEM Reliability", there are a number of different ways that it could be measured.

In jurisdictions around the world, a variety of different measures are used (e.g. focusing on the time of disruption, the amount disrupted, the cost of this disruption or a probability of disruptions occurring). Each measure provides a subtly different picture of the reliability being achieved in the electricity market.

No matter what the measure adopted, in most jurisdictions there is a desire to use this measure over several different timeframes, to measure:

- The *current actual* level of reliability of the NEM (i.e. a largely historical measure);
- The *forecast short-term* level of reliability of the NEM (i.e. within a timeframe that provides for changes to the allocation of available generation, and anticipated demand); and
- The *forecast medium-term* level of reliability of the NEM (i.e. within a timeframe that provides for changes to the anticipated availability of generation and demand);
- The *forecast long-term* level of reliability of the NEM (i.e. within a timeframe that provides for the development of new generation or demand facilities).

It is important to note that, for three of the four time horizons noted above, "NEM Reliability" can only be forecast and cannot be known for certain.

The methodologies that can be used in measuring the NEM Reliability over each of these timeframes vary. Hence, this can be a cause of confusion amongst stakeholders of the NEM. Furthermore, in most instances when the term "reliability" is used, the reader has been unfortunately left to infer to which timeframe the author is referring.

The NGF is particularly interested in the *forecast long-term* reliability of the NEM, and the perceptions formed by various NEM stakeholders with respect to the level of this *forecast long-term* reliability. For this reason, the ROAM Consulting assessment has focused on this timeframe.

In conjunction with the inception of the NEM, a single measure of reliability was prescribed by the NECA Reliability Panel for use in the market. This measure was particularly applicable to the forecasting of long-term reliability for the NEM. Furthermore, a minimum reliability threshold (in relation to this measure) was also prescribed for the market.

Over the course of the past five years, other measures of the balance between supply and demand have been developed for various purposes and over the various time horizons. In some cases, the measures selected have not been appropriate for various reasons. These activities have not alleviated the confusion that currently exists with respect to NEM Reliability.

In this assessment, ROAM Consulting has completed a comparison of the level of *forecast long-term* reliability that eventuates through the use of different models but with identical input assumptions.

2·3) Garbage in is Garbage out

Even with the use of a correct methodology over an appropriate timeframe, the measure of reliability produced is only as accurate as the input assumptions made in the application of the methodology.

Hence, ROAM Consulting has ascertained both:

- The accuracy of the various input data used in the calculation of reliability, given the methodology currently used; and
- The level of sensitivity apparent in the calculated reliability of the NEM to variation in various input parameters;

2·4) All 3 Aspects

ROAM Consulting believes that all facets are integral to the perceptions held by NEM stakeholders with respect to its reliability.

Thus, this assessment has incorporated consideration of all aspects. This consideration is provided in three sections following, though it is recognised that the issues raised in each are interrelated.

3) ASPECT #1 – METHODOLOGY USED

Section Introduction

In this section, ROAM Consulting has:

1) *Illustrated why it is necessary that a probabilistic methodology is used for the determination of forecast future reliability;*
2) *Demonstrated the extent to which accuracy of key input assumptions is important; and*
3) *Provided examples of how the forecast levels of reliability might be easily conveyed.*

Since the formation of the NEM in 1998, a **single, definitive standard** has been prescribed for the measurement of the level of reliability of the NEM.

This standard was prescribed, following considered analysis at the beginning of the market, by the NECA Reliability Panel[5] (which is the body responsible for maintaining appropriate reliability levels in the NEM).

The standard prescribed is the level of unserved energy (USE) in a given region. A **maximum level of unserved energy within any region of 0·002%** has been set by the Reliability Panel as the standard (although the other factors such as distribution network performance will affect overall reliability of supply to individual customers):

- ❖ With the use of this measure, *historic levels* of reliability can be assessed by dividing the estimated amount of energy that has been curtailed in any given year by the total amount of energy delivered;
- ❖ Additionally, the *forecast level* of reliability can be estimated through the use of a probabilistic market model to run multiple iterations of likely market development scenarios (with the multiple iterations factoring in the effects of key random market events, such as plant outages):

[5] NECA established the Reliability Panel in June 1997. It is required under the Code to:
(a) Determine, on the advice of NEMMCO, the power system security and reliability standards;
(b) Determine guidelines for the exercise of NEMMCO's power to issue directions in connection with maintaining or re-establishing the power system in a reliable operating state; and
(c) Determine guidelines and policies for NEMMCO's exercise of its power to enter into contracts for the provision of reserves.
(d) Report and make recommendations to NECA and participating jurisdictions on overall power system reliability; and
(e) Make recommendations to NECA on market changes or changes to the Code on any other matters the Panel considers necessary.

- Prior to the start of the NEM, probabilistic studies were undertaken by the responsible bodies in each of the states – with these studies focused specifically on the supply/demand situation in each state, but taking into account existing and future interconnections;
- Since the start of the NEM, NEMMCO has periodically completed an estimation of the likely future levels of USE right across the NEM by carrying out similar probabilistic studies of future reliability of supply;
- ROAM Consulting is of the view that the methodologies used by NEMMCO (on these occasions) for probabilistic analysis are in accordance with international best practice, though it is noted that:
  - Detailed reports of each of these studies have not been made generally available to the market; and
  - Similar probabilistic methods have not been used, to date, in the preparation of the Statement of Opportunities or other public-access document;

3·1) The "Intervention Reserve Threshold"

As part of NEMMCO's role in managing the operations of the market, NEMMCO uses the *"Intervention Reserve Threshold"* as the level of regional Reserve Margin at which to trigger its intervention in the particular region of the market.

The Reserve Margin is calculated as the excess of available supply (MW) over and above peak demand (MW) – with allowances made for capability of interconnector supply. When applied in a future context, the calculation is typically performed using an estimation of forecast demand under more extreme weather cases – hence lending the measure some conservatism.

On several occasions since the start of the NEM, NEMMCO has recalculated the Reserve Margin required in each region to ensure the level of reliability in the NEM remains within the 0·002% USE standard set by the Reliability Panel.

These reviews are documented as follows:

June 1998. NECA Reliability Panel. *"Reliability Panel Determination on Reserve Trader and Direction Guidelines"*.

This was the initial study that set the starting level of *"Intervention Reserve Threshold"* at the higher of either:

- The size of the largest contingency in the region; and
- The level calculated to achieve the 0·002% reliability standard.

In practice, this meant that the *Intervention Reserve Threshold* was set by the level of the largest contingency (which was the largest unit size in Queensland, Victoria and South Australia, and was 1,320MW in NSW (which was two times the size of the largest unit and the same as the level used during the NEM1 market – it was also larger than the 830MW initially proposed)).

Importantly it is noted (s6·2·3 p15) that:

> *"the Panel is still of the view presented in the consultation paper that reserve trader activity should, as far as possible, not become enmeshed with investment in new resources …*

Hence, a six-month time horizon was placed on NEMMCO's ability to call tenders for contracts under the reserve trader provisions[6].

It is important to note, then, that the concept of Intervention Reserve Threshold was not developed with the intent of its application over the time horizon of the *forecast long-term* NEM Reliability.

June 1999. NEMMCO. *"Reliability Panel Re-evaluation of Minimum Reserves"*.

As a result of this review, the *Intervention Reserve Threshold* for NSW was reduced to the level of the largest unit (660MW), bringing that region into line with the others in the NEM.

17 July 2002. NEMMCO. *"NEMMCO Advice on Minimum Reserve Margins for the NEM"*.

6 It is noted that this 6-month limit to the applicability of the Intervention Reserve Threshold has since been extended to a 3-year time horizon (as part of NECA's capacity mechanism review in 2000).

This review was implemented primarily to take into account the likely impact of the newly commissioned QNI interconnector on the level of NEM Reliability.

The Reliability Panel requested McLennan Magasanik Associates (MMA) to review the levels proposed by NEMMCO. In their report (pages vii and viii), MMA indicates that:

> *NEMMCO's analysis is based on a largest unit reserve criterion that is shown to provide **a higher standard of reliability** than the Reliability Panel considers is required for the NEM*
>
> *This simple approach is **too conservative** when inter-regional load diversity and reserve surpluses are available to support an adjacent region but this is not taken into account under this methodology.*
>
> *Thus this standard would result in **additional costs to the market** if it became a basis for intervention by NEMMCO….*
>
> *If NEMMCO were to take a less conservative approach in future reviews, then more attention would need to be given by NEMMCO to quantifying the impact of market uncertainties in the analysis and defining how the uncertainty in the assessment affects how the reserve margin standard is to be applied in each application using risk management principles.*
>
> (emphasis added)

ROAM Consulting concurs with these recommendations.
In particular, ROAM Consulting wishes to emphasize the fact that the use of Reserve Margin analysis is overly simplistic and is not appropriate for *long-term forecast* NEM Reliability assessment.

2nd February 2004. NEMMCO. *"2003 Review of Minimum Reserve Levels – for South Australia and Victoria"*.

As a result of this review, completed by ROAM Consulting for NEMMCO, the *"Intervention Reserve Threshold"* for the combined Victorian and South Australian regions was adjusted to be 530MW, of which 265MW must be available in South Australia.

This adjustment was made in recognition of the fact that the Reserve Margin methodology delivers a conservative outlook on the future of the market (and hence higher levels of reliability than are prescribed under the Reliability Panel 0·002% criterion).

In review of this documentation, the following key points can be made:

1) NEMMCO has adopted the approach of setting the *Intervention Reserve Threshold* at the **greater of** either of the following:

   a) A value calculated through the use of multi-scenario probabilistic market modelling to ensure that the minimum (0·002% USE) reliability requirements would be met; and

   b) The largest single contingency within each region (i.e. this has now reverted to the size of the largest unit in the region).

2) This *Intervention Reserve Threshold* only has real practical application within 3-years of the actual date of dispatch (that being the time horizon within which NEMMCO intervention under Reserve Trader provisions is possible).

   a) NEMMCO has used the *Intervention Reserve Threshold* to formulate reserve notices provided in the MT PASA process, which stretches out 2 years from the current trading date;

   b) NEMMCO has used the *Intervention Reserve Threshold* in initiating the Reserve Trader process when forecast levels of reserve were below prescribed threshold levels;

   c) Despite the limitations on the time horizon of the measure, the Intervention Reserve Threshold has been used in the completion of modelling related to Regulatory Test applications;

   d) NEMMCO has also chosen to adopt the methodology of calculating Reserve Margins and the comparison of the results to the current *Intervention Reserve Threshold* as an integral part of the recent issues of the Statement of Opportunities, which is focused on a 10-year planning horizon;

   e) The *Intervention Reserve Threshold* has also been cited on occasions of threatened Government interventions in the market.

3) In each of the reviews noted above, it has been concluded that, by establishing the *Intervention Reserve Threshold* at the level of the largest unit in the region, the level of reliability in the region **will always exceed the minimum required** by the Reliability Panel, and in most cases will exceed this amount by a considerable margin;

4) Hence, in adopting this approach over the past 5 years, NEMMCO has ensured that the NEM is being *considerably more reliable* than the minimum acceptable standards, as prescribed by the Reliability Panel. In acceptance of this fact, the reviews outlined above have been focused on progressive reductions to the level of *Intervention Reserve Threshold* to deliver greater efficiencies in the market whilst still ensuring that the reliability delivered is greater than the minimum acceptable level (0·002% USE) specified by the Reliability Panel;

5) Over the course of the 5 years of operation of the NEM, the more general term “Minimum Reserve Level” has come to be used instead of the official terminology *Intervention Reserve Threshold*:

a) With the broadening of this terminology has also come a belief that the measure of Reserve Margin is equivalent to a measure of reliability in the NEM – and, as such, it has come to be believed by some NEM stakeholders that:

BELIEF #1) In the short-term, a reduction in *Intervention Reserve Threshold* represents an unreasonable reduction in the level of reliability in the NEM; and

BELIEF #2) In the longer-term, it is possible to forecast the future reliability of the NEM through the use of a simplistic Reserve Margin calculation;

b) ROAM Consulting believes that ***neither of these beliefs are true***.

i) Unlike the forecasting of USE, the calculation of Reserve Margin uses a deterministic approach that, by virtue of its nature, provides a less accurate picture of the level of reliability of the market;

ii) This is a fact, because the measure does not take into account all the factors that influence reliability (such as load shape, generator availability, number of generators supplying the load, number and size of interconnections with neighbouring regions and the plant mix, which includes the proportion of plant that has limited energy production).

The most recent issue of the *”Statement of Opportunities”* (SOO) (for 2003, released on 31 July 2003) utilizes the Reserve Margin indicator (referenced to the values of the *Intervention Reserve* Threshold) as the only measure of the supply/demand balance in the NEM.

ROAM Consulting believes that this singular use of Reserve Margin has meant that a broader group of stakeholders have made inferences from this measure with respect to the reliability of the NEM – and that these inferences are not strictly correct, and in some cases are misleading.

3·2) Why use a Probabilistic Model?

Prior to, and following, the establishment of the NEM, substantial changes have occurred in the generation, transmission and control systems that collectively deliver power to energy users.

The major changes in recent years include:

- The market has brought (on a national basis) real time measurement and display of technical and market data to participants via dedicated communications and public display on the internet updated on a 5 minute basis.
  - These innovations provide a much higher level of transparency to all participants and observers than existed prior to the NEM, and should result in actual reliability more closely tracking forecast levels;
  - For example, wholesale customers can observe availability and price in real time and decide whether to invoke Demand Side Management (DSM) options with customers;
  - Generators can decide whether to bid in additional generating capacity to meet short-term peak demands
- The NEM has become more interconnected:
  - Queensland has been interconnected to the remainder of the NEM through two parallel interconnectors (QNI and Directlink), which has increased the number of connected states, with their associated major load and generation base, from 3 to 4, and consequently increased the potential load diversity, particularly between regions that are located at extreme ends of the NEM;
  - Victorian and South Australian interconnection has been augmented by the addition of Murraylink, a 220MW dc link;
  - Snowy to Victoria capacity has been upgraded by 400MW nominal;
- The availability of generation plant has improved, and capacities are being upgraded;
- The extent of Demand-Side participation in the wholesale market has increased (though still small in comparison to the total energy traded in the NEM).

The net result of recent changes is that, from a reliability perspective, the NEM operates more effectively as a single pool and less as individual regions (though there is still room for transmission expansion). Local issues (such as marginal loss factors and constraints) can have a significant effect on the relative dispatch and revenue of generators without, in general terms, reducing reliability as a whole.

Future anticipated changes will be equally significant and include:

- The development of Basslink, which could provide a large potential reliability benefit (of similar effect on Southern States of the NEM as QNI has had on Northern States);

- The increased penetration of wind power plants; and

- Changes on the demand-side, which will include:
  - The more rapid growth in peak demand than overall energy consumption, meaning a "peakier peak" will emerge in all regions;
  - The shift of demand patterns in NSW such that the highest demand in NSW is forecast to occur in summer within a few years; and
  - Possibly an increase in the extent to which active, price driven, demand-side management is available as a natural counter to the rapid growth in (temperature-dependent) peak demand.

Such changes will continue into the future – hence, a comprehensive assessment of forecast reliability needs to be regularly undertaken to fully appreciate the effects of market developments on reliability throughout the NEM.

The effects of all these factors **can only be studied through probabilistic simulations**[7]. Such simulations are the only means by which the coincident impacts of the following six key influencing variables can be studied:

- *Influencing Variable #1)* The excess of installed capacity over the level of demand in the market;
- *Influencing Variable #2)* The degree to which this installed capacity is available at any given point in time (and particularly at times of peak in demand);
- *Influencing Variable #3)* The unit stock of the generation plant relative to the size of the system;
- *Influencing Variable #4)* The system load factor (or the shape of the daily and seasonal demand profile);
- *Influencing Variable #5)* Any existing or potential interconnector limitations (within and between regions); and
- *Influencing Variable #6)* Any fuel or other energy limitations applicable to the installed and available generation capacity.

These factors are further described in Appendix 1.

[7] Deterministic modelling, such as the application of minimum reserve levels on a regional basis, provides a relatively simple check on utilization of interconnectors at peak times, with and without diversity taken into account, but **is not a sufficient basis for quantifying reliability of supply**. For example, the criterion that each region should have sufficient capacity to avoid load shedding due to a single credible contingency (ie the outage of the largest unit) is flawed. Load shedding according to this criterion would only occur if all regions suffered a loss of the largest unit at the same time. In effect, the deterministic criterion is flawed partly because it fails to take account that supply can usually be obtained over unconstrained interconnectors if the largest unit in a given region is lost at time of peak.

3·3) How to complete a Probabilistic Model

To deliver an accurate assessment of the level of reliability in the NEM, the modelling performed must take into account factors including the following:

- The rules used to dispatch the market (i.e. with generators assumed to bid prices in accordance with their cost structure – this being the most typical mode of market operation);
- The physical nature of the electricity supply system:
  - On the supply-side, the model will need to take into account:
    - The capacities of all generation units across the NEM – and any constraints there might be on their capacities;
    - Scheduled maintenance intervals for all units (in line with forecast planned outage rates for each unit);
    - (Monte-Carlo based) randomization of forced outages, based on forced outage rates for each unit;
  - Transmission capability, and how this capability will be affected by transmission line outages (planned and forced) on the major interconnectors between and within regions; for these studies the modeling has incorporated dynamic transmission limits as defined in the present version of the NEMMCO supply-demand calculator.
  - On the demand-side, the level of demand in each region, the shape of this demand; the availability of Demand Side response during high price periods, and the diversity of the demand-shape between each region;
  - Ability of energy-limited plants in each state, especially Snowy, Southern Hydro, and Wivenhoe, to provide reliable supply without exceeding short and long term energy production limits.
- External constraints imposed on the market (such as environmental constraints).

A more detailed description of the model is provided in Appendix 4.

3·4) Modelling of a "Medium FOR Case"

To illustrate the difference that is apparent when using a probabilistic model (compared with a deterministic model), ROAM Consulting has completed a forecast of the market using the same assumptions as contained in the *Statement of Opportunities* for 2003.

In completing this forecast, identical input data has been used as has been provided within the SOO. Hence, the results of the deterministic calculations and probabilistic modelling can be directly compared in order that the implications on the perception of the level of reliability of the NEM can be assessed.

Details of the modelling of the Medium FOR case have been included as an appendix to this report. The key conclusions drawn following the completion of this study (as relating to the level of reliability) are listed below.

3·4·1 KEY INPUT ASSUMPTIONS

Given that the modelling is performed on a time-sequential basis, anticipated time-sequential load traces have been developed for the full 10-years of the study by growing an historical annual load trace in order to meet forecast growth of energy consumption and (summer and winter) peaks in demand.

In developing these load traces, ROAM Consulting has used a proprietary methodology that has been successfully benchmarked against those developed by other companies. The resultant load traces developed through the application of this methodology have been independently verified by a number of different clients on different occasions.

For the Medium (Generation Plant) Forced Outage Rate (FOR) case, the medium case economic growth scenario has been assumed for all regions of the NEM. As such, time-sequential load profiles have been developed for each region through the application of the methodology noted above.

In completing this assessment, generic assumptions have been made about the expected outage rates for all generation plant around the NEM. Generic assumptions have been used (and a sensitivity case modeled with large variations to these assumptions) in order that the degree to which the calculated reliability varies with these parameters could be gauged.

As a separate exercise within this project, reported availability figures for each generation company have been analysed in order to provide specific data that can be used in future studies. These numbers are provided in the following chapter.

3·4·2 KEY OUTPUTS GENERATED

As a result of the modelling performed, discrete market forecasts have been produced for each of 17,520 half-hour time points in every given year over the 10-year period of the study:

- For each time point, generation capacity has been dispatched in bid price order in line with the rules of the NEM and to meet all known (generation, transmission and other) constraints;

- Simultaneously, the level of unserved energy in each time point has also been individually determined for each of the 6 regions used to reflect interconnector transmission limitations in this study. These levels are recorded in a database and can be analysed to determine the total level of unserved energy (and the distribution of this USE) over any given year, and for every iteration.

Given that the modelling was performed over numerous iterations[8] (incorporating randomized plant outages), the average level of USE has been calculated as the average across each of the iterations modeled in the study.

Price outcomes are not critical to these investigations, hence have not been addressed in this report.

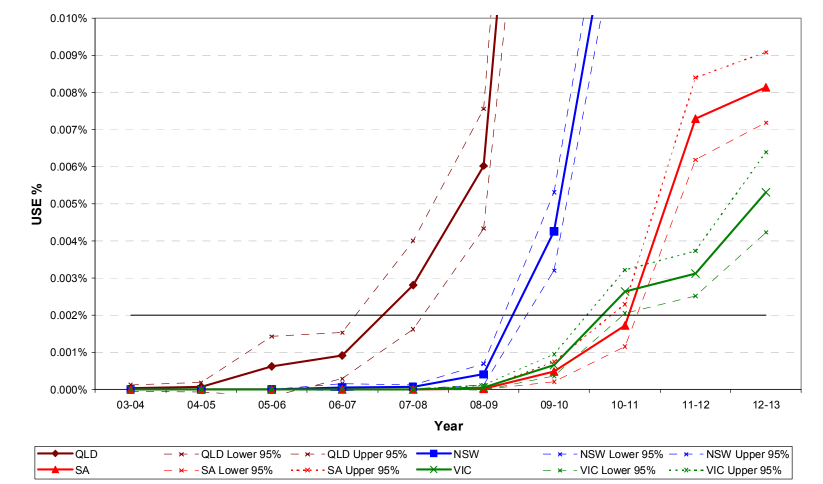
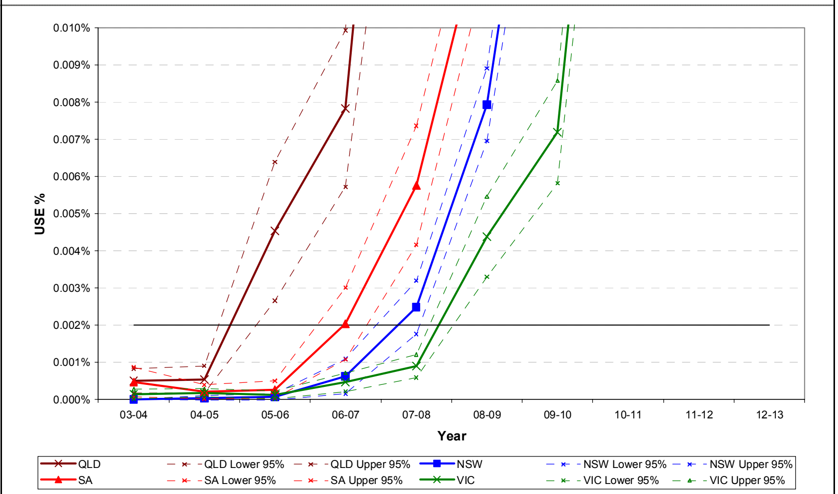
Further details of the outputs generated in the study have been included in the appendix.

[8] For all simulations presented in this report, 100 iterations (simulation-years) of dispatch were performed for each half hour of the year (17520 half hours per year).

3·4·3 KEY OBSERVATIONS MADE ABOUT RELIABILITY

The following graphs have been provided to illustrate the trend forecast in unserved energy in the Medium FOR case scenario[9].

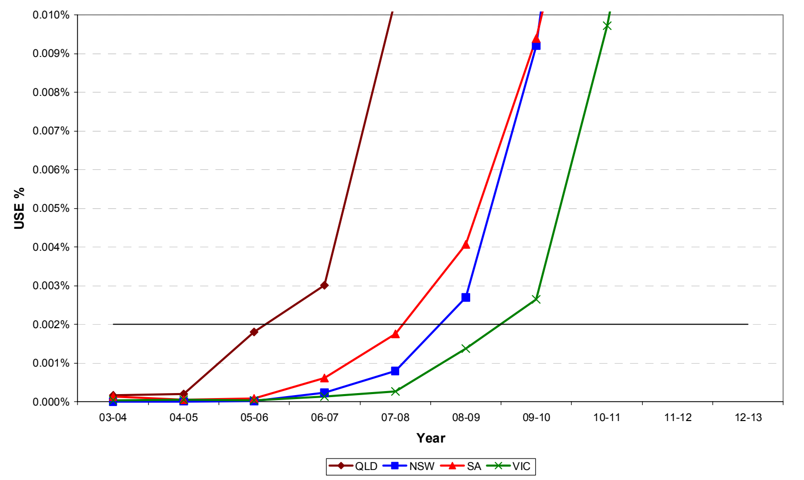
Figure 3·01 Forecast Trend in Levels of USE under Medium FOR Case *Averaged Across All Iterations*

50% POE case	
10% POE case	

---

9 It must be remembered that this scenario (as with the case presented in the SOO) assumes that there is no new development of capacity, other than that foreseen as committed.

Figure 3·01 Forecast Trend in Levels of USE under Medium FOR Case
Averaged Across All Iterations

Weighted 50% POE and 10% POE	

The first two charts incorporate 5% and 95% confidence intervals for the projections of mean USE. These have been based on an analysis of the 100 simulation years of calculation for each year. Choosing the upper bound (95% confidence interval) rather than the average of the 100 annual samples would, in nearly every case, not change the timing of new capacity.

To produce "weighted" USE values, the demand forecasts have been given weightings of 30.44% for the 10% POE and 69.56% for the 50% POE (with the implication that the 90% POE case would be even less severe than the 50% POE case). This is in accordance with the weighting factors used by NEMMCO in its market assessments, and is described in *Assessment of NEMMCO's 2001 Calculation of Reserve Margins* (MMA, 2002).

Confidence intervals cannot be calculated after weighting factors have been applied.

The following table has been prepared to illustrate the different perception of reliability that might be gained if using a simpler deterministic method of assessment as opposed to the more accurate (but complex) probabilistic method.

Table 3·01 Comparison of Deterministic (SOO) and Probabilistic (ROAM) Modeling Outcomes

	Source: ***SOO 2003*[10]** **Deterministic** **Reserve Margin (under the medium growth scenario)**	**Source:** ***ROAM Modelling*** **Probabilistic** **Level of USE (under the Medium FOR case, incorporating the medium growth scenario)**
Queensland	Insufficient reserves forecast for summer 2005/06	Reliability standard breached in 2006/07 (i.e. **1 year later than implied in the SOO**)
NSW	Insufficient reserves forecast for summer 2005/06	Reliability standard breached in 2008/09 (i.e. **3 years later than implied in the SOO**)
Victoria	Insufficient reserves forecast for summer 2003/04	Reliability standard breached in 2009/10 (i.e. **6 years later than implied in the SOO**)
South Australia	Insufficient reserves forecast for summer 2003/04	Reliability standard breached in 2008/09 (i.e. **5 years later than implied in the SOO**)

3·5) Sensitivity Cases

Another advantage of the use of probabilistic assessments of the likely reliability of the NEM is that several different potential market development scenarios can be modelled and assessed in parallel in order that the sensitivity of the conclusions drawn in relation to reliability (or other market performance measures) can be assessed in relation to various possible changes.

This section contains an overview of the results of the sensitivity cases – as they impact on calculations of reliability in the NEM.

[10] Since publication of the SOO 2003, the minimum reserve margin in the combined Victoria and South Australia regions has been reduced by NEMMCO to 530MW, delaying the timing of a reserve shortfall to 2006/07, according to the deterministic methodology.

3·5·1 SENSITIVITY TO PLANT OUTAGE RATES

The Medium FOR Case input data provides for 2.5% forced outage rates for all thermal generators other than in Queensland (which has been assumed to have 5% forced outage rates). These assumptions have been described in further detail in Appendix 4.

As discussed in Appendix 1, the level of NEM Reliability will be significantly dependent on the actual level of outage rates experienced with generation plant around the NEM. In order to develop some understanding of the level of sensitivity exhibited to generator outage rates, two sensitivity cases were run – one in which a uniform 5% forced outage rate was assumed for all plant (the Higher FOR case) and the second in which a uniform 2·5% forced outage rate has been assumed for all thermal plant (the Lower FOR case).

The results delivered following modelling of the critical years of the Higher FOR case have been summarised in the following figure.

Figure 3·02 Forecast Trend in USE under High FOR Sensitivity
Averaged Across All Iterations

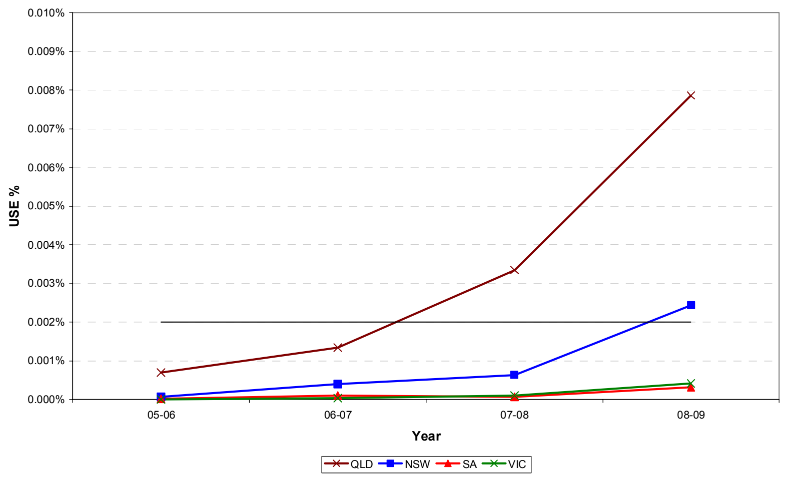
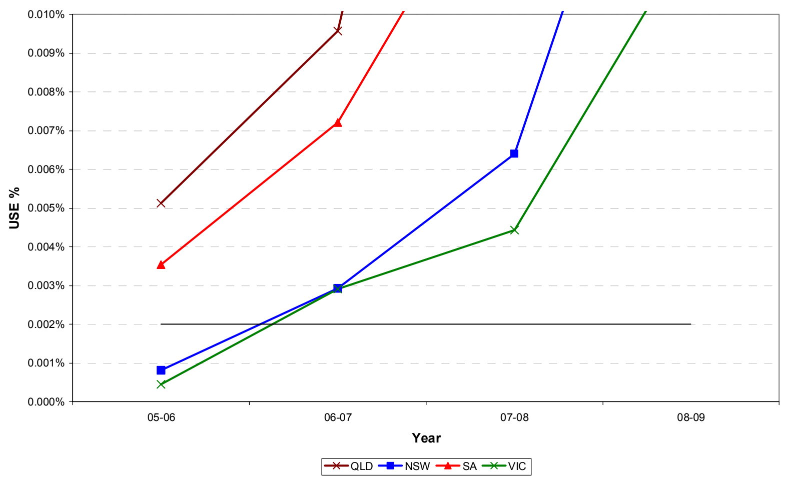
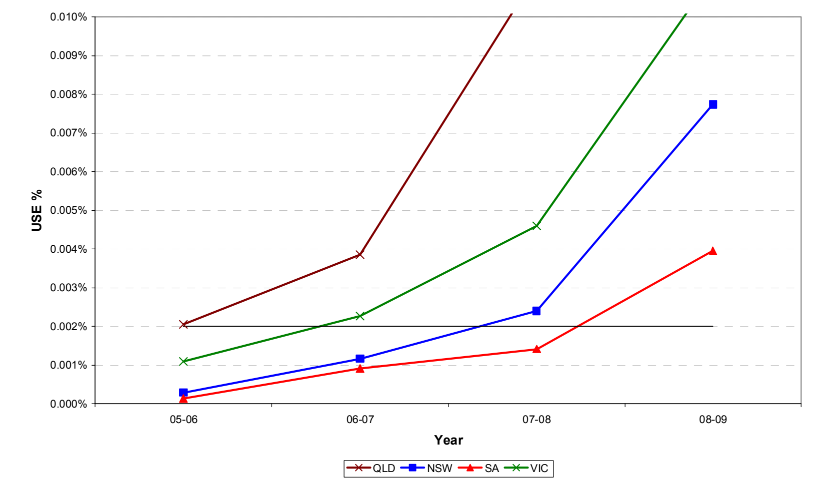
50% POE case	
10% POE case	

Figure 3·02 Forecast Trend in USE under High FOR Sensitivity
Averaged Across All Iterations

Weighted 50% POE and 10% POE[11]	

The outcomes revealed in this study are largely in line with expectations:

- In NSW, Victoria and South Australia (the regions where the FOR had been assumed as twice as high for this case) all exhibited significantly higher levels of forecast USE. This has been shown to be particularly evident with the extreme weather shapes assumed in the 10% POE case (which exhibit USE more than doubled in SA, Victoria and NSW);

- In Queensland (where FOR was not adjusted in this sensitivity) a relatively minor change was exhibited. This resulted because of the impact of inter-regional sharing of reserves at time of tight supply/ demand.

Such an extreme situation (in which all thermal generators exhibit FOR of 5%) is unlikely in reality, given the apparent forced outage rates of generators, as discussed in Section 4.2.

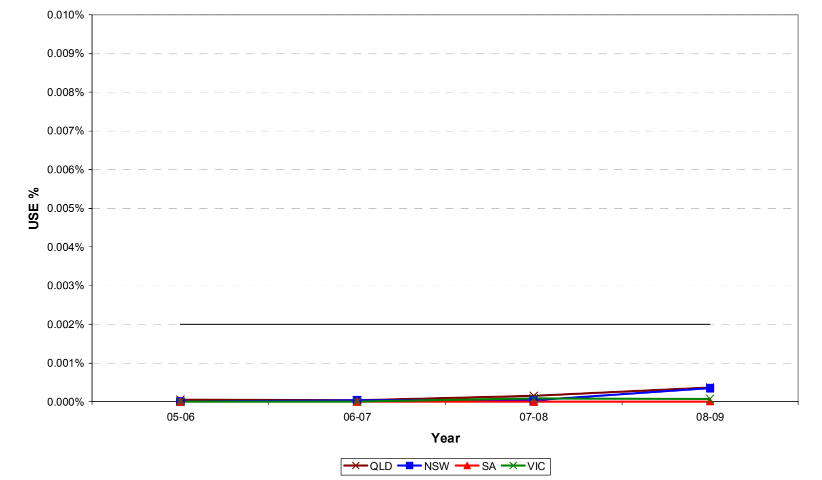
In contrast, the second sensitivity has been developed on the basis of an assumed level of 2·5% FOR for all thermal plant in all regions.

The results of this sensitivity study have been presented below:

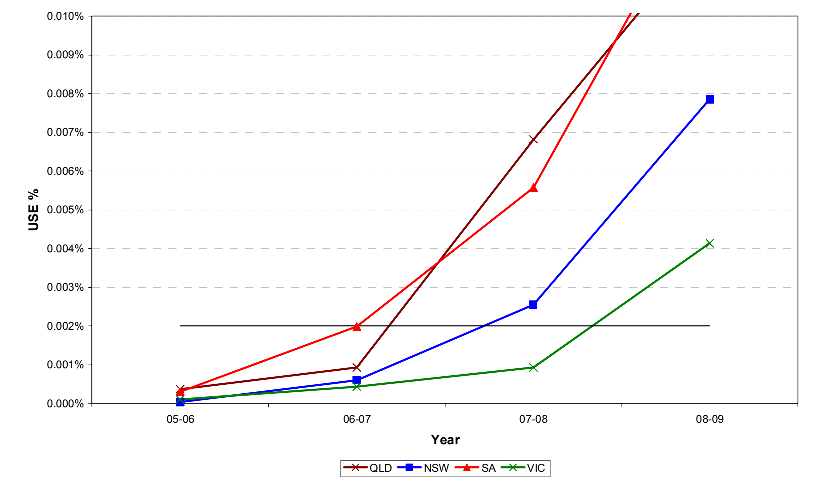
[11] The forecasts have been given weightings of 30.44% for the 10% POE and 69.56% for the 50% POE (with the implication that the 90% POE case would be even less severe than the 50% POE case). This is in accordance with the weighting factors used by NEMMCO as described in *Assessment of NEMMCO's 2001 Calculation of Reserve Margins* (MMA, 2002).

Figure 3·03 Forecast Trend in USE under Low FOR Sensitivity
Averaged Across All Iterations

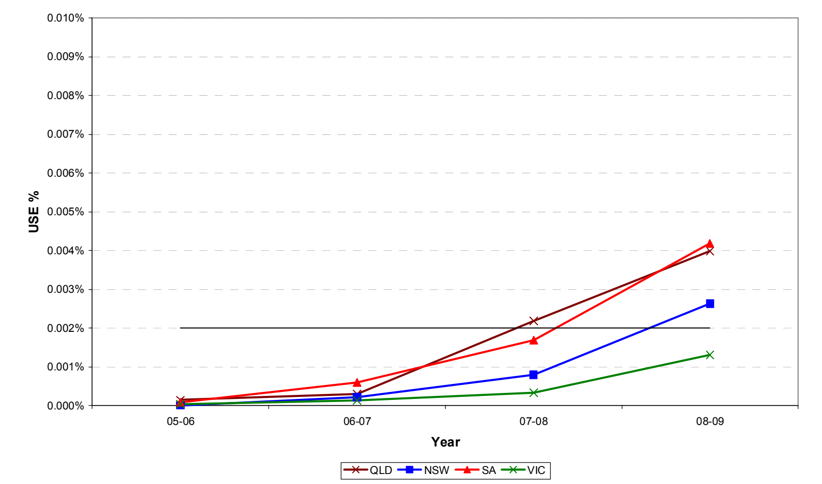
50% POE case



10% POE case



Weighted 50% POE and 10% POE[12]



[12] The forecasts have been given weightings of 30.44% for the 10% POE and 69.56% for the 50% POE (with the implication that the 90% POE case would be even less severe than the 50% POE case). This is in accordance with the weighting factors used by NEMMCO as described in *Assessment of NEMMCO's 2001 Calculation of Reserve Margins* (MMA, 2002).

In this study, it has been shown that, except for Queensland, the USE estimate is virtually unchanged. The effect of a common level of forced outage rates would be to bring Queensland more closely into line with other regions in terms of forecast USE.

Forced outage rates are discussed further in Section 4.2, which shows that a higher level of forced outages may be applicable in Queensland owing to the effect of several new generation supercritical coal-fired units with higher forced outage rates.

3·5·2 SENSITIVITY TO ECONOMIC GROWTH RATES

The Medium FOR case (discussed above) was developed on the basis of an assumed MEDIUM rate of economic growth in all four NEM states. This is considered the most likely outcome that will eventuate over the 10 years of the study.

However, some states may exhibit rates of economic growth in certain years that are higher or lower than those on which the MEDIUM load growth case has been constructed.

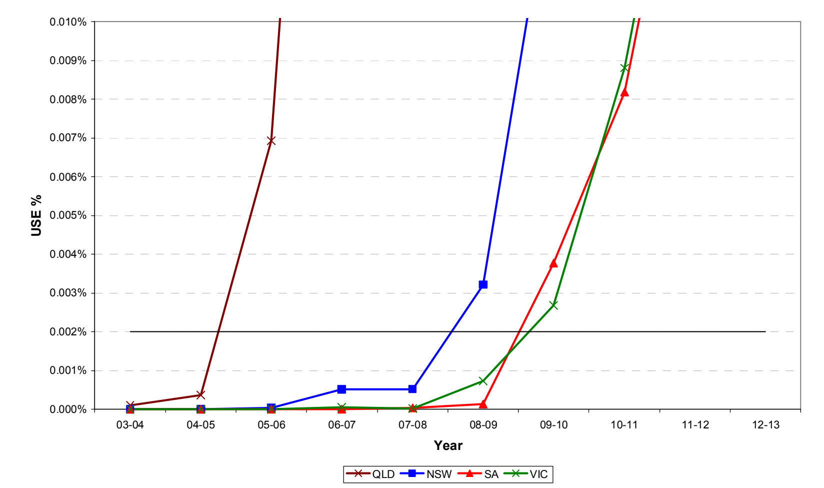
This issue is addressed further in the following chapter. In order that a robust picture of the reliability of the NEM is developed, it is necessary to model the level of USE in the NEM that would eventuate under both the HIGH and LOW forecast rates of economic growth.

3·5·2·1 High Economic Growth

The following chart illustrates the results derived from the modelling of 10 consecutive years of High growth in energy consumption across all regions. This sensitivity is applied to the 50% POE demand only.

Figure 3·04 Forecast Trend in USE under High Economic Growth Case
Averaged Across All Iterations

50% POE case



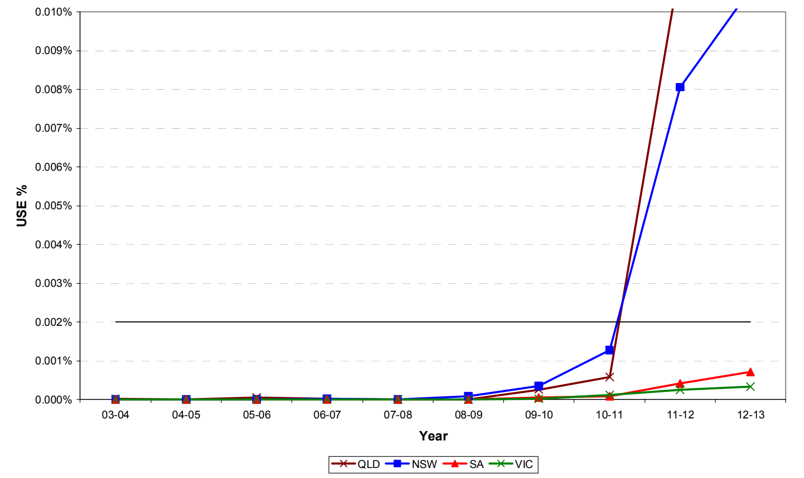
Though this may be an unlikely scenario, its inclusion in the modelling can provide an indication of the level of sensitivity that NEM Reliability exhibits in relation to forecast energy growth rate.

As can be seen, under such a scenario, the level of forecast USE rises much more rapidly in all regions.

3·5·2·2 Low Economic Growth

The following chart illustrates the results derived from the modelling of 10 consecutive years of Low growth in energy consumption across all regions. This sensitivity is applied to the 50% POE demand only.

Figure 3·05 Forecast Trend in USE under Low Economic Growth Case
Averaged Across All Iterations

50% POE case	

Similarly, this would also be an unlikely scenario, but would defer the need for new generation capacity for several years in all regions, compared with the medium economic scenario.

3·5·3 SENSITIVITY TO THE COINCIDENCE OF DEMAND

The demand forecasts used in all the cases discussed above were built from the specific reference years listed in Appendix 4. As outlined in Appendix 1, the forecast level of NEM Reliability will be dependent on the shape of load in each region, and the level of diversity applicable between each region.

In this sensitivity study, the demand forecasts were built from the same reference year, as follows:

- ❖ the 50% POE forecast was built from the 2002-03 reference year across all regions (i.e. this reference year was thus different from that previously selected for Queensland and NSW);

- ❖ the 10% POE forecast was built from the 2000-01 reference year across all regions (i.e. this reference year was thus different from that selected for Queensland and NSW).

This approach was taken in order that different scenarios incorporating different levels of peak demand diversity could be modeled. The level of diversity exhibited in each of these years has been separately assessed as part of section 4, and can be compared with levels identified in Appendix 4:

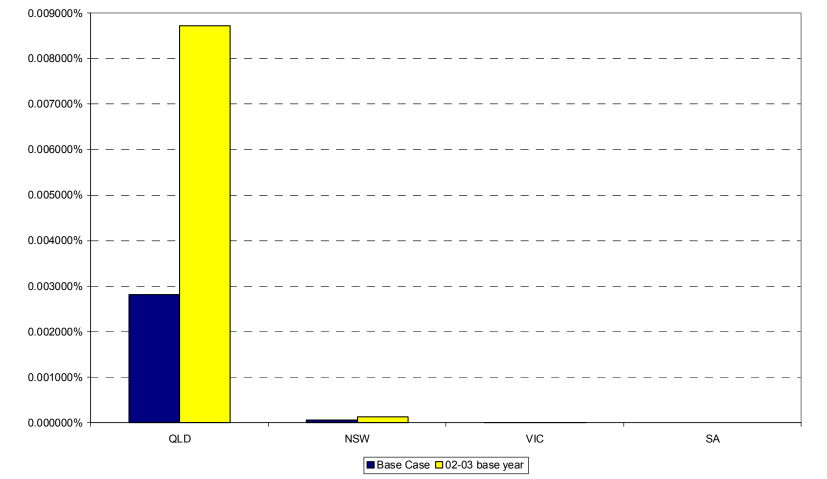
Table 3·02 Comparison of Levels of Diversity

	50% POE case	10% POE case
Original Reference Years[13]	7·8%	5·4%
Modified Reference Years	6·78%	5·54%

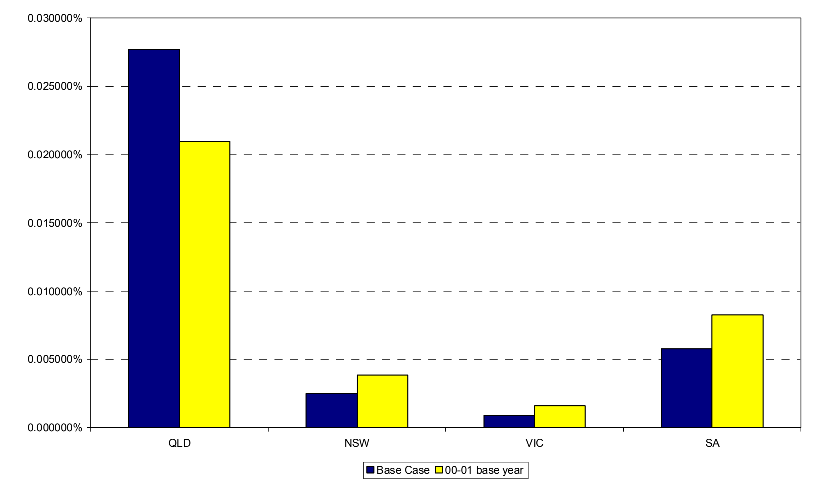
For the purposes of this sensitivity study, only a single year (2007-08) was modeled in order that the level of sensitivity could be determined to the selection of a different reference year. The results of this modelling are illustrated below.

Figure 3·06 Forecast Trend in Levels of USE with Altered Reference Year
Averaged Across All Iterations

50% POE case



10% POE case



[13] For further details, see table A4·2 in Appendix 4.

These diagrams indicate that there may be a loose correlation between diversity and forecast level of NEM Reliability as:

- A reduction in the level of diversity (from 7·8% to 6·8% in the modified 50% case) reveals a significant increase in forecast levels of USE; whilst
- A slight increase in the level of diversity (from 5·4% to 5·54% in th modified 10% case) reveals a slight decrease in the level of USE in Queensland (with offsetting increases in NSW, Victoria and SA).

However, it can be seen that the effect is not as significant as the impact of the other two variables (generator outage rates and energy growth levels) discussed above.

This assessment has been extended by modelling two additional cases (again only for a single year (2007-08), in which the 10% and 50% load traces were manually "un-diversified" in order to ensure a greater degree of correlation of peak demands across all regions.

Specifically, the daily load curves for each region were aligned in descending order of magnitude of peak demand (for a given day-of-week, and given season). This methodology would ensure that the peak in demand in all four regions would occur on the same day (but not necessarily at the same time). This represents a situation part way between using historical diversity and using zero diversity, as in the deterministic minimum reserve level calculations presently applied by NEMMCO.

The results of the modelling performed on this basis have been summarized below:

Figure 3·07 Forecast Trend in USE under Undiversified Load Sensitivity
Averaged Across All Iterations

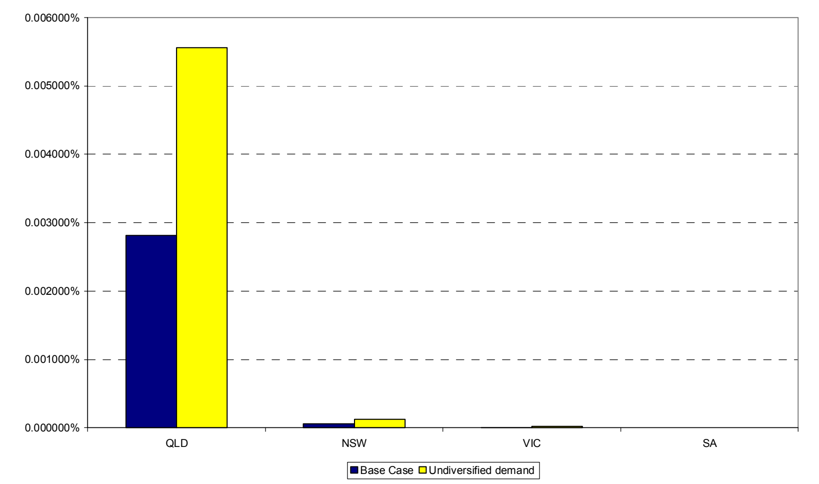
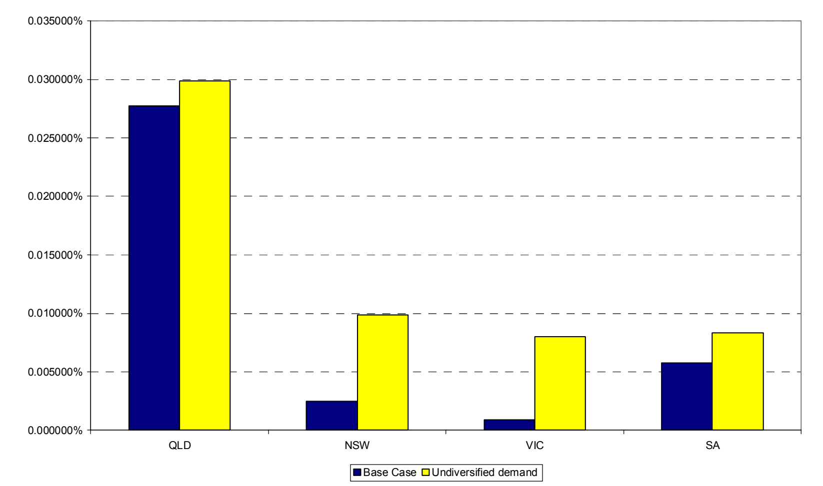
50% POE case	

Figure 3·07 Forecast Trend in USE under Undiversified Load Sensitivity
Averaged Across All Iterations

10% POE case



This analysis illustrates that "un-diversifying" load would substantially increase USE in all regions, and thus advance the time that the reliability standard cannot be met with existing and committed installed capacity.

This outcome results from lining up the peak days across all regions, and thus creating a "peakier" aggregate NEM-wide load shape, without altering the overall annual energy demand. The probability of this occurring depends on the likelihood of coincident high temperature weather events in all regions and is discussed in Section 4·1·4.

3·5·4 SENSITIVITY TO INTERCONNECTIONS

Basslink is scheduled to be commissioned at the end of 2005. It can be seen from the results included above that the introduction of Basslink will have a significant beneficial effect on the forecast level of USE in Victoria and neighbouring regions.

However, if Basslink commissioning was deferred, or the link becomes unserviceable for any reason, the impact on SA and Victoria would be to reduce the level of reliability. Such a scenario has been modeled (for four years) in this sensitivity study.

For moderate weather (i.e. 50% POE) conditions, the absence of Basslink is shown to have minimal impact. However, if Basslink was not in service, and extreme (i.e. 10% POE) weather conditions were experienced, the forecast outcome would breach the standard in 2005-06 and be well in excess of that the following year.

This situation is shown in the following charts.

Figure 3·08 Forecast Trend in Levels of USE under Interconnection Sensitivity (no Basslink)
Averaged Across All Iterations

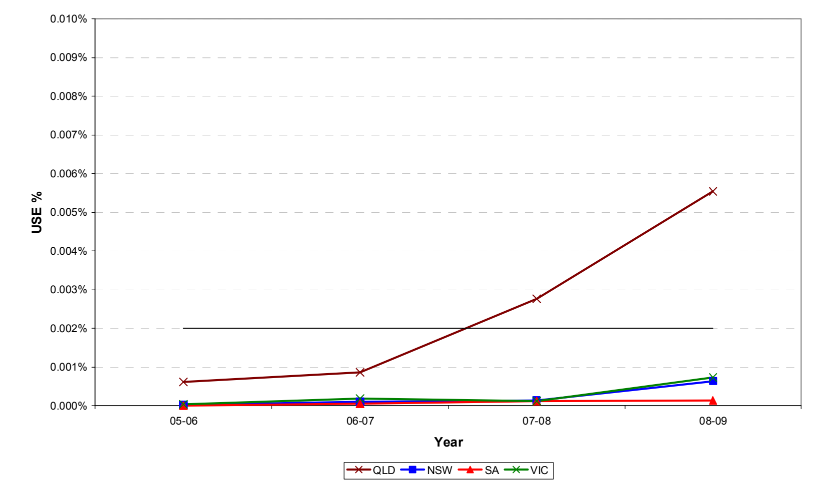
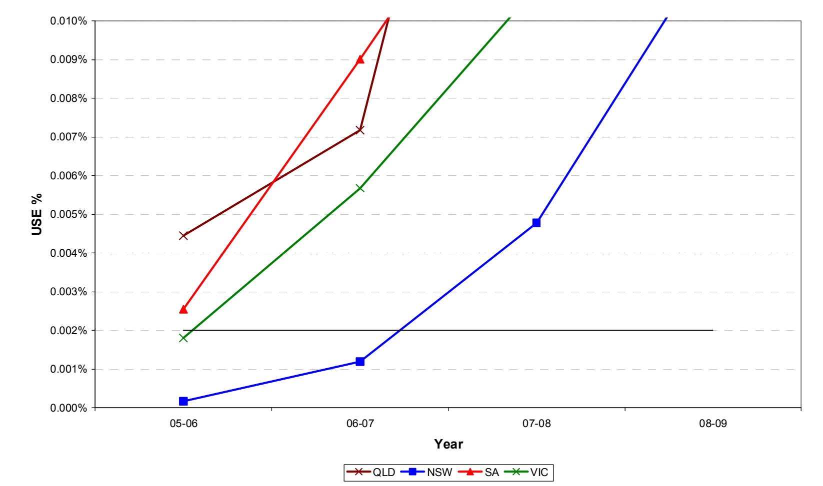
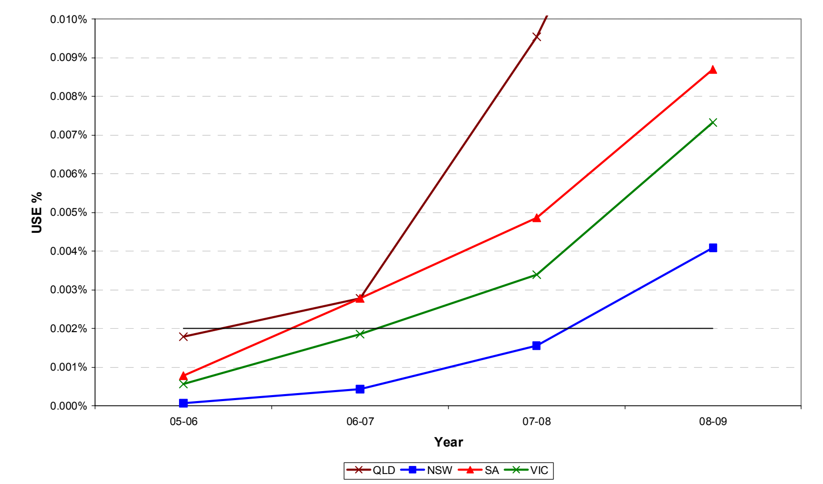
50% POE case	
10% POE case	

Figure 3·08 Forecast Trend in Levels of USE under Interconnection Sensitivity (no Basslink)
Averaged Across All Iterations

Weighted 50% POE and 10% POE[14]	

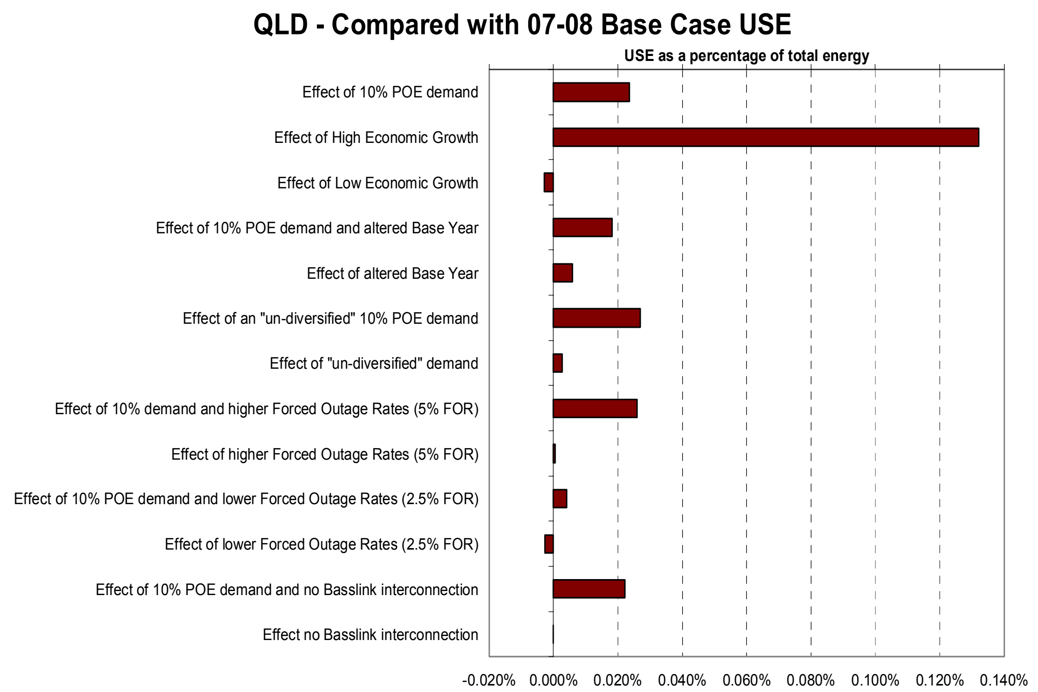
3·5·5 SUMMARY OF SENSITIVITIES

The figures on the following pages have been assembled to provide a graphical view of the relative impact of each of the sensitivity factors has upon NEM Reliability.

These figures (one for each region) illustrate the extent to which demand profiles and FORs have an impact on reliability forecasts. This finding reinforces the need to use a probabilistic methodology, which can take these variables into account.

[14] The forecasts have been given weightings of 30.44% for the 10% POE and 69.56% for the 50% POE (with the implication that the 90% POE case would be even less severe than the 50% POE case). This is in accordance with the weighting factors used by NEMMCO as described in *Assessment of NEMMCO's 2001 Calculation of Reserve Margins* (MMA, 2002).

Figure 3·09 Illustration of Sensitivity of USE Forecasts to Various Factors (for the year 07-08)



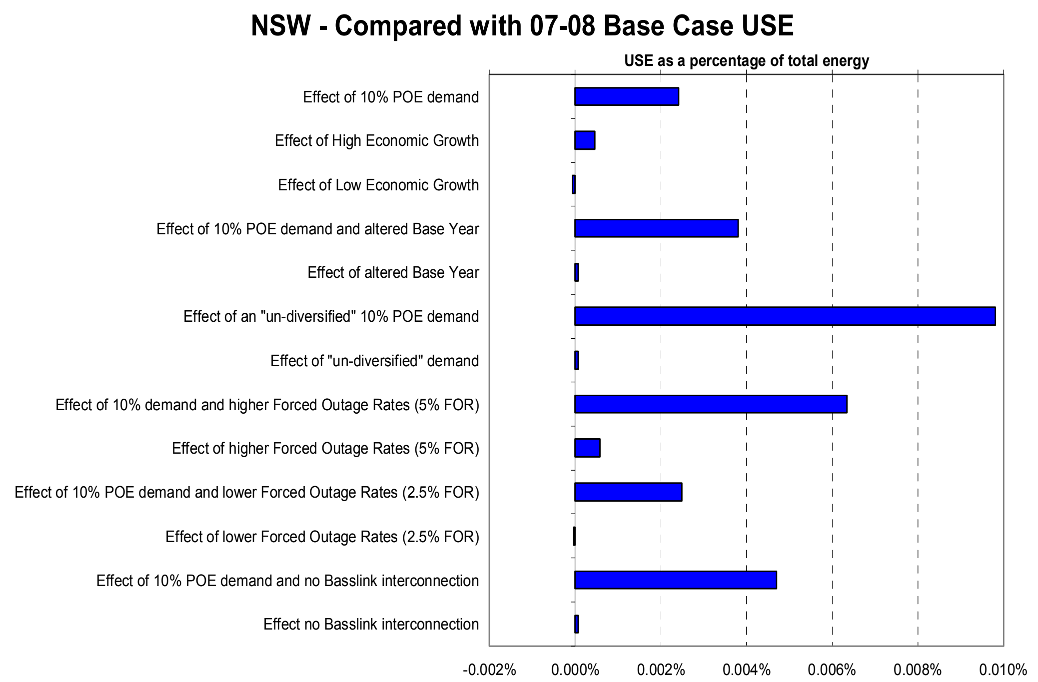
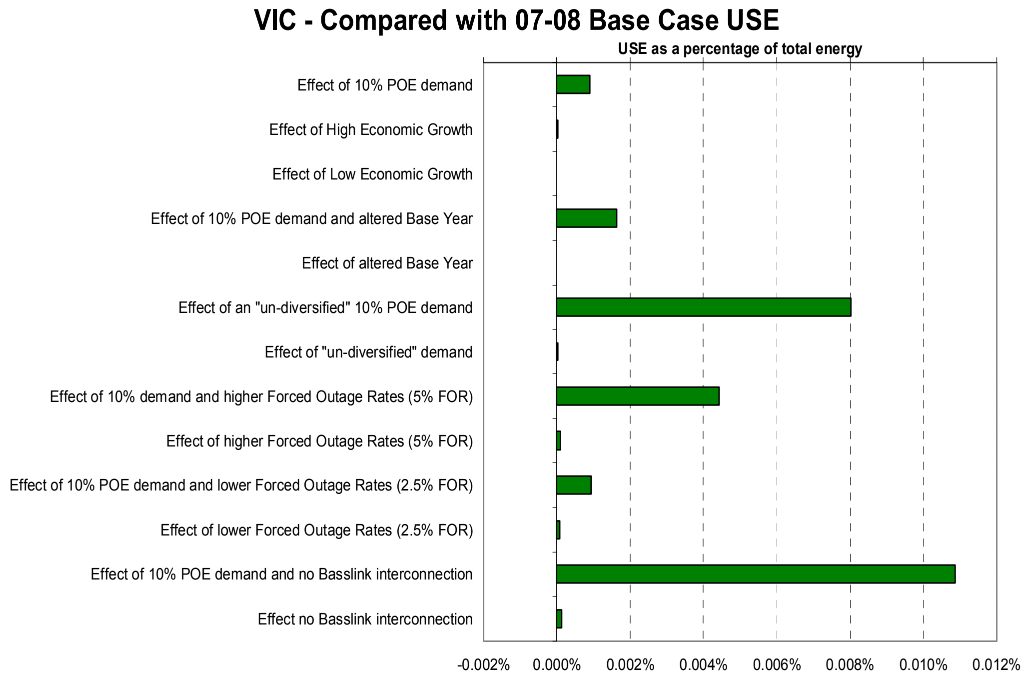
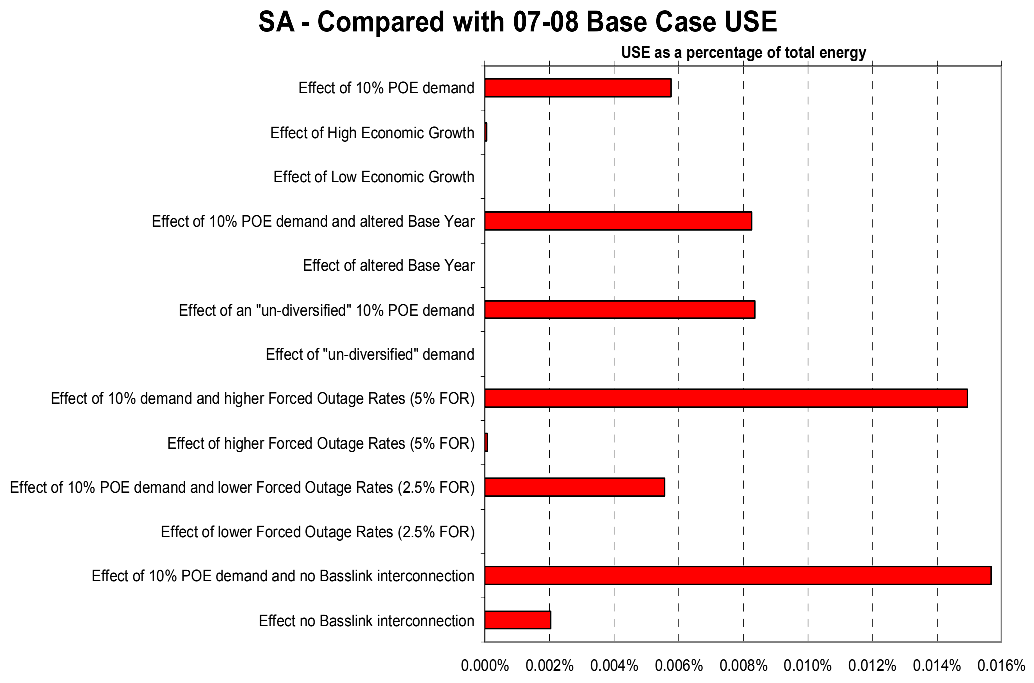


Figure 3·09 Illustration of Sensitivity of USE Forecasts to Various Factors
(for the year 07-08)





4) ASPECT #2 – DATA USED

As noted above, it is possible to use a probabilistic methodology for assessing the likely future reliability of the NEM, and it is possible to use a simpler deterministic model to highlight trends in the balance of supply and demand (though it is not possible with the deterministic model to precisely determine the level of reliability in the market).

Appendix 1 lists 6 factors that can have a large influence on NEM Reliability. The sensitivity of forecast NEM Reliability to these factors was assessed (through the use of probabilistic modelling) as part of Section 3.

However, it should be noted that these forecasts have been generated with the use of specific assumptions in relation to a number of sets of key input data. It must be stressed that, should the input data contain errors or inconsistencies, the results generated through methodology applied (no matter how rigorous) will also contain errors and inconsistencies.

Hence, it is essential as part of this assessment to ascertain the level of accuracy present in a number of key sets of input data used in the forecasting of reliability. This assessment has been described in this section for a number of key data sets.

4·1) Accuracy of Demand Data

A key determinant of the level of reliability in the NEM is the speed at which demand for electricity grows across the NEM.

Furthermore, the opportunity for utilization of existing generation resources will depend on the location of this demand – and also on the time-of -day, day-of-week, and seasonal profile of the demand. Hence, the level of reliability of the NEM will also depend on these factors.

As noted above, a probabilistic modelling methodology must be applied to facilitate the consideration of all these parameters. The validity of the modelling will also be dependent on the accuracy of the forecasts for how this demand will grow over time, and how the shape of the demand will change over time.

4·1·1) FORECAST ANNUAL ENERGY GROWTH

In the sensitivity studies included in section 3, ROAM Consulting has demonstrated the level of importance that must be placed on ensuring the most accurate forecasts are used for growth in energy consumption.

If a "high" rate of growth in energy consumption were to eventuate for several consecutive years (and across all regions), the studies have demonstrated that the reliability standards would be breached a year or more in advance of the situation that would exist if a more moderate (and likely) rate of growth in energy were experienced.

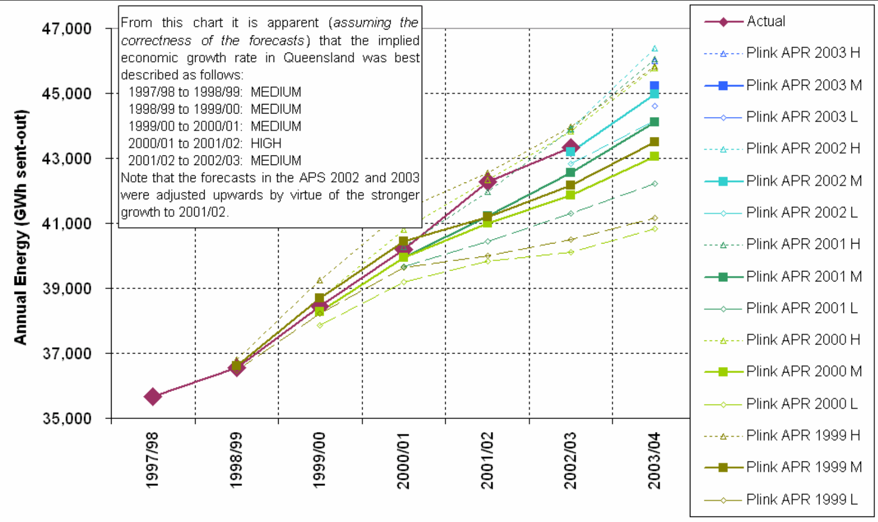
In order to determine the accuracy of the forecasts of regional energy growth developed by each of the Jurisdictional Planning Bodies (in conjunction with

NIEIR), ROAM Consulting *could have* assessed the validity of the methodology currently used for the forecasting of demand growth.

As a *more practical approach*, ROAM Consulting has compared the results generated with the existing methodology to the actual levels of energy consumed in each NEM Region over recent years. In this way, it has been possible to determine a confidence level that could be applied to forecasts generated in the future with the use of a similar methodology.

In the charts included below, the actual levels of energy demand in each region have been illustrated for recent years. Against these values has been trended the forecasts provided[15] by the Jurisdictional Planning Bodies on an annual basis.

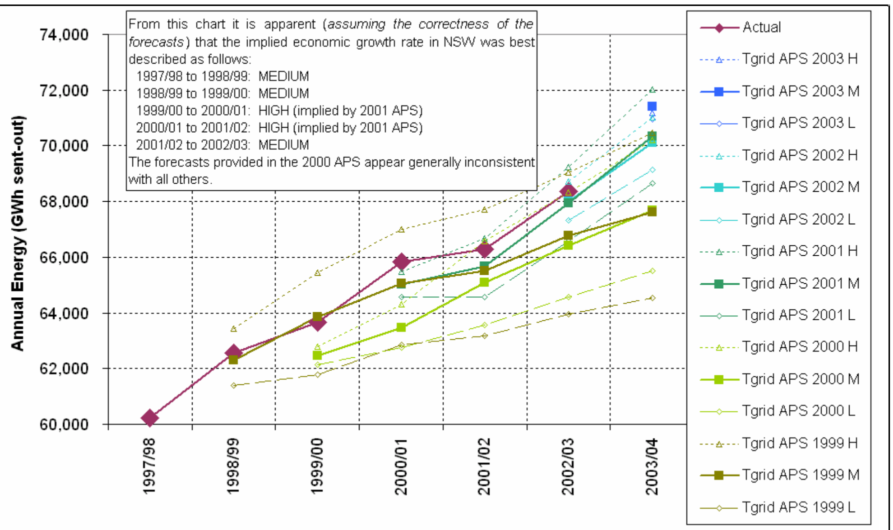
Figure 4·01 Comparison of Actual Energy Sent-Out Against Previous Forecasts

Qld	 As shown here, the forecasts produced by Powerlink have (in most cases) aligned closely with the actual level of energy consumption experienced in each year. However, it is seen that (despite an almost linear growth in energy consumed between 1998/99 and 2001/02) forecasts provided in 1999, 2000 and 2001 all contained the estimate that the rate of growth would cool in 2001/02. These projections appear to have been one year too early.

15 For instance, in 1999 the Jurisdiction Planning Body released a forecast of likely levels of energy consumption in the region spanning the 10-year period from 2000 through till 2009.
It is important that the accuracy of the projections produced out into the future is also verified (and not just one-year into the future) as the modelling required to produce the Annual Reliability Review will need to span a 10-year horizon. Hence, it is also important to have an understanding of the level of uncertainty there appears to be surrounding long-term demand forecasting.

Figure 4·01 Comparison of Actual Energy Sent-Out Against Previous Forecasts

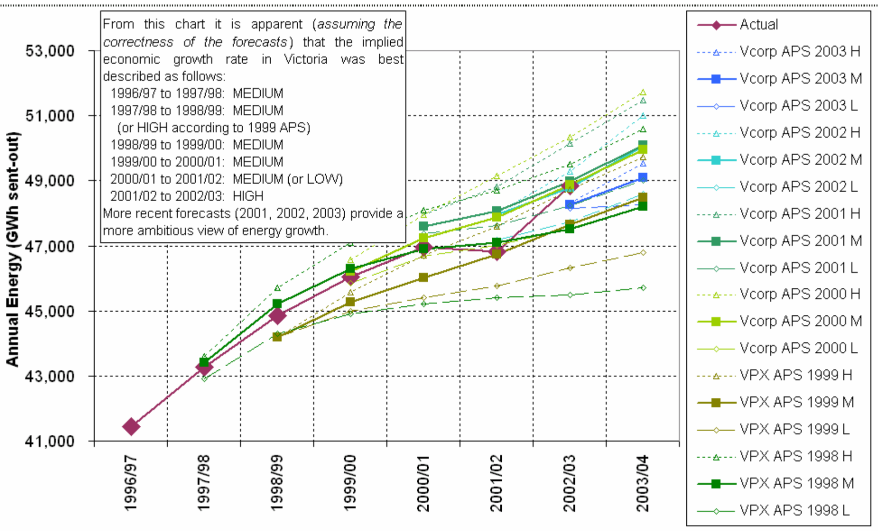
NSW



In NSW, it is apparent that the (whilst there is a general degree of correlation with actual energy consumptions), in some years (e.g. APS 2000) the forecasts have incorporated a significant error in relation to the actual levels of energy consumption.

The magnitude of these errors can be seen to be as much as the year-on-year growth in energy.

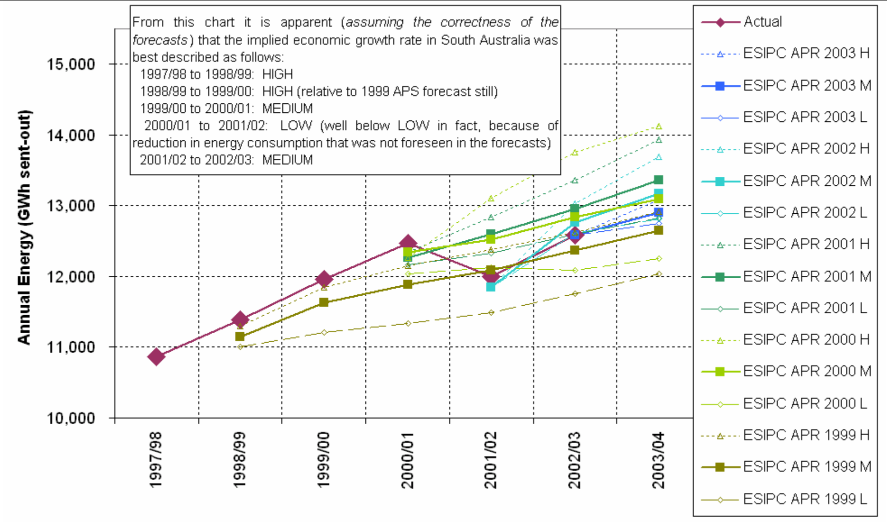
Victoria



In Victoria, it can be seen that the actual levels of energy sent-out for the state through to 2001-02 have aligned very closely with the levels forecast in the 1998 annual statement (whereas the 1999 statement was significantly inaccurate).

The large increase in load to 2002/03 was not forecast correctly, but was seen in the forecasts released in 2000 and 2001 as the extension of the trend that had been exhibited through to 2000/01 (excepting the drop in demand experienced in 2001/02).

Figure 4·01 Comparison of Actual Energy Sent-Out Against Previous Forecasts

<table>
<tr>
<td>South Australia</td>
<td>


South Australia, too, has exhibited a linear trend of increase in energy consumption through till 2000/01. This trend was underestimated in the forecasts of 1999.

The significant (-4%) contraction in consumption in 2001/02 was not foreseen. Forecasts generated in 2000 through till 2003 have all assumed a similar percentage growth in consumption, which is slightly below that achieved in the period through till 2000/01.

Hence, there is a small amount of evidence to suggest that the forecasts generated by the Jurisdictional Planning Body have tended to underestimate the actual rate of growth in energy consumption. Whether this trend will continue into the future or not cannot be known for certain.
</td>
</tr>
</table>

The following points are made in summary:

- The actual energy sent-out in each region for any given year has mostly fallen within the bounds of the Low and High forecasts generated in any given year, and has generally trended with the Medium forecasts. Hence, in most cases, the forecast energy consumption identified under the Medium forecast will provide a reasonable accuracy;

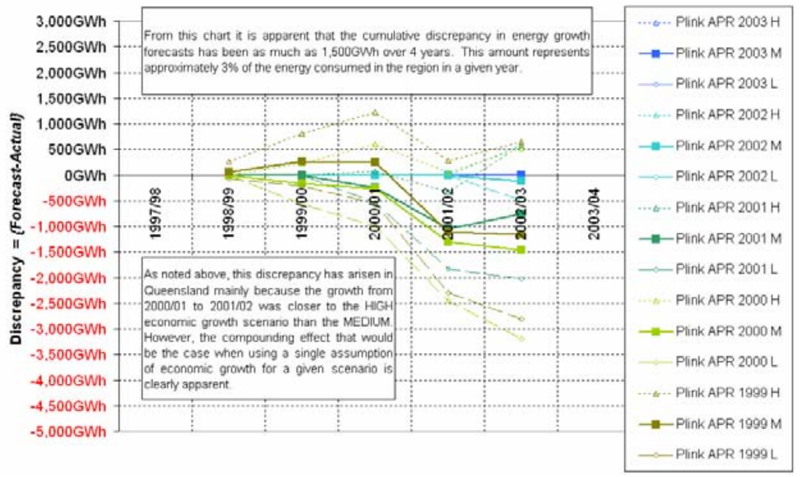
- Over a 10-year forecast time horizon, the evidence has indicated that the energy consumption assumed for any given year may be too high or low by an order of magnitude being the annual rate of growth in this consumption;

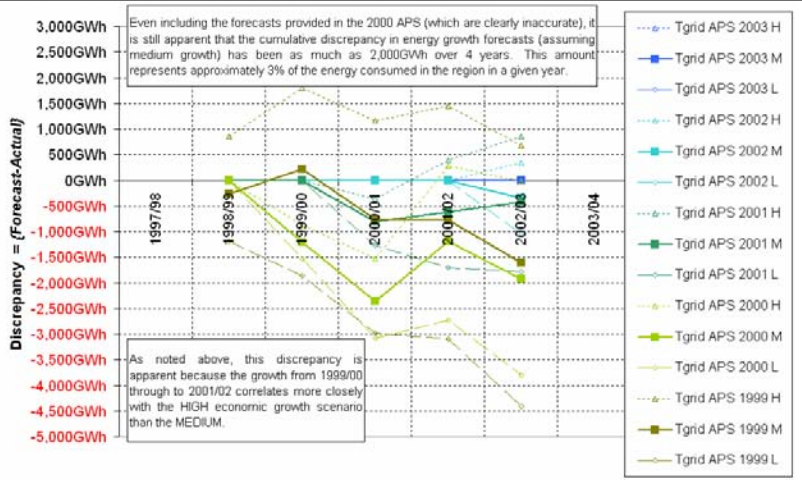
- The forecasts supplied in each issue of the Jurisdictional Planning Body's Annual Planning Statement can vary significantly from one year to the next:
  - Some of these discrepancies are due to a readjustment of the base level of demand following a year of high economic growth;
  - However other discrepancies appear generally inconsistent with forecasts generated in previous (and subsequent) years for no

apparent reason[16]. The risk of this occurring with future forecasts is real, and should be factored into any forecasts generated

This situation can be further addressed by viewing the extent to which the energy sent-out in any given year has been *over*-estimated in each of the forecasts generated. This is shown in the series below.

Figure 4·02 Discrepancy between Actual Energy and Previous Forecasts

<table>
<tr>
<td>Queensland</td>
<td>


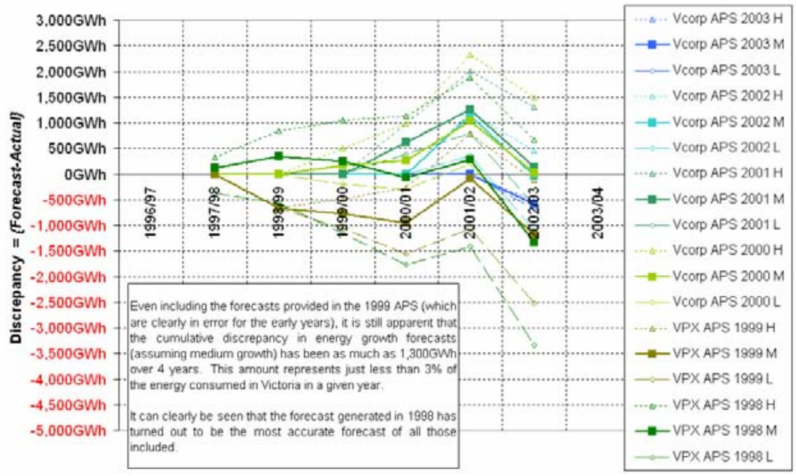
The 1,500GWh discrepancy represents approximately one year's forecast average growth in consumption for the Queensland region.
</td>
</tr>
<tr>
<td>NSW</td>
<td>


The 2,000GWh is a little more than the forecast average annual growth in energy for NSW.
</td>
</tr>
</table>

[16] One possible explanation for this apparent discrepancy may have been the assumption of a higher than actual level of embedded generation (which would not be captured in an energy sent-out measurement).

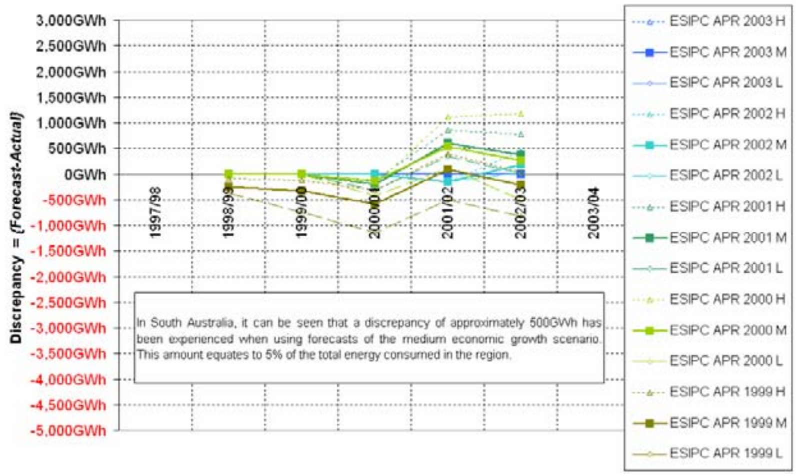
Figure 4·02 Discrepancy between Actual Energy and Previous Forecasts

Victoria



The 1,300GWh discrepancy equates to approximately 1 1/2 year's average forecast growth in consumption (under the medium case) over the next 10 years,.

South Australia



Note that the 500GWh error typically exhibited over the 5-year horizon of available data equates to approximately two year's average forecast growth in consumption (under the medium case) over the next 10 years.

From this series of charts, it is apparent that:

❖ The medium growth rate forecasts appear to provide a reasonable level of accuracy – especially taking into account the fact that the economic growth actually experienced from one year to the next is unlikely to be exactly that on which the growth forecasts have been based;

❖ Over the five-year period analysed, the discrepancies observed between forecast and actual energy consumption levels equate to perhaps 3→5% of total consumption in the region, and represent between 1 year and 2 year's typical growth in energy consumption;

- If this trend were to continue over the coming decade (the focus of the Annual Reliability Review), it is plausible that the total discrepancy present at the end of the decade could equate to up to 4 year's of growth in energy. If forecast consumption levels were to grow more rapidly than forecast, it would follow that USE levels would rise more rapidly than forecast – perhaps leading to breaching of the reliability standard up to 4 year's prior to the timing forecast under the assumed growth levels.

In summary, the forecasts provided for growth in annual energy consumption mostly correlate with medium economic growth projections. However, there are sufficient areas of discrepancy apparent in only 5 years of history to reinforce the need to model at least the medium and high economic growth scenarios (if not also the low load growth case) in order to ensure that the forecasts generated will encompass what actually develops in the market.

The above analysis indicates that:

ROAM Recommendation

*The probabilistic modelling conducted for the development of the "Annual Reliability Review"** should consider, at least, the medium and high economic growth scenarios (and preferably the low economic scenario as well) in order to provide a robust view of the envelope of possibilities apparent in the future of the market.*

*** Annual Reliability Review is discussed in section 5.*

4·1·2) FORECAST SUMMER DEMAND PEAKS

For each economic growth scenario, each Jurisdictional Planning Body has now standardized on the forecasting of three different levels of peak demand for each of the summer and winter seasons. The three different levels have been designed to reflect different load shapes resulting from mild, average and extreme weather patterns at the time of peak demand.

ROAM Consulting has compared the results generated through the existing methodology to the actual levels of regional peak (summer) demand experienced in the NEM over the previous five summers. In this way, it has been possible to determine a confidence level that could be applied to forecasts generated in the future with the use of a similar methodology.

ROAM Consulting has concentrated, at this stage, on peak summer demands as the aggregate summer demand (and rapid growth in this summer demand) will mean that reliability issues will be more likely to emerge at this time.

In the charts included below, the actual peak demand experienced in each region has been illustrated for recent years. Against these values has been trended the forecasts provided by the Jurisdictional Planning Bodies on an annual basis.

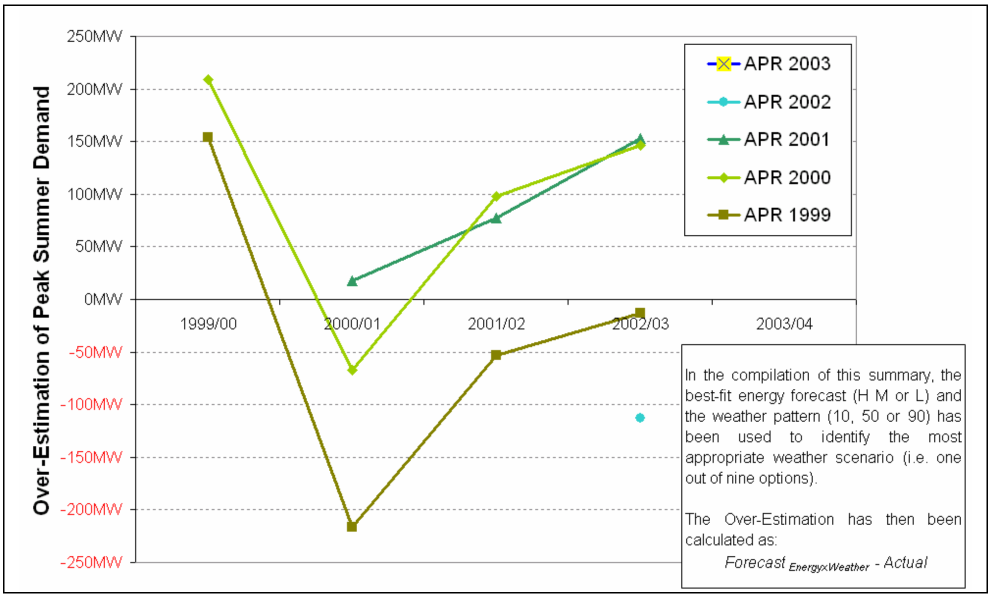
Given that the different forecasts generated in each economic scenario relate to the weather patterns assumed to be present at the time of peak demand, ROAM Consulting has also included a snapshot of key weather data for the relevant capital cities in the week surrounding the peak demand event.

4·1·2·1 Queensland

The Queensland region is traditionally summer peaking. By virtue of the sustained, high temperatures experienced in Queensland during the summer periods, the summer peak in demand is seen to last consistently for the duration of a working day.

Detailed analysis of the period of peak summer demand during each year has been included in Appendix 3. The results of this analysis (for the "most appropriate" annual forecast) are summarized in the following chart.

Figure 4·03 Over-Estimation of Peak Demand
Queensland Region



In this chart, the most appropriate[17] peak demand forecast of the nine available has been selected and compared against the demand actually experienced in that summer.

[17] To select the "most appropriate" peak demand forecast, the correlation of energy forecasts and actuals (shown above in figure 4·01) has been used. In addition, weather patterns around the time of peak demand have been examined to identify whether the weather pattern was more representative of mild (90% POE), moderate (50% POE) ,or extreme (10% POE) weather shape. By using this selection methodology, a "most appropriate" peak demand forecast of the nine provided in each annual planning statement has been determined.

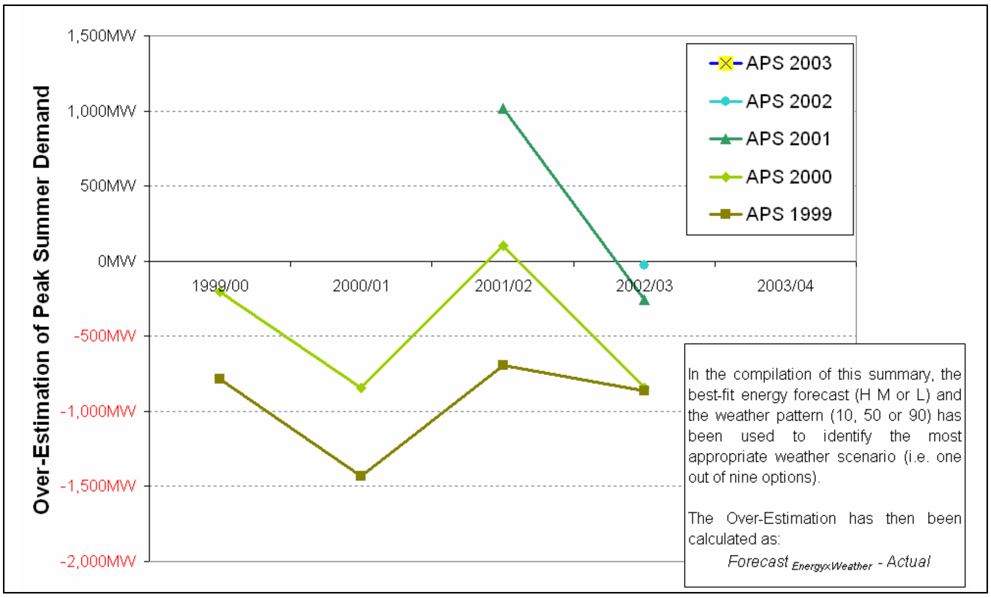
As illustrated in this diagram, the forecasts of peak demand have proved accurate (to within 200MW, or 3% of peak demand) across the majority of annual planning statements.

4·1·2·2 NSW

The NSW region is traditionally winter peaking, though its peak summer demand is growing at such a faster rate that the region will convert to summer peaking in the near future.

Detailed analysis of the period of peak summer demand during each year has been included in Appendix 3. The results of this analysis (for the "most appropriate" annual forecast) are summarized in the following chart.

Figure 4·04 Over-Estimation of Peak Demand
NSW Region



Similarly, the "most appropriate" peak demand forecast of the nine available has been selected and compared against the demand actually experienced in that summer.

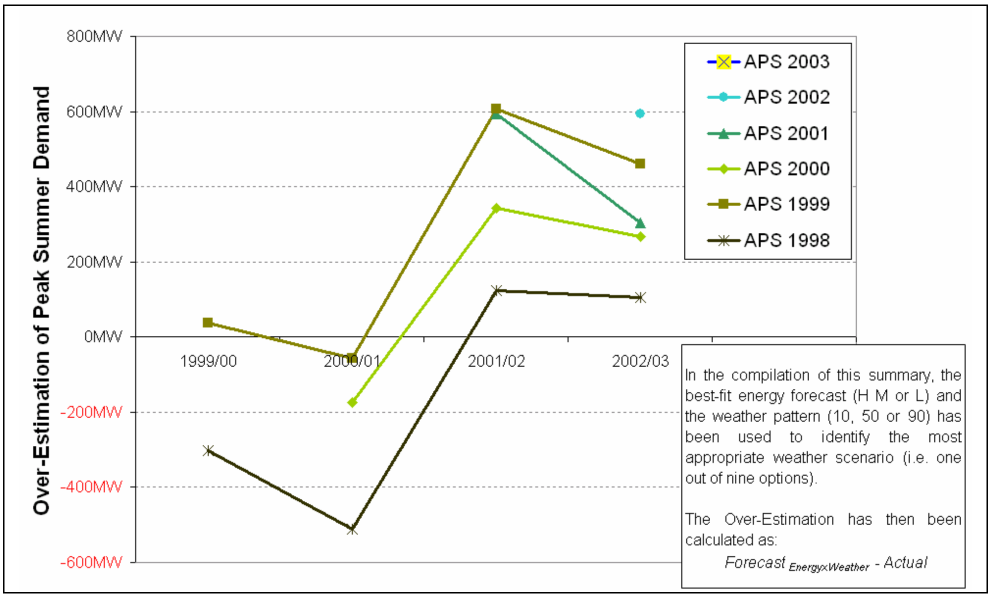
In contrast to the case for Queensland, this has revealed that there have generally been significant discrepancies between the forecasts generated (relevant to the weather shape and economic scenario in question) and the actual demand experienced in NSW, with discrepancies of 1,000MW or more (10-15% of peak demand) illustrated.

4·1·2·3 Victoria

The Victoria region is traditionally summer peaking. Because of the very high summer temperatures experienced over a relatively small number of days most summers, the peak demand in Victoria is of a very "peaky" shape, as opposed to the peak demand in Queensland (which is of a more sustained shape during daylight hours).

Detailed analysis of the period of peak summer demand during each year has been included in Appendix 3. The results of this analysis (for the "most appropriate" annual forecast) are summarized in the following chart.

Figure 4·05 Over-Estimation of Peak Demand
Victorian Region



Similarly, the "most appropriate" peak demand forecast of the nine available has been selected and compared against the demand actually experienced in that summer.

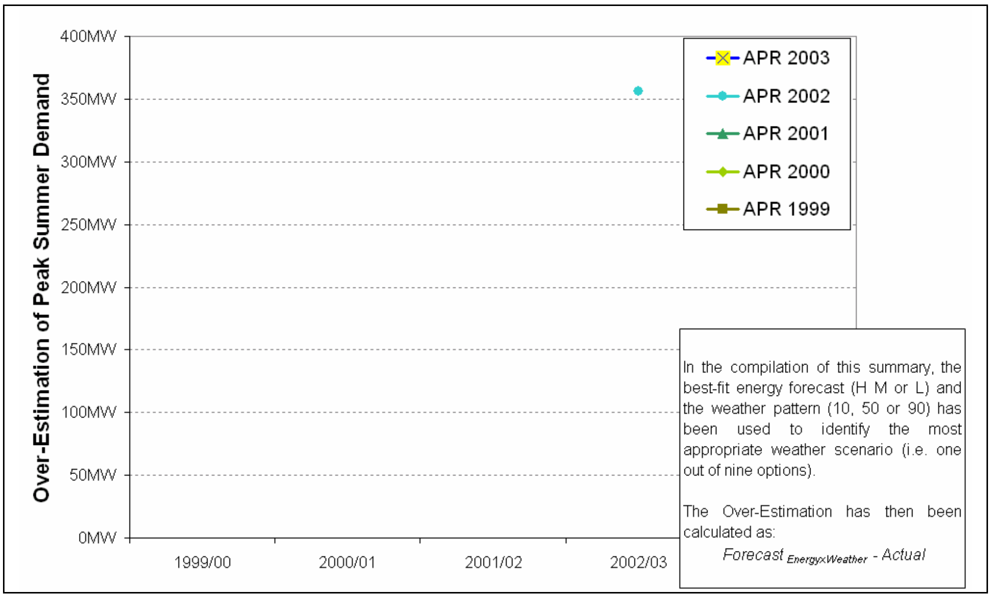
As was the case for NSW (and unlike the case for Queensland), significant discrepancies have been revealed when comparing the forecasts generated (relevant to the weather shape and economic scenario in question) with the actual demand experienced in Victoria. Discrepancies of 600MW are illustrated (which would be 7% of peak demand).

4·1·2·4 South Australia

The South Australia region is traditionally summer peaking. Because of the nature of the peak temperatures experienced in South Australia in a relatively small number of days each summer, the region experiences a very pronounced peak in demand for a small number of hours each year.

Detailed analysis of the period of peak summer demand during each year has been included in Appendix 3. The results of this analysis (for the "most appropriate" annual forecast) are summarized in the following chart.

Figure 4·06 Over-Estimation of Peak Demand
South Australian Region



As noted in Appendix 3, the Jurisdictional Planning Body only began the production of 9 discrete forecasts (with respect to three weather shapes and 3 economic scenarios) for the 2002 issue of the Annual Planning Review.

The only case illustrated above shows a 350MW discrepancy (which represents a discrepancy in excess of 10% of peak demand in South Australia).

4·1·2·5 Summary for all Regions

The peak summer demand forecasts generated (relevant to the actual energy consumed and weather patterns) have been shown to contain significant discrepancy to reality.

This discrepancy are caused (at least in part) because the development of the growth rates in peak demand and the development of the growth rates in energy are performed independently (and from a top-down perspective), making it more likely that such discrepancies can arise.

However, it is important to note that the Jurisdictional Planning Bodies release nine different forecasts for peak demand.

In Appendix 3, illustration is provided of how the actual demand experienced during a given year has generally fallen within the upper and lower bounds of these nine forecasts. Hence, it is concluded that, to ensure a robust forecast of the future of the market, all nine permutations of peak demand growth should be considered in the probabilistic modelling performed.

The above analysis indicates that:

ROAM Recommendation

The probabilistic modelling conducted for the development of long-term forecasts of the NEM should consider, for all economic development scenarios studied, the 10%, 50% and 90% probability of exceedence weather patterns and resultant load shapes.

4·1·3) DIVERSITY BETWEEN DEMAND PEAKS

When modelling the reliability of the NEM, another key variable that must be taken into account is the level of diversity that exists between peak demands in each of the four regions.

As shown in section 3·5·3, a reduction in the level of diversity between regional demand peaks will have the effect of ensuring a "peakier" whole-of-NEM load shape and contribute to higher levels of USE.

4·1·3·1 Summer Peak Demand

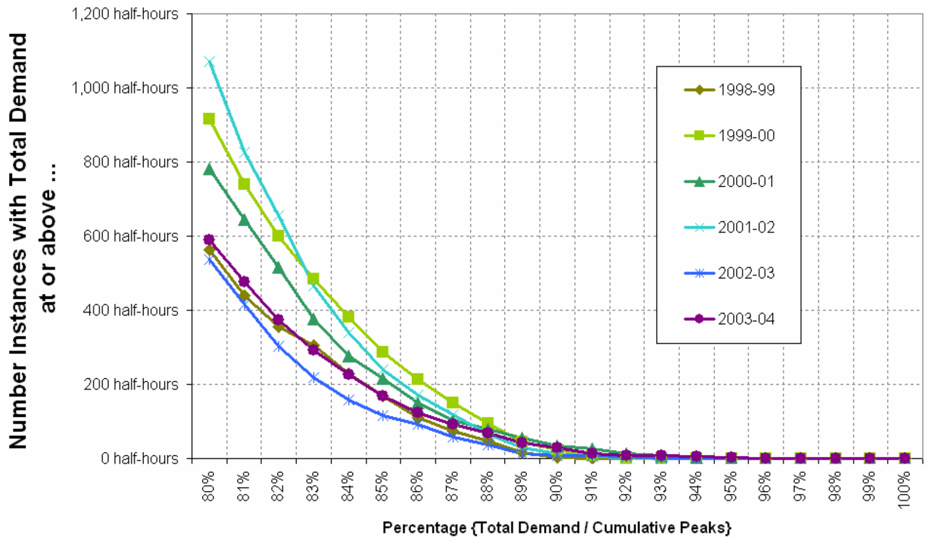
Because of the size and nature of the Australian continent, it is historically uncommon that all four capital cities (Brisbane, Sydney, Melbourne and Adelaide) have experienced peak summer temperatures simultaneously. Whilst high temperature weather patterns tend to coincide in Adelaide and Melbourne, there is a fair degree of separation between these events and those happening in the northern regions.

As a result, it is unlikely that the demand in all four regions will peak at the same time. Because of this level of diversity in peak demands, probabilistic modelling can reveal the additional reserve-sharing benefits that can accrue to regions during their time of peak demand by virtue of the lower level of plant utilization in other (non-peaking) regions.

In past editions of the *"Statement of Opportunities"*, NEMMCO has stressed the need to take into account the level of diversity that naturally exists in the NEM when completing reliability modelling. As noted above, the use of the deterministic model does not make this possible (unless benchmarked against another model) – but the probabilistic modelling does take this into account explicitly through the use of fully time sequential load traces in the modelling of each region.

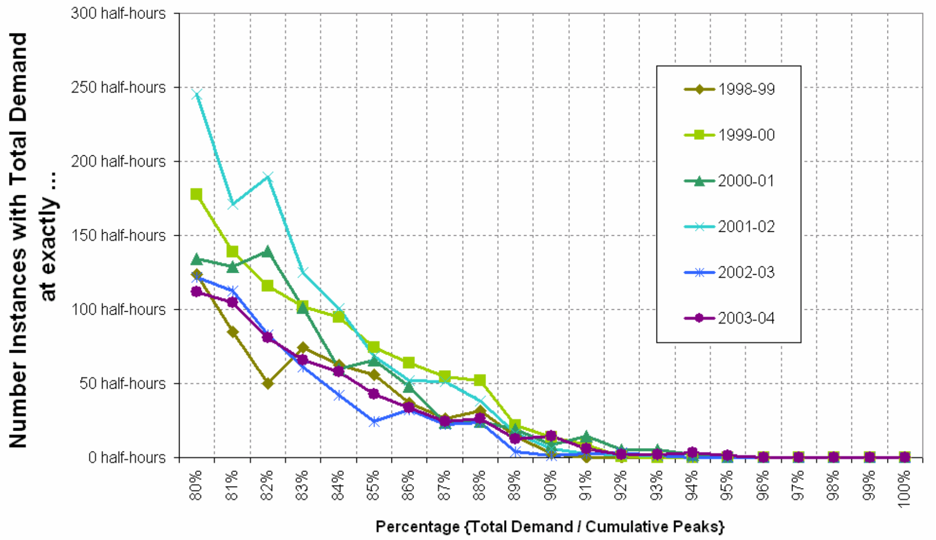
The degree to which this diversity exists can be seen in the series of charts that have been illustrated below.

Figure 4·07 Historical Diversity in Summer Demand



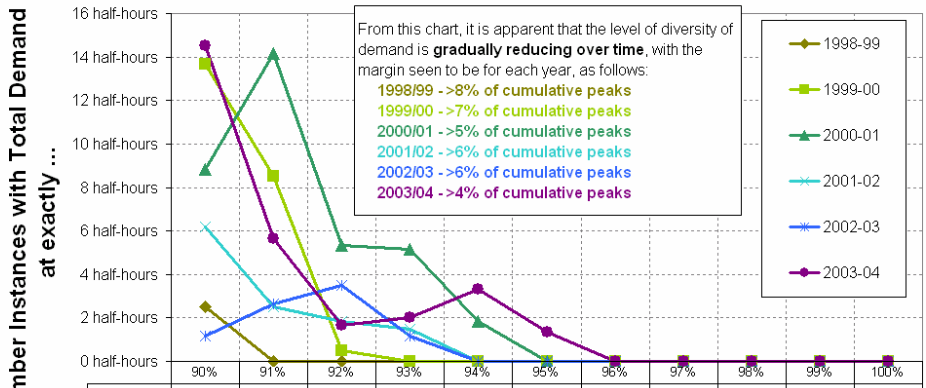
In this diagram, the number of half-hours are shown where aggregated NEM demand was at or above certain percentages of the sum of the discrete regional demand peaks apparent in that year. The level of diversity can be seen in the extent to which these curves separate from unity.

In the following chart, the same data is presented on a discrete percent-by-percent basis, in order that the level of diversity can be more accurately assessed.



To facilitate the interpretation of the data, the chart has again been included, but with the focus this time on the very few instances in each year when demand was greater than 90% of the cumulative peak.

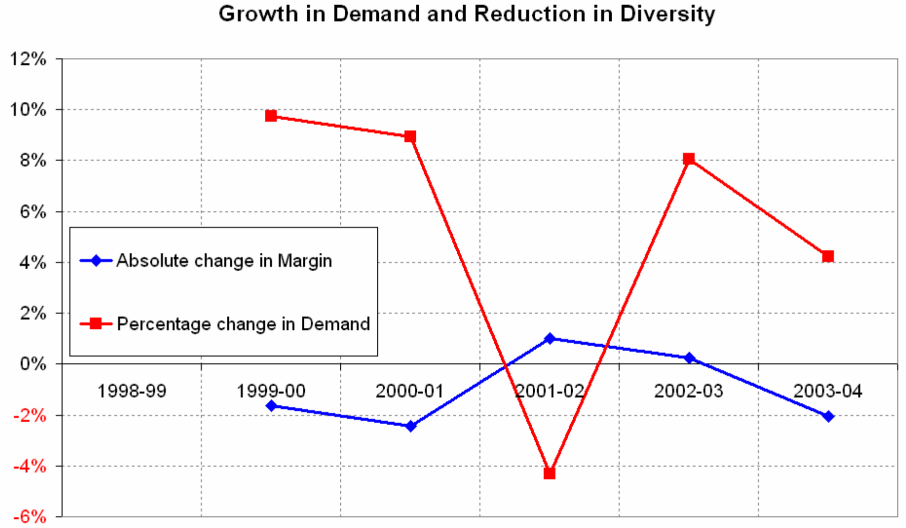
Figure 4·07 Historical Diversity in Summer Demand



	90%	91%	92%	93%	94%	95%	96%	97%	98%	99%	100%
1998-99	2.5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1999-00	13.7	8.5	0.5	0.	0.	0.	0.	0.	0.	0.	0.
2000-01	8.8	14.2	5.3	5.2	1.8	0.	0.	0.	0.	0.	0.
2001-02	6.2	2.5	1.8	1.5	0.	0.	0.	0.	0.	0.	0.
2002-03	1.2	2.7	3.5	1.2	0.	0.	0.	0.	0.	0.	0.
2003-04	14.5	5.7	1.7	2.	3.3	1.3	0.	0.	0.	0.	0.

Percentage {Total Demand / Cumulative Peaks}

As can be seen in this diagram, no instance has been seen in any summer over the past 5 years where the aggregate NEM-wide demand has been within 4% of the cumulative peaks for the year. On total demand of 30GW, this represents a total of 1,200MW of demand.



These two charts do indicate, however, a trend towards a reduction in the level of diversity in the NEM over the past 6 years. Whether this trend will be ongoing or is just an outcome of a limited data set is not yet known.

ROAM Recommendation

Probabilistic modelling is essential to the correct assessment of the impact of diversity in relation to NEM Reliability.

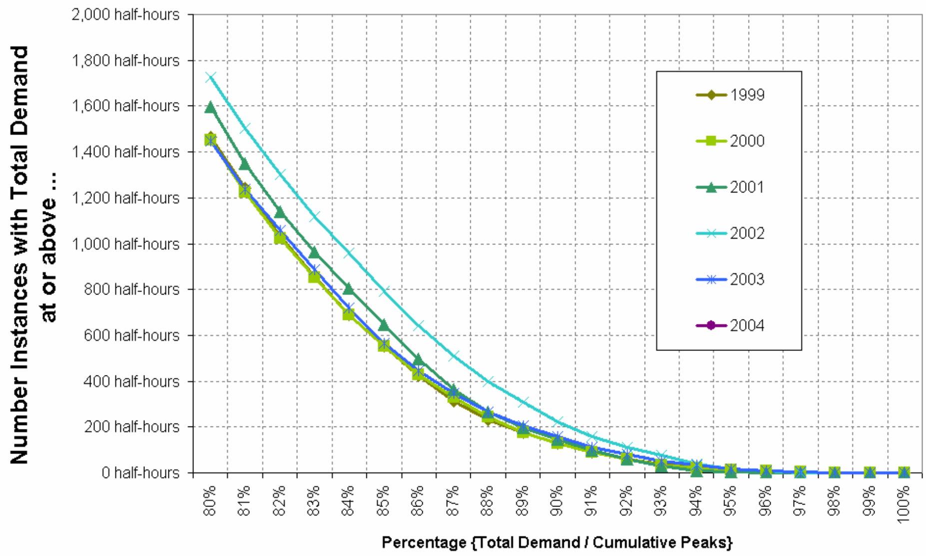
In building forecast load traces for each region, the most recent year should generally be used in order to ensure that the level of diversity currently exhibited in the market is reflected in the forecasts.

4·1·3·2 Winter Peak Demand

It is already known in the industry that there tends to be a greater degree of alignment of extreme winter weather patterns across the east coast of Australia. Hence, the level of diversity applicable to winter demands is not as high as it is for summer (though the whole-of-NEM peak demand is significantly lower).

The degree to which this diversity exists can be seen in the series of charts that have been illustrated below.

Figure 4·08 Historical Diversity in Winter Demand

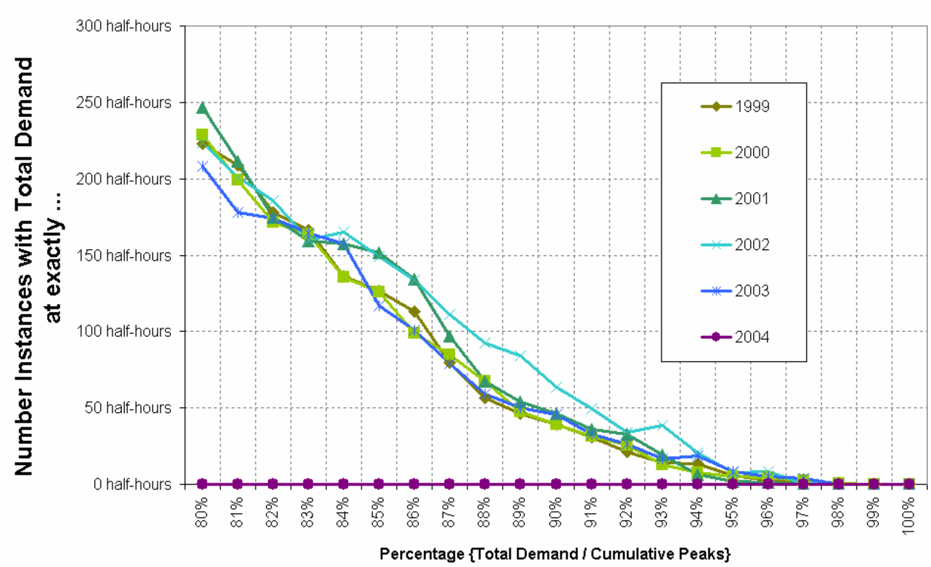


In this diagram, the number of half-hours are shown where aggregated NEM demand was at or above certain percentages of the sum of the discrete regional demand peaks apparent in that year. The level of diversity can be seen in the extent to which these curves separate from unity.

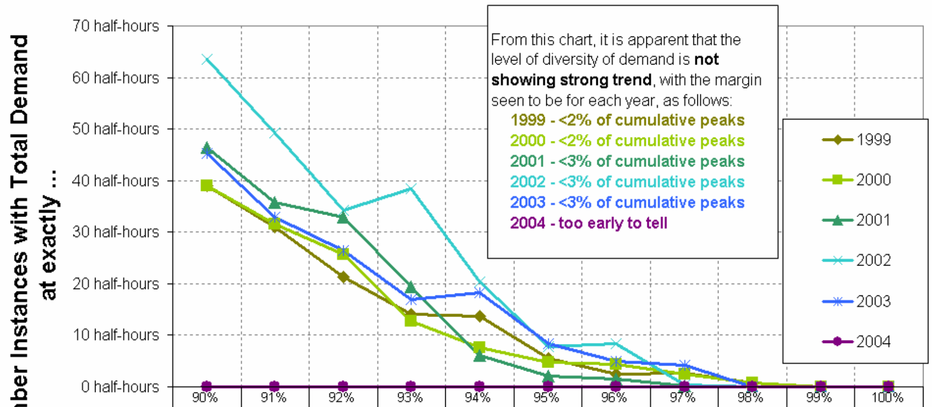
Figure 4-08 Historical Diversity in Winter Demand

Of particular interest in this chart is the greater degree of "sameness" exhibited for each year's winter period than that demonstrated for each summer period (illustrated in the figure above).

In the following chart, the same data is presented on a discrete percent-by-percent basis, in order that the level of diversity can be more accurately assessed.



To facilitate the interpretation of the data, the chart has again been included, but with the focus this time on the very few instances in each year when demand was greater than 90% of the cumulative peak.



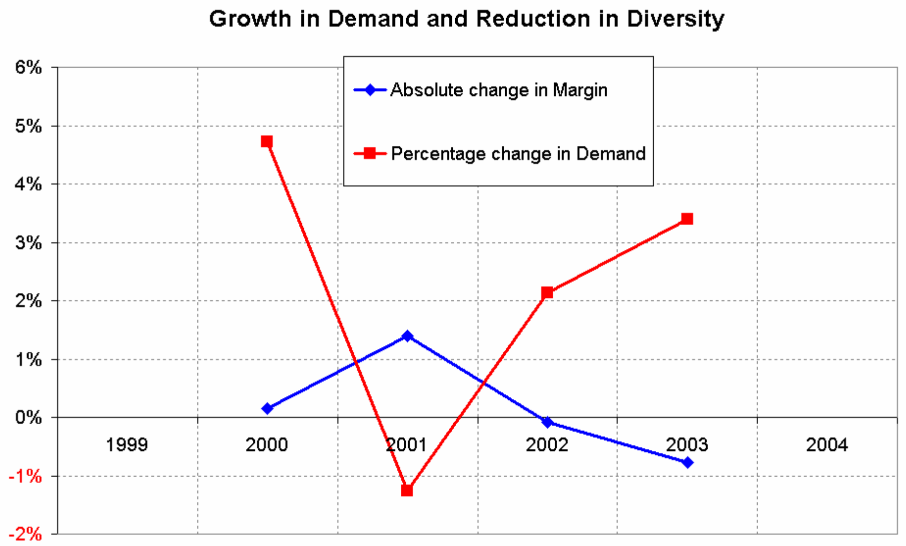
	90%	91%	92%	93%	94%	95%	96%	97%	98%	99%	100%
1999	39.	31.	21.3	14.2	13.7	5.5	2.5	2.7	0.7	0.	0.
2000	39.	31.5	25.7	12.8	7.7	4.8	4.3	2.5	0.7	0.	0.
2001	46.3	35.8	32.8	19.3	6.2	2.	1.5	0.2	0.	0.	0.
2002	63.5	49.3	34.2	38.5	20.3	7.8	8.3	0.3	0.	0.	0.
2003	45.3	32.8	26.5	17.	18.3	8.3	5.	4.2	0.	0.	0.
2004	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Percentage {Total Demand / Cumulative Peaks}

As can be seen in this diagram, the whole-of-NEM peak demand has been within 2% of the cumulative peaks on occasions during the winter periods in 1999 and 2000, and within 3% of cumulative peaks in each of the 5 most recent years.

Figure 4·08 Historical Diversity in Winter Demand

This implies that there is less than half the amount of diversity that has been observed during the summer periods.



These two charts also indicate a trend towards a reduction in the level of diversity in the NEM over the past 6 years (as was the case revealed above for summer diversity).

Whether this trend will be ongoing or is just an outcome of a limited data set is not yet known.

4·2) Accuracy of Generation Data

As highlighted in the market modelling performed by ROAM Consulting as part of this project, the forced outage rates of generators can have an impact on the level of reliability of the NEM (especially when the supply/demand balance grows tight).

ROAM Consulting recognises the importance of ensuring that forced outage rates are accurately modelled in the probabilistic modelling, as plant availability can have a significant impact on the reliability of the NEM (as illustrated through the sensitivity studies included in section 3).

4·2·1 GENERATOR FORCED OUTAGE RATE

Both PWC and MMA have recommended a more uniform, rigorous and repeatable approach be developed for the monitoring of generator forced outage rates. ROAM Consulting concurs with this view.

The preparation of the *Annual Reliability Review* (discussed further below) will necessitate the use of a methodology for the accurate determination of generator (forced and planned) outage rates that can be assumed for the 10-year time horizon of the studies. This process will need to be repeatable by independent third parties and for this reason must be able to be completed on the basis of information in the public domain.

ROAM Consulting believes that such a process is currently possible.

Since September 2001, NEMMCO has been releasing each generator's declared availability to the market for each dispatch period. Given that generators can choose to price their capacity out of the market (whilst still technically declaring the capacity available, if it is so), ROAM Consulting believes that this data can be analysed in order to calculate both a planned and forced outage rate on a historical basis.

Over the 10-year horizon that would be the focus of the long-term forecasts, it would be reasonable to assume that outage rates would not change markedly from these historical figures unless significant changes were implemented at the generation companies.

As an illustration of how this data could be used, ROAM Consulting has performed a preliminary analysis of this availability data to produce the following indications of forced outage rate. However, it should be noted that:

1) Given that the market has identified no formal use for this data (such as what is proposed here), some generators may have chosen to provide indications in the NEMMCO files that did not match with the physical reality of the availability of their plant;

2) Additionally, the availability data simply identifies (per unit), the capacity available to the market:
   a) As such, it is possible to calculate a total plant unavailability but inferences are required in order to denote outages as either "planned" or "forced";
   b) For the purposes of completing this assignment, ROAM Consulting has made the simplifying assumption whereby:
      i) Any outage lasting for less than 7 days is a forced outage, whereas
      ii) Unavailability lasting for longer than 7 days is most likely a planned outage.

c) On the basis of this generic classification, an average forced outage rate[18] has been calculated on the basis of the 27 months from October 2001 through to December 2003;

d) ROAM Consulting acknowledges the shortcomings of this rudimentary method, but proposes that this could be overcome in future by the use of the following logic:

i) If a plant had been identified as to be unavailable in the ST-PASA process, the outage could be classified as "planned"; however

ii) If a plant had been identified as available for the period in question, the outage could be classified as "forced".

e) The facilitation of this process would require a small increase to the information disclosed by NEMMCO into the public domain.

3) ROAM Consulting recognises that the time period used for this calculation is not sufficiently long enough to provide a perfectly accurate picture of the nature of the forced outage rates at these stations:

a) However, it has been necessary to work within the constraints of the data available;

b) As a cross-check of this data, a similar calculation has been run across the 5 years of history of dispatch (unit dispatch target[19]) data published by NEMMCO. This data has been used to derive an average unit (planned and forced) unavailability over the longer time horizon. The results of these calculations are discussed in the table.

The following table lists the forced outage rates calculated for each of the major units around the NEM on the basis of this logic.

[18] It should be noted that, by virtue of the method used, this outage rate would take into account all outages at the plant, whether caused by fuel supply disruptions, plant failure, industrial relations issues or other causes.

[19] In this calculation, it has been assumed that zero output has equated to the plant being unavailable. As only the larger (base-load and intermediate) plants have been analysed in this manner, the results should provide (in most instances) a reasonable reflection of reality.

Table 4·01 Approximate Generator Forced Outage Rate
Derived from Declared Availability Data for Base-Load Plant

Station	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**	**Unit 7**	**Unit 8**	**Comments**
Bayswater	1·5%	2·1%	0·6%	2·4%					The numbers appear a little low, given the broader average unit availability figures calculated across the 5 year period 1999→2003, as follows: Unit 1: 5·4% Unit 2: 10·4% Unit 3: 10·5% Unit 4: 7·3%
Callide B	0·7%	1·4%							The formula used has revealed a very low forced outage rate for the Callide B station. This data is reasonably compatible with the broader average unit unavailability figures calculated over the period 1999→2003 as follows: Unit 1: 2·5% Unit 2: 3·5%
Callide C	4·1%	5·7%							These figures are impacted by the commissioning schedule used for the plant, and also reflect the post-commissioning operational problems experienced initially.
Eraring	1·4%	1·1%	2·9%	0·3%					The numbers appear slightly low, given the broader average unit availability figures calculated across the 5 year period 1999→2003, as follows: Unit 1: 11·0% Unit 2: 7·3% Unit 3: 8·9% Unit 4: 5·8%
Gladstone	3·8%	1·3%	1·7%	3·0%	3·9%	2·6%			The numbers are at the lower bound of what would be expected for the Gladstone station. The broader average unit availability figures calculated across the 5 year period 1999→2003 have been calculated as follows: Unit 1: 13·4% Unit 2: 17·2% Unit 3: 10·6% Unit 4: 11·2% Unit 5: 17·9% Unit 6: 19·6%

Table 4·01 Approximate Generator Forced Outage Rate
Derived from Declared Availability Data for Base-Load Plant

Station	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Comments
Hazelwood	3·8%	5·0%	5·5%	7·1%	3·7%	4·4%	2·6%	3·6%	The numbers derived from the declared availability figures correlate reasonably well with the broader average unit availability figures calculated across the 5 year period 1999→2003, as follows: Unit 1: 10·8% Unit 2: 10·5% Unit 3: 6·0% Unit 4: 13·2% Unit 5: 6·8% Unit 6: 12·2% Unit 7: 9·4% Unit 8: 10·8%
Liddell	3·5%	2·5%	3·8%	3·0%					The numbers derived from the declared availability figures are low, but may be reasonable given Macquarie Generation's rotational approach to dispatch of the station. This philosophy is reflected in the broader average unit availability figures calculated across the 5 year period 1999→2003, as follows: Unit 1: 49·6% Unit 2: 31·7% Unit 3: 52·6% Unit 4: 34·1%
Loy Yang A	1·2%	4·4%	2·5%	2·6%					The numbers derived from the declared availability figures correlate reasonably well with the broader average unit availability figures calculated across the 5 year period 1999→2003, as follows: Unit 1: 5·3% Unit 2: 7·6% Unit 3: 5·4% Unit 4: 9·9%

Table 4·01 Approximate Generator Forced Outage Rate
Derived from Declared Availability Data for Base-Load Plant

Station	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Comments
Loy Yang B	1·7%	1·8%							These numbers do not take account the long-term forced outage that resulted from the failure of the unit transformer on Unit 2. This has been reflected, however, in the calculations based on unit output, as follows: Unit 1: 5·7% Unit 2: 10·4% The outage, which lasted more than 3 months in mid-2000, has added approximately 5% to the unavailability of the unit across 5 years.
Millmerran	10·6%	5·8%							The forced outage figures have been impacted by the commissioning schedule used at the plant.
Mount Piper	1·9%	0·8%							The formula used has revealed a low forced outage rate for the Mt Piper station. This data is reasonably compatible with the broader average unit unavailability figures calculated over the period 1999→2003 as follows: Unit 1: 7·1% Unit 2: 6·1%
Morwell	0·0%	8·0%	2·3%						These forced outage rates correlate reasonably against the average unit availability figures calculated over the period 1999→2003 as follows: Unit 1: 1·9% Unit 2: 32·9% Unit 3: 6·2% Further analysis would be required to confirm the true level of availability for Unit 2.
Munmorah	0·6%	0·9%							These low figures reflect the fact that the units have seldom been operated in recent times (total unavailability is in excess of 80% for each unit over the same period).
Northern SA	2·8%	2·4%							These forced outage rates correlate reasonably against the average unit availability figures calculated over the period 1999→2003 as follows: Unit 1: 7·4% Unit 2: 8·5%

Table 4·01 Approximate Generator Forced Outage Rate
Derived from Declared Availability Data for Base-Load Plant

Station	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Comments
Pelican Point	3·8%								This derived approximate forced outage rate compares with an availability figure of 92% calculated from the same data. Any calculations based on unit output are not valid because of the impact of the commissioning of the plant.
Stanwell	0·3%	0·2%	1·4%	0·9%					The formula used has revealed a very low forced outage rate for the Stanwell station. This data is reasonably compatible with the broader average unit unavailability figures calculated over the period 1999→2003 as follows: Unit 1: 5·4% Unit 2: 4·1% Unit 3: 4·3% Unit 4: 4·3%
Tarong	0·7%	0·0%	1·8%	0·1%					The formula used has revealed a very low forced outage rate for the Tarong station. This data is reasonably compatible with the broader average unit unavailability figures calculated over the period 1999→2003 as follows: Unit 1: 4·5% Unit 2: 7·5% Unit 3: 3·0% Unit 4: 3·5%
Tarong North	8·0%								The high level of forced outage rate calculated for Tarong North also incorporates the impact of the commissioning process used at the plant.
Vales Point	2·3%	2·3%							In calculating average unit "unavailability" 1999→2003, figures were both above 10%, as follows: Unit 1: 15·2% Unit 2: 13·8% Further analysis would be required in order to determine a more accurate picture of unit availability at Vales Point.
Wallerawang	3·4%	2·7%							In calculating average unit "unavailability" 1999→2003, figures were very large, reflecting the intermediate nature of operations at the plant, as follows: Unit 1: 15·8% Unit 2: 32·2% These figures are not accurate for this station.

Table 4·01 Approximate Generator Forced Outage Rate
Derived from Declared Availability Data for Base-Load Plant

Station	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Comments
Yallourn	4·6%	7·1%	3·9%	4·6%					In calculating average unit unavailability 1999→2003, figures for all 4 units were calculated as being greater than 10%, as follows: Unit 1: 12·2% Unit 2: 14·1% Unit 3: 11·1% Unit 4: 13·3% These numbers would have included the impact of the industrial relations dispute in early 2000.

ROAM Recommendation

Future probabilistic modelling should consider incorporating the derived forced outage rates included above.

Over time (as a greater base of declared availability data is published) the results generated by the application of this method will more closely reflect the long-term average forced outage rates at each station.

5) ASPECT #3 – COMMUNICATION METHODS

5·1) The "Annual Reliability Review"

The National Electricity Code contains provisions (clause 8·8·3(b)) for the NECA Reliability Panel to:

> *"At least once each calendar year and at such other times that NECA may request, the Reliability Panel must* ***conduct a review of the performance of the market in terms of reliability of the power system****, the power system security and reliability standards, …"* (emphasis added)

To address the provisions of this clause, the NECA Reliability Panel releases, on an annual basis towards the end of the year, their Annual Report.

5·1·1) REVIEW OF THE ANNUAL REPORTS

In conducting a review of the most recent Annual Reports of the NECA Reliability Panel, ROAM Consulting has found the following:

1) The recent Annual Reports have provided coverage to each of the separate topics of reliability and security;

   a) With respect to reliability, the reports have provided a discussion of the following facets:

      i) A general (very brief) note is made in each report about the extent to which there has actually been unserved energy in any region during the previous year, and:

         - in cases where there has been unserved energy, whether this has been related to market operation, and also
         - a (brief) review of why these events have occurred.

      ii) Greater detail is provided of a review conducted by NECA and the Reliability Panel of the distribution of instantaneous Reserve Margins experienced in each region across the previous year:

         - Particular attention has been focused on the instances where Reserve Margins may have been lower than (or approached) the relevant *Intervention Reserve Threshold*;
         - Consideration has also been given to the likely Reserve Margins implied ahead-of-time in NEMMCO's PASA processes (and the extent to which NEMMCO has needed to issue Low (likely) Reserve notices to ensure the market corrects this imbalance);

iii) The Annual Reports have also contained significant analysis of procedural issues relating to NEMMCO's and NECA's processes of ensuring reliability in the NEM.

b) The discussion provided with respect to the security of the NEM was not reviewed by ROAM Consulting as this was not within the scope of this project;

2) It is important to note, however, that **none of the reports have included any consideration of the forecast future reliability of the NEM**:

a) As discussed above, it is essential that consideration of reliability of the NEM address reliability over four timeframes (real-time & historical, forecast short-term, forecast medium-term, and forecast long-term);

b) It can be implied from the lack of this discussion that the NECA Reliability Panel has failed to report[20] on the long-term reliability of the NEM;

3) In the absence of such a document (and in response to the demands of various stakeholders of the NEM), NEMMCO has gradually shifted the focus of NEMMCO's Statement of Opportunities in an attempt to address two different requirements:

a) summarising the "state of health" of the market,

b) identifying a range of development opportunities for all sectors of the market.

This review should provide discussion of the level of reliability achieved in the NEM over each of the timeframes introduced above (historical, forecast short-term, forecast medium-term and forecast long-term).

5·1·2) PROPOSED FUTURE IMPROVEMENTS

The imminent changes to the governance arrangements to the market could provide an opportunity to implement these changes, for the benefit of all NEM Stakeholders. However, it is outside the scope of this assignment for ROAM Consulting to propose the appropriate arrangements for implementing the enhancements proposed below.

ROAM Consulting recognizes that the issue of NEM Reliability is one of the most important issues which the market must address on an ongoing basis. It follows that NEM Stakeholders have shown a particular keenness in understanding, and contributing to discussions about, NEM Reliability.

As such, ROAM Consulting believes that it is important that greater emphasis be placed on the publication and dissemination of an annual review of (historical and forecast) reliability levels across the NEM.

20 Indeed, some of the discussion contained in previous issues of the Annual Report would imply that the NECA Reliability Panel is supportive of the expansion of the focus of the *Statement of Opportunities* in attempt to make it, in effect, also a **"Statement of Reliability"**.

To do this, ROAM Consulting proposes that the current coverage of reliability in both the Annual Reports[21] and the Statement of Opportunities be combined into a single document that should be specifically focused on the issue of reliability. To reflect this change in emphasis, ROAM Consulting proposes the new report be titled the ***"Annual Reliability Review"*** (ARR).

To ensure the compatibility with the Statement of Opportunities (which will be modified, as proposed below), ROAM Consulting proposes that the Annual Reliability Review should be released on or before 30 September each year. This would provide at least 2 months for the compilation of the ARR following publication of the SOO, and ensure that the ARR would be available prior to the commencement of the summer peak in demand.

ROAM Consulting proposes that the content of the *Annual Reliability Review* would differ from previous Annual Reports in the following respects:

5·1·2·1) The Review of Historical Reliability

5·1·2·1·1) Historical Levels of USE

Currently, the NECA Reliability Panel Annual Report provides a review of historical levels of USE on an annual basis. However, the level of information provided with respect to these levels is limited.

In the *Annual Reliability Review*, a greater level of detail should be provided about the extent of USE experienced since the inception of the NEM – including:

- Curves trending the level of USE experienced over time;
- USE duration curves, similar to those included for the forecasts above; and
- A tabular explanation of the reasons behind each and every instance of USE that has been experienced over time (or direct reference to an external document that provides this description).

5·1·2·1·2) Historical Levels of Reserve Margin

ROAM Consulting recognizes that the measure of Reserve Margin will still have a place in the NEM as a ready-reference (though approximate) indicator of the balance between supply and demand.

[21] Procedural issues relating to the operation of the Reliability Panel could be best left covered in the existing (briefer) Annual Report framework.

Hence, in order to place the measure in an understandable framework, it is recommended that a trend of historical levels of actual (instantaneous) reserves be included in the *Annual Reliability Review*.

The following figure provides an illustration of how this might be presented:

- ❖ On a whole-of-NEM basis, the *Instantaneous Reserve Margin* can be easily derived as the excess of available capacity for each dispatch interval;
- ❖ On a regional basis, however, the effect of interconnector transfers should be taken into account. It is proposed that this is done in the derivation of an *Instantaneous Regional Reserves* by treating exports as additional demand in a region (and imports the opposite).

Figure 5·01 Historical Monthly Levels of Reserve Margin

Whole of NEM

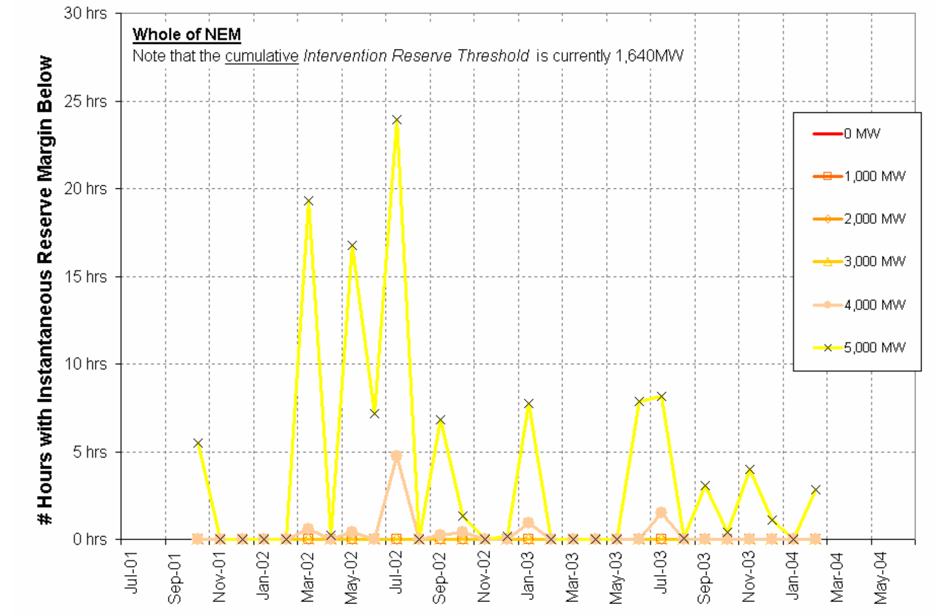


Figure 5·01 Historical Monthly Levels of Reserve Margin

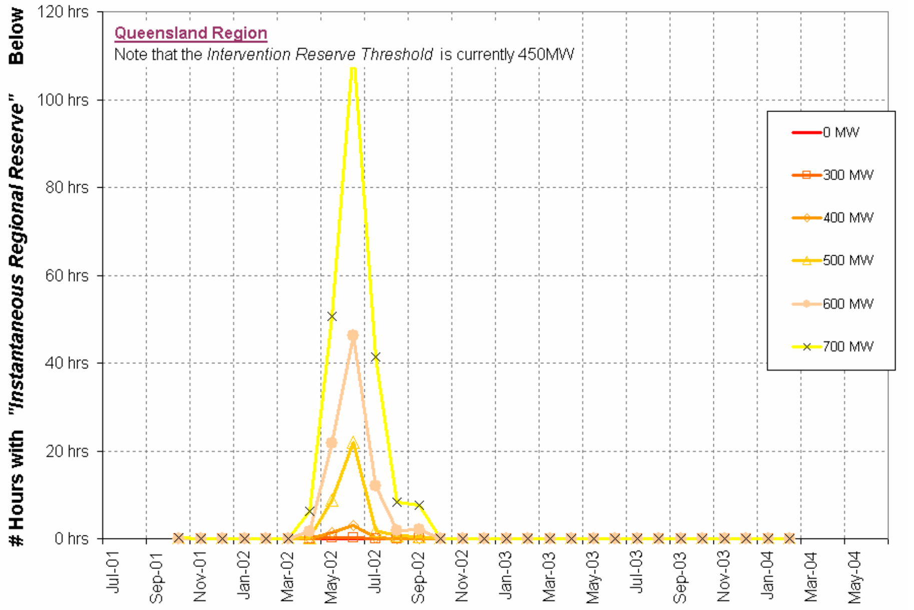
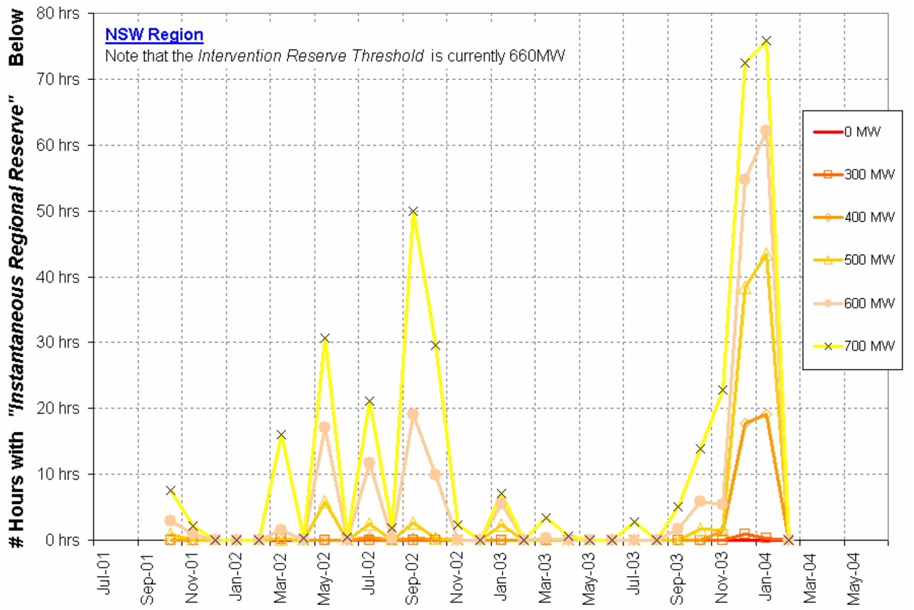
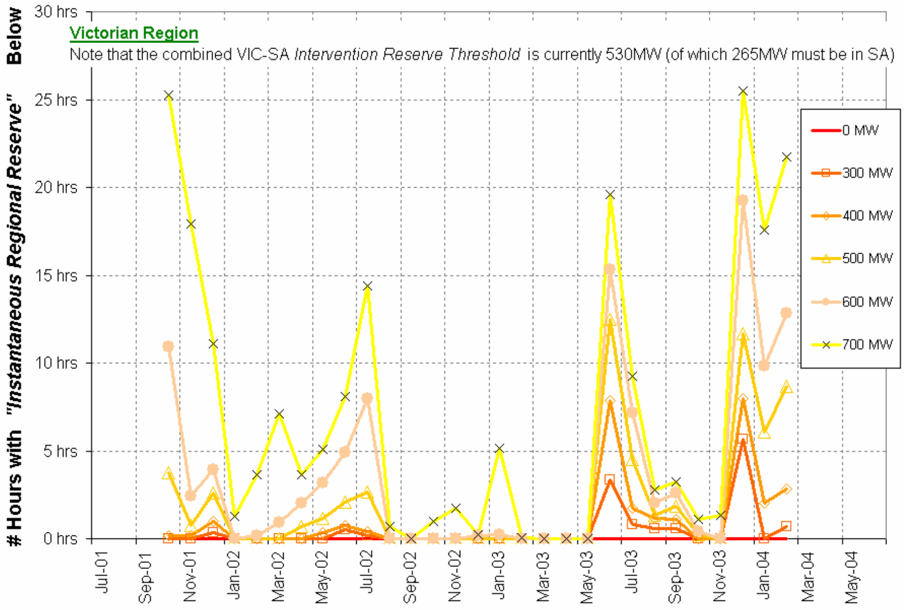
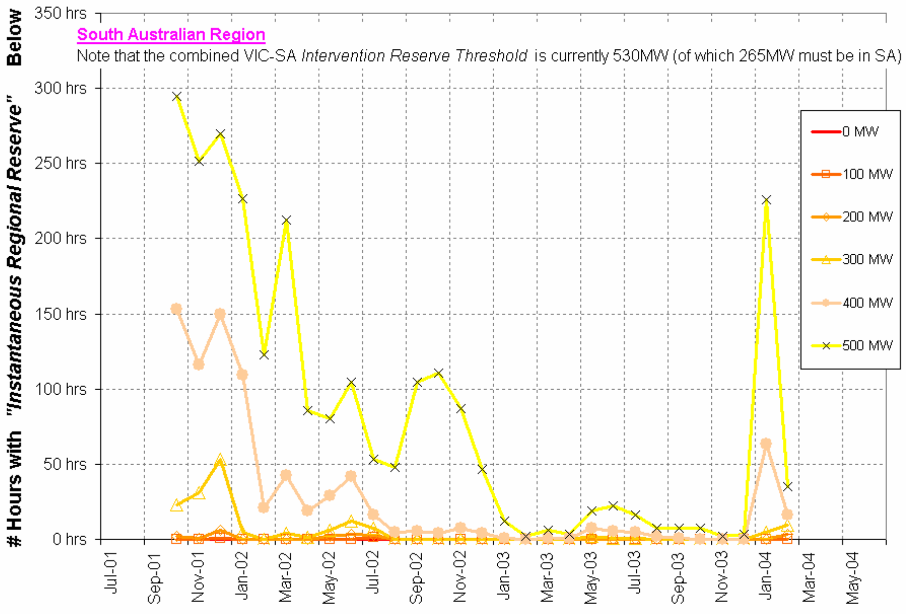
Queensland	
NSW	

Figure 5·01 Historical Monthly Levels of Reserve Margin

Victoria



South Australia



Further analysis of this data is provided in Appendix 3.

It is important to note, however, that these measures (whilst providing an indication of the trend in the balance between supply and demand) **do not provide an absolute indication** of the level of reliability.

5·1·2·1·3) Review of the PASA process

ROAM Consulting has considered the coverage provided to NEMMCO's application of the PASA process in previous Annual Reports.

The NEM has been designed such that participants will make changes in the capacity offered to the market in response to the issue of low (forecast) reserve notices. Hence, the fact that this is actually occurring should be viewed as an encouraging sign of the correct operation of the market.

However, through the coverage of this dynamic included in previous Annual Reports, the Reliability Panel has risked NEM stakeholders making the inference that the fact that, because there had been forecast instances of low reserve in the market, the level of reliability has been poor. ROAM Consulting proposes that the *Annual Reliability Review* should focus predominantly on the *actual levels* of instantaneous reserve delivered in each dispatch period.

The review of the accuracy of demand forecasts used in the PASA process provides a useful background to assist stakeholders view the data currently being released by NEMMCO and should be retained for the *Annual Reliability Review*.

5·1·3) MARKET FORECASTS (10-YEAR HORIZON)

The second half of the Annual Reliability Review should incorporate a forecast of likely future levels of reliability over a number of different load growth scenarios. The measure of reliability used in these assessments would be USE.

In general terms, the approach taken to this section of the report might be similar to section 3 of this report. The NECA Reliability Panel may need to contract an independent party (or parties) that specializes in this form of probabilistic analysis in order to develop this assessment every year.

In summary, ROAM Consulting would propose that this section of the assessment would need to contain the following.

5·1·3·1) Probabilistic Modelling

As noted above, the long-term forecast NEM Reliability should be assessed through the use of multi-iteration, probabilistic market modelling.

5·1·3·2) Multiple Scenarios

In order to accurately portray the uncertainty surrounding the forecasting process, it will be essential that forecasts are generated for each of three different load growth scenarios (High, Medium and Low) identified by NEMMCO in the *Statement of Opportunities*. Each scenario should be run for 10 years and the level of USE forecast in each scenario-year should be included in the *Annual Reliability Review*.

Other data that would be produced through the modelling process (e.g. market prices and generator dispatch levels) would not need to be reported in the *Annual Reliability Review*, except to the degree deemed necessary in order that NEM stakeholders could gain full confidence of the results of the modelling.

5·2) The "Statement of Opportunities"

The National Electricity Code contains provisions (clause 3·13·3(o)) for NEMMCO to:

> *"By 31 July in each year, NEMMCO must prepare and publish at a reasonable charge to cover the cost of production, a statement of opportunities, including at least the following information for the subsequent 10 year period:*
>
> (1) *Projections of aggregate MW demand and energy requirements in each region;*
>
> (2) *Generating capabilities of existing generating units for which formal commitments have been made for construction or installation;*
>
> (3) *Planned plant retirements;*
>
> (4) *A summary of network capabilities and constraints based upon Annual Planning Reports and the Inter-Regional Planning Committee's annual interconnector review conducted pursuant to clause 5·6·4; and*
>
> (5) *Operational and economic information about the market to assist planning by both Market Participants and potential Market Participants"*

In the 6 years since the opening of the market, the NEMMCO *Statement of Opportunities* (SOO) has become perhaps the most widely-read, regular report on the state of the market.

It is important to note that the clause **does not specifically prescribe NEMMCO to include consideration of the state of NEM Reliability**. Rather, as noted above, ROAM Consulting has inferred that NEMMCO has included this focus in the production of the NEM because of the lack of this coverage in an *Annual Reliability Review* or other independent document.

Whilst (existing and potential) market participants will naturally consider the measure of reliability of the market as one indicator of the potential opportunity for business development in the NEM, this will not be the only factor. Even in cases where the NEM is forecast to have surplus capacity for the entirety of the 10-year report horizon, participants might choose to develop new projects because of cost advantages inherent in new technologies (or implied through changes to government policies), or for a wide range of other potential reasons.

ROAM Consulting has formed the view that, in attempting to *also* report on the level of NEM Reliability *in addition to* the responsibilities prescribed in the Code, the *Statement of Opportunities* has developed into a document that satisfies neither objective exceptionally well. It would be possible for readers of the SOO to develop an incorrect view of the level of NEM Reliability.

By the establishment of an independent *Annual Reliability Review* that would be published after and with reference to the *Statement of Opportunities*, NEMMCO would thus have greater latitude to refocus the SOO on the purpose outlined for the document in the Code. For instance, the *Statement of Opportunities* could be developed to incorporate more consideration of the "economic information" included in sub-clause (5) of the clause above.

ROAM Recommendation

The Statement of Opportunities should be produced (on or before 31 July each year) by NEMMCO to focus on the commercial opportunities for development in the NEM.

This document should be reference another document (the "Annual Reliability Review") that would be published (on or before 30 September each year) to review of the level of reliability achieved historically in the NEM, and forecast future NEM Reliability.

6) SUMMARY AND CONCLUSIONS

ROAM Consulting has determined that the use of a deterministic methodology for the determination of forecast future NEM Reliability is inadequate given the importance of the issue.

Indeed, the models produced by ROAM Consulting have illustrated that the story implied through the deterministic methods applied in the production of the 2003 issue Statement of Opportunities are quite misleading. Specifically, ROAM Consulting has demonstrated that it will be the reverse order of regions in which additional capacity will need to be installed in order to meet the NECA Reliability Panel 0·002% USE reliability standard.

ROAM Consulting sees as essential a move to a more sophisticated probabilistic modelling methodology in order that the various influencing factors can be considered simultaneously.

ROAM Consulting proposes that a new report (the *"Annual Reliability Review"*) be produced on an annual basis and released to the public on or before 30 September every year.

This document would draw from the demand growth, network development and capacity development projections included in the Statement of Opportunities and present forecasts of the level of unserved energy out 10 years into the future. These forecasts should be produced through the application of a probabilistic modelling methodology incorporating Monte-Carlo consideration of random plant outages.

The introduction of this new report will allow NEMMCO to refocus the production of the Statement of Opportunities on its initial objective – that of providing potential investors in the market an understanding of the opportunities that are and will be present.

In completing the probabilistic forecasts, a number of different scenarios should be modeled, incorporating the three different economic development scenarios (and within each of these the three different potential weather patterns).

D. GLOSSARY

FOR	A Generator's Forced Outage Rate
Intervention Reserve Threshold	The level of reserves in each region at which NEMMCO is triggered to begin the process of contracting for available capacity under the Reserve Trader Provisions. The level of the Intervention Reserve Threshold is reviewed regularly by the NECA Reliability Panel with the level set on the recommendation of NEMMCO.
Reserve Margin	The Margin of Installed Capacity in the NEM over and above the Peak Demand in the NEM during the period of interest
Reserve Plant Margin	Reserve Margin divided by the Peak Demand This is expressed as a percentage.
SOO	The Statement of Opportunities, released by NEMMCO around August in every year, provides a 10-year view of the development of the market – specifically for the purposes of helping market participants to identify commercial opportunities apparent in the wholesale market.
Unserved Energy	The amount of energy-usage curtailed over a given period due to incidents in the generation and transmission sectors of the market.

E. APPENDICES

APP 1) REFERENCES

ACIL Tasman. April 2003. "*SRMC and LRMC of Generators in the NEM: A Report to the IRPC and NEMMCO".*

McLennan Magasanik Associates Pty Ltd (MMA). 10 September 2002. "Assessment of NEMMCO's 2001 Calculation of Reserve Margins". http://www.neca.com.au/Files/RP_MMA_review_of_NEMMCO_reserve_margin_recalculation.pdf

NECA. June 1998. *"Reliability Panel Determination on Reserve Trader and Direction Guidelines"*. http://www.neca.com.au/Files/RP_Standards_and_Guidelines_Determination.pdf

NECA. October 2001. *"Reliability Panel Draft Annual Report 2000-2001"*. http://www.neca.com.au/Files/RP_annual_report_2000_01.pdf

NECA. November 2002. *"Reliability Panel Annual Report 2001-2002"*. http://www.neca.com.au/Files/RP_annual_report_2001_02.pdf

NECA. November 2003. *"Reliability Panel Annual Report 2002-2003"*. http://www.neca.com.au/Files/RP_annual_report_2002_03.pdf

NEMMCO. July 2002. *"NEMMCO Advice on Minimum Reserve Margins for the NEM."* http://www.nemmco.com.au/operating/systemops/240-0005.pdf

NEMMCO. 2 February 2004. *"2003 Review of Minimum Reserve Levels – for South Australia and Victoria"* http://www.nemmco.com.au/operating/systemops/240-0007.pdf

NEMMCO. 1999. *"1999 – Statement of Opportunities"*.

NEMMCO. 2000. *"2000 – Statement of Opportunities"*.

NEMMCO. 2001. *"2001 – Statement of Opportunities"*.

NEMMCO. 31 July 2002. *"2002 – Statement of Opportunities"*.

NEMMCO. 31 July 2003. *"2003 – Statement of Opportunities"*; *"2003 Statement of Opportunities Launch Presentation".* http://www.nemmco.com.au/publications/soo/soo2003.htm

PricewaterhouseCoopers. 3 August 2001. *"Review of NEMMCO's 2001 Statement of Opportunities"*. http://www.neca.com.au/Files/A_Review_of_Nemmco_Statement_of_Opportunities_Aug_01.pdf

APP 2) KEY FACTORS INFLUENCING RELIABILITY

There are four key characteristics that establish the inherent reliability of supply in a power system. For each of these factors the reliability of supply (expressed as USE) varies very strongly, that is, in a geometric or exponential way. They are[22]:

1) **Reserve plant margin (RPM)**. The reliability for any power system, expressed as USE, improves with increasing reserve plant margin:

    a) Reserve plant margin is usually expressed as percent of installed capacity above the forecast peak 50% PoE half-hourly forecast annual demand;

    b) Reserve Margin (RM), as defined for each region of the NEM, is a similar parameter – RM is expressed as MW of spare capacity above the 10% PoE peak demand;

2) **Plant availability**. The reliability, expressed as USE, improves with the average availability of generating plant. Availability is the proportion of time that a generating plant is available at its rated capacity, and takes account of the different impacts of both planned and forced outages;

3) **Average generating unit capacity compared with system generating capacity**. For a given power system size, more small generating units provide better system reliability than fewer large generating units with the same aggregate capacity. The characteristics of the generating plant being installed in the power system therefore influence the system reliability.

4) **Load factor of the load[23]**. The reliability decreases with increasing system load factor. The longer the time at high load levels the greater the chance of a generation breakdown occurring and resulting in USE. The reliability is dependent on the load shape as well as the load factor, since a relatively flat load with occasional extreme peaks will have a different effect from a load of the same load factor with large daily differences between overnight and daytime loads;

These factors have been confirmed by other published work.

[22] I.A. Rose 'Generation Planning' 1990 Residential School in Power System Electrical Engineering, University of Tasmania, 1990.

[23] Load Factor = Average Load/Peak Load (for any defined time interval, daily, monthly, annually…)

For example, the Irish "Generation Adequacy Statement" (published by the transmission system operator) states[24]:

> *LOLE[25] is used to assess system adequacy because unlike other measures, such as capacity margin, it takes the following factors into account;*
>
> 1) *The load at every hour of the year is considered to have an influence on system adequacy, not just the hours of peak demand.*
>
> 2) *Plant availability performance is taken into account. High availability plant is of more benefit than low availability plant from the system adequacy perspective.*
>
> 3) *The number and relative sizes of generating units impacts on the LOLE calculation. A large number of small units will provide more security than a small number of large units, other factors being equal.*

There are two other characteristics that are not covered above that apply to systems which have additional characteristics that may reduce reliability:

5) **Effect of interconnector limitations between areas or regions;.** The NEM is potentially impacted by interconnector limitations, since there is insufficient interconnector capacity to ensure that interconnector limitations will always permit surplus generating capacity in one region to be distributed to another region with a generating capacity shortfall.

6) **Effect of energy limitations on effective plant capacity**. Additionally, the NEM is potentially impacted by energy limitations, since there is approximately 5,000MW of energy limited hydro capacity in the NEM, including the Snowy, Southern Hydro, Shoalhaven, Wivenhoe and North Queensland hydros.

The above six factors in combination will determine the reliability of the NEM. Thus, significant effort is required to address the characteristics of each of these factors in sufficient detail to provide a clear understanding of both:

- The **absolute level** of reliability resulting from the chosen assumptions; and
- The **sensitivity** of the reliability to changes in the assumptions.

Both the *data collection* and the *modelling* efforts are important and must be completed diligently in order to deliver a high-quality assessment. When sensitivity studies are conducted, they should address each of the six factors in turn, including key assumptions underlying the factors.

[24] Generation Adequacy Report 2003-2009 Transmission System Operator Ireland.

[25] Loss of load expectation.

APP 3) REVIEWING HISTORICAL DATA

App3·1) Peak Summer Demands

APP 3-1-1) QUEENSLAND

The following charts illustrate the results of the analysis performed with respect to the forecasts generated for peak demand growth.

Figure A3·01 Comparing Forecast and Actual Peak Demand
Queensland Region (1999-00)

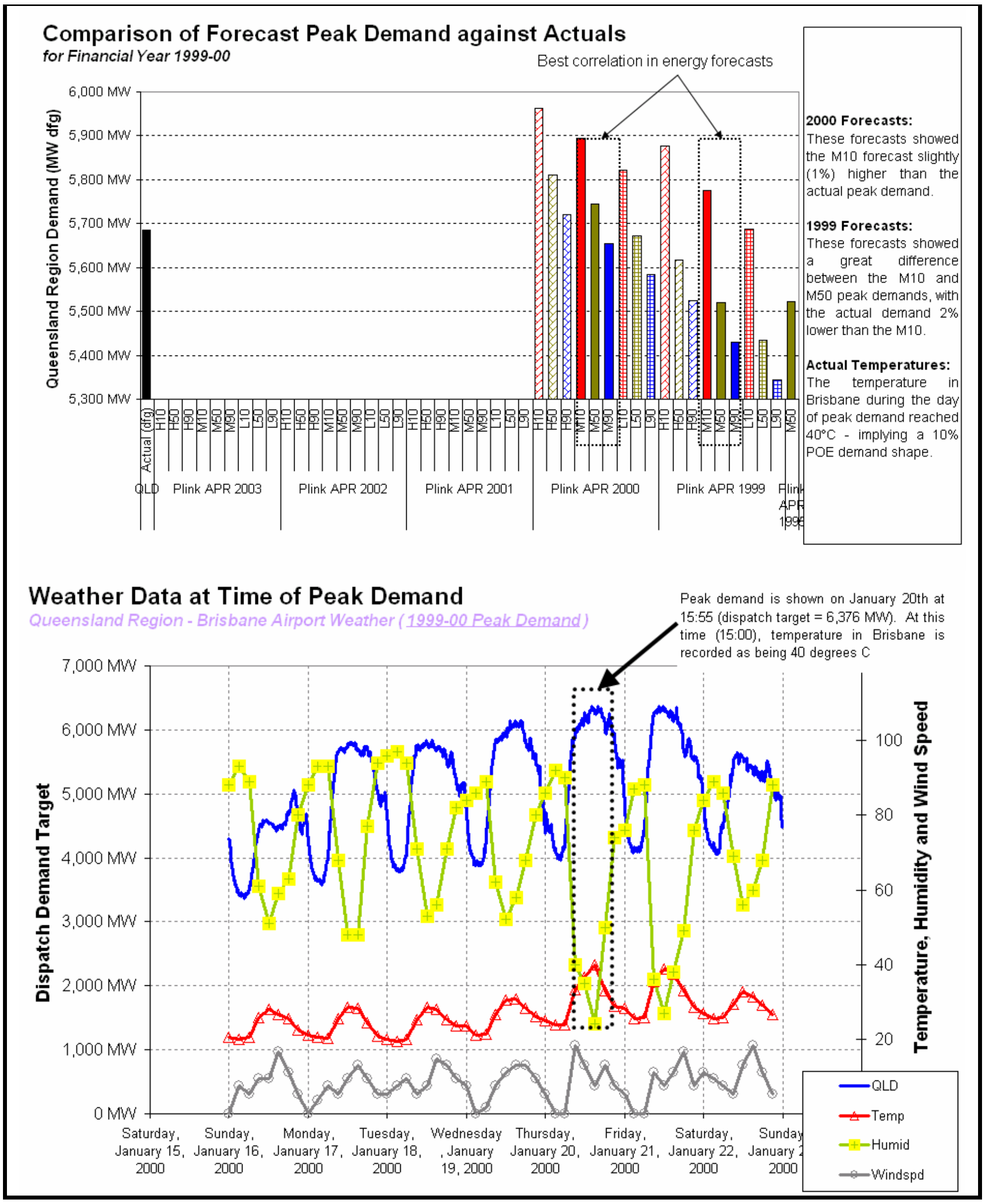


Figure A3·02 Comparing Forecast and Actual Peak Demand
Queensland Region (2000-01)

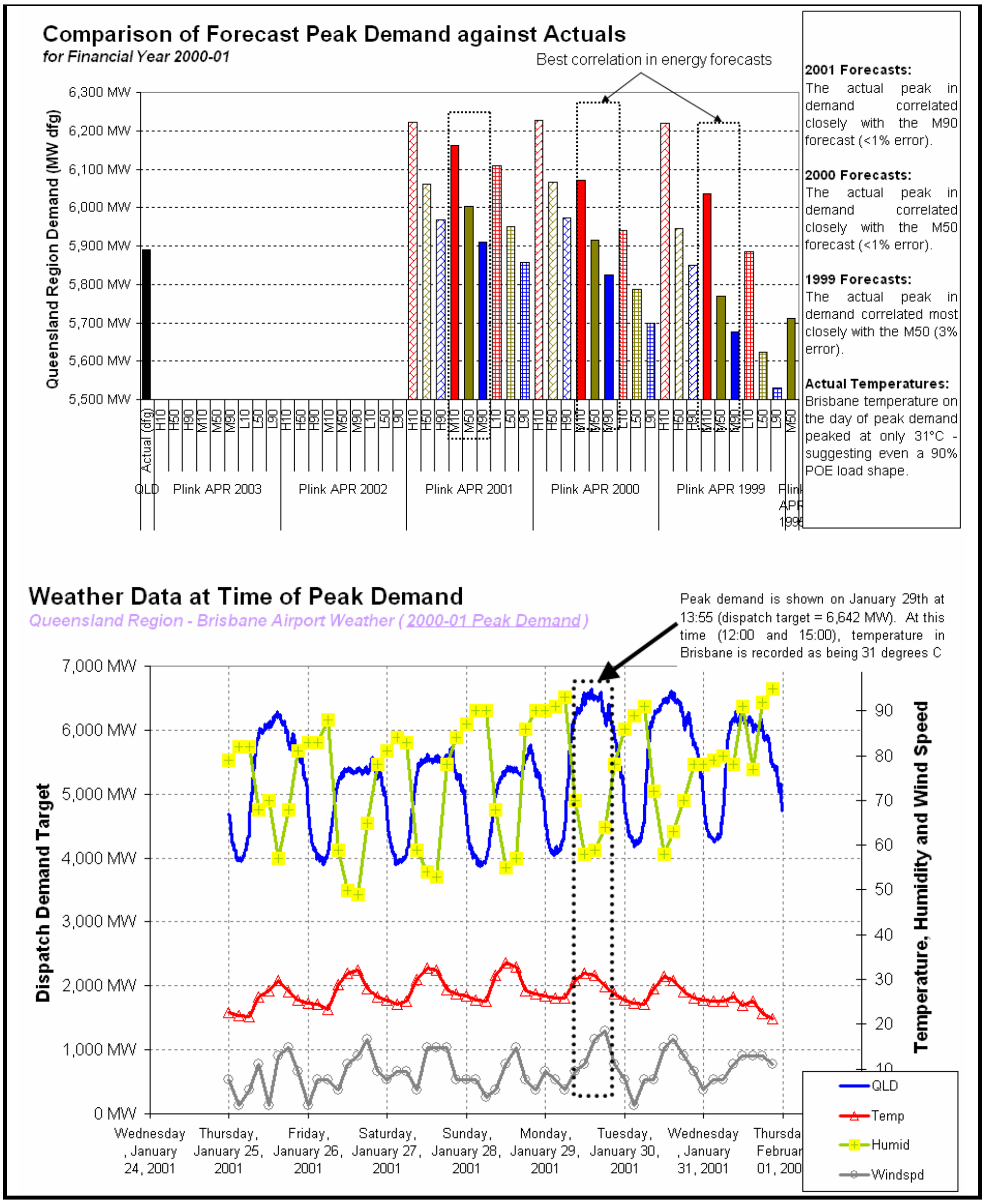


Figure A3·03 Comparing Forecast and Actual Peak Demand
Queensland Region (2001-02)

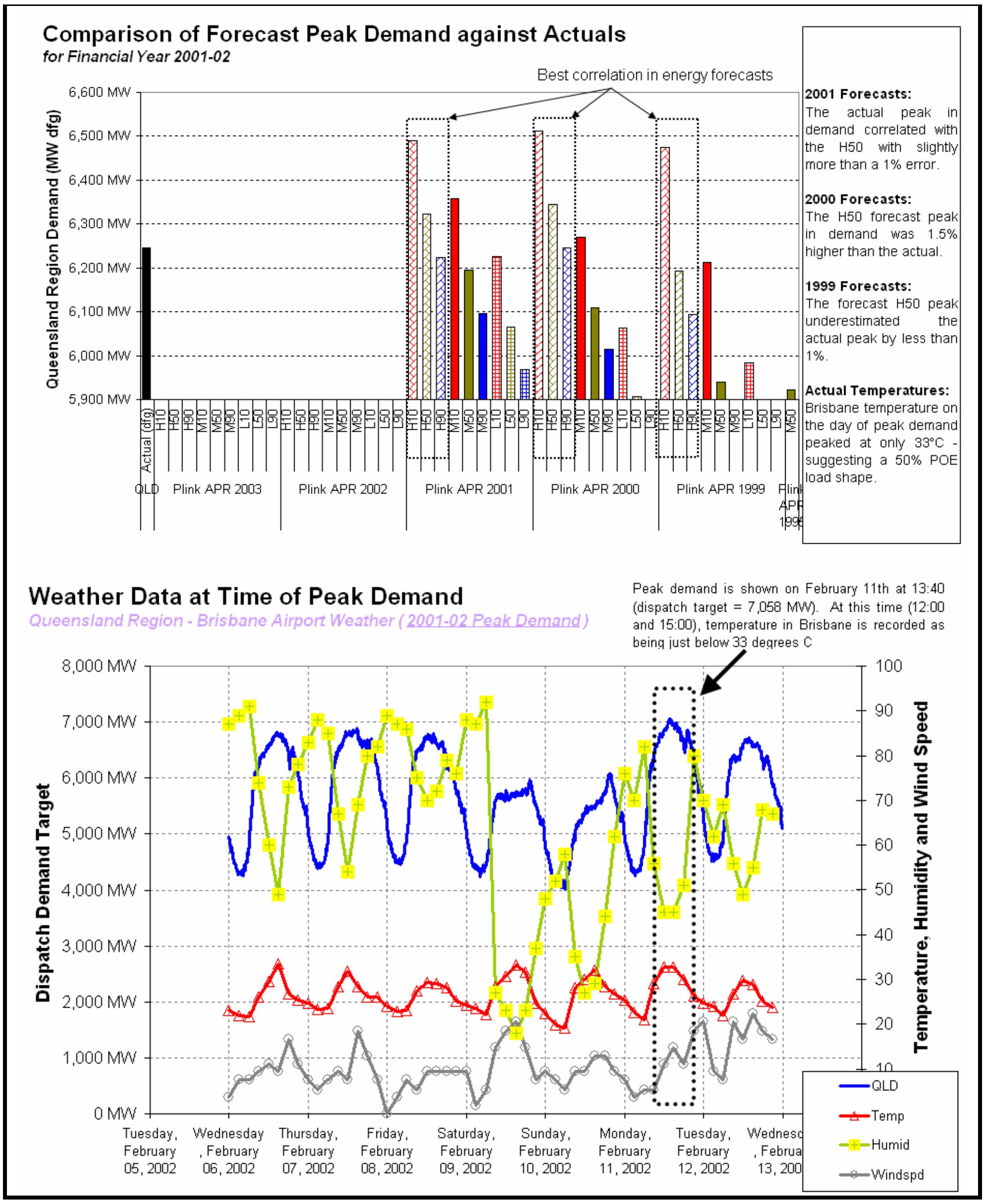


Figure A3·04 Comparing Forecast and Actual Peak Demand
Queensland Region (2002-03)

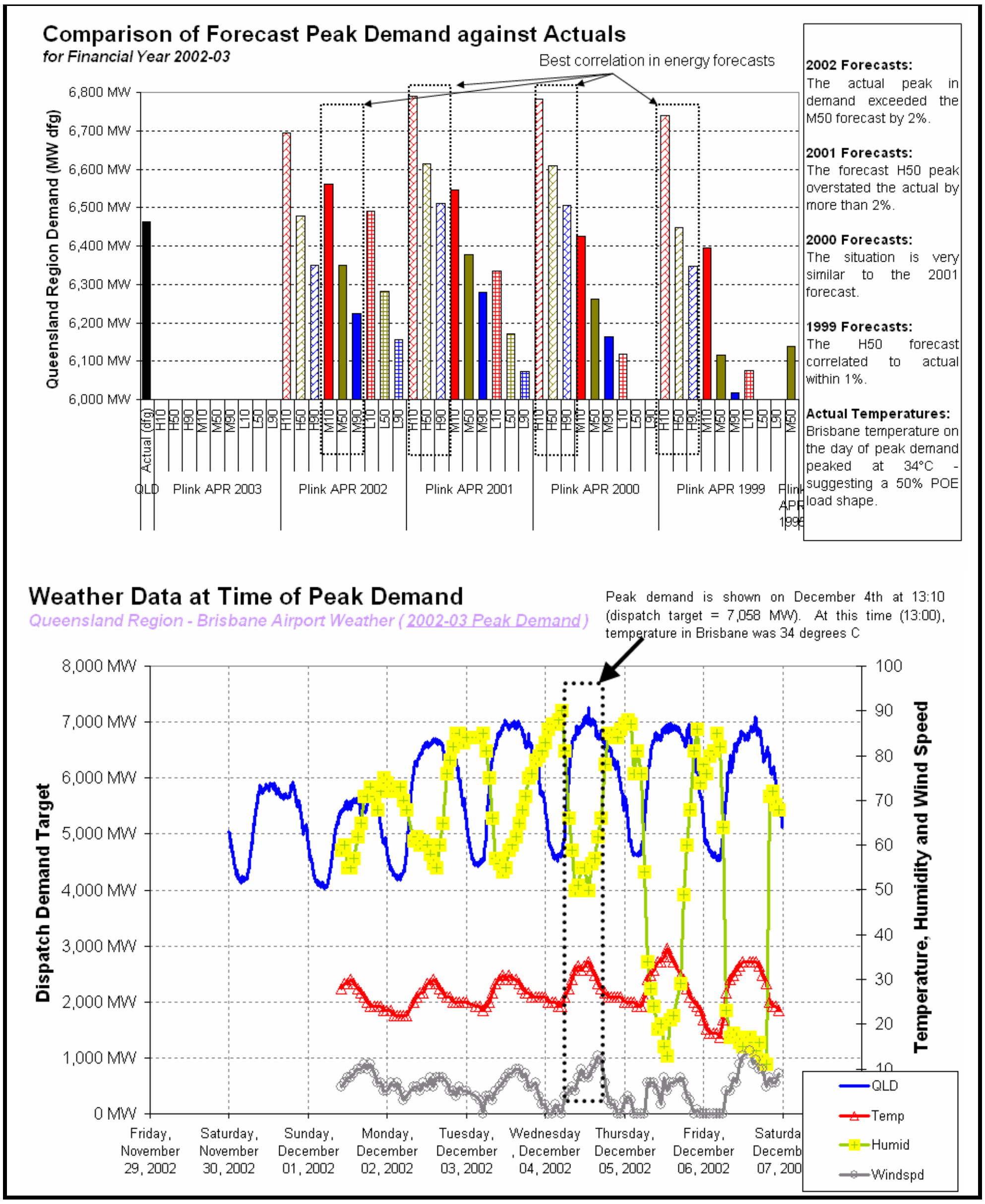
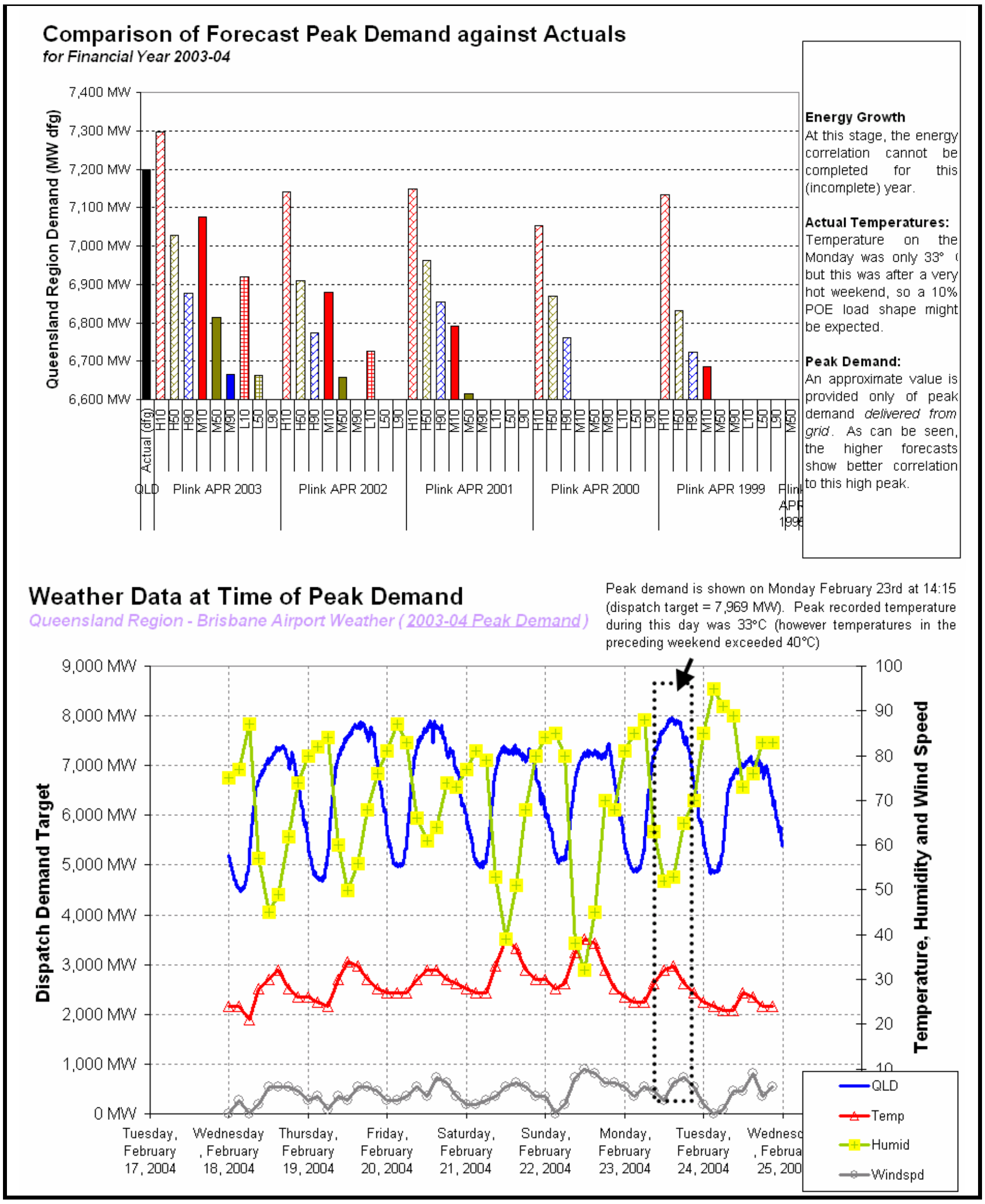


Figure A3·05 Comparing Forecast and Actual Peak Demand
Queensland Region (2003-04)



As a result of this analysis for Queensland it can be concluded that even though on occasions the projections in peak demand have turned out to be an accurate reflection on reality, there are sufficient examples where this has not been the case to reinforce the need for all projections to be modeled in order to deliver a robust assessment of the future of the region.

APP 3-1-2) NSW

The following charts illustrate the results of the analysis performed with respect to the forecasts generated for peak demand growth.

Figure A3·06 Comparing Forecast and Actual Peak Demand
NSW Region (1999-00)

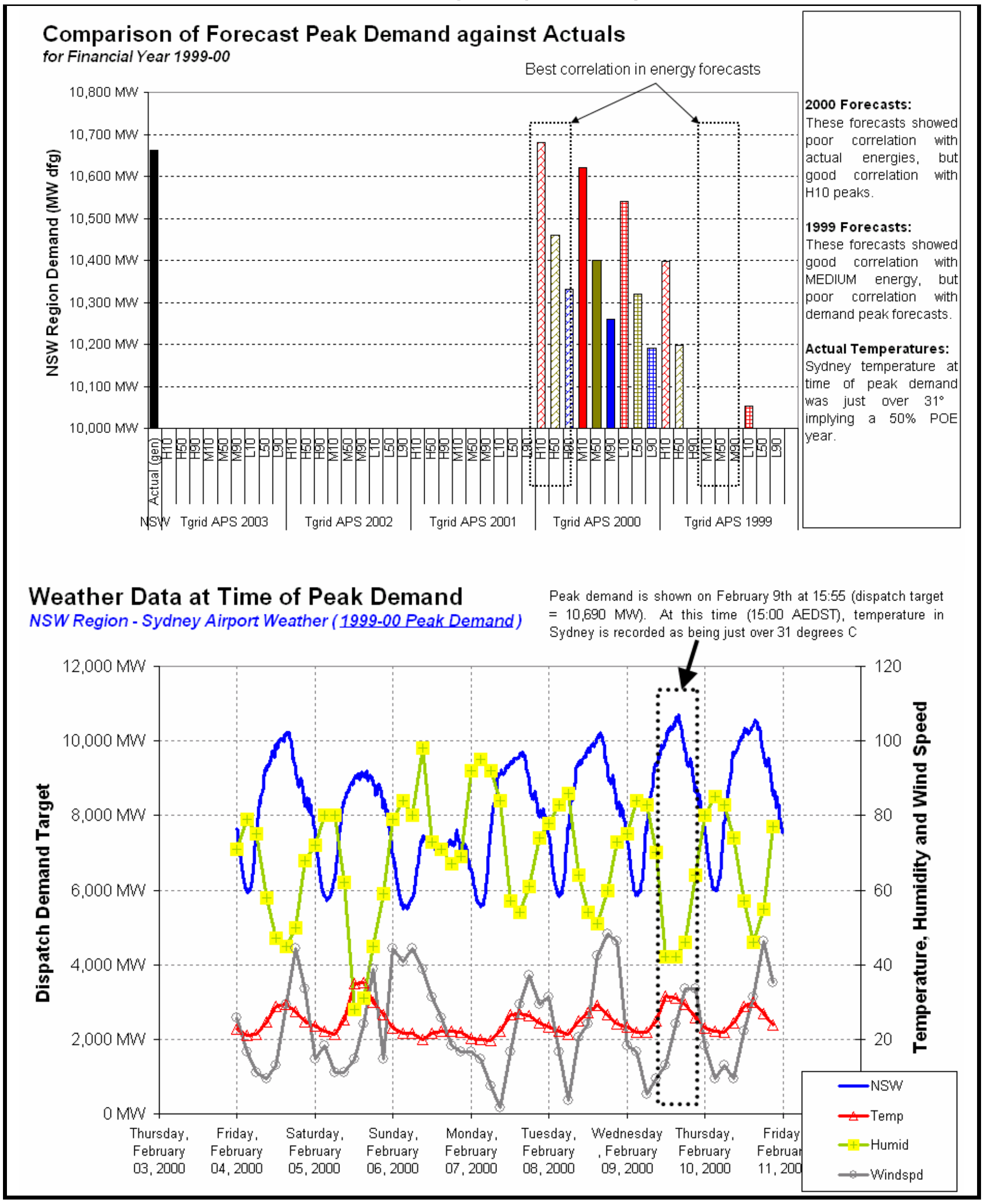


Figure A3·07 Comparing Forecast and Actual Peak Demand
NSW Region (2000-01)

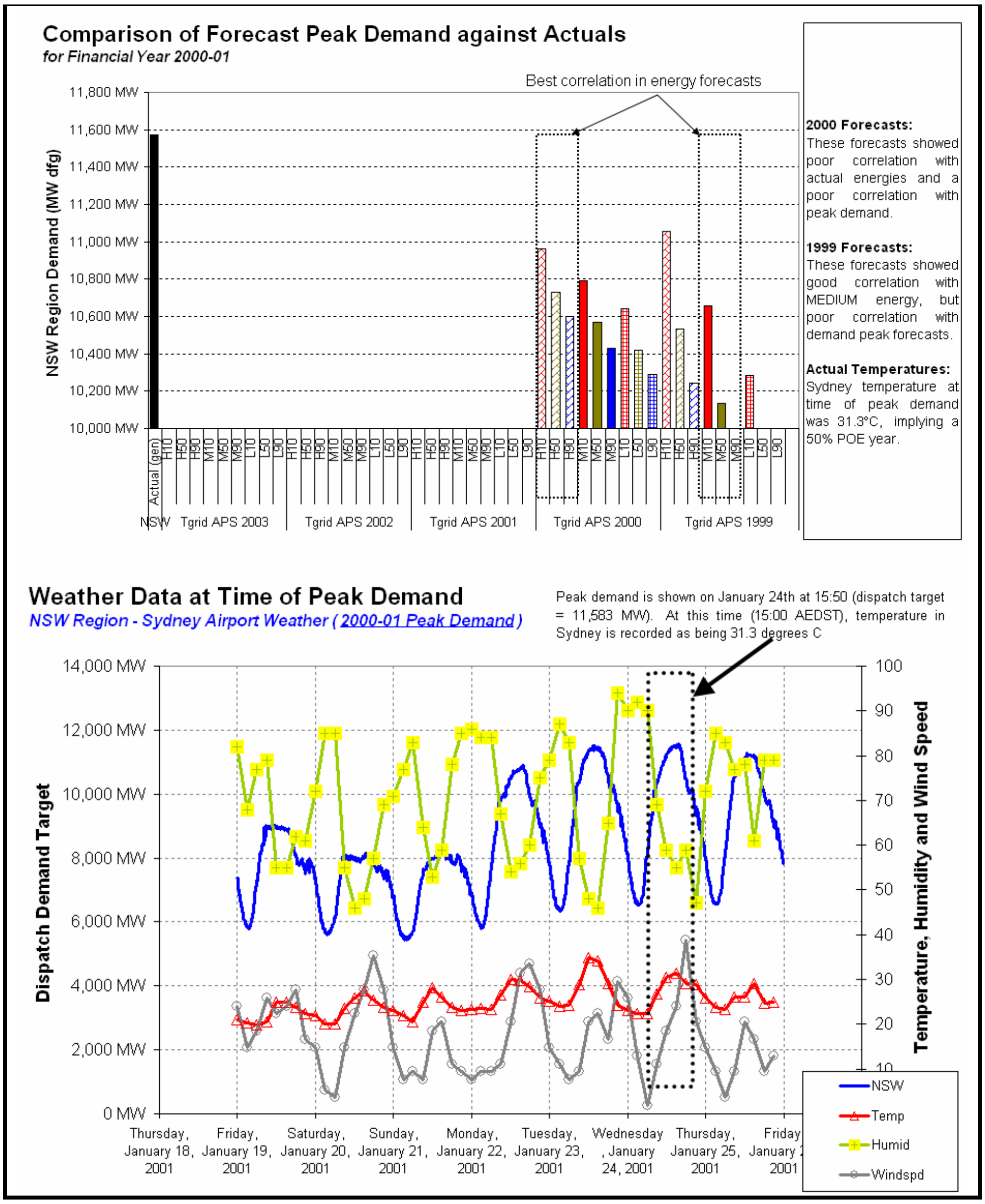


Figure A3·08 Comparing Forecast and Actual Peak Demand
NSW Region (2001-02)

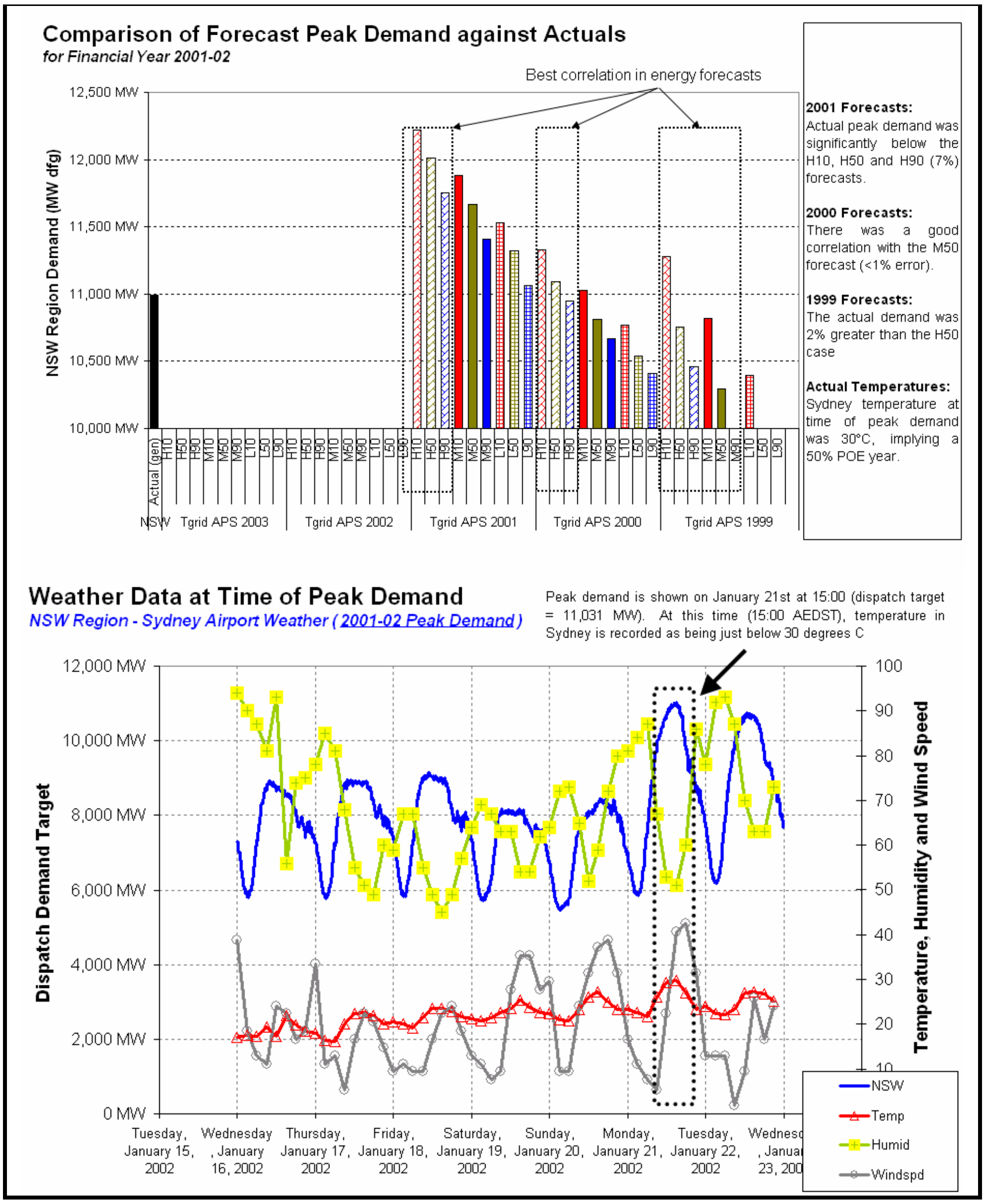


Figure A3·09 Comparing Forecast and Actual Peak Demand
NSW Region (2002-03)

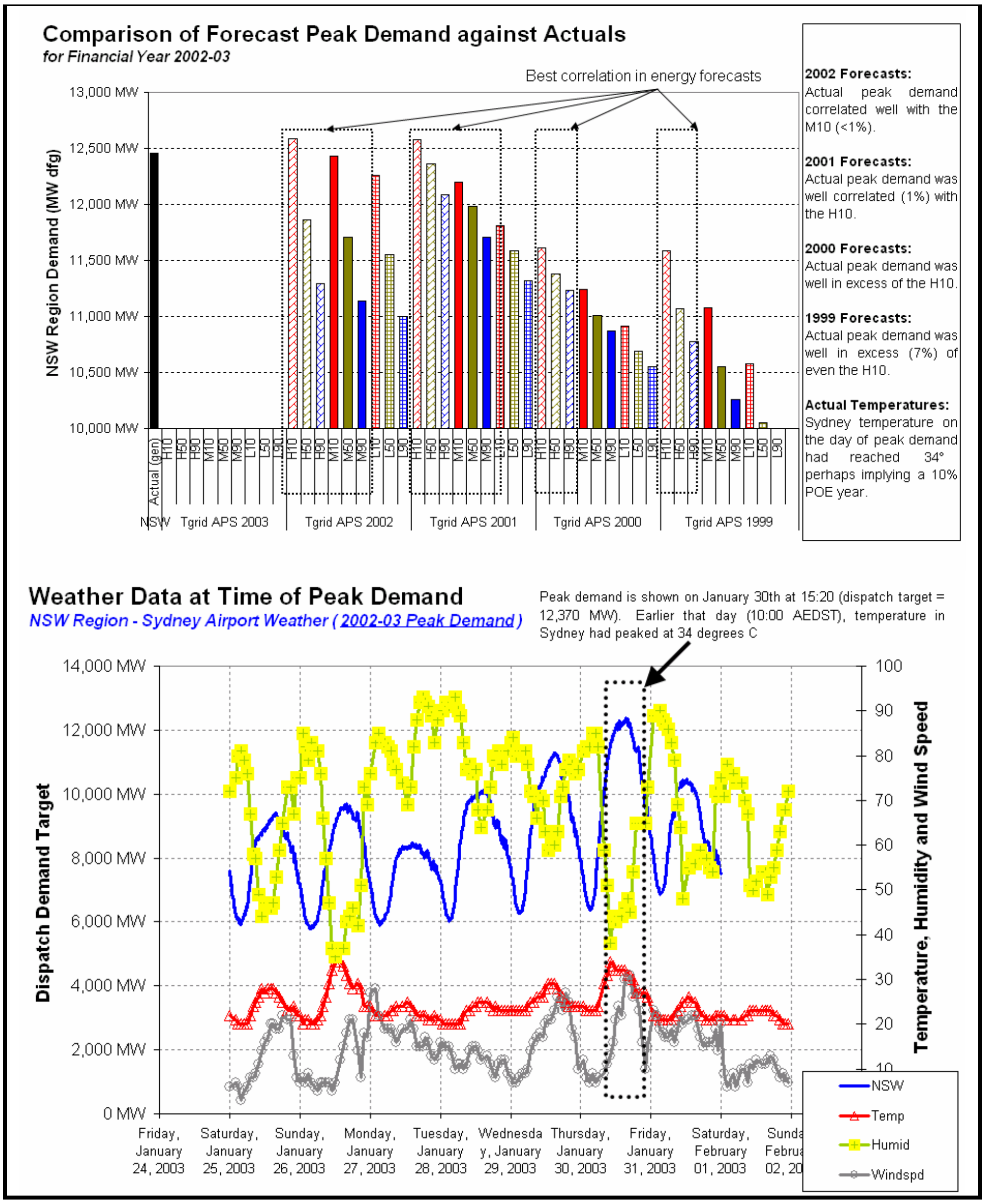
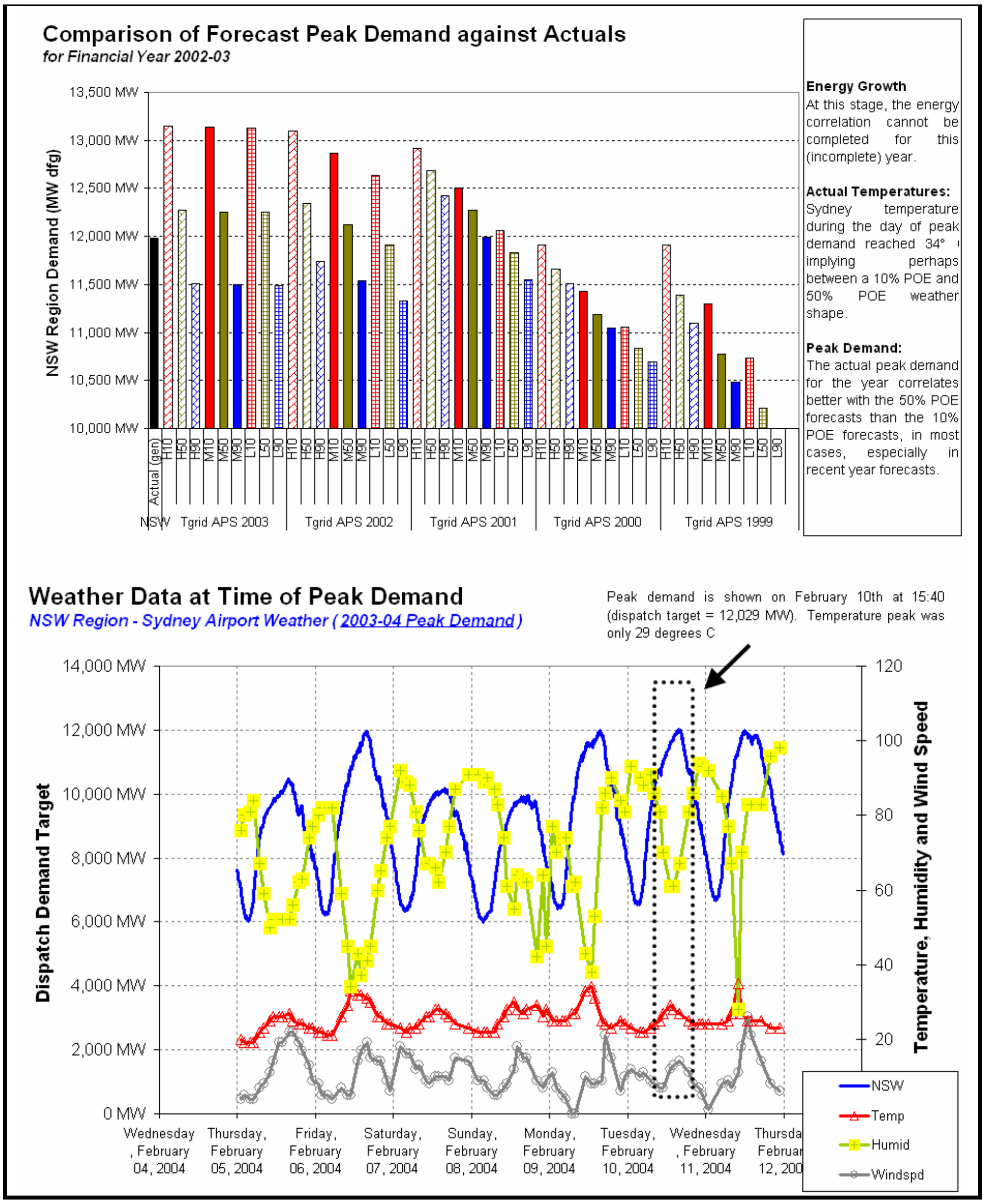


Figure A3·10 Comparing Forecast and Actual Peak Demand *NSW Region (2003-04)*



As a result of this analysis for NSW it can be concluded that even though on occasions the projections in peak demand have turned out to be an accurate reflection on reality (though not necessarily for the relevant weather shape and economic scenario), there are sufficient examples where this has not been the case to reinforce the need for all projections to be modeled in order to deliver a robust assessment of the future of the region.

APP 3-1-3) VICTORIA

The following charts illustrate the results of the analysis performed with respect to the forecasts generated for peak demand growth.

Figure A3·11 Comparing Forecast and Actual Peak Demand
Victoria Region (1999-00)

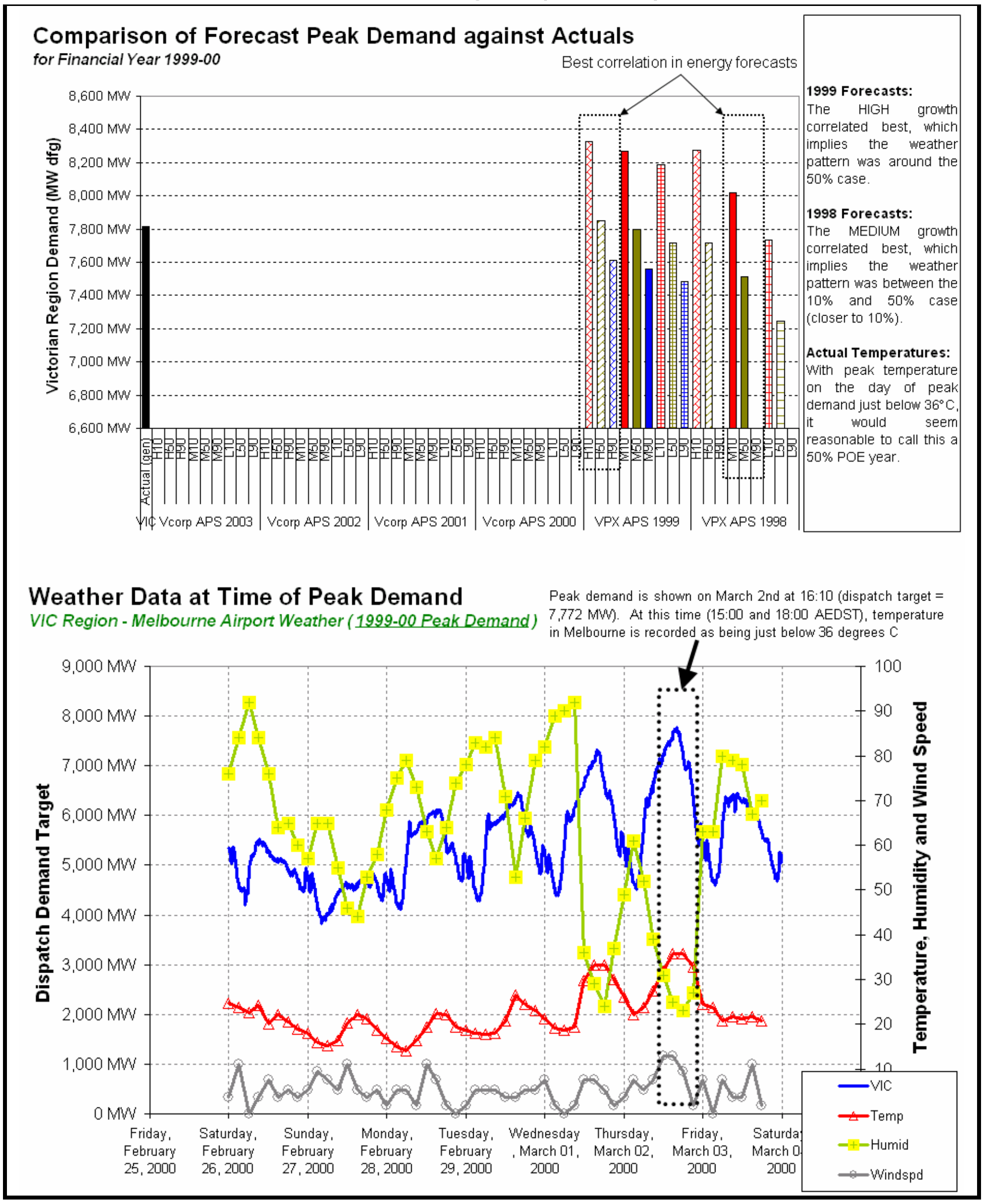


Figure A3·12 Comparing Forecast and Actual Peak Demand
Victoria Region (2000-01)

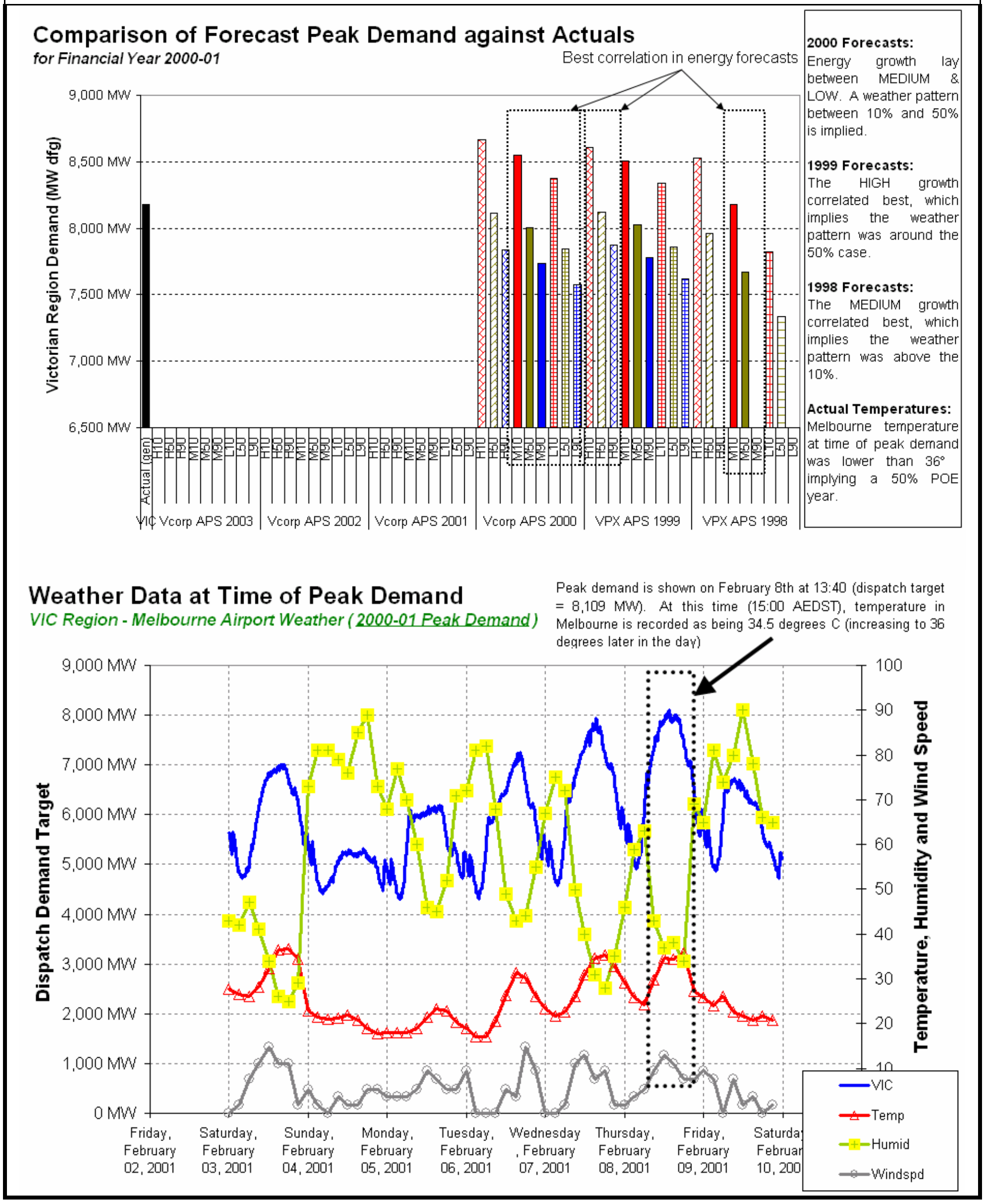


Figure A3·13 Comparing Forecast and Actual Peak Demand
Victoria Region (2001-02)

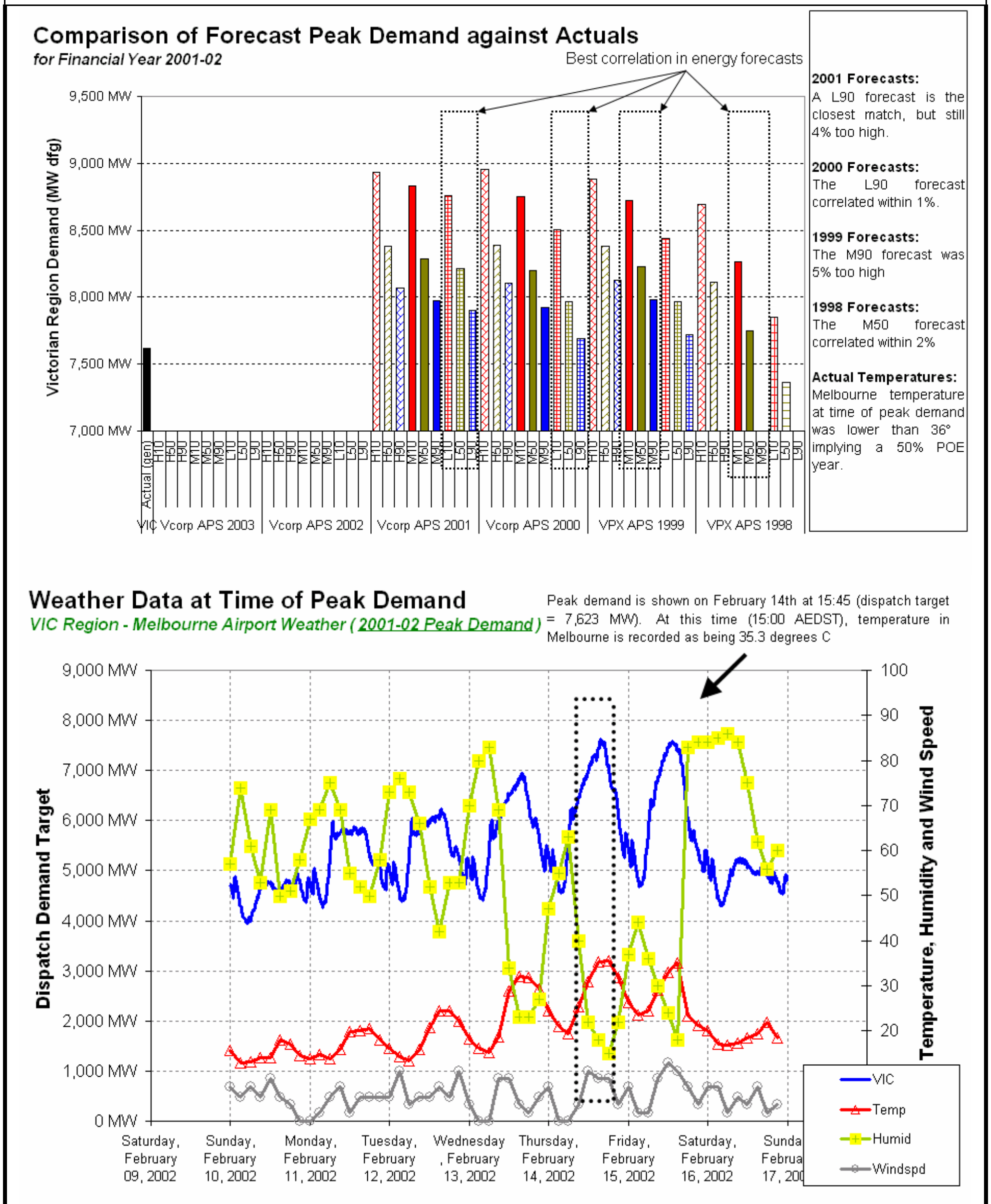


Figure A3·14 Comparing Forecast and Actual Peak Demand
Victoria Region (2002-03)

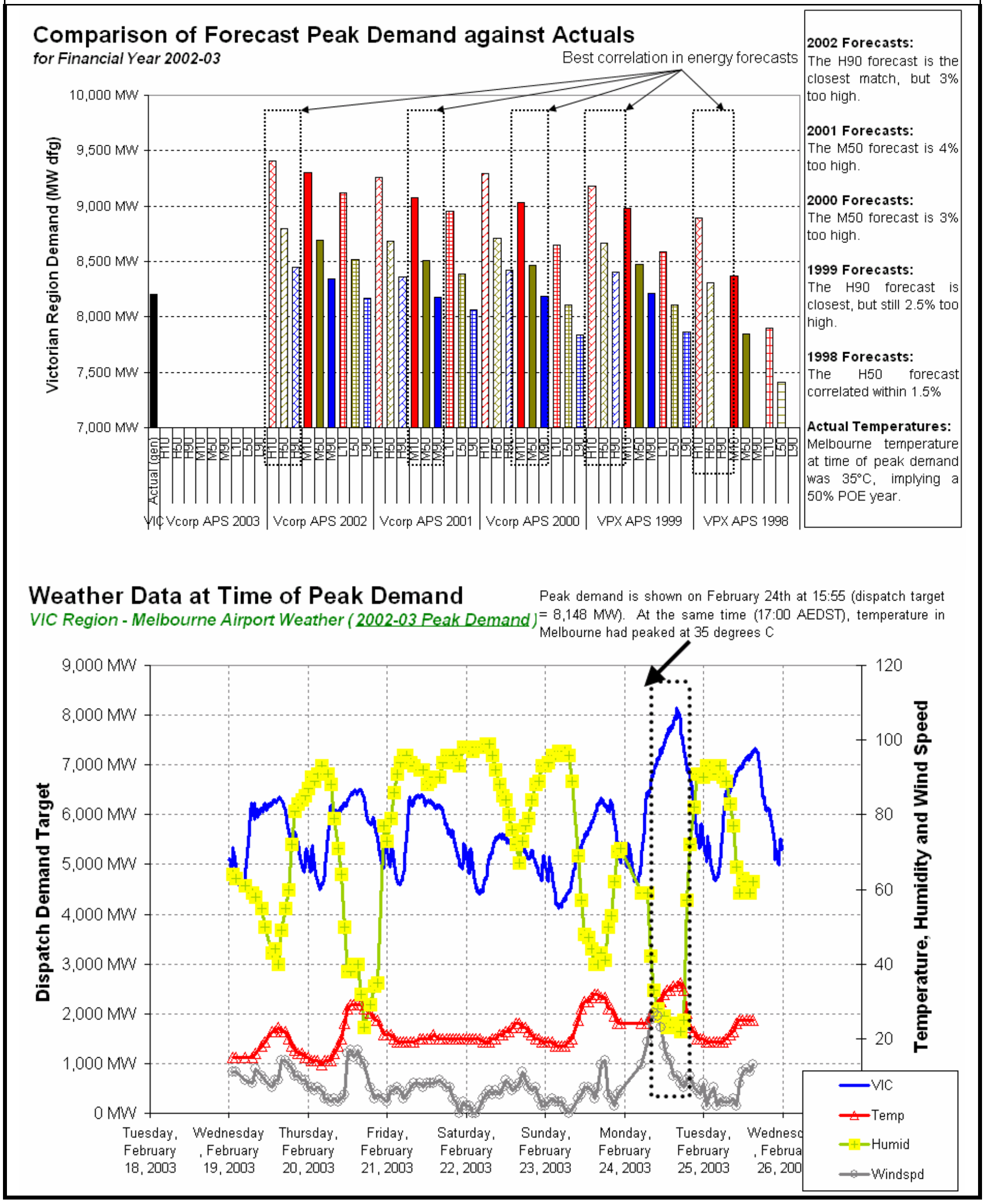
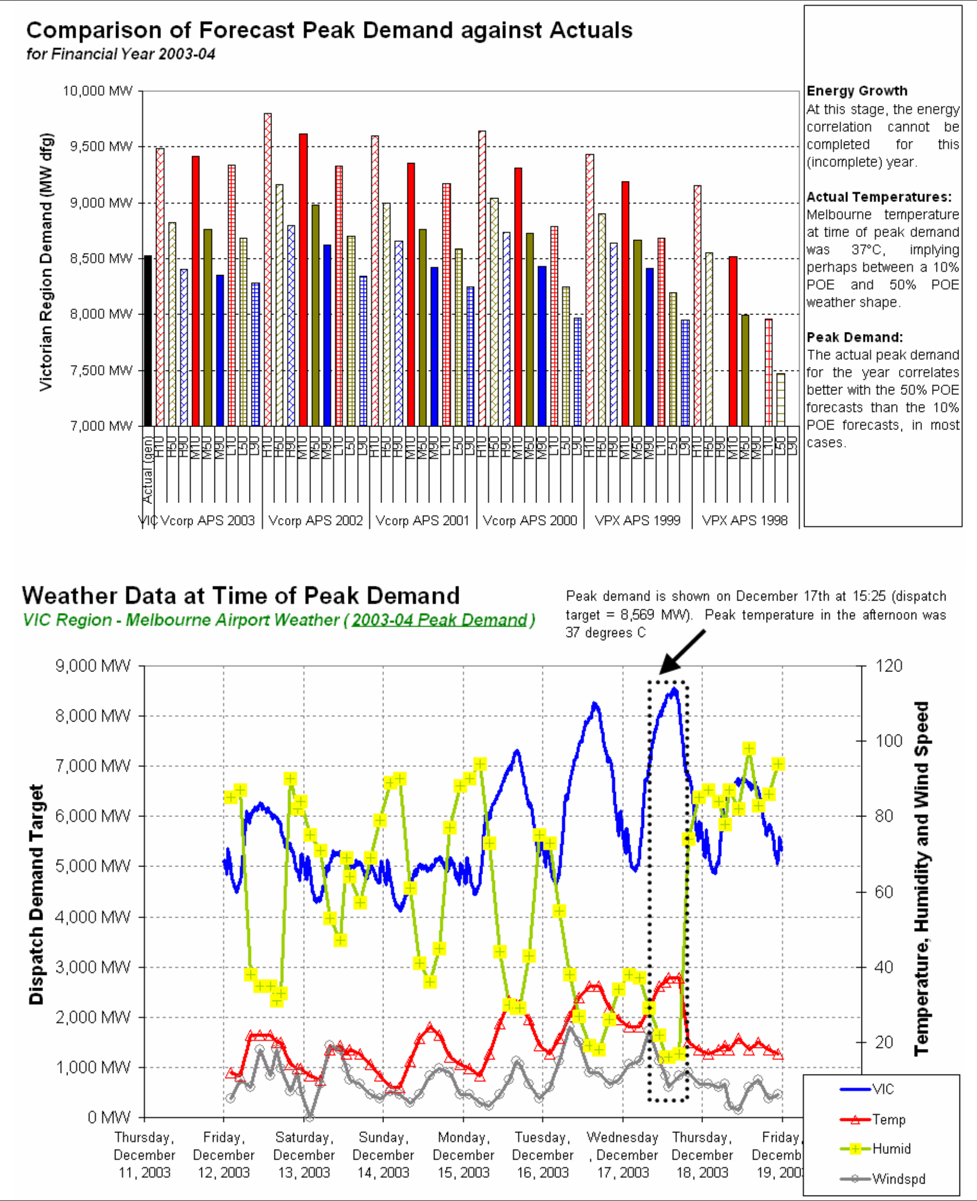


Figure A3·15 Comparing Forecast and Actual Peak Demand
Victoria Region (2003-04)



As a result of this analysis for Victoria it can be concluded that even though on occasions the projections in peak demand have turned out to be an accurate reflection on reality (though not necessarily for the relevant weather shape and economic scenario), there are sufficient examples where this has not been the case to reinforce the need for all projections to be modeled in order to deliver a robust assessment of the future of the region.

APP 3-1-4) SOUTH AUSTRALIA

The following charts illustrate the results of the analysis performed with respect to the forecasts generated for peak demand growth.

Figure A3·16 Comparing Forecast and Actual Peak Demand
South Australian Region (1999-00)

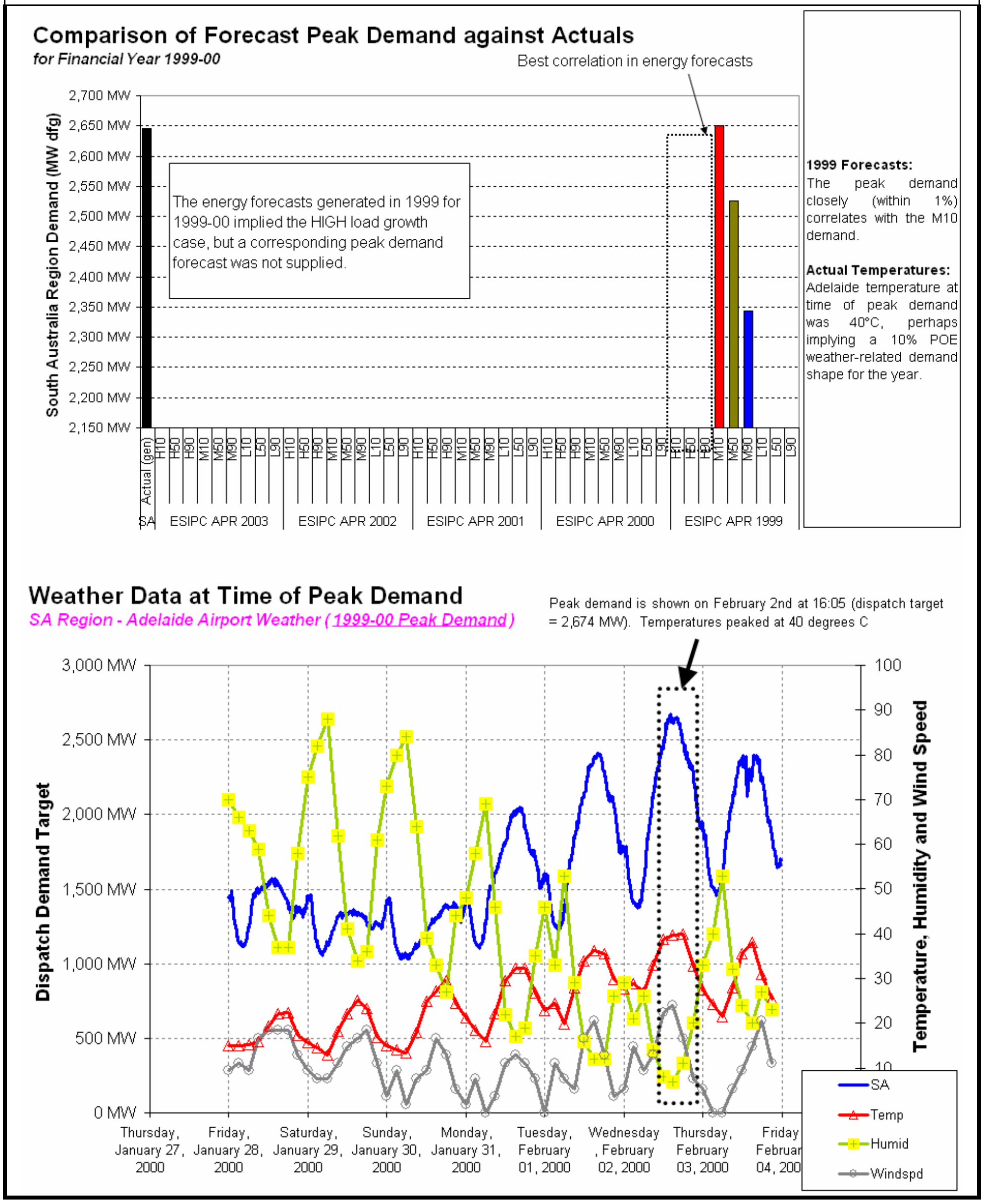


Figure A3·17 Comparing Forecast and Actual Peak Demand
South Australian Region (2000-01)

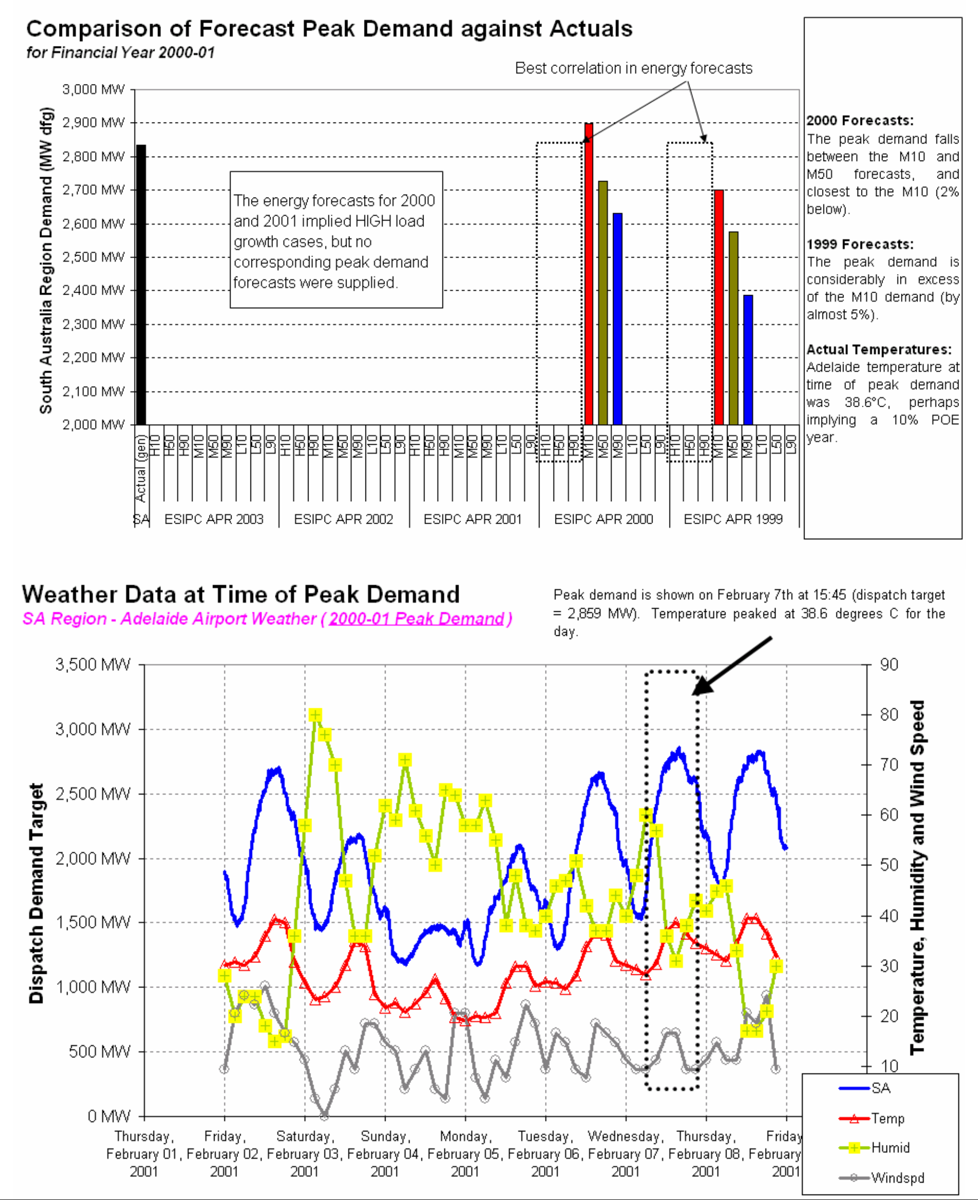


Figure A3·18 Comparing Forecast and Actual Peak Demand
South Australian Region (2001-02)

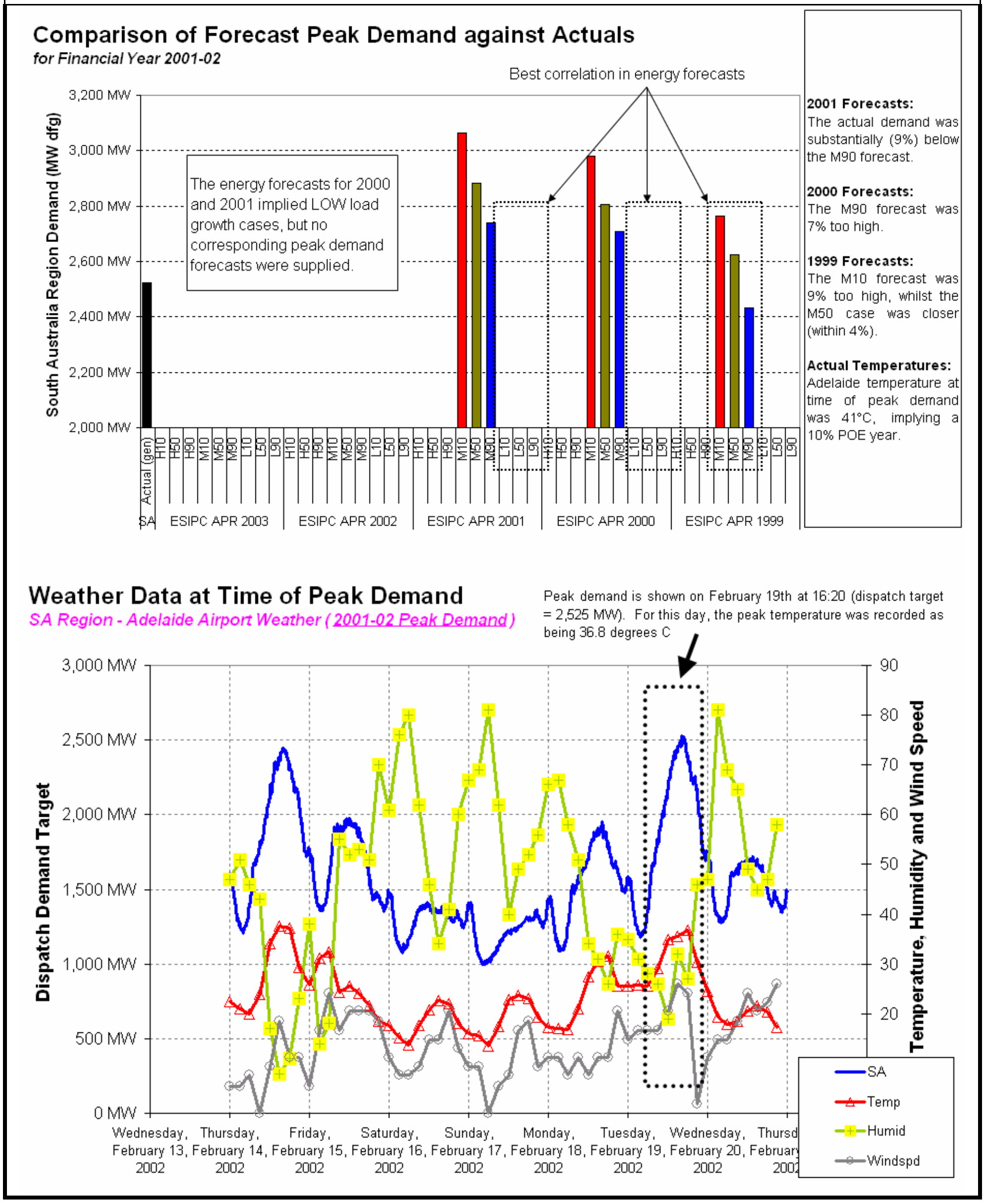


Figure A3·19 Comparing Forecast and Actual Peak Demand
South Australian Region (2002-03)

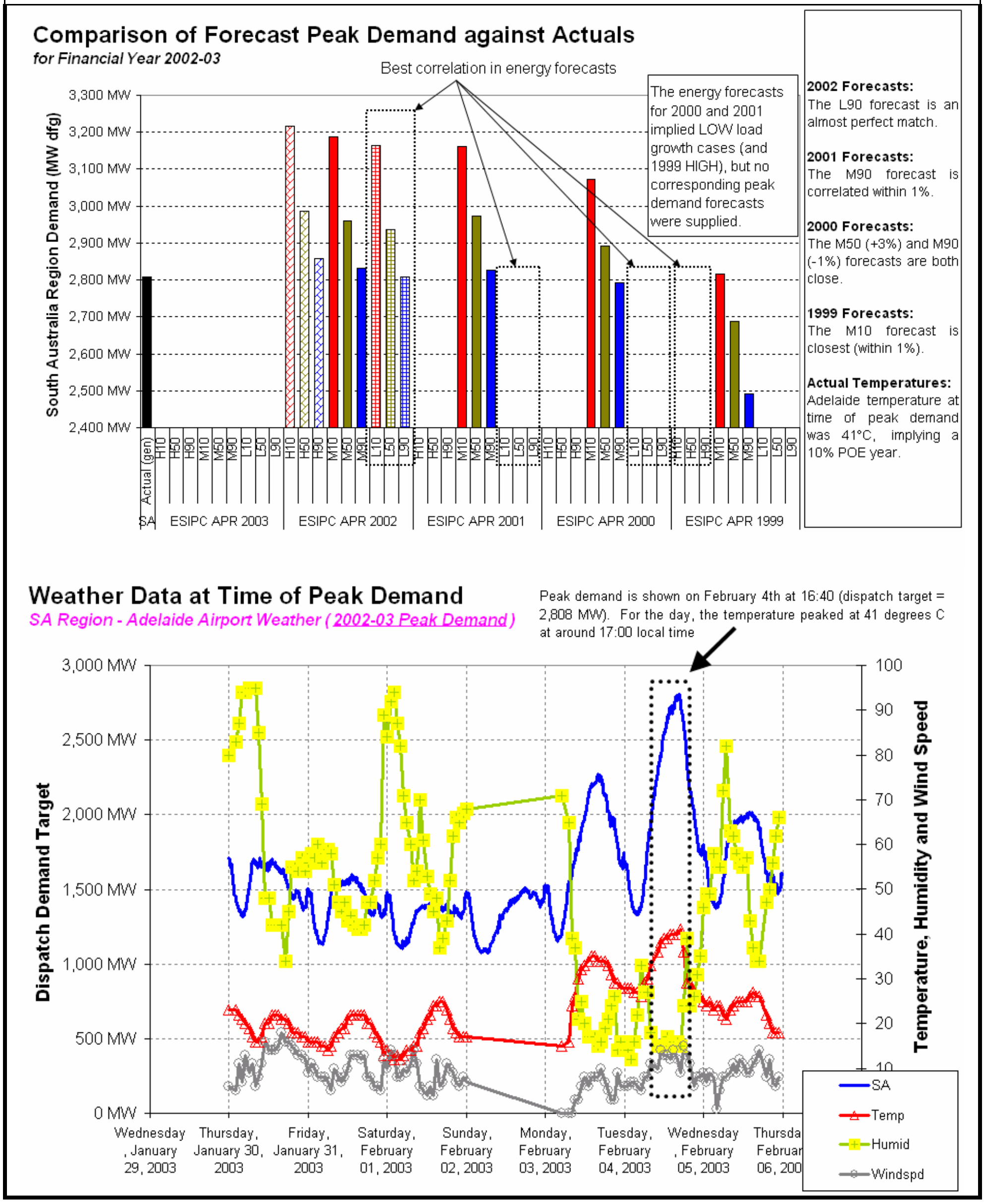
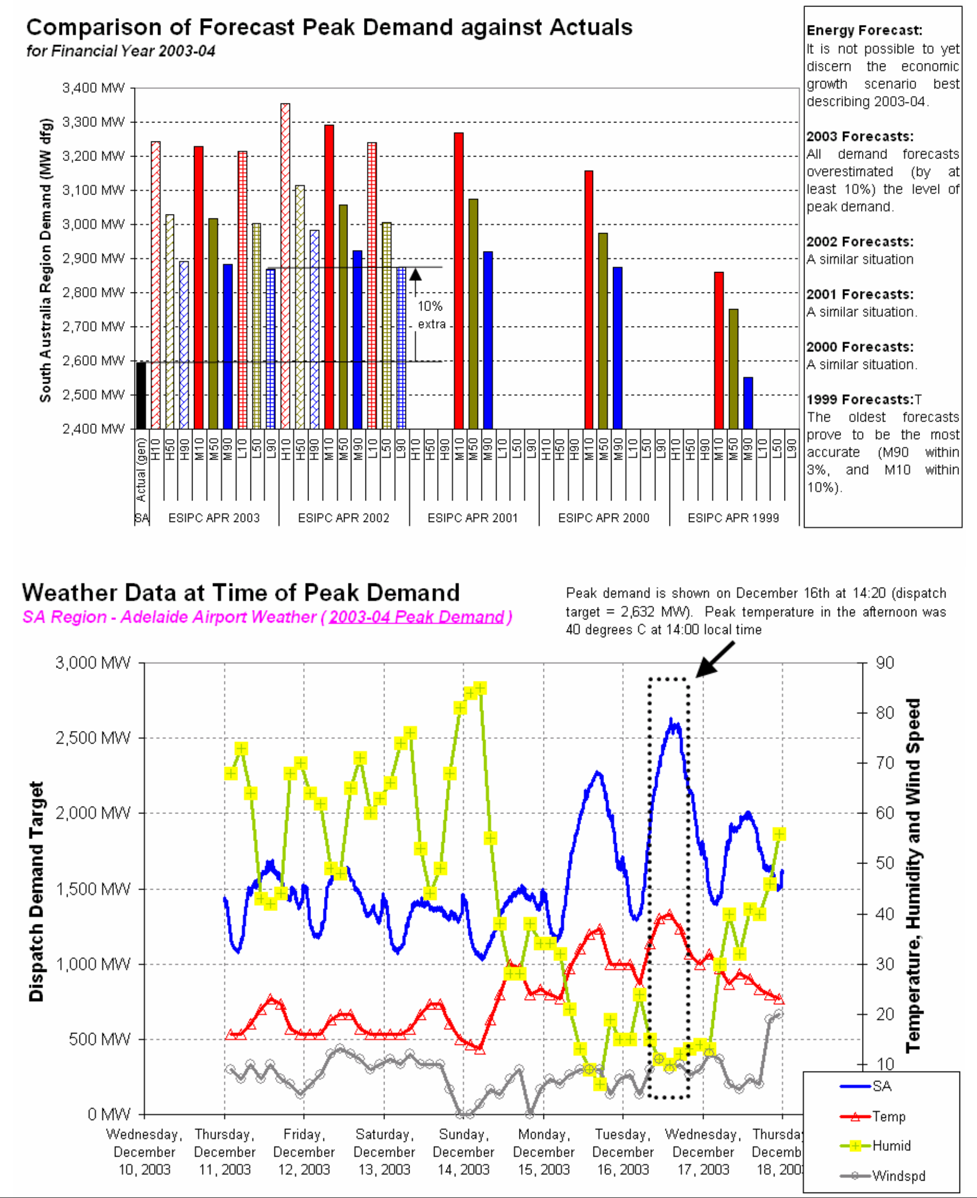


Figure A3·20 Comparing Forecast and Actual Peak Demand
South Australian Region (2003-04)



As a result of this analysis for South Australia it can be concluded that even though on occasions the projections in peak demand have turned out to be an accurate reflection on reality (though not necessarily for the relevant weather shape and economic scenario), there are sufficient examples where this has not been the case to reinforce the need for all projections to be modeled in order to deliver a robust assessment of the future of the region.

App3·2) NEM-Wide Instantaneous Reserve Margin

In section 5, a number of diagrams were included to illustrate the trend in the levels of NEM-wide Instantaneous Reserve margin.

As explained in that section, the Instantaneous Reserve Margin was calculated for each dispatch interval over the 29-month period from September 2001 through till the end of February 2004. The following series of charts illustrate the distribution of this measure, on a monthly basis, over the period.

Figure A3·21 Historical Distribution of Reserve Margin
Whole of NEM

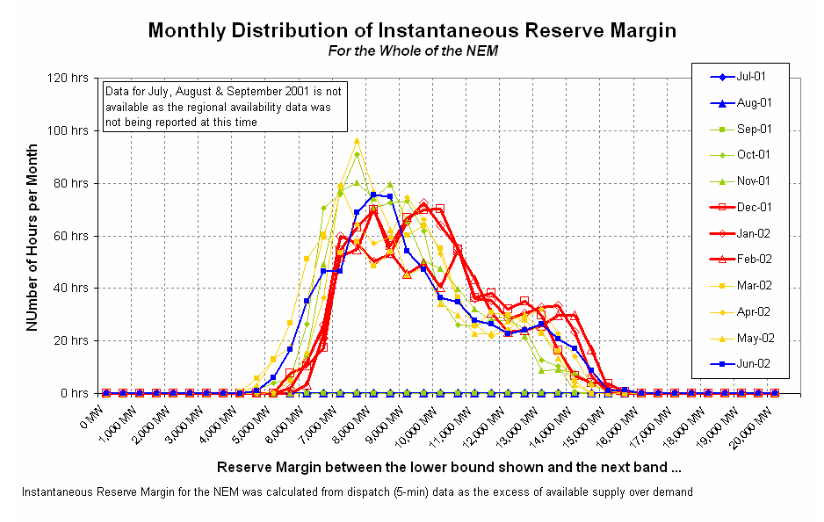
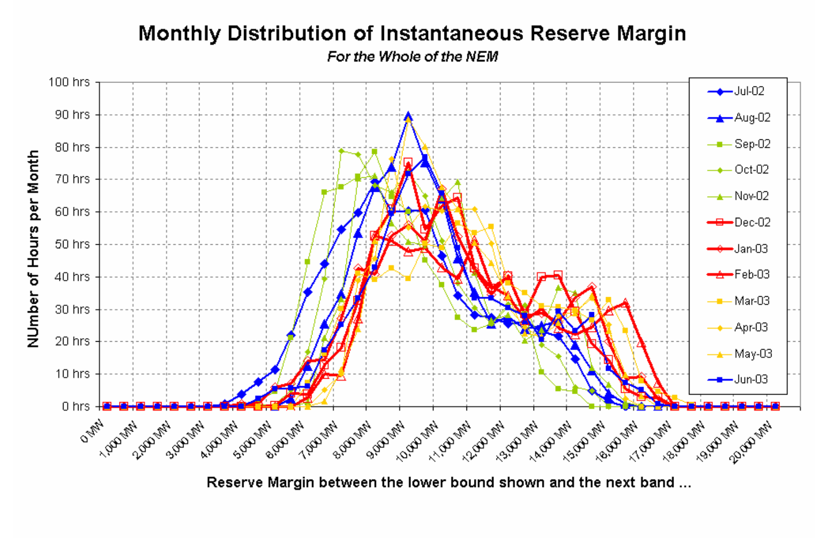
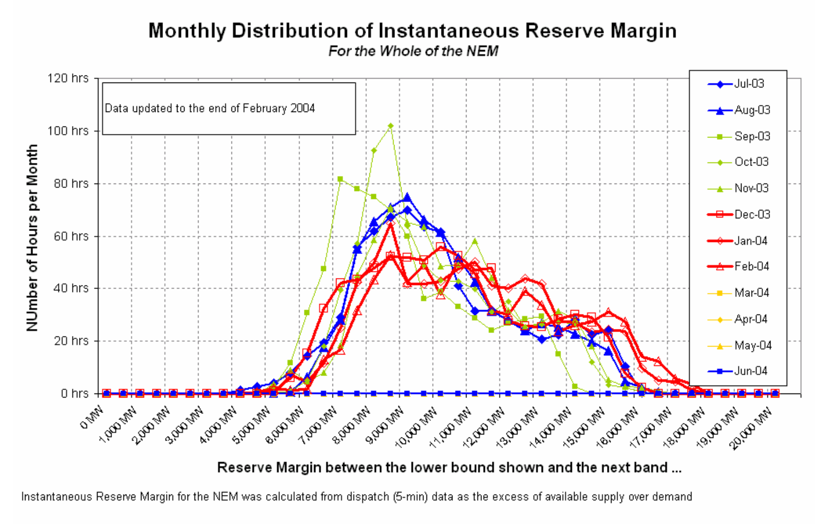
2001/02	
2002/03	

Figure A3·21 Historical Distribution of Reserve Margin
Whole of NEM

2003/04	

From this diagram it can clearly be seen that the Instantaneous Reserve Margin across the NEM:

- Has generally been between 7,000MW and 10,000MW over the 29 months studied;
- Has never dropped below 3,000MW, and rarely drops below 4,000MW (note that the cumulative Intervention Reserve Threshold across the NEM currently stands at 1,640MW); and
- Has generally increased over the past 29 months as a result of the development of more than 3,000MW of new capacity across the NEM in the same period.

App3·3) Instantaneous Regional Reserve Margin

As outlined in section 5, a similar calculation can be performed for each individual region. However, this calculation is complicated by the presence of instantaneous imports or exports from the region.

There are a number of different methods by which these could be taken into account. ROAM Consulting has formulated an Instantaneous Regional Reserve measure as follows:

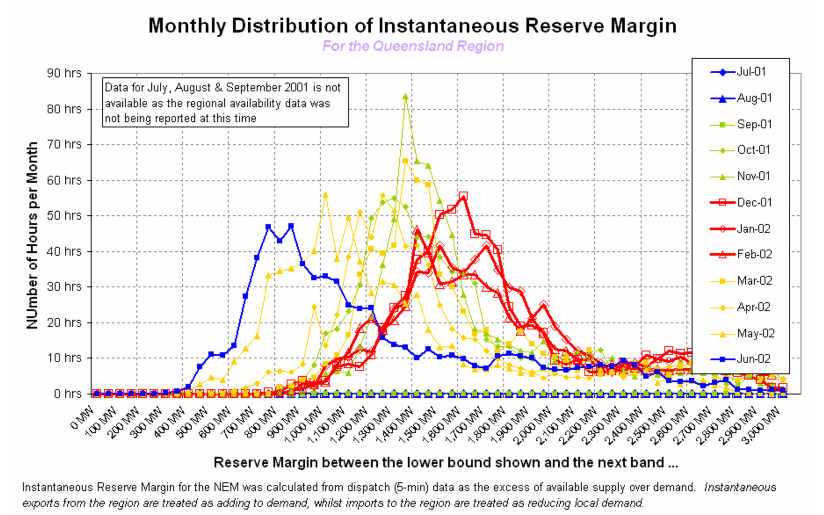
Instantaneous Regional Reserve = Available Supply – (Demand + Exports – Imports)

In this way, the Instantaneous Regional Reserve will provide an indication of the extent to which a region could supply its own reserve requirements without impacting on the existing transmission flows.

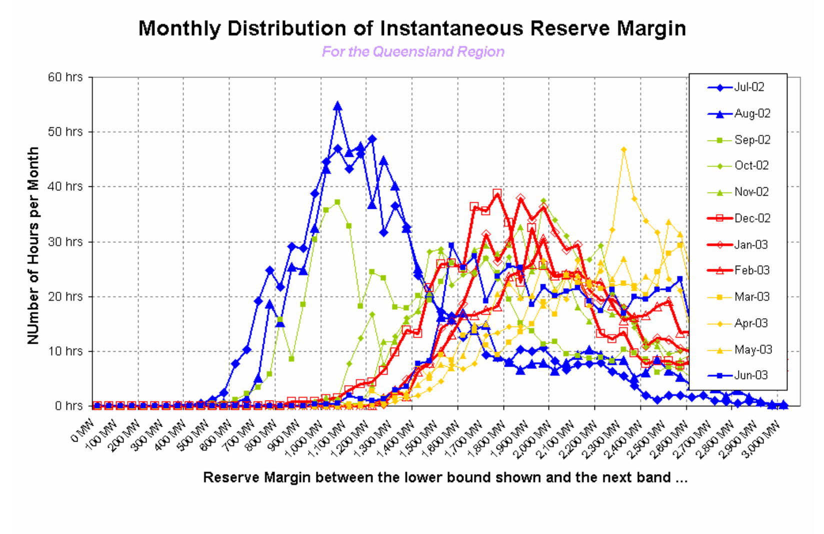
The calculation has been performed for the Queensland region, with the results shown in the following three charts.

Figure A3·22 Historical Distribution of Reserve Margin
Queensland

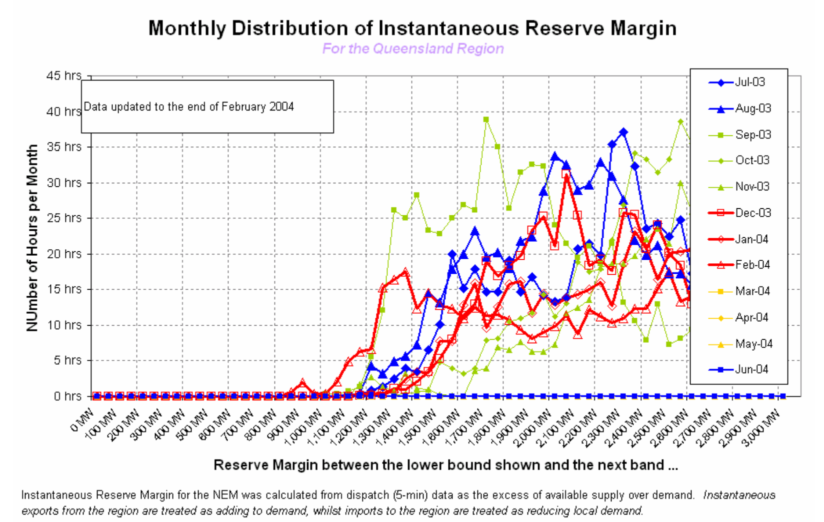
2001/02



2002/03



2003/04



In this series, it can clearly be seen that the local reserves in Queensland have increased greatly as a result of the development of new capacity in the region (and despite higher average exports from the region).

A similar calculation has been performed for the NSW region, with the results shown below:

Figure A3·23 Historical Distribution of Reserve Margin
NSW

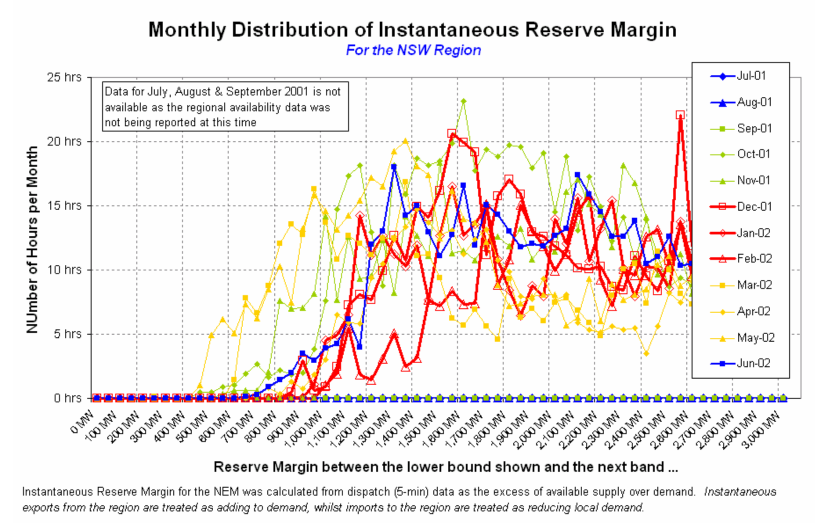
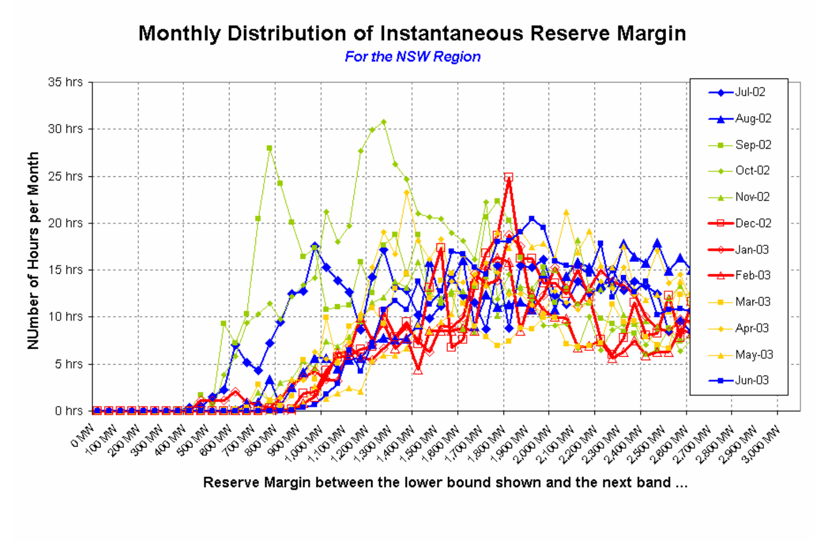
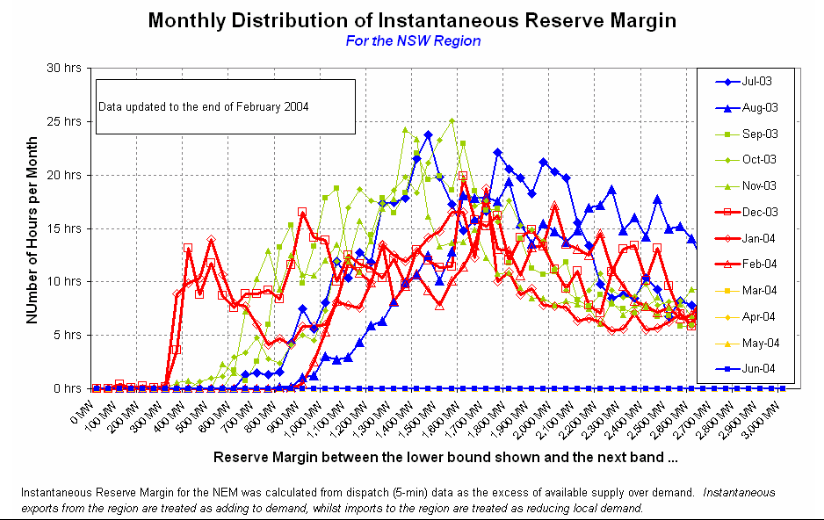
2001/02	
2002/03	

Figure A3·23 Historical Distribution of Reserve Margin
NSW

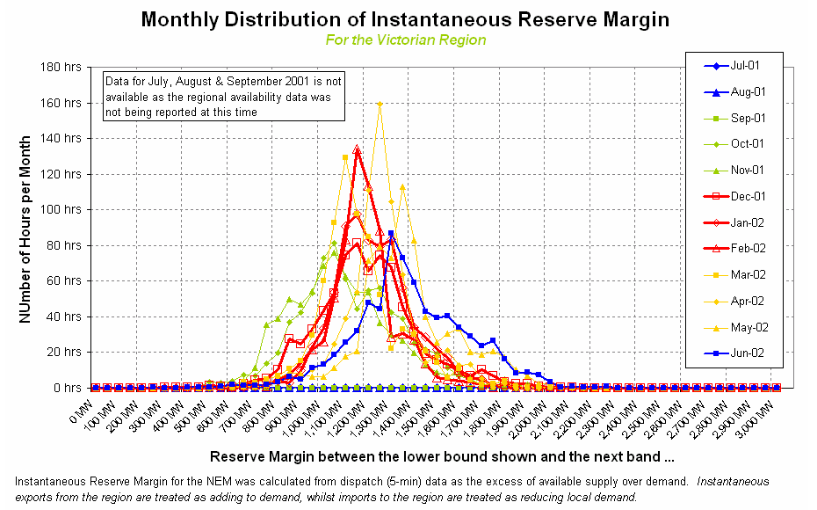
2003/04	

Once again, the impact of the new plant in Queensland can be seen – with the exception of the summer months, when typically lower net transfers into NSW from Queensland are seen due to the higher local demand in Queensland.

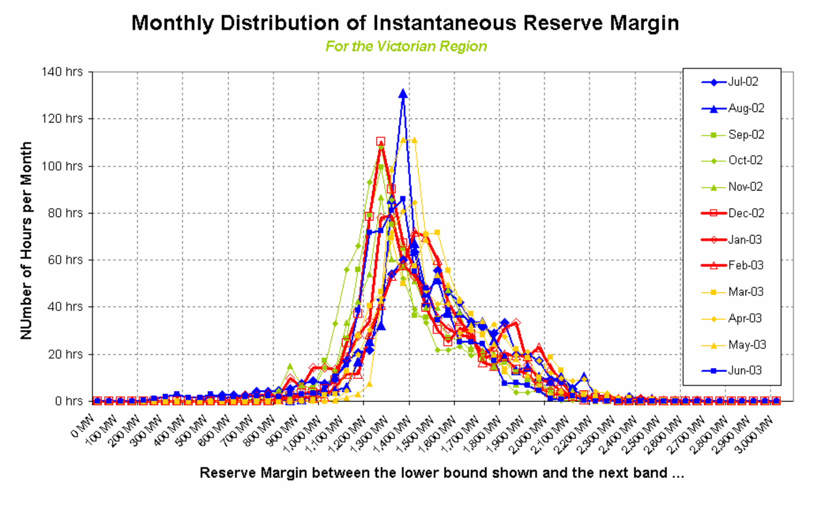
The following series illustrates the monthly distributions applicable to Victoria.

Figure A3.24 Historical Distribution of Reserve Margin
Victoria

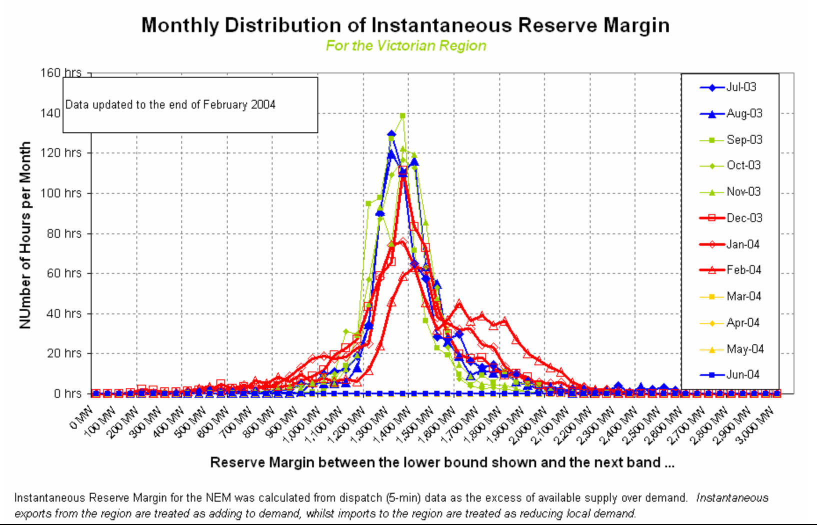
2001/02



2002/03



2003/04



These charts illustrate how (provided the interconnection capacity could be relied upon), Victoria has experienced high levels of local reserve capacity.

Finally, a similar trend has been included for South Australia.

Figure A3.25 Historical Distribution of Reserve Margin
South Australia

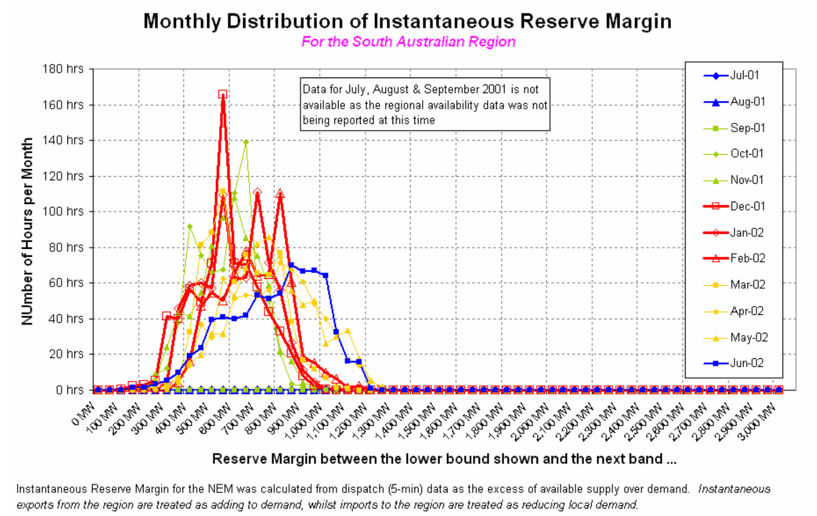
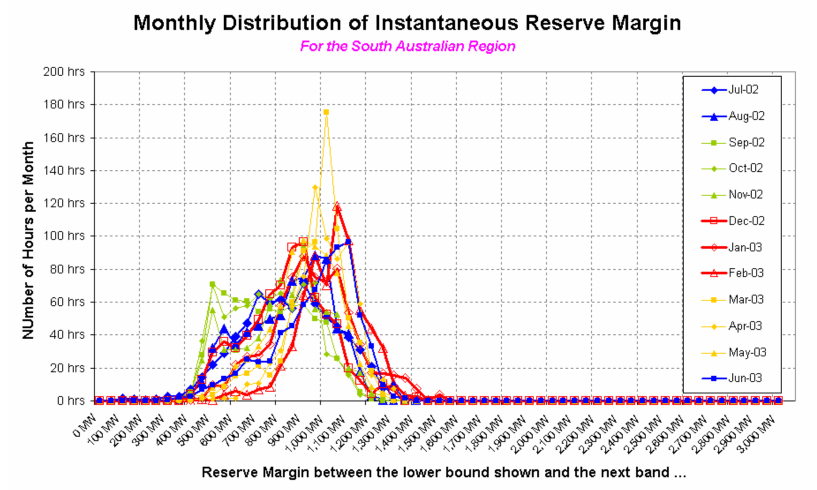
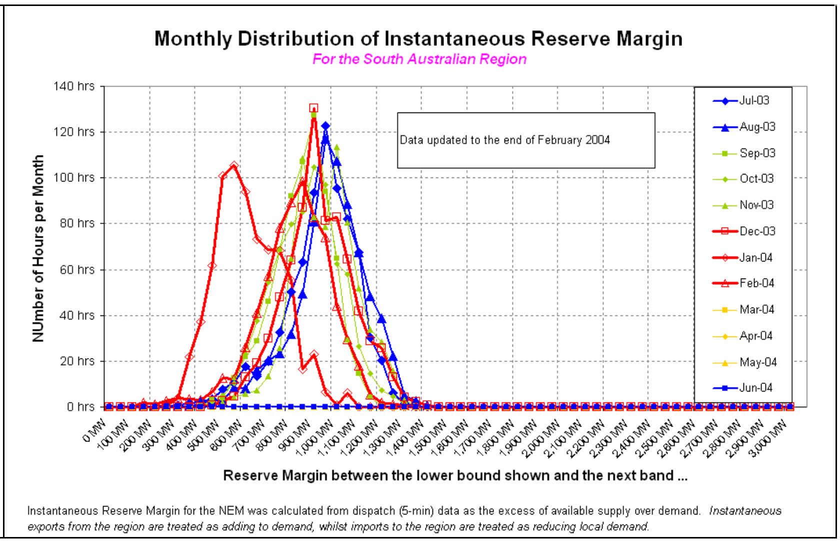
<table>
<tr>
<td>2001/02</td>
<td>
</td>
</tr>
<tr>
<td>2002/03</td>
<td>
</td>
</tr>
</table>

Figure A3.25 Historical Distribution of Reserve Margin
South Australia

2003/04	

These charts illustrate how, with the exception of January 2004, local available reserves in South Australia have also increased over the past 29 months.

APP 4) THE MODELLING OF THE MEDIUM FOR CASE

App4·1) The Model Used

APP 4-1-1) THE FORECASTING PROCESS

ROAM Consulting used the 2-4-C market-forecasting package in delivering this assessment. For this study, the latest upgraded version of 2-4-C incorporating significant advances in modeling has been used.

APP 4-1-2) THE STANDARD VERSION OF 2-4-C

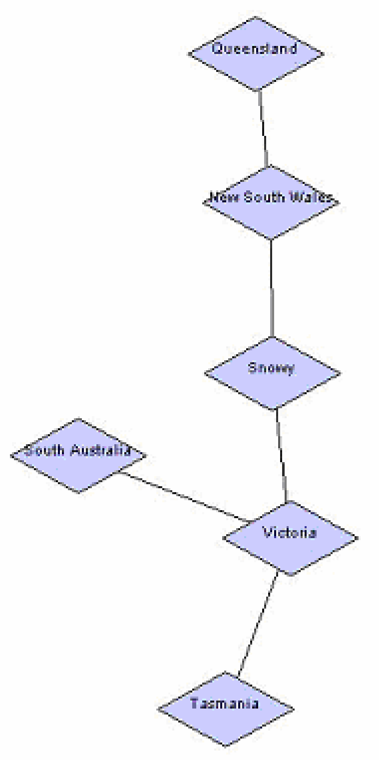
All constraint limitations between nodes (or groups of nodes) are accurately taken into consideration in the LP-based dispatch algorithm (for each discrete half hour time interval).

Hence, we are able to derive a flow distribution (for each discrete half hour time interval) across all links in the market model. This data can thus be analysed to reveal:

- Trends in bulk energy transfers over these links; and
- Trends in the incidence of transmission constraints.

The data generated by 2-4-C allows analysis to be performed on a half hourly basis.

The incidence of constrained flow over the networks between regions has a substantial influence on electricity pricing and generation levels across the NEM.



2-4-C simulates dispatch of the NEM based on a large range of assumptions with respect to the supply and demand sides, the market and the electricity system.

Key features of the 2-4-C forecasting tool include the following:

❖ Dispatch is modeled on a half-hourly basis, with approximately 17,520 discrete time periods modeled for each year;

- The LP-based dispatch optimisation engine (that has been designed to mimic the processes of the SPD market dispatch engine) ensures accurate consideration of all existing and proposed intra- and inter-regional interconnectors, and

- Use of multiple simulation-years of the Advanced Mode of generator outage simulation can ensure appropriate consideration of the impact of simultaneous generator unit outages

- ROAM Consulting has incorporated the full suite of dynamic constraint equations provided in the NEM Supply-Demand calculator to dynamically calculate transmission flow limits based on simulated operating conditions in every half hour of simulation.

Please contact ROAM Consulting if you wish further information on the 2-4-C Market Forecasting software.

App4·2) Input Assumptions

APP4·2·1) DEMAND

The load traces used in this study have been built by ROAM Consulting from historical load shapes. Separate shapes have been prepared for each region for 10% and 50% POE years, based on appropriate load shapes from the five years of available data (since the start of the NEM).

The years that have been chosen as representative load shapes for the 50% and 10% POE forecasts are shown in the following table. They are the same reference years selected by NEMMCO for recent market assessments as detailed in the *2003 Review of Minimum Reserve Levels - for South Australia and Victoria* (NEMMCO, 2004).

Table A4·01 – Reference Years for Demand Forecasts

Reference year	**50% POE demand**	**10% POE demand**
Queensland	2000/01	2002/03
New South Wales	2000/01	2002/03
Victoria	2002/03	2000/01
South Australia	2002/03	2000/01
Tasmania	1999/00	1999/00

Loads have been grown to conform to the energy and demand forecasts provided by NEMMCO in the 2003 SOO.

The following table shows the individual region peak demands and the aggregate diversified demand that has been modelled for the probabilistic simulations.

The 2004/05 financial year is shown as an example year (all years modelled will follow the same pattern)

Table A4·02 – Diversified and Undiversified Peak Demands – 2004/05

Region	**50% POE peak demand**	**10% POE peak demand**
QLD	8,132 MW	8,448 MW
NSW	13,040 MW	13,680 MW
VIC	9,045 MW	9,730 MW
SA	3,093 MW	3,312 MW
TOTAL (undiversified)	33,310 MW	35,170 MW
TOTAL (diversified as modelled)	30,715 MW	33,278 MW
Percent Margin	**7·8%**	**5·4%**

It is noted that the margins apparent in the input data used in this modelling contain a slightly greater degree of diversity than was apparent in recent historical years.

Since the demand forecasts are built from actual historical load shapes, they inherently have diversity in them. The effects of reduced or increased diversity can be studied by realigning the peaks in the different regions, based on the forecast probability of coincidence of extreme weather events in the various regions.

The probability of obtaining coincidence of peak demands will be substantially different for the 10% and 50% POE cases and needs to be separately examined.

As a result of diversity, which will always exist at peak times to some extent, the real reserve margins in the NEM considerably exceed the reserve margins calculated on the basis of no diversity (as is presently the case for the deterministic calculations used by NEMMCO). This tends to present a picture of inadequate reserves.

APP4·2·2) *GENERATING CAPACITY*

The generating capacity data included in this set of forecasts is based upon the 2003 SOO. All projects considered by NEMMCO to have "committed" status are incorporated into the study. Exceptions to the available capacity information found in the SOO are as follows:

- Callide A – Not returned to service during forecast period.
- Wivenhoe – Capacity set to full 500MW (rather than 300MW), but restricted via capacity factor modelling.

Overload capacity is not modelled in this study.

App4·2·2·1) Maintenance Outages

A standardised maintenance schedule was developed for use in these forecasts. The following table summarises the maintenance allocated to all generating units included in the study:

Table A4·03 – Standardised Planned Maintenance Parameters

Type of plant	**Days of maintenance per year**
Thermal coal	18
Gas turbine	7
Combined-cycle / Gas-fired thermal	14
Hydro plant other than Snowy	18
Snowy hydro	37

Maintenance was allocated for each unit by scheduling the large units through to the small units progressively into periods of low demand. The scheduling process results in little or no maintenance in peak periods and the bulk of the maintenance spread over those areas where the load factor is low.

App4·2·2·2) Forced Outage Rates

Standardised Forced Outage Rates were adopted for all units in the NEM. The values used were as specified in the following table:

Table A4·04 – Standardised Forced Outage Rates

Type of plant	**Forced Outage Rate**	**Mean Time to Repair**
Thermal plant	2.5%	24 hrs
Queensland Thermal plant	5.0%	24 hrs
Hydro plant	1.0%	24 hrs

(A Forced Outage Rate of 5% has been assumed for the Medium FOR case for Queensland thermal units, based on the newer generators in that region being less reliable)

App4·2·2·3) Energy limited generation

Fixed generation profiles have been assigned to the Snowy Hydro units in order to ensure its typical energy limits are not breached. When required for reliability purposes, the Snowy units are also able to bid their remaining available capacity. Post-checking was then performed to ensure this additional generation did not over-schedule the hydro units. The output of the Southern Hydro power stations, Wivenhoe, and the North Queensland Hydro units are also managed in this manner.

App4·2·2·4) Generator Bidding Behaviour

As the focus of this study is reliability of supply, spot prices are of secondary importance. Therefore, to maintain a realistic order of dispatch, all units in the NEM are assigned bid profiles according to their SRMC costs, as listed in the report *SRMC and LRMC of Generators in the NEM: a Report to the IRPC and NEMMCO* (ACIL Tasman, 2003).

APP4·2·3) INTERCONNECTORS

App4·2·3·1) Interconnector Capacity

The capacity of all interconnectors is governed by the set of dynamic equations specified in the *Supply Demand Calculator* supplied with the 2003 SOO. The nominal limits of each of the interconnectors are modified in every half-hour dispatch period by the dynamic equations, which factor important constraints such as voltage stability and thermal limits, in order to provide accurate calculation of the dynamic interconnector limits. The nominal limits specified in these equations conform to those published in the 2003 SOO.

App4·2·3·2) Transmission Losses

Inter-regional loss factors over ac and dc interconnectors are modelled using dynamic loss equations supplied by NEMMCO.

Market forecasting has been completed on a gross basis. Therefore, the energy profiles assumed for each node have incorporated allowance for (transmission and distribution) losses and auxiliary energy.

APP4·2·4) DEMAND-SIDE PARTICIPATION

The vast majority of demand in the wholesale market currently operates as a series of aggregated loads for the purposes of schedule and dispatch.

Though some individual customers may be more responsive to price in the market, the majority of end-consumers are still shielded from short-term price fluctuations through retail contracts. Thus, incentives to reduce demand during high-price periods are dissipated.

In this study, as detailed in the SOO 2003, DSP is modeled as a limited amount of negative generation on a region by region basis, that is responsive to high prices.

App4·3) Outputs

APP4·3·1 VARIABILITY OF USE ACROSS ITERATIONS

In the main body of the report, the trend in the forecast level of USE (averaged across all iterations) has been included as an accurate measure of the future reliability of the NEM.

It should be noted that these average levels are derived from discrete trends revealed in a large number of iterations of the given scenario – with each trend reflecting a possible (though not necessarily the most likely) outcome in the market. Analysis of the variability of the results across each of the iterations can provide a means through which the sensitivity of the predictions can be gauged.

The following charts have been included to provide examples of the spread of USE within the one hundred iterations performed.

Figure A4.01 Forecast Trend in USE under Medium FOR Case
Shown Discretely for Each Iteration of the year 07-08

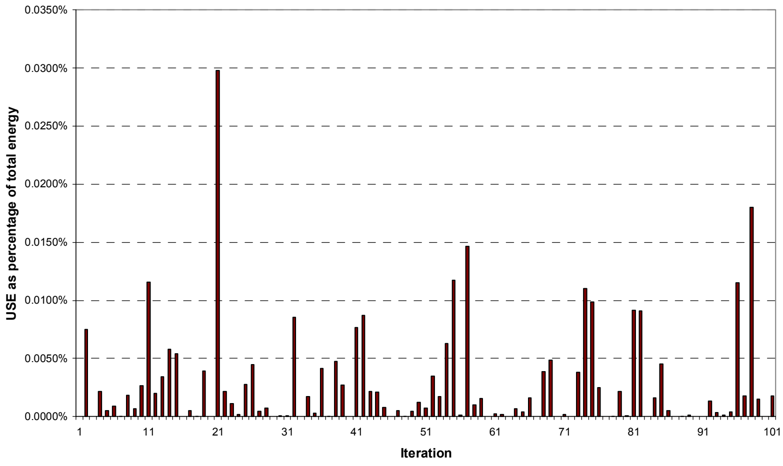
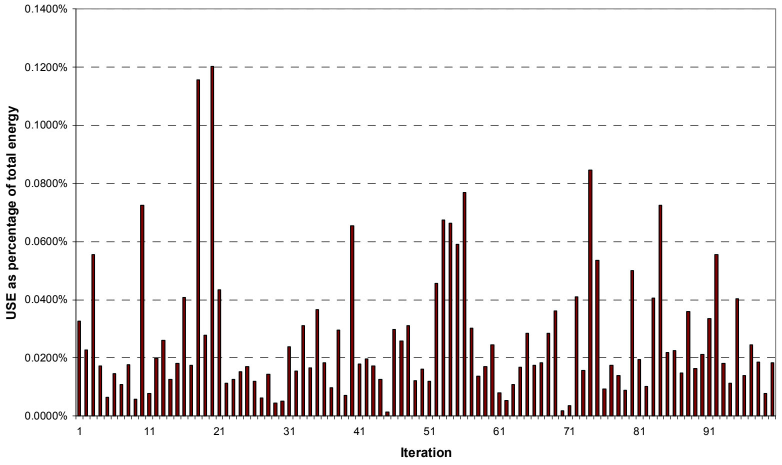
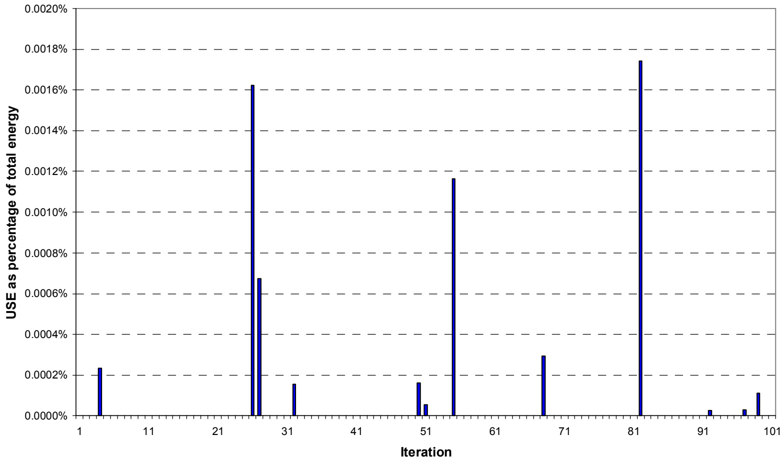
Queensland 50% POE	
Queensland 10% POE	
NSW 50% POE	

Figure A4.01 Forecast Trend in USE under Medium FOR Case
Shown Discretely for Each Iteration of the year 07-08

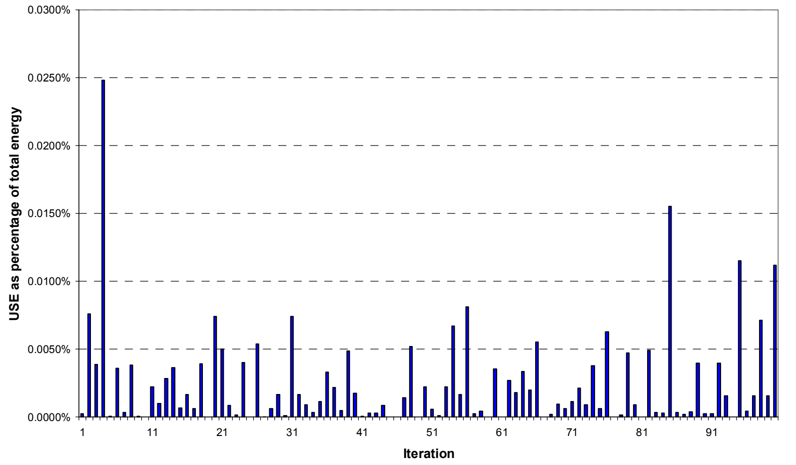
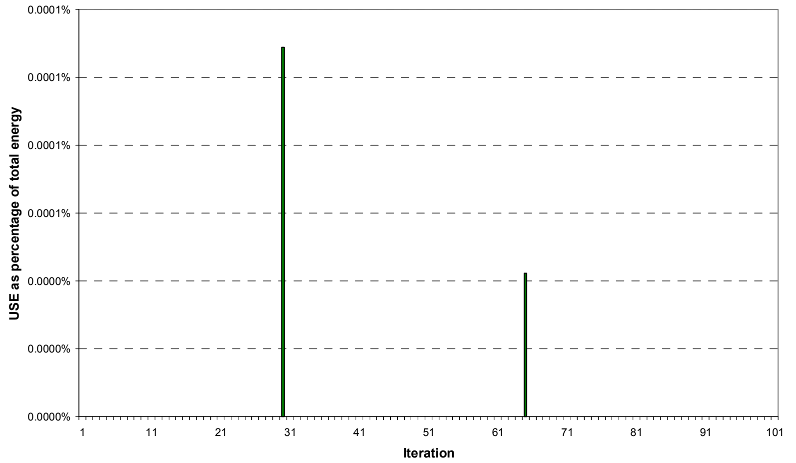
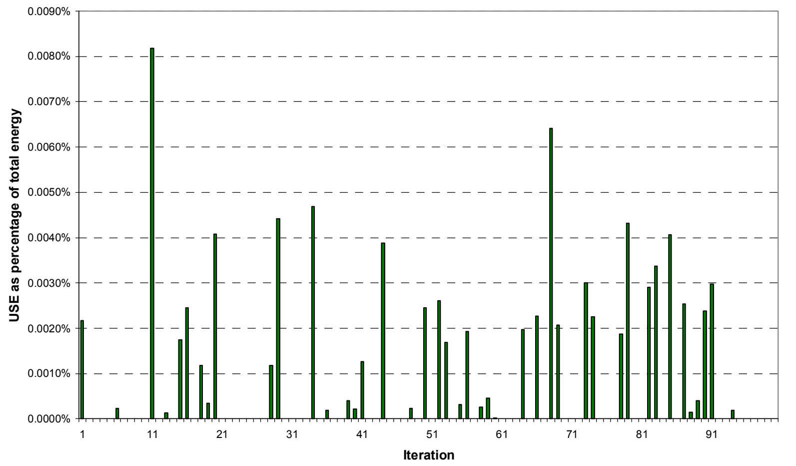
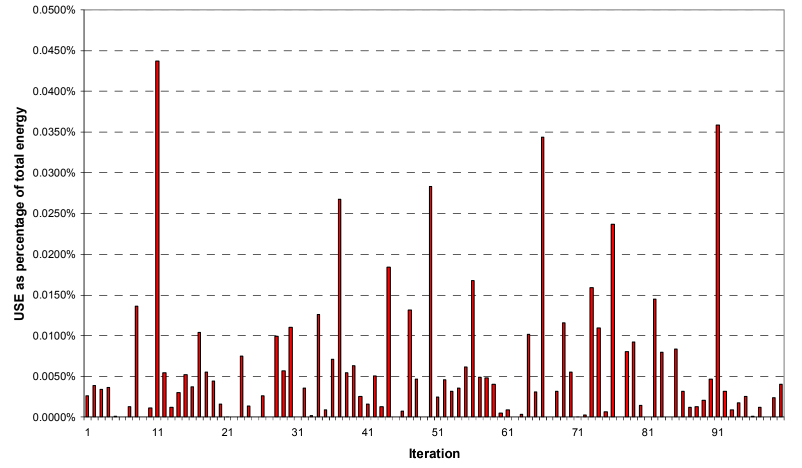
NSW 10% POE	
Victoria 50% POE	
Victoria 10% POE	

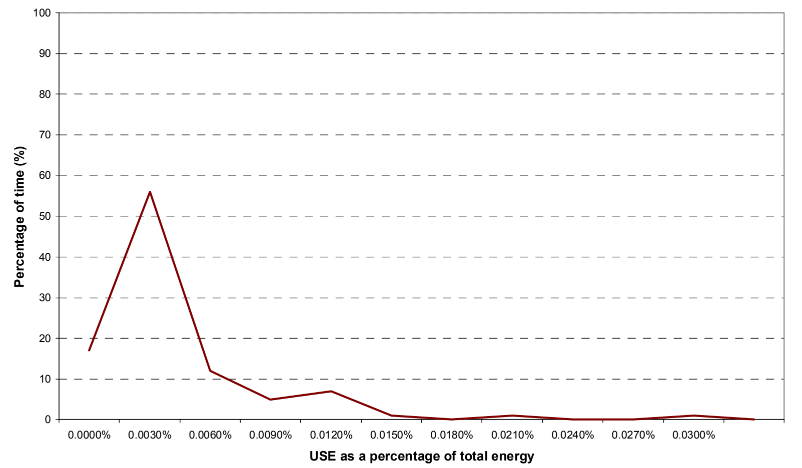
Figure A4.01 Forecast Trend in USE under Medium FOR Case
Shown Discretely for Each Iteration of the year 07-08

South Australia 10% POE[26]	

Iterations showing very high levels of USE are typically the result of a coincidence of several large units undergoing forced outages.

The following diagrams show the frequency distribution of the USE present in the one hundred iterations of the Medium FOR Case for the year 07-08. The 50% and 10% POE cases are presented.

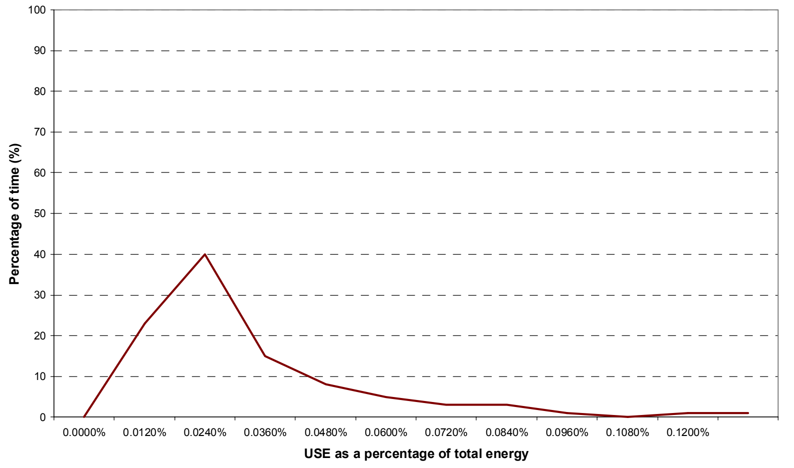
Figure A4.02 Frequency distribution of USE under Medium FOR Case
for Each Iteration of the year 07-08

Queensland 50% POE	

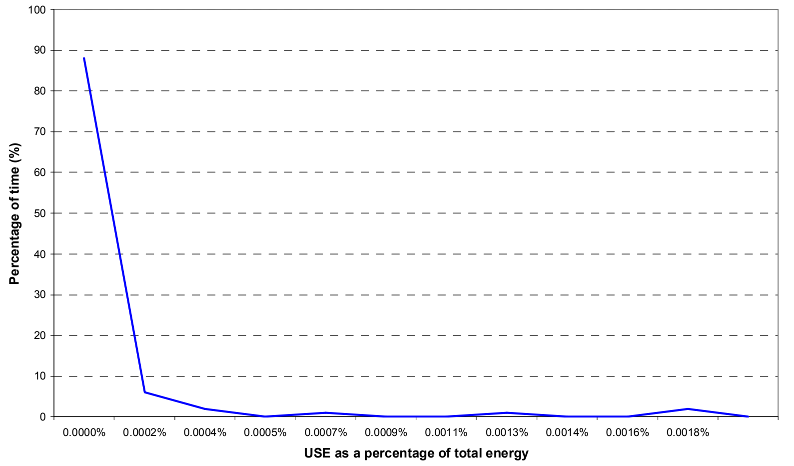
[26] Note that in the 50% POE forecast of 07-08, no USE was present in South Australia.

Figure A4.02 Frequency distribution of USE under Medium FOR Case
for Each Iteration of the year 07-08

Queensland
10% POE



NSW
50% POE



NSW
10% POE

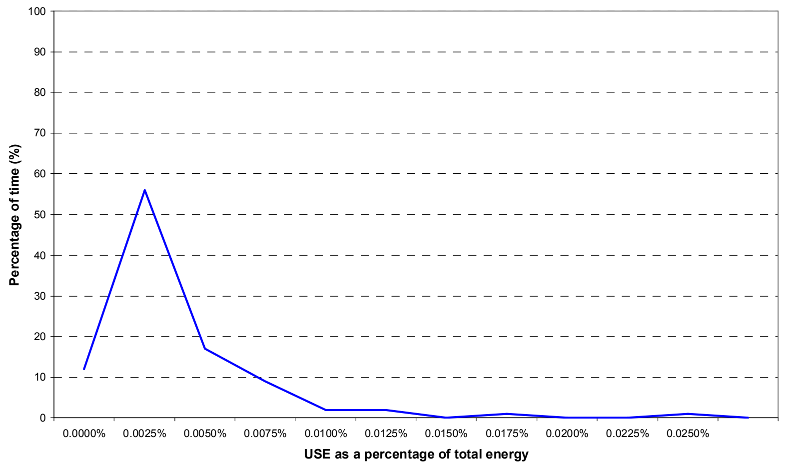
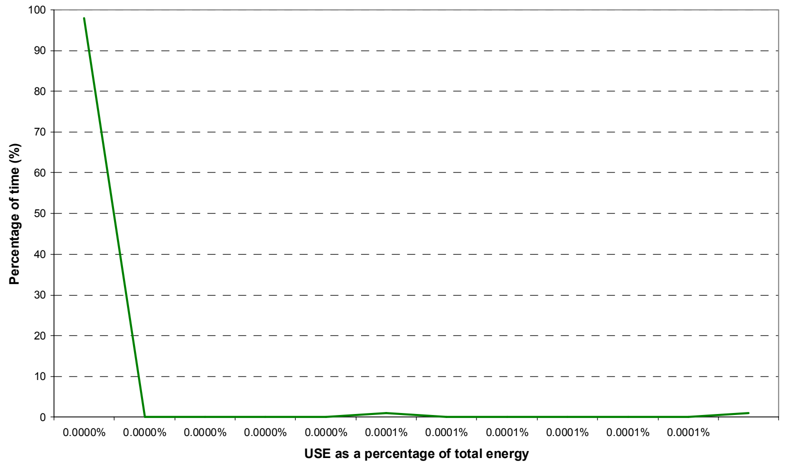
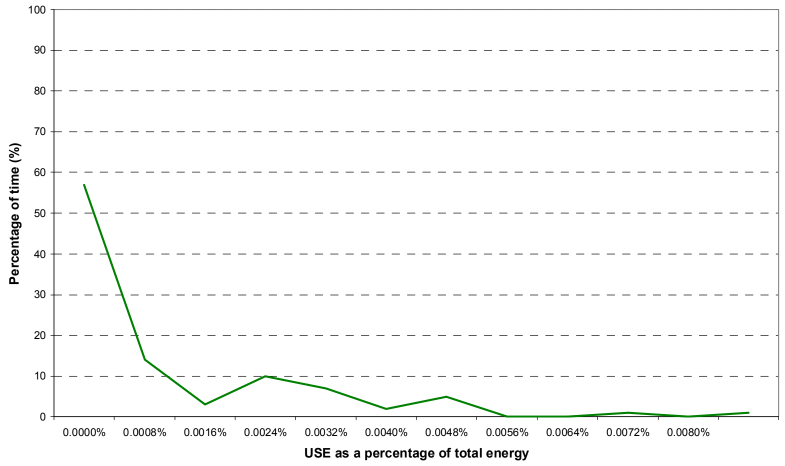


Figure A4.02 Frequency distribution of USE under Medium FOR Case
for Each Iteration of the year 07-08

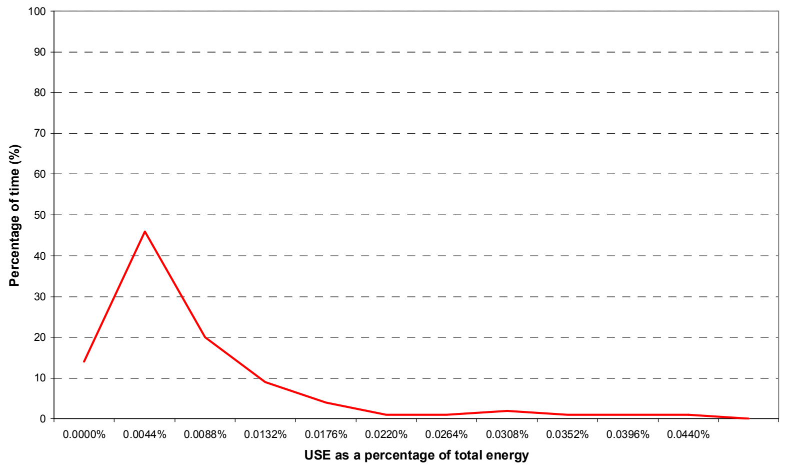
Victoria
50% POE



Victoria
10% POE



South Australia
10% POE[27]



[27] Note that in the 50% POE forecast of 07-08, no USE was present in South Australia.