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# Appendix B Load forecasting

## B.1 VALIDATION OF MAXIMUM DEMAND PROJECTIONS

### B.1.1 Background

The 2006 Statement of Opportunities (SOO) included a comparison of the maximum demand (MD) projections prepared for the 2005 SOO and the actual seasonal (summer and winter) MDs.

**KEMA's recommendation**

As part of its review of the SOO load forecast preparation processes [1], KEMA recommended that the:

- model validation include more comprehensive backcasts, which should take into account actual economic conditions as well as actual temperatures;
- backcasts should validate more than the first projected year of each set of 10-year projections; and
- errors between the values obtained from the backward looking process and the actual recorded values be used to produce a measure of the forecast's accuracy. Probability distributions associated with the unexplained portion of this error might be incorporated into the calculation of the spread of the different probability of exceedence (POE) levels.

**2007 SOO historical methods for validating MD projections**

The 2007 SOO introduces two new methods for validating the regional MD projections using historical information [1]:

- back assessment; and
- backcasting.

**Back assessment**

Back assessment involves comparing previous MD projections with actual values. The 2007 SOO includes two back assessments:

- One-year-out back assessments compare actual MDs with the most recent projections made for the same period (for example, the 2006/07 actual MD is compared with the 2006/07 summer MD projections made in 2006 SOO).
- Two-year-out back assessments compare actual MDs with the second most recent projections made for the same period (for example, the 2006/07 actual MD is compared with the 2006/07 summer MD projections made in 2005 SOO).

These one and two-year time frames correspond to the MT PASA outlook period, the results of which are used to determine the need for market intervention.

This analysis includes all previous SOOs, starting from the 1999 publication.

[1] As agreed by the Load Forecasting Reference Group (LFRG) and the Ihnter-Regional Planning Committee (IRPC).

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### Back assessment analysis

The back assessment provides a qualitative indication of:

- the suitability of the spread of the 10% POE, 50% POE and 90% POE values for each MD projection;
- the accuracy of the 50% POE MD projections (which should be at the median of the actual MD values); and
- improvements in the forecasting techniques over the long term.

### Backcasting

Backasting involves calculating previous MDs (taking actual economic conditions and temperatures into account) using current forecasting methodologies (as per the KEMA recommendation), and comparing the results with the actual MDs that occurred at the time. The purpose of backcasting is to assess the effectiveness and accuracy of current models for projecting MD.

Because the backcast makes its comparison with actual MD values (real data), the performance of new or modified models can be established immediately.

### Backcasting analysis

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 the ERR is the difference between the model output and actual MD in %.

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);
- test the importance of a potential input variable by adding it to the model and re-calculating the backcast (stepwise regression);
- demonstrate accuracy improvements after significant changes are made to the forecasting methodology;
- compare forecast accuracy between different regions; and
- compare the performance of the current and the previous year's forecast models. This analysis is not available in the 2007 SOO, as a backcast was not produced in 2006, but will be available in 2008.

## B.1.2 Queensland

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

### Queensland back assessment

Figure B.1and Figure B.2 show the Queensland one-year-out and two-year-out summer MD back assessments.

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

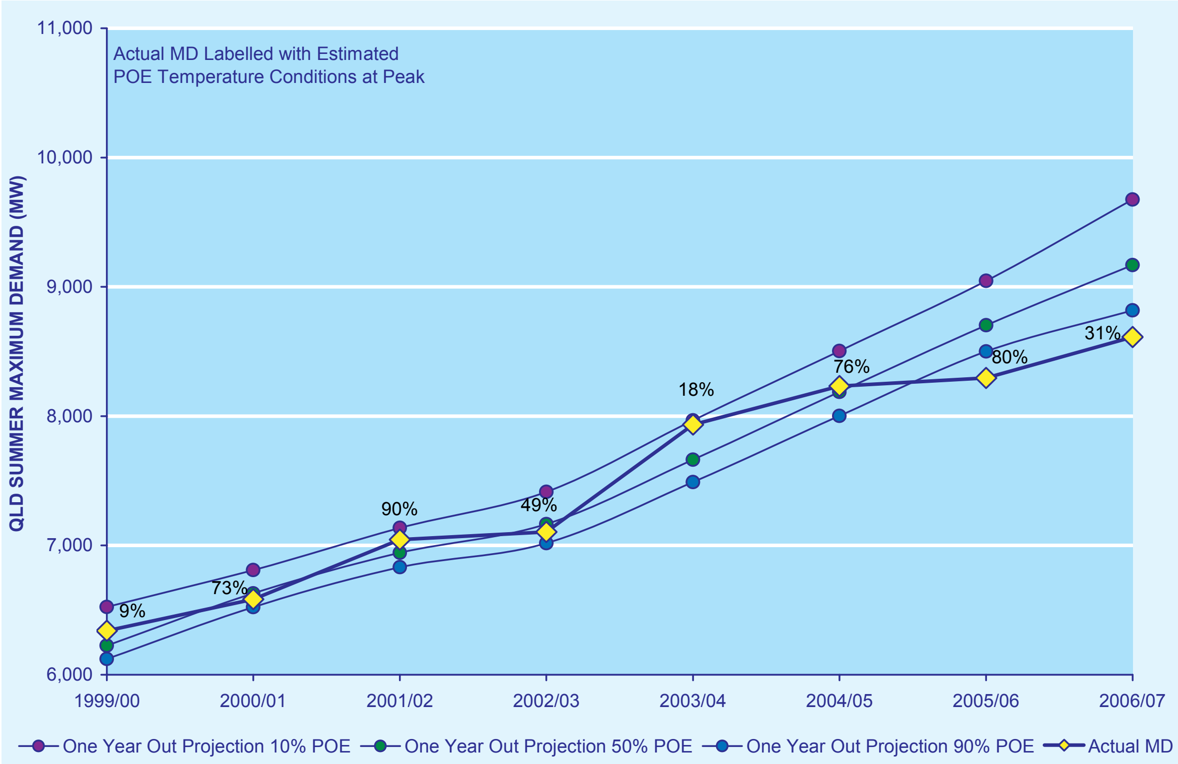


**Figure B.2 Queensland Summer MD Two-Year-Out Back Assessment**

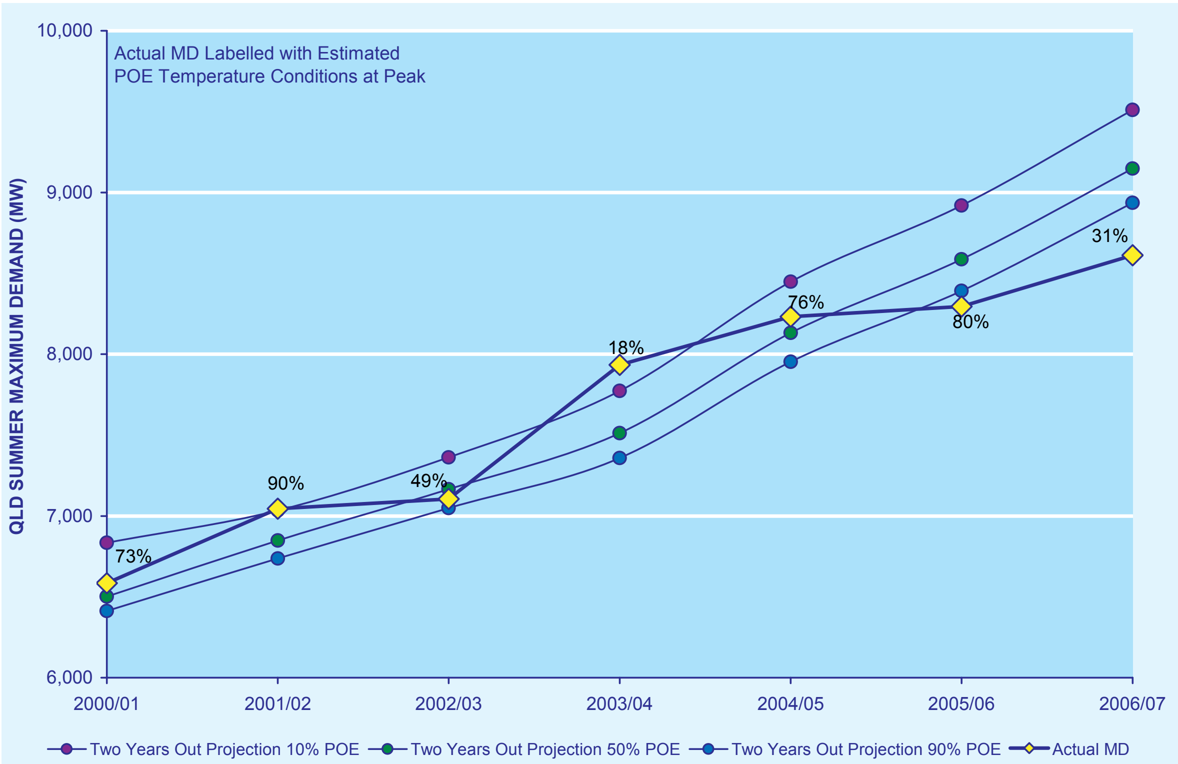

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Figure B.1 and Figure B.2 show the following:

- One-year-out and two-year-out projections for 2005/06 and 2006/07 did not match the actual summer MD. Both the one-year-out and two-year-out 90% POE projections for the 2005/06 and 2006/07 summers are higher than the actual MDs achieved. Given the summer temperature conditions (80% POE and 31% POE, respectively), the 90% POE projections should have been below these levels.
- Two-year-out projections for 2001/02 and 2003/04 did not match the actual summer MD. The actual 2001/02 summer MD (a 90% POE temperature condition), matches the 10% POE projection for that year. The actual 2003/04 summer MD (an 18% POE temperature condition), is higher than the 10% POE projection for that year.

Powerlink Queensland provided the following details [2]:

- The background to the actual 2005/06 summer peak involved an unusually large weather pattern variation, which resulted in a higher than average diversity of demand.
- The background to the actual 2006/07 summer peak involved a:
    - greater than average diversity of weather patterns at the time of the actual summer 2006/07 peak (though to a lesser degree than summer 2005/06);
    - later than usual occurrence of the 2006/07 summer peak, resulting in lower than expected MD [2];
    - drop in expected population growth;
    - higher than expected embedded non-scheduled generation at the time of summer peak;
    - delay in the commissioning of several block loads; and
    - mild summer in South East Queensland resulting in a reduction in the use of air-conditioning.
- The mismatches between the two-year-out projections for 2001/02 and 2003/04 and the actual MDs are mainly due to unexpected increases in domestic air-conditioning sales. The MD forecast had been revised upwards in the one-year-out projections to more appropriately factor in the impact of the air conditioning loads.

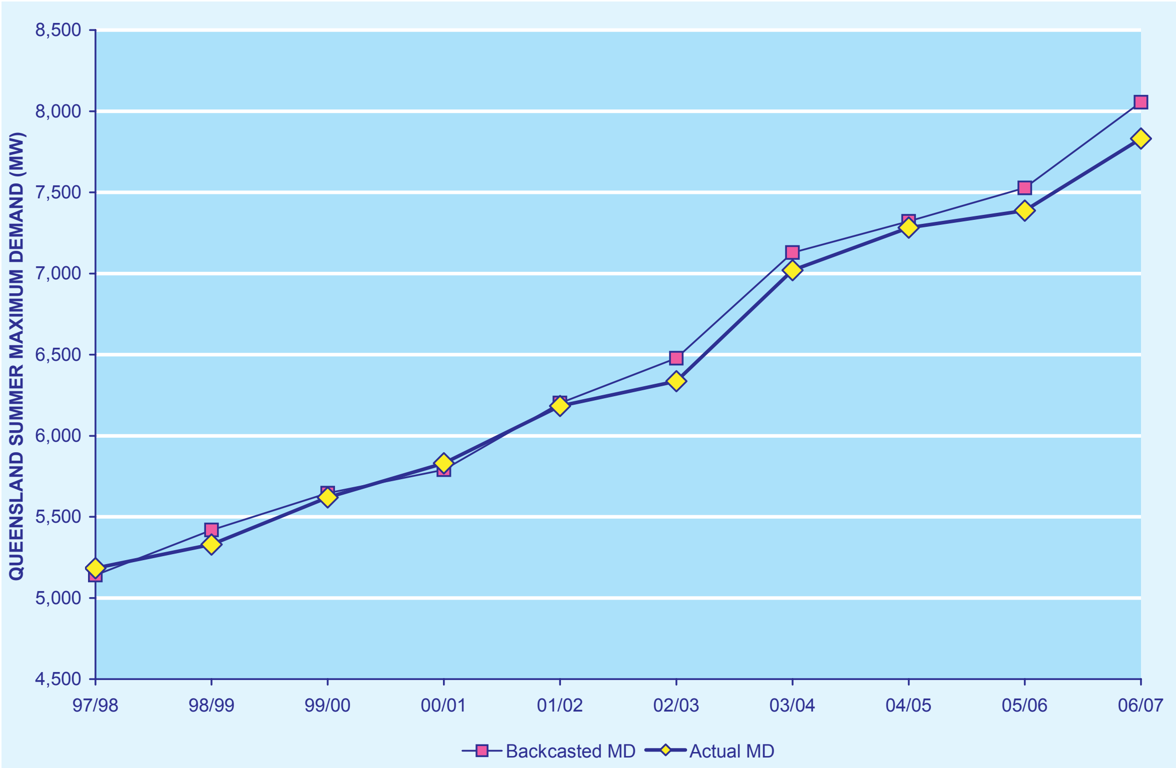
The one-year-out and two-year-out projections for the rest of the time accurately encompassed the actual MDs, which enables confidence in the forecasting methodology.

**Queensland backcast**

Queensland has a four-area temperature dependence model to cover the region's diverse weather patterns. To provide a meaningful correlation between Queensland demand and weather conditions, Powerlink Queensland analysed the diversity between these areas, in accordance with practices endorsed by KEMA. Substantial variation also occurs in the large industrial loads at the time of high Queensland summer demand, so that it is necessary to correct historical Queensland peak demands

[2] As a result of the peak occurring in mid-March, despite being a hot day in South East Queensland, its contribution to this maximum was lower than expected. During the nominal summer months, the northern half of Queensland experienced consistently wet and mild conditions with hot weather only arriving in March.

**Figure B.3 Queensland Summer MD Backcast**




for both weather pattern diversity and industrial load. This backcast analysis provides a single point reference for measuring the performance of this methodology.

Figure B.3 shows a 10-year backcast using the forecasting methodology for 2007. This backcast shows that the backcast MDs are close to the actual MDs, with an RMSE of 1.51 %, which enables a high degree of confidence in the forecasting methodology.

### B.1.3 New South Wales

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

New South Wales back assessment

Figure B.4 and Figure B.5 show the New South Wales one-year-out and two-year-out summer MD back assessments.

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

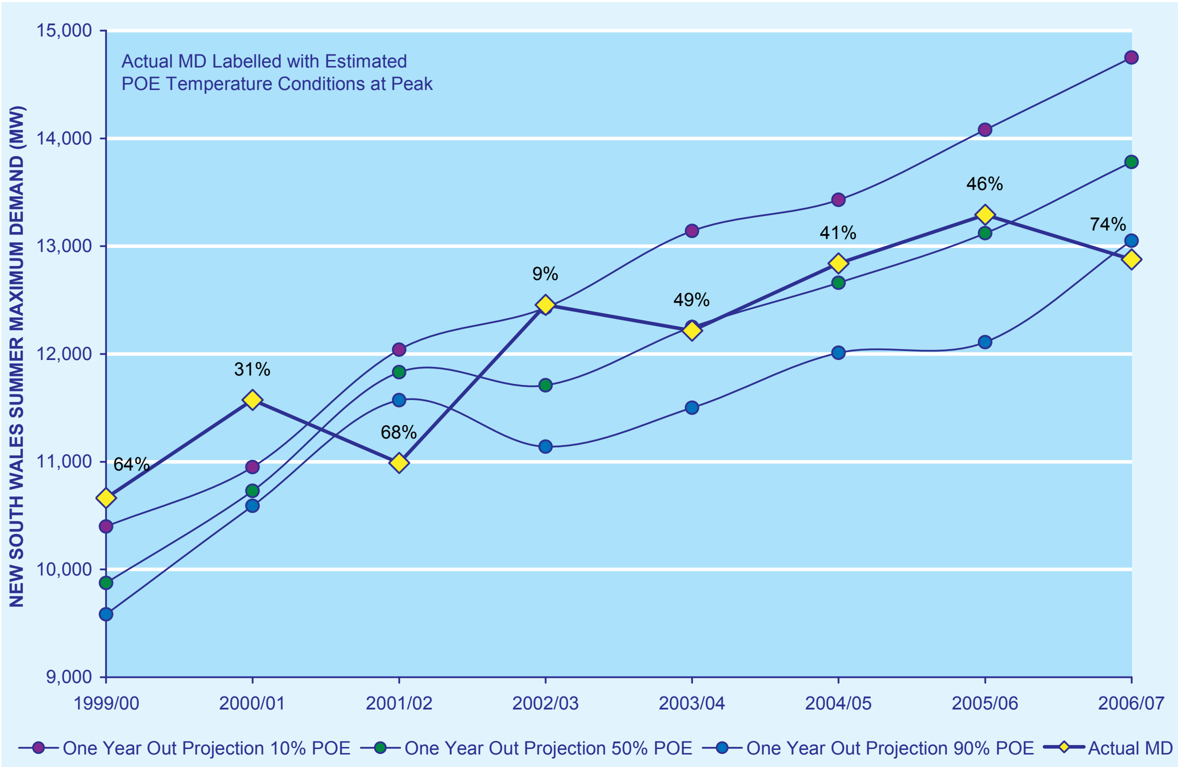



**Figure B.5 New South Wales Summer MD Two-Year-Out Back Assessment**

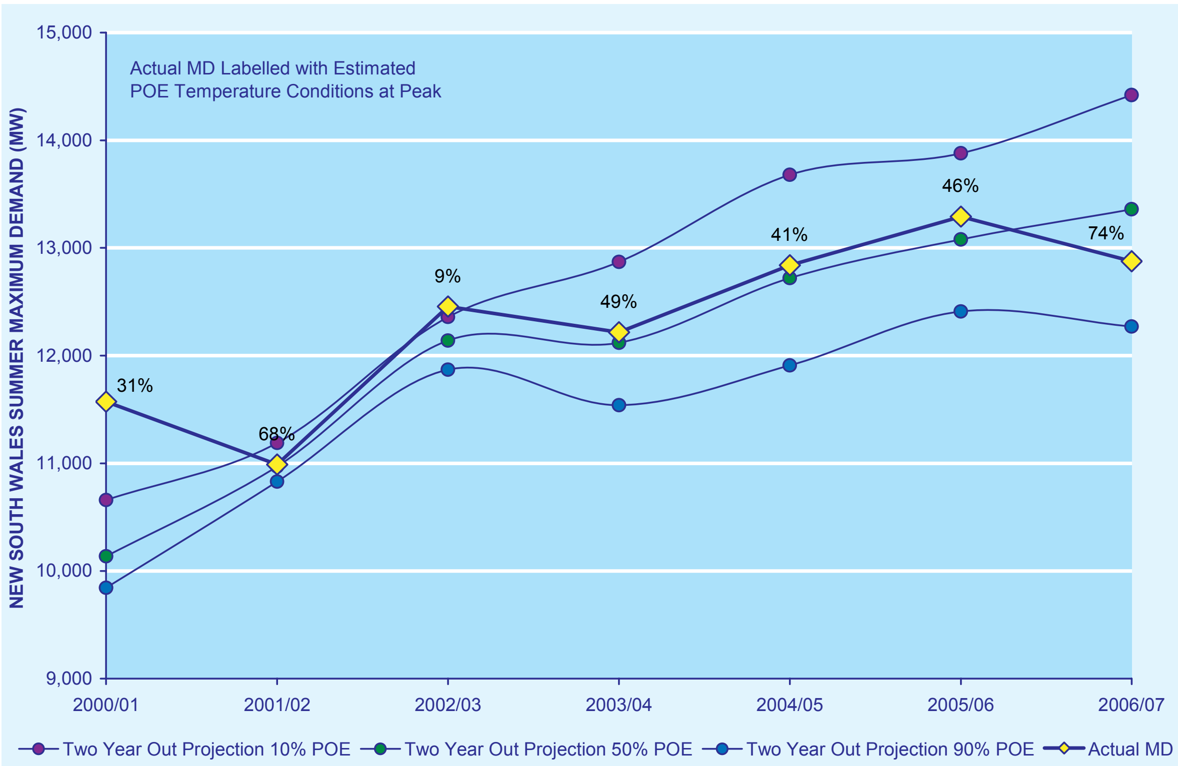



Figure B.4 and Figure B.5 show the following:

- One-year-out and two-year-out projections for the years 2000/01 – 2002/03 have a narrow range and fail to encompass some of the actual summer MDs, including the:

- one-year-out summer MD projections from 1999/00 - 2001/02; and
- two-year-out summer MD projections for the 2000/01 summer, which are well below the actual summer MD.

- One-year-out summer MD projections for 2006/07 did not encompass the actual MD, with the 90% POE projection being higher than the actual MD. The corresponding conditions (a 74% POE temperature condition), however, indicate that the 90% POE projection should be well below this level.

TransGrid provided the following details [3]:

- 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 been the case.
- The mismatch between the one-year-out summer 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, as additional weather information becomes available.

The one-year-out and two-year-out projections for the rest of the time encompassed the actual MDs (indicating a significant improvement in the load forecast methodology), which enables confidence in the forecasting methodology.

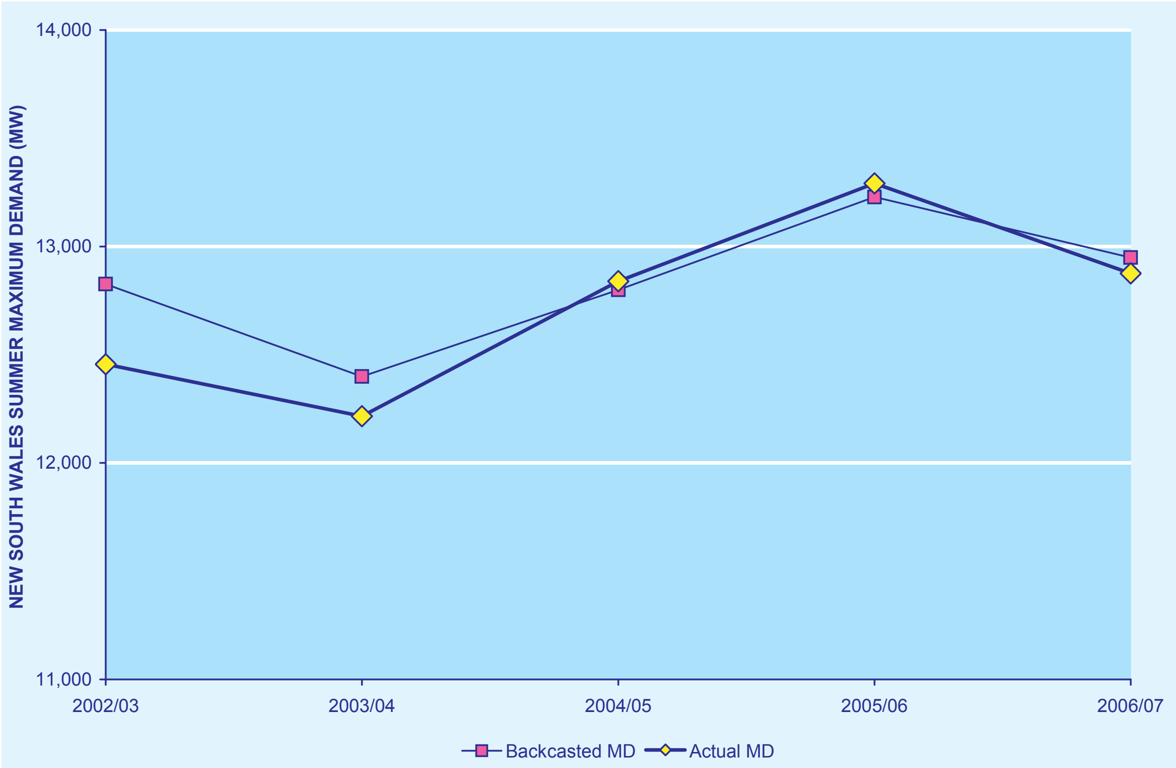
**New South Wales backcast**

The TransGrid forecasting model is highly complex, and includes three distinct, separately developed models [4]. This backcast analysis provides a single point reference for measuring the performance of the overall model.

**Error! Reference source not found.** shows the 5-year backcast using the forecasting methodology for 2007 [3]. This backcast shows that the backcast MDs are close to the actual MDs, with an RMSE of 1.5%, which enables a high degree of confidence in the forecasting methodology.

[3] TransGrid supplied backcast values for the past five years only. The available historical data was considered insufficient for producing out-of-sample backcast values for earlier years.

**Figure B.6 New South Wales Summer MD Backcast**




### B.1.4 Victoria

This section presents the summer back assessments and backcast analysis for the Victoria region.

**Victorian back assessment**

Figure B.7 and Figure B.8 show the Victorian one-year-out and two-year-out summer MD back assessments.

**Figure B.7 Victoria Summer MD One-Year-Out Back Assessment**

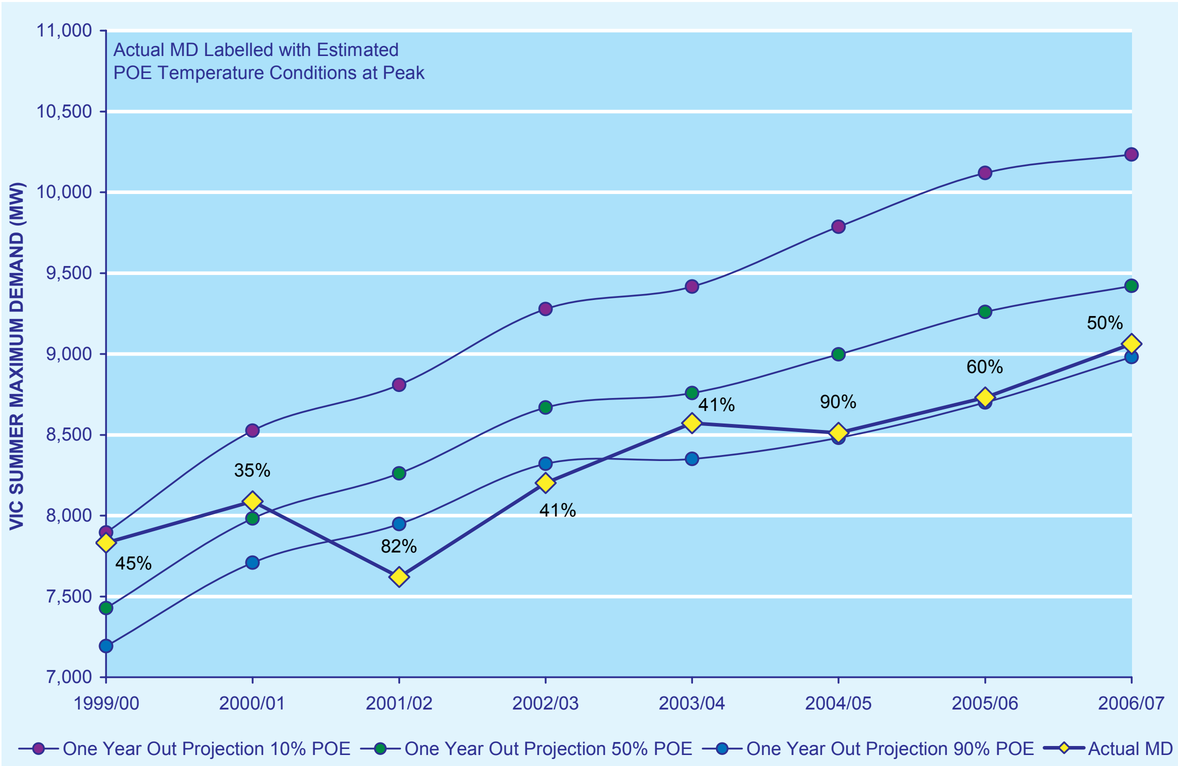



**Figure B.8 Victoria Summer MD Two-Year-Out Back Assessment**


Figure B.7 and Figure B.8 show the following:

- The one-year-out and two-year-out 50% POE projections for the 2006/07 summer were higher than the actual 2006/07 summer MD, which corresponded to 50% POE temperature conditions, .

- There was a general trend of summer MD projection over-estimation, as most of the actual summer MDs are either close to or below the 90% POE projections.

VENCorp provided the following details [5]:

- The mismatch between the projections for 2006/07 and the actual summer MD involved:
  - a widespread transmission outage that abruptly reduced electricity supplies to Victoria after 3:00 pm (EST) on 16 January 07, the day the summer MD occurred (the summer MD would most likely be higher, if the transmission outage had not occurred); and
  - demand-side participation (DSP) observed on the day of the summer MD.
- The general trend of summer MD projection over-estimation was caused by the underlying methodology used to develop the summer MD projections. This methodology forecast summer MDs that would occur if the defined 90%, 50% and 10% POE reference temperature levels were to prevail across the region on a weekday during February when all usual loads such as schools and industry were present. Due to the combined effects of these pre-defined conditions, this methodology tends to forecast summer MDs with POE levels lower than 90%, 50% and 10%.

The Victorian summer MD projections included in the 2007 SOO were prepared using a revised forecast method to reflect the true POE for summer MD projections. See the Victorian Annual Planning Report (APR) [6] for more information.

**Victorian backcast**

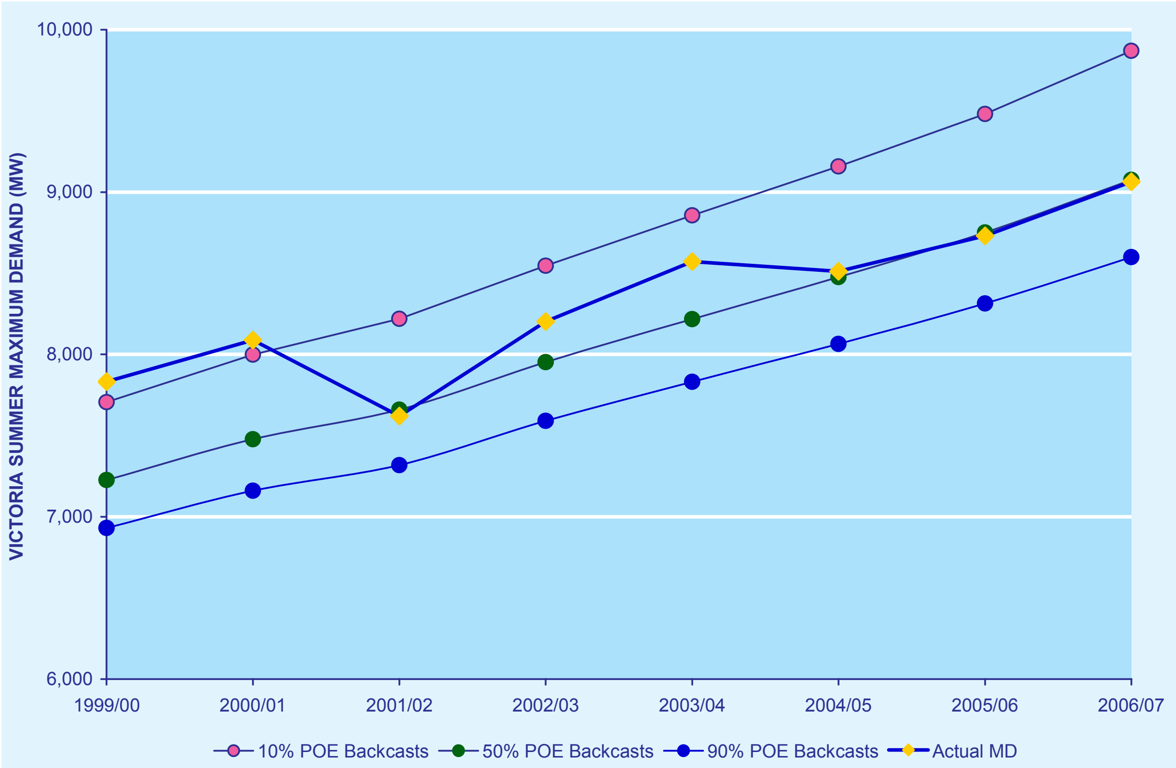
For the 2007 SOO, VENCorp engaged NIEIR to revise the Victorian summer MD forecast methodology to reflect the true POE for summer MD projections. The new forecast approach involves:

- generating a preliminary forecast using NIEIR's pre-existing forecast method, which is based on economic drivers and air-conditioning stock;
- generating another preliminary forecast, represented by a distribution of synthetic summer MDs based on a range of possible combinations of temperature, day-type, and time-of-peak-demand events, deriving from historical information; and
- deriving the final forecast by reconciling the two preliminary forecasts.

Figure B.9 shows the 8-year backcast using the forecasting methodology for 2007 [4].

[4] For consistency, VENCorp supplied backcast values for the past 8 years only.

**Figure B.9 Victoria Summer MD Backcast**




This backcast shows that from 2001/02 onwards, the backcast summer MD projections encompass the actual MDs.

The backcast summer MD projections provided by VENCorp represent a range of 10%, 50% and 90% POE conditions, not a single value for the actual conditions that occurred at the time. As a result, a single RMSE could not be calculated.

NEMMCO and VENCorp will discuss the provision of backcast summer MDs corresponding to actual conditions, so a single RMSE number can be calculated and used as a future benchmark.

### B.1.5 South Australia

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

#### South Australian back assessment

Figure B.10 and Figure B.11 show the South Australian one-year-out and two-year-out summer MD back assessments.

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**Figure B.10 South Australia Summer MD One-Year-Out Back Assessment**


**Figure B.11 South Australia Summer MD Two-Year-Out Back Assessment**


Figure B.10 and Figure B.11 show the following:

- One-year-out POE projections did not encompass the actual summer MDs. Given the summer temperature conditions, the 90% POE projections from 2002/03 onwards should have been below the actual summer MDs.

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- Six out of the last eight summer MDs are lower than the one-year-out 90% POE projections.
- Most of the actual summer MDs are either below or close to the 90% POE projections. This suggests that the methodology tends to over-estimate the summer MD projections.

ESIPC provided the following details [7]:

- These outcomes were mainly due to the underlying methodology used to develop the summer MD projections. This methodology forecast summer MDs that would occur if the defined 90%, 50% and 10% POE reference temperature levels were to prevail across the region on a weekday during February when all usual loads such as schools and industry were present. Due to the combined effects of these pre-defined conditions, this methodology tends to forecast summer MDs with lower than expected POE levels.
- During the past several years, ESIPC has been working towards improving the methodology used to prepare the forecasts by incorporating a wider range of uncertainties and understanding the entire distribution of half-hourly summer demand levels. This work has now progressed to the stage where a new forecasting methodology had been adopted for the 2007 South Australian summer MD projections. The intention has been to develop forecasts that are conditional only on economic conditions and not on the time of the season or unusual weather events (such as cool changes moving across South Australia early on the day that the summer peak occurs). Consideration will be given in the future to extending this methodology to the South Australian winter peak demand forecasts. See the South Australian APR [8] for more information about the change to ESIPC's forecasting methodology.

**South Australian backcast**

A new forecast methodology developed by Monash University's Business and Economic Forecasting Unit was used to prepare the 2007 South Australian summer MD projections. This new methodology:

- represents the culmination of several years of research into alternative forecasting techniques for South Australia, as reported in previous South Australian APRs; and
- builds upon earlier research undertaken by a PhD candidate sponsored by ESIPC.

Figure B.12 shows the 10-year backcast using the forecasting methodology for 2007 [5].

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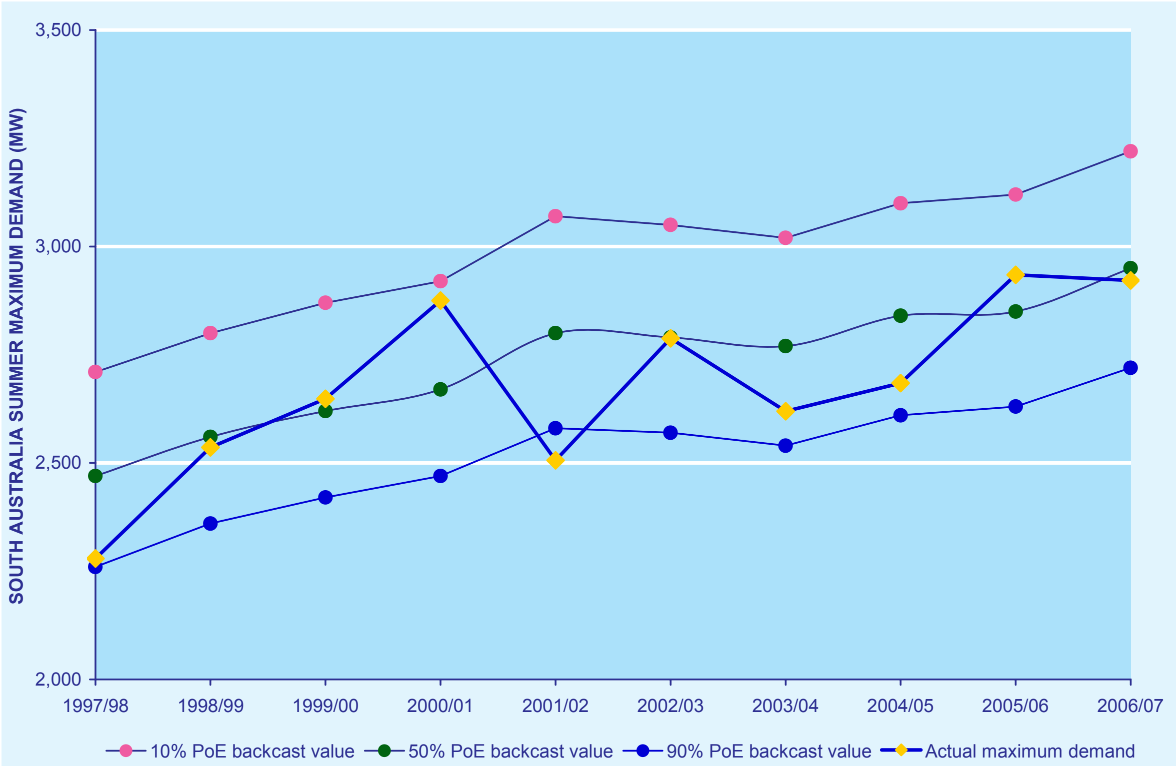
[5] The 10-year backcast is based on native MD.

**Figure B.12 South Australia Summer MD Backcast**




This backcast shows that:

- four out of the 10 actual MDs lie above the 50% POE level, while five would be expected on average;
- one MD in the past 10 years is less than the 90% POE level, in line with the 95% POE condition occurring in that year;
- one MD in the past 10 years is near the 10% POE level;
- there was a pause in MD growth in 2002/03 and 2003/04, following the real price increases experienced in South Australia at around that time - more typical levels of growth reappeared in later years as the price effect passed and subsequent retail prices fell slightly; and
- the backcast POE MD projections appear to be consistent with the historical data.

The backcast summer MD projections provided by ESIPC represent a range of 10%, 50% and 90% POE conditions, not a single value for the actual conditions that occurred at the time. As a result, a single RMSE could not be calculated.

NEMMCO and ESIPC will discuss the provision of backcast summer MDs corresponding to actual conditions, so a single RMSE number can be calculated and used as a future benchmark.

### B.1.6 Tasmania

This section presents the winter back assessments and backcast analysis for the Tasmania region. A winter MD analysis is presented because Tasmania is winter peaking.

**Tasmanian back assessment**

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Figure B.13 and Figure B.14 show the Tasmanian one-year-out and two-year-out summer MD back assessments. These figures show a different actual MD for 2005. This is because the MD projections before and after Tasmania joined the NEM in 2005 were made on a different basis. Projections made prior to this date were for MD supplied by all grid-connected generating units. Projections made after this date were for MD supplied by scheduled generating units only (excluding demand supplied by non-scheduled generating units).

**Figure B.13 Tasmania Winter MD One-Year-Out Back Assessment**

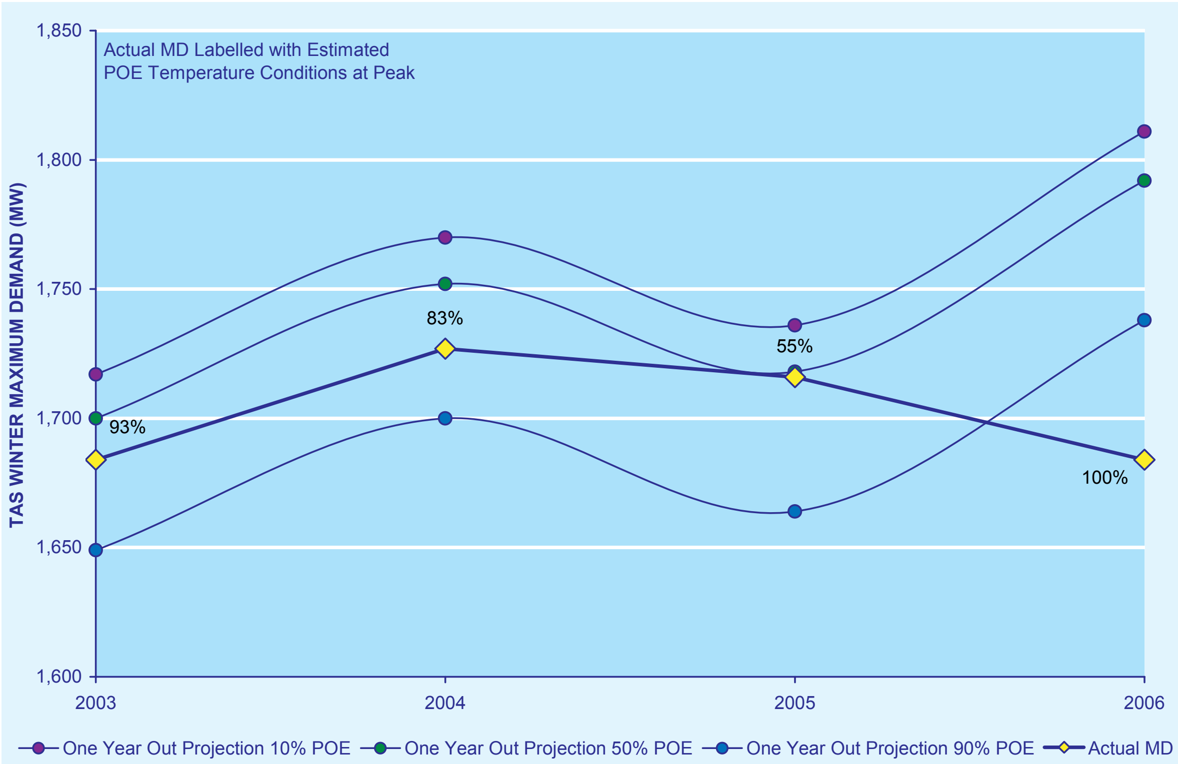

**Figure B.14 Tasmania Winter MD Two-Year-Out Back Assessment**

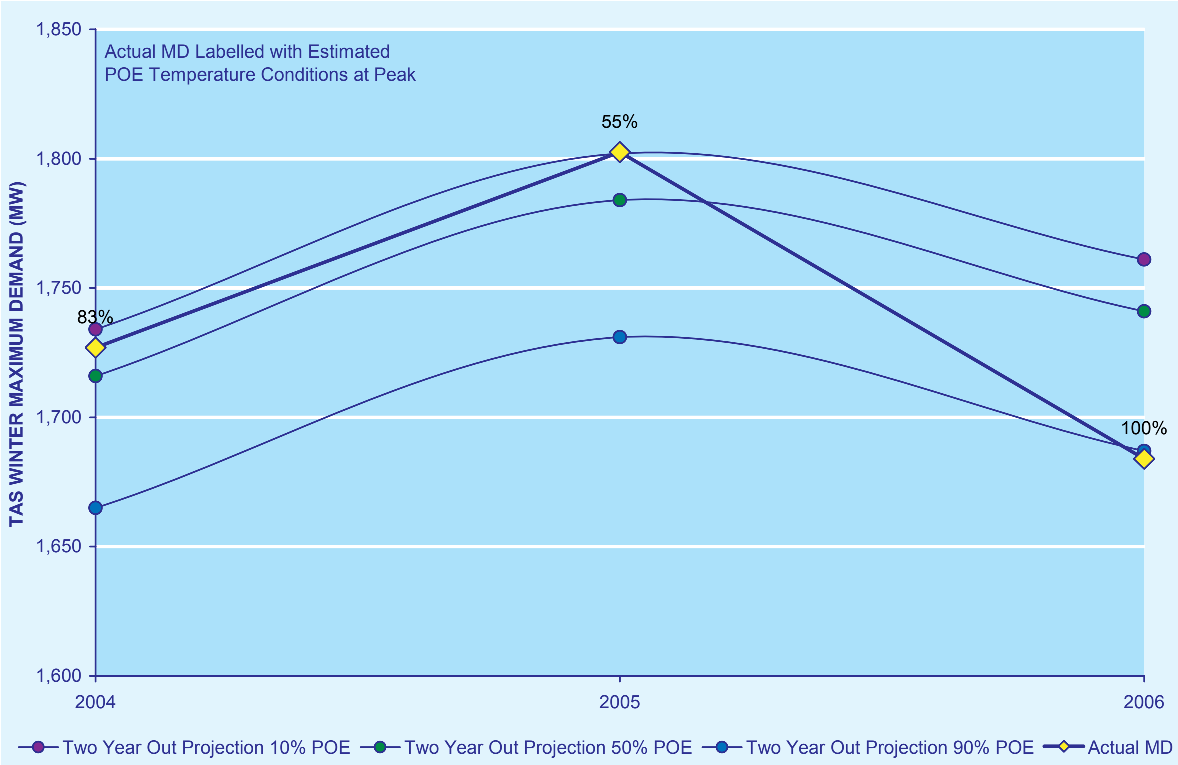


Figure B.13 and Figure B.14 show that the following:

- One-year-out projections for 2003 were lower than expected. The corresponding conditions (a 93% POE temperature condition) indicate that the 90% POE projection should be above the actual winter MD.
- Two-year-out projections for 2004 and 2005 were lower than expected. The corresponding conditions (83% POE and 55% POE temperature conditions, respectively) indicate that the 50% POE projection should be above the actual winter MD.

Transend advises [9] that the discrepancies are mainly caused by variation in major industrial loads, which could contribute up to around 30 MW differences between the projected MDs and the actual MDs.

**Tasmanian backcast**

Transend engaged NIEIR to prepare the winter MD projections for the Tasmanian region, using NIEIR's load forecasting methodology. A recent review of this methodology resulted in changes to the POE reference temperatures this year (see Chapter 3, Section 3.8.4, for more information).

Figure B.15 shows the 10-year backcast using the forecasting methodology for 2007 [6].

[6] The 10-year backcast is based on native MD.

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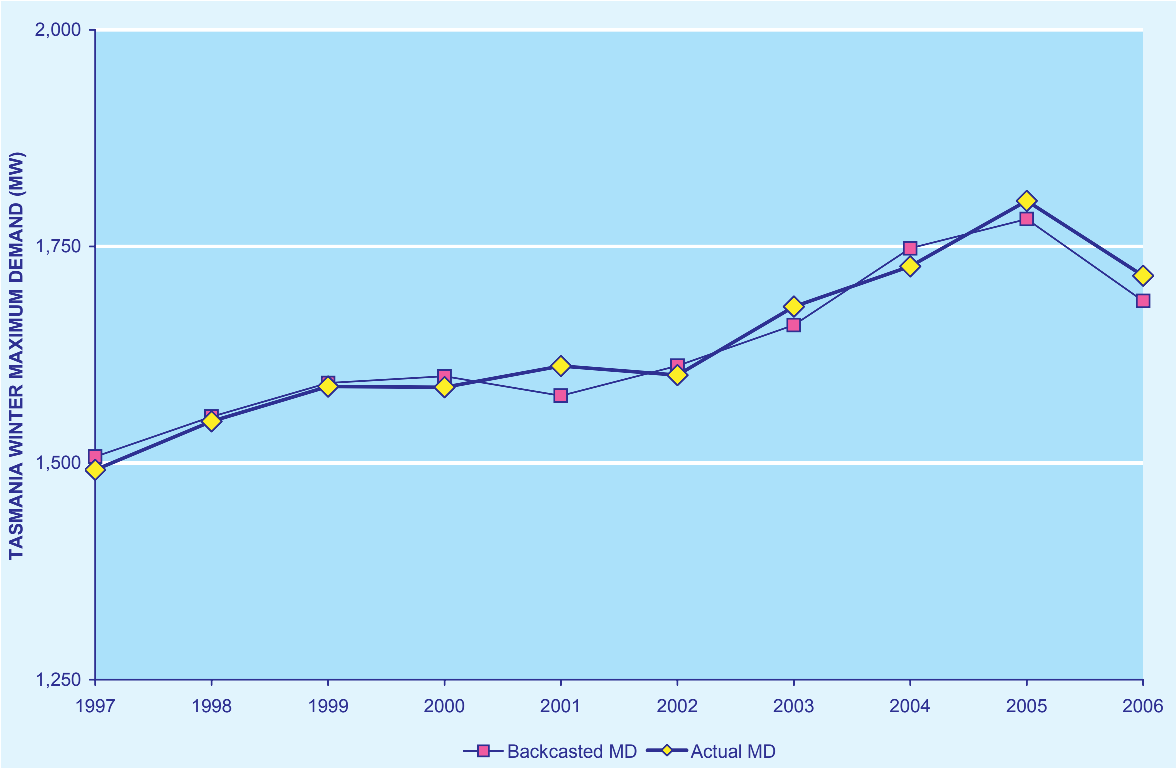
**Figure B.15 Tasmania Winter MD Backcast**




This backcast shows that the backcast MDs are close to the actual MDs, with an RMSE of 1.2%, which enables a high degree of confidence in the forecasting methodology.

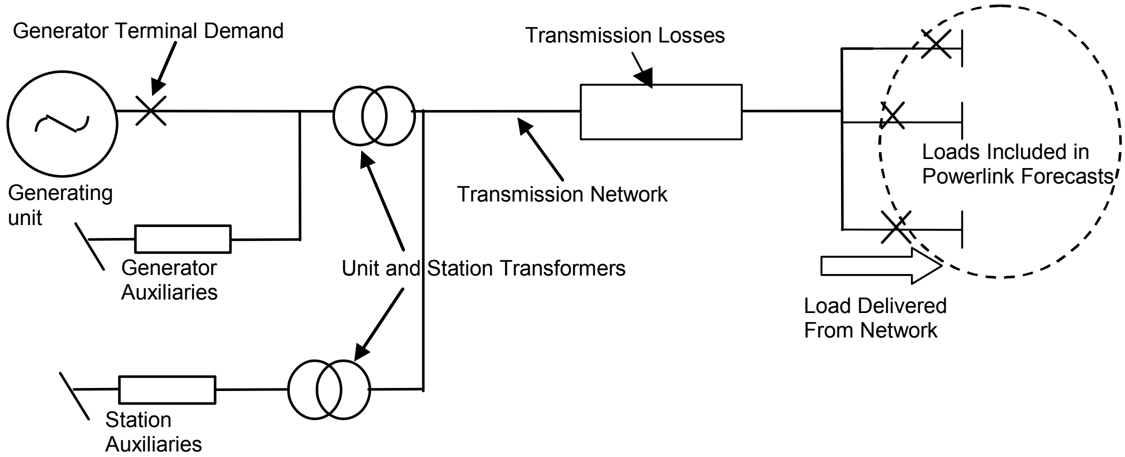
## B.2 QUEENSLAND SCHEDULED MD PROJECTIONS

Powerlink Queensland prepares MD projections on a delivered-from-network basis. NEMMCO, however, requires MD projections on a generator-terminal basis. This section describes how the delivered-from-network projections are converted to generator-terminal projections.

### B.2.1 Delivered-from-network demand

Figure B.16 illustrates the concept of delivered-from-network demand.

**Figure B.16 Load Forecasts on a Delivered-From-Network Basis**




Delivered-from-network demand is equal to generator-terminal demand, minus:

- generator and station auxiliary loads;
- generating unit and station transformer losses; and
- transmission system losses.

### B.2.2 Conversion to generator-terminal demand

The following equation was provided by Powerlink Queensland to calculate the generator-terminal demand projections.

Generator-terminal demand = $(D + L50m * (D/D50m)^{1.75}) / 0.94$

Where:

- D is the delivered-from-network demand;
- L50m is the transmission loss for the 50% POE medium-growth forecast (for that year and season); and
- D50m is the delivered-from-network demand for the 50% POE medium-growth forecast (for that year and season).

The equation assumes that station auxiliaries and losses are equal to 6.0% of the generator-terminal demand, and the transmission loss is proportional to the demand, raised to the power 1.75.

This equation was developed in consultation with Powerlink Queensland.

Table B.1 lists Powerlink Queensland's projections for transmission losses [10-12].

**Table B.1 Transmission Loss for the 50% POE Medium-Growth MD Projections**

| Winter MD | | Summer MD | |
|---|---|---|---|
| Year | Tr Loss | Year | Tr Loss |
| 2008 | 320 | 2007/08 | 416 |
| 2009 | 333 | 2008/09 | 435 |
| 2010 | 346 | 2009/10 | 452 |
| 2011 | 359 | 2010/11 | 469 |
| 2012 | 370 | 2011/12 | 486 |
| 2013 | 383 | 2012/13 | 504 |
| 2014 | 395 | 2013/14 | 520 |
| 2015 | 405 | 2014/15 | 536 |
| 2016 | 416 | 2015/16 | 553 |
| 2017 | 428 | 2016/17 | 570 |

### B.2.3 Delivered-from-network demand forecasts

Table B.2 and Table B.3 list Powerlink Queensland's delivered-from-network demand forecasts.

**Table B.2 Delivered-From-Network Winter Demand Projection Provided by Powerlink Queensland (MW)**

| | 90% | | | 50% | | | 10% | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Medium | High | Low | Medium | High | Low | Medium | High | Low |
| 2004 actual | | | | 6367 | | | | | |
| 2005 actual | | | | 6555 | | | | | |
| 2006 actual | | | | 6,891 | | | | | |
| 2007 | 7018 | 7184 | 6892 | 7,113 | 7283 | 6986 | 7248 | 7421 | 7117 |
| 2008 | 7297 | 7611 | 7042 | 7,397 | 7715 | 7138 | 7536 | 7862 | 7271 |
| 2009 | 7589 | 8098 | 7210 | 7,692 | 8209 | 7307 | 7837 | 8364 | 7443 |
| 2010 | 7880 | 8608 | 7378 | 7,987 | 8727 | 7477 | 8137 | 8892 | 7616 |
| 2011 | 8171 | 9190 | 7524 | 8,283 | 9316 | 7626 | 8437 | 9489 | 7766 |
| 2012 | 8426 | 9675 | 7635 | 8,542 | 9808 | 7739 | 8701 | 9992 | 7880 |
| 2013 | 8727 | 10203 | 7808 | 8,847 | 10346 | 7914 | 9012 | 10539 | 8058 |
| 2014 | 8988 | 11200 | 7933 | 9,114 | 11351 | 8042 | 9283 | 11555 | 8188 |
| 2015 | 9228 | 11688 | 8023 | 9,358 | 11849 | 8135 | 9532 | 12062 | 8282 |
| 2016 | 9483 | 12228 | 8099 | 9,619 | 12399 | 8213 | 9798 | 12624 | 8361 |
| 2017 | 9738 | 12769 | 8175 | 9,880 | 12950 | 8290 | 10063 | 13185 | 8440 |

**Table B.3 Delivered-From-Network Summer Demand Projection Provided by Powerlink Queensland (MW)**

| | 90% | | | 50% | | | 10% | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Medium | High | Low | Medium | High | Low | Medium | High | Low |
| 2004/05 actual | | | | 7282 | | | | | |
| 2005/06 actual | | | | 7388 | | | | | |
| 2006/07 actual | | | | 7,832 | | | | | |
| 2007/08 | 8206 | 8426 | 8021 | 8,477 | 8705 | 8284 | 8926 | 9169 | 8722 |
| 2008/09 | 8567 | 8921 | 8262 | 8,856 | 9223 | 8539 | 9332 | 9722 | 8997 |
| 2009/10 | 8894 | 9389 | 8484 | 9,200 | 9714 | 8774 | 9703 | 10248 | 9251 |
| 2010/11 | 9228 | 10045 | 8710 | 9,551 | 10394 | 9012 | 10081 | 10969 | 9508 |

| | 90% | | | 50% | | | 10% | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Medium | High | Low | Medium | High | Low | Medium | High | Low |
| 2011/12 | 9554 | 10477 | 8896 | 9,894 | 10849 | 9209 | 10451 | 11458 | 9723 |
| 2012/13 | 9908 | 11013 | 9124 | 10,266 | 11411 | 9450 | 10851 | 12060 | 9983 |
| 2013/14 | 10214 | 11942 | 9324 | 10,589 | 12364 | 9662 | 11202 | 13053 | 10215 |
| 2014/15 | 10515 | 12457 | 9507 | 10,908 | 12906 | 9858 | 11549 | 13639 | 10430 |
| 2015/16 | 10845 | 12975 | 9703 | 11,257 | 13451 | 10066 | 11928 | 14227 | 10658 |
| 2016/17 | 11176 | 13492 | 9899 | 11,606 | 13996 | 10275 | 12307 | 14816 | 10886 |

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