

30 October 2008

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Dear Ian

### **Report to the Reliability Panel on Demand Forecasts**

As required by Section 3.13.3 (u) of the National Electricity Rules, I am pleased to report to the Reliability Panel on:

1. the accuracy of the demand forecasts in the most recent Statement of Opportunities; and
2. any improvements to the forecasting process that will apply to the next Statement of Opportunities (SOO).

### **Accuracy of the demand forecasts**

The accuracy of the 2008 demand forecasts is assessed in Appendix B of the 2008 SOO and the attached Load Forecasting Review (Attachment 1) is based on this Appendix. However, it may be useful to illustrate, by means of an example, the reason for the apparent complexity of Attachment 1. To this end, Figure A (attached below) compares the forecasts for the 2008 winter scheduled maximum demand (medium scenario) for each of the NEM regions, published in the 2008 SOO, with actual outcomes.

You will observe that there are three forecasts for each region, each of which represents loads expected to be met or exceeded with different probabilities. These probabilities reflect the uncertain outcomes, but well understood range, of a number of factors affecting electricity demand, including variation of future weather conditions.

The actual outcomes for the southern regions were close to the 50% probability of exceedence (POE) (median percentile) forecasts, while actual outcomes for the New South Wales and Queensland regions were both higher than the 10% POE (10<sup>th</sup> percentile) forecasts. This implies either that the forecasts were too low, or that the 2008 winter was exceptionally cold, or some combination. We now know that the 2008 winter was colder than usual in both Sydney and Brisbane, so the forecast looks reasonable on this basis.

However, not much more can be concluded about the accuracy of these forecasts with the information currently available. Hence Attachment 1 looks at forecast accuracy from two different perspectives:

- Firstly, *back assessment* compares the forecasts for each POE level with actual outcomes over an extended time. This allows a visual assessment to be made of forecast performance over time. Back assessment generally tests the accuracy of the models used to produce previous forecasts as well as the assumed values of the economic variables used as inputs to the models.
- Secondly, *backcasting* is used to produce forecasts of a historical period using the current forecasting methodologies and utilising our knowledge of actual weather and economic conditions over that historical period. Since the backcast is thereby reduced to a single variable, traditional quantitative assessment methods can be applied to test forecast accuracy. Backcasting tests only the underlying models used to produce the current forecast.

## Improvements to the forecasting process

In the 2008 SOO, not all Jurisdictional Planning Bodies (JPBs) used the same approach to produce the backcasts. It is NEMMCO's intention that the next SOO should include backcasts produced in a consistent manner, because:

1. a uniform treatment would enable more meaningful comparisons of forecast reliability between regions; and
2. in this context, it is important to test, not just how well the relevant model fits the estimation sample data, but also its ability to predict values outside of the estimation sample (as a better indicator of confidence in the ability of the model to forecast future values).

There is additional information on the 2008 demand forecasts in Chapter 3 of the 2008 SOO and the details of each JPBs forecasting process is set out in their respective Annual Planning Reports. For any other specific enquiries about the accuracy of the demand forecasts or proposed improvements, please call Richard Hickling on 02 9239 9117.

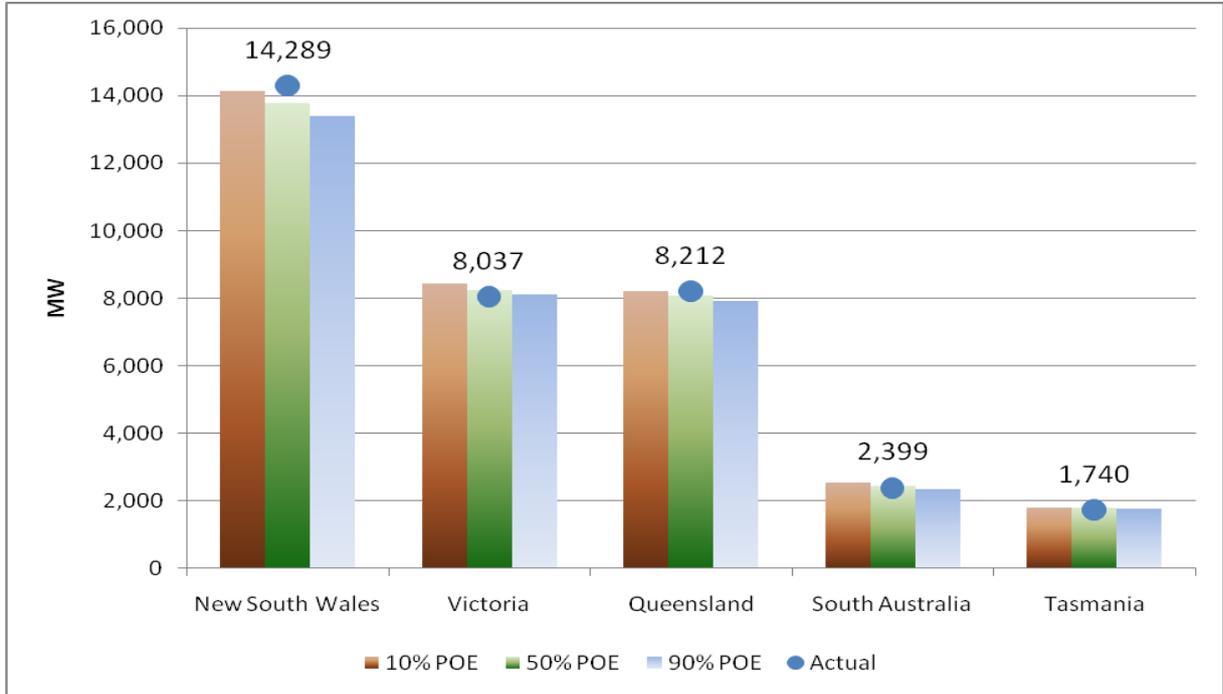
Yours sincerely



**Brian Spalding**  
Chief Operating Officer

Enc.

**Figure A: Forecast and actual MDs for winter 2008**





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# **Attachment 1 Load forecasting review**

## **1.1 VALIDATION OF MAXIMUM DEMAND PROJECTIONS**

### **2008 SOO historical methods for validating maximum demand projections**

This attachment presents the summer (winter in the case of Tasmania) back assessment and backcast analysis for each NEM region for the purposes of reviewing and validating the scheduled maximum demand (MD) projections for the 2008 SOO.

The 2008 SOO used two methods for reviewing and validating regional seasonal scheduled MD projections provided by the jurisdictional planning bodies (JPBs)<sup>1</sup>:

- back assessment; and
- backcasting.

#### **1.1.1 Back assessment**

Back assessment involves comparing preceding scheduled MD projections with actual (historical) MD values. The 2008 SOO includes two back assessments:

- **One-year-out** back assessments compare regional scheduled MD projections made for the next season with actual values. For example, a 2006 SOO regional summer scheduled MD projection for 2006/07 is compared with the actual (historical) regional summer MD for 2006/07<sup>2</sup>.
- **Two-year-out** back assessments compare regional scheduled MD projections made for the season after next with actual values. For example, a 2006 SOO regional summer scheduled MD projection for 2007/08 is compared with the actual (historical) regional summer MD for 2007/08.

The dates featured with each back assessment chart indicate the season for which the:

- projection is made; and
- actual (historical) value is recorded.

One and two-year back assessment time frames are used because NEMMCO bases decisions to investigate potential NEM intervention on the MT PASA operational tool, which provides a two year outlook.

Back assessment analysis includes scheduled MD projections from all previous SOOs (starting from the 1999 publication), which provides a qualitative indication of:

- the suitability of the spread of the 10% POE, 50% POE and 90% POE values for each MD projection;

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<sup>1</sup> A JPB is an entity nominated (under Clause 5.6.3(b)(2) of the Rules) by the relevant Minister of the relevant participating jurisdiction as having transmission system planning responsibility in that participating jurisdiction, for the purposes of being a member of the Inter-Regional Planning Committee (IRPC). The current JPBs include Powerlink Queensland (Queensland), TransGrid (New South Wales and the Australian Capital Territory), The Victorian Energy Networks Corporation (VENCorp) (Victoria), The Electricity Supply Industry Planning Council (ESIPC) (South Australia), and Transend Networks (Tasmania).

<sup>2</sup> The actual time between the publication of projections and the occurrence of the subsequent seasonal MD may be 6 to 8 months.

- the accuracy of the 50% POE scheduled MD projections (which should be at the median of the actual MD values); and
- improvements in the forecasting techniques over the long term.

**1.1.2 Backcasting**

Backcasting involves 'forecasting' historical MDs, which involves applying current forecasting techniques to project values of seasonal MD that have already occurred. Backcasting takes actual economic and climatic conditions and temperatures into account to produce a single point MD projection for each season<sup>3</sup> for comparison with the actual (historical) seasonal MDs.

Backcasting provides a quantitative indication of the accuracy of current forecasting methodology. Because the backcast makes its comparison with actual MD values (real data), the performance of the latest forecasting models can be established immediately.

The backcast results provide a quantitative indication of the accuracy of the model by comparing the backcasts with the historical MD values. This is calculated in terms of the root mean squared error (RMSE):

$$RMSE = \sqrt{\frac{\sum ERR^2}{n}},$$

Where:

- *ERR* is the percentage difference between the model output and actual MD.
- *n* is the number of projections tested.

This value can be used to:

- test the importance of a selected input variable by removing it from the model and re-calculating the backcast (stepwise regression, usually applied to in-sample<sup>4</sup> backcasting);
- test the importance of a potential input variable by adding it to the model and re-calculating the backcast (stepwise regression, usually applied to in-sample backcasting);
- demonstrate accuracy improvements after significant changes are made to the forecasting methodology; and
- compare the performance of the current and the previous year's forecast models.

**1.1.3 Other continuous improvement initiatives**

The Load Forecasting Reference Group (LFRG), which is convened by NEMMCO and includes representatives from the JPBs, is committed to continuous improvement of the demand forecasting process.

Backcasting analysis for Victoria and Transend in 2008 used in-sample forecasts, rather than the recommended out-of-sample forecasts. In-sample forecasting consists of using all available historical information to estimate a forecasting model and then fitting the data over the same

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<sup>3</sup> As the various factors that lead to a spread of possible MD values (represented by the different POE projections for each season) are known, a single point projection of MD for the historical season is possible.

<sup>4</sup> In-sample backcasting analyses, the same historical data as was used to develop the model.

historical period using the estimated model. In contrast, out-of-sample forecasting involves setting aside some of the available historical data before estimating the model, then producing a forecast outside of the estimation sample. In the interests of comparability between regions and in order to test the genuine reliabilities of the current forecasting methodologies, it is recommended that future backcasting exercises be based exclusively on out-of-sample forecasts. Other initiatives that the LFRG are planning to consider for further development of benchmarking and review of forecasting techniques include:

- backcasting (out-of-sample) single point projections at resolutions of 30 minutes (as provided by ESIPC for the 2008 SOO, see Figure 12) to evaluate the accuracy of the underlying forecast model;
- measurement of backcast accuracy by mean absolute error (MAE) and , when comparing performance across regions, mean absolute percentage error (MAPE) measures;
- measurement of weekly MD's excess percentage (EP) and mean absolute excess percentage (MAEP) to evaluate the modelled probability density functions which underlie the 10%, 50% and 90% POE forecasts; and
- continue to compare historic annual MD's with modelled 10%, 50% and 90% POE levels and assess the assumptions regarding the modelled probability distributions.

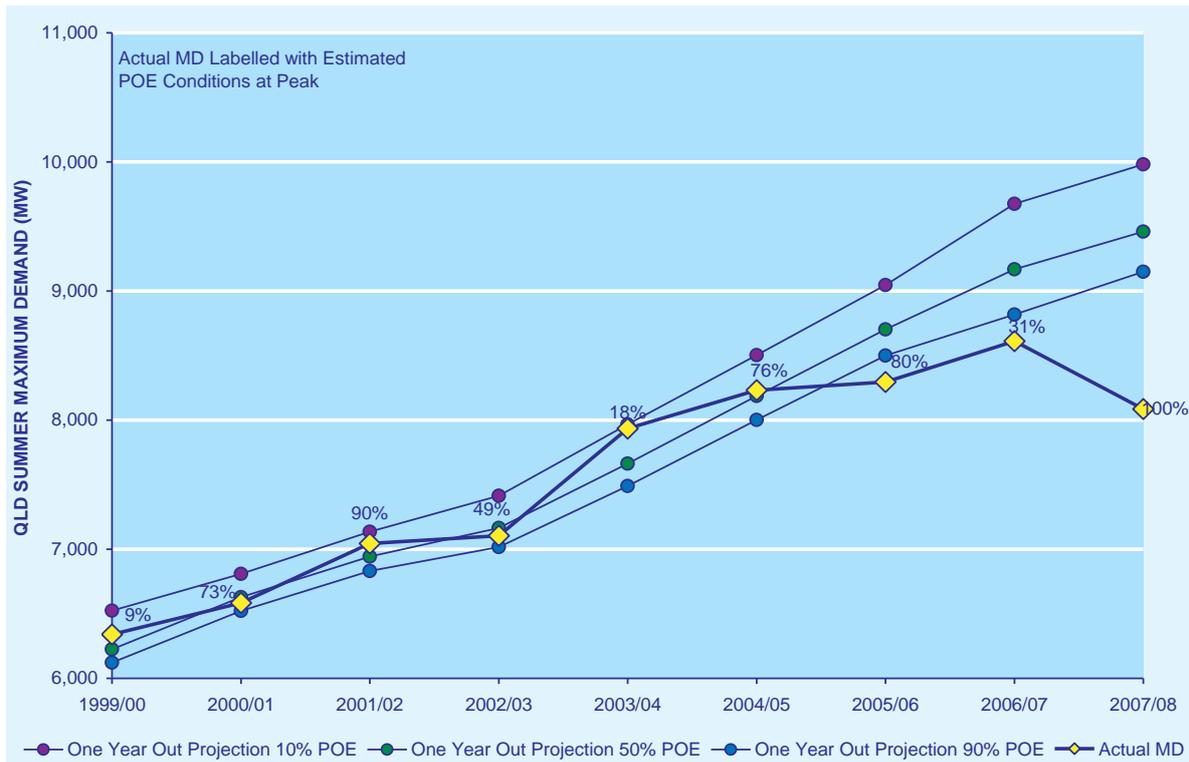
## 1.2 QUEENSLAND

This section presents the summer scheduled MD back assessments and backcast analysis for the Queensland region.

### 1.2.1 Back assessment

Figure 1 and Figure 2 shows the one-year-out and two-year-out summer scheduled MD back assessments.

**Figure 1 Queensland Summer Scheduled MD One-Year-Out Back Assessment**



**Figure 2 Queensland Summer Scheduled MD Two-Year-Out Back Assessment**

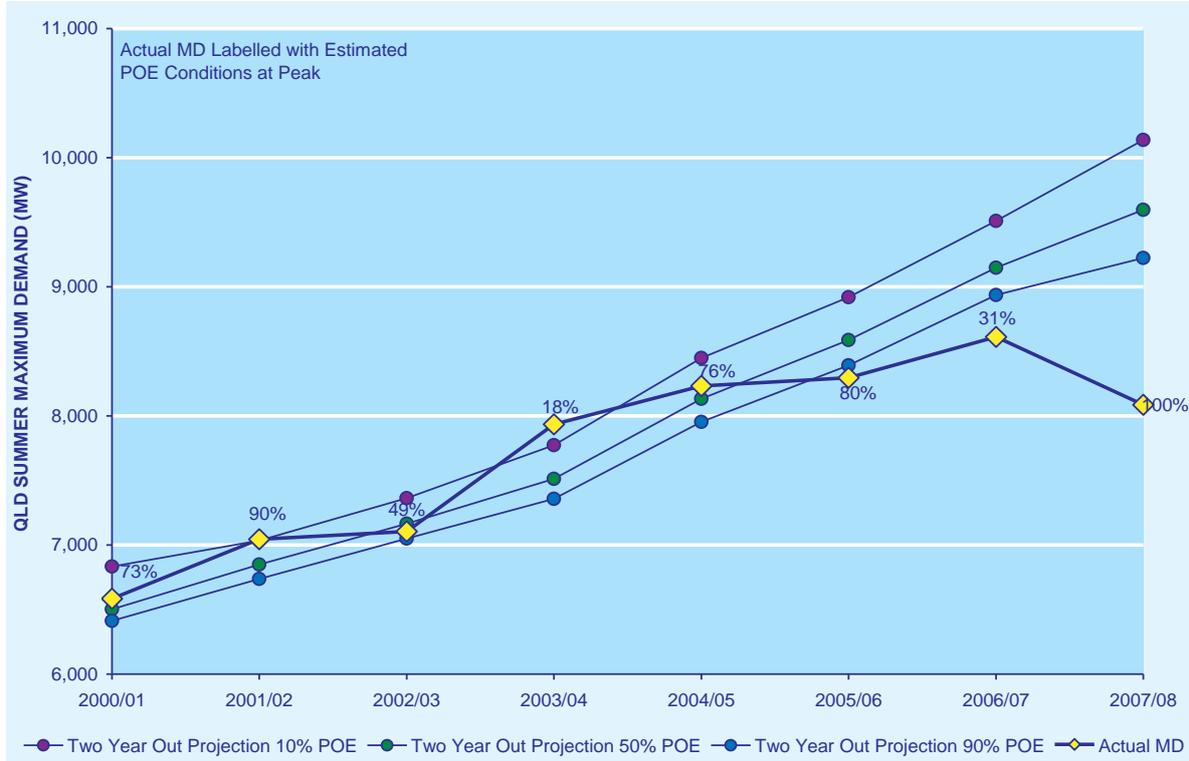


Figure 1 and Figure 2 show the following:

- The one and two-year out projections for the 2007/08 summer scheduled MD are much higher than the observed value.
- The 100% POE assessment for the 2007/08 summer scheduled MD indicates that an equivalent set of factors with a similar effect on demand are not expected to happen again.
- Projections for the other recent summer scheduled MDs (2004/05-2006/07) depart from the actual values when assessed POE conditions are taken into account. The 2004/05 projections are low compared to the actual values and the 2005/06 and 2006/07 projections are increasingly high compared to the actual values.
- Early projections of scheduled MD also depart from the actual values when considering the assessed scheduled MD conditions, except for 2002/03.

Powerlink Queensland advises as follows:

- Use of a single Queensland weighted average temperature for assigning the POE level of previous actual demands is problematic and only provides a guide.
- Population growth in 2007 was greater than expected at 2.4%.
- The actual 2005/06 and 2006/07 summer peaks involved diversity of demand between load centres across the region that were higher than both historically observed and modelled diversity values.
- The mild 2007/08 summer, however, produced even greater diversity.

- Factors leading to lower than expected summer 2007/08 demand include:
  - a lack of hot days across all areas of Queensland, resulting in a greatly reduced signal to turn on domestic air conditioning over the whole summer;
  - some delayed railway and port infrastructure projects together with earlier water restrictions lowering coal mining output; and
  - flooding rains in the second half of summer significantly curtailing coal mining and some coal handling port activity.
- The losses due to transmission networks, power station transformers and auxiliary loads during times of peak demand during winter 2007 and summer 2006/07 and 2007/08 were significantly lower than forecast, which will be investigated.
- Higher than expected growth in embedded, non-scheduled generation at the time of peak demand has reduced scheduled demand.
- While greater diversity between areas has now been built into the latest Powerlink projections, future projection levels are mostly driven by upcoming major load projects.

**1.2.2 Backcast**

Figure 3 shows the 10-year backcast. Since Powerlink’s forecasting methodology largely consists of combining local area forecasts provided by DNSPs, a lengthy backcast period was able to be analysed, using current diversity and other relevant assumptions.

**Figure 3 Queensland Summer Scheduled MD Backcast**

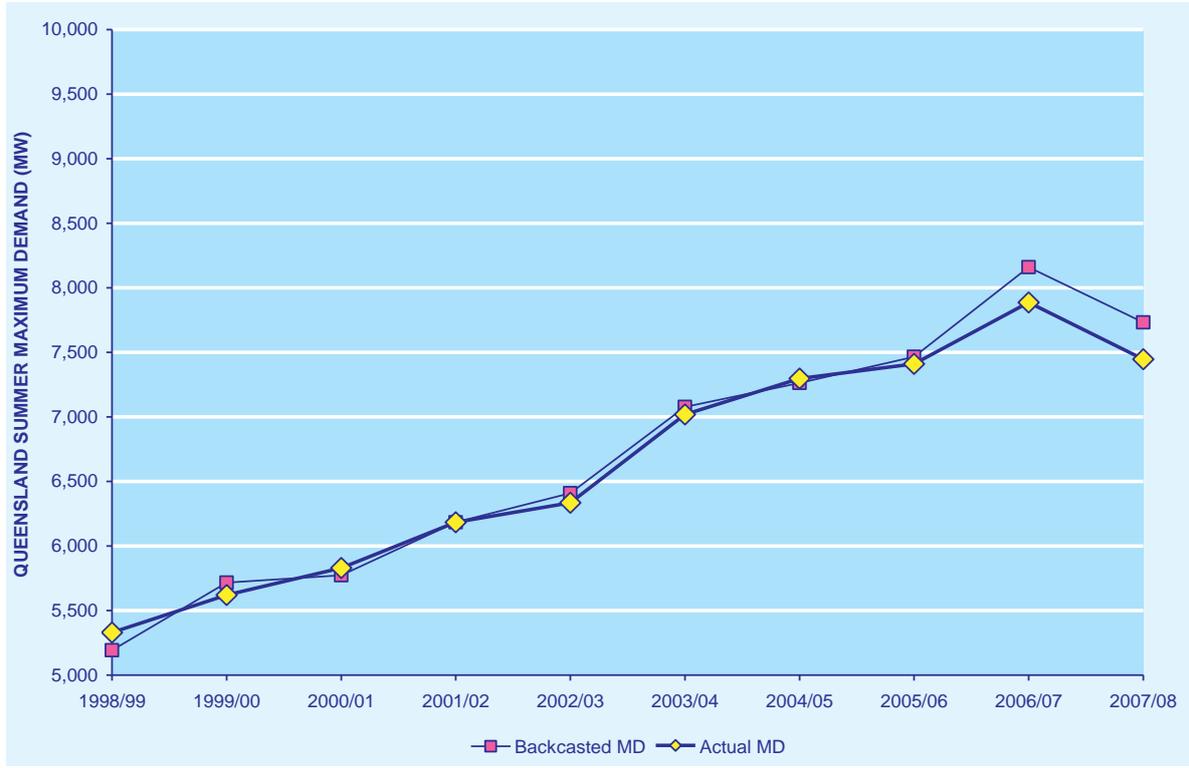


Figure 3 shows history-corrected backcast values that are close to actual summer scheduled MDs until 2006/07.



**Table 1 Queensland Summer Scheduled MD Backcast RSME Values**

Year	RSME (%)
2007	1.51
2008	1.96

Table 1 shows that the summer scheduled MD backcast RSME value compared to last year has increased.

Powerlink Queensland advises as follows:

- Powerlink Queensland has a four-area temperature dependent model to cover the region’s diverse weather patterns. To provide a meaningful correlation between regional demand and weather conditions, Powerlink Queensland analysed the diversity between these areas.
- Substantial variation also occurs in the large industrial loads during high Queensland summer demand, making it necessary to correct historical Queensland peak demands for both weather pattern diversity and industrial load. This backcast analysis provides a single point reference for measuring the performance of this methodology. Over recent summers, however, there has been a substantial trend to increased diversity or non-coincidence of area peak demands, exacerbated by mild weather over the last two summers. This reduces the effectiveness of this single point temperature analysis.
- The latest RSME value shows greater error than for last year’s backcast due to the substantial abnormality of the 2007/08 summer scheduled MD, even after applying standard correction methods. Powerlink has factored in increased average year diversity into its latest forecasts.
- Summer 2007/08 presented a lack of hot days across all areas in Queensland, resulting in a greatly reduced signal to turn on domestic air conditioning over the whole summer. This is partly accounted for by the backcast trend line’s actual history corrections to explain the occurrence of low loading. Additionally, in summer 2007/08, an estimated load of 97 MW was curtailed by the closure of several coal mines and one coal handling port due to flooding. This was accounted for in the backcasting.

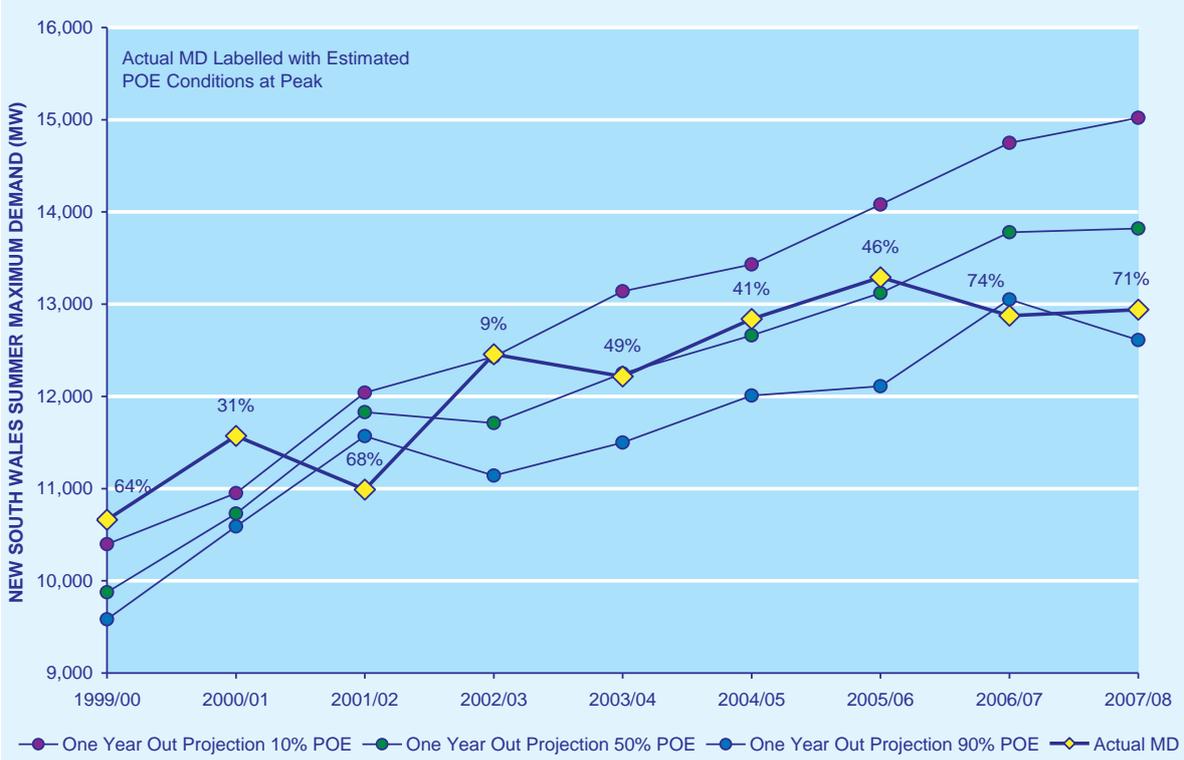
## 1.3 NEW SOUTH WALES

This section presents the summer scheduled MD back assessments and backcast analysis for the New South Wales region.

### 1.3.1 Back assessment

Figure 4 and Figure 5 show the one-year-out and two-year-out summer scheduled MD back assessments.

**Figure 4 New South Wales Summer Scheduled MD One-Year-Out Back Assessment**



**Figure 5 New South Wales Summer Scheduled MD Two-Year-Out Back Assessment**

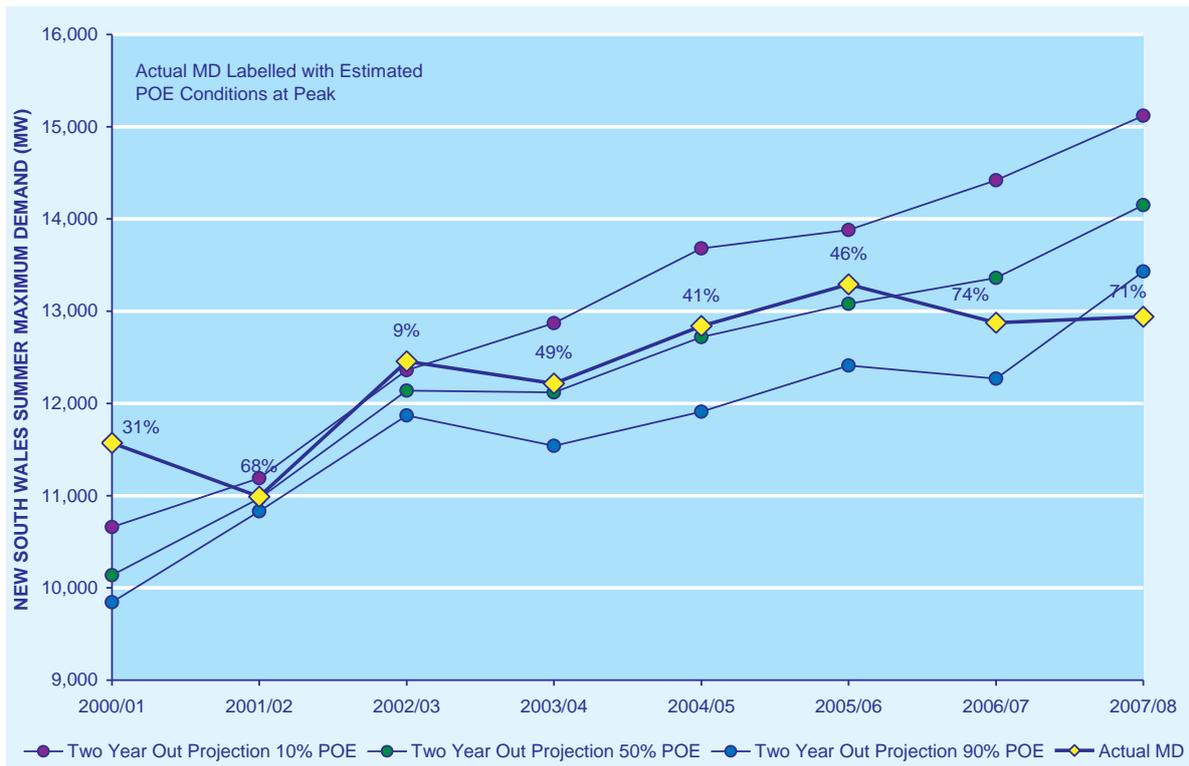


Figure 4 and Figure 5 show the following:

- Projections for the more recent summer scheduled MDs (since 2002/03, with the exception of the 2006/07 one-year-out and the 2007/08 two-year-out projections), taking into account the assessed POE levels, are close to the actual values.
- The 2006/07 one-year-out and the 2007/08 two-year-out summer scheduled MD projections, published in the 2006 SOO, are high compared to the actual values.

TransGrid advises as follows:

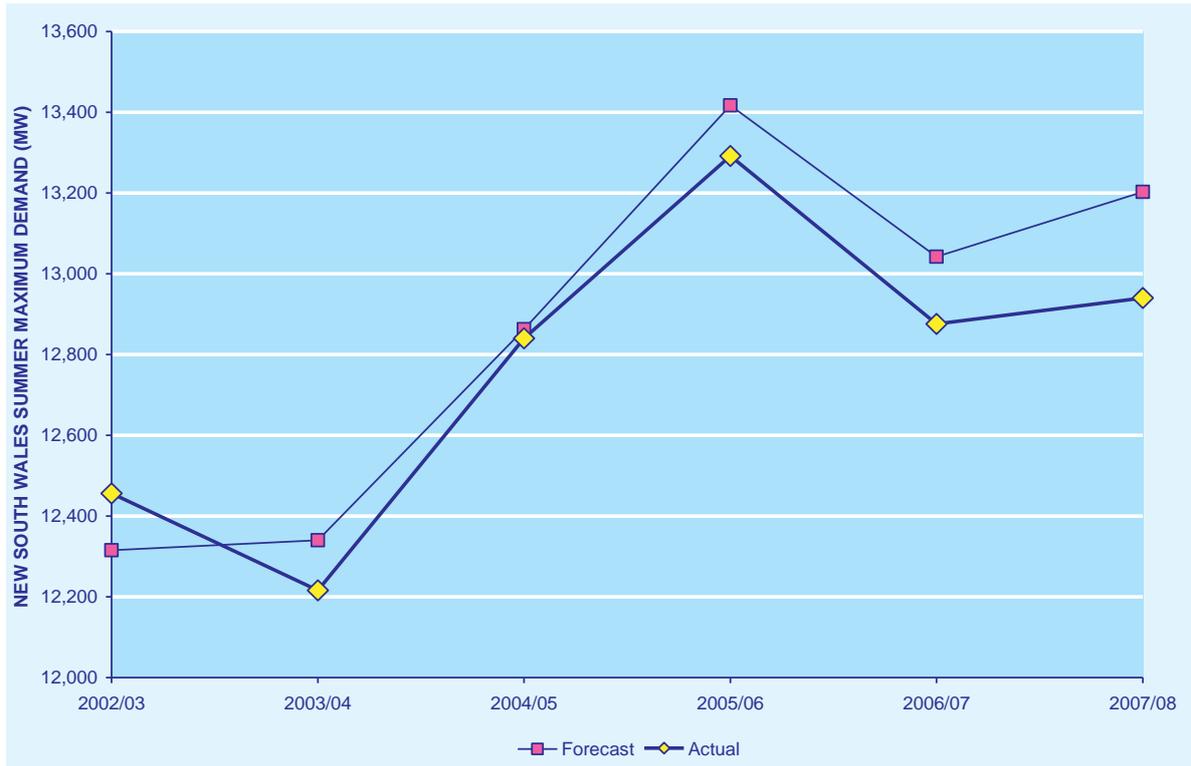
- The early mismatches (1999/00-2001/02) are mainly due to a general failure to anticipate the rapid increase in air-conditioning penetration that occurred at that time, resulting in a narrower range between the 10% and 90% POE projections than should have occurred.
- The mismatch between the one-year-out summer scheduled MD projections for 2006/07 and the actual summer MD is due to changes in methodology. In particular, the base for the 90% POE projections developed in 2006 was approximately 500 MW above the level that would currently be estimated. TransGrid believes the current method produces more reliable predictions of the percentiles of demand and is more robust to variation, in particular as additional weather information becomes available.

### 1.3.2 Backcast

Figure 6 shows the 6-year backcast<sup>5</sup> from the same model used to produce the 2008 SOO forecast. Table 2 compares the latest backcast RSME value with last year's value.

<sup>5</sup> TransGrid only supplied backcast values for the past six years. The available historical data was considered insufficient for producing out-of-sample backcast values for earlier years.

**Figure 6 New South Wales Summer Scheduled MD Backcast**



**Table 2 New South Wales Summer Scheduled MD Backcast RSME Values**

Year	RSME (%)
2007	1.5
2008	1.25

Figure 6 shows that the backcast scheduled MDs are close to the actual MDs, which enables a high degree of confidence in the forecasting methodology.

TransGrid advises as follows <sup>[1]</sup>:

- The forecasting model is highly complex and includes three distinct, separately developed models. TransGrid has developed an out-of-sample backcast analysis to provide a single point of reference for measuring the performance of the overall model.

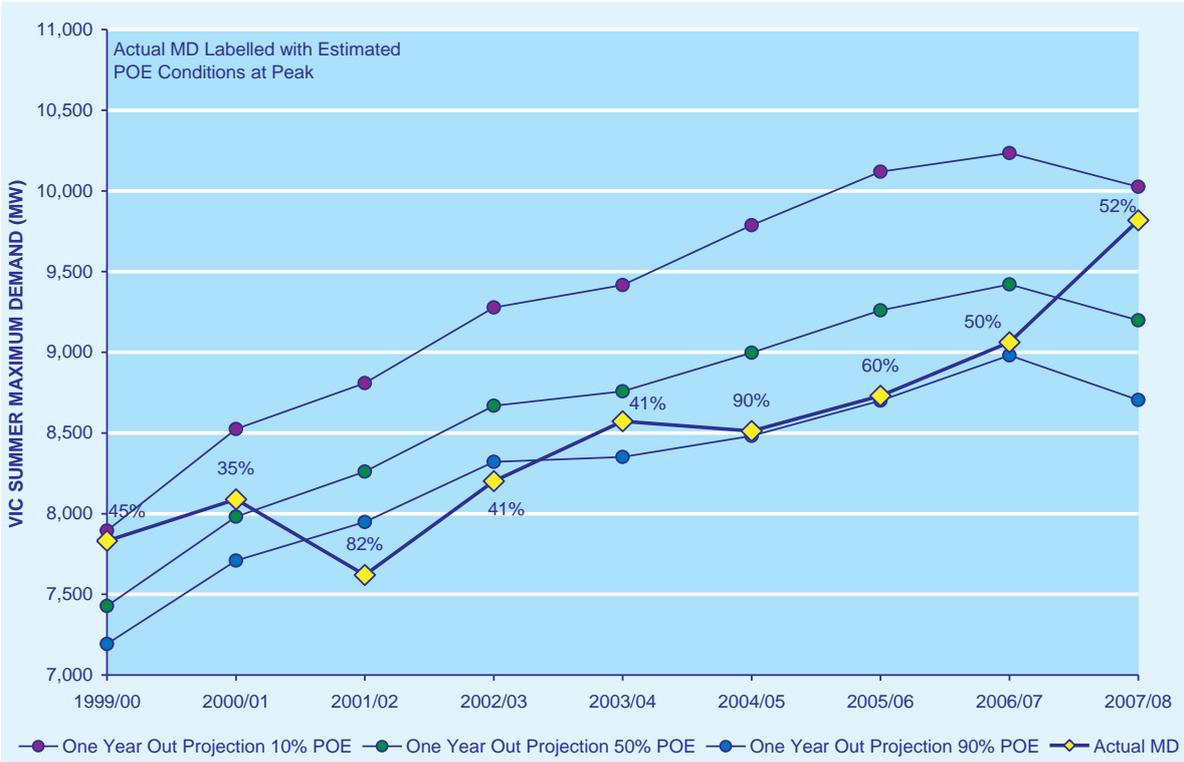
## 1.4 VICTORIA

This section presents the summer scheduled MD back assessments and backcast analysis for the Victorian region.

### 1.4.1 Back assessment

Figure 7 and Figure 8 shows the one-year-out and two-year-out summer scheduled MD back assessments.

**Figure 7 Victorian Summer Scheduled MD One-Year-Out Back Assessment**



**Figure 8 Victorian Summer Scheduled MD Two-Year-Out Back Assessment**

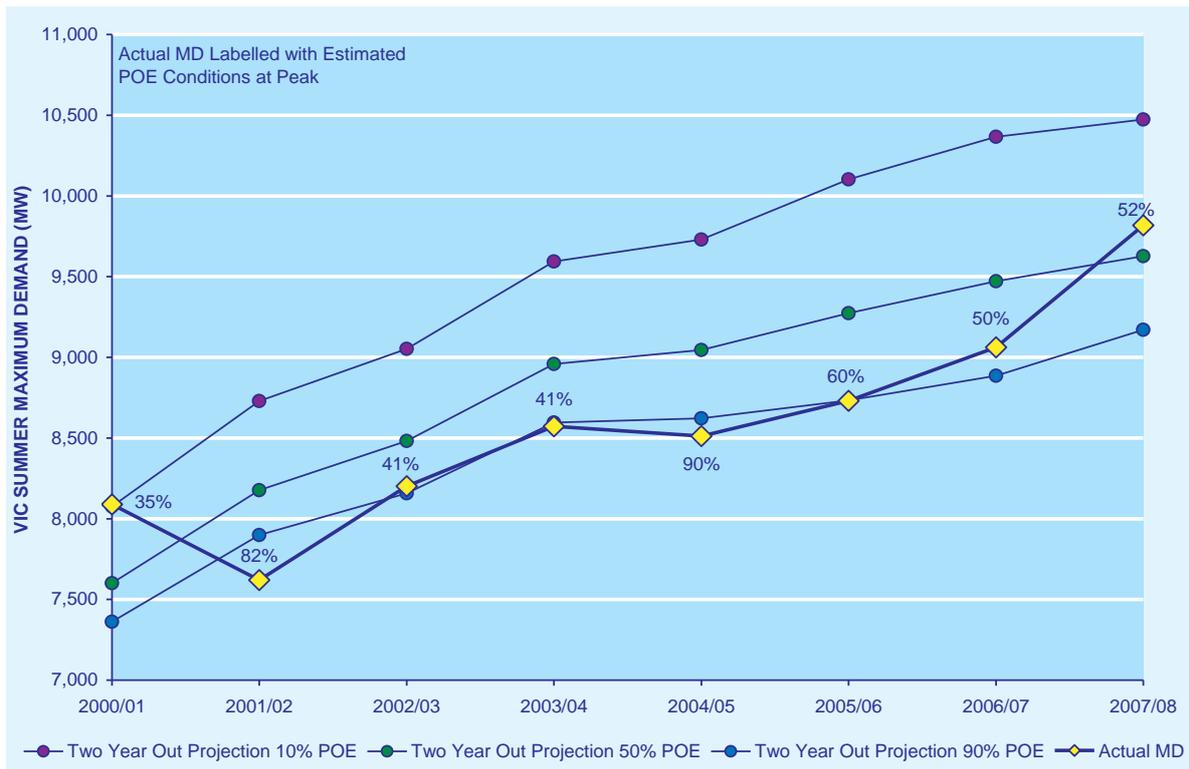


Figure 7 and Figure 8 shows the following:

- The projections for the 2007/08 summer scheduled MD, considering the assessed POE level, are low to very low compared to the actual values.
- Projections for other recent and earlier projections (2001/02-2006/07) are consistently high to very high compared to the actual values.

VENCorp advises as follows:

- VENCorp has been working towards improving the methodology used to prepare the forecasts by incorporating a wider range of factors affecting demand and understanding the entire distribution of half-hourly summer demand levels.
- The new forecasting methodology was applied to the summer scheduled MD forecasts in the 2007 SOO (one-year-out 2007/08 projections), and has been extended this year to the winter projections.

See the Victorian APR for more information about VENCorp’s forecasting methodology.

## 1.4.2 Backcast

Figure 9 shows the 11-year backcast from the same model used to produce the 2008 SOO forecast.

**Figure 9 Victorian Summer Scheduled MD Backcast**



The 2008 SOO Victorian summer scheduled MD was able to be backcast over an extended time due to the use of in-sample forecasts. The RSME is 2.59%. VENCORP performed this analysis for the first time in 2008. Therefore, there is no previous value of RMSE available for comparison.

Figure 9 shows that the backcast values generally follow the same trend as the actual scheduled MD values.

VENCORP advises as follows:

- For the 2008 SOO, VENCORP used a simulation model to generate the required summer and winter POE scheduled MDs, which:
  - considers the economic outlook, load growth from new industrial projects, and projected air-conditioner penetration; and
  - generates a large number of synthetic summer scheduled MDs based on synthetic temperatures created from historical temperatures.

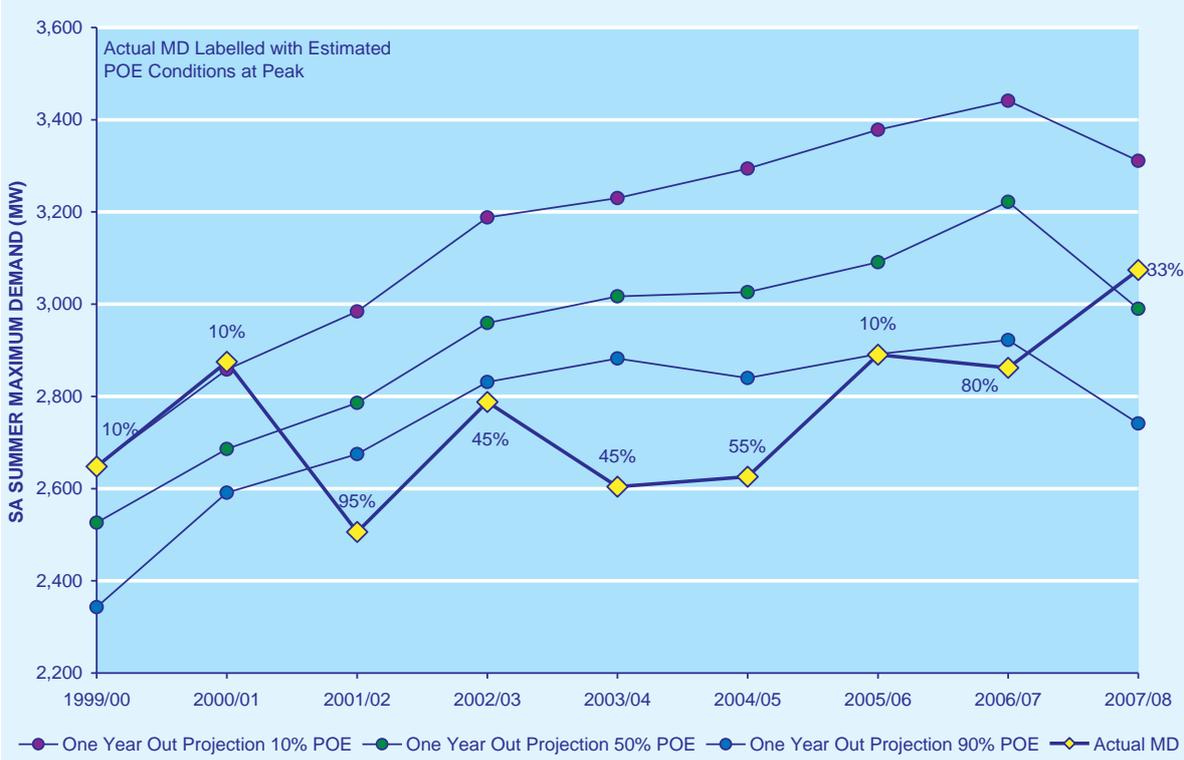
## 1.5 SOUTH AUSTRALIA

This section presents the scheduled summer back assessments and backcast analysis for the South Australian region.

### 1.5.1 Back assessment

Figure 10 and Figure 11 shows the one-year-out and two-year-out summer scheduled MD back assessments.

**Figure 10 South Australian Summer Scheduled MD One-Year-Out Back Assessment**



**Figure 11 South Australian Summer Scheduled MD Two-Year-Out Back Assessment**

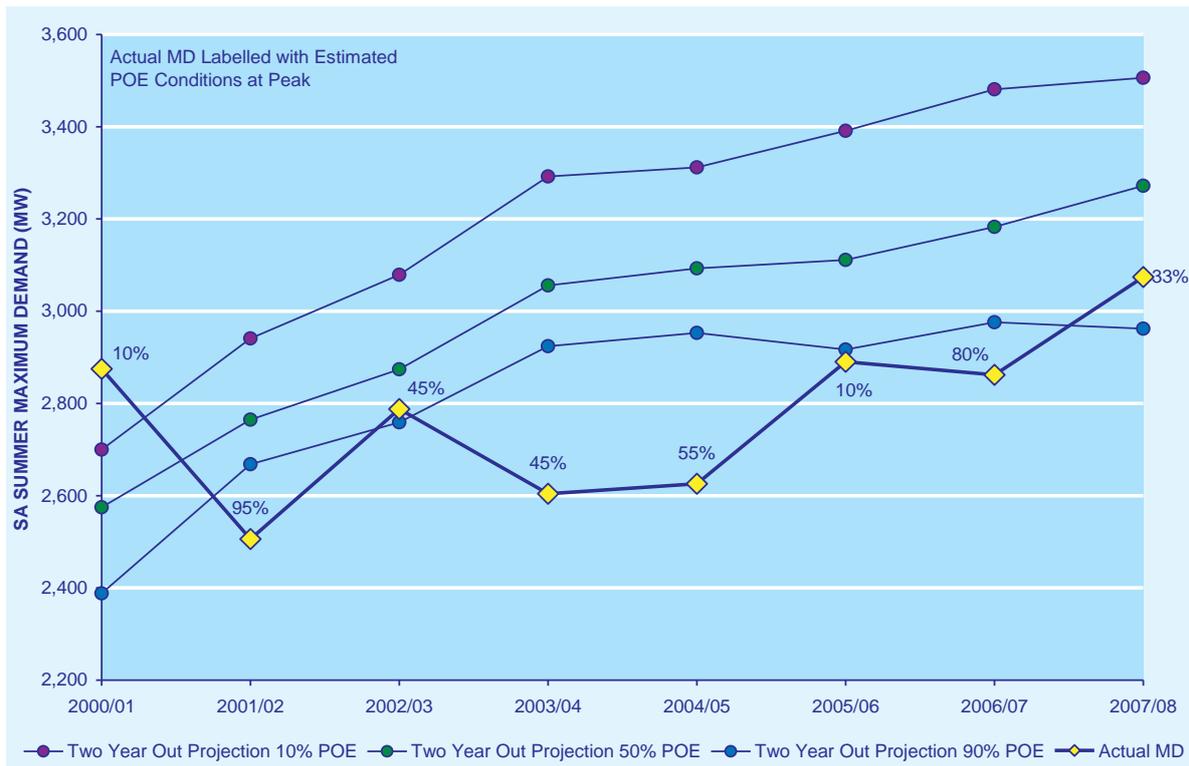


Figure 10 and Figure 11 show the following:

- The one-year-out projections for the 2007/08 summer scheduled MD, considering the assessed POE level, are close to the actual value (the shape of the forecast distribution is known).
- The 2002/03-2006/07 and 2007/08 two-year-out projections, considering the assessed POE level, are consistently high to very high compared to the actual values.

ESIPC advises as follows:

- ESIPC adopted a new simulation-based forecasting methodology for the 2007 SOO (2007/08 one-year-out projection), and used this methodology again for the 2008 SOO. A review of past forecast performance must therefore distinguish between the forecasts prepared using the old and the new methodologies.
- The forecasts prepared for the 2006 SOO and in earlier years were based on ESIPC’s old forecasting methodology. Those forecasts include:
  - all of the two-year-out forecasts shown in Figure 11; and
  - the one-year-out forecasts shown in Figure 10 up to and including forecasts for the 2006/07 summer.
- Most of the forecasts prepared using the old methodology displayed a clear tendency to overstate maximum demands, or equivalently, to assign probabilities to particular demand levels that were too low. For example, six of the eight summer scheduled MDs prior to the 2006/07 summer reported in Figure 10 were at or below the forecast 90% POE level. The probability of this occurring by chance, assuming the forecasts were accurate, is only 0.002%. This performance reflects the failure of the forecasting methodology employed in those years to account properly for all of the factors that determine the probability distribution of summer MDs.

- ESIPC has been working with Monash University to develop a new simulation-based forecasting methodology that accounts for a wide range of factors that determine peak demand levels. The modelling outputs include forecasts of the entire probability distribution of summer MDs, conditional only on the long-term economic assumptions provided by the National Institute of Economic and Industrial Research (NIEIR) reports <sup>[2-4]</sup>.
- ESIPC has published reports on its website that describe the new forecasting methodology and related approach to forecast performance assessment <sup>[5]</sup>. Monash University has also published related material describing the new forecasting methodologies <sup>[6]</sup>.

See the South Australian APR for more information about ESIPC's forecasting methodology <sup>[7]</sup>.

## **1.5.2 Backcast**

ESIPC produced an ex-post (out-of-sample) backcast for a single year only (2007/08). Given the relatively short sample of data used to develop the forecasting model, it was not considered practical to produce out-of-sample forecast for more than one year. The backcast was performed for native demand and the results are summarised as follows:

- Actual Summer Native MD                    3,172 MW
- Backcast Summer Native MD                3,202 MW

The 2008 SOO South Australian summer MD backcast RSME is 0.96%.

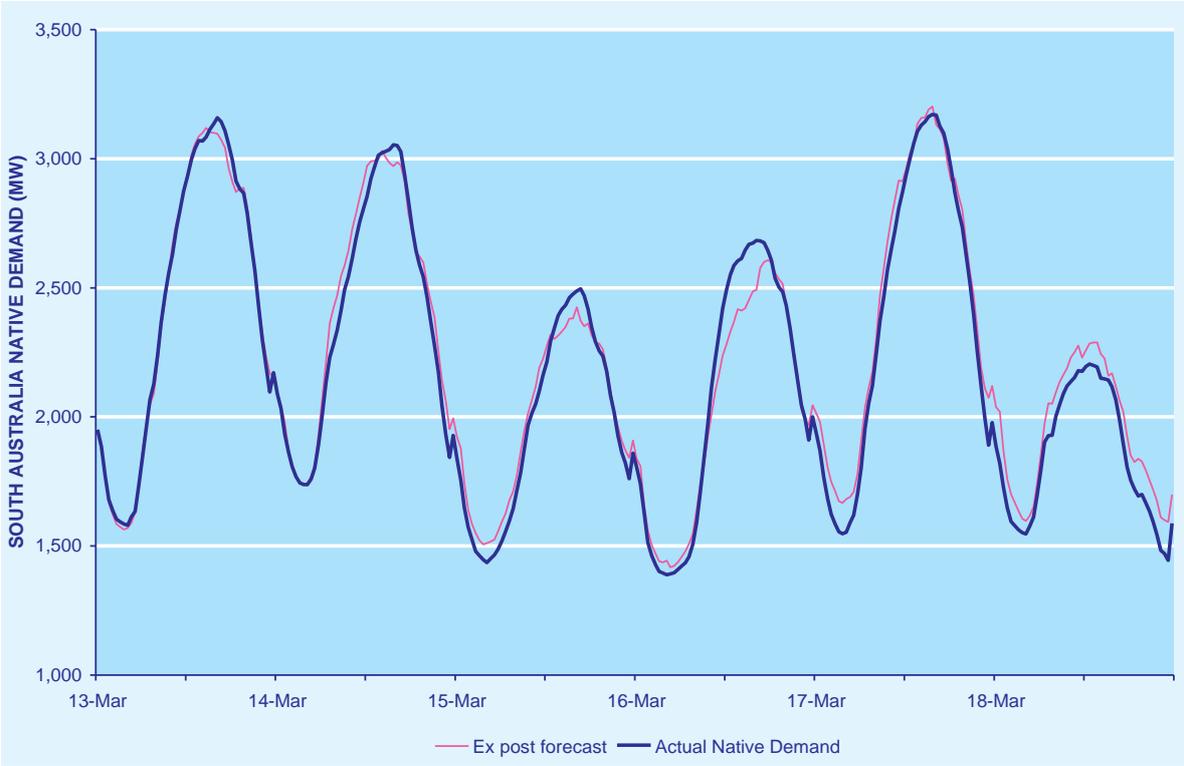
This single year backcast shows a significant correlation between the backcast value and the actual value. ESIPC performed this analysis for the first time in 2008. Therefore, there is no previous value of RMSE available for comparison.

ESIPC advises as follows <sup>[6]</sup>:

- As part of the forecast development work, Monash University has also developed new methods for assessing the performance of MD forecasts. The assessment methods cover both the:
  - point forecasts associated with the underlying demand model; and
  - distribution forecasts derived from the simulation process and used to identify POE levels.
- On an ex-post evaluation basis (i.e., after updating the model with actual economic and temperature data for the 2007/08 summer), the underlying demand model is shown to have predicted the 2007/08 summer native MD with an error of less than 1%.

- The ex-post backcast for the 2007/08 year was performed at a half-hourly resolution. Figure 12 shows the backcast for the time of the 2007/08 summer native MD <sup>[6]</sup>.

**Figure 12: South Australian Half-Hourly Backcast at the Time of the 2007/08 Summer Native MD (17 March)**



- Figure 12 shows a very good agreement between the backcast native demand and actual values at a range of demand levels at the time of the regional summer MD.

## 1.6 TASMANIA

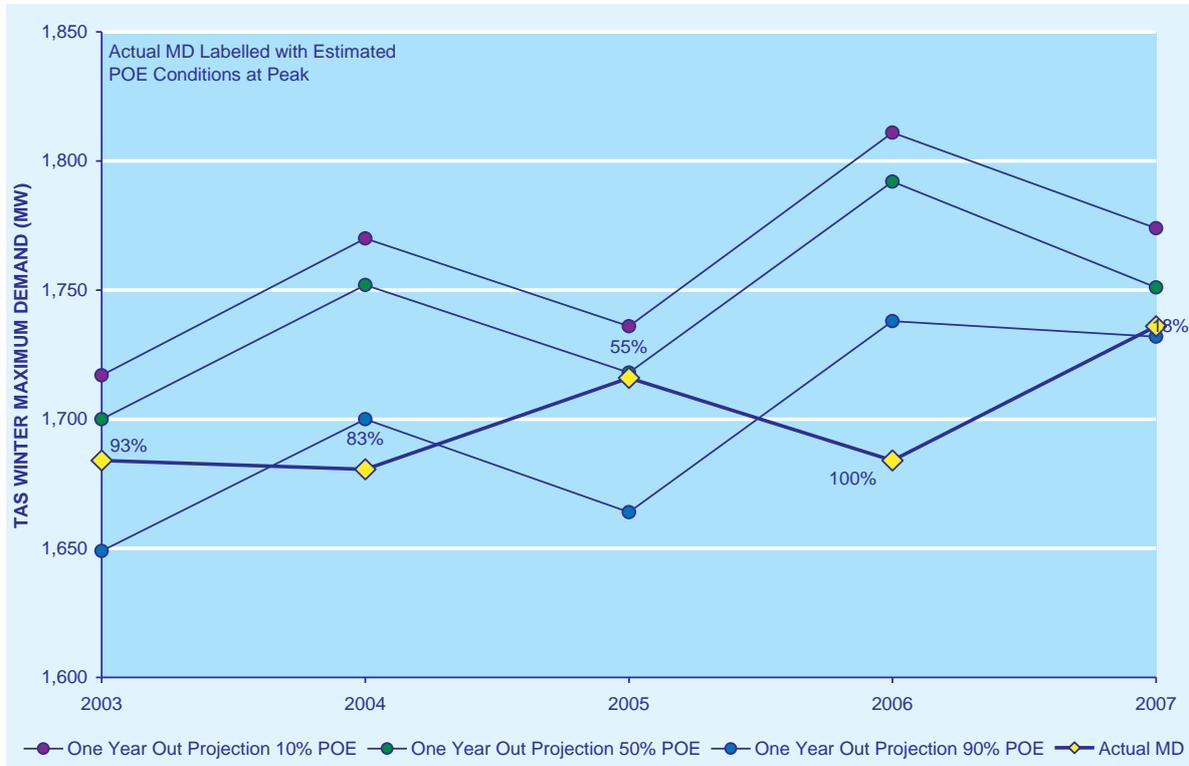
This section presents the winter back assessments and backcast analysis for the Tasmanian region. A winter scheduled MD analysis is presented because the Tasmanian annual scheduled MD occurs in winter.

### 1.6.1 Back assessment

Figure 13 and Figure 14 shows the one-year-out and two-year-out winter scheduled MD back assessments. These figures show different actual scheduled MDs for 2005 (to each other). This is because the scheduled MD projections before and after Tasmania joined the NEM (in 2005) were developed on a different basis. The projections developed:

- before this date were based on grid-connected generation; and
- after this date were based on scheduled generation only (excluding demand supplied by non-scheduled generating units).

**Figure 13 Tasmanian Winter Scheduled MD One-Year-Out Back Assessment**



**Figure 14 Tasmanian Winter Scheduled MD Two-Year-Out Back Assessment**

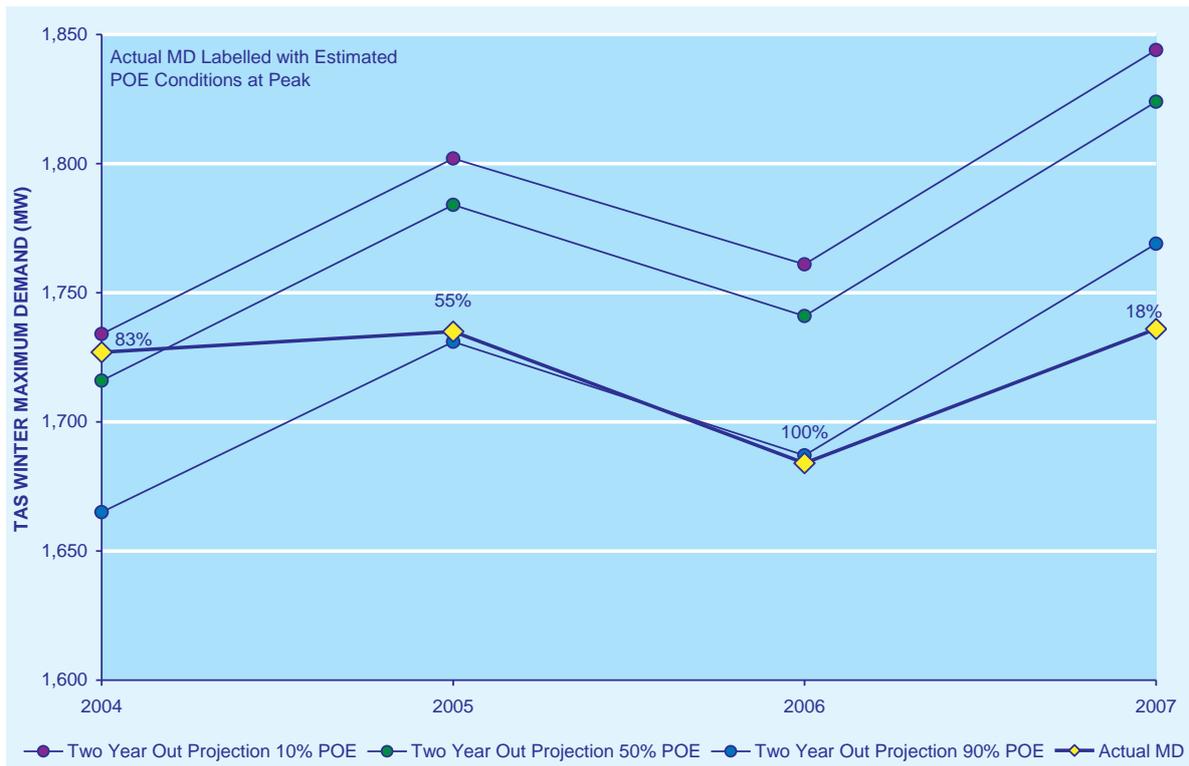


Figure 13 and Figure 14 show the following:

- The one-year out projections for the 2006 winter scheduled MD are higher than the observed value. It is not possible to comment on the extent to which the projections are greater than the actual value, as the overall shape of the scheduled MD distribution is not well known.
- The two-year-out 90% POE projection for the 2006 winter scheduled MD is much closer to the actual MD. There are, however, differences between the one-year and two-year out projections for 2006 winter scheduled MD.
- The remaining projections, considering the assessed POE level, depart from the actual values, apart from the one-year-out projections for the 2005 winter. The one-year-out projections for winter 2004 and 2007, and the two-year-out projections for winter 2005 and 2007, considering the assessed POE levels, are all very high compared to the actual values. The one-year-out projections for winter 2003 and two-year-out projections for winter 2004, considering the assessed POE levels, are low and very low, respectively, compared to the actual values.

Transend advises as follows:

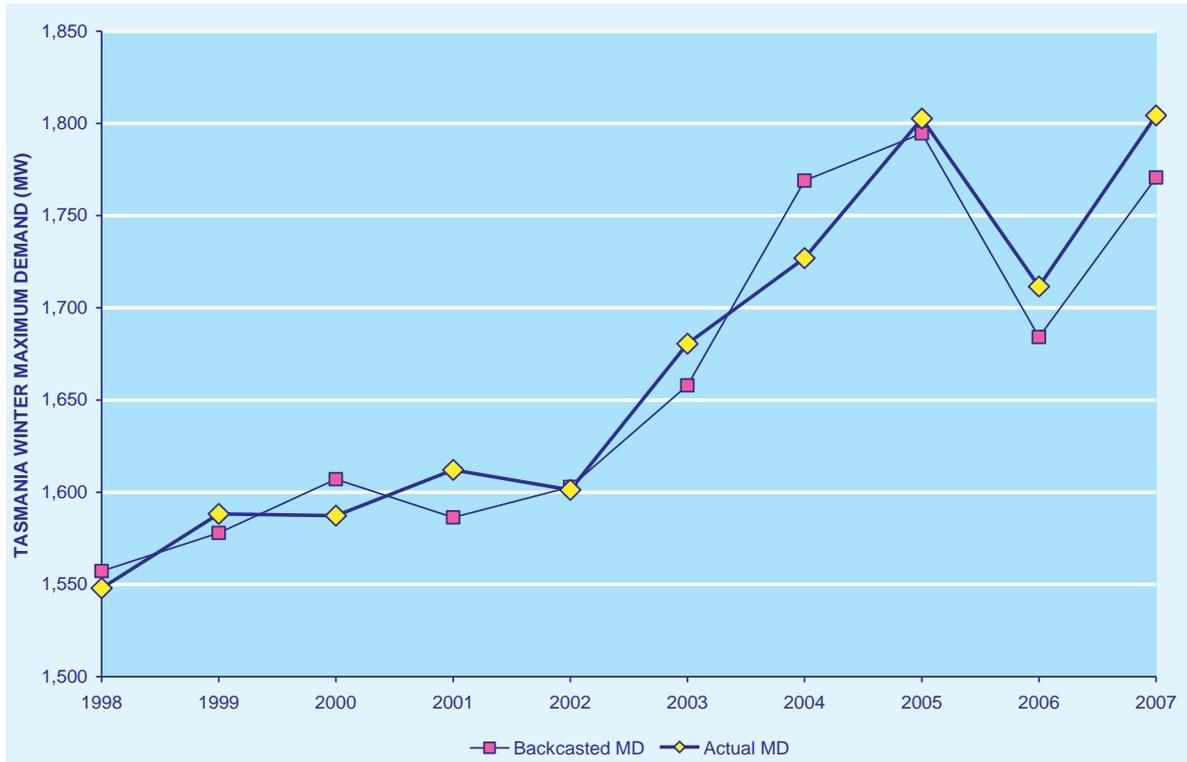
- The scheduled MD for the 2006 winter has been assessed as a POE of 100% because the corresponding temperature at the time of this MD was higher than allowed by the forecasting model (which is based on historical information).
- Projection discrepancies are mainly caused by:
  - actual industrial load being some 40 MW lower than expected at system scheduled MD for winter 2007;
  - variations in major industrial load from one year to the next, which contributes up to 40 MW (approximately) of the difference between the projected scheduled MDs and the actual MDs;

- the economic performance in 2007, which was below what was expected when the projections were developed; and
- variations in actual temperatures at the time of the scheduled MD, which also contributed to the differences between the actual and projected winter scheduled MD.

### 1.6.2 Backcast

Figure 15 shows the 10-year backcast<sup>6</sup> from the same model used to produce the 2008 SOO forecast. Table 3 compares the latest backcast RSME value with last year's value.

**Figure 15 Tasmanian Winter MD Backcast**



**Table 3 Tasmanian Winter Scheduled MD Backcast RSME Values**

Year	RSME (%)
2007	1.2
2008	1.4

Figure 15 shows that the backcast values generally follow the same trend as the actual scheduled MD values. The 2008 SOO Tasmanian winter scheduled MD was able to be backcast over an extended time due to the use of in-sample forecasts

Transend advises as follows:

- Transend engaged NIEIR to prepare the winter scheduled MD projections for the Tasmanian region, using NIEIR's load forecasting methodology. A recent review of this methodology resulted

<sup>6</sup> The 10-year backcast is based on native MD.

in changes to the POE reference temperatures for 2007 (see the 2007 SOO, Chapter 3, Section 3.8.4, for more information).

- The actual scheduled MDs represent total actual demands, including major industrial loads. Variations in major industrial load, however, can contribute to backcasting error by up to 40 MW. The backcast graphs have been adjusted to reflect this variation. Therefore, remaining variations between forecast and actual scheduled MD illustrated in Figure 15 reflect the performance of the forecasting model.

## **1.7 REFERENCES**

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