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7 December 2010

Mr Neville Henderson
Chairman, Reliability Panel
Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235
(submissions@aemc.gov.au)

Dear Neville

Report to 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 Electricity Statement of Opportunities (ESOO); and
2. any improvements to the forecasting process that will apply to the next ESOO.

As in previous years the accuracy of point forecasts is assessed in two ways:

- 'back assessment' compares actual outcomes to date with previously published forecasts; and
- 'backcasting' compares actual outcomes over a limited historical period with forecasts produced using the current forecasting model.

The attached report, Appendix B from the 2010 ESOO, provides this analysis.

The 2011 ESOO will continue to pursue consistency in approach between jurisdictions, with the Load Forecasting Reference Group (LFRG) researching options for the quantitative assessment of forecast probability distributions.

For any other specific enquiries about the accuracy of the demand forecasts or proposed improvements, please contact Ashley Lloyd, Senior Manager Energy Forecasting on 03 9609 8372 or ashley.lloyd@aemo.com.au.

Yours sincerely

John Howarth
Executive General Manager, Transmission Services

cc:

Attachments:

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Contents

Appendix B - Assessment of Energy and Maximum Demand Projections

B.1 Introduction

This appendix reviews the quality of the energy and maximum demand (MD) projections provided for each region. The assessments provide evidence that each region:

- uses an energy and MD forecasting methodology that accurately reflects the impact of all relevant underlying drivers, and
- has developed that methodology over time to account for apparent inaccuracies in previous results.

The most significant variations between projections and actual values are due to varying diversity between different load centres in Queensland and unanticipated variations in major industrial loads in Tasmania.

Background

This energy and MD projection assessment is coordinated by the Load Forecasting Reference Group (LFRG) and is made available to the AEMC's Reliability Panel in accordance with Section 3.13.3 (u) of the National Electricity Rules (NER).

The methods used to review and validate the regional energy and MD projections include:

- back assessment (to compare previous projections with actual outcomes)
- backcasting (to validate the methodology used to develop the current projections), and
- probability of exceedence (POE) estimates (to test the procedures used to allocate POE values to actual MDs).

The projections for each region are provided separately and follow different methodologies. Therefore the assessments vary slightly between regions, even though consistency is the aim.

B.1.1 Summary

A great deal of consideration has gone into ensuring that each region's projections represent similar measures and embody similar assumptions. A similar level of consideration has been accorded to the assessment of these projections, in order to work towards similar assessment methods for each region.

There remain, however, differences in the significance of issues affecting energy and MD across the regions, and therefore variation in individual projection methodologies. Both the projection methodologies and the assessment of the projections are subtly improved each year. The following qualifications therefore apply to the conclusions drawn from the assessments.

- Comparisons between regions may not be valid because the assessments may not have been done in a strictly comparable manner or over a similar time frame.
- Comparisons of the performance of one region in 2010 with previous years' performances may not be entirely valid because of changes in the manner of the assessments.

- The statistics presented below are necessarily calculated on a limited sample of data and this therefore limits the confidence with which any inferences can be drawn.

B.1.2 Methods of validation of the projections

Validation of the projections is carried out for AEMO in three ways:

- Back assessment involves a comparison of previous years' projections with actual outcomes to date.
- Backcasting is a method of testing the out-of-sample forecasting performance of the current projection methodology.
- Probability of exceedence (POE) comparisons indicate whether the currently estimated probability density function, represented by 90%, 50%, and 10% POE MD, is similar to the actual probability density function of historical MDs.

Back assessment

The back assessments compare projections published in previous ESOOs with actual values to date. The 2010 ESOO includes two back assessments for both energy and MD:

- **One-year-out** back assessments compare regional energy or MD projections made for the next year with actual values. For example, a 2009 ESOO regional summer MD projection for 2008/09 is compared with the actual outcome for 2008/09[1].
- **Two-year-out** back assessments compare regional energy or MD projections made for the year after next with actual values. For example, a 2008 ESOO regional summer MD projection for 2008/09 is compared with the actual outcome for 2008/09.

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

- the projection is made, and
- the actual value is recorded.

The primary reason for using one- and two-year back assessment time frames is because AEMO bases decisions to investigate potential National Electricity Market (NEM) intervention on the Medium-term Projected Assessment of System Adequacy (MT PASA), which uses a two-year outlook based on the ESOO demand projections. The use of a back assessment timeframe of three years or longer also becomes increasingly problematic, in terms of the limited history of ESOO projections and its relevance to the current projection methodology.

Back assessment analysis includes projections from all previous ESOOs (starting from the 1999 publication). It therefore provides a qualitative indication of the:

- accuracy of the 50% POE MD projections (which should be at the median of the actual MD values over an extended period)
- suitability of the spread of the 90%, 50%, and 10% POE values for each MD projection, and
- improvements in the forecast outcomes over the history of the ESOO.

Backcasting

In the ESOO, the term 'backcasting' means simulating the forecasting model over a historical test period. This allows an immediate comparison of simulated and actual dependent variable values. All

[1] The actual time between the publication of projections and the occurrence of the subsequent seasonal MD may be six to eight months.

forecasting models depend on input variables such as economic activity and temperature, which themselves need to be forecast into the future. Since these inputs to the forecasting model are known with certainty over the historical test period, backcasting can be used as a test of the forecasting model itself (rather than a test of the accuracy of input variable forecasts).

In order to produce the backcast, a sample of the most recent data that would otherwise be available for model estimation is reserved for the forecast comparison. Since this procedure generates simulations outside the estimation period, backcasting is a stringent test of the forecasting model that closely replicates the out-of-sample performance of the model when generating the projections presented in Chapter 4.

Backcasting provides a quantitative measure of the accuracy of the current forecasting methodology. Because the backcast allows comparison between simulated and actual dependent variable values, the performance of the latest forecasting models can be tested immediately. Performance is gauged both graphically and analytically, by calculating the:

- root mean squared percentage error (*%RMSE*)
- Theil inequality coefficient (*U*), and
- decomposition of *U* into the bias (U^B), variance (U^v) and covariance (U^c) proportions.

Forecast accuracy, as measured by %RMSE, may be defined as the closeness of the mean of the forecast to the mean of the actual series. Calculation of the %RMSE is described in Figure B-1.

Figure B-1—Calculation of the %RMSE

Percentage root mean square error calculation

The percentage root mean square error is calculated as follows:

$$\%RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{(MD_t^s - MD_t^a)}{MD_t^a}\right)^2}$$

Where:

- MD_t^s and MD_t^a are the simulated and actual values of the independent variable (MD), respectively, in season *t*, and
- the comparison takes place over *T* seasons.

Since %RMSE is a proportional measure, it can be used to:

- compare the performance of different models or variations on the same model
- test for the importance of selected input variables, or their omission, during model development
- demonstrate the impact on forecast accuracy after changes are made to the forecasting methodology, and
- compare the performance of the current and the previous years' forecast models

The Theil inequality coefficient provides a relative measure of forecast accuracy in terms of deviation from the (largely unachievable) perfect forecast. The breakdown of this coefficient provides useful information on the sources of forecast inaccuracy. For example, a relatively accurate forecast over a short time period may have a persistent bias that can lead to significant inaccuracy over the long term. Furthermore, a straight line projection can turn out to be a relatively accurate forecast of the general trend, despite the fact that actual outcomes displayed a good deal of fluctuation around such a straight line. Calculation of the Theil inequality coefficient and its components is described in Figure B-2[2].

[2] See also Pindyck, R.S. and D.L. Rubinfeld (1981). Econometric Models and Economic Forecasts, Second Edition, McGraw-Hill International, pp 364-365.

Figure B-2— The Theil inequality coefficient calculation

The Theil inequality coefficient is calculated as follows:

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(MD_t^s - MD_t^a)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(MD_t^s)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}(MD_t^a)^2}}$$

The numerator of the *U* statistic is the absolute level of the root mean square error, but the denominator is scaled so that *U* will always fall between 0 and 1. A perfect forecast produces *U*=0, whereas if *U*=1, the forecast is as bad as it possibly could be.

The decomposition of U produces the following proportions:

$$U^B = \frac{\left(\overline{MD}^s - \overline{MD}^a\right)^2}{\left({}^1\!/_T\right)\sum_{t=1}^{T}(MD_t^s - MD_t^a)^2}$$

$$U^V = \frac{(\sigma_s - \sigma_a)^2}{\left({}^1\!/_T\right)\sum_{t=1}^{T}(MD_t^s - MD_t^a)^2}$$

$$U^C = \frac{2(1-\rho)\sigma_s\sigma_a}{\left({}^1\!/_T\right)\sum_{t=1}^{T}(MD_t^s - MD_t^a)^2}$$

Where:

- $\overline{MD}^s$, $\overline{MD}^a$, σ_s and σ_a are the means and standard deviations of the simulated and actual MD, respectively, and
- ρ is their correlation coefficient, $\rho = \left({}^1\!/_{\sigma_s\sigma_a T}\right)\sum_{t=1}^{T}\left(MD_t^s - \overline{MD}^s\right)\left(MD_t^a - \overline{MD}^a\right)$.

The bias proportion U^B is an indication of systematic error, since it compares the average values of simulated and actual MD. If this component is not close to zero, it indicates that the model produces a systematic bias and revision of the model may be necessary.

The variance proportion U^V indicates the model's ability to replicate the variability of the actual MD. If U^V is large, it indicates considerable fluctuation in the actual series when the simulations show little fluctuation, or vice versa.

The covariance proportion U^C measures the remaining unsystematic error. Since it is unreasonable to expect the perfect correlation of simulated and actual MD, the majority of any error should ideally be unsystematic.

Note that: $U^B + U^V + U^C = 1$

Probability of exceedence comparison

POE estimation uses the current MD projection methodology to determine the probability of possible MDs in each historical season.

The jurisdictional planning bodies (JPBs) develop MD projections at standardised percentiles of an estimated statistical distribution. These are the 90%, 50%, and 10% POE levels. The 90% POE MD level for a particular season is the level that is met or exceeded in a particular season 90% of the time in repeated sampling. Similarly, the 50% and 10% POE MD levels for a particular season are the levels that are met or exceeded in a particular season 50% and 10% of the time, respectively, in repeated sampling.

Since there is only one actual MD for each season, the 90%, 50%, and 10% POE MDs must be estimated. This can be carried out using an appropriate forecasting model, with either:

- a repeated sampling process, or
- by substitution of weather variables representing the appropriate POE.

The same process working in reverse identifies the POE level of any actual MD in a historical season by placing it within an ordered range of simulated MDs.

It is important to identify the historical 90%, 50%, and 10% POE MD levels, because this reflects on the procedure adopted to establish the correct levels for the projections.

- If the 10% POE MD projection is set too high, the actual probability of exceeding this MD projection in any particular season will be lower than indicated and any low reserve condition (LRC) points in the supply-demand balance or MT PASA will be shown as occurring too early.
- If the 10% POE MD projection is set too low, the actual probability of exceeding this MD projection in any particular season will be higher than indicated, and any LRC points in the supply-demand balance or MT PASA will be shown as occurring too late.
- If the spread between the 10% POE MD projection and the 90% POE projection is wide, the conditions that determine the actual MD on the day it occurs (especially temperature) implicitly assume high significance relative to the underlying growth rate.
- If the spread between the 10% POE MD projection and the 90% POE MD projection is narrow, the conditions that determine the actual MD on the day it occurs (especially temperature) implicitly assume low significance, relative to the underlying growth rate.

Section B.2 provides an analysis of the performance of the MD projections for the 2009-10 year. Sections B.3 to B.7 include a qualitative assessment of the 90%, 50%, and 10% POE MD levels for each region, in which the estimated MDs at each POE level are shown graphically against MDs that actually occurred.

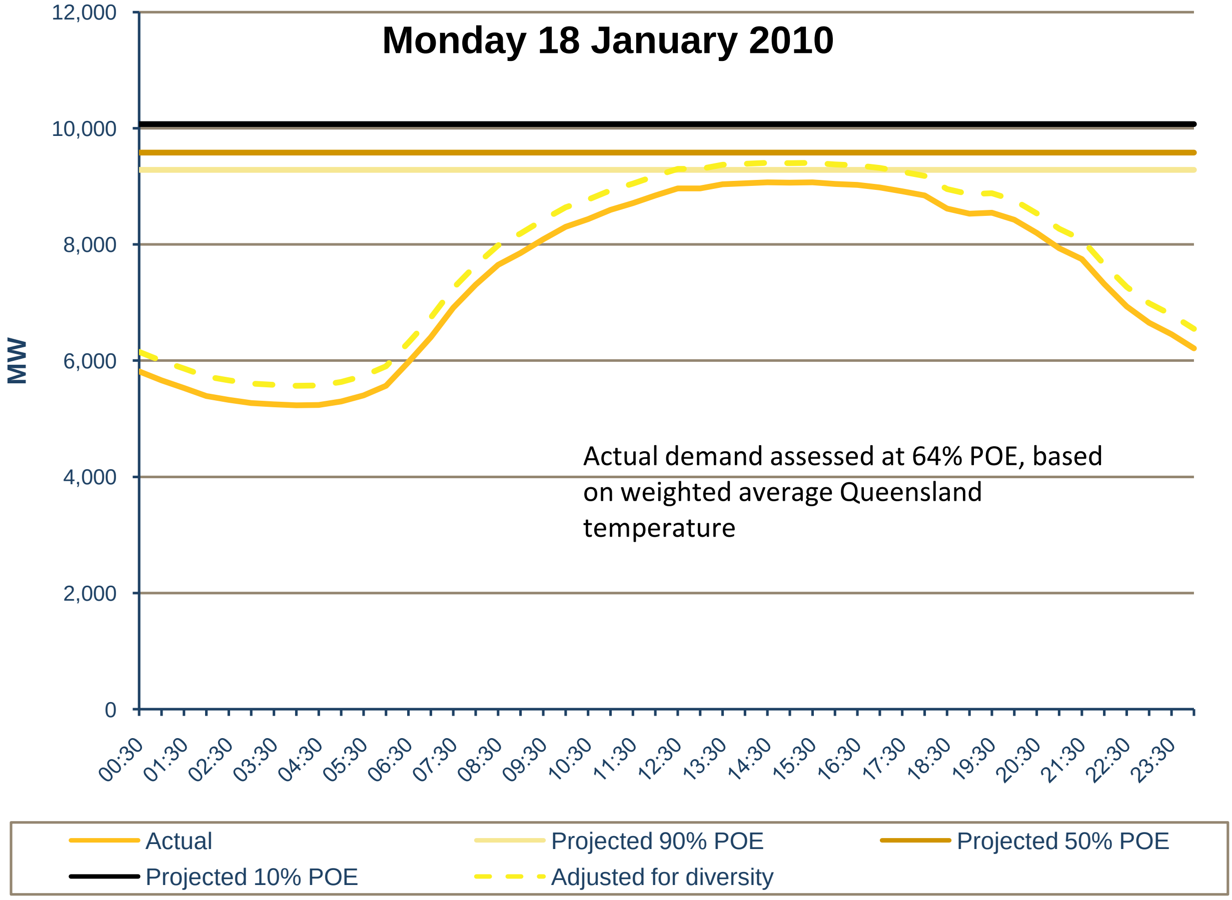
B.2 The MD projection performance for 2009/10

This section compares the regional MD projections published in the 2009 ESOO with recent actual MDs. Together with the assessed POE level of the actual MD, this provides a visual guide to the short-term accuracy of the 2009 projections.

B.2.1 Queensland

Taking into account the assessed POE MD level, the 2009 Queensland projection appears too high. However, the projection was based on a weighted average of historical diversities between major load centres within the Queensland region. The actual diversity was much higher than the assumption upon which the projections were based. When the actual MD is corrected for the impact of different diversity (as estimated by Powerlink), the projections appear much more reasonable.

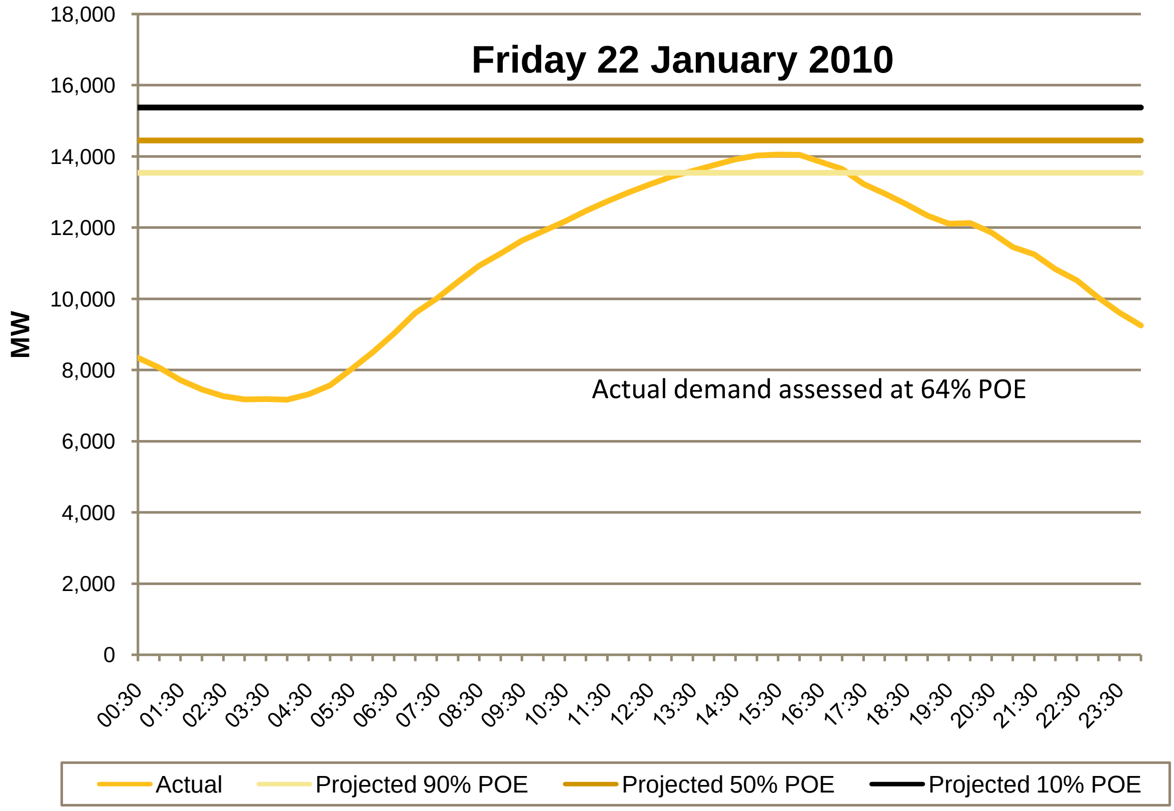
Figure B-3 - Queensland day of maximum demand, summer 2009/10



B.2.2 New South Wales

Taking into account the assessed POE MD level, the 2009 New South Wales projection appears close to the actual outcome.

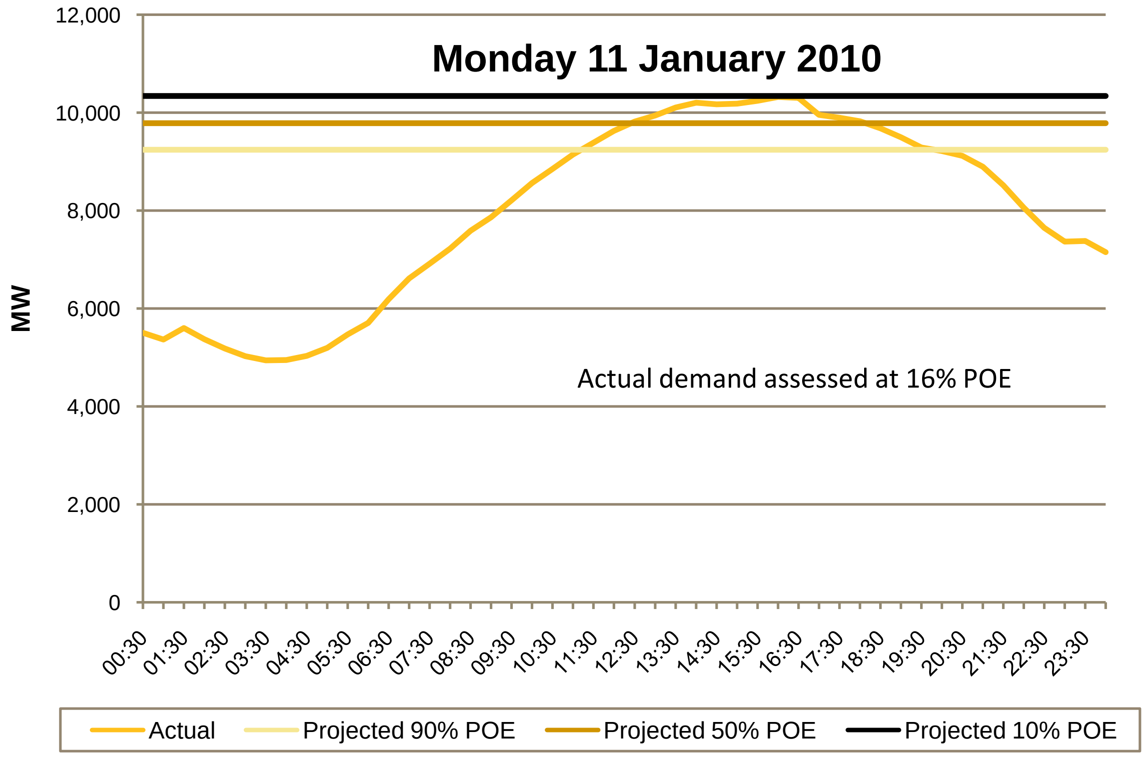
Figure B-4 - New South Wales day of maximum demand, summer 2009/10



B.2.3 Victoria

Taking into account the assessed POE MD level, the 2009 Victorian projection appears close to the actual outcome.

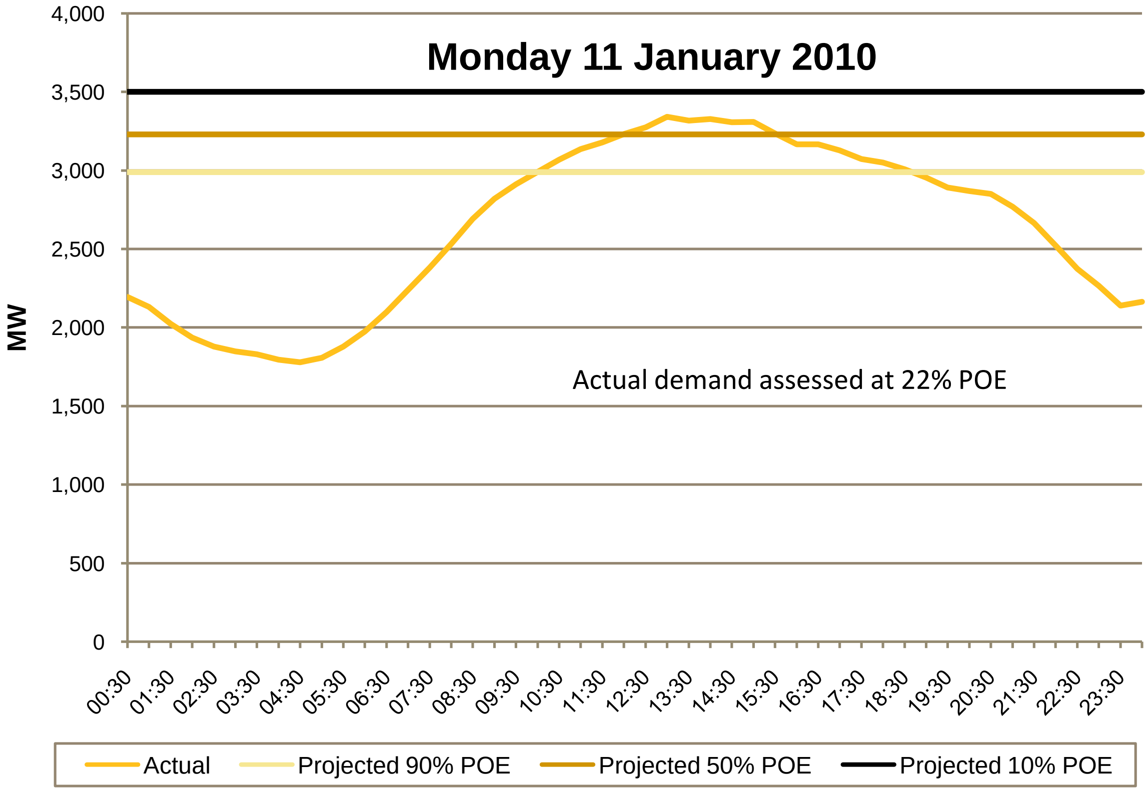
Figure B-5 - Victorian day of maximum demand, summer 2009/10



B.2.4 South Australia

Taking into account the assessed POE MD level, the 2009 South Australian projection appears close to the actual outcome.

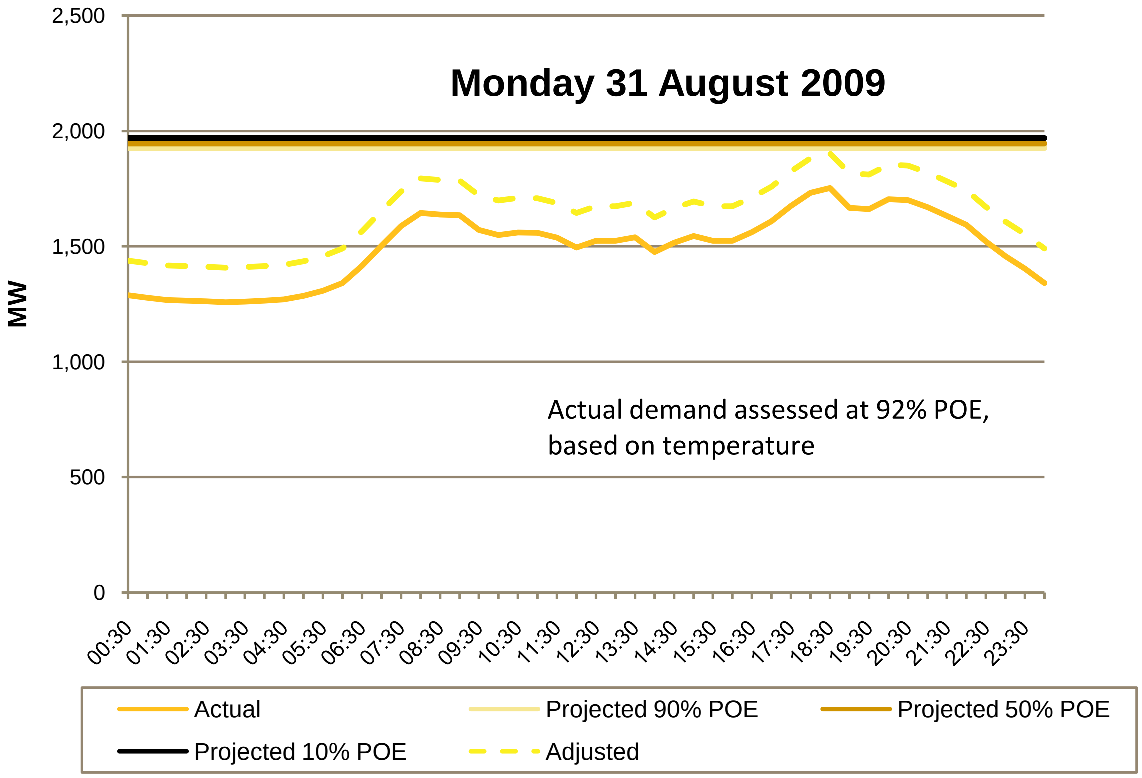
Figure B-6 - South Australian day of maximum demand, summer 2009/10



B.2.5 Tasmania

The actual Tasmanian MD was significantly below the 2009 forecast. This was due to the operational down-scaling of several major industrial customers, due to the anticipated economic downturn. The actual demand is also shown, adjusted for this impact. After taking account of the changes in major industrial loads and the assessed POE level, the forecast is close to the actual.

Figure B-7 - Tasmanian day of maximum demand, winter 2009



B.3 Queensland

This section presents the back assessments, backcast analysis and POE MD estimation for the Queensland region.

These assessments provide evidence of:

- projections that almost certainly maintained a high level of local accuracy at major load centres within Queensland, and
- recent increases in diversity between major load centres causing inaccuracy in the overall Queensland projections.

As the projections are determined on the basis of historical diversity factors, a permanent change in diversity will initially lead to inaccurate projections, but will increasingly be more accurately reflected in the projections over time.

Back assessment

Figure B-8 and Figure B-9 show the Queensland one-year-out and two-year-out summer MD back assessments. Estimated POE MDs are shown above the actual MDs and each of the 90%, 50%, and 10% POE MD projections are also shown.

In any single year, the difference between actual and projected summer MDs is due to a possible combination of any of the following:

- variation in actual conditions from any of the standard POE MD conditions (principally due to prevailing weather)
- variation in actual conditions from the input assumptions underlying the projections (principally due to economic conditions)
- systematic forecast error (resulting in persistent bias), and
- non-systematic forecast error (by definition, unpredictable random error).

Figure B-8 and Figure B-9 illustrate the following:

- Projections for all years since 2005/06 appear to have missed an apparent slowing in actual MD growth.
- Recent projections may have accurately tracked the actual growth rate but at too high a level, compared with the assessed POE levels.
- MD growth rates for individual major load centres within Queensland have recently been higher than for the Queensland region as a whole.
- Powerlink have advised of a recent trend of increasing actual diversity between major Queensland load centres, whereas the projections are heavily dependent on historical diversity ratios.
- The methodology adopted by Powerlink to assess historical POE levels is based on a weighted average temperature measure that may not include all factors relevant to the determination of overall Queensland demand, therefore the precision with which POE levels can be assessed around the median MD may be relatively low.

Figure B-8—Queensland summer MD one-year-out back assessment

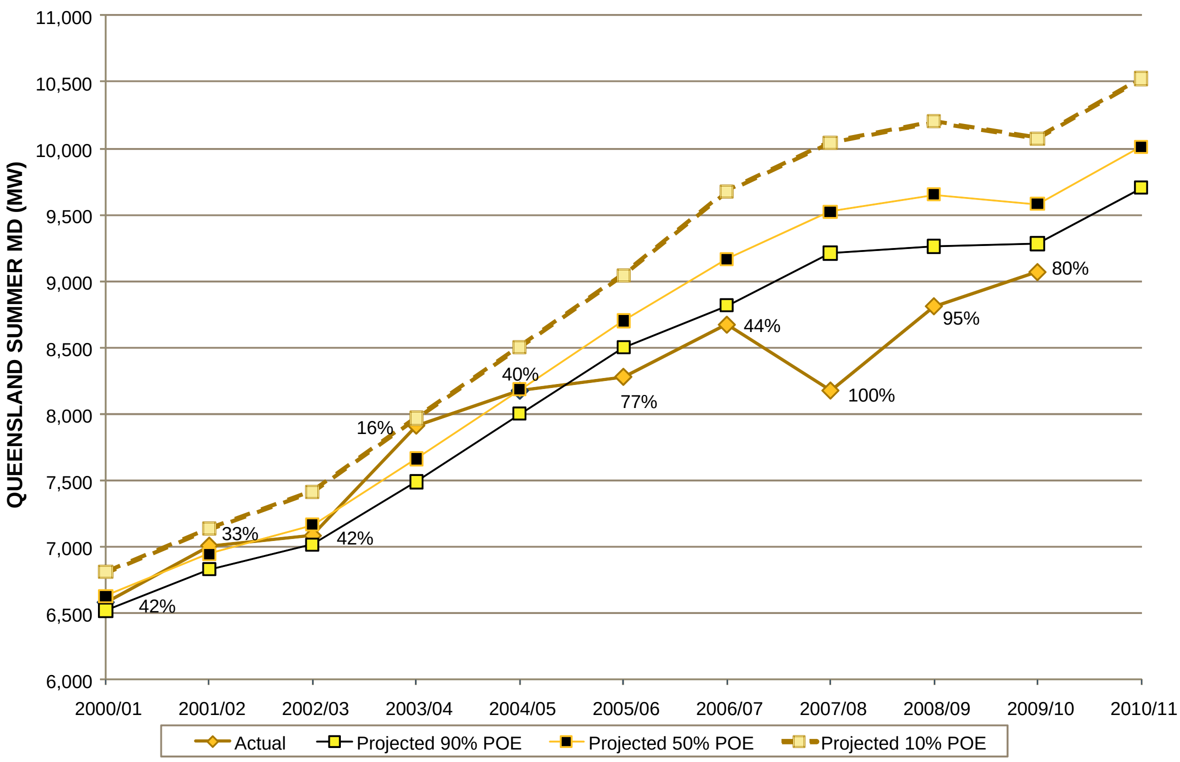


Figure B-9—Queensland summer MD two-year-out back assessment

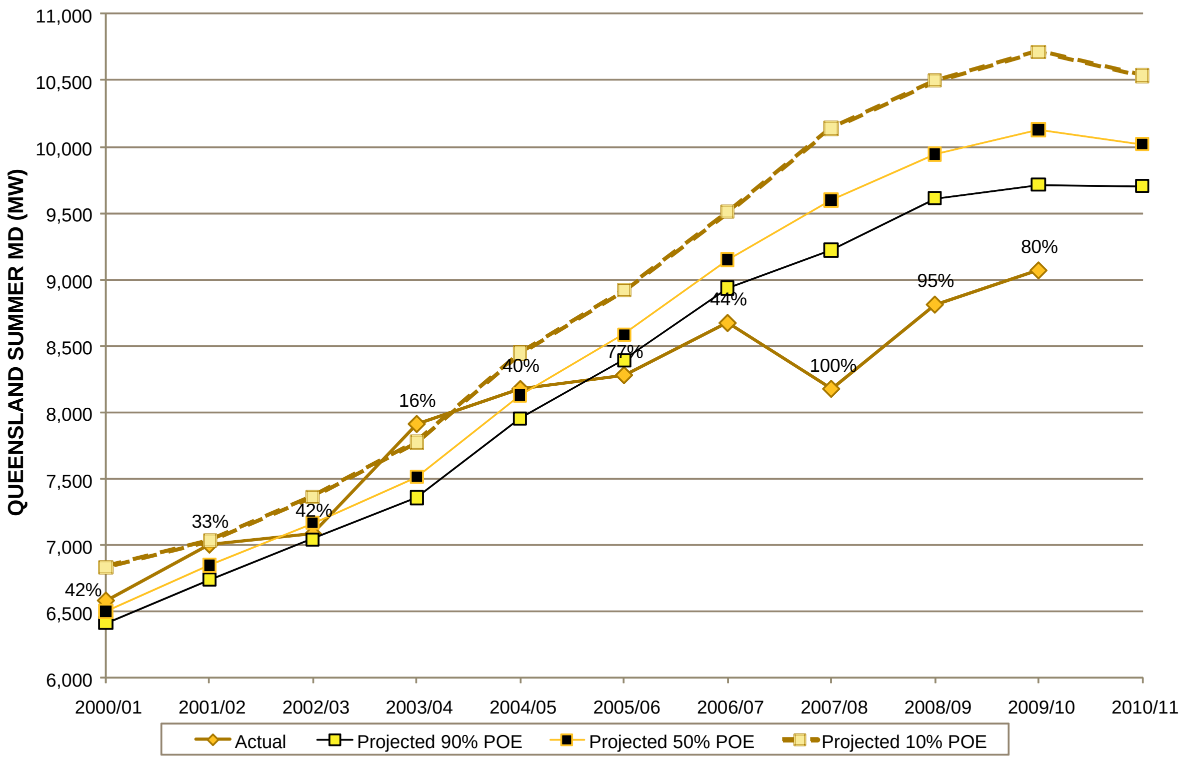
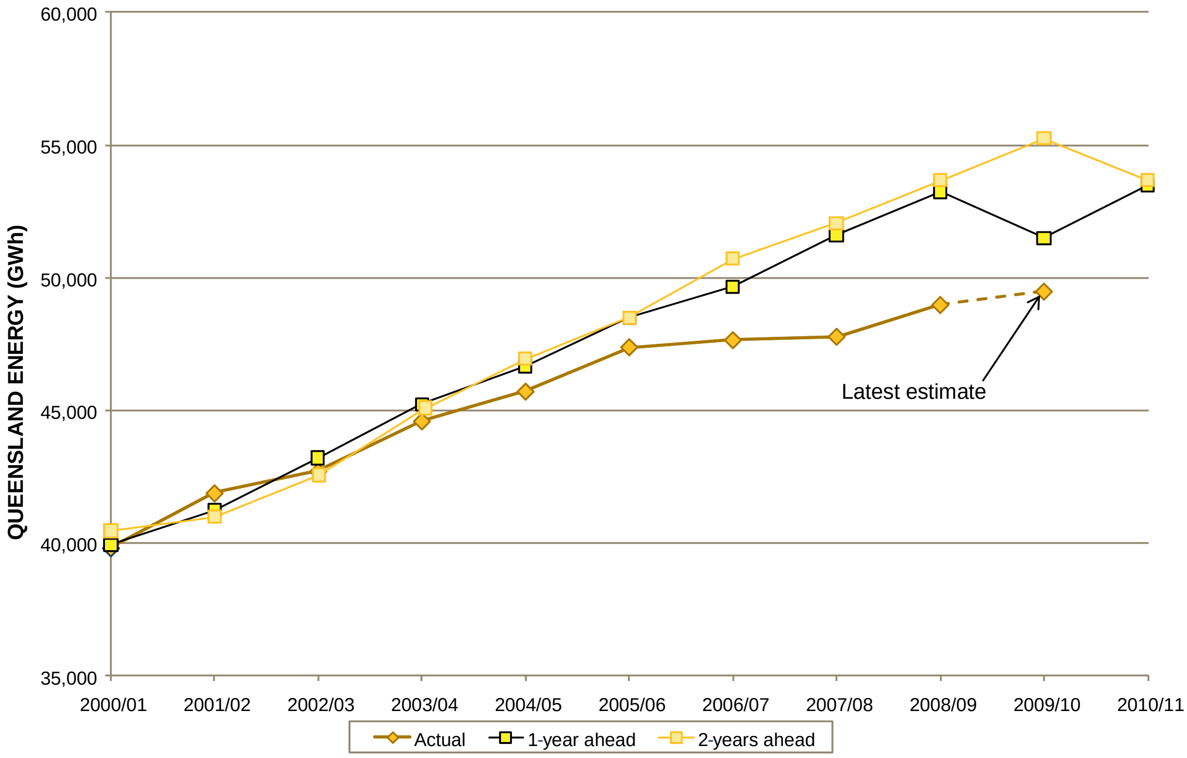


Figure B-10 shows the Queensland one-year-out and two-year-out energy back assessments. The yearly energy projections assume average weather conditions, while the actual data reflects weather conditions that actually occurred.

In any single year, the difference between actual and projected energy is due to a possible combination of any of the following:

- Variation in actual conditions from the input assumptions underlying the projections (due to economic and weather conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-10—Queensland energy one- and two-year-out back assessment



Backcast

Figure B-11 shows the 10-year Queensland summer MD backcast. This was produced by Powerlink Queensland in a different manner to other regions, because Powerlink's primary projection methodology relies on the aggregation of connection point forecasts provided by Queensland distribution network service providers, whereas other regions primarily rely on the top-down modelling approach to which backcasting can be more readily applied. The backcast for Queensland was developed by AEMO with Powerlink's assistance as follows:

- A straight line trend was fitted to Queensland MD data over a 10-year historical period.
- Adjustments were made to the historical trend for differences between actual standardised population and economic growth in each year.
- Further adjustments were applied to account for differences between expected and actual major industrial loads.

This procedure mimics to some extent (with the exception of adjustments for changes in diversity between major load centres) the actual projection process. Therefore, differences between actual and simulated values shown in Figure B-11 generally reflect errors generated by the projection process (including changes in diversity) rather than differences between expected and actual inputs to the process.

Summary statistics associated with the data in Figure B-11 are shown in the last column of Table B-1 alongside broadly comparable statistics for the 2009 backcasting exercise.

Figure B-11—Queensland summer MD backcast

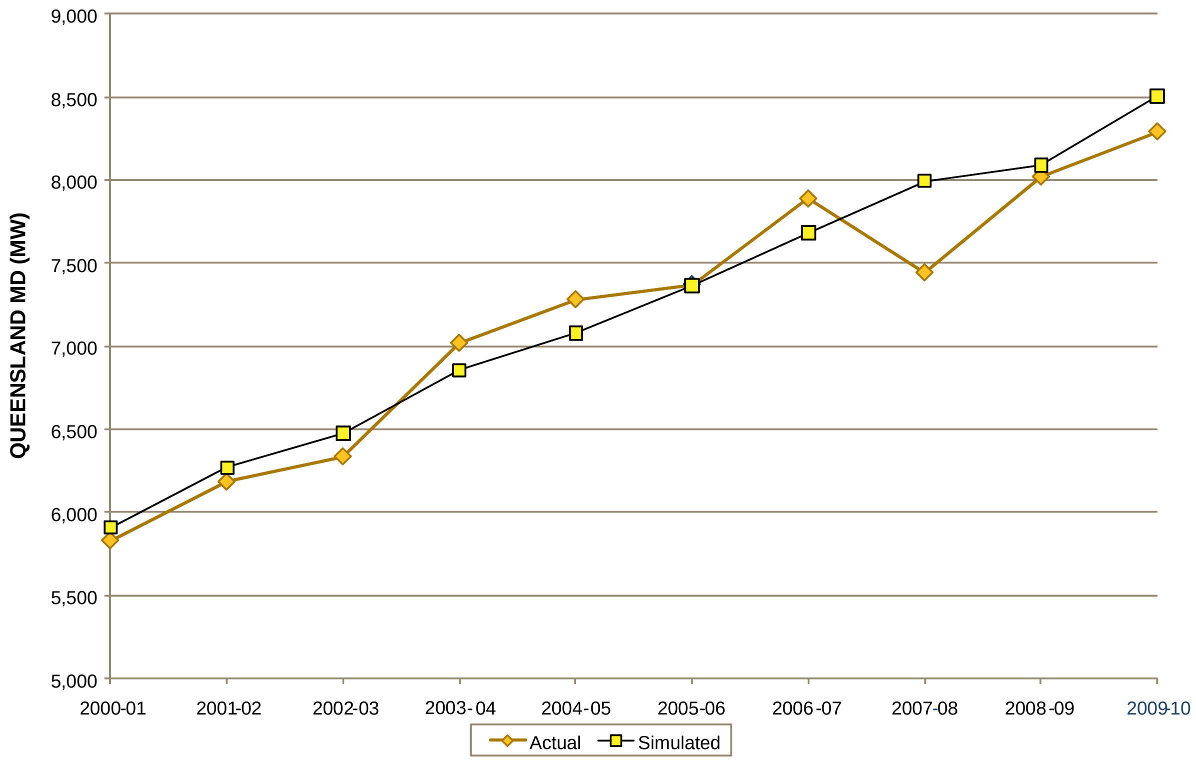


Table B-1—Queensland summer MD backcast results

Measure	2009 result	2010 result
Root mean squared percentage error (%RMSE)	2.75	3.02
Theil's inequality coefficient (U)	0.014	0.015
Bias proportion (U^B)	0.001	0.063
Variance proportion (U^V)	0.267	0.016
Covariance proportion (U^C)	0.733	0.921

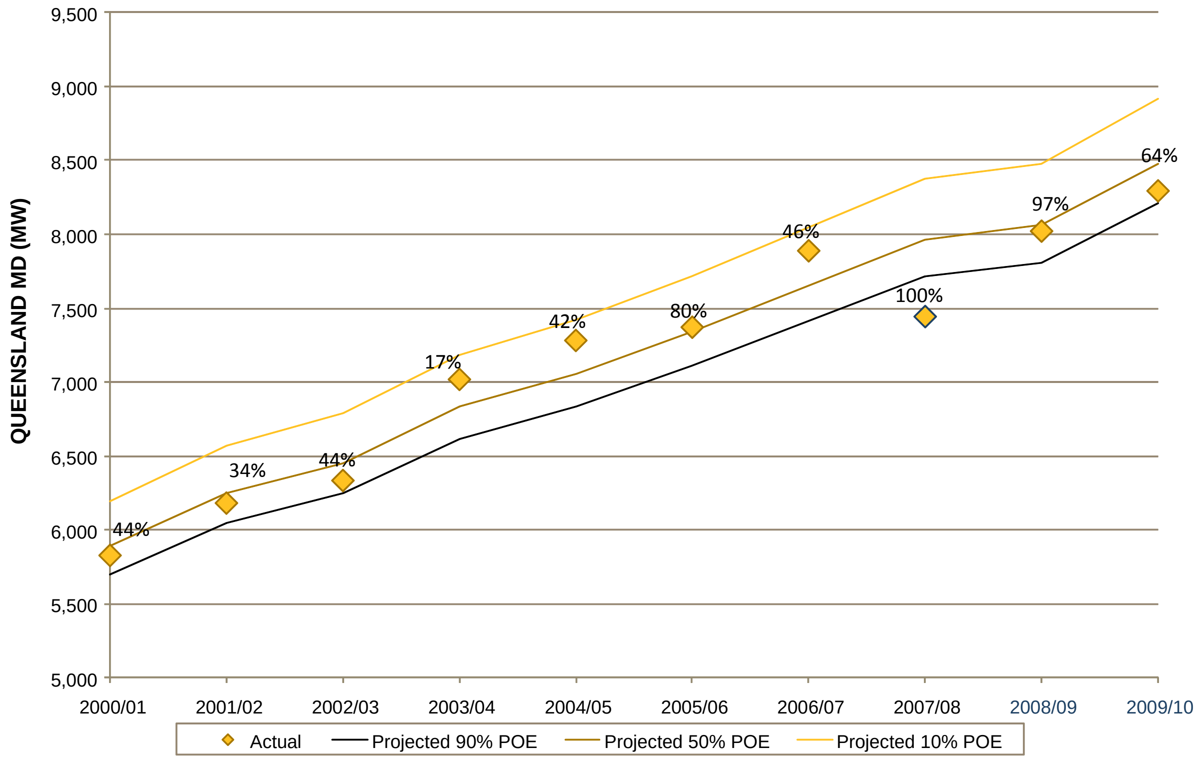
Figure B-11 shows simulated values relatively close to actual values over an extended period. Evidence of this is confirmed in Table B-1, which shows a root mean square error of just over 3% for 2010 and consistently low Theil coefficients. However, in the last three years the actual MD has slipped below the simulated value and the bias proportion has increased from 0.001 in 2009 to 0.063 in 2010. This places doubt, either on the underlying assumption of linear growth in Queensland MD, or on the size of the adjustment calculated for the impact of the recent economic downturn.

Probability of exceedence estimation

Figure B-12 shows actual MDs and estimated demand levels at standardised POEs. In relation to the assessed POE MD levels, the projected MDs are not always aligned with actual MDs. This reflects the influence of changing diversity and the assessment of whole-of-region POE levels using a single weighted average temperature measure.

The actual MDs for the summers of 2007/08 and 2008/09 were assessed to have occurred at or close to the 100% POE MD level. This reflects the unprecedented combination of mild weather and very high diversity between demands in major load centres within Queensland.

Figure B-12—Queensland summer MD estimated at standardised POEs



B.4 New South Wales

This section presents the back assessments, backcast analysis and POE MD estimation for the New South Wales region.

Back assessment

Figure B-13 and Figure B-14 show the New South Wales one-year-out and two-year-out summer MD back assessments. Estimated POE MDs are shown above the actual MDs and each of the 90%, 50%, and 10% POE MD projections are also shown.

In any single year, the difference between actual and projected summer MDs is due to a possible combination of any of the following:

- Variation in actual conditions from any of the standard POE MD conditions (principally due to prevailing weather).
- Variation in actual conditions from the input assumptions underlying the projections (principally due to economic conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-13 and Figure B-14 illustrate the following.

- Projections supplied by TransGrid prior to 2001/02 appear to have made insufficient allowance for variation in summer MD due to extreme weather. The rapid penetration in air-conditioning that occurred at that time could not easily have been anticipated by any forecaster.
- Projections published in the 2006 ESOO (for 2006/07 one-year-out and 2007/08 two-year-out) were high relative to the actual MDs. These outcomes led TransGrid to develop a more sophisticated methodology for estimating POE levels.
- Projections for most of the period since 2002/03, taking into account the assessed POE MD levels, are otherwise close to the actual MDs.

Figure B-13—New South Wales summer MD one-year-out back assessment

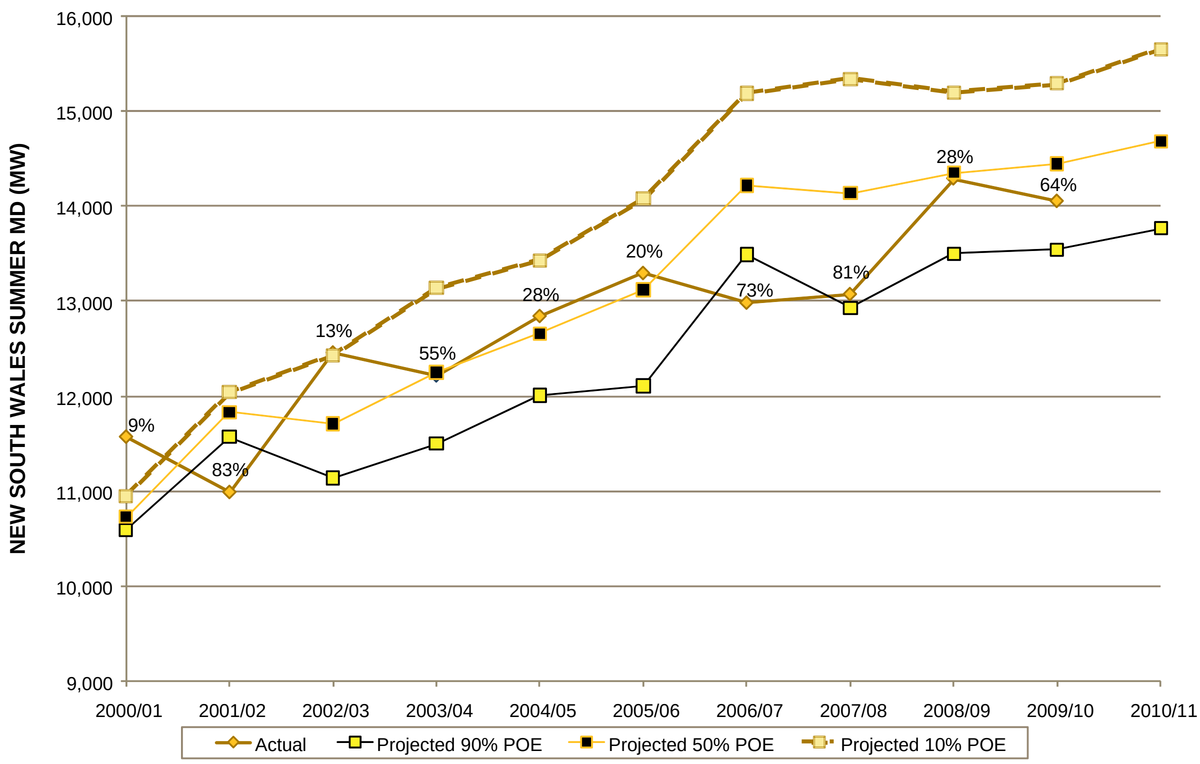


Figure B-14—New South Wales summer MD two-year-out back assessment

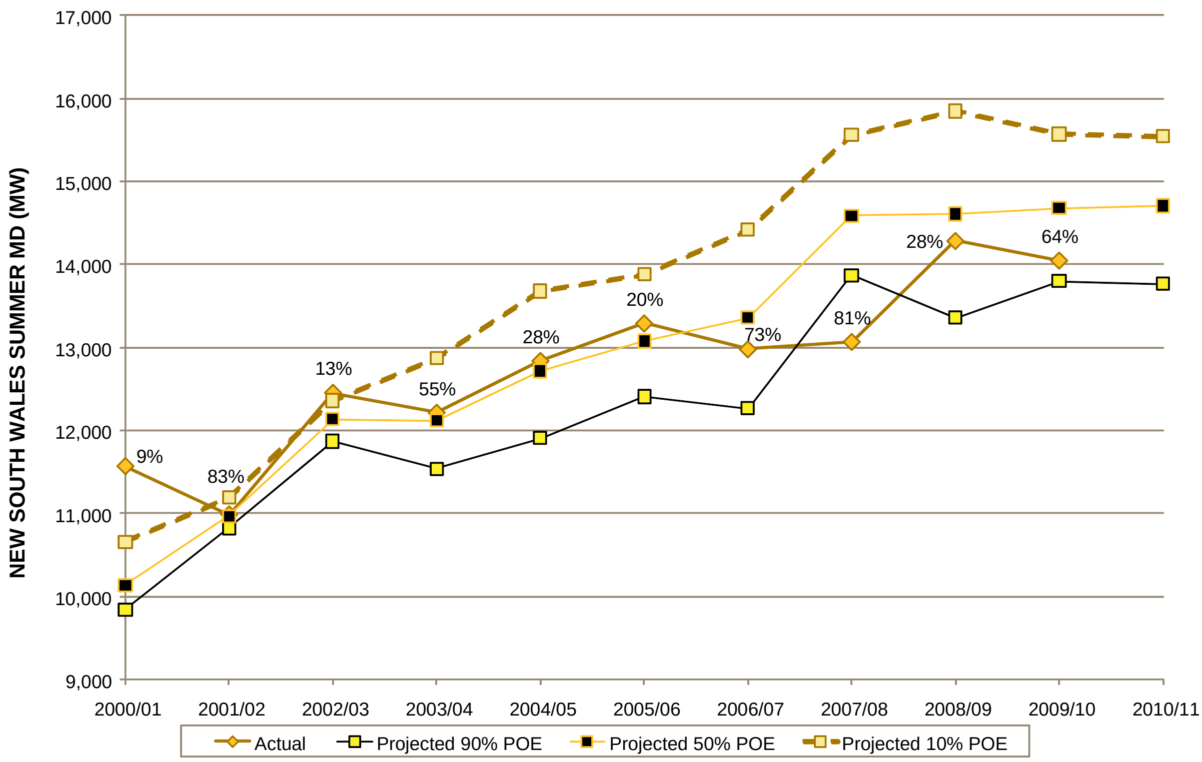


Figure B-15 shows the New South Wales one-year-out and two-year-out energy back assessments. The yearly energy projections assume average weather conditions, while the actual data reflects weather conditions that actually occurred.

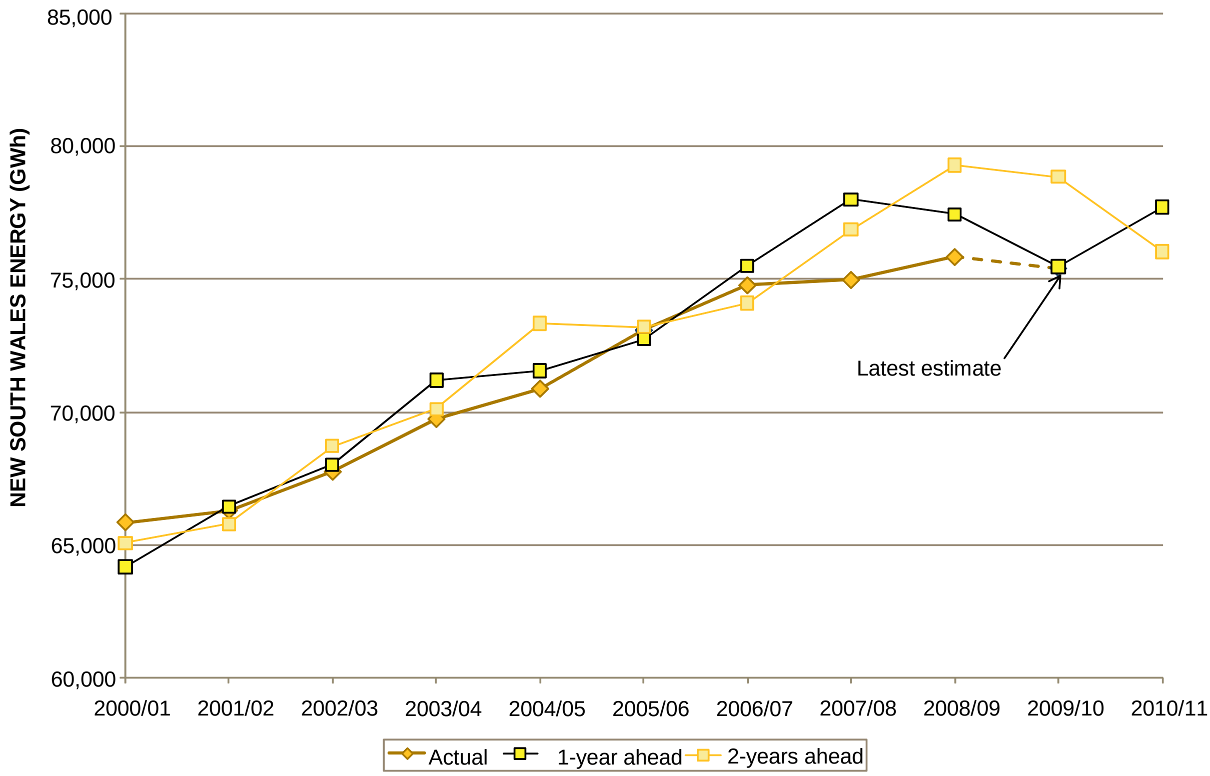
In any single year, the difference between actual and projected energy is due to a possible combination of any of the following:

- Variation in actual conditions from the input assumptions underlying the projections (due to economic and weather conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-15 illustrates the following:

- Projections published in the 2007 ESOO for the period 2007/08 to 2008/09 did not anticipate the downturn in the actual growth rate of energy.
- Subsequent forecasts have corrected for this.
- The projections have otherwise tracked actual energy relatively closely.

Figure B-15—New South Wales energy one- and two-year-out back assessment



Backcast

Figure B-16 shows the six-year New South Wales summer MD backcast. This was produced by TransGrid as follows.

- The current forecasting model was re-estimated six times using data that was available up to and including 2003/04. Each of these re-estimations was carried out for one of the respective actual POE MD levels pertaining to the six forecast years 2004/05 to 2009/10.
- These models were used to predict MDs for each of the six forecast years, taking into account actual economic conditions.
- One data point was selected from each set of predictions, so that the corresponding POE MD for that data point matched the actual POE for that year. The resulting series is an out-of-sample prediction of the actual summer MD that allows for the weather and economic conditions that actually occurred.

This procedure ensures that differences between actual and simulated values shown in Figure B-16 are solely due to some combination of:

- systematic forecast model error (resulting in persistent bias), and
- non-systematic forecast model error (by definition, unpredictable random error).

Summary statistics associated with the data in Figure B-16 are shown in the last column of Table B-2, alongside comparable statistics for the 2008 and 2009 backcasting exercises.

Figure B-16—New South Wales summer MD backcast

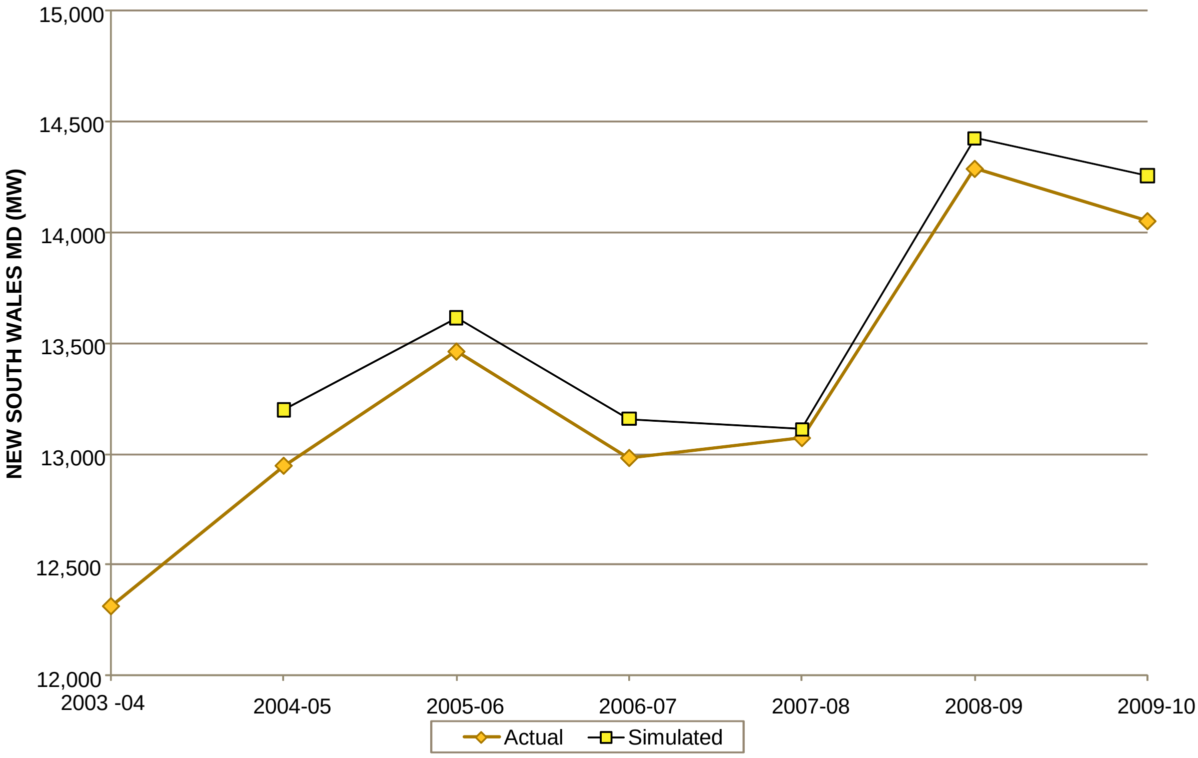


Table B-2—New South Wales summer MD backcast results

Measure	2008 result	2009 result	2010 result
Root mean squared percentage error (%RMSE)	1.23	0.95	1.30
Theil's inequality coefficient (U)	0.006	0.005	0.006
Bias proportion (U^B)	0.354	0.670	0.857
Variance proportion (U^V)	0.180	0.236	0.000
Covariance proportion (U^C)	0.466	0.095	0.143

Figure B-16 shows that backcast MDs are relatively close to the actual MDs, which enables a high degree of confidence in the forecasting methodology. Table B-2 confirms this, with a root mean square error of 1.30%. This may be thought of as equivalent to being able to place a dependable tolerance of about plus or minus 180 MW on any forecast derived using this methodology, if the actual input data was known with certainty.

However, both Figure B-16 and Table B-2 show evidence of a persistent upward bias in the forecast. In fact the bias proportion of 0.857 in Table B-2 shows that bias is by far the largest source of forecasting model error. The bias proportion has also increased this year, compared with previous years. Fortunately the bias shown as the gap between actual and simulated values in Figure B-16 is relatively constant, so the predicted growth rate is less likely to be biased. This suggests that this relatively small (in MW) bias could easily be corrected.

Figure B-17 shows the six-year energy backcast, which was produced as follows:

- The current forecasting model was re-estimated once using data up to and including 2002/03.

- The re-estimated model was then used to develop a projection for the period 2003/04 to 2008/09, using economic and weather input variables that reflected actual conditions.

This procedure ensures that differences between actual and simulated values are solely due to a combination of:

- systematic forecast model error (resulting in persistent bias), and
- non-systematic forecast model error (by definition, unpredictable random error).

Summary statistics associated with the data in Figure B-17 are shown in Table B-3.

In a similar fashion to the summer MD results, simulated backcast energy is close to actual energy and follows a similar growth rate. The root mean square error of 1.41% for 2010 is roughly equivalent to being able to place a dependable tolerance of about plus or minus 950 GWh on any forecast derived using this methodology, if the actual input data was known with certainty. However, as with the summer MD, the backcast energy is persistently higher than actual energy and the bias proportion at 0.655 is the largest source of forecast model error.

Since the energy forecast is a sequential input to the summer MD forecast, it is likely that at least some of the forecast error identified via the backcast process is inherent in the energy model component. The sources of bias in a forecast originate in either a badly specified forecasting model, or a structural change in the data being forecast. The TransGrid energy and MD projections, as described in the Annual Planning Report, appear to be based on a well-specified set of statistical models. The source of apparent forecast bias is therefore likely to be due to emerging structural change in New South Wales, such as a step-change in end-use energy efficiency.

Figure B-17—New South Wales energy backcast

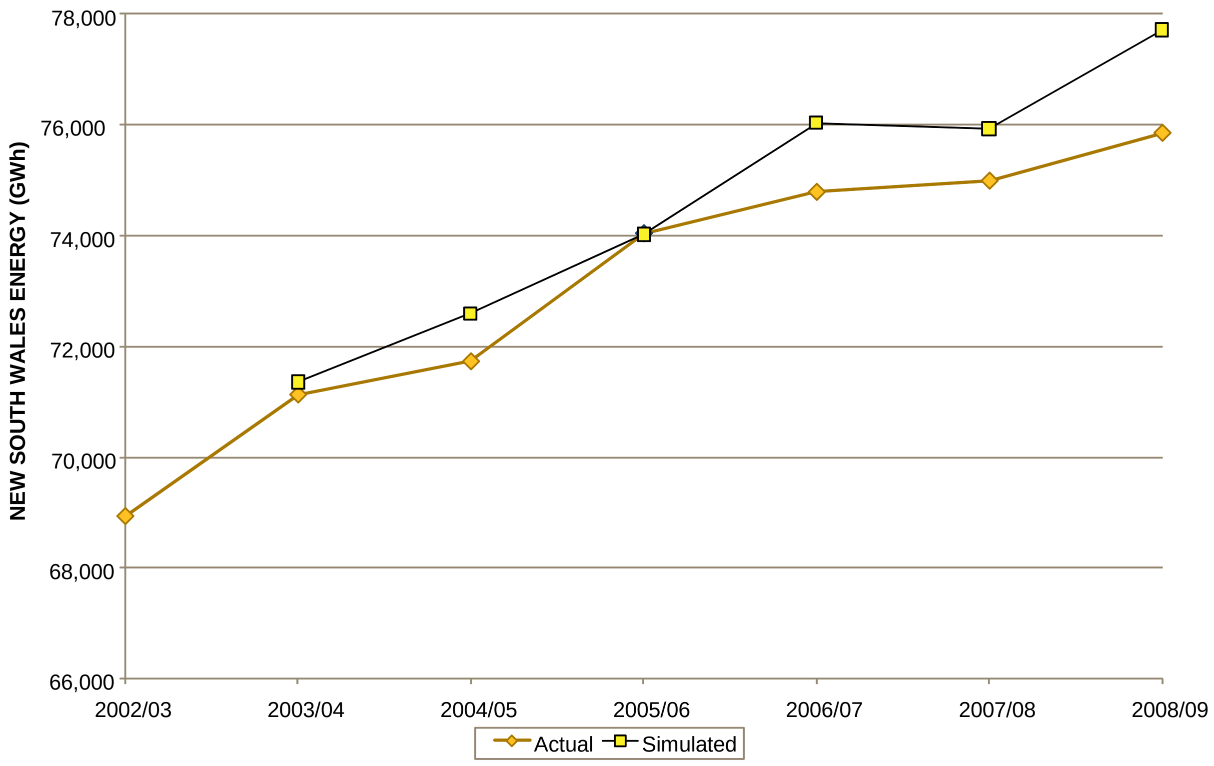


Table B-3—New South Wales energy backcast results

Measure	2009 result	2010 result
Root mean squared percentage error (%RMSE)	1.62	1.41
Theil's inequality coefficient (U)	0.008	0.007
Bias proportion (U^B)	0.812	0.655
Variance proportion (U^V)	0.086	0.170
Covariance proportion (U^C)	0.102	0.174

Probability of exceedence estimation

Figure B-18—New South Wales summer MD estimated at standardised POEs

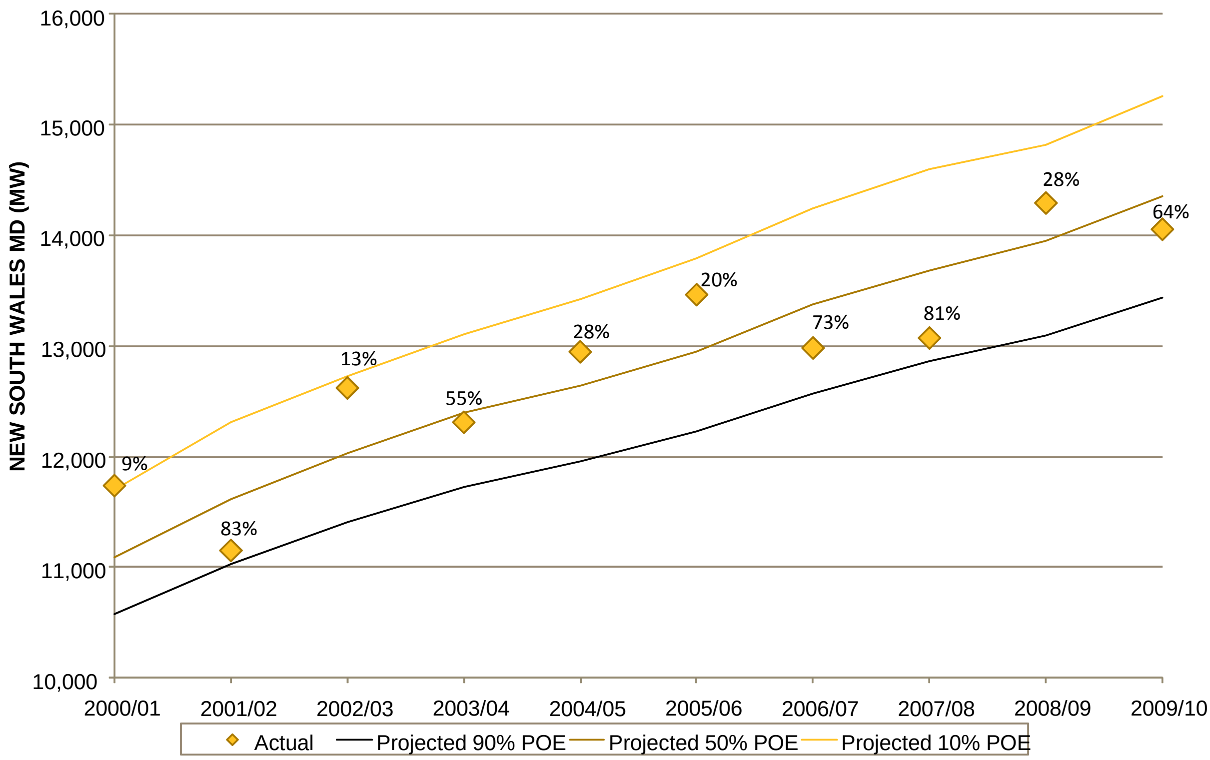


Figure B-18 shows actual MDs and estimated MD levels at standardised POEs. The actual MDs are:

- mostly contained within the 90% POE and 10% POE estimated values, and
- also spread evenly around the 50% estimated value.

This is what would be expected on average over the course of any 11-year period. The data therefore provide a high degree of confidence in the estimation of demand at standardised MD POEs.

B.5 Victoria

This section presents the back assessments, backcast analysis and POE estimation for the Victorian region.

Back assessment

Figure B-19 and Figure B-20 show the Victorian one-year-out and two-year-out summer MD back assessments. Estimated POE MDs are shown above the actual MDs and each of the 90%, 50% and 10% POE projections are also shown.

In any single year, the difference between actual and projected summer MDs is due to a possible combination of any of the following:

- Variation in actual conditions from any of the standard POE conditions (principally due to prevailing weather).
- Variation in actual conditions from the input assumptions underlying the projections (principally due to economic conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-19 and Figure B-20 illustrate the following.

- Up to the 2006 ESOO, the level of the projections is high, relative to the assessed POE levels. The persistent degree of over-projection during this period was in the order of 500 MW. Projected growth rates were nonetheless relatively accurate.
- The altered methodology for assessing POE levels from 2007 onwards has resulted in much more reasonable projections, relative to the assessed POE levels.

Figure B-19—Victorian summer MD one-year-out back assessment

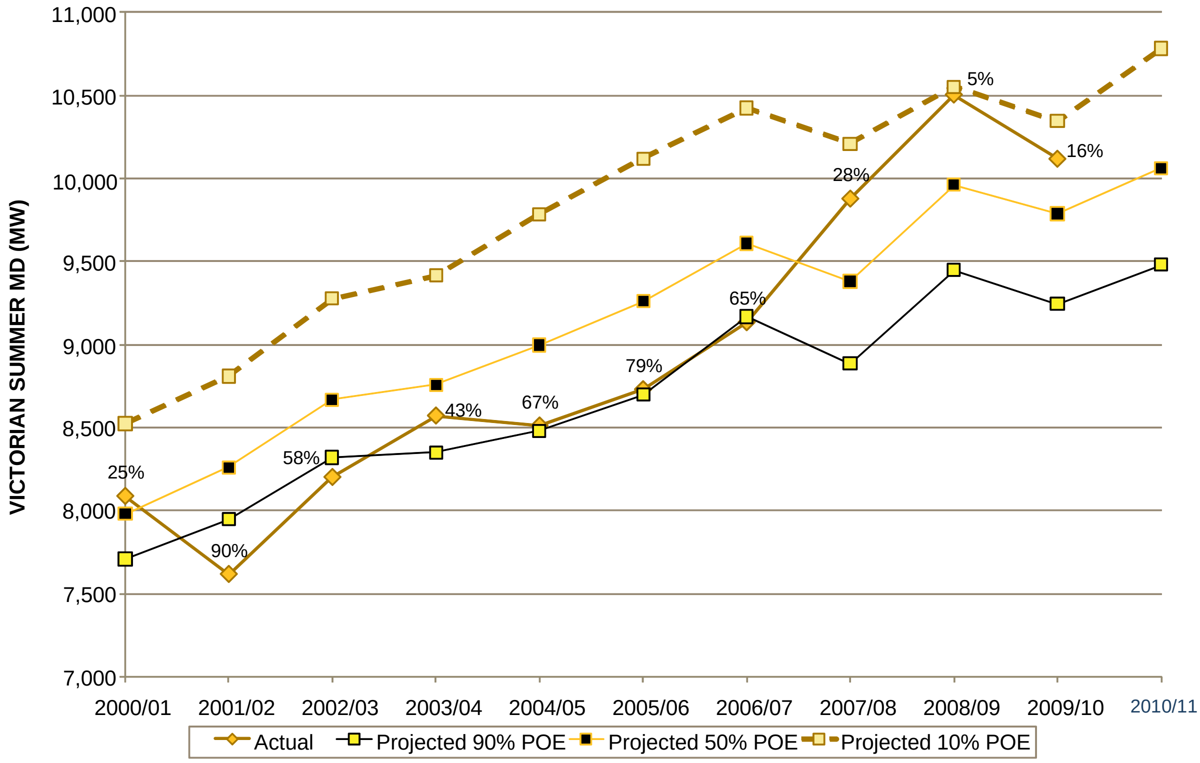


Figure B-20—Victorian summer MD two-year-out back assessment

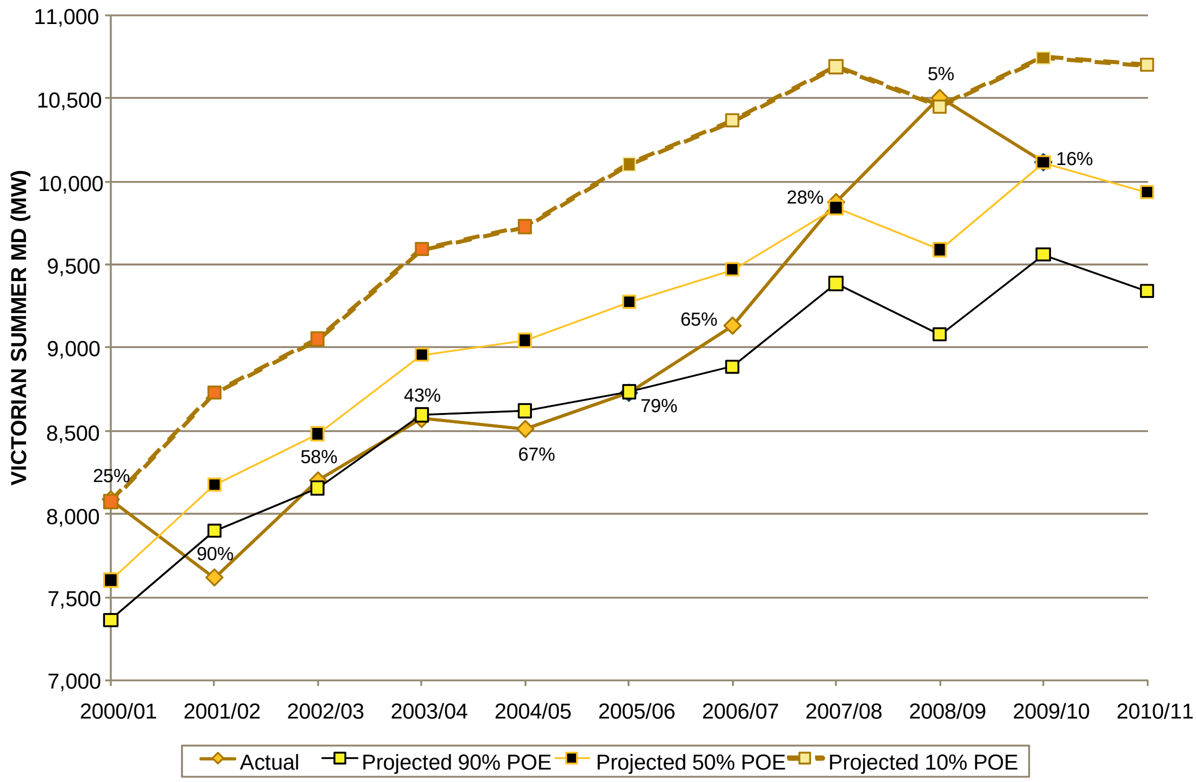


Figure B-21 shows the Victorian one-year-out and two-year-out energy back assessments. The yearly energy projections assume average weather conditions, while the actual data reflects weather conditions that actually occurred.

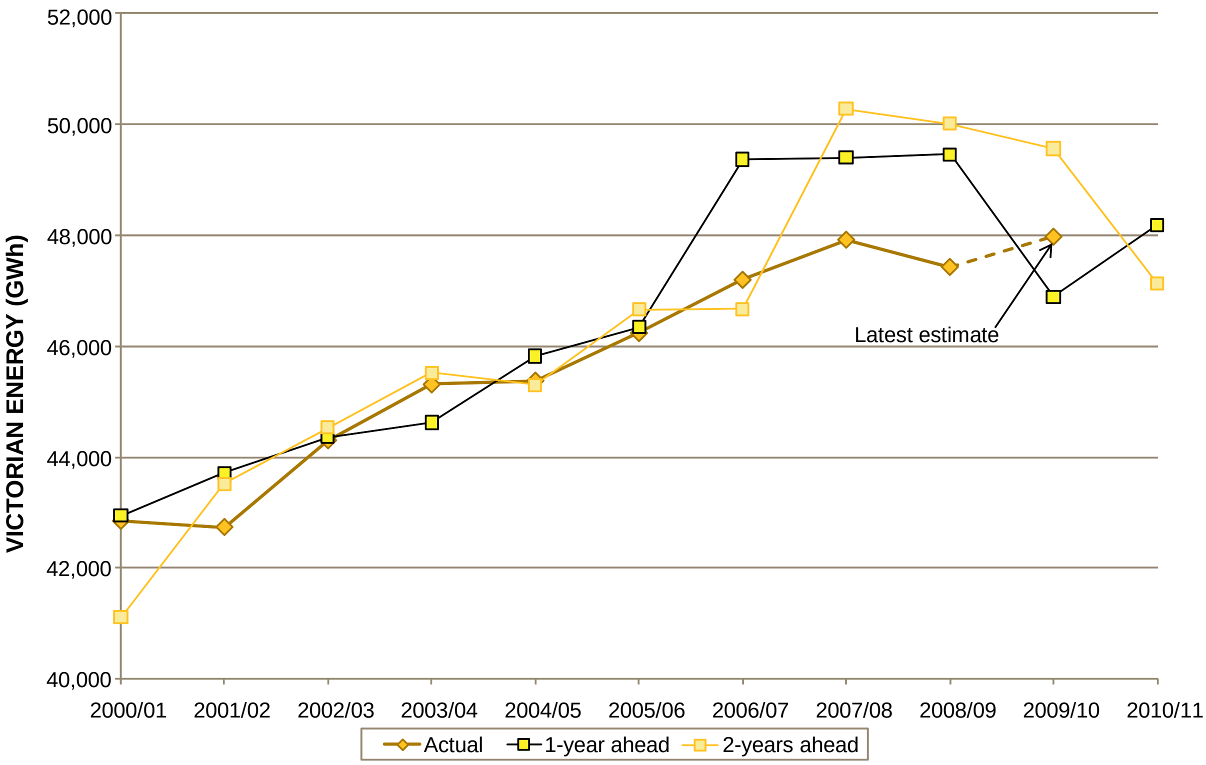
In any single year, the difference between actual and projected energy is due to a possible combination of any of the following:

- Variation in actual conditions from the input assumptions underlying the projections (due to economic and weather conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-21 illustrates the following:

- Projections published in the 2007 ESOO for the period 2007/08 to 2008/09 did not anticipate the downturn in the actual growth rate of energy, and subsequent forecasts have corrected for this.
- The projections have otherwise tracked actual energy relatively closely.

Figure B-21—Victorian energy one- and two-year-out back assessment



Backcast

Figure B-22 shows the five-year Victorian summer MD backcast. This was produced for AEMO as follows.

- The current forecasting model was re-estimated six times using only data that was available up to and including 2004/05. Each of these re-estimations was carried out for one of the respective actual POE MD levels pertaining to the five forecast years 2005/06 to 2009/10.
- These models were used to predict MDs for each of the five forecast years, taking into account actual economic conditions.

- One data point was selected from each set of predictions, so that the corresponding POE for that data point matched the actual POE for that year. The resulting series is an out-of-sample prediction of the actual summer MD that allows for the weather and economic conditions that actually occurred.

This procedure ensures that differences between actual and simulated values shown in Figure B-22 are solely due to a combination of:

- systematic forecast model error (resulting in persistent bias), and
- non-systematic forecast model error (by definition, unpredictable random error).

Summary statistics associated with the data in Figure B-22 are shown in the last column of Table B-4, alongside comparable statistics for the 2009 backcasting exercise.

Figure B-22—Victorian summer MD backcast

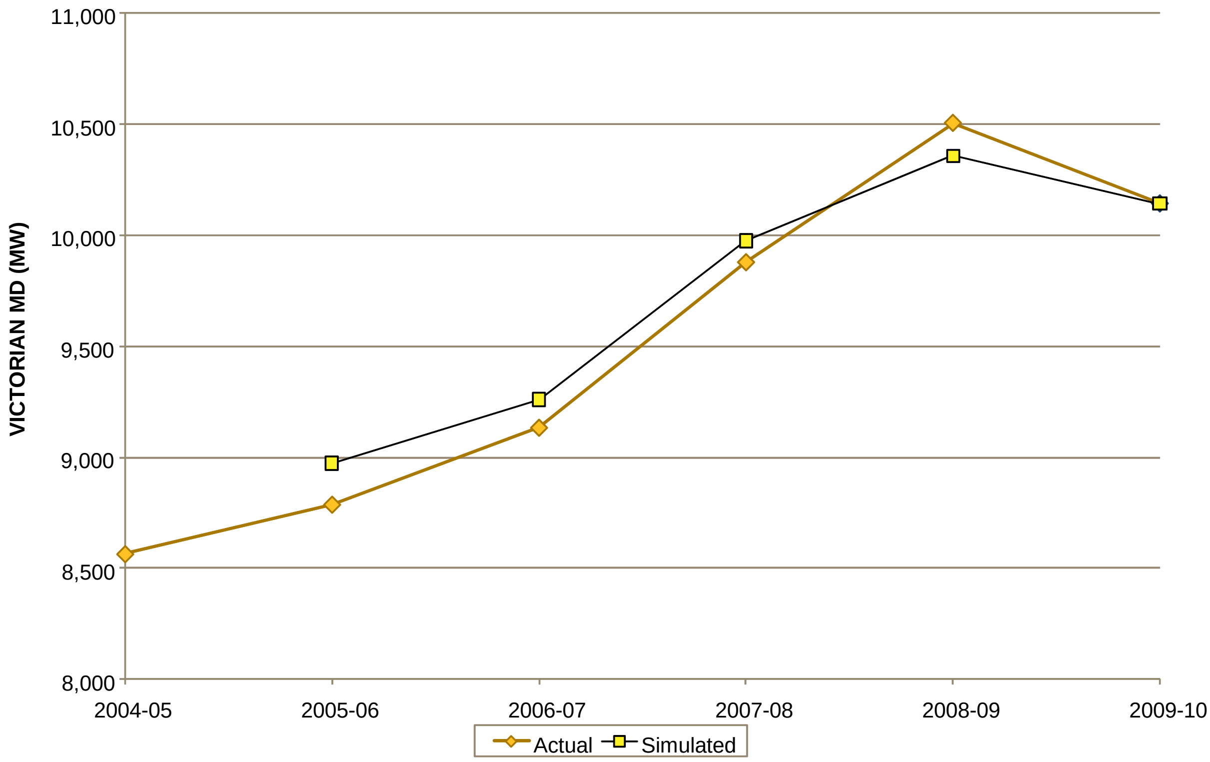


Table B-4—Victorian summer MD backcast results

Measure	2009 result	2010 result
Root mean squared percentage error (%RMSE)	1.69	1.36
Theil's inequality coefficient (U)	0.009	0.007
Bias proportion (U^B)	0.583	0.170
Variance proportion (U^V)	0.389	0.668
Covariance proportion (U^C)	0.028	0.162

Figure B-22 shows that backcast MDs are relatively close to the actual MDs, which enables a high degree of confidence in the forecasting methodology. Table B-4 confirms this, with a root mean square error of 1.36%. This may be thought of as equivalent to being able to place a dependable tolerance of approximately plus or minus 130 MW on any forecast derived using this methodology, if the actual input data was known with certainty.

Table B-4 shows two further aspects of the forecast. Firstly, the bias proportion is high, but not unacceptable for such a small sample. Secondly, the variance proportion is relatively high, implying that rapid changes in the actual MDs are only replicated slowly by the projections. The bias proportion has improved this year, compared with 2009, seemingly at the expense of an increase in the variance proportion.

No definitive conclusion can be drawn from these statistics, since the 2010 backcast was made on the basis of a sample of five years, while the 2009 backcast used a six-year sample.

Probability of exceedence estimation

Figure B-23—Victorian summer MD estimated at standardised POEs

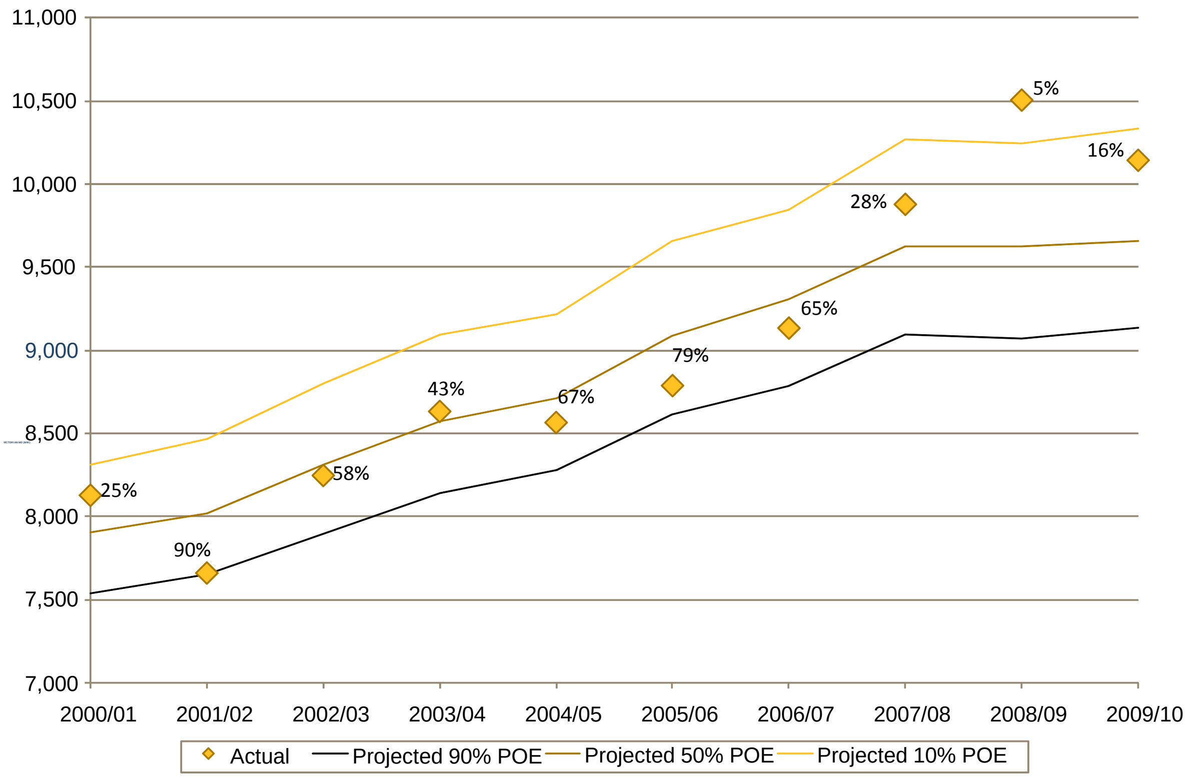


Figure B-23 shows actual MDs and estimated MD levels at standardised POEs. The actual MDs are:

- mostly contained within the 90% POE MD and 10% POE MD estimated values, and
- also spread evenly around the 50% estimated value.

This is what would be expected on average over the course of any 11-year period. The data therefore provide a high degree of confidence in the current estimation of demand at standardised POEs.

B.6 South Australia

This section presents the back assessments, backcast analysis and POE estimation for the South Australian region.

Back assessment

Figure B-24 and Figure B-25 show the South Australian one-year-out and two-year-out summer MD back assessments. Estimated POEs are shown above the actual MDs and each of the 90%, 50%, and 10% POE MD projections are also shown.

In any single year, the difference between actual and projected summer MDs is due to a possible combination of any of the following:

- Variation in actual conditions from any of the standard POE conditions (principally due to prevailing weather).
- Variation in actual conditions from the input assumptions underlying the projections (principally due to economic conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-24 and Figure B-25 illustrate the following:

- The projections for years prior to 2007/08 were generally very high compared to the actual MDs, considering the assessed POE MD levels.
- All projections made since the 2007 ESOO appear more reasonable, compared to the actual MDs.
- A new forecasting methodology was adopted in 2007 and has been used since.

Figure B-24—South Australian summer MD one-year-out back assessment

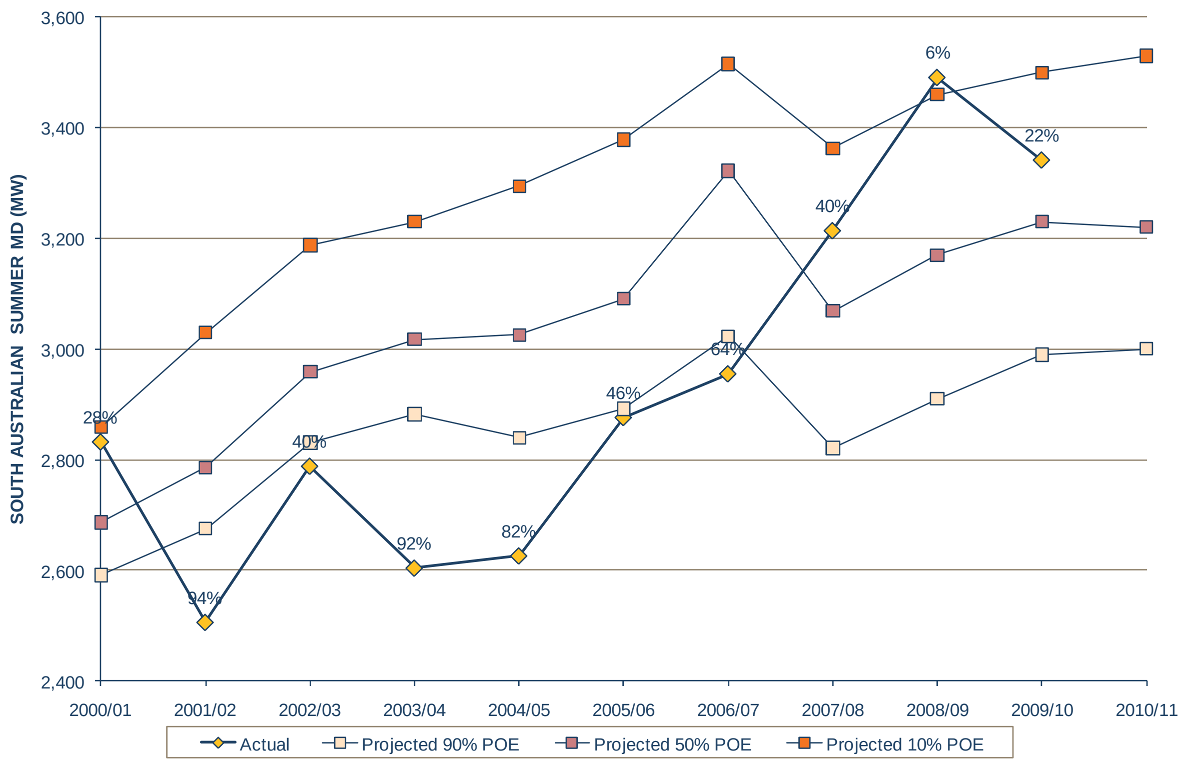


Figure B-25—South Australian summer MD two-year-out back assessment

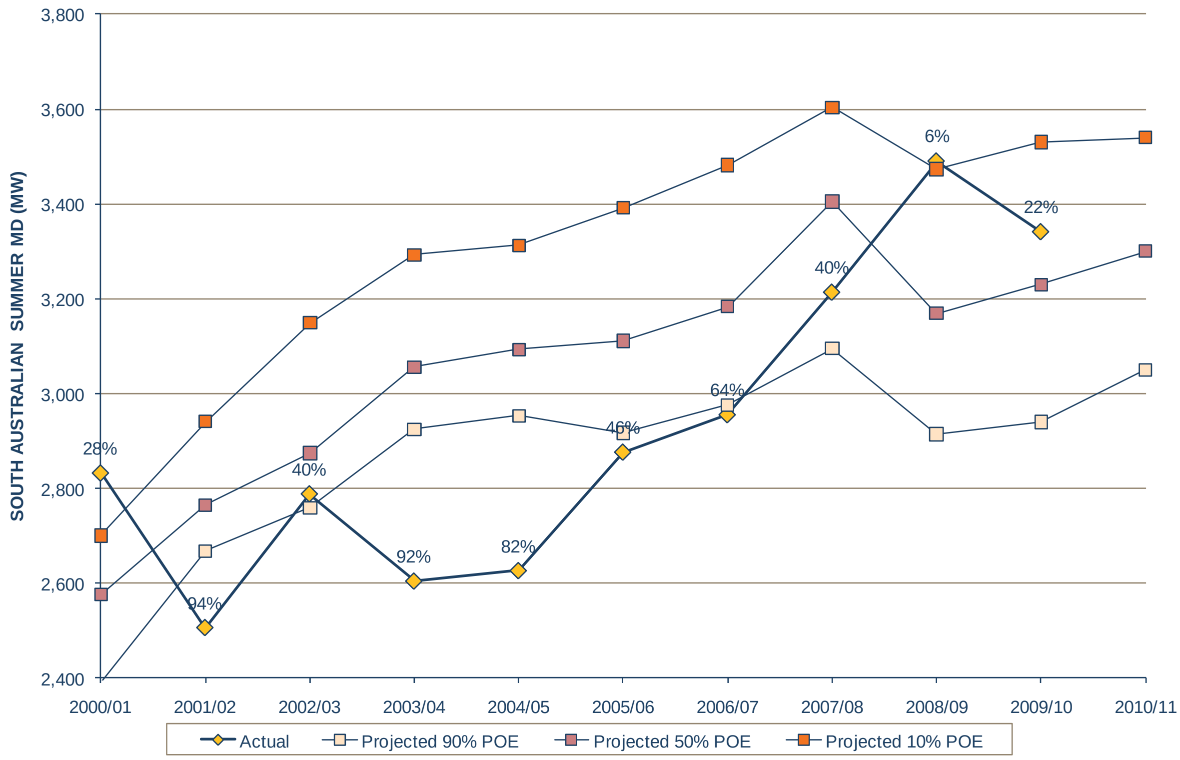


Figure B-26 shows the South Australian one-year-out and two-year-out energy back assessments. The yearly energy projections assume average weather conditions, while the actual data reflects weather conditions that actually occurred.

In any single year, the difference between actual and projected energy is due to a possible combination of any of the following:

- Variation in actual conditions from the input assumptions underlying the projections (due to economic and weather conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-26 illustrates the following:

- Energy projections made prior to the 2007 ESOO were generally higher than the actual outcomes.
- As reflected in the 1-year-out projection from 2006/07 onwards and the 2-year-out projection from 2007/08 onwards, recent projections have been highly accurate.
- A new forecasting methodology was adopted in 2007 and has been used since.

Figure B-26—South Australian energy one- and two-year-out back assessment

Backcast

Figure B-27 shows the two-year South Australian backcast, showing actual and simulated MDs minus major industrial loads (which are forecast using information available to AEMO on investment intentions, rather than by modelling). The simulated values were produced for AEMO as follows:

- The simulation model was based on load data prior to summer 2008/09.
- The ex-post simulation used actual temperatures and other input data as they occurred during the summers of 2008/09 and 2009/10.
- A single maximum was selected from a series of half-hourly simulated values for each summer.
- The original simulation errors were then used to re-specify the model before reproducing adjusted simulated MDs.

Figure B-27 shows the statistics associated with both the original and the adjusted backcast for 2010, as well the %RMSE for the 2009 backcast, for which only one data point was used.

The models originally developed in 2007 were found to over-predict demand under the extreme temperatures experienced in the 2008/09 summer, when demand appeared to have reached saturation levels during a prolonged heatwave. Data from this period was used to re-estimate the models, which resulted in improved demand predictions during extreme weather.

Figure B-27—South Australian summer MD backcast

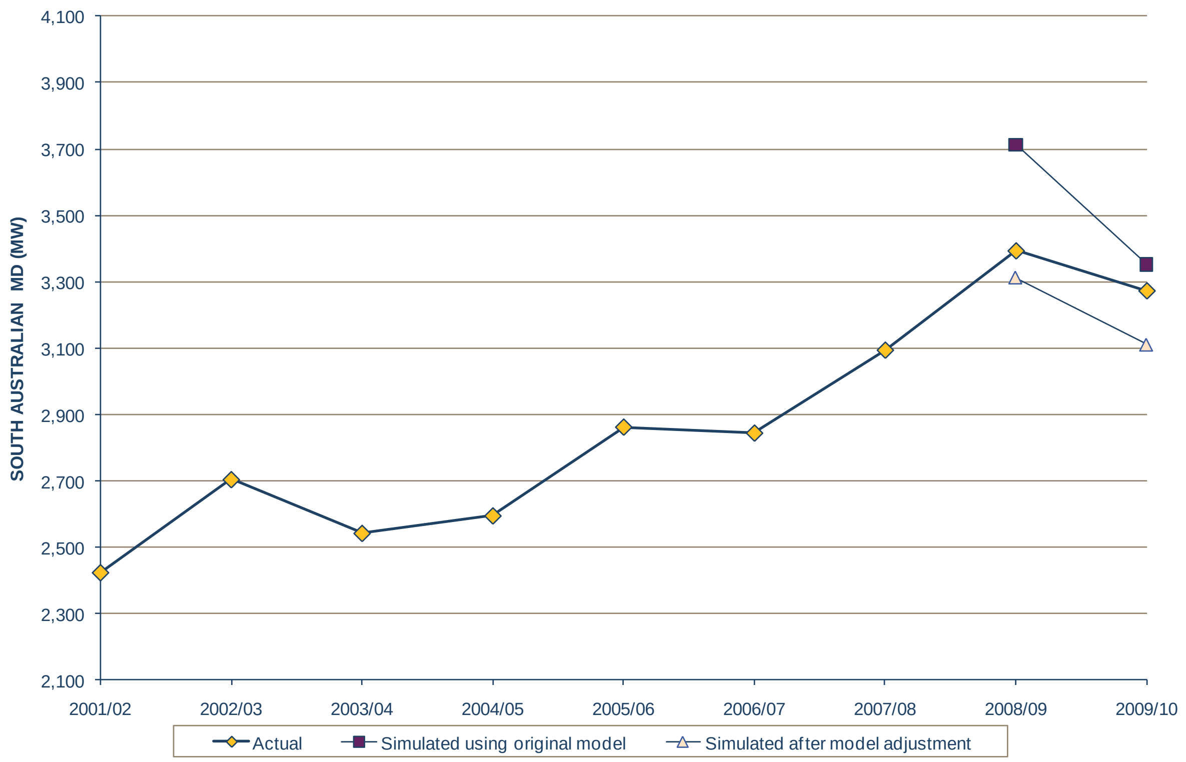


Table B-5—South Australian summer MD backcast results

Measure	2009 result	2010 result before adjustment	2010 result after adjustment
Root mean squared percentage error (%RMSE)	11.89	6.89	3.89
Theil's inequality coefficient (U)		0.034	0.020
Bias proportion (U^B)		0.733	0.897
Variance proportion (U^V)		0.267	0.103
Covariance proportion (U^C)		0.000	0.000

Probability of exceedence estimation

Figure B-28—South Australian summer MD estimated at standardised POEs

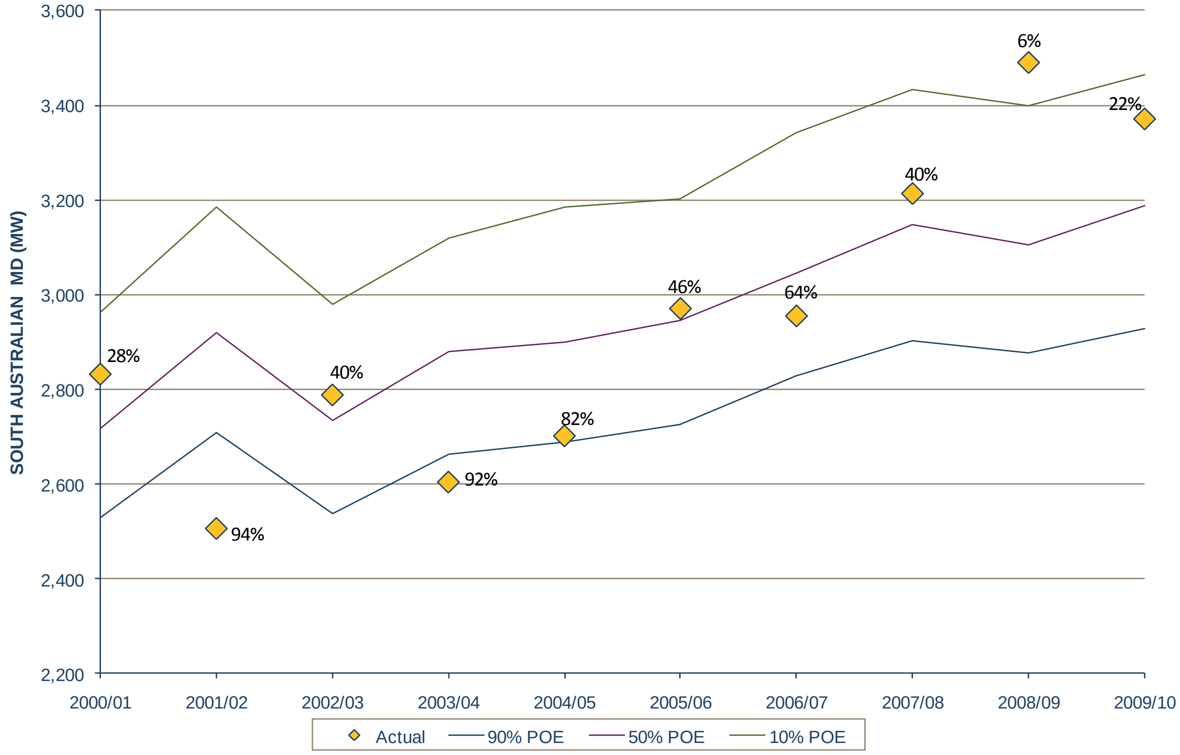


Figure B-28 shows actual MDs and estimated MD levels at standardised POEs. In relation to the assessed POE levels, the projected MDs well aligned with actual MDs. The data therefore provide a very high degree of confidence in the estimation of demand at standardised POEs.

B.7 Tasmania

This section presents the back assessments, backcast analysis and POE estimation for the Tasmanian region.

These assessments provide evidence of:

- projections that maintained a high level of accuracy, on average, over several years, and
- short-term departures of the projections from actual MDs due to unexpected changes in the operation of major industrial loads.

Back assessment

- Projections for the years 2003 to 2005 are broadly aligned with actual MDs, considering the assessed POE MD levels.
- The one-year-out projections for 2006 and 2007 (published in 2006 and 2007, respectively) and the two-year-out projections for 2007 and 2008 (published in 2006 and 2007, respectively) are high relative to the actual MDs, taking into consideration the assessed POE levels. The sharp rise projected for these years actually took place in the following years.

- The subsequent downturn in 2009 is related to temporary unannounced shutdowns of major industrial loads due to the economic downturn. A return to an average historical growth pattern is anticipated by Transend from 2010 onwards.

Figure B-29 and Figure B-30 show the Tasmanian one-year-out and two-year-out summer MD back assessments. Estimated POE MDs are shown above the actual MDs and each of the 90%, 50%, and 10% POE MD projections are also shown.

In any single year, the difference between actual and projected summer MDs is due to a possible combination of any of the following:

- Variation in actual conditions from any of the standard POE conditions (principally due to prevailing weather).
- Variation in actual conditions from the input assumptions underlying the projections (principally due to economic conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).
- Projections for the years 2003 to 2005 are broadly aligned with actual MDs, considering the assessed POE MD levels.
- The one-year-out projections for 2006 and 2007 (published in 2006 and 2007, respectively) and the two-year-out projections for 2007 and 2008 (published in 2006 and 2007, respectively) are high relative to the actual MDs, taking into consideration the assessed POE levels. The sharp rise projected for these years actually took place in the following years.
- The subsequent downturn in 2009 is related to temporary unannounced shutdowns of major industrial loads due to the economic downturn. A return to an average historical growth pattern is anticipated by Transend from 2010 onwards.

Figure B-29 and Figure B-30 illustrate the following.

- Projections for the years 2003 to 2005 are broadly aligned with actual MDs, considering the assessed POE MD levels.
- The one-year-out projections for 2006 and 2007 (published in 2006 and 2007, respectively) and the two-year-out projections for 2007 and 2008 (published in 2006 and 2007, respectively) are high relative to the actual MDs, taking into consideration the assessed POE levels. The sharp rise projected for these years actually took place in the following years.
- The subsequent downturn in 2009 is related to temporary unannounced shutdowns of major industrial loads due to the economic downturn. A return to an average historical growth pattern is anticipated by Transend from 2010 onwards.

Figure B-29—Tasmanian winter MD one-year-out back assessment

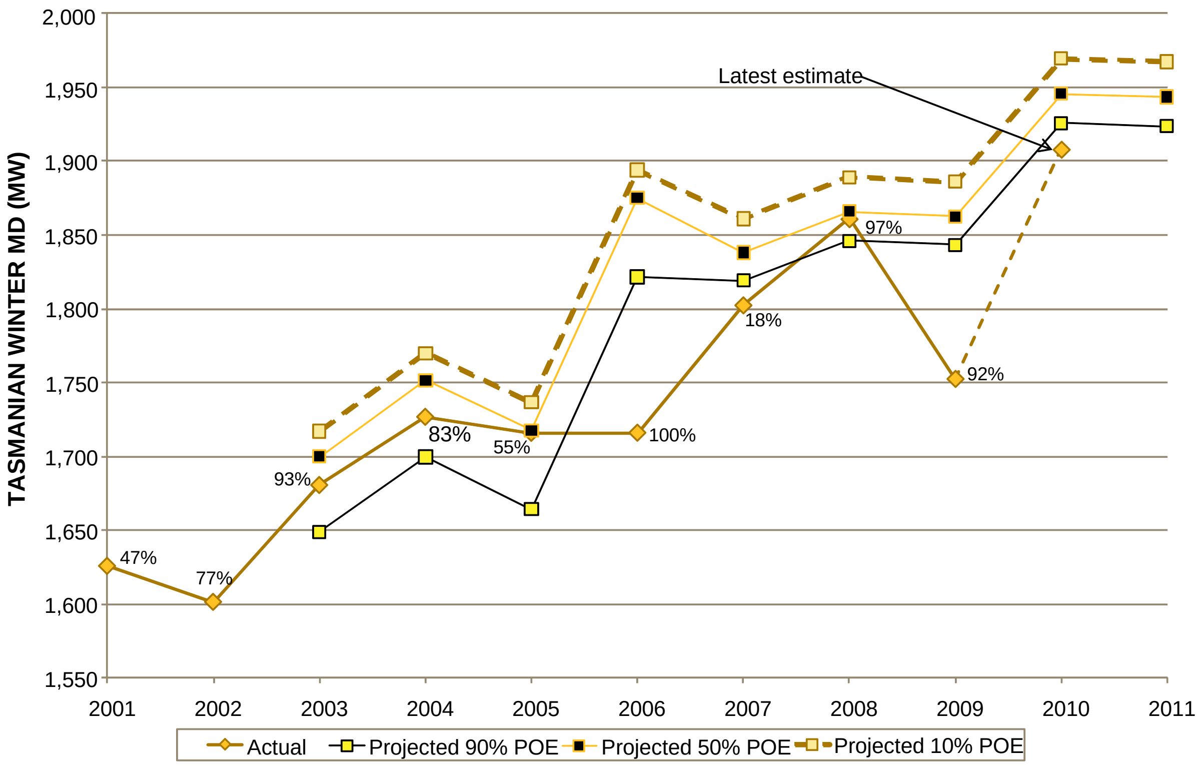


Figure B-30—Tasmanian winter MD two-year-out back assessment

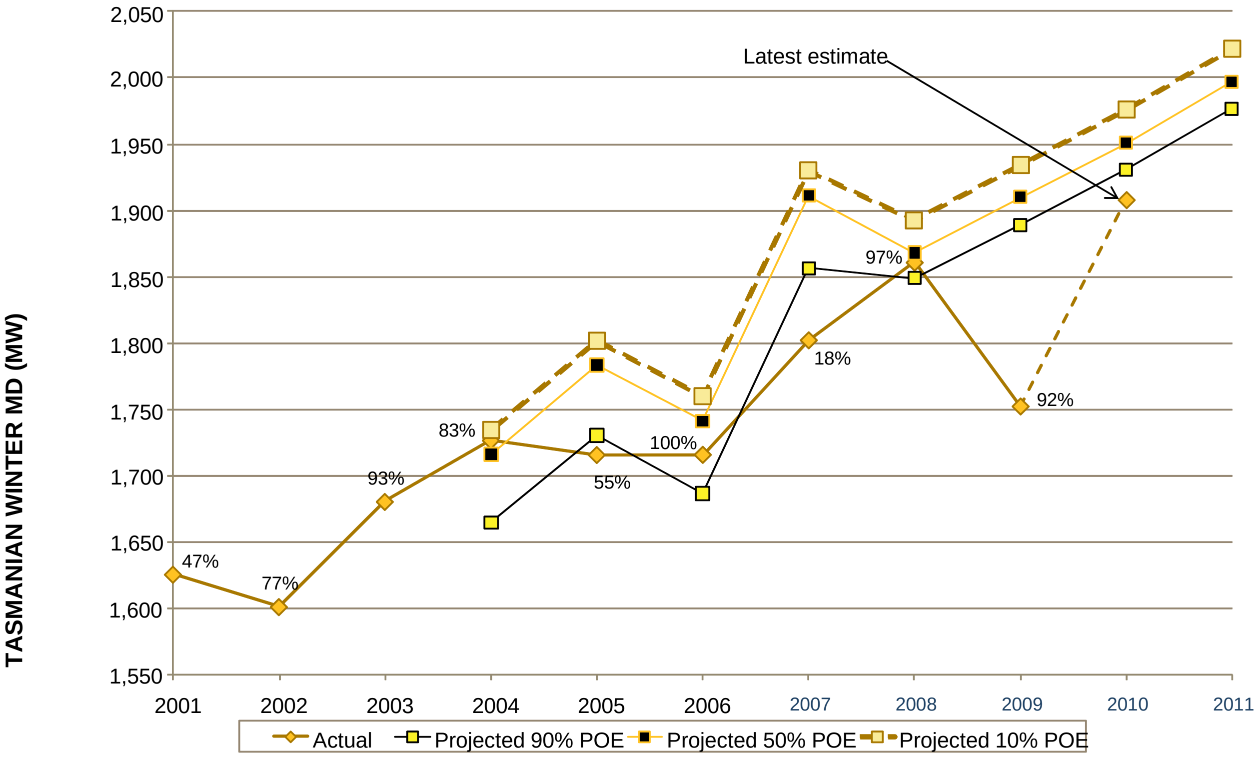


Figure B-31 shows the Tasmanian one-year-out and two-year-out energy back assessments. The yearly energy projections assume average weather conditions, while the actual data reflects weather conditions that actually occurred.

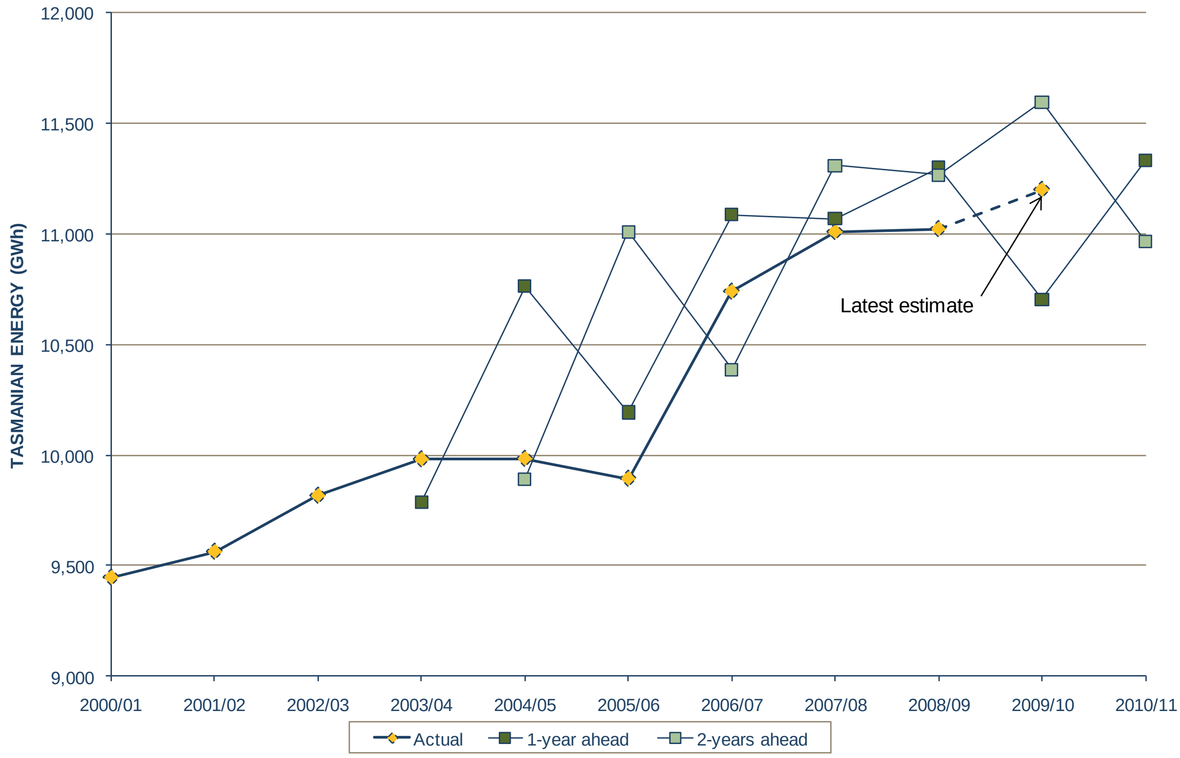
In any single year, the difference between actual and projected energy is due to a possible combination of any of the following:

- Variation in actual conditions from the input assumptions underlying the projections (due to economic and weather conditions).
- Systematic forecast error (resulting in persistent bias).
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-31 illustrates the following:

- As with the MD projections, the energy projections have broadly tracked the growth of actual energy since 2003/04. However, the initial steep rises in the one-year-out projections for 2004/05 and the two-year-out projections for 2005/06 preceded the rise in actual energy, which did not take place until 2006/07.
- A significant proportion of Tasmanian load comprises major industrial loads, and the behaviour of these customers can result in relatively large variations in the total load from year-to-year.

Figure B-31—Tasmanian energy one- and two-year-out back assessment



Backcast

Figure B-32 and Table B-6 show the results of the 10-year Tasmanian winter MD backcast. This was provided by Transend Networks and differs from the backcasts for other regions. The Tasmanian backcast was produced as follows:

- The current winter MD forecasting model was estimated using data up to and including 2009.

- This model was then used to simulate winter MDs for the last 10 years at the actual temperatures and economic conditions at those times.

This means that the backcast shown in Figure B-32 and in the last column of Table B-6 represents an in-sample prediction, rather than the more rigorous out-of-sample prediction. Statistics shown in Table B-6 for the 2009 backcasting exercise (which was based on a sample of only three data points) are therefore not strictly comparable. Despite this, the results are broadly similar and show projected MD growth close to actual MD growth.

Figure B-32—Tasmanian winter MD backcast

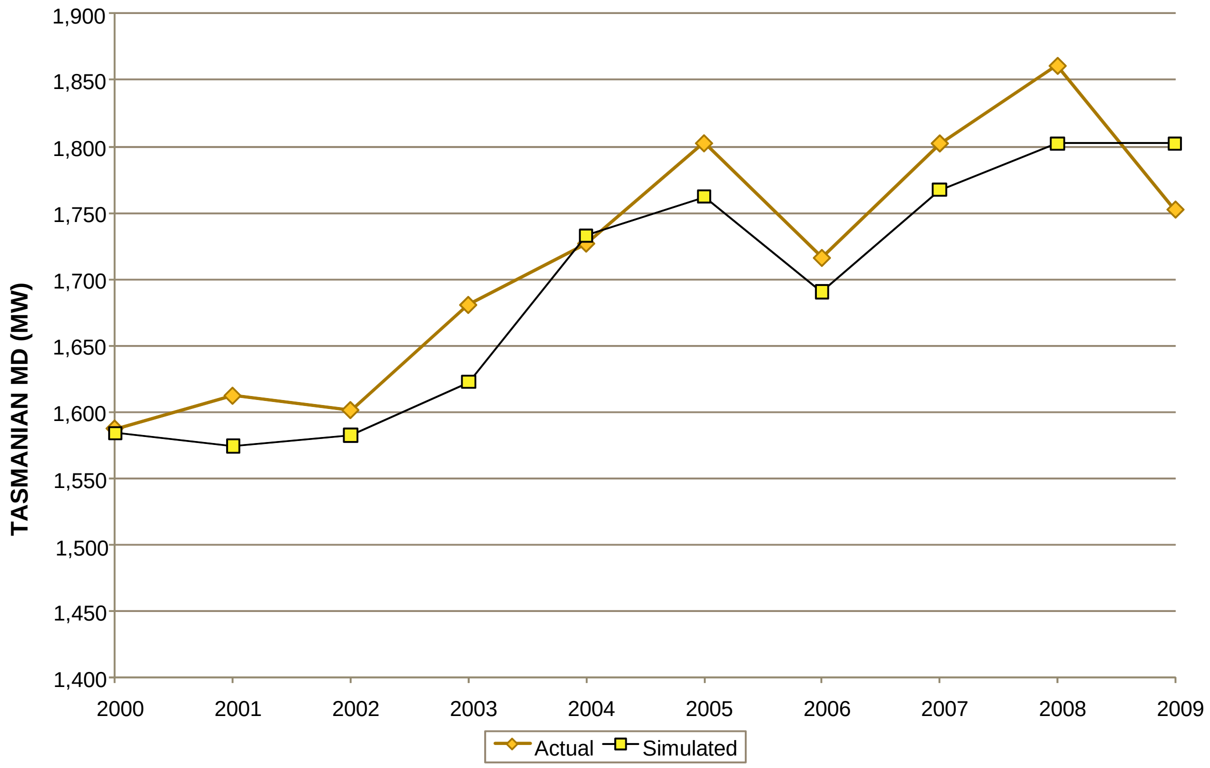


Table B-6—Tasmanian winter MD backcast results

Measure	2009 result	2010 result
Root mean squared percentage error (%RMSE)		2.19
Theil's inequality coefficient (U)		0.011
Bias proportion (U^B)		0.336
Variance proportion (U^V)		0.000
Covariance proportion (U^C)		0.663

Probability of exceedence estimation

Figure B-33—Tasmanian summer MD estimated at standardised POEs

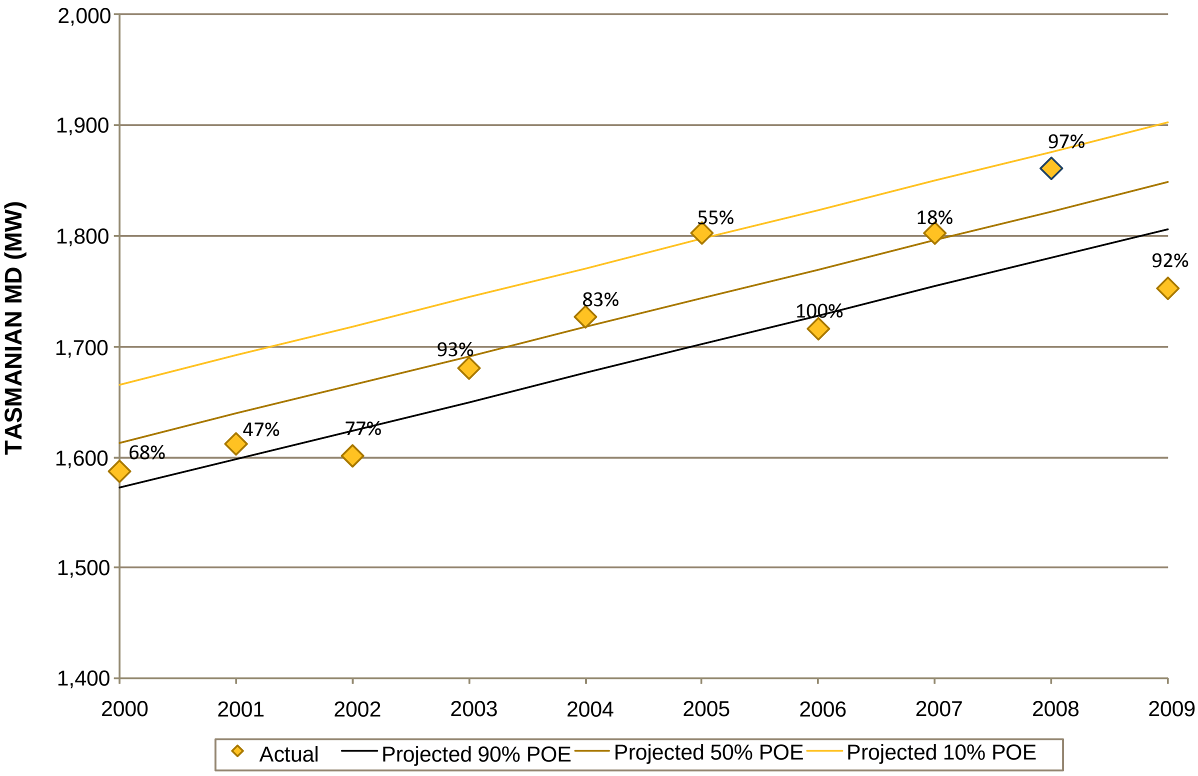


Figure B-33 shows actual MDs and estimated demand levels at standardised POEs. The actual MDs are mostly contained within the 90% POE and 10% POE estimated values. However, in relation to the assessed POE levels, the actual MDs are not generally well aligned. This reflects the following aspects of the data construction:

- The actual MDs include fluctuations from year-to-year due to varying temperatures and changes to major industrial loads.
- The projected 90% POE, 50% POE, and 10% POE levels are derived as a straight line trend, based on average historical MD growth.
- The assessed actual POE levels are derived from an analysis of the likely occurrence of temperatures only.

These procedures may be better represented by making suitable adjustments to the projected POE levels for the difference between projected and actual major industrial loads.