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6 November 2009

Mr Ian Woodward
Chairman, Reliability Panel
Australian Energy Markets Commission
PO Box A2449
SYDNEY SOUTH NSW 1235
By email: submissions@aemc.gov.au

Dear Ian

Report to the Reliability Panel on Demand Forecasts

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

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

Accuracy of the demand forecasts

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.

For the 2009 ESOO these processes were followed in a more consistent manner for each region. The quantitative analysis was also extended to include:

- assessments of the energy forecasts (where possible) as well as summer MD; and
- Theil's inequality coefficient and its breakdown into bias, variance and covariance proportions, as well as percentage root mean square error.

All the current backcasting analyses are based on out-of sample forecasts.

The other important aspect of forecast accuracy relates to the probability distribution forecast, for example, how accurately the level of the 10% POE MD is determined. To this end we have shown the historical POE levels estimated by each jurisdiction graphically.

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Improvements to the forecasting process

The 2010 ESOO will continue to pursue consistency in approach between jurisdictions. In addition, the LFRG is pursuing options for the quantitative assessment of forecast probability distributions.

There is additional information on the 2009 demand forecasts in Chapter 3 of the 2009 ESOO and the details of each JPBs forecasting process is set out in their respective Annual Planning Reports. For any other specific enquiries about the accuracy of the demand forecasts or proposed improvements, please call Richard Hickling on 02 9239 9117 or email Richard.Hickling@aemo.com.au.

Yours sincerely

John Howarth
Executive General Manager Transmission Services

cc:

Attachments:

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Appendix C Assessment of Energy and Demand Projections

C.1 VALIDATION OF ENERGY AND MAXIMUM DEMAND PROJECTIONS

2009 ESOO methods for validating energy and maximum demand projections

The Load Forecasting Reference Group (LFRG), which was convened by the National Electricity Market Management Company (NEMMCO) [1] and includes representatives from the jurisdictional planning bodies (JPBs) [2], is committed to continuous improvement of the demand forecasting process. As part of this continuous improvement process, this appendix reviews the quality of the energy and maximum demand (MD) projections provided by the JPBs for the 2009 Electricity Statement of Opportunities (ESOO) (see also Section C.1.4 for information about other continuous improvement initiatives).

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

- back assessment (to compare previous projections with actual outcomes – see Section C.1.1 for more information);
- backcasting (to validate the methodology used to develop the current projections – see Section C.1.2 for more information); and
- probability of exceedence (POE) estimates (to test the procedure used to allocate probability of occurrence values to actual MDs – see Section C.1.3 for more information).

As the production of the regional energy and MD projections follows different methodologies, there is some minor variation in the quality reviews for these projections. These reviews (see Section C.2 to Section C.6) include:

- summer MD (winter MD for Tasmania) and energy back assessments;
- annual energy backcasts (for New South Wales, South Australia and Tasmania only);
- summer MD (winter MD for Tasmania) backcasts; and
- summer MD (winter MD for Tasmania) POE estimates.

C.1.1 Back assessment

Back assessment involves comparing projections published in previous ESOOs with actual (historical) values. The 2009 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 season with actual values. For example, a 2007 ESOO regional summer MD projection for 2007/08 is compared with the actual outcome for 2007/08 [3].

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[1] Now the Australian Energy Market Operator (AEMO).

[2] A JPB is an entity nominated (under Clause 5.6.3(b)(2) of the National Electricity Rules (Rules)) by the relevant Minister of the relevant participating jurisdiction as having transmission system planning responsibility in that participating jurisdiction. The current JPBs include Powerlink Queensland, TransGrid (New South Wales), AEMO (formerly VENCorp and ESIPC) (Victoria and South Australia, respectively), and Transend Networks (Tasmania).

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

- **Two-year-out** back assessments compare regional energy or MD projections made for the season 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 dates featured with each back assessment chart indicate the season for which the:

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

One and two-year back assessment time frames are used because the Australian Energy Market Operator (AEMO) bases decisions to investigate potential NEM intervention on the Medium-term Projected Assessment of System Adequacy (MT PASA) operational tool, which provides a two year outlook.

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

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

C.1.2 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 independent variable values. All 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 3.

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

The accuracy of the model is established by comparing the simulated and actual MDs, 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.

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 is calculated as follows [4]:

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

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

C.1.3 Probability of exceedence estimation

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

The JPBs develop MD projections at standardised percentiles of an estimated MD 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.

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

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 the actual MD for any historical season.

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 the Medium-term Assessment of System Adequacy (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 (including 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 (including temperature) implicitly assume low significance, relative to the underlying growth rate.

Section C.2 to C.6 undertakes a qualitative comparison of historical estimated 90%, 50% and 10% POE MD levels, which are shown graphically against actual MDs and their estimated actual POEs.

C.1.4 Other continuous improvement initiatives

Other initiatives that the LFRG is considering for further development of benchmarking and review of forecasting techniques include:

- backcasting (out-of-sample) single point projections at resolutions of 30 minutes (as provided by ESIPC, see Section C.5.2) to evaluate the accuracy of the underlying forecast model;
- additional forecasting measures of backcast accuracy, including mean absolute error (MAE) and, when comparing performance across regions, mean absolute percentage error (MAPE) measures;
- a review of terminology, including drawing distinctions between;
  - ex ante simulations (the original simulations that use only the information at the time that the original projection was made);
  - ex post simulations (simulations made using the original model using actual data for the projected period);
  - in-sample simulations (simulations made by examining the fit of simulated data within the estimation sample for the model); and
  - out-of-sample simulations (simulations made by using the model to project forward outside the estimation sample); and
- measurement of the weekly MD excess percentage (EP) and mean absolute excess percentage (MAEP) to evaluate the modelled probability density functions which underlie the 90%, 50% and 10% POE forecasts; and
- continuing to compare historic annual MDs graphically with modelled 90%, 50% and 10% POE levels and using the binomial distribution to assess whether the observed pattern of outcomes has a high probability of occurring or not.

C.2 QUEENSLAND

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

C.2.1 Back assessment

Figure C.1, Figure C.2 and Figure C.3 show the Queensland one-year-out and two-year-out summer MD and energy back assessments.

Variation from year to year between the actual and projected values is due to a combination of:

- variation in actual conditions (including temperature, intra-regional diversity, economic activity and population growth) away from the assumptions underlying the projections; and
- any remaining systematic and non-systematic forecast errors.

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

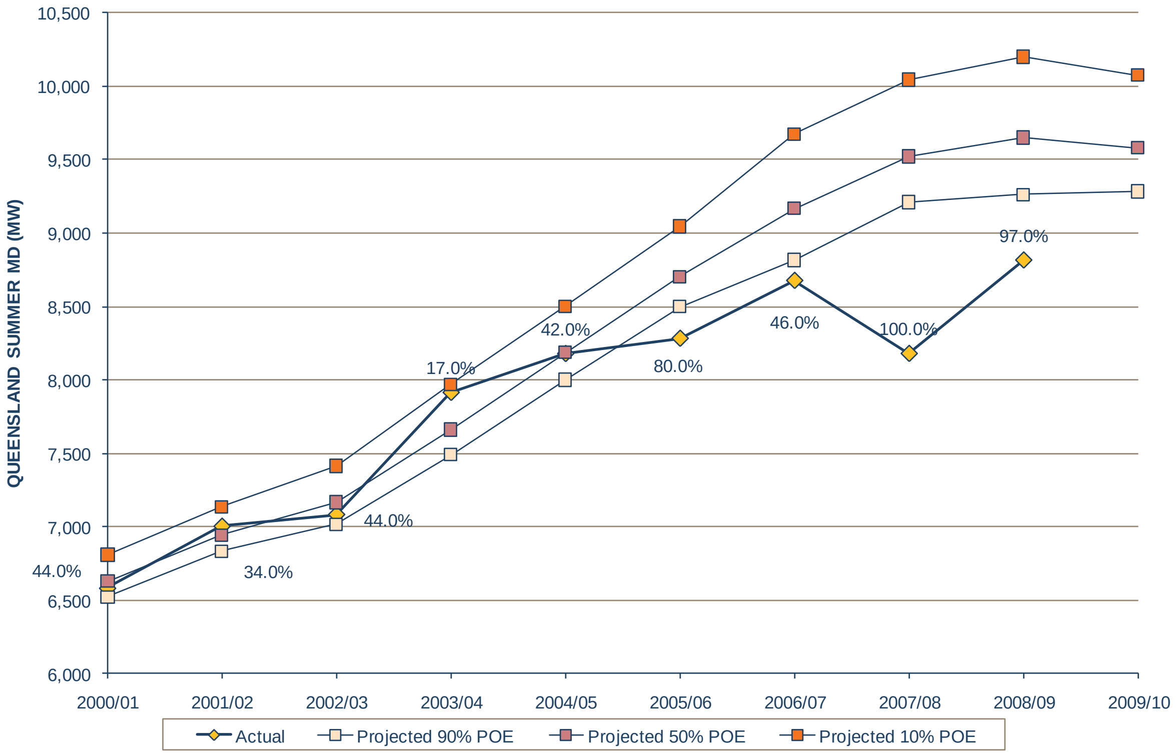


Figure C.2 Queensland Summer MD Two-Year-Out Back Assessment

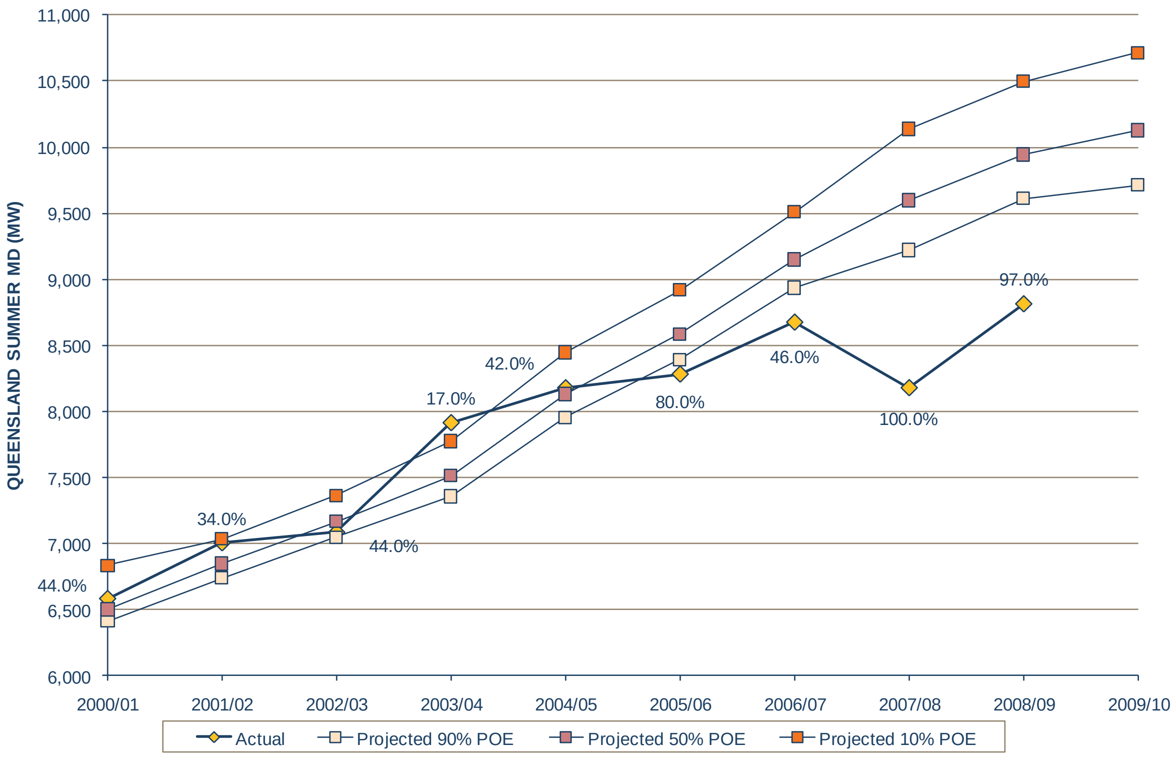


Figure C.3 Queensland Energy One- and Two-Year-Out Back Assessment

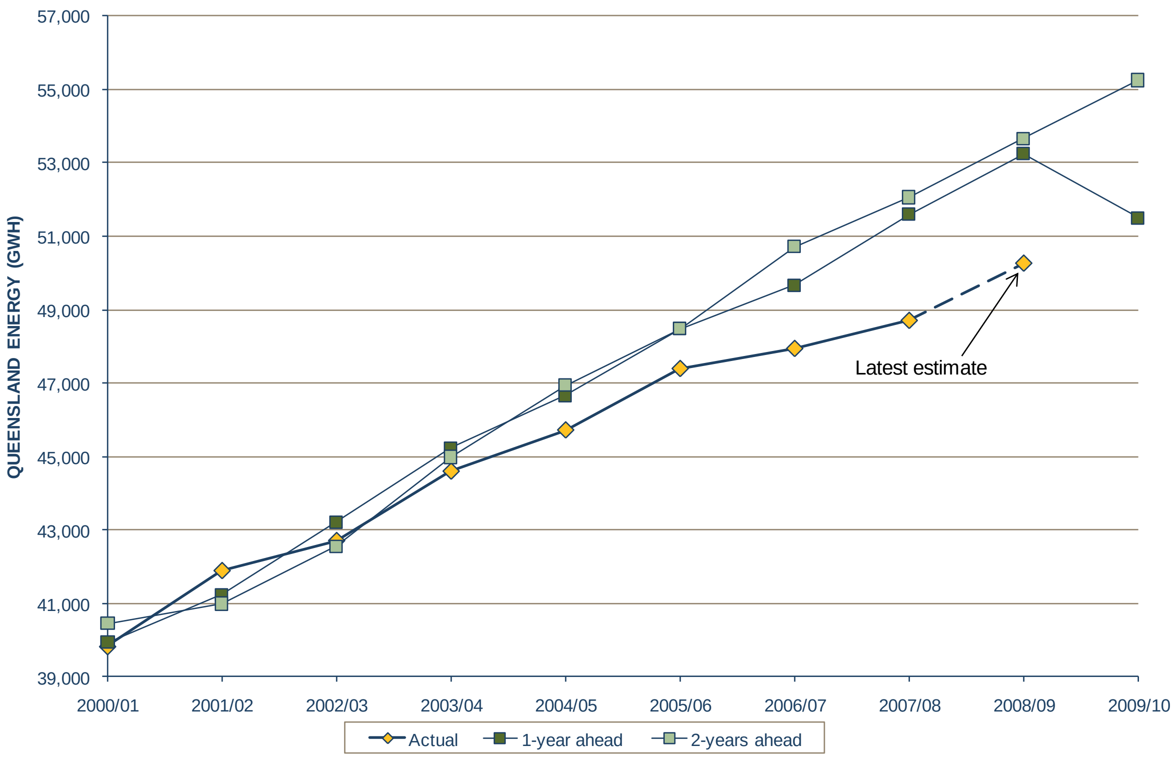


Figure C.1, Figure C.2 and Figure C.3 suggest the following:

- Values previously projected for 2007/08 and 2008/09 missed an apparent slowing in actual MD and energy growth.
- The latest forecasts are more in line with the apparent actual trends.

It should be noted that intra-regional diversity (major areas within the region achieving their local MDs at different times) is highly variable in Queensland. The actual diversity is highly significant in determining the actual MD for Queensland as a whole. However, as recommended by the 2005 KEMA review[1], Powerlink Queensland's projections use a 10-year rolling average of historical diversity factors to develop the Queensland 50% POE MD projection. The estimated variation of the 90% POE and 10% POE values away from the 50% POE projection is based solely on temperature variability.

Powerlink Queensland advises the following:

- Use of a single Queensland weighted average temperature for assigning the POE level of previous actual demands is problematic and only provides a guide.
- The trend of increasing diversity at summer MD between load centres across the region continued in summer 2008/09.
- While greater diversity between areas has now been built into the latest Powerlink Queensland projections, future projection levels are mostly driven by upcoming major load projects.

C.2.2 Backcast

The Queensland backcast may not be directly comparable with backcasts for other regions because Powerlink Queensland's energy and MD projection methodology relies primarily on the aggregation of connection point forecasts provided by Queensland distribution network service providers (DNSPs). Therefore, the 10-year backcast shown in Figure C.4 was prepared as follows:

- A forecast trend for Queensland MD 'as delivered' was prepared for the historical backcast period, using population and economic growth predictions, assumptions about major industrial loads made prior to the historical backcast period, and constant intra-regional diversity.
- The original forecast trend was adjusted for the differences between actual and predicted population and economic growth and major industrial loads.

Figure C.4 and Table C.1 show the backcast and summary statistics resulting from this procedure. Figure C.4 shows 'delivered from network' values [5]. These are not directly comparable with values shown in Figure C.1 and Figure C.2, which are 'as generated'.

[5] Delivered from network excludes electricity used by generator auxiliaries, generator transformers and transmission network losses.

Figure C.4 Queensland Summer MD Backcast

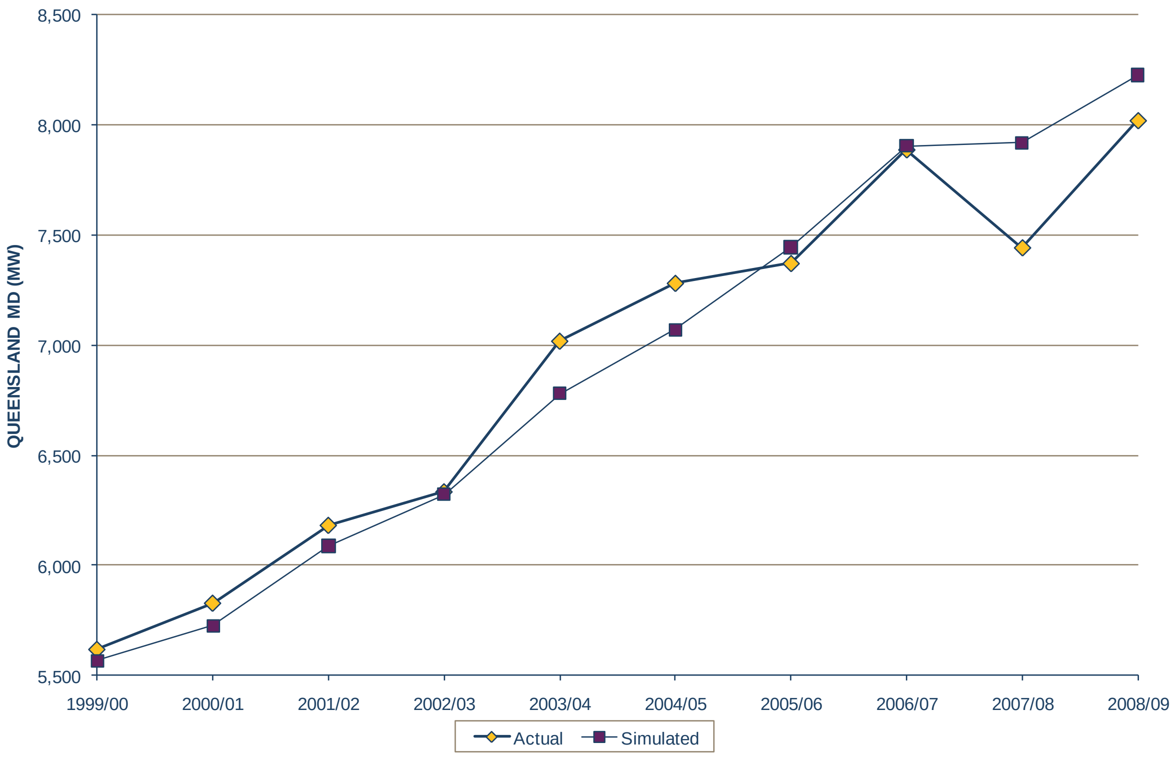


Table C.1 Queensland Summer MD Backcast Summary Statistics

Measure	Result
Root mean squared percentage error (%RMSE)	2.75
Thiel's inequality coefficient (U)	0.014
Bias proportion (U^B)	0.001
Variance proportion (U^V)	0.267
Covariance proportion (U^C)	0.733

Figure C.4 shows simulated values that are close to actual values over an extended period. Table C.1 shows that the %RSME is 2.75% and the U-value is 0.014. These values are relatively low, reflecting the precision of the forecast. Meanwhile the bias proportion, at 0.001, is very low, reflecting a near-perfect spread of the simulated values both above and below the actual values.

Powerlink Queensland advises the following:

- A four-area temperature dependent model covers the region's diverse weather patterns. To provide a meaningful correlation between regional demand and weather conditions, Powerlink Queensland analysed the diversity between these areas.
- Substantial large industrial load variation also occurs during high summer demand, making it necessary to correct historical Queensland peak demands for both weather pattern diversity and industrial load. This backcast analysis provides a single point reference for measuring the performance of this methodology. Over recent summers, however, there has been a substantial trend to increased diversity or non-coincidence of area peak demands. This reduces the effectiveness of this single point temperature analysis.
- The latest RSME value shows a reduction in error compared to the 2008 backcast due mainly to the trend of increasing diversity being built into the model.

C.2.3 Probability of exceedence estimation

Figure C.5 shows actual Queensland MDs and estimated POE levels. This figure shows that in the last 10 summers, the actual MDs have been relatively evenly spread around the 50% POE level. The last two summers occurred at or close to the 100% POE level.

The actual MD for summer 2007/08 was unprecedented, in terms of extremely:

- mild weather; and
- high intra-regional diversity at the time of the Queensland regional MD.

Figure C.5 Queensland Summer MD Estimated at Standardised POEs

See the Queensland annual planning report (APR) for more information [2].

C.3 NEW SOUTH WALES

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

C.3.1 Back assessment

Figure C.6, Figure C.7 and Figure C.8 show the New South Wales one-year-out and two-year-out summer MD and energy back assessments.

Variation from year to year between the actual and projected values is due to a combination of:

- variation in actual conditions (including temperature, economic activity, energy prices and population growth) away from the assumptions underlying the projections; and
- any remaining systematic and non-systematic forecast errors.

Figure C.6 New South Wales Summer MD One-Year-Out Back Assessment

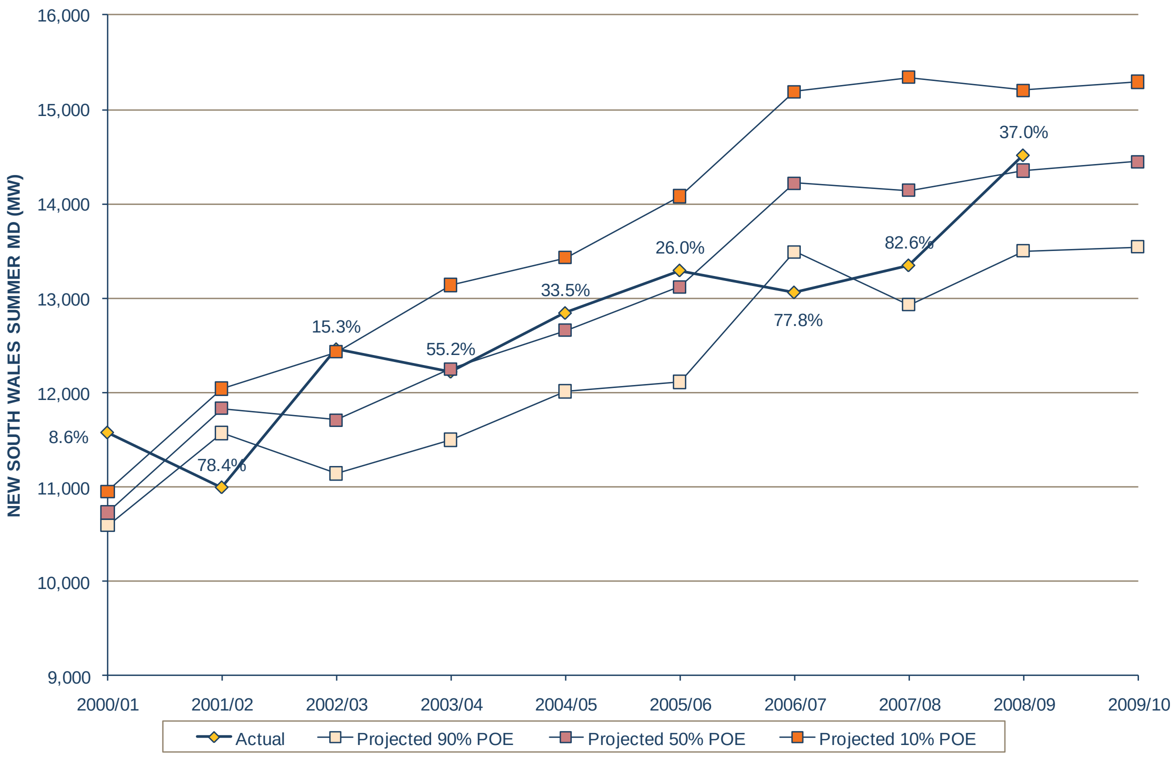


Figure C.7 New South Wales Summer MD Two-Year-Out Back Assessment

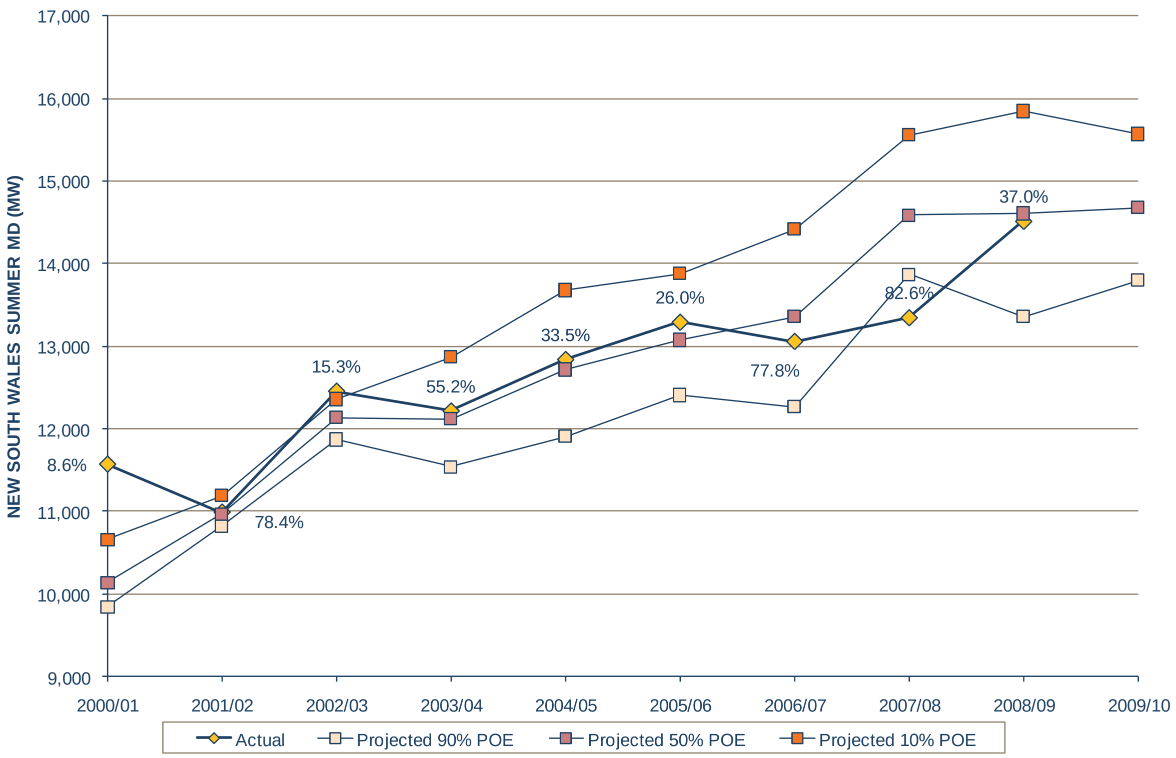


Figure C.8 New South Wales Energy One- and Two-Year-Out Back Assessment

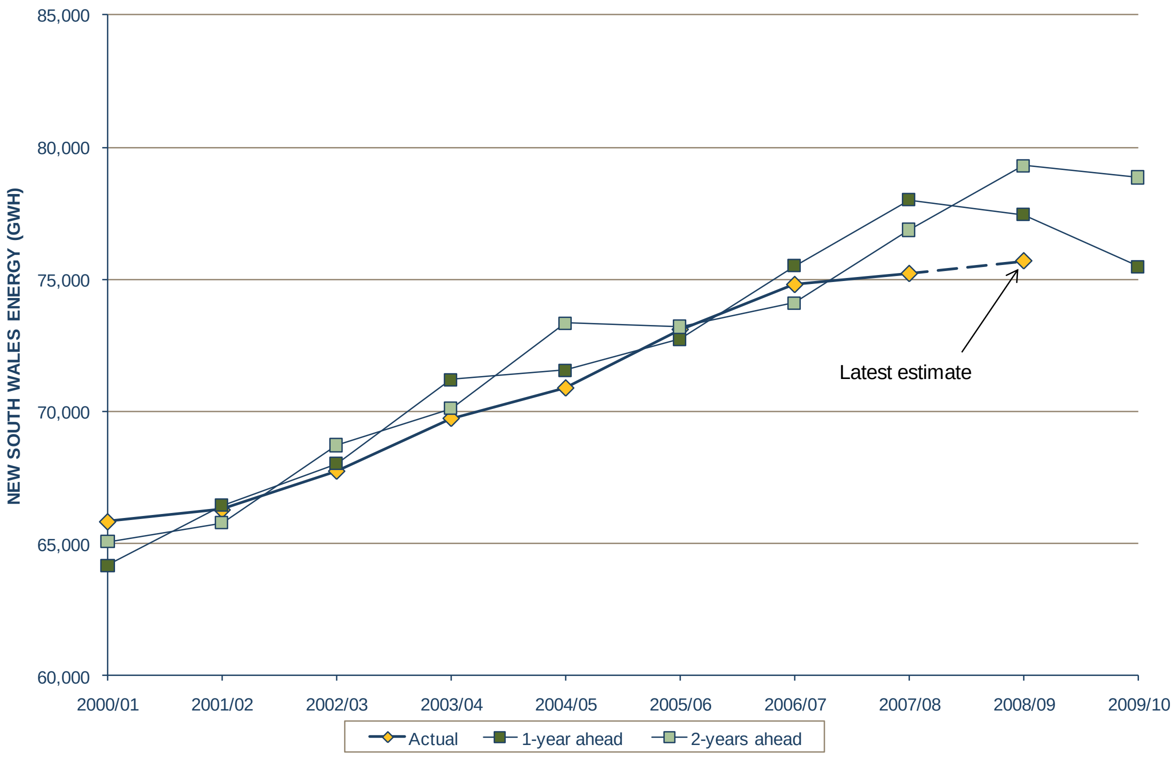


Figure C.6 and Figure C.7 show the following:

- The projections made in 2004/05 (one-year-out for 2006/07 and two-year-out for 2007/08) were high relative to the actual MDs.
- Projections for most of the period since 2002/03, taking into account the assessed POE levels, are otherwise close to the actual values.

Figure C.8 shows that:

- projections made in 2006/07 (one-year-out for 2007/08 and two-year-out for 2008/09) missed the turn-down in the actual growth rate; but
- subsequent forecasts have corrected for this; and
- the projections have otherwise generally tracked actual energy relatively closely.

TransGrid advises the following:

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

C.3.2 Backcast

Figure C.9 shows the 6-year New South Wales summer MD backcast [6]. This backcast was produced as follows:

- The current simulation model was estimated using data up to and including 2002/03, for six different POE levels representing each of the actual POE levels for 2003/04 to 2008/09.
- The models were then used to develop six sets of projections for the period 2003/04 to 2008/09.
- One data point was taken from each set of projections to correspond with the actual POE for that data point.

This procedure ensures that the backcast for each season takes into account the actual conditions pertaining at that time. Actual economic conditions are also assumed over the backcast period. This ensures that differences between actual and simulated values reflect only on the quality of the simulation methodology.

Table C.2 compares the summary statistics associated with the data in Figure C.9.

Figure C.9 New South Wales Summer MD Backcast

Table C.2 New South Wales Summer MD Backcast Summary Statistics

Measure	2008 Result	2009 Result
Root mean squared percentage error (%RMSE)	1.23	0.95
Thiel's inequality coefficient (U)	0.006	0.005
Bias proportion (UB)	0.354	0.670
Variance proportion (UV)	0.180	0.236
Covariance proportion (UC)	0.466	0.095

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

Figure C.9 shows that the backcast MDs are close to the actual MDs, which enables a high degree of confidence in the forecasting methodology. However, there is a persistent tendency to under-forecast summer MD. Table C.2 confirms these observations, with a relatively high bias proportion coexisting with very low levels of forecast error.

Figure C.10 shows the 6-year energy backcast[7]. This backcast was produced as follows:

- The current simulation model was estimated using data up to and including 2001/02.
- This model was then used to develop a projection for the period 2002/03-2007/08.

This procedure takes into account the actual economic and other model input conditions over the backcast period. This ensures that differences between actual and simulated values reflect only on the quality of the simulation methodology.

Table C.3 compares the summary statistics associated with the data in Figure C.10.

Figure C.10 New South Wales Energy Backcast

Table C.3 New South Wales Energy Backcast Summary Statistics

Measure	Result
Root mean squared percentage error (%RMSE)	1.62
Thiel's inequality coefficient (U)	0.008
Bias proportion (UB)	0.812
Variance proportion (UV)	0.086
Covariance proportion (UC)	0.102

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

Figure C.10 shows that the backcast MDs are close to the actual MDs, which enables a high degree of confidence in the forecasting methodology, although there is a persistent tendency to over-forecast energy. Table C.3 confirms these observations, with a relatively high bias proportion coexisting with very low levels of forecast error.

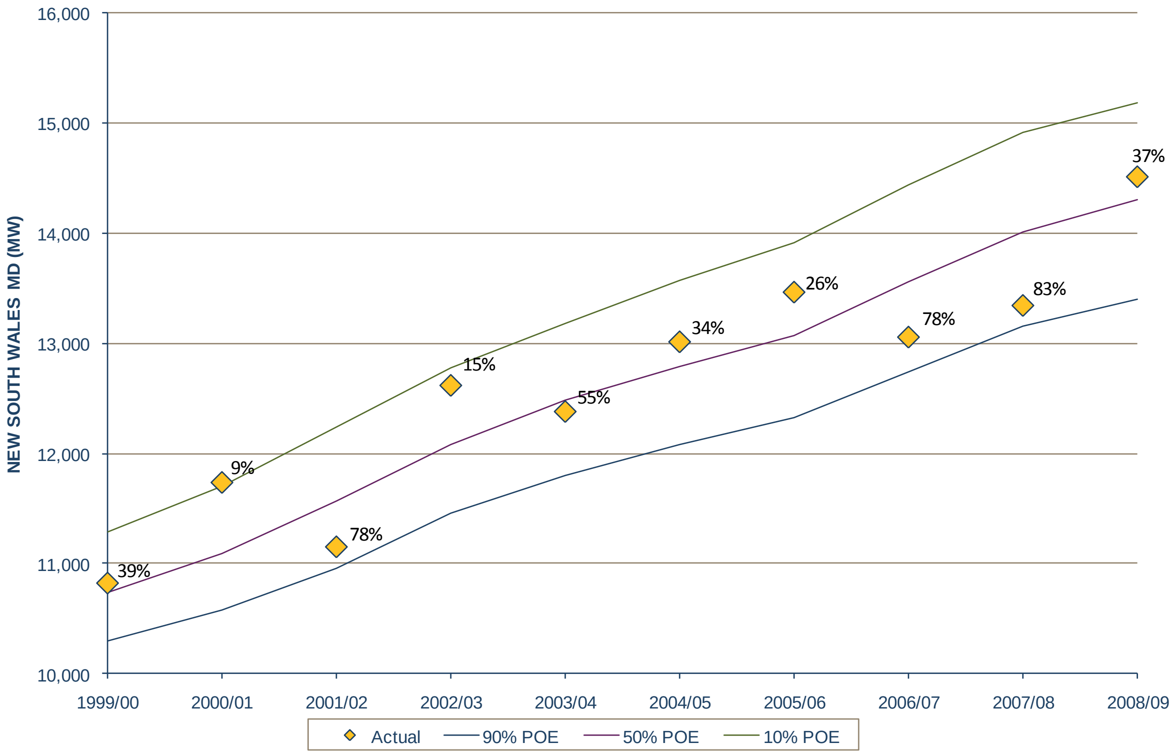
TransGrid advises the following [3;4]:

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

C.3.3 Probability of exceedence estimation

Figure C.11 shows actual New South Wales MDs and estimated POE levels. The actual MDs are mostly contained within the 90% POE and 10% POE estimated lines, and the actual MDs are spread evenly around the 50% POE line. This provides a high degree of confidence in the estimation of POE levels.

Figure C.11 New South Wales Summer MD Estimated at Standardised POEs



C.4 VICTORIA

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

C.4.1 Back assessment

Figure C.12, Figure C.13 and Figure C.14 show the Victorian one-year-out and two-year-out summer MD and energy back assessments.

Variation from year to year between the actual and projected values is due to a combination of:

- variation in actual conditions (including temperature, economic activity, energy prices and population growth) away from the assumptions underlying the projections; and
- any remaining systematic and non-systematic forecast errors.

Figure C.12 Victorian Summer MD One-Year-Out Back Assessment

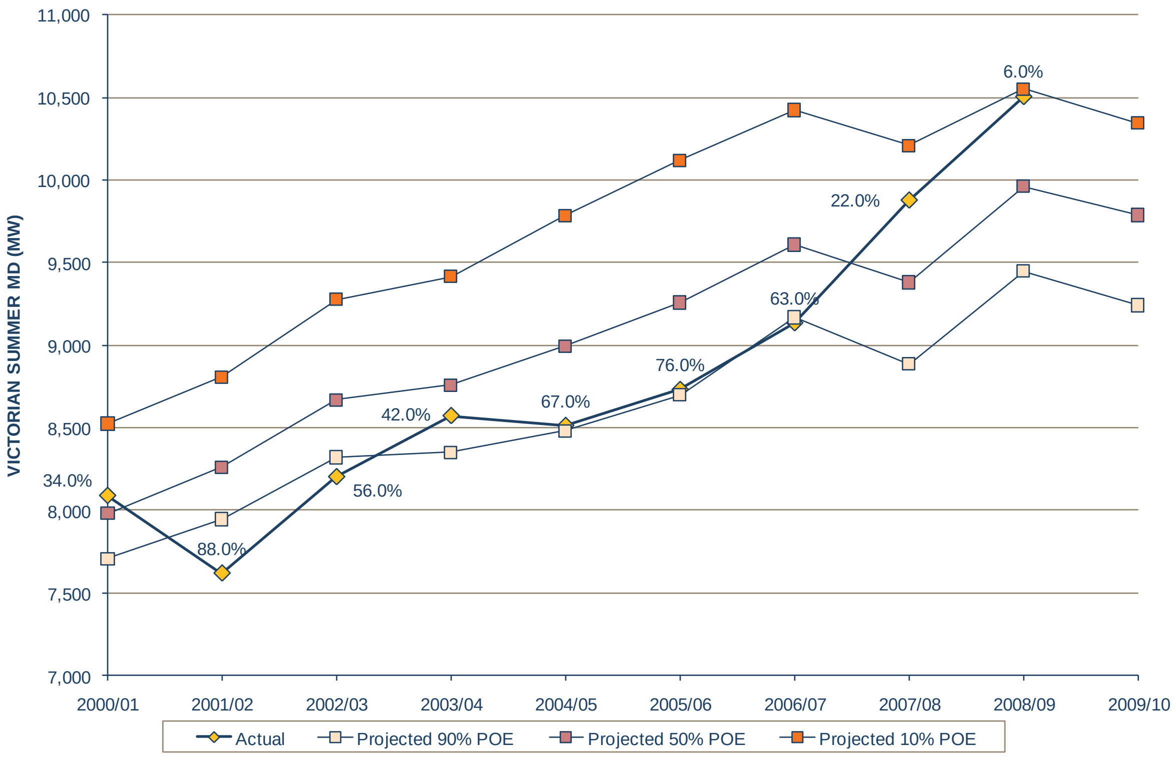


Figure C.13 Victorian Summer MD Two-Year-Out Back Assessment

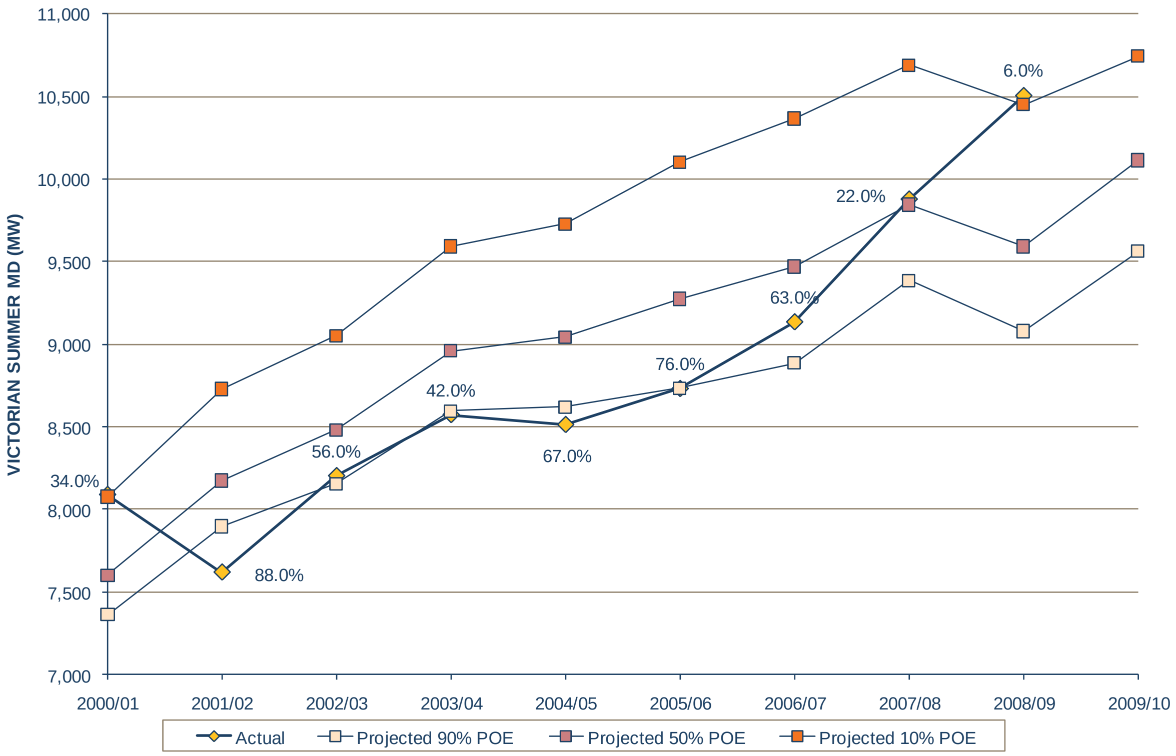


Figure C.14 Victorian Energy One- and Two-Year-Out Back Assessment

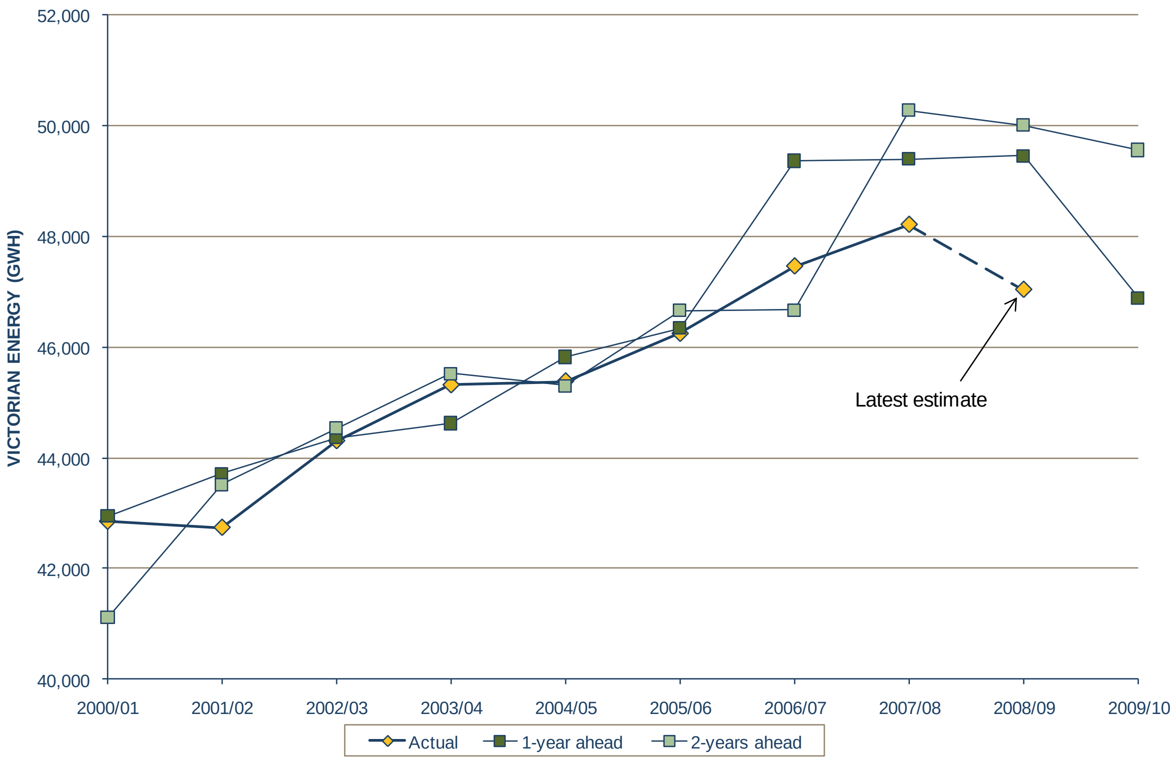


Figure C.12 and Figure C.13 show the following:

- The projections for the summer MD for the years 2001/02 to 2006/07, considering the assessed POE levels, are very high compared to the actual values.
- Projections for more recent summers appear more reasonable compared to the actual values.

Figure C.14 shows the energy one-year-out and two-year-out back assessment for Victoria. This figure shows that:

- projections for 2007/08 were above actual energy; but
- subsequent forecasts appear to have corrected for this; and
- the projections have otherwise generally tracked historical energy relatively closely.

VENCorp [8] advises the following:

- Prior to 2007, VENCorp's summer forecasting methodology displayed a tendency to over-forecast the summer MD. From 2007, VENCorp used a simulation methodology incorporating a wide range of factors that affect demand to determine a probability distribution of summer demand levels.
- From 2007, VENCorp's summer MD forecast has shown a high degree of forecast accuracy.
- VENCorp has published a report on its website that describes the current MD forecasting methodology in detail [5].
- The annual energy projections are highly correlated with economic conditions. The difference between the forecast for the 2008/09 energy consumption and the actual (estimated) 2008/09 energy consumption was due to a sharp downturn in Victorian economic growth.

[8] Now part of AEMO.

See the Victorian APR and Victorian Electricity Forecast Report for more information about VENCorp's forecasting methodology [5;6].

C.4.2 Backcast

Figure C.15 shows the 7-year Victorian summer MD backcast [9]. The model used to simulate the backcast:

- was developed with pre-2002/03 data only; and
- is otherwise identical to the current model used to generate the 2009 ESOO projections.

The backcast simulated by the model uses actual inputs for the period 2002/03-2008/09, so that differences between actual and simulated values reflect only on the quality of the simulation methodology.

Table C.4 compares the summary statistics associated with the data in Figure C.15.

Figure C.15 Victorian Summer MD Backcast

Table C.4 Victorian Summer MD Backcast Summary Statistics

Measure	Result
Root mean squared percentage error (%RMSE)	1.69
Thiel's inequality coefficient (U)	0.009
Bias proportion (UB)	0.583
Variance proportion (UV)	0.389
Covariance proportion (UC)	0.028

Figure C.15 shows that the backcast MDs are close to the actual MDs, which enables a high degree of confidence in the forecasting methodology, although there is a persistent tendency to under-forecast summer

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

MD. Table C.4 confirms these observations, with a relatively high bias proportion coexisting with very low levels of forecast error.

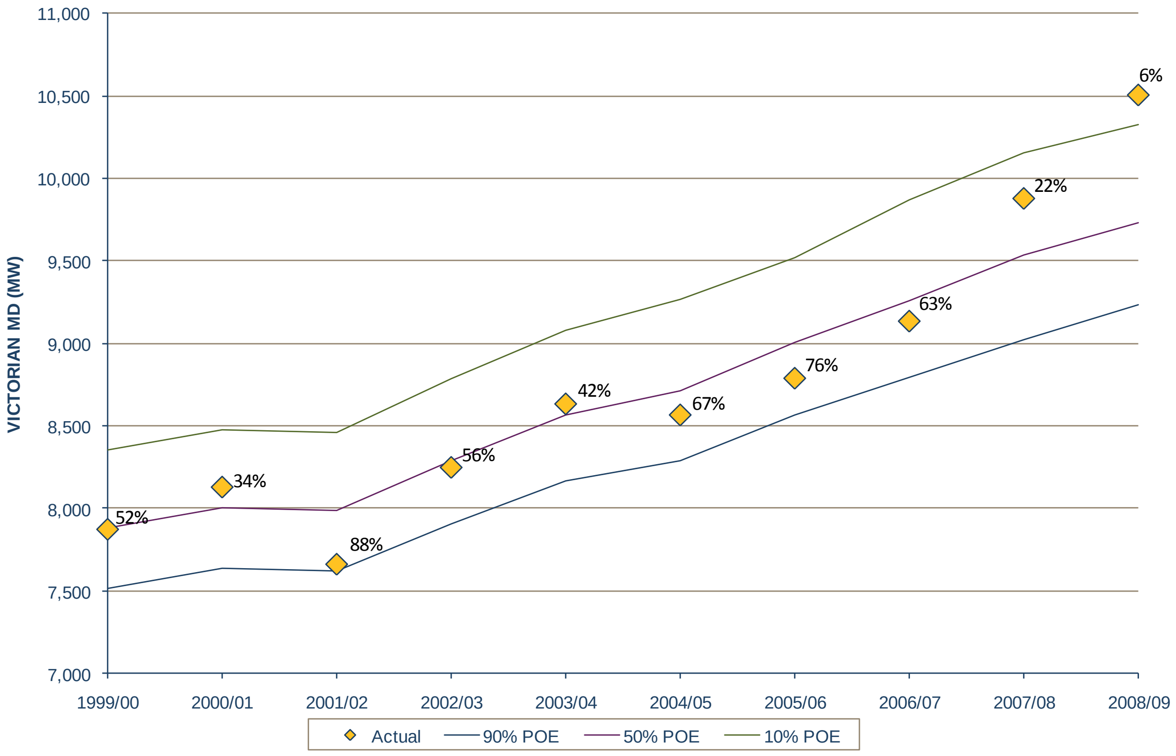
VENCorp advises the following:

- The out-of-sample backcast shows a good degree of correlation between the simulated and actual MDs, but a growing trend of under-forecasting.
- The under-forecasting of summer MDs is a reflection of the observed warming trend in Victorian temperatures. This observed warming trend is implicitly included in the 2009 Victorian summer MD forecasts, which utilise the observed temperature data up to the end of the most recent summer.
- The summer and winter MD simulation models are reviewed and improved each year. For the 2010 models, particular attention will be paid to the warming trend, and the expected increased frequency of extreme weather events.

C.4.3 Probability of exceedence estimation

Figure C.16 shows actual Victorian MDs and estimated POE levels. The actual MDs are mostly contained within the 90% POE and 10% POE estimated lines and the actual MDs are spread evenly around the 50% POE line. A major exception to this pattern occurred in 2008/09, but this is not unexpected, given the record hot weather conditions and the occurrence of the actual MD at an estimated 6% POE level. Taken overall, Figure C.16 provides a high level of confidence in the estimation of POE levels.

Figure C.16 Victorian Summer MD at Standardised POEs



C.5 SOUTH AUSTRALIA

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

C.5.1 Back assessment

Figure C.17, Figure C.18 and Figure C.19 show the South Australian one-year-out and two-year-out summer MD and energy back assessments.

Variation from year to year between the actual and projected values is due to a combination of:

- variation in actual conditions (including weather and economic conditions) away from the assumptions underlying the projections; and
- any remaining systematic and non-systematic forecast errors.

Figure C.17 South Australian Summer MD One-Year-Out Back Assessment

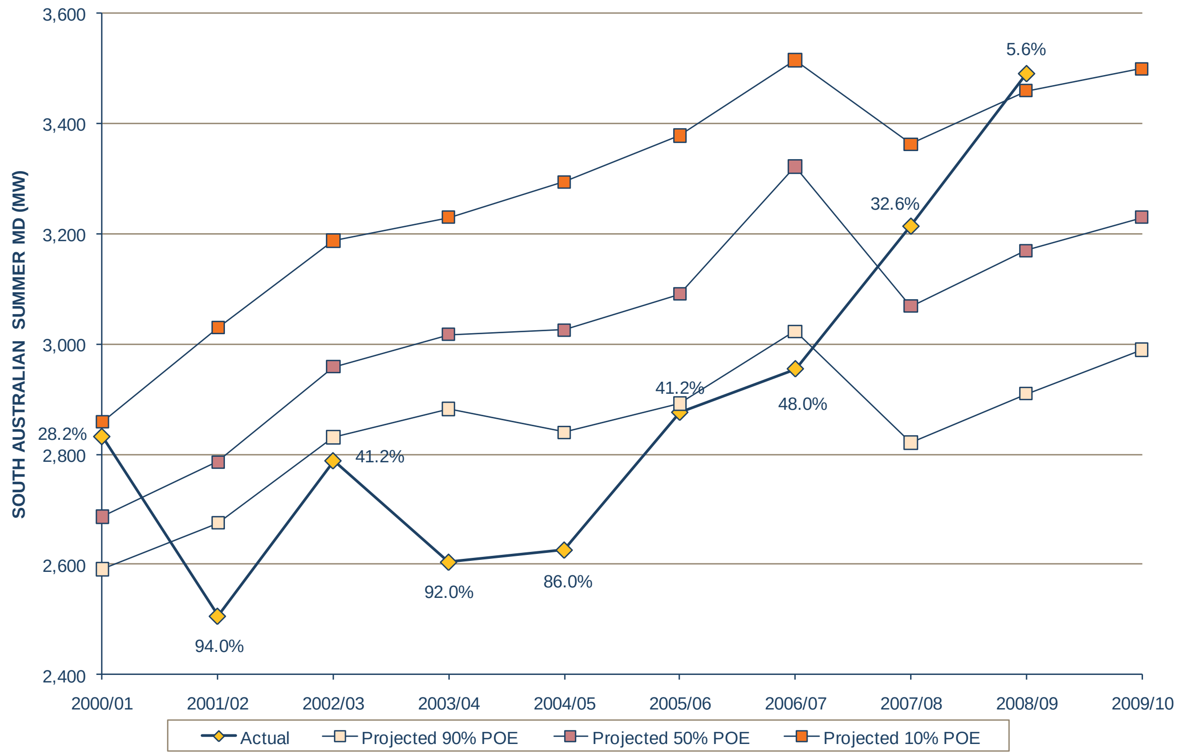


Figure C.18 South Australian Summer MD Two-Year-Out Back Assessment

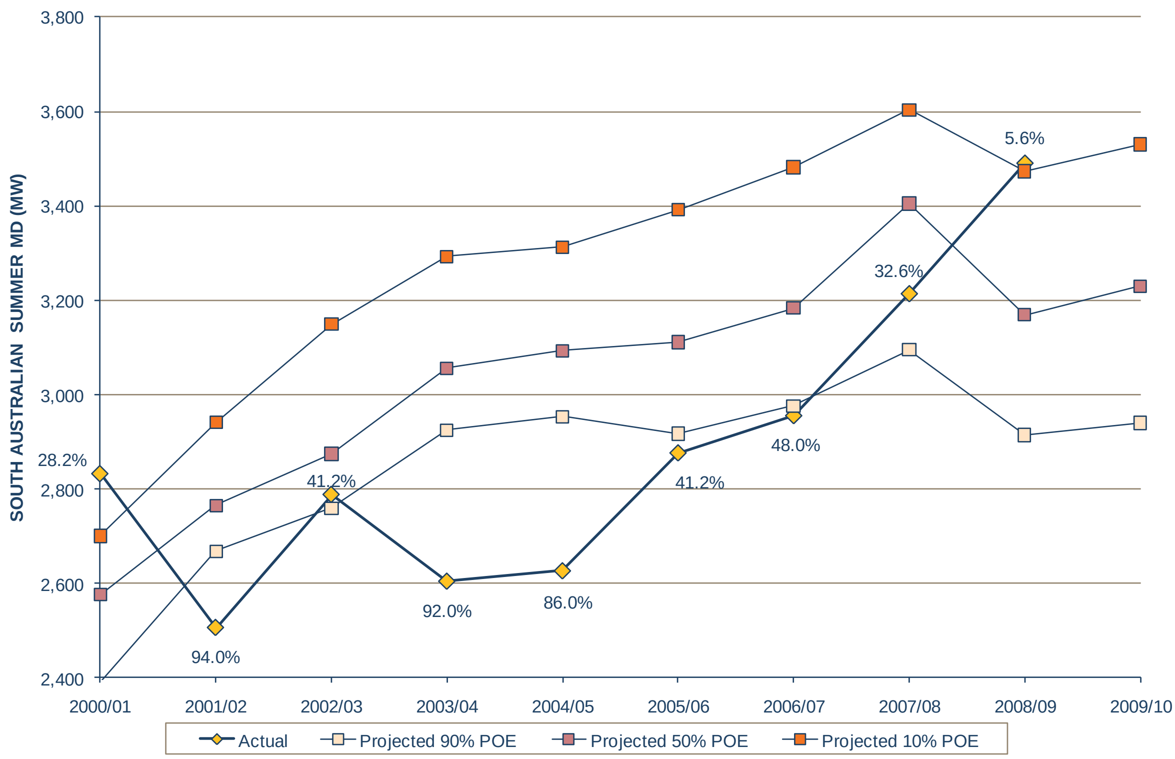


Figure C.19 South Australian Energy One- and Two-Year-Out Back Assessment

Figure C.17 and Figure C.18 show the following:

- The projections for the summer MD for the years 2001/02 to 2006/07, considering the assessed POE levels, are very high compared to the actual values.
- Projections for more recent summers appear more reasonable compared to the actual values.

Figure C.19 shows that energy projections for years prior to 2005/06 were generally higher than actual outcomes.

ESIPC [10] advises the following:

- A new forecasting methodology was used from 2007 onwards. A review of past forecast performance must therefore distinguish between the forecasts prepared using the old and new methodologies.
- The forecasts prepared prior to and including the 2006 ESOO were based on ESIPC's old forecasting methodology. Most of the forecasts prepared using that methodology displayed a clear tendency to overstate MDs, or equivalently, to assign probabilities to particular demand levels that were too low. For example, six of the eight summer MDs prior to the 2006/07 summer reported in Figure C.17 were at or below the 90% POE level. The probability of this occurring by chance, assuming the forecasts were accurate, is only 0.002%. This performance reflects the failure of the forecasting methodology employed in those years to account properly for all of the factors that determine the probability distribution of summer MDs.
- Since 2007, ESIPC worked with Monash University to develop a new simulation-based forecasting methodology that accounts for a wide range of factors that determine half-hourly demand levels. The modelling outputs include forecasts of the probability distribution of a number of variables of interest, including summer and winter weekly and annual MDs and annual energy volumes. This work with Monash University has also included the development of new forecasting evaluation methodologies, including the evaluation of forecast probability distributions used to identify the POE MD level forecasts for the ESOO. South Australia's 2009 APR includes an extensive section on evaluating the performance of its energy and MD forecasts [7]. The APR and a number of supporting reports published on ESIPC's website describe Monash University's forecasting methodology and the related approach to forecast performance assessment [8].

C.5.2 Backcast

Figure C.20 shows a single year South Australian summer MD backcast [11], showing actual and simulated MDs minus major industrial loads. This simulation:

- was developed using a model based on data from prior to summer 2008/09;
- uses actual temperatures and other variables as they occurred during summer 2008/09 as inputs to the model; and
- represents the single maximum from a series of half-hourly simulated values for that summer.

The original simulation errors were used to re-specify this model before producing the 2009 ESOO summer MD projections.

Table C.5 shows the percentage root mean square error (%RMSE) associated with the data in Figure C.20 [12].

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[10] Now part of AEMO.

[11] ESIPC only supplied backcast values for one summer (based on simulation of each half hour for that entire season). The available historical data was considered insufficient for producing out-of-sample backcast values for earlier years.

[12] Theil statistics cannot be calculated for a single observation.

Figure C.20 South Australian Summer MD Backcast

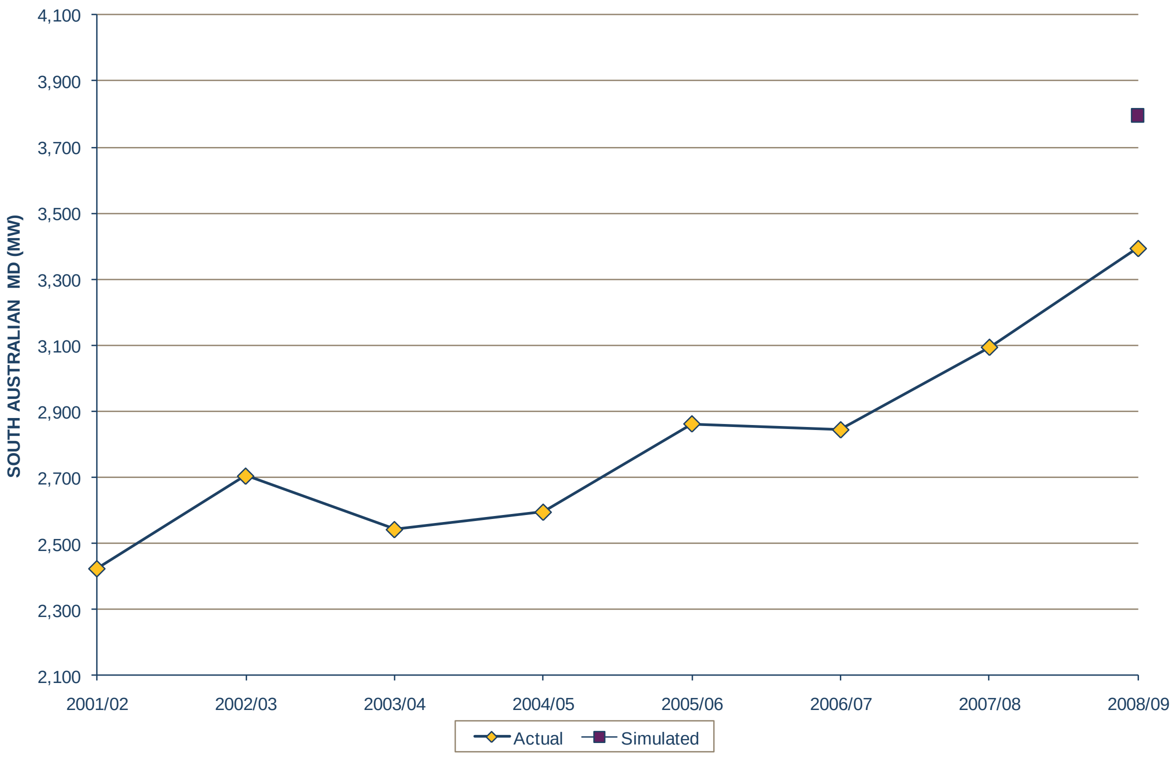


Table C.5 South Australian Backcast Summary Statistics

Measure	Result
Root mean squared percentage error (%RMSE)	11.89

Figure C.20 and Table C.5 show that the original simulation methodology over-predicted the actual MD for summer 2008/09. However, this occurred during the most extreme heatwave ever recorded in South Australia.

Figure C.21 shows the single year energy backcast for South Australia. This backcast was produced in a similar fashion to the summer MD backcast.

This procedure takes into account the actual economic and other long-term model input conditions over the backcast period. This ensures that differences between actual and simulated values reflect only on the quality of the simulation methodology.

Table C.6 shows the %RMSE associated with the data shown in this figure.

Figure C.21 South Australian Energy Backcast

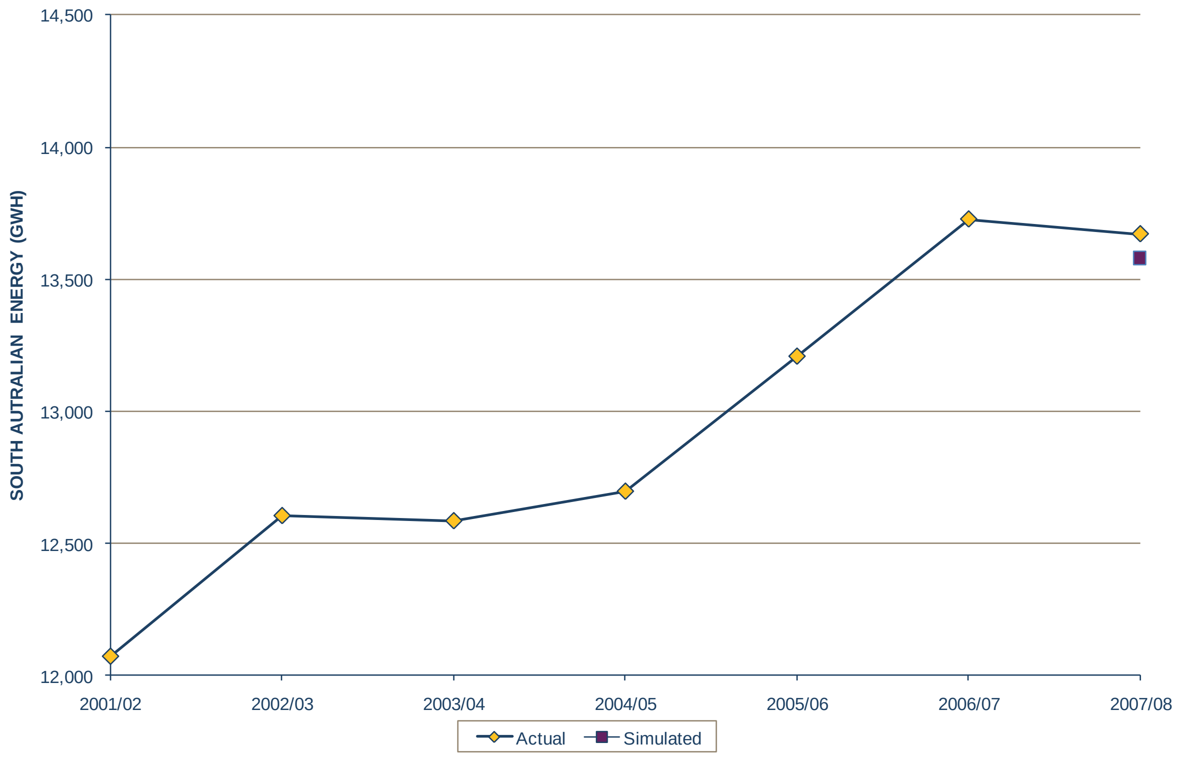


Table C.6 South Australian Energy Backcast Summary Statistics

Measure	Result
Root mean squared percentage error (%RMSE)	0.66

Figure C.21 and Table C.6 show a close fit between forecast and actual energy.

ESIPC advises the following [7]:

- ESIPC recognised that the model structure employed during 2007 and 2008 displayed an over-forecasting tendency under extreme weather conditions. Therefore, suitable model enhancements were implemented prior to developing the 2009 energy and MD projections.
- The models originally developed in 2007 were found to over-predict demand under the extreme temperatures experienced in the 2008/09 summer. The January-February 2009 heatwave experienced throughout Victoria and South Australia saw daytime and overnight temperatures exceed 1-in-50 and 1-in-100 year levels and set new benchmarks for many areas of South Australia. Rather than continuing to climb with higher and higher temperatures (as the original model would have predicted), demand appears to have approached saturation levels during the prolonged heatwave, with most available cooling appliances operating and some businesses closing down due to the hot weather.
- Data from this period has been used to re-estimate the models and adjustments have been made to correct for extreme weather over-prediction (demonstrated in Figure C.22).

Figure C.22 shows actual half-hourly demands and simulations made for a two-week period using both the original and updated ESIPC demand models. Simulated values before correction correspond to the values appearing in Figure C.20, whereas simulated values after correction correspond to values equivalent to the 2009 ESOO summer MD projections. Figure C.22 shows a close fit between the simulated demand after residual correction and actual values over a range of demand levels at the time of the regional summer MD.

Figure C.22 Ex-post Demand Predictions and Actual South Australian Demand during the 2008/09 Summer Heatwave

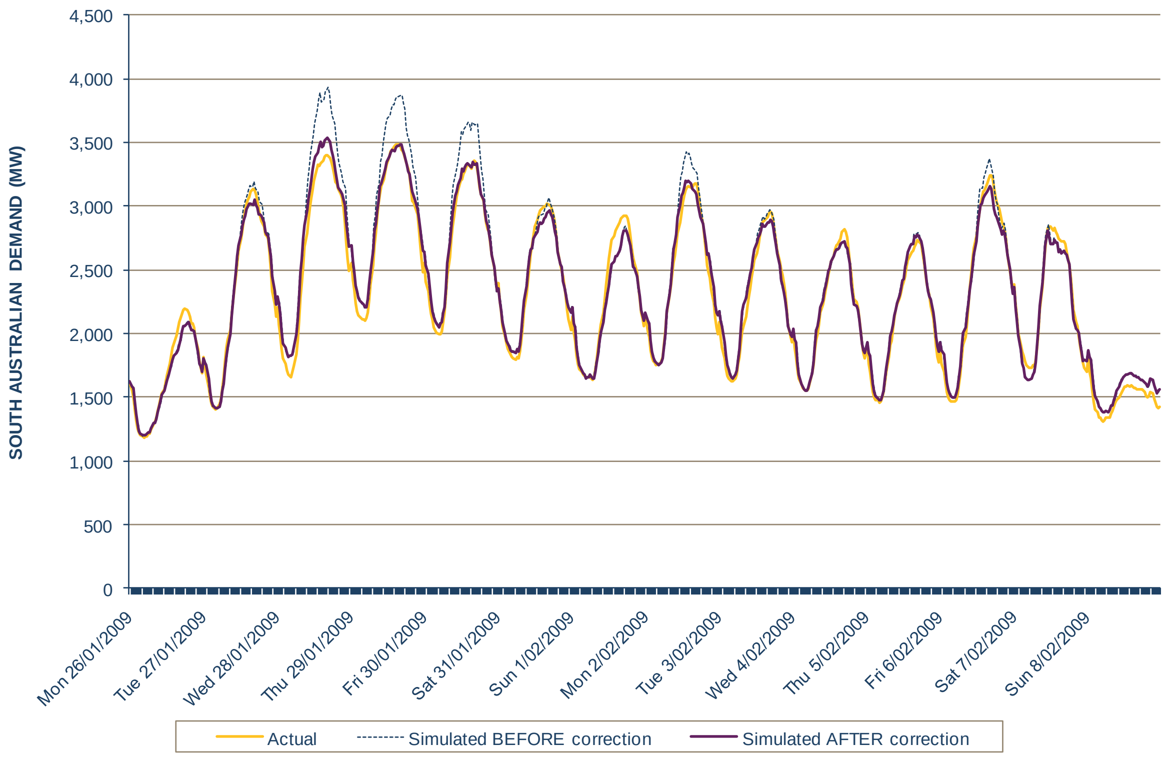


Table C.7 also shows summary statistics for the fit of MD's predicted for the summer of 2008/09 inclusive before and after correction (as described).

Table C.7 South Australian Summer MD Within-Sample Prediction Performance

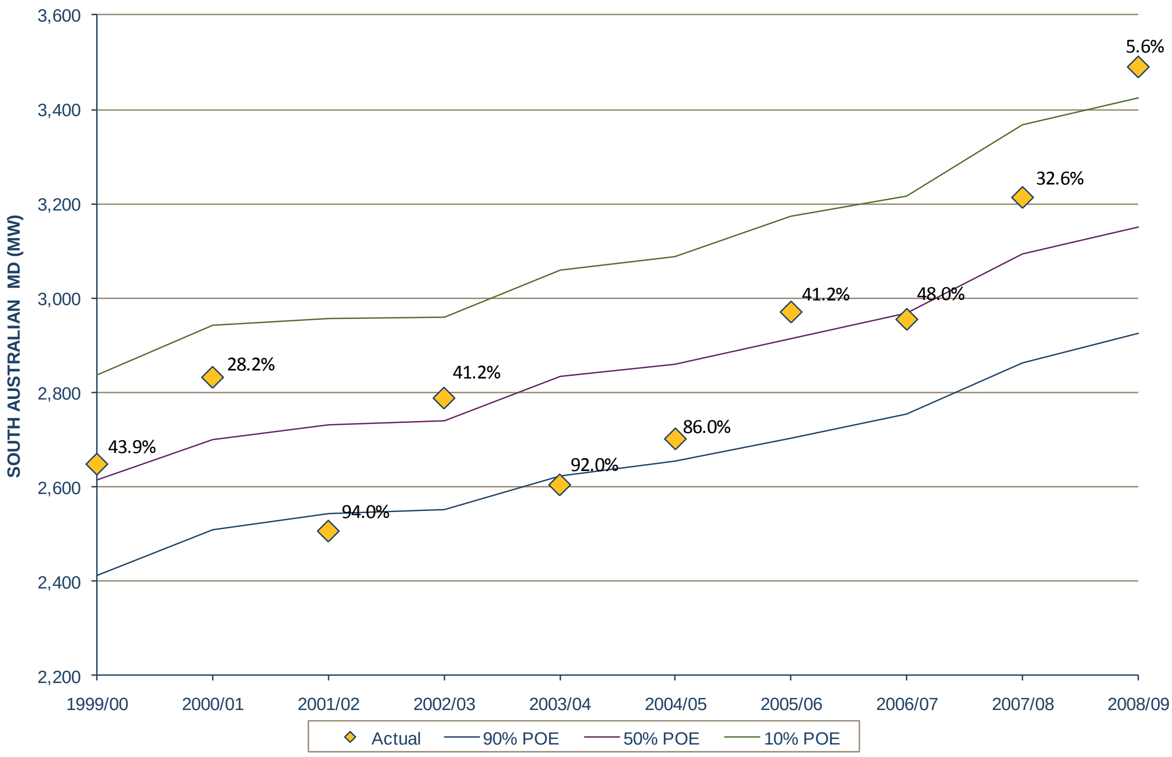
Measure	Before Correction	After Correction
Root mean squared percentage error (%RMSE)	4.95	3.56
Thiel's inequality coefficient (U)	0.027	0.017
Bias proportion (UB)	0.293	0.571
Variance proportion (UV)	0.353	0.008
Covariance proportion (UC)	0.353	0.421

C.5.3 Probability of exceedence estimation

Figure C.23 shows actual South Australian MDs and estimated POE levels. The actual MDs are mostly contained within the estimated 90% POE and 10% POE forecasts, and the actual MDs are spread evenly around the 50% POE forecast. A major exception to this pattern occurred in 2008/09, but this is not unexpected, given the record hot weather conditions. Taken overall, Figure C.23 provides a high level of confidence in the estimation of POE levels.

Further evaluation of the distribution of South Australian demand is presented in Chapter 2 of the South Australian APR [7].

Figure C.23 South Australian Summer MD at Standardised POEs



C.6 TASMANIA

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

A winter MD analysis is presented because the Tasmanian annual MD occurs in winter.

C.6.1 Back assessment

Figure C.24, Figure C.25 and Figure C.26 show the Tasmanian one-year-out and two-year-out winter MD and energy back assessments.

Variation from year to year between the actual and projected values is due to a combination of:

- variation in actual temperature conditions, economic activity and the operation of major industrial customers away from the assumptions underlying the projections; and
- any remaining systematic and non-systematic forecast errors.

Figure C.24 Tasmanian Winter MD One-Year-Out Back Assessment

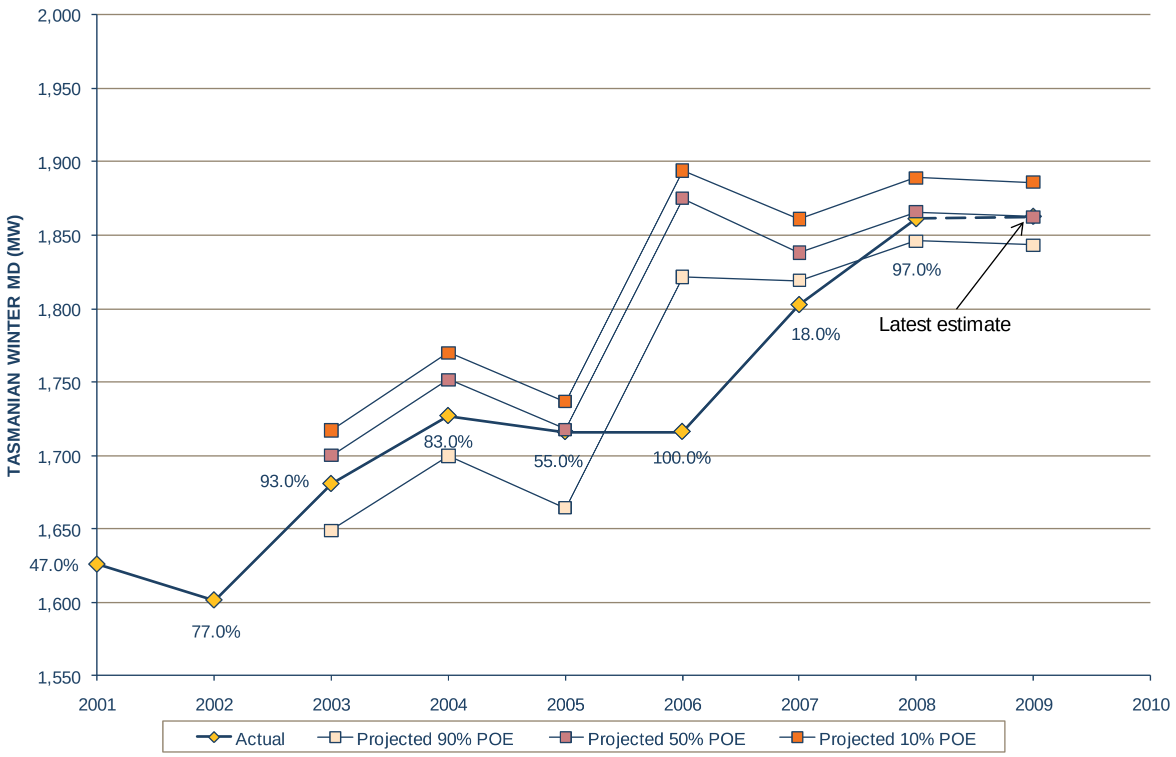


Figure C.25 Tasmanian Winter MD Two-Year-Out Back Assessment

Figure C.26 Tasmanian Energy One- and Two-Year-Out Back Assessment

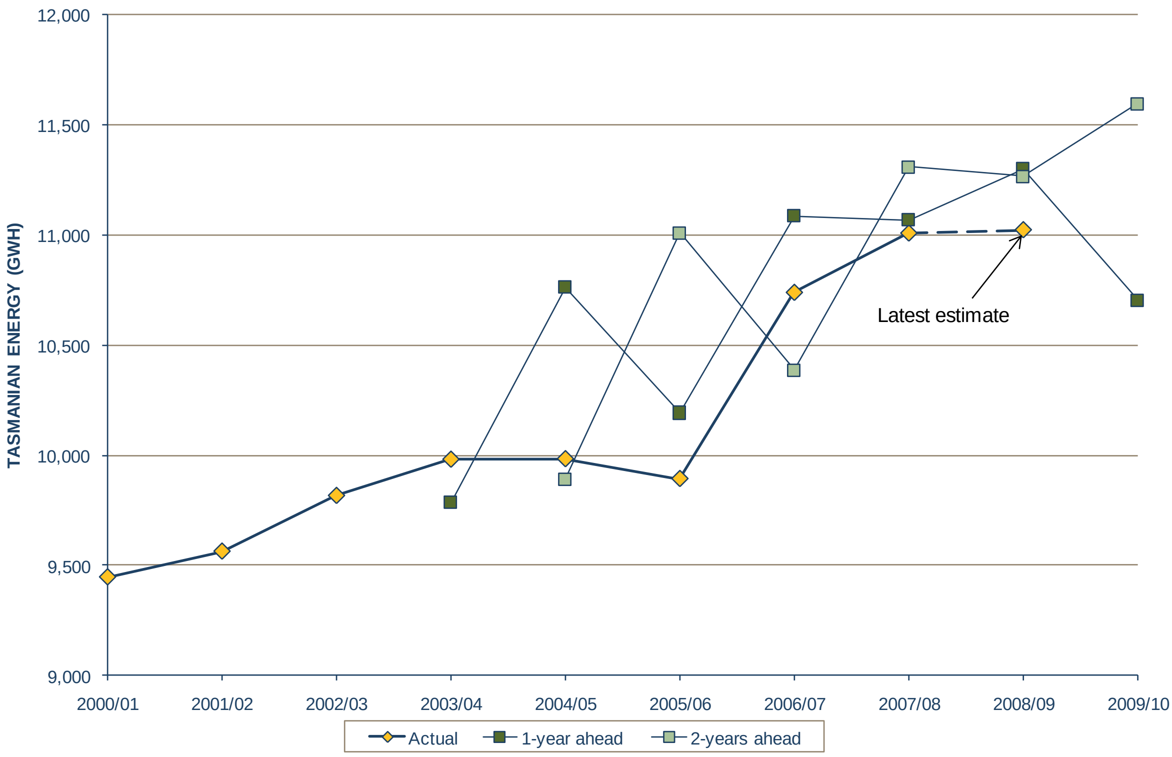


Figure C.24 and Figure C.25 show the following:

- The one-year-out projections for 2006 and the two-year-out projections for 2007 (both published in 2006) are 50-180 MW higher than the observed value. The projections for these years anticipated the steep rises that took place in 2007 and 2008 but appeared to predict that they would happen earlier.

Figure C.26 shows that:

- the one-year-out projection for 2004/05 and the two-year-out projection for 2005/06 (projections published in 2004) are 780-1,120 GWh higher than actual outcomes, anticipating large rises that subsequently did not take place until 2006/07 and 2007/08.

Transend Networks advises that the projection discrepancies are mainly caused by:

- actual industrial load being some 40 MW lower than expected at system MD for winter 2007;
- variations in major industrial load from one year to the next, which contributes up to 40 MW (approximately) of the difference between the projected MDs and the actual MDs;
- the economic performance in 2007, which was below what was expected when the projections were developed; and
- variations in actual temperatures at the time of the MD, which also contributed to the differences between the actual and projected winter MD.

C.6.2 Backcast

Figure C.27 shows the 3-year Tasmanian winter MD backcast [13]. This backcast was produced as follows:

[13] Transend Networks only supplied backcast values for the past three years. The available historical data was considered insufficient for producing appropriate backcast values for earlier years.

- The current winter MD forecasting model was estimated using data up to and including 2005.
- This model was then used to simulate winter MDs for 2006, 2007 and 2008 at the actual temperatures and economic conditions at those times.

This procedure ensures that differences between actual and simulated MDs reflect only on the quality of the forecast model.

Table C.8 presents the summary statistics associated with the data in Figure C.27.

Figure C.27 Tasmanian Winter MD Backcast

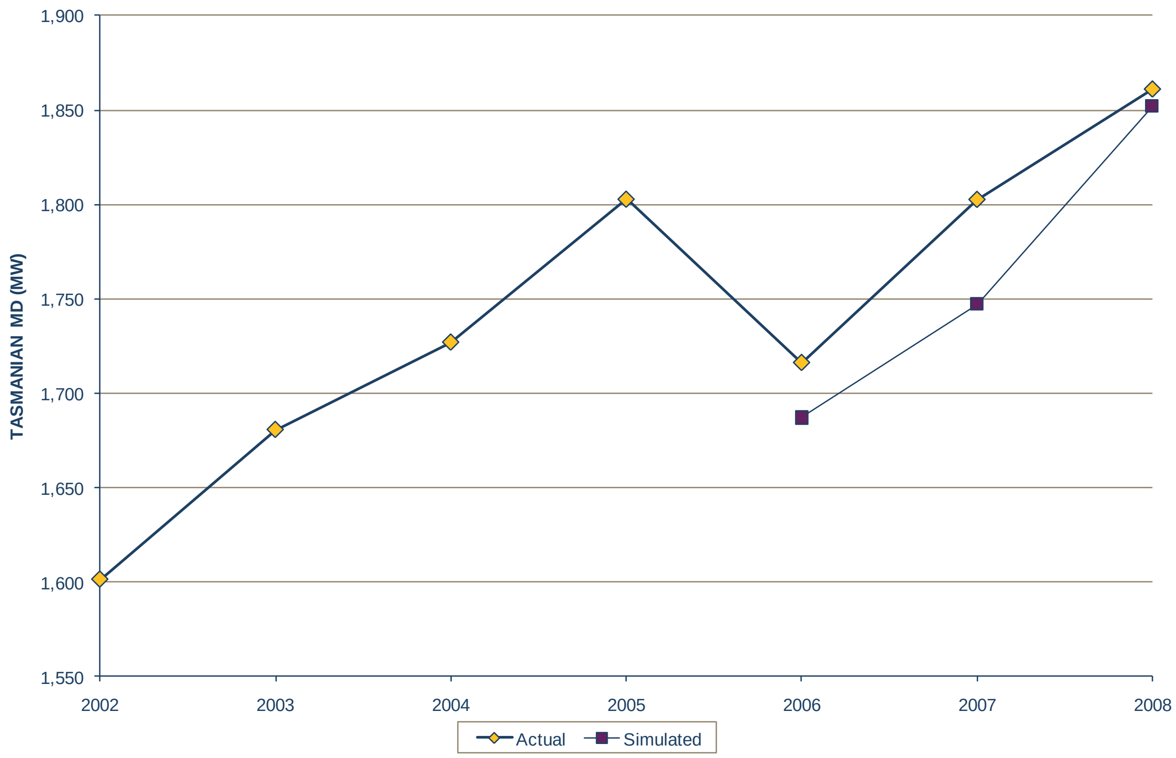


Table C.8 Tasmanian Winter MD Backcast Summary Statistics

Measure	Result
Root mean squared percentage error (%RMSE)	2.04
Thiel's inequality coefficient (U)	0.010
Bias proportion (UB)	0.728
Variance proportion (UV)	0.057
Covariance proportion (UC)	0.215

Figure C.27 shows that the backcast values generally follow the same trend as the actual MD values. Although the simulated values are persistently low relative to the actual values, the most recent simulated value has an error of less than 10 MW. Table C.8 confirms a high bias proportion, but since this statistic is based on only three observations, it is difficult to draw firm conclusions.

Transend advises the following:

- NIEIR was engaged to prepare the winter MD projections for the Tasmanian region, using NIEIR's load forecasting methodology.

- The actual MDs represent total actual demands, including major industrial loads. Variations in major industrial load, however, can contribute to backcasting error by up to 40 MW.

Figure C.28 shows the 3-year energy backcast for Tasmania. Table C.9 presents summary statistics associated with the comparison of the simulated and actual values shown in this figure.

Figure C.28 Tasmanian Energy Backcast

Table C.9 Tasmanian Energy Backcast Summary Statistics

Measure	Result
Root mean squared percentage error (%RMSE)	2.30
Thiel's inequality coefficient (U)	0.011
Bias proportion (UB)	0.886
Variance proportion (UV)	0.069
Covariance proportion (UC)	0.045

Figure C.28 and Table C.9 show an energy over-forecast bias, albeit based on a very limited sample.

C.6.3 Probability of exceedence estimation

Figure C.29 shows:

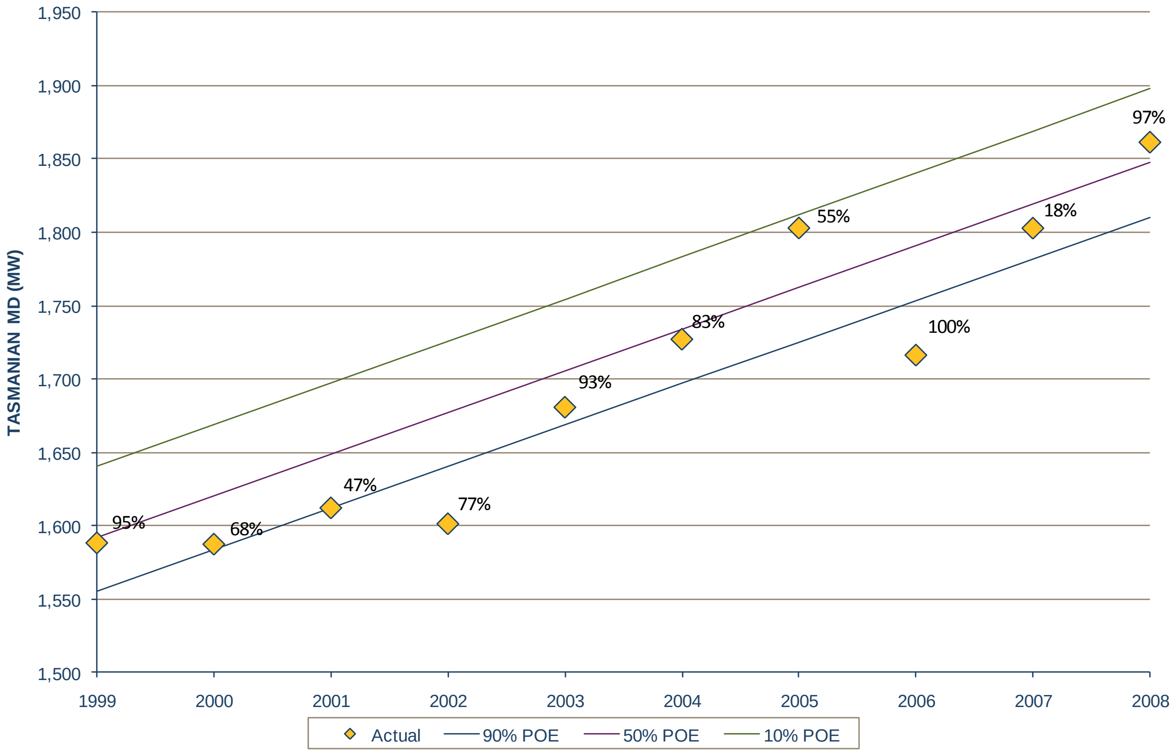
- actual Tasmanian winter MDs;
- the POEs of the actual MDs estimated on the basis of temperature analysis; and
- estimated MD levels in each year at the reference 90%, 50% and 10% POE levels.

Most of the actual MDs are contained within the 90% POE and 10% POE estimated forecasts. However, the actual MDs are concentrated below the 50% POE forecast

Transend Networks advises that:

- The MD for the 2006 winter has been assessed as a 100% POE because the temperature at the time was higher than the forecasting model allowed for (which is based on historical information).

Figure C.29 Tasmanian Winter MD at Standardised POEs



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