AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

23 December 2011

Mr Neville Henderson
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Reliability Panel
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Dear Mr Henderson,

Report to Reliability Panel on the accuracy of NEM demand forecasts

As required by Section 3.13.3 (u) of the National Electricity Rules, I am pleased to provide the attached report, Appendix B from the 2011 ESOO, to the Reliability Panel.

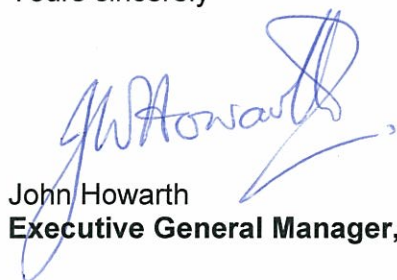The accuracy of maximum demand forecasts is assessed in two ways:

- 'Back assessment' which compares actual outcomes with previously published forecasts.

- 'Backcasting' compares actual outcomes over a limited historical period with simulated outcomes using the current forecasting model and actual variables instead of forecasts for the model inputs.

It should be noted that assessing the accuracy of demand forecasts is undertaken by the jurisdictional planning body that provides these forecasts to AEMO, and the appropriateness of each region's assessment has not been reviewed by us. Assessing the accuracy of forecasts which are of a probability of exceedance forecast is inherently difficult recognising that any one year's outcome is only one point on the probable distribution of demand that could have occurred in that year. In the current uncertain economic environment these difficulties are compounded. We have attached a brief description of the analysis presented by each jurisdictional planner as prepared by the Load Forecasting Reference Group.

AEMO is currently mapping out a National Forecasting program of work, which aims at providing more transparency on demand forecasts to market participants, and includes the requirement of establishing standardised approaches for assessing the accuracy of demand forecasts (see AEMO website http://www.aemo.com.au/forecasting/0400-0053.pdf). The outcome of this work is planned for delivery by mid 2012, and at that time AEMO will provide a more comprehensive review of demand forecast accuracy to the reliability panel.

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

Attachment: ESOO 2011 Appendix B – Assessment of Energy and Demand Projections

APPENDIX B - ASSESSMENT OF ENERGY AND DEMAND PROJECTIONS

Summary

This appendix reviews the quality of the energy and maximum demand (MD) projections provided for each National Electricity Market (NEM) region. The assessments provide evidence that each regional jurisdictional planning body (JPB):

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

The most significant variations between projections and actual values are due to:

- An anticipated rebound in energy consumption during 2010–11 that failed to materialise
- Varying diversity between different load centres in Queensland, and
- Unanticipated variations in major industrial loads in Tasmania.

Ensuring that each region's projections represent similar measures and assumptions has been comprehensively considered. Similar considerations apply to the assessment of these projections, to achieve similar assessment methods for each region.

Variation in individual projection methodologies differences persist due to the significance of factors affecting energy and MD between regions. Both the projection methodologies and the assessment of the projections are improved year by year. As a result, the following qualifications apply to the conclusions drawn from the regional assessments:

- Comparisons between regions may not be valid because the assessments may not have been done in exactly the same way 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 way they were assessed.
- The statistics presented are necessarily calculated on a limited sample of data that limits the confidence of any inferences drawn.

AEMO drew the following conclusions about the 2010 energy and MD projections for each region:

- The Queensland projections have been consistently high.
- The New South Wales projections have remained accurate.
- Victorian projections are accurate, but anticipated a rebound in energy consumption that has not yet occurred.
- The relative accuracy of the South Australian projections has improved.
- Tasmanian projections are variable due to the difficulty of anticipating the behaviour of a number of large industrial customers.

B.1 Background

This energy and MD projection assessment is coordinated by AEMO and made available to the Australian Energy Market Commission (AEMC) 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, and may vary slightly between regions, even though consistency is the aim.

B.1.1 Methods of validation of the projections

Validation of the projections is carried out 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.
- Comparisons of POE indicate whether the estimated probability density function, represented by 90%, 50% and 10% POE MDs, is similar to the actual probability density function of historical MDs.

B.1.2 Back assessment

Back assessments compare projections published in previous ESOOs with actual values to date. The 2011 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 2008 ESOO regional summer MD projection for 2008–09 is compared with the actual outcome for 2008–09.
- Two-year-out back assessments compare regional energy or MD projections made for the year after next with actual values. For example, a 2007 ESOO regional summer MD projection for 2008–09 is compared with the actual outcome for 2008–09.

The primary reason for limiting back assessment to one-year and two-year time frames is because AEMO bases its decisions to investigate potential 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.

Back assessment analysis includes projections from all previous ESOOs (starting from the 1999 publication), providing 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 projection outcomes over the history of the ESOO.

B.1.3 Backcasting

The term 'backcasting' refers to simulating the forecasting model over a historical test period. This allows an immediate comparison of simulated and actual outcomes. All forecasting models depend on input variables such as economic activity and temperature that require forecasts. Since these inputs to the forecasting model are known 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 3.

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:

- Percentage root mean square error (%RMSE) – (see Figure B-1)
- Theil inequality coefficient (U) – (see Figure B-2), and
- Decomposition of U into the bias (UB), variance (Uv) and covariance (Uc) 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.

Figure B-1 — Percentage root mean square error calculation

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 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 expressed as a deviation from the (theoretical) perfect forecast. The components of this coefficient provide useful information about the sources of forecast inaccuracy. For example, a relatively accurate forecast over a short time period may have a

persistent bias that could lead to significant inaccuracy over the long term. A straight line projection could turn out to be a relatively accurate forecast of the general trend, despite the fact that actual outcomes displayed significant fluctuation around such a straight line. Calculation of the Theil inequality coefficient and its components is described in Box B 2.

Figure B-2 — Theil inequality coefficient calculation

Theil inequality coefficient calculation

The Theil inequality coefficient is calculated as follows:

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

Where:

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

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 has maximum error.

The decomposition of U produces the following proportions:

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

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

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

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 compares the average values of simulated and actual MD and when not close to zero, indicates systematic error.

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

U^C is the remaining unpredictable random remaining error.

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

Probability of exceedence comparison

POE estimation determines the probability of possible MDs in each historical season.

The MD projections are developed at 90%, 50%, and 10% POE of an estimated statistical distribution. 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 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 variable values representing the appropriate POE.

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 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 or with greater magnitude.

- If the 10% POE MD projection is 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 or with lower magnitude.

- 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 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 to Section B.6 includes, for each respective region, a qualitative assessment of 90%, 50%, and 10% POE MDs, in which the estimated MDs at each POE level are shown graphically against MDs that actually occurred.

B.2   Queensland

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

B.2.1   Summary

These assessments provide evidence of:

- Projections that 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.

B.2.2   Back assessment

Figure B-3 and Figure B-4 show the Queensland one-year-out and two-year-out summer MD back assessments. Estimated POEs are shown with 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), and
- Non-systematic forecast error (by definition, unpredictable random error).

Figure B-3 and Figure B-4 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.

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-3 — Queensland summer MD one-year-out back assessment

Figure B-4 — Queensland summer MD two-year-out back assessment
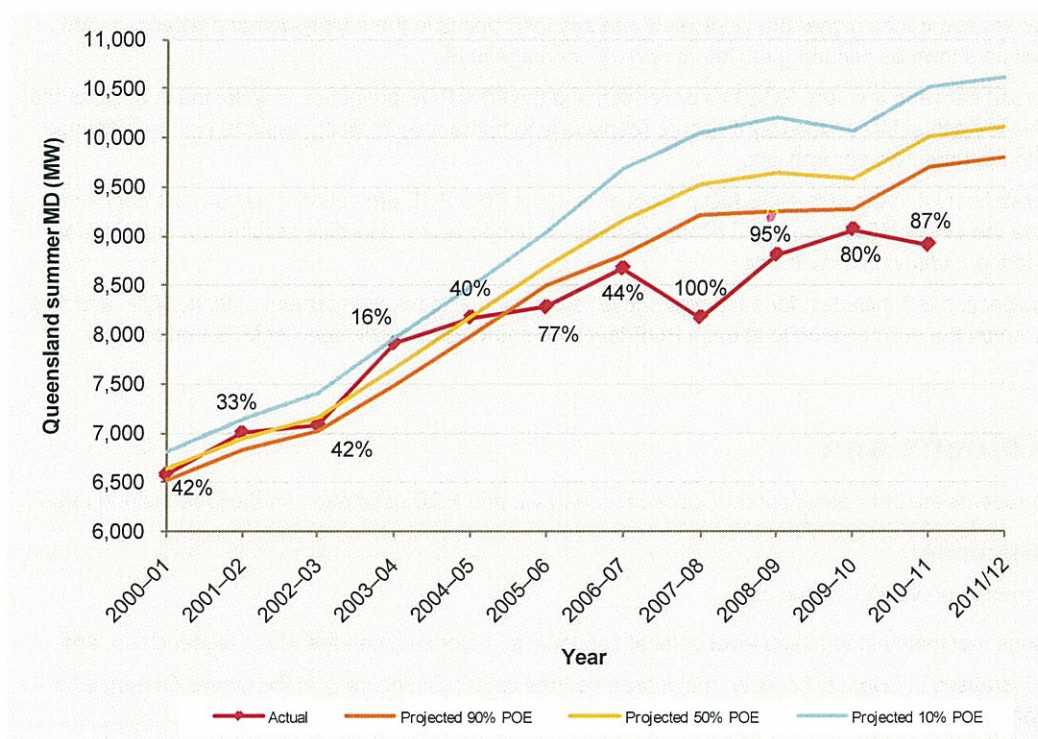
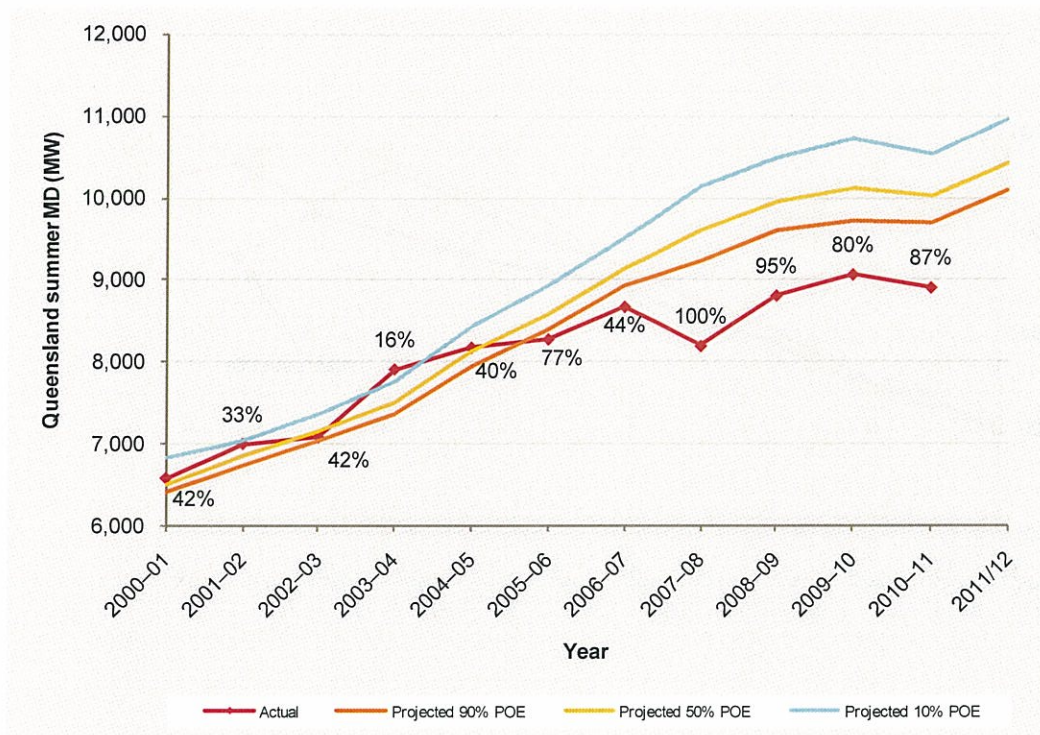Figure B-4 — Queensland summer MD two-year-out back assessment

Figure B-5 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 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-5 illustrates the following:

- Projections for all years since 2005–06 appear to have missed an apparent slowing in actual energy growth.
- There was a significant one-off impact on forecast performance due to cyclone and flood damage, combined with a mild summer, during 2010–11.

Figure B-5 — Queensland energy one- and two-year-out back assessment
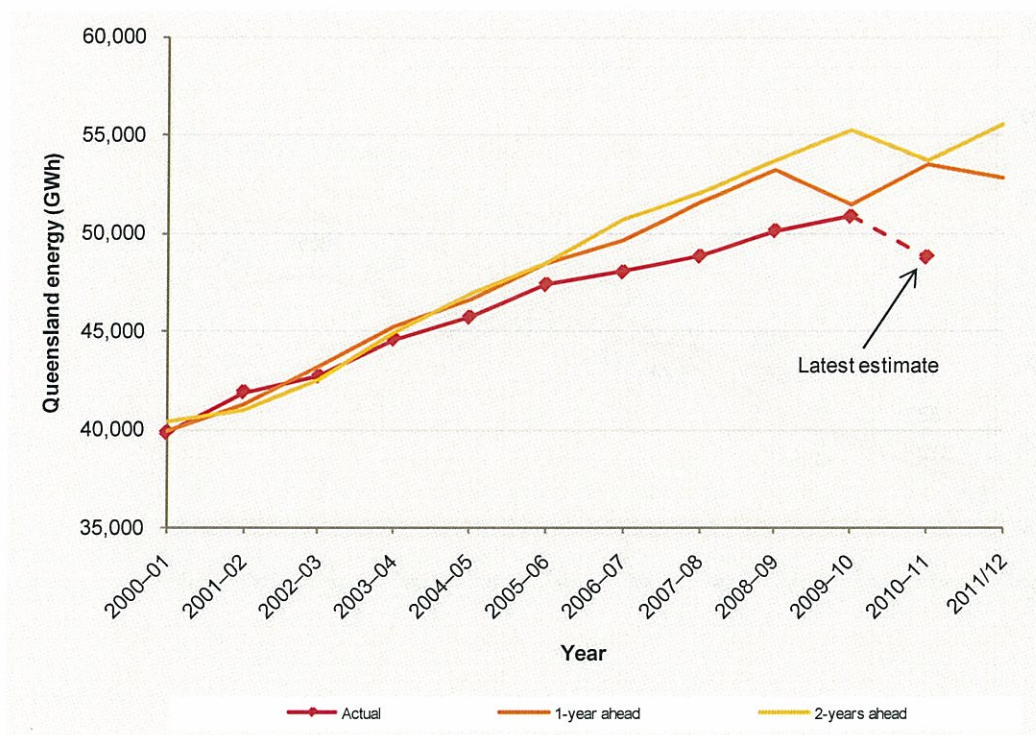
B.2.3 Backcast

Figure B-6 shows the 10-year Queensland summer MD backcast. Produced by Powerlink in a different manner to other regions (because Powerlink's primary projection methodology relies on the aggregation of connection point forecasts provided by the Queensland distribution network service providers (DNSP), whereas other regions primarily rely on a top-down modelling approach that more readily facilitates backcasting) the backcast for Queensland was developed 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 partially mimics (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-6 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-6 are shown in Table B-1, alongside broadly comparable statistics for the 2009 backcasting exercise.
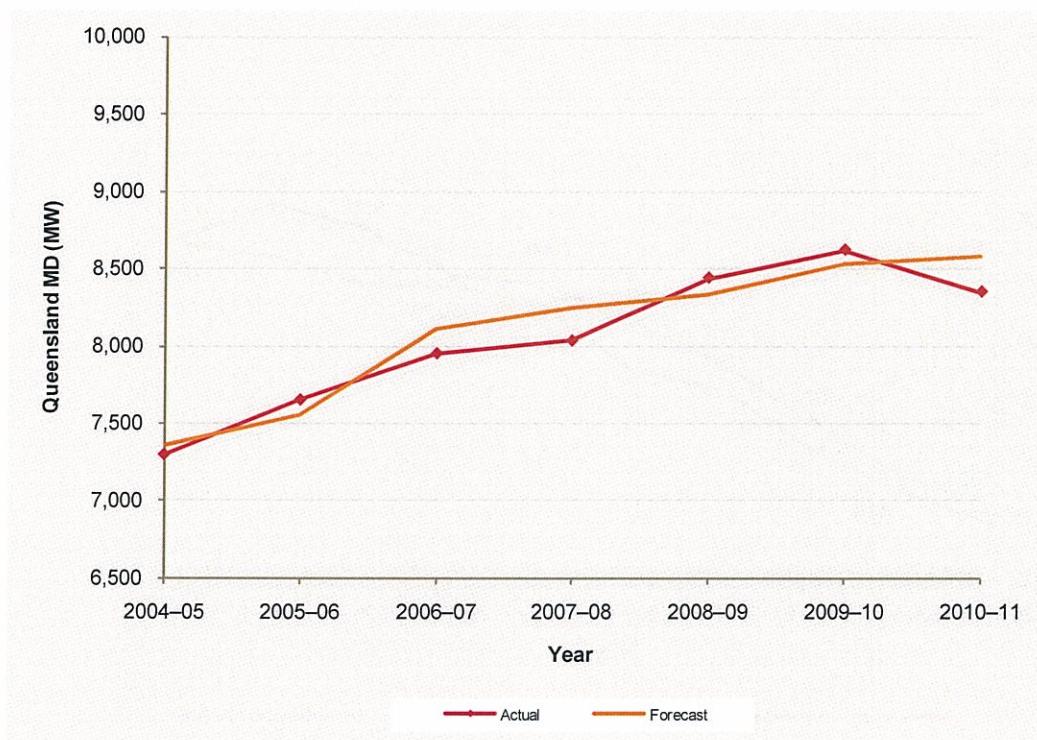
Figure B-6 — Queensland summer MD backcast

Table B-1 — Queensland summer MD backcast results

Measure	2010	2011
Percentage root mean square error (%RMSE)	3.02	5.59
Theil inequality coefficient (U)	0.015	0.032
Bias proportion (UB)	0.063	0.866
Variance proportion (UV)	0.016	0.000
Covariance proportion (UC)	0.921	0.134

Simulated values are moved evenly around the actual values over an extended period, with Table B.1 showing a %RMSE of 5.59% for 2011 and a Theil coefficient of 0.032. The forecast values don't capture all the year to year variations of the actuals.

B.2.4   Probability of exceedence estimation

Figure B-7 shows actual MDs and estimated demand levels at standardised POEs. In relation to the assessed POE 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 level. This reflects the unprecedented combination of mild weather and very high diversity between demands in major load centres within Queensland.

Figure B-7 — Queensland summer MD estimated at standardised POEs
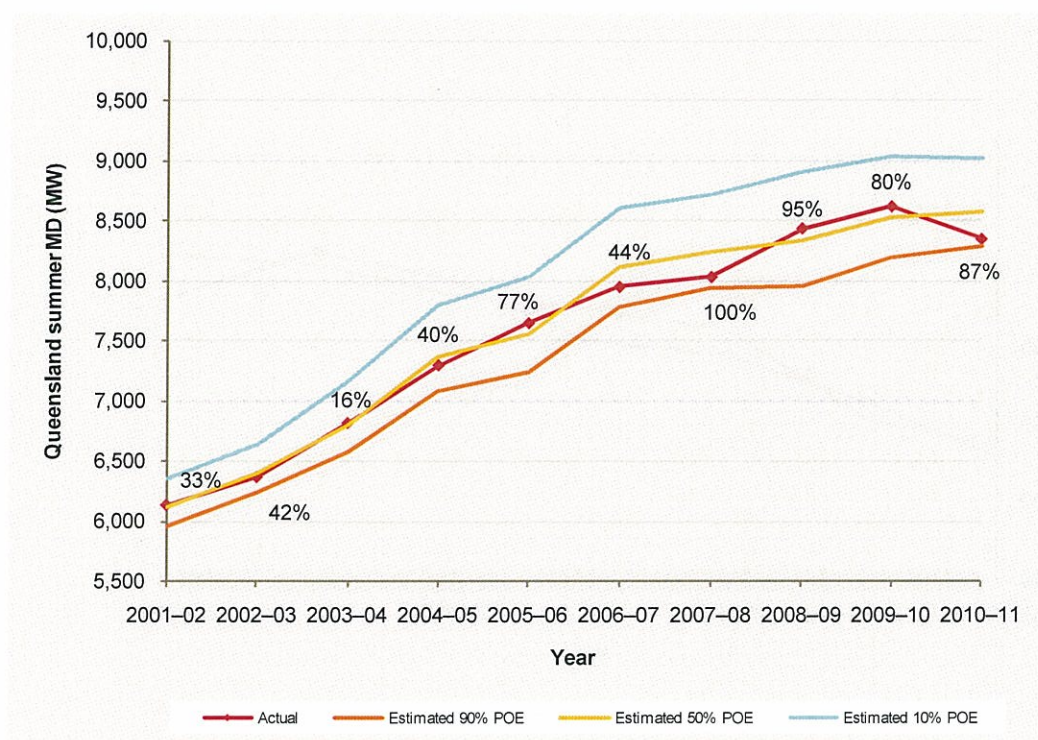
B.3　New South Wales

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

Summary

These assessments provide evidence of:

- Projections that have generally maintained a high level of accuracy, and
- Modifications to the forecasting process in response to learning from previous outcomes.

However, the backcast results provide evidence of a slight upward bias in the projections, which may be due to structural changes in New South Wales energy use.

B.3.1　Back assessment

Figure B-8 and Figure B-9 show the New South Wales one-year-out and two-year-out summer MD back assessments. Estimated POEs are shown with 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-8 and Figure B-9. illustrate the following.

- Projections supplied by TransGrid for 2000–01 were below the actual summer MD, which coincided with extremely hot weather. The rapid penetration in air-conditioning that occurred at that time was not generally anticipated by the forecast.

- 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. This 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 levels, are otherwise close to the actual MDs.

Figure B-8 — New South Wales summer MD one-year-out back assessment
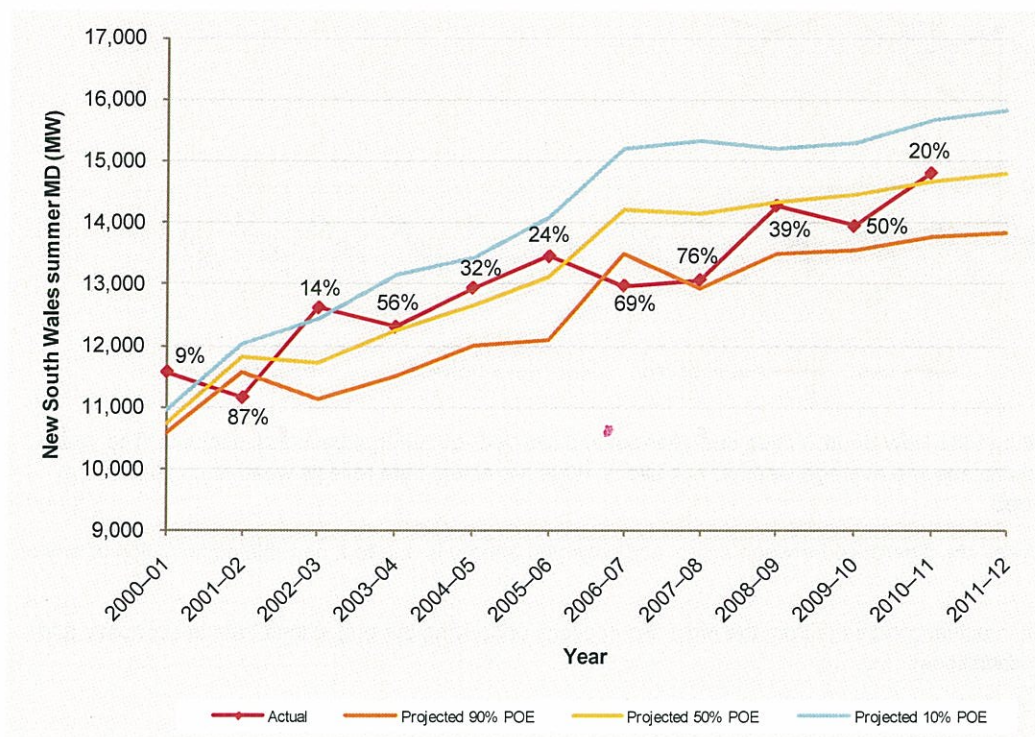
Figure B-9 — New South Wales summer MD two-year-out back assessment
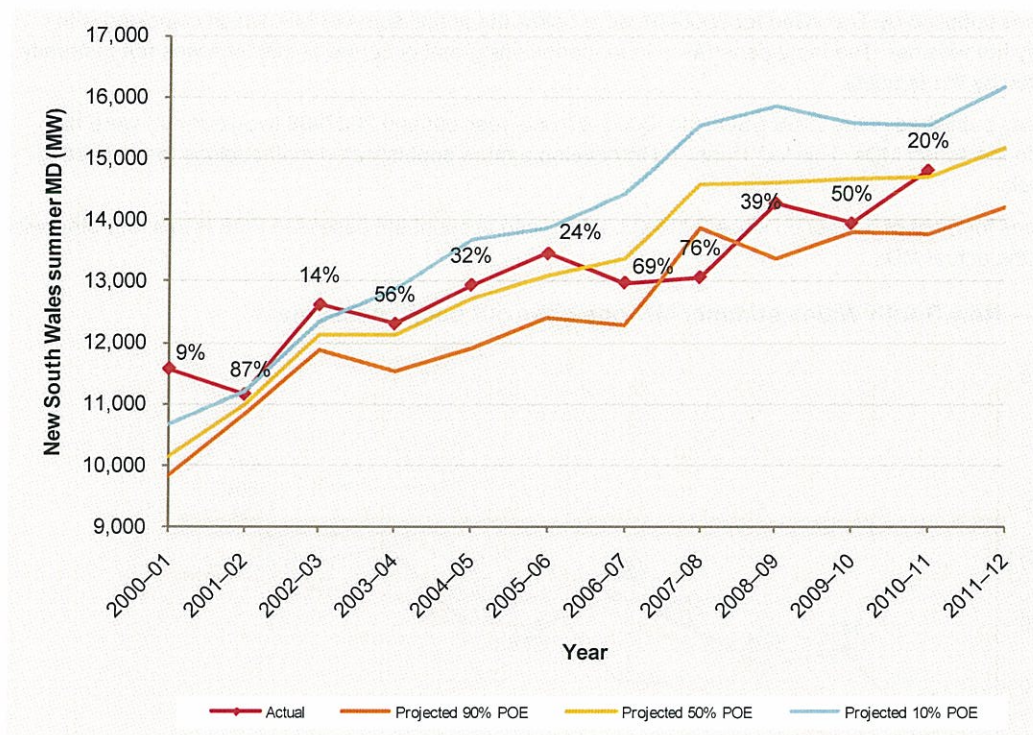

Figure B-10 shows the New South Wales one-year-out and two-year-out energy back assessments. The yearly energy projections assume average weather conditions, while the actual data reflects weather conditions that actually occurred.

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-10 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 to a large extent corrected for this).
- Projections published in the 2010 ESOO for 2010–11 and 2011–12 anticipated a rebound in energy consumption that has so far not materialised.
- The projections have otherwise tracked actual energy closely.

Figure B-10 — New South Wales energy one- and two-year-out back assessment
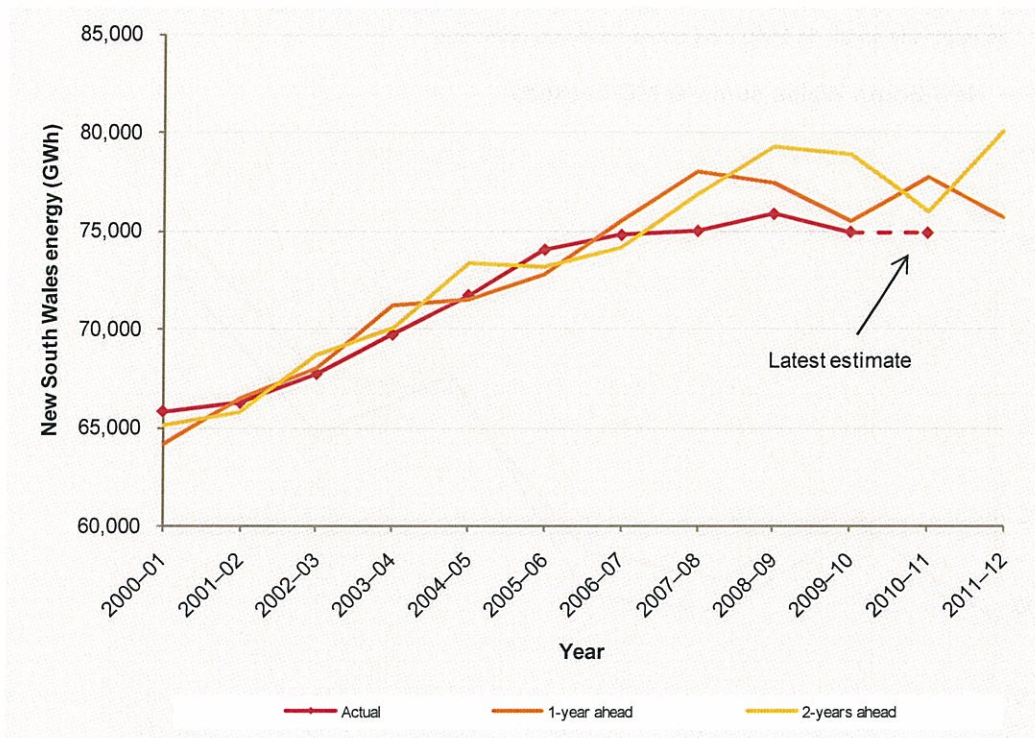
B.3.2   Backcast

Figure B-11 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 only 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 levels pertaining to the six forecast years 2004–05 to 2009–10.

- The re-estimated 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 forecasts, so that the corresponding POE for that data point matched the actual POE for that year. The resulting series is an out-of-sample forecast of the actual summer MD that allows for the weather and economic conditions that occurred.

This procedure ensures that differences between actual and simulated values shown in Figure B.11 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-11 are shown in Table B-2, alongside comparable statistics for the 2008 and 2009 backcasting exercises.

Figure B-11 shows that backcast MDs are relatively close to the actual MDs, which enables a high degree of confidence in the forecasting methodology. Figure B-2 confirms this, with a RMSE of 1.58% (equivalent to being able to assign a dependable tolerance of approximately plus or minus 230 MW to any forecast derived using this methodology, if the actual input data was known).

However, both Figure B-11 and Table B-2 show evidence of a persistent upward bias in the forecast, with the proportion of 0.649 in Table B-2 showing that bias is still the largest source of forecasting model error.

The bias proportion has decreased this year, compared with previous years, and the gap between actual and simulated values in Figure B-11 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-11 — New South Wales summer MD backcast
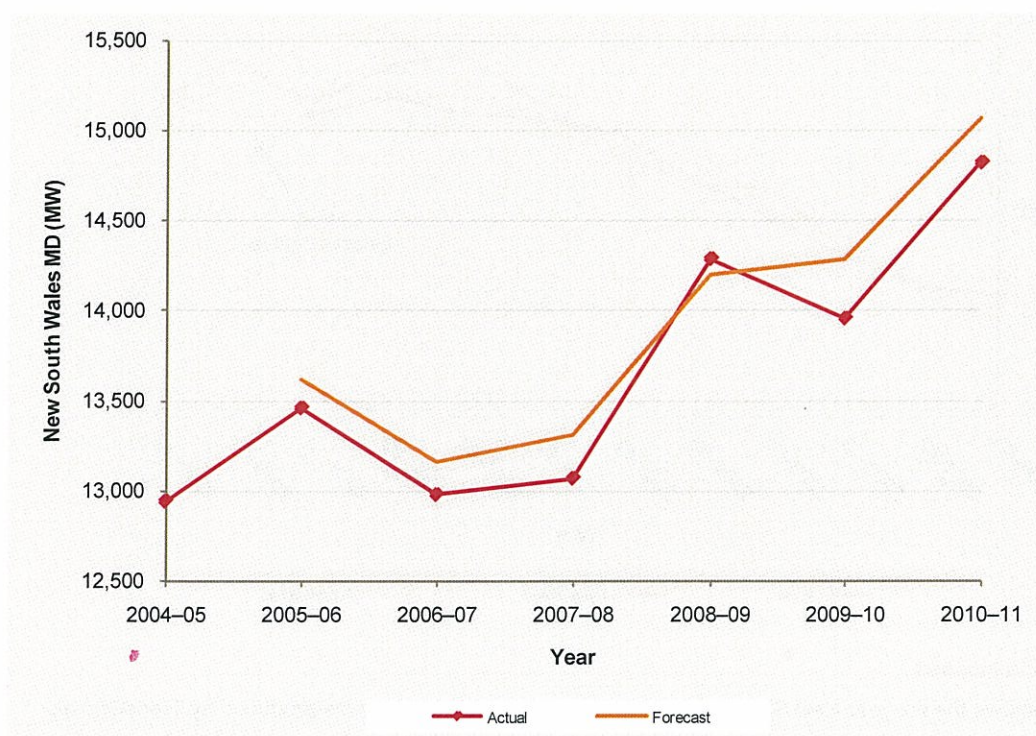
Table B-2 — New South Wales summer MD backcast results

Measure	2009	2010	2011
Percentage root mean square error (%RMSE)	0.95	1.30	1.58
Theil inequality coefficient (U)	0.005	0.006	0.008
Bias proportion (UB)	0.670	0.857	0.649
Variance proportion (UV)	0.236	0.000	0.000
Covariance proportion (UC)	0.095	0.143	0.350

Figure B-12 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-12 are shown in Table B-3.

Figure B-12 — New South Wales energy backcast
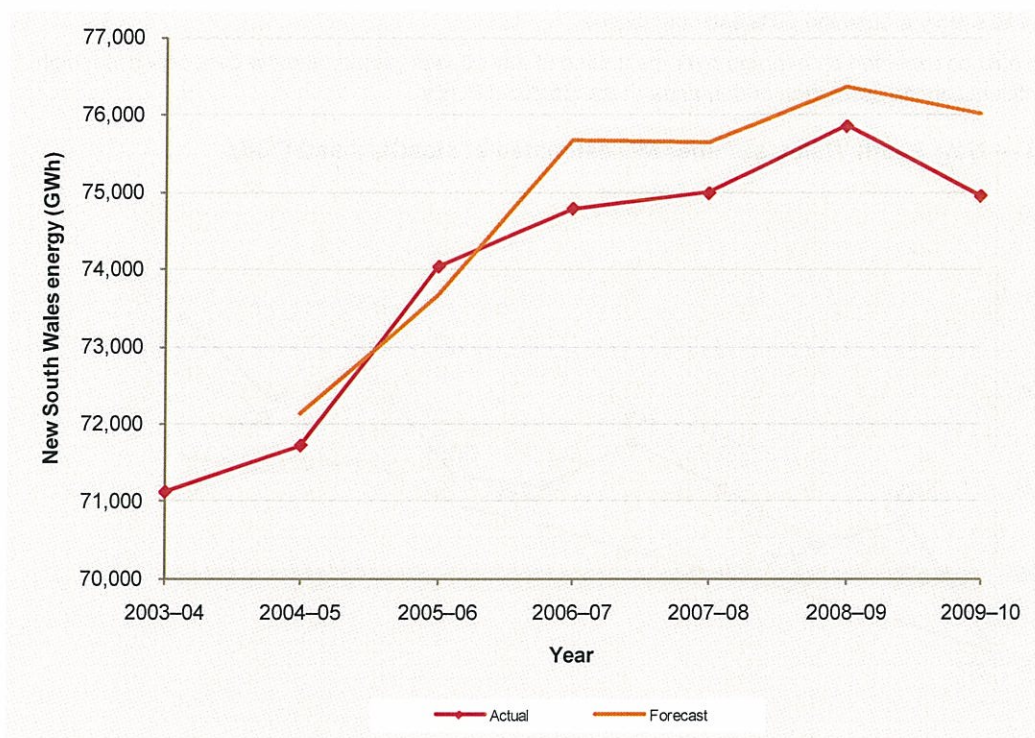
Table B-3 — New South Wales energy backcast results

Measure	2010	2011
Percentage root mean square error (%RMSE)	1.41	0.93
Theil inequality coefficient (U)	0.007	0.005
Bias proportion (UB)	0.655	0.572
Variance proportion (UV)	0.170	0.086
Covariance proportion (UC)	0.174	0.342

Similarly to the summer MD results, simulated backcast energy is close to actual energy and follows a similar growth rate. The %RMSE of 0.93% for 2011 is equivalent to being able to assign a dependable tolerance of approximately plus or minus 700 GWh on any forecast derived using this methodology, if the actual input data was known. However, as with the summer MD, the backcast energy is persistently higher than actual energy and the bias proportion at 0.572 is still 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 an imperfectly specified forecasting model, or a structural change in the data being forecast. The TransGrid energy and MD projections, as described in the 2011 New South Wales 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.

### B.3.3   Probability of exceedence estimation

Figure B-13 shows actual MDs and estimated demand levels at standardised POEs. The actual MDs are:

- Mostly contained within the 90% 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 10-year period, and the data provides a high degree of confidence in the estimation of demands at standardised POEs.

Figure B-13 — New South Wales summer MD estimated at standardised POEs
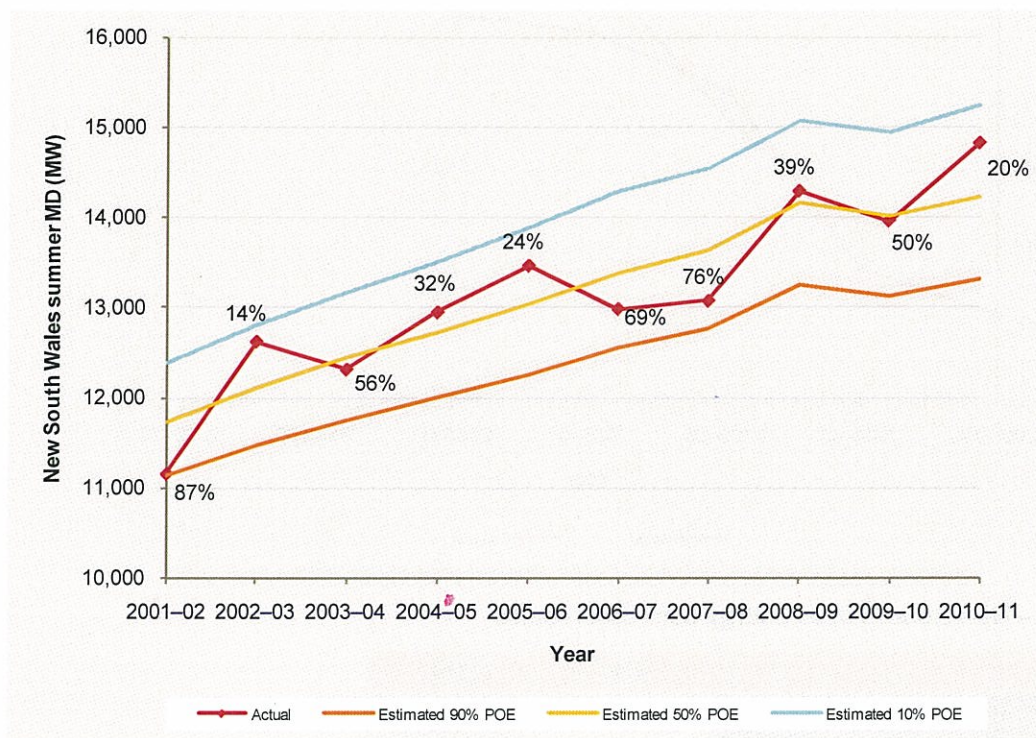
B.4   Victoria

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

B.4.1   Summary

These assessments provide evidence of:

- Projections that have recently maintained a high level of accuracy, and
- Modifications to the forecasting process in response to learning from previous outcomes.

B.4.2   Back assessment

Figure B-14 and Figure B-15 show the Victorian one-year-out and two-year-out summer MD back assessments. Estimated POEs are shown with 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-14 and Figure B-15 illustrate the following:

- Up to the 2006 ESOO, projections are 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 resulted in more accurate projections, relative to the assessed POE levels.
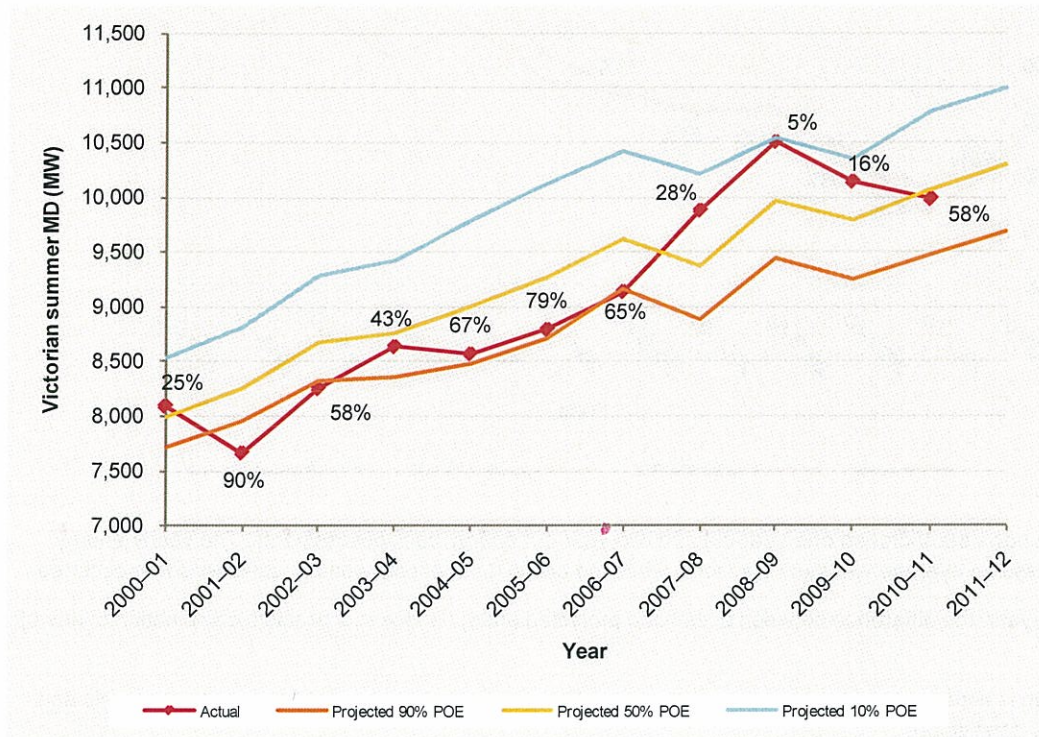
Figure B-14 — Victorian summer MD one-year-out back assessment

Figure B-15 — Victorian summer MD two-year-out back assessment
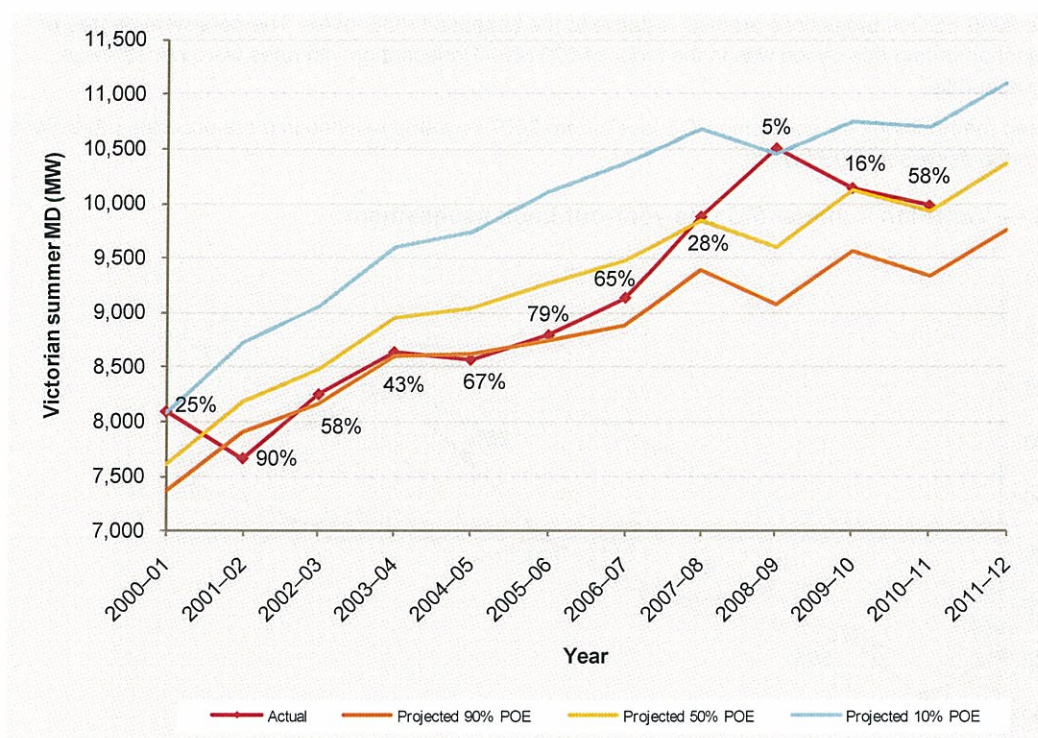
Figure B-16 shows the Victorian one-year-out and two-year-out energy back assessments. The yearly energy projections assume average weather conditions, while the actual data reflects weather conditions that occurred.

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-16 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 initially corrected for this, and then anticipated a rebound in energy consumption that has still not occurred.

- The projections have otherwise tracked actual energy relatively closely.

Figure B-16 — Victorian energy one- and two-year-out back assessment
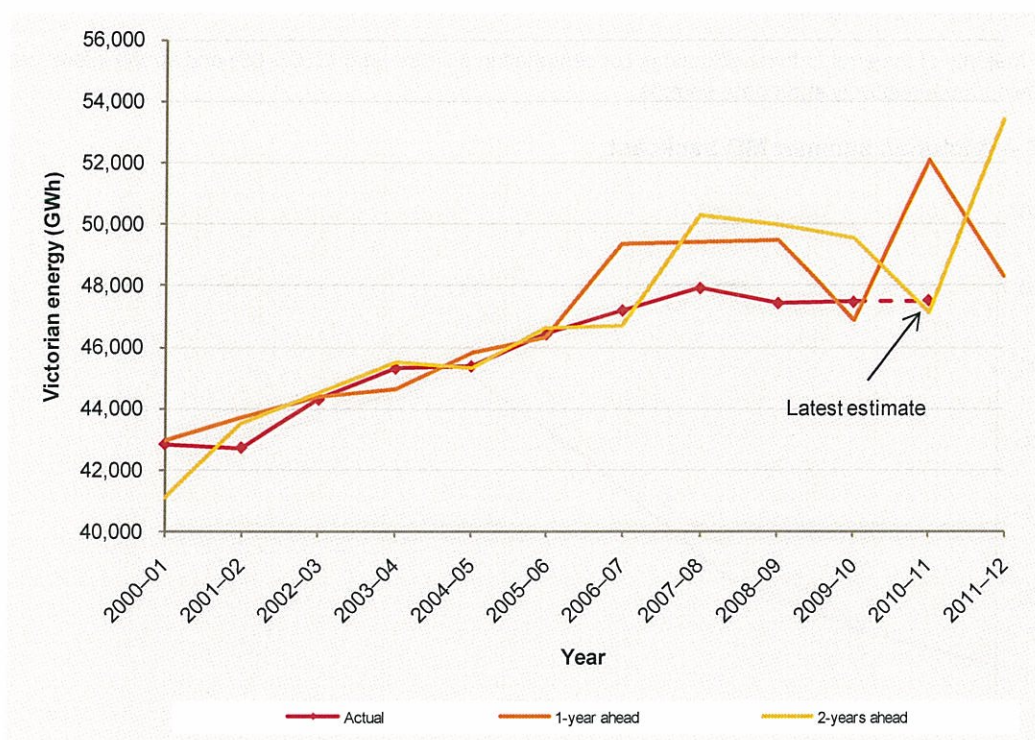
B.4.3   Backcast

Figure B-17 shows the six-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 levels pertaining to the five forecast years 2005–06 to 2009–10.

- The re-estimated 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 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 occurred.

This procedure ensures that differences between actual and simulated values shown in Figure B-17 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-4, with comparable statistics for the 2009 backcasting exercise.

Figure B-17 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 %RMSE of 2.52% (equivalent to being able to assign a dependable tolerance of approximately plus or minus 170 MW to any forecast derived using this methodology, if the actual input data was known).

Table B-4 shows two further aspects of the forecast. Firstly, the bias proportion is high, implying systematic deviation of the forecast from the actual MD. Secondly, the variance proportion is relatively low, implying that rapid

changes in the actual MDs are only replicated slowly by the projections. The bias result shows a larger bias but a smaller variance than the 2010 results.

However, the majority of the error in this backcast is concentrated in a single year (2008–09) and strong inferences cannot be drawn from a relatively short data sample.

Figure B-17 — Victorian summer MD backcast
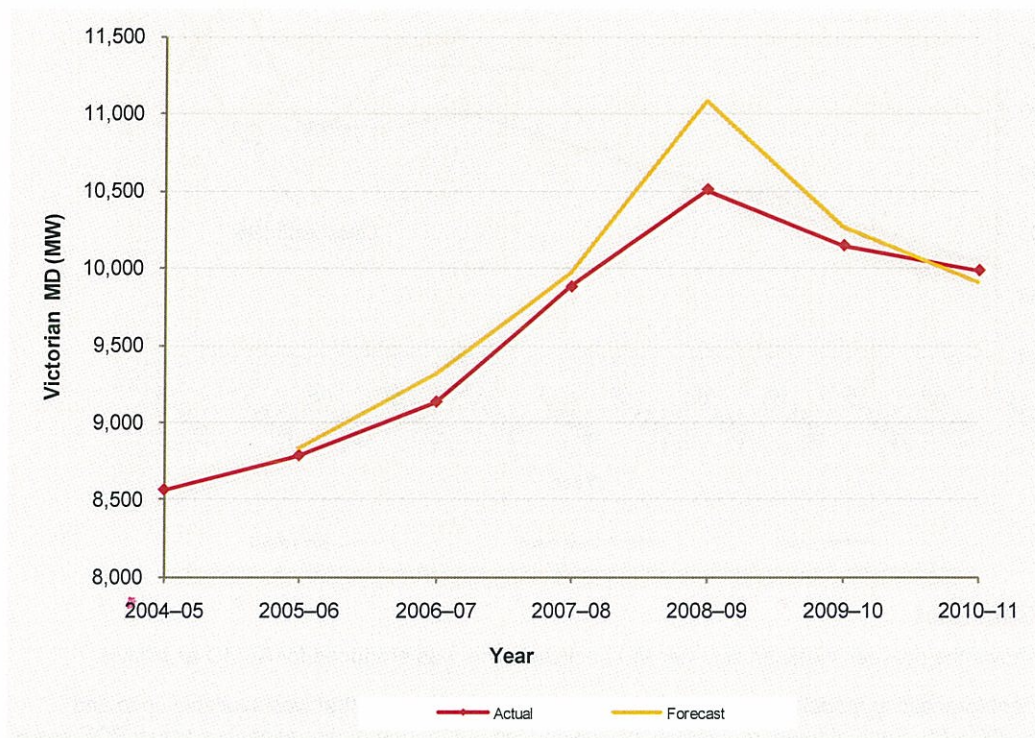
Table B-4 — Victorian summer MD backcast results

| Measure	2010	2011
Percentage root mean square error (%RMSE)	1.36	2.52
Theil inequality coefficient (U)	0.007	0.013
Bias proportion (UB)	0.170	0.380
Variance proportion (UV)	0.668	0.210
Covariance proportion (UC)	0.162	0.410

B.4.4   Probability of exceedence estimation

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

- Mostly contained within the 90% 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 10-year period, providing a high degree of confidence in the current estimation of demands at standardised POEs.

Figure B-18 — Victorian summer MD estimated at standardised POEs
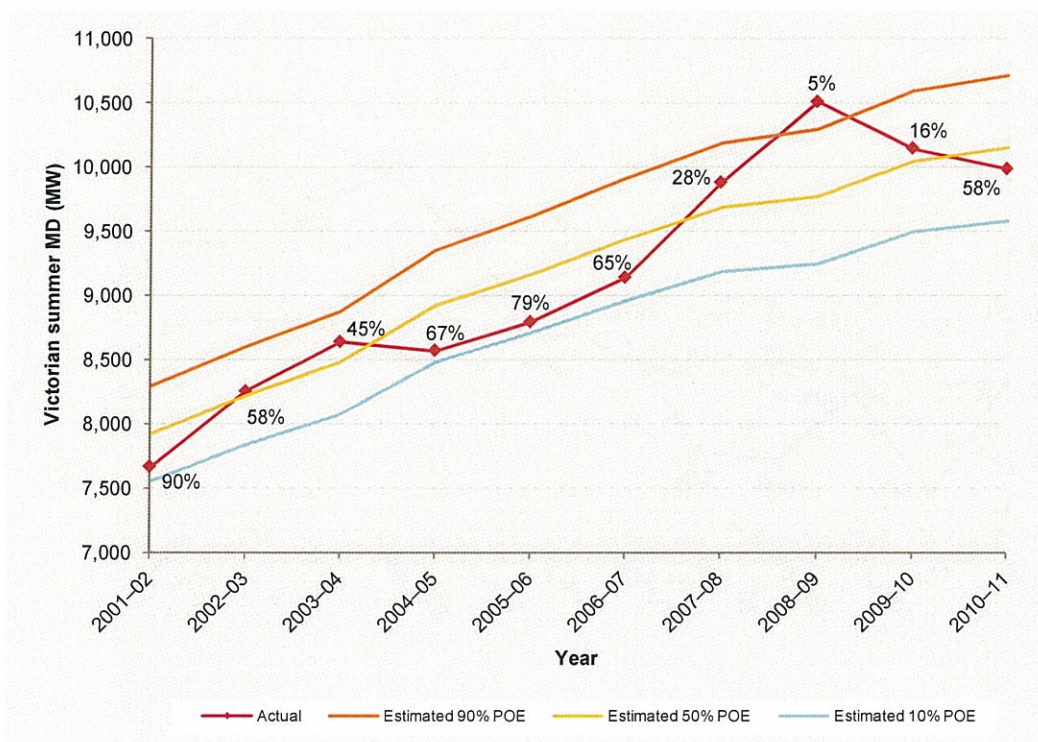
B.5   South Australia

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

B.5.1   Back assessment

Figure B-19 and Figure B-20 show the South Australian one-year-out and two-year-out summer MD back assessments. Estimated POEs are shown with 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:

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

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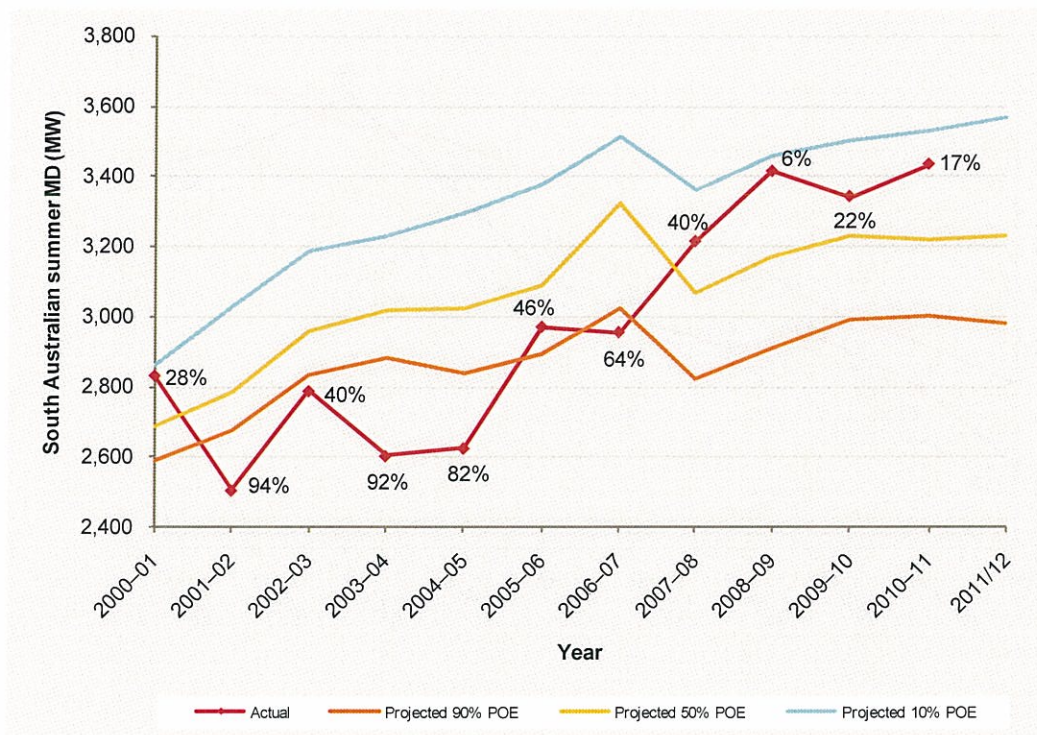

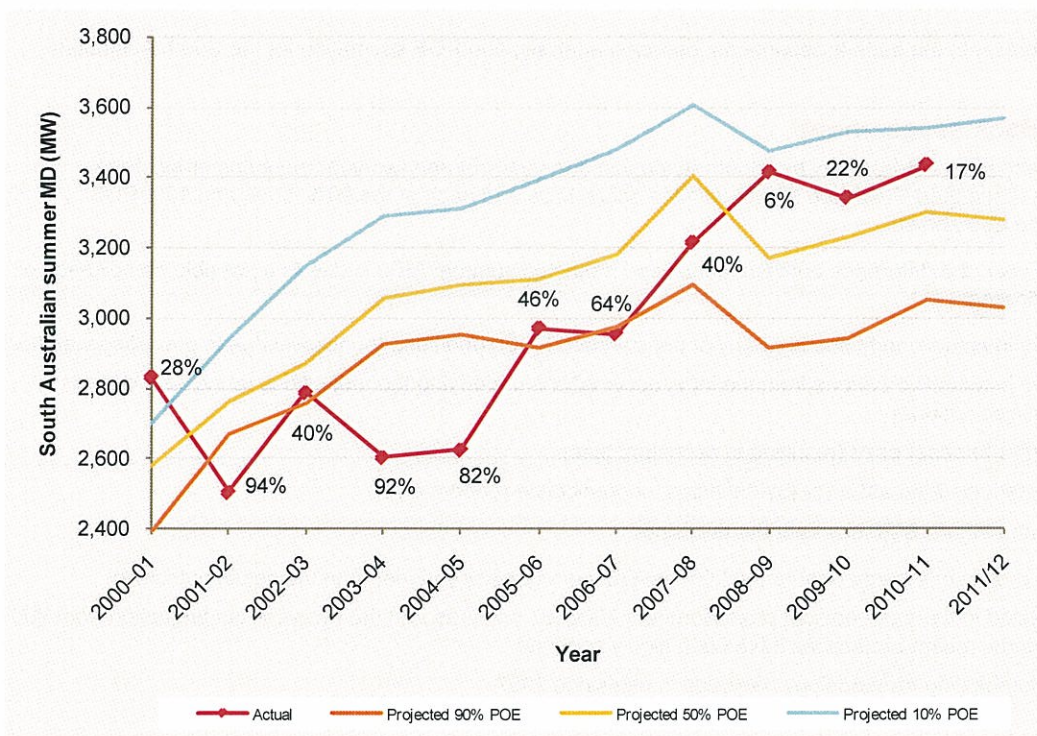**Figure B-20 — South Australian summer MD two-year-out back assessment**

Figure B-21 shows the South Australian one-year-out and two-year-out back assessments. The yearly energy projections assume average weather conditions, while the actual data reflect weather conditions that occurred. South Australian energy projections have tracked actual energy consumption closely, with the exception of the timing of the large increase between 2004–05 and 2006–07.

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 — South Australian energy one- and two-year-out back assessment
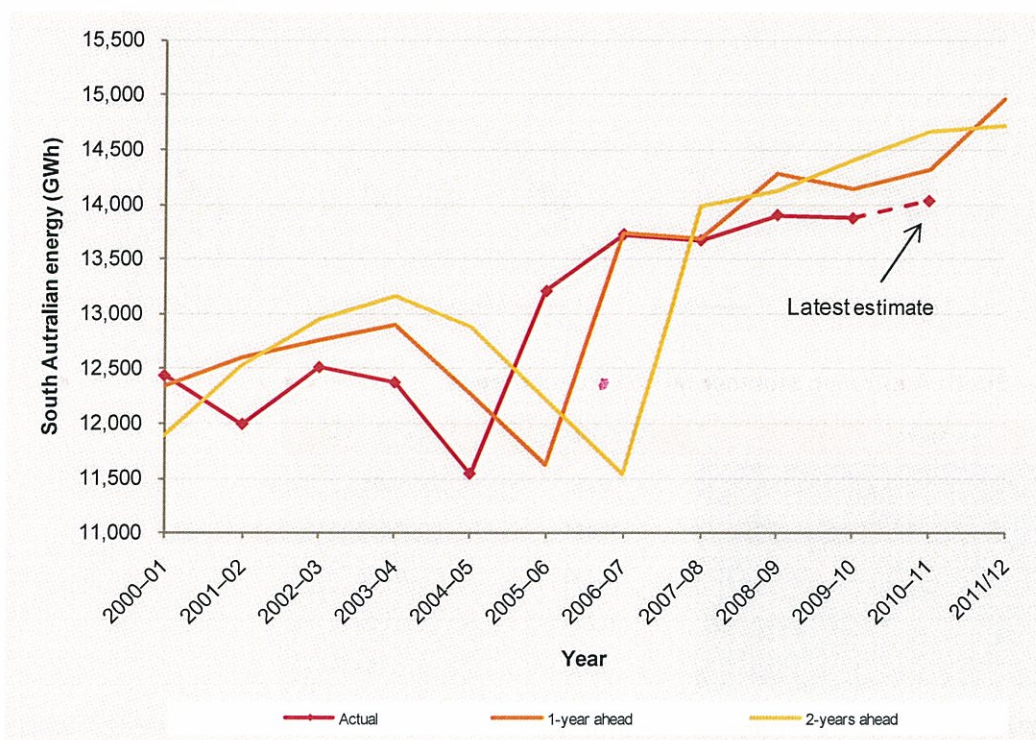
B.5.2   Backcast

Figure B-22 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 recent summers.

- A single maximum was selected from a series of half-hourly simulated values for each summer.

- The original simulation's errors were then used to re-specify the model before reproducing adjusted simulated MDs.

Summary statistics associated with the data in Figure B-22 are shown in Table B-5 which shows a %RMSE of 3.54% for 2011 (an improvement on the previous year).
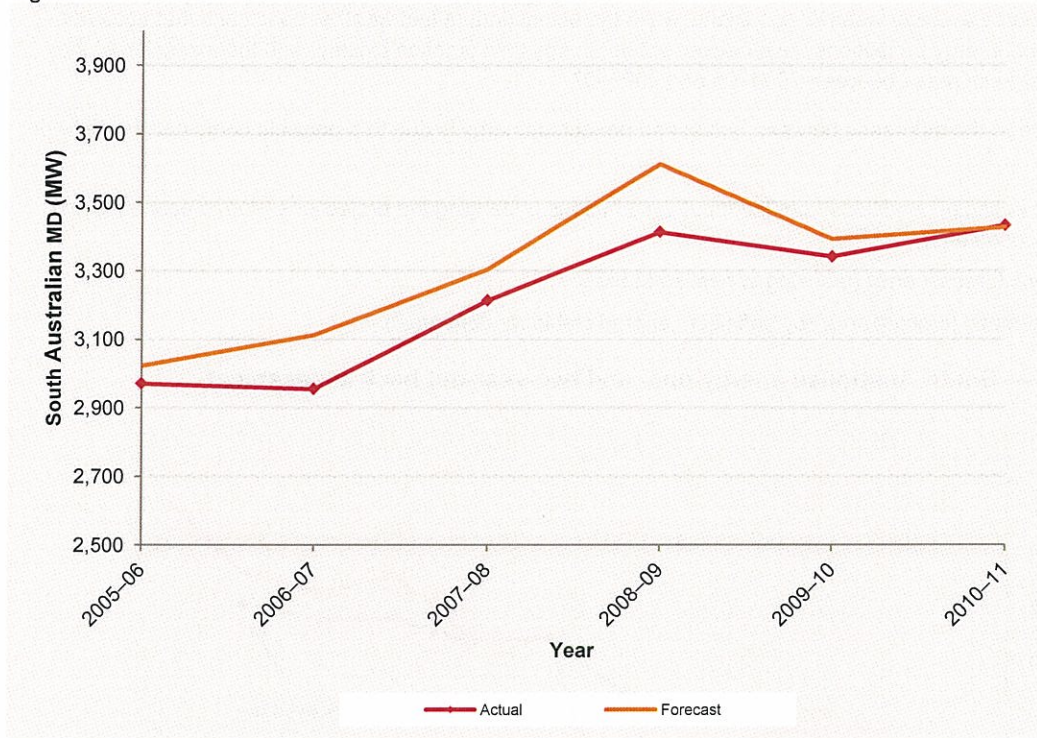
Figure B-22 — South Australian summer MD backcast



Table B-5 — South Australian summer MD backcast results

Measure	2010 Result	2011 Result
Percentage root mean square error (%RMSE)	6.89	3.54
Theil inequality coefficient (U)	0.034	0.017
Bias proportion (UB)	0.733	0.635
Variance proportion (UV)	0.267	0.000
Covariance proportion (UC)	0.000	0.364

B.5.3 Probability of exceedence estimation

Figure B-23 shows actual and estimated MD levels at standardised POEs. In relation to the assessed POE levels, the projected MDs well aligned with actual MDs, at least since 2006–07. The data therefore provide a very high degree of confidence in the estimation of demand at standardised POEs using the current projection procedure.

Figure B-23 — South Australian summer MD estimated at standardised POEs

Legend: Actual · Estimated 90% POE · Estimated 50% POE · Estimated 10% POE
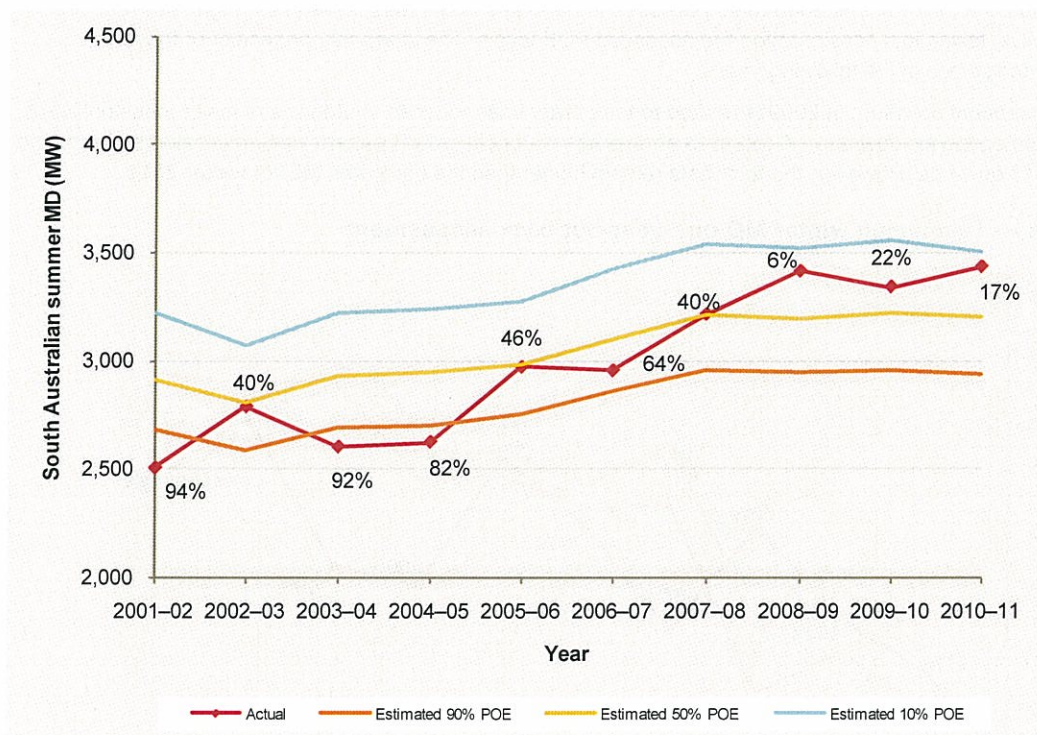
B.6 Tasmania

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

Summary

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.

B.6.1 Back assessment

Figure B-24 and Figure B-25 show the Tasmanian one-year-out and two-year-out summer MD back assessments. Estimated POE MDs are shown with 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:

- Projections for the years 2003 to 2005 are broadly aligned with actual MDs, considering the assessed POE 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 (also 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 was anticipated by Transend from 2010 onwards. However, the forecasts remain higher than the estimated MD for winter 2011.

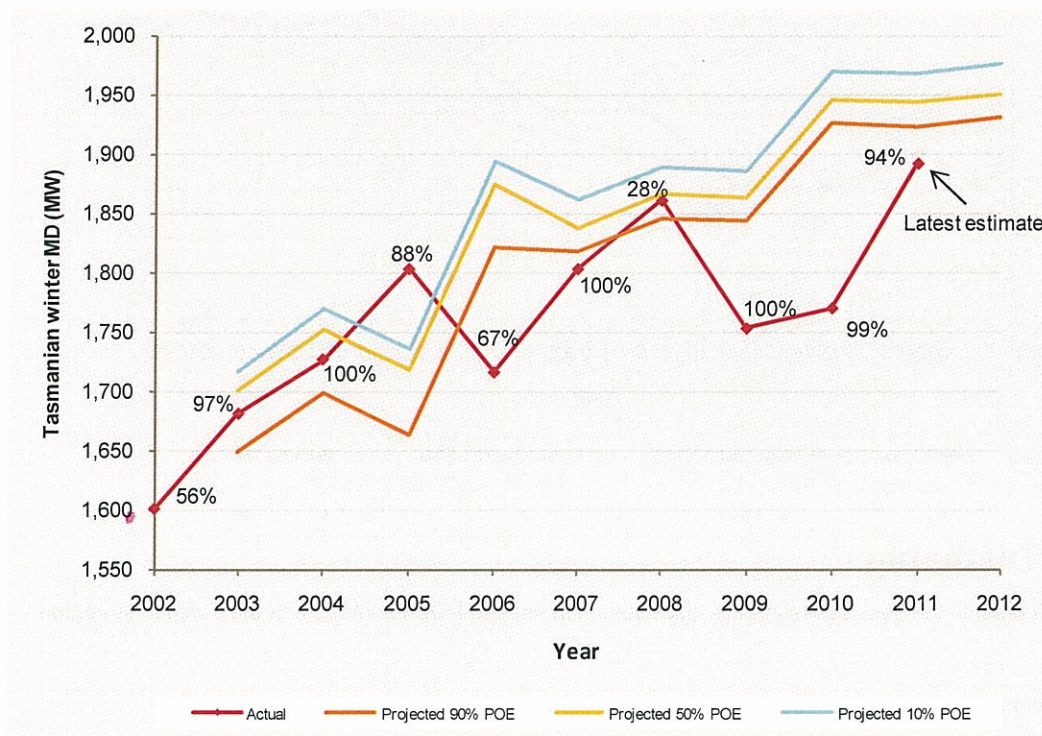**Figure B-24 — Tasmanian winter MD one-year-out back assessment**

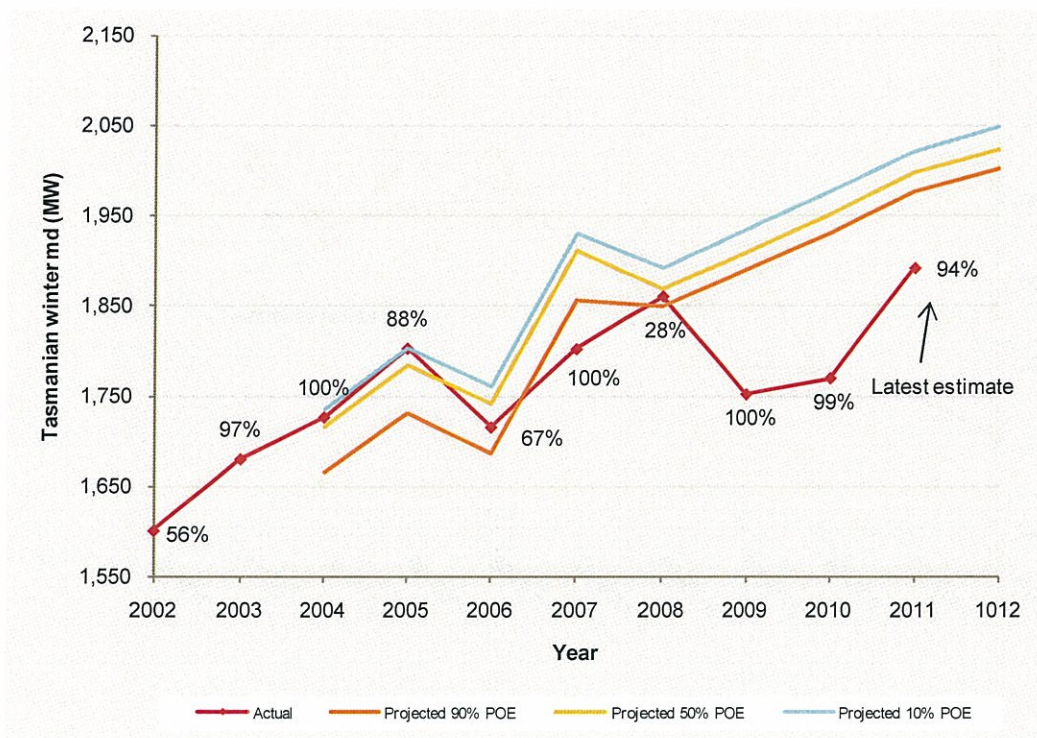**Figure B-25 — Tasmanian winter MD two-year-out back assessment**

Figure B-26 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 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:

- The energy projections have broadly tracked the growth of actual energy since 2003–04.
- 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-26 — Tasmanian energy one- and two-year-out back assessment
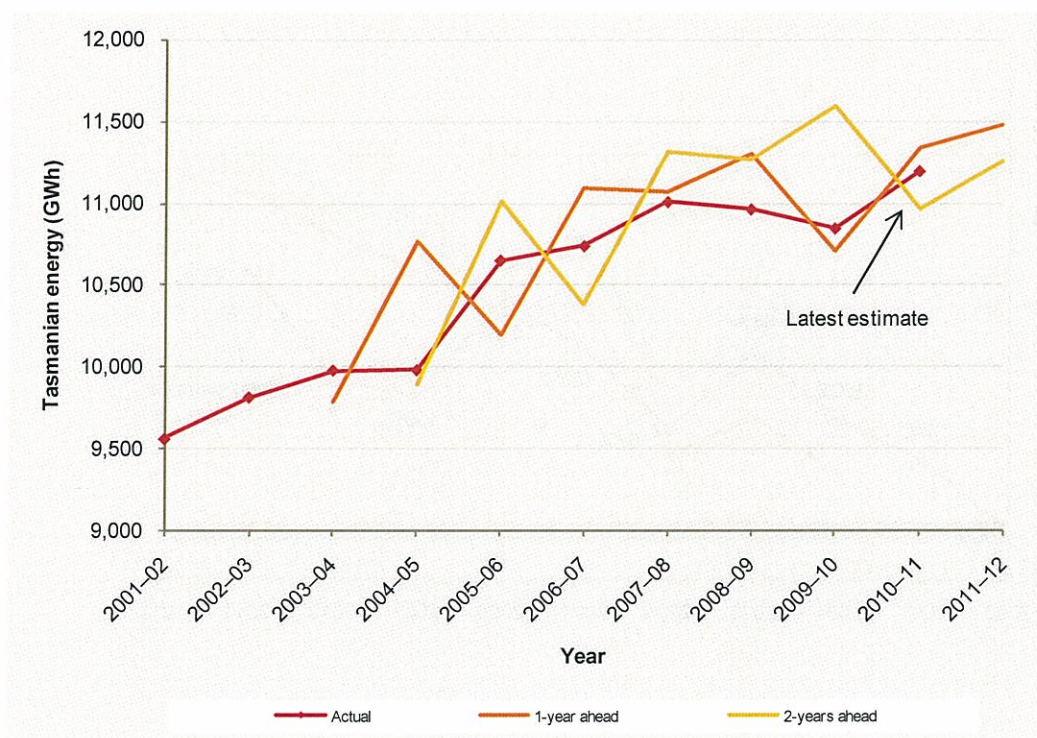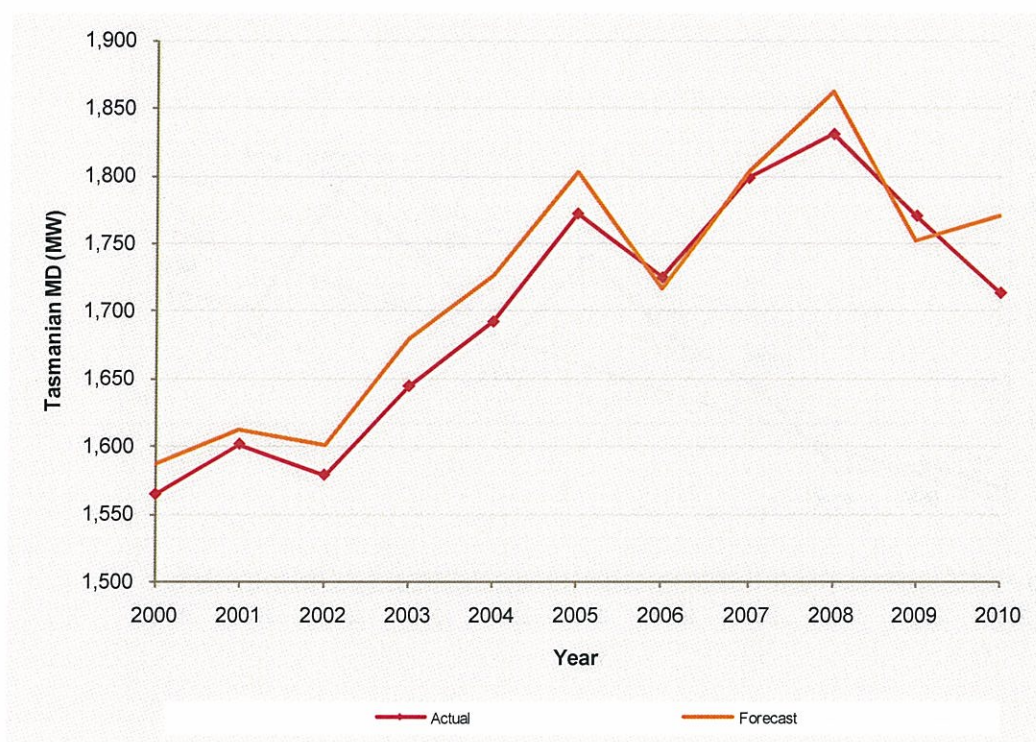

B.6.2   Backcast

Figure B-27 and Table B-6 show the results of the 10-year Tasmanian winter MD backcast. This was provided by Transend 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 2010.
- This model was then used to simulate winter MDs for the last 10 years at the actual temperatures and economic conditions at the time.

As a result, the backcast shown in Figure B-27and the last column of Table B-6 represent an in-sample prediction, rather than the more rigorous out-of-sample prediction. Statistics shown in Figure B-27 and Table B-6 show 2011 results that improved since 2010, and projected MD growth close to actual MD growth.

Figure B-27 — Tasmanian winter MD backcast

Table B-6 — Tasmanian winter MD backcast results

Measure	2010	2011
Percentage root mean square error (%RMSE)	2.19	1.74
Theil inequality coefficient (U)	0.011	0.009
Bias proportion (UB)	0.336	0.285
Variance proportion (UV)	0.000	0.033
Covariance proportion (UC)	0.663	0.683

B.6.3 Probability of exceedence estimation

Figure B-28 shows actual MDs and estimated demand levels at standardised POEs. The actual MDs are mostly contained within the 90% 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%, 50%, and 10% POE levels are derived as a straight line trend, based on average historical MD growth.

- The assessed actual POE levels derive 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.

Figure B-28 — Tasmanian winter MD estimated at standardised POEs