Parsons Brinckerhoff: Review of Transend load forecasting process and methodology

Appendix 9

Tasmanian Networks Pty Ltd

Transend Networks Pty Ltd

Review of Transend load forecasting process and methodology

8 October 2012

Transend Networks Pty Ltd

Revision	Details	Date	Amended By
01	Draft	24 September 2012	B Smith-Kerr
02	Final	8 October 2012	B Smith-Kerr

Author: B Smith-Kerr.....

Signed: .....

Reviewer: J Thompson.....

Signed: .....

Approved by: J Thompson.....

Signed: .....

Date: .....

Distribution: .....

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8 October 2012

Mr Dinesh Perera
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Dear Dinesh

Review of Transend load forecasting process and methodology

We have completed our review of Transend's load forecast. Based on our review of the information provided it is Parsons Brinckerhoff's opinion that Transend's forecasting practices are reasonable when considered from the perspective of the characteristics used by the Australian Energy Regulator (AER) in its recent Aurora Energy Pty Ltd determination.

We note that this conclusion is made by Parsons Brinckerhoff based on our independent high level review of the documentation provided and interviews with key staff of Transend and the National Institute of Economic and Industry Research. It should also be noted that this opinion is expressed in regards to the reasonableness of the forecasting process and methodology, and is not an opinion in relation any specific results of the forecasting process (i.e. any specific forecast).

Please find attached our final report. Should you wish to discuss the report, please don't hesitate to contact me on 0400 027 952 or Bernadette Smith-Kerr on (02) 9272 1413.

Yours sincerely

John Thompson
Principal Consultant, Strategic Consulting
Parsons Brinckerhoff Australia Pty Limited

Contents

Executive summary

Transend is the owner and operator of the electricity transmission system in Tasmania. Each year, Transend produces a 30 year load forecast for each substation and each identified geographical region within Tasmania. To produce this forecast, Transend obtains substation level forecasts from Aurora and state maximum demand forecasts from the National Institute of Economic and Industry Research (NIEIR).

Parsons Brinckerhoff (PB) has been engaged to undertake a high level review of the reasonableness of Transend Networks Pty Ltd (Transend) load forecasting process and methodology. In order to assess the reasonableness of this forecasting practice, PB considered the characteristics of a realistic demand forecast as identified by the Australian Energy Regulator (AER) in its recent Aurora Energy Pty Ltd (Aurora) determination.

Our high level assessment of Transend's forecasting practices included a review of inputs and assumptions, forecasting process, the forecast methodology and outputs of this process. We performed a desktop review of relevant documentation and met with key forecasting personnel at Transend and NIEIR. It should be noted that no direct review of Aurora's forecasting practice was undertaken, and for the purposes of this review PB relied upon relevant documentation and advice provided by Transend in forming our view.

In PB's opinion both Transend and Aurora have significantly improved their forecasting processes since our previous review in 2008. In particular, we have been advised that Aurora now utilises a temperature normalised econometric forecast which is fully documented. In addition, Transend has improved its documentation of the methodology and process, and now produces a temperature normalised forecast (as a result of Aurora's and NIEIR's temperature normalisation practices). However, PB is of the view that the robustness of Transend's load forecasting process could be significantly improved by migrating the process from a Microsoft Excel based implementation to an application based approach running on a suitable database. In our view, this would address a number of remaining issues; specifically, ensuring a consistent practice, reducing key person risk, improving data management and maintenance of data definitions, as well as supporting audit trails and version control practices.

Based on our review of the information provided, it is PB's opinion that Transend's forecast is reasonable from the perspective of the characteristics recently applied by the AER, and hence is likely to produce realistic forecasts. PB notes that this is a conclusion on the reasonableness of the model process and methodology, not on the forecasting results as such. That is, PB's review was undertaken as a high level review focusing on the forecasting process and methodology, and no attempt was made to examine the accuracy of the load forecasting results themselves.

1. Introduction and background

Transend Networks Pty Ltd (Transend), as Tasmania's transmission network service provider, is responsible for preparing the load forecast for the Australian Energy Market Operator (AEMO) and the Office of The Tasmanian Energy Regulator (OTTER).

As part of preparation for Transend's 2014-19 revenue proposal to be submitted to the Australian Energy Regulator (AER), Transend's directors are required to certify the reasonableness of the key assumptions that underpin Transend's proposal. Transend's load forecast is a key assumption, as this forecast drives capital expenditure and operating expenditure for the business, and in turn the revenue requirements for Transend over the regulatory period.

Parsons Brinckerhoff (PB) has been engaged to provide an independent view on the reasonableness of Transend's load forecasting practices. This document sets out PB's findings and presents our independent view on the reasonableness of Transend's load forecast. This view was formed from a high level review of documentation and interviews with key staff regarding Transend's forecasting process as well as the supporting National Institute of Economic and Industry Research (NIEIR) forecasting process. In forming a view on Aurora's forecasts (a key input to Transend's forecasts), PB relied upon relevant information provided by Transend and NIEIR. That is, PB did not directly interview Aurora staff regarding their current forecasting practices.

Specifically, PB's review considered the following:

- forecasting process and methodology
- key assumptions and inputs
- forecasting model

1.1 Scope and objectives of the review

PB has been engaged by Transend to assess whether or not the business' load forecast is reasonable. To undertake this assessment PB has:

- reviewed Transend's overall forecasting process, including a high level review of the:
  - process employed by Transend in reconciling the Aurora Energy Pty Ltd (Aurora) bottom up demand forecast and the NIEIR state forecast
  - NIEIR load forecasting process
- conducted a high level evaluation covering the:
  - validity of the assumptions used in the NIEIR forecasting model and Transend's reconciled load forecast
  - validity of the key inputs used in the NIEIR forecasting model and Transend's reconciled load forecast
  - evaluation of the NIEIR forecasting methodology at a high level
- considered the extent to which Transend has addressed recommendations made by PB in our 2008 review of the Aurora and Transend forecasting processes

In this report, PB sets out its independent view of the reasonableness of Transend's load forecasting process, and we make recommendations for further improvement of the forecasting process.

1.2 Key recommendations from PB's last report

In 2008, Transend engaged PB to complete a high level review of the load forecasting process and methodology of both Transend and Aurora. In that review, PB noted that whilst the approach by each business was relatively sound, there were areas where the processes could be improved. The table below summarises PB's recommendations and relevant actions taken by Transend and Aurora since the last review. It should be noted that PB has based its view on the actions taken by Aurora on information provided by Transend, and we have not verified this information with Aurora.

Recommendation	Action taken
The forecasting process should be fully documented, including the processes, the models employed, as well as all pre and post data verification and data management rules.	Transend produced a comprehensive document which explains the load forecasting procedure and methodology; a detailed functional description of the load forecast spreadsheet is included. The document is updated annually.
The forecasts should be temperature normalised to reduce variance and make explicit the demand conditions being modelled and forecast.	Aurora's new model produces temperature normalised forecasts. By definition, given that Aurora's and NIEIR's forecasts are both temperature normalised, Transend's load forecast is also temperature normalised.
There should be greater exposure of staff to the forecasting process to reduce reliance on a small number of key individuals (particularly in the case of Aurora's processes) and ensure process continuity.	Transend is working to train additional staff to reduce reliance on the key forecaster. Aurora now uses ACIL Tasman in the development and maintenance of its forecasting process and models. Hence reliance on key persons is eliminated.
Consideration should be given to the inclusion of information concerning the error in the forecast estimate, and discussion on variance drivers including the impacts of unusual major loads.[1]	NIEIR performs statistical analysis on its forecasts to assess forecasting error. As described in Aurora's demand forecast report (2012, p.17-18), Aurora performs an internal review to make sure that the substation demand forecast generated by its model fits with each substation site. This sense check is performed by an Aurora staff member with knowledge of each site. Adjustments are made to the forecast where appropriate and any changes are recorded with supporting evidence.
The model should be calibrated and updated on a continuous basis, and error reporting should be undertaken on a periodic basis to support this.	Transend conducts an analysis of previous load forecasts against actual demand data to assess the reasonableness of the forecast. This review is accompanied by a subsequent update of Transend's forecasting spreadsheet and forecasting methodology document, as appropriate.
Aurora should consider improving its reporting format to ensure the forecast is communicated in a manner that guarantees its clear interpretation.	Aurora has improved its documentation of the modelling process, and provides a greater level of detail on data definition and assumptions in its report to Transend.
Inputs and stated assumptions should be explicit and included in forecast reports or in supporting referenced documents.	Inputs and stated assumptions are included in the annual versions of the following documents, authored by Transend, NIEIR and Aurora, respectively:

[1] *Note that temperature variance should be eliminated (as far as practical) through temperature normalisation of the input data and the forecast.*

Recommendation	Action taken
	1. 'Transend Load Forecasting Procedure and Methodology', Issue 3.0, June 2012 2. 'Electricity sales and maximum demand forecasts for Tasmania to 2042 – A report for the Transend Networks Pty Ltd', May 2012 3. 'Distribution Network Connection Maximum Demand Forecast', March 2012
The model(s) used should be fully specified, and the relationships between variables documented.	The 'Transend Load Forecasting Procedure and Methodology' specifies the model through a detailed functional description of the load forecast spreadsheet.
A study should be undertaken to substantiate the impact of temperature normalisation on forecast accuracy, and the use of the forecast in network planning and operational modelling.	NIEIR has performed an assessment of the temperature sensitivity of Tasmanian daily demands in an effort to improve the accuracy of the peak electricity demand forecasts. NIEIR calculates sensitivity per degree Celsius in winter and summer, both including and excluding Transend's major customers.
Consideration should be given to conducting a periodic review of the forecast to maintain forecast credibility, promote further development of the forecasting processes, and ensure good practice.	Transend reviews its forecast model and procedure at least annually. This is accompanied by an update of the spreadsheet and methodology document, as appropriate.
A statistically based error measurement process should be implemented to promote forecast credibility.	NIEIR performs statistical error measurement on historical input data provided by Transend and during the development of its model equations and forecasts.
Aurora should consider the use of alternative models and/or an upgrade of the current model, as appropriate.	Aurora's current forecasting model was developed by ACIL Tasman, and ongoing development, revision and maintenance is undertaken by ACIL Tasman (as required).

1.3 Review approach

This section sets out PB's approach to this review, including the definition of reasonableness used in assessing the forecasting practices of Transend, NIEIR, and Aurora as well as an overview of the review process applied.

1.3.1 Defining 'reasonableness'

By its very definition, a reasonable forecast must be one that is based on reason. It must be developed using a sound, logical and rational approach that is moderate, not excessive, and hence, inevitably it must be realistic in nature. Given this definition, and the need for Transend to demonstrate reasonableness in its submissions to the Australian Energy Regulator, PB has based its review of Transend's load forecast on the Australian Energy Regulator's (AER's) definition of a realistic forecast as applied by the AER in its recent Aurora determination. In this determination, the AER (2011, p. 76) states that 'to develop realistic expectations of the future, forecasting techniques should include the following characteristics:

- Accuracy and unbiasedness of data – an unbiased forecast of demand should include careful management of data (removal of outliers, data normalisation), data quality and forecasting model construction (choosing a model based on sound theoretical grounds that closely fits the sample data).

- Transparency and repeatability – as evidenced by good documentation, including documentation of the use of judgment, which ensures consistency and minimises subjectivity in forecasts.
- Appropriate incorporation of key drivers (inputs) of demand and exclusion of spurious drivers.
- Model validation and testing – including, where appropriate, assessment of statistical significance of explanatory variables, 'goodness of fit', in-sample forecasting performance of the model against actual data, diagnostic checking of the old models, out of sample forecast performance.
- Accuracy and consistency of forecasts at different levels of aggregation – affects the overall reasonableness of the forecasts, as accuracy at the total level may mask errors at lower levels that cancel each other out.
- Use of the most recent input information.'

These characteristics are consistent with PB's view of industry best practice for demand forecasting as used through this review and in our 2008 review of Transend's and Aurora's forecasting practices.

1.3.2 Approach to work

In undertaking this high level review, PB has based its assessment on the AER's characteristics of a realistic forecast as set out above. Specifically we have considered the following characteristics:

- inputs and assumptions should exhibit the following characteristics:
  - the most recent available information is used
  - outliers are removed
  - data is normalised
  - accurate and unbiased
  - quality of data is known and reasonable
- the forecast model should:
  - appropriately incorporate key drivers and exclude spurious drivers
  - be chosen based on sound theoretical grounds
  - closely fit the sample data
  - be used in a transparent and repeatable way
  - be subject to validation and testing to review for accuracy and consistency
- outputs should be:
  - normalised (for temperature)
  - subject to validation and testing
  - reviewed for accuracy and consistency at different levels of aggregation.

Throughout our review PB has applied these characteristics and in order to establish whether the load forecast is reasonable in respect of the characteristics set out above, PB:

1. performed a desktop review of the following:
   a. Transend Networks Pty Ltd 2012, *Transend Load Forecasting Procedure and Methodology*, "Transend (2012)"
   b. Transend's load forecast spreadsheet
   c. National Institute of Economic and Industry Research 2012*, Electricity sales and maximum demand forecasts for Tasmania to 2042* (NIEIR's report to Transend, "NIEIR (2012)")
   d. Parsons Brinckerhoff 2008, *Review of Transend Load Forecast Methodology*
   e. Australian Energy Regulator 2011, *Draft Distribution Determination Aurora Energy Pty Ltd 2012-13 to 2016–17*

f. Aurora Energy Pty Ltd 2012, *2011 Distribution Network Connection Maximum Demand Forecast*, "Aurora (2012)"
g. SKM MMA 2011, *Review of Aurora Energy's maximum demand forecasting methodologies in its 2012 to 2017 regulatory proposal*

2. interviewed key Transend and NIEIR staff to conduct a high level review of the forecasting processes and practices used.

All aspects of this review process took place during August and September 2012.

1.4 Overview of Transend's forecasting process

Transend is the owner and operator of the electricity transmission system in Tasmania. Each year, Transend produces a 30 year load forecast for each substation and each identified geographical area within Tasmania.

In order to produce this forecast, Transend obtains substation level forecasts from Aurora, direct supplied customer forecasts from its direct supplied customers and state maximum demand forecasts from NIEIR.

Transend reconciles the substation level forecast with the state maximum demand forecast by scaling the substation forecast with diversity factors, loss factors and through scaling to reconcile the aggregated forecasts with NIEIR's state demand forecast.

In this report, PB begins by presenting a high level review of the NIEIR forecast model to determine the reasonableness as a key input to the Transend load forecast. We go on to assess the other key inputs to the Transend load forecast – metering data, Aurora's substation forecast and diversity factors – and conclude with a high level review of the Transend load forecasting model.

Reviewing the elements of the Transend load forecast in this way has enabled PB to form an opinion on the reasonableness of Transend's forecasting process.

2. NIEIR's forecast

The National Institute of Economic and Industry Research (NIEIR) provides an electricity sales and a maximum demand forecast to Transend annually. These forecasts form key inputs to Transend's load forecasting process.

In this section, we set out our high level review of NIEIR's forecasting practice with reference to the key characteristics of a realistic forecast as defined in section 1.3.

PB's review is based on information from NIEIR's report to Transend (2012) and our meeting with the key forecasters at NIEIR. It is important to note that for commercial reasons, PB did not review NIEIR's proprietary model.

2.1 Forecasting process and methodology overview

Methodology:

NIEIR (2012) describes the methodology employed in producing its forecasts as follows (pp. 12 and 14):

'Electricity consumption forecasts are based on econometric models which link Tasmanian electricity sales by industry to real output growth by industry, electricity prices, and weather conditions.

Residential sales are determined from a model including average consumption per dwelling, weather, real income, and electricity prices.'

'Electricity sales to Tasmania's four major industrial customers are treated separately, as are Transend's directly supplied customers (currently 10 customers).'

'Forecasts of summer and winter maximum demands for Tasmania were developed using econometric regression equations based on data supplied by Transend Networks. In broad terms, these relationships (equations) relate the ratio of maximum demands to energy to average temperature at system maximum demand (MD).'

Process:

NIEIR works with Transend in producing its forecast, including verification of all key inputs and providing Transend with a draft forecast for review before finalising its state maximum demand forecast.

Output:

A temperature normalised set of 30 year energy and maximum demand forecasts for low, medium and high energy and demand scenarios for winter and summer maximum demand for total State maximum demand, retail customers, direct supplied customers, electrical energy sales, and electrical energy sent out. NIEIR provides Transend with:

1. a spreadsheet containing the forecast data. Transend's load forecast spreadsheet is set up so that the data can be cut and pasted without modification.
2. a comprehensive report describing methodology, assumptions and forecasts.

2.2 Inputs and assumptions

The key inputs to NIEIR's forecasting process are:

- macroeconomic and energy market forecast from AEMO prepared by PricewaterhouseCoopers and NIEIR[2]. This data is used as the basis for the 'medium' ('base') economic scenario.
- weather data from the Bureau of Meteorology
- half hour market metering data for generation sent out, substation demand data, and annual sales by class from Transend.
- NIEIR's own internal economic forecasts, using data from the Australian Bureau of Statistics (this data is used as the basis for the 'low' and 'high' economic scenario)
- market and industry research on the top four major industrial customers and other directly connected customers.

PB's view of NIEIR's inputs and assumptions when compared with the characteristics of a realistic demand model as discussed in section 1.3 are set out below.

Characteristic	*Commentary*
Most recent available information is used	NIEIR's models and forecasts are reviewed annually; estimates and assumptions are updated as required. For example, Australian Bureau of Statistics data is updated on a quarterly basis.
Outliers are removed	In preparing its forecast, NIEIR 'cleans' input data to remove outliers from the historic metering data (e.g. impact of system switching), temperature data, and other data used in the forecasting process.
Data is normalised	NIEIR provides Transend with temperature normalised forecasts. PB notes that NIEIR's forecast assumes a warming trend, based on observations of historical data[3].
Accurate and unbiased	NIEIR performs sense checks of the data provided by its sources, including looking for outliers or changes in trends, and adjusting data if required. This includes adjusting generation data for Basslink transfers and loss factors. Statistical analysis is performed to ensure any bias in the data is identified and corrected.
Quality of data is known and reasonable	Based on NIEIR's description of its validation and testing of inputs (outlined above), the quality of the data would be expected to be reasonable. NIEIR's input data is of known quality; the model methodology includes a record of all input data and its sources.

2.3 Forecasting methodology and process

PB's view of NIEIR's forecasting methodology and process when compared to the characteristics of a realistic demand model as discussed in section 1.3 are set out below.

Characteristic	*Commentary*
Appropriately incorporates key drivers and excludes spurious drivers	NIEIR's report 'Electricity sales and maximum demand forecasts for Tasmania to 2042' describes the inputs, assumptions and methodology of the forecast modelling and specifies the demand model. PB has considered the inputs, assumptions and methodology as documented and in our opinion, they are all relevant to particular

[2] *AEMO 2012, Economic outlook information paper' and AEMO 2012, 2012 National Electricity Forecasting Report. The latter includes a state forecast for Tasmania.*

[3] *This is consistent with the AER's acceptance of a warming trend in previous determinations, AER (2011, p.88).*

Model should be chosen based on sound theoretical grounds that closely fits the sample data	forecasts developed by NIEIR for Transend. NIEIR has incorporated key drivers of the demand and energy forecasts and monitors historical data for additional explanatory variables. For example, when analysis suggested there was a shift in the time profile of peak demands, NIEIR attempted to re-estimate the winter maximum demand equations to allow for both morning and evening peaks. The evening model proved unstable and unsatisfactory results were obtained. Thus, the evening peak was not included as a driver in the forecast model.
Model used in a transparent and repeatable way	NIEIR's report to Transend outlines the state forecast inputs, methodology and assumptions, including the regression equations used to calculate maximum demand. NIEIR advise that their forecasting model is documented, however not all aspects of their process is documented. For commercial reasons, PB did not review the actual model and hence while full transparency is not possible, we are of the opinion that repeatability of the process generally is. The NIEIR models have version numbers and date stamps; these are automatically recorded when output is created. Data is stored in a database that automatically creates version control and provides relevant security capability.
Validation and testing to review for accuracy and consistency	The model and the methodology paper is reviewed and updated at least annually. PB understands that these changes are generally minor and largely relate to calibration matters rather than the model's overall specification. NIEIR performs statistical analysis of its models, in line with the AER's characteristics. The results of these tests are included in the methodology paper. This analysis covers: • 10 year back casting of actual maximum demand versus ex-post, out-of-sample forecasts based on actual conditions • 10 year back casting of actual maximum demand versus ex-post, within-sample calculated 10%, 50% and 90% POE levels • assessment of 'goodness of fit' of the maximum demand equations (incorporating the explanatory variables) PB notes that NIEIR has included the results of error analysis in their report and while the maximum demand equations have a lower R-squared value than we would have anticipated, in our opinion they are not unreasonable for the type of relationships being modelled. We also note that in our opinion the key drivers of the demand equations are reasonable and appropriate for the forecasts being produced. NIEIR's process of testing and validating input data, together with its statistical testing of the model provides for the ongoing review of accuracy and consistency.

2.4 Outputs

PB's view of NIEIR's forecast outputs when compared to the characteristics of a realistic demand model as discussed in section 1.3 are set out below.

Characteristic	*Commentary*
Outputs are normalised (for temperature)	NIEIR provides Transend with temperature normalised forecasts. PB notes that NIEIR's forecast assumes a warming trend, based on observations of historical data[4].
Outputs are subject to validation and testing	NIEIR performs statistical analysis of the forecast outputs, performing back testing against historical data to test the validity of the model and its outputs. NIEIR provides detail of this statistical testing in its report to Transend.

[4] *This is consistent with the AER's acceptance of a warming trend in previous determinations, AER (2011, p.88).*

2.5 Conclusions

PB has undertaken a high level review of the NIEIR load forecasting process and methodology, including consideration of the validity of key inputs and assumptions used in the forecasting process. This review is based on the information from NIEIR's report to Transend (2012) and an interview with NIEIR's key forecasters. It should be noted that for commercial reasons, PB did not review NIEIR's proprietary forecasting models.

Based on NIEIR's described process, including descriptions of the inputs and assumptions used, data normalisation, validation and testing throughout the process, PB is of the opinion that NIEIR's forecasting process and methodology is reasonable as described section 1.3 and appropriate for Transend's use as a key input to its forecasting practices.

3. Transend's load forecast

In this section, we set out our high level review of Transend's forecasting practice with reference to the key characteristics of a realistic forecast as defined in section 1.3.

PB reviewed the Transend Load Forecasting Procedure and Methodology document and the load forecasting model. PB also reviewed information provided by Transend on Aurora's forecasting process, and considers this in this section along with Transend's forecasting practices. Additionally, PB met with Transend's key forecasting personnel to discuss the forecasting process and methodology.

3.1 Forecasting process and methodology overview

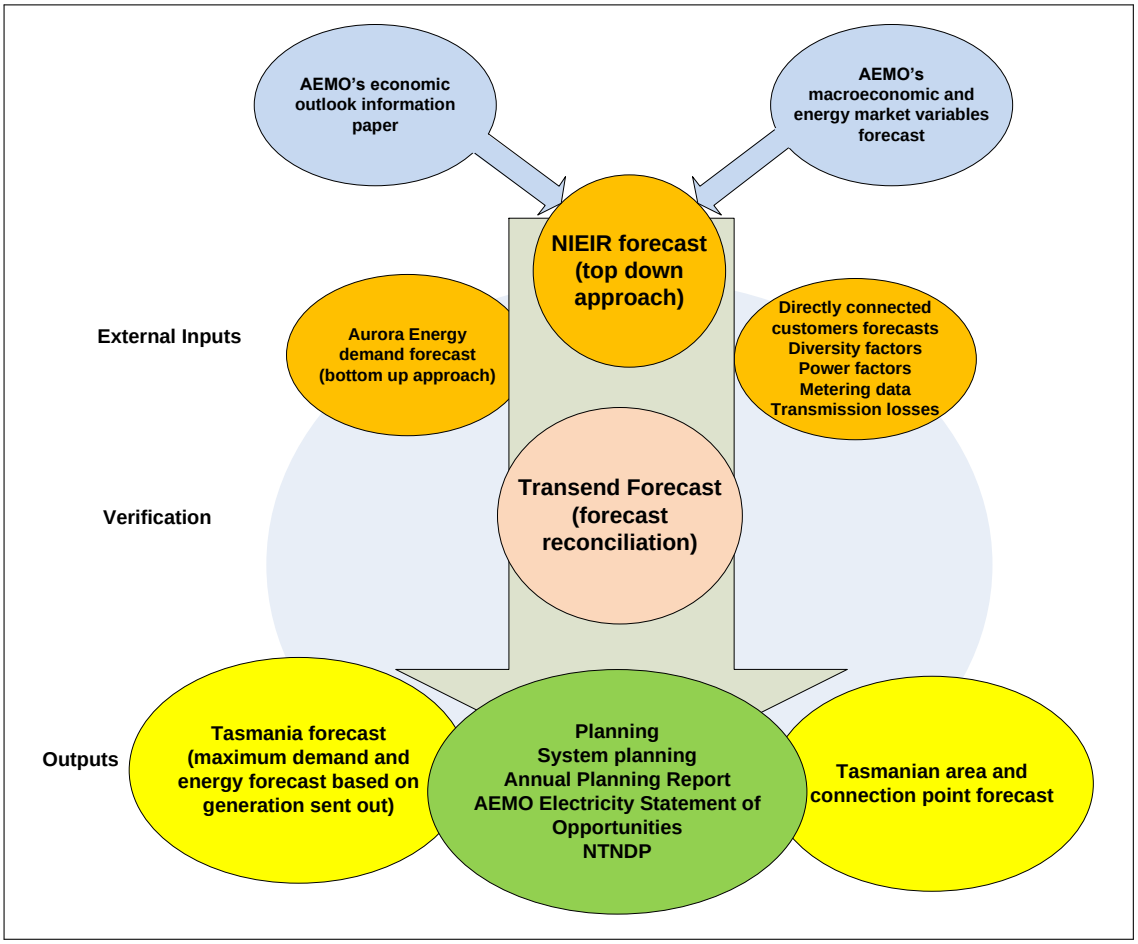
Methodology:

Transend's load forecast is developed using substation level forecasts and state level demand forecasts for Tasmania. Diversity factors (or coincidence factors) are calculated and applied to allow the substation forecasts to be aggregated so that the non-coincident demands of each of the substations sums to the state level demand forecasts.

Process:

Figure 1 provides a high level overview of Transend's forecasting process.

Figure 1: High level overview of Transend's load forecasting methodology



Source: Transend Networks Pty Ltd 2012

An overview of Transend's forecasting process is shown in Figure 2. It is noted that Transend has implemented this process using spreadsheets that are supported by manual data handling and management practices.

PB notes that Transend works closely with Aurora and NIEIR throughout the forecasting process and participates in discussions around forecast assumptions (e.g. economic data) as well detailed reviews of the metering data inputs.

Both Aurora and NIEIR provide Transend with draft forecasts for review and discussion before finalising their respective forecasts. Transend undertakes a review of Aurora's forecast against historical data and prior forecasts, calculating percentage variances and identifying unusual data. Transend consults with Aurora on any large changes, unusual data or unexplained variations. A similar process is also undertaken with NIEIR's forecasts prior to its use as in input in Transend's forecasts.

PB notes that this open communication between Aurora, NIEIR and Transend improves the overall quality of data and thus the reasonableness of the forecasts.

With regards to security, PB notes that Transend's model is password protected so that only authorised Transend forecasting staff can update inputs or amend the model. Some cells are also locked to prevent inadvertent change or data deletion by the forecasters and the end users of the forecast.

Currently, only two people know how to update the model. While this may be positive from a security perspective, in PB's opinion it also introduces key person risk. PB notes that Transend is currently making an effort to ensure that at least two people are trained to update and maintain the forecasting model.

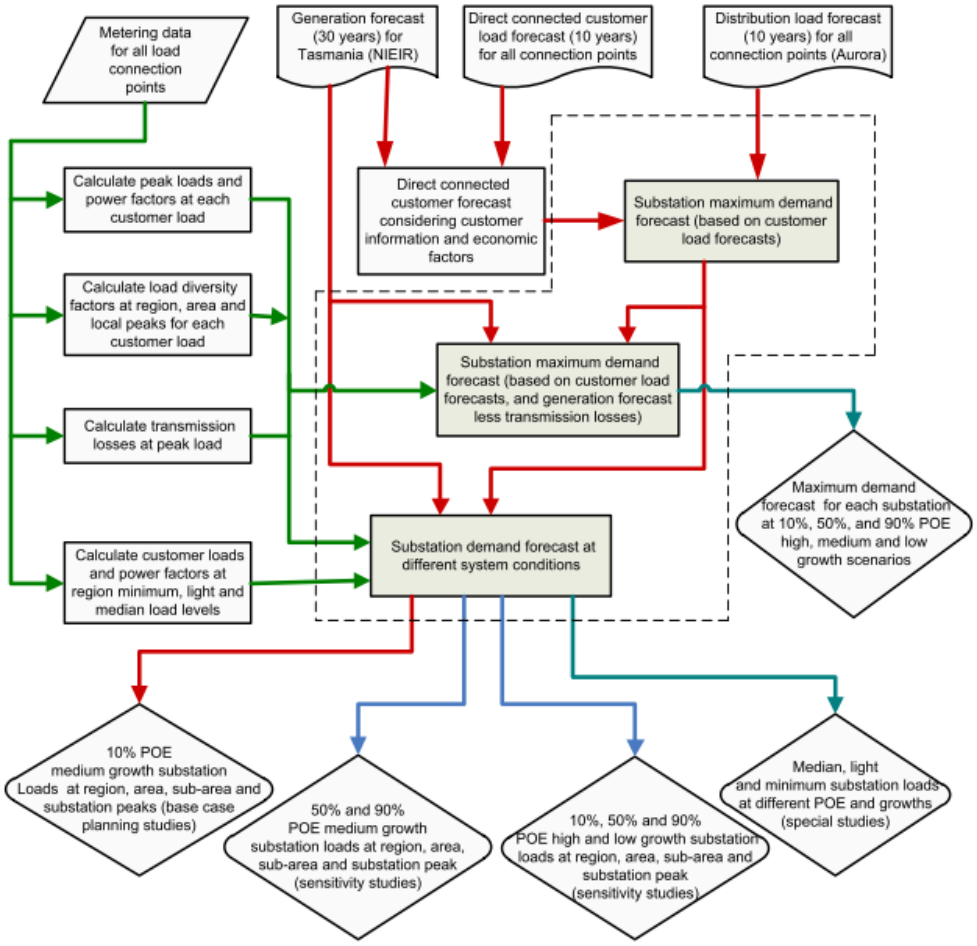
Prior to the release of the forecast, Transend's System Planning Manager undertakes an independent review of the forecast to check its reasonableness. Following this review, the demand forecast is released to the end users in a spreadsheet form that is set up to allow end users to generate forecast scenarios and perform sensitivity analysis on the 'Calculations' worksheet.

The model provides users with an 'Instructions' page. This provides enough information for the user to navigate the model, as well as providing descriptions of the data content of each worksheet. Since the models are version-controlled and stored in one central location, all end users will have access to the same version of the model, ensuring consistent information across the business.

The 'Calculations' sheet includes comments to explain how the assumptions are translated into the data, for example, if 'region' is selected, as opposed to 'area' or 'local', the comment clarifies that this means that all substation values are at region peak.

The sheet also states the version number of the model and the date of the version. Where necessary, the modelling team provides further information on the underlying data. For example, the 'Transend Load Forecasting Procedure and Methodology' and Aurora's forecast report.

Figure 2: Overview of Transend's load forecasting process



Source: Transend Networks Pty Ltd 2012, Transend Load Forecasting Procedure and Methodology

Output:

A 30 year demand forecast for each substation, each geographical area and the state. These forecasts are provided in a spreadsheet that allows users to define the specific forecast they require for planning purposed. PB notes that the spreadsheet is password secured so that the forecast or the forecasting model cannot be inadvertently altered.

3.2 Inputs and assumptions

The key inputs to Transend's load forecast model are:

1. metering data (Aurora and Transend)
2. substation level forecasts (Aurora's forecasts)
3. direct connected customer forecasts (NIEIR forecasts by connection point for major industrial customers)
4. state level maximum demand and energy sales forecasts (NIEIR's forecasts)
5. diversity factors

The following sections set out PB's high level review of the assumptions and inputs to Transend forecasting model by key input. Each input is considered in comparison to the characteristics of a realistic forecast as discussed in section 1.3.

It is important to note that PB has based its findings in relation to Aurora's practices on information provided by Transend and this information has not been independently verified with Aurora.

3.2.1 Metering data (Aurora and Transend)

The metering data consists of half hour market metering data at each customer connection point and substation, as well as Aurora's annual energy sales data. This metering data is obtained for the following customer classes:

- residential
- commercial
- industrial
- major industrial (four largest energy users)
- public lighting

PB's view of the management of this metering data when compared to the characteristics of a realistic forecast as discussed in section 1.3 are set out below

Characteristic	*Commentary*
Most recent available information is used	This is half hourly data that is collected on energy market timeframes. Transend uses the most recent available information from the market metering data and refreshes the data used for forecasting a 14 month moving window basis to ensure substitute values are replaced with actual values over time.
Outliers are removed	These are real measured numbers subject to the accuracy requirements of the energy market metrology rules. While there may be outliers due to system switching and other events, these are removed or appropriately adjusted using substitute values.
Data is normalised	Normalisation is not applicable for this data itself; however, normalisation is undertaken by NIEIR and Aurora through their respective forecasting processes.
Accurate and unbiased	Market metering data is used and anomalies dues to system events are checked for an addressed as noted above.
Quality of data is known and reasonable	This data is official metering data, accepted for use by AEMO and its quality is specified by the market metrology rules.

3.2.2 Substation forecasts (Aurora Energy)

A 10 year demand and energy forecast at each terminal substation is provided by Aurora. These forecasts are based on a 'medium growth'[5] scenario for winter and summer as well as for each of the 10% and 50% POE[6] temperatures.

Transend extrapolates the 10 year substation level forecast over the next 20 years (i.e. producing a 30 year forecast) using the average growth rate for that station over the past 10 years unless Aurora provides a substation-specific forecast. PB notes that in some cases growth rates are assumed to be zero. These forecasts may also capture additional information such assumptions on load transfers and irrigation loads where these are known.

PB's view of Aurora's forecasts, when compared to the characteristics of a realistic forecast as discussed in section 1.3, are set out below.

5 *The medium growth forecast is based on ACIL Tasman's medium economic growth scenario.*
6 *Probability of exceedence.*

Characteristic	*Commentary*
Most recent available information is used	Transend uses Aurora's most recent forecast for forecasting purposes. This data is provided annually in November/December. There is a time lag between the Aurora forecast being finalised in November/December and Transend producing its load forecast in June the next year. Transend and Aurora meet during Aurora's forecast development to discuss underlying economic assumptions in an effort to minimise the risk of substantial variation between the forecasts.
Outliers are removed	According to p. 15 of Aurora (2012), data validation is undertaken to ensure the data is reasonably free of problems like missing observations and other errors.
Data is normalised	According to p. 16 of Aurora (2012), weather correction of the data to the 10% and 50% POE levels is undertaken during the forecasting process. This involves the use of a regression model which calculates individual temperature sensitivities for each substation site. Aurora also removes weekends and the Christmas/New Year period, as these almost never correspond to seasonal peaks.
Accurate and unbiased	To ensure that its demand forecasts are accurate and unbiased, Aurora (2012) describes a process of meter data 'cleaning' to adjust for load switching, historical and forecast permanent transfers, as well as the impact of irrigation loads. Meter data validation is also undertaken to ensure data is reasonably free from problems such as missing observations or substitutions (p. 15-17).
Quality of data is known and reasonable	Aurora (2012) provides a detailed description of Aurora's forecast process. Based on the information provided, PB is of the view that Aurora's data validation processes are a robust approach to ensuring that the quality of data is known and reasonable.

3.2.3 Direct connected customer load forecasts (NIEIR)

NIEIR provides 30 year forecasts for each directly connected customer by connection point. These forecasts include four major customers and 10 additional connection points.

In developing its forecast, NIEIR takes into consideration the relevant market and industry data, as well as economic forecasts developed by both NIEIR and others. PB notes that a fifth major industrial customer that is proposed, but not yet operational, has been included by NIEIR in its current high economic growth scenario forecast.

PB's view of the NIEIR direct connect customer forecast inputs compared to the characteristics of a realistic forecast as discussed in section 1.3 are set out below.

Characteristic	*Commentary*
Most recent available information is used	NIEIR produces its final forecast at the end of May/early June. Transend produces its forecast in June, using NIEIR's most recent forecast.[7]
Outliers are removed	Transend provides NIEIR with historical metering data for directly connected customers. Transend checks this data using graphical techniques before providing this data to NIEIR. Thus, outliers are removed from the input to NIEIR's directly connected customer forecasts that use this historical data as their basis along with industry/market data. NIEIR's forecasts do not contain outliers.
Data is normalised	NIEIR (2012) states its assumptions on weather/temperature sensitivity in its report (p. 14). The demand profile of direct connection customers is primarily driven by

[7] *PB notes that a new customer signed an agreement with Transend after NIEIR had completed its forecast. Transend adjusted the load forecast and noted this assumption. NIEIR will include the client in next year's forecast.*

	production demand and directly connected customers are assumed to be weather/temperature insensitive.
Accurate and unbiased	Transend's customers provide a ten year load forecast to Transend which uses this data as a quality check by comparing the customer's forecasts with NIEIR's direct connected customer forecasts. Transend notes that there are limitations to the forecasts provided by customers. Specifically: • forecast maximum demands are typically stated as the contracted maximum demand • customers are unable (or unwilling) to provide details of plant expansions or demand increases • load increases tend to occur in step changes and often with short notice. In an effort to improve the quality of the data, NIEIR, with the assistance of Aurora Energy, develops alternative scenarios for electricity usage for directly connected customer. These take into account the prospects for the industry concerned as well as existing know contracts, and other market intelligence.
Quality of data is known and reasonable	PB has reviewed the processes undertaken by Transend and NIEIR to validate the data used in the directly connected customer forecast and is of the view that it could be expected to ensure the quality and reasonableness of this input.

3.2.4 State maximum demand forecast (NIEIR)

NIEIR produces 30 year maximum demand forecasts for Tasmania for the 'medium', 'high', and 'low' economic growth scenarios. A key input to these forecasts is the macroeconomic and energy market forecast from AEMO prepared by PricewaterhouseCoopers and NIEIR[8]. Essentially, NIEIR produces nine different generation forecasts for Transend – a forecast for each medium, high and low economic scenarios, as well as for each of the following three temperature conditions based on a detailed analysis of ambient temperature data for Tasmania:

- 10th percentile: temperature met once in every ten years (10% POE)
- 50th percentile: temperature met once in every two years (50% POE)
- 90th percentile: temperature met nine out of ten years (90% POE).

The table below sets out PB's findings with reference to the key elements of the AER's definition of a realistic forecast

PB's view of the NIEIR state maximum demand forecast input compared to the characteristics of a realistic forecast as discussed in section 1.3 are set out below.

Characteristic	*Commentary*
Most recent available information is used	NIEIR produces its final forecast annually at the end of May/early June, using up-to-date economic forecasts and weather data. The data provided by Transend as inputs is the most recent available information. Transend produces its forecast in June, using NIEIR's most recent forecast.
Outliers are removed	In preparing its forecast, NIEIR 'cleans' input data to remove outliers from the historic metering data (e.g. impact of system switching, etc.), temperature data and other data.

8 *AEMO 2012, Economic outlook information paper' and AEMO 2012, 2012 National Electricity Forecasting Report. The latter includes a state forecast for Tasmania.*

Data is normalised	NIEIR provides Transend with temperature normalised forecasts. PB notes that NIEIR's forecast assumes a warming trend, based on observations of historical data[9].
Accurate and unbiased	NIEIR performs sense checks of the metering data inputs, including looking for outliers or changes in trends, and adjusting data as required. This includes adjusting generation data for Basslink transfers and loss factors. Statistical analysis is performed to ensure any bias in the data is identified and corrected. PB conducted a high level review of NIEIR's forecasting methodology and process (see section 0) and concluded that NIEIR's forecast is reasonable, when considered against the characteristics of a realistic forecast as discussed in section 1.3.1.
Quality of data is known and reasonable	NIEIR's methodology sets the assumptions underpinning the forecast, as well recording the data used as inputs and its sources. NIEIR assesses the input data for reasonableness to ensure it uses the most appropriate inputs and assumptions. For example, after reviewing AEMO's economic growth scenarios, prepared by PricewaterhouseCoopers and NIEIR, NIEIR concluded that NIEIR's own economic forecast would be more appropriate for use in the energy demand forecast (sectoral view).

3.2.5 Diversity factors (Transend)

Diversity factors are used to scale Aurora's substation demand forecasts and NIEIR's customer demand forecasts to equate (in the aggregate) to the state peak demand forecast. Hence, diversity factors determine the contribution of individual customer demand at a substation to the state maximum demand.

Diversity factors are calculated annually using the most recent year's actual historical load data. The factors are based on an average of the peak over the five maximum demand days and are assumed to be constant for the forecast period. These factors are identified for winter and summer separately. Winter and summer are assumed as June to August and December to February respectively.

PB's view of the derivation of diversity factors compared to the characteristics of a realistic forecast as discussed in section 1.3 are set out below.

Characteristic	*Commentary*
Most recent available information is used	Diversity factors are updated annually, and Transend uses the most recent available market metering data.
Outliers are removed	Diversity factors are based on an average of five peak days - averaging removes outliers.
Data is normalised	Diversity factors are not normalised.
Accurate and unbiased	As noted above, summer and winter diversity factors are calculated using an average of the five peak days based historical metering data.
Quality of data is known and reasonable	Diversity factors are calculated using market metering data and historical load data. Based on our review of documentation we are of the opinion that the inputs to the calculation of diversity factors are known and reasonable. The methodology Transend uses to calculate diversity factors is consistent with that used by NIEIR and is in line with the AER's methodology.

9 *This is consistent with the AER's acceptance of a warming trend in previous determinations. See Aurora 2012–17 draft distribution determination, Demand forecasts (page 88).*

3.2.6 Conclusion on reasonableness of inputs and assumptions

Based on the observations set out above, it is PB opinion that the when compared to the characteristics of a realistic forecast as discussed in section 1.3.1 the inputs and assumptions to Transend's forecasting process are reasonable.

3.3 Transend's demand forecast model

PB's view of Transend's demand forecast model compared to the characteristics of a realistic forecast as discussed in section 1.3 are set out below.

Characteristic	*Commentary*
Appropriately incorporates key drivers and excludes spurious drivers Model should be chosen based on sound theoretical grounds that closely fits the sample data	In PB's opinion, the key inputs to the model (substation loads, state maximum demand forecasts, direct connection data and metering data/diversity factors) are appropriate for the demand forecasting undertaken by Transend for the purposes of network planning. Transend (2012) describes the modelling process and specifies the model. PB is of the opinion that the model does not include any spurious drivers and that it represents the known relationships between the various inputs (as discussed above).
Model used in a transparent and repeatable way	Transend uses the TRIM document management system. All information is kept and archived, within a TRIM container (folder) for each version of the model. All supporting documentation is saved in the same TRIM container. This includes input files and email correspondence explaining inputs, where applicable. When modifications are made to the model, the old version is archived in a separate TRIM container and the model methodology paper is updated in a new document version. A comprehensive functional description of the model is provided in the 'Transend Load Forecasting Procedure and Methodology'. The load forecasting spreadsheet includes an 'Instructions' sheet and provides notes on various assumptions for the end user. PB is of the view that although the model is used in a transparent and repeatable way, the use of an Excel spreadsheet increases the risk of human error in the forecasting process. In particular, the practices and processes that increase risk are: • cutting and pasting data from spreadsheets provided by Aurora and NIEIR • leaving some formula cells unlocked • the replication of equations for each data subset within the model - these could be changed accidentally without the action being recorded • audit trails of changes are limited and potentially unreliable • as with all spreadsheets testing is complicated by the copying of critical formula throughout the spreadsheet • the reliance on an individual user to record all changes to the model.
Validation and testing to review for accuracy and consistency	The model is reviewed and the methodology paper is updated at least annually. Changes are usually minor. Transend performs testing of its model by comparing previous forecasts to actual outcomes but does not perform statistical analysis at any stage of the modelling process. PB believes that this is reasonable, given the Transend load forecast is not based on complex mathematical functions.

3.3.1 Conclusion on Transend's demand forecasting model

Based on the observations set out above, PB is of the opinion that Transend's demand forecast model is reasonable when compared to the characteristics of a realistic forecast as discussed in section 1.3.

However, PB considers that the use of spreadsheets to manage forecasting data and implement the forecasting process reduces the reliability of the forecasting process and hence may affect the reasonableness of the forecast. In our view, Transend's forecasting process is relatively stable and well defined and would be best implemented through an appropriate application running on a suitable database.

3.4 Forecast outputs

PB's view of Transend's demand forecast output when compared to the characteristics of a realistic forecast as discussed in section 1.3 are set out below.

Characteristic	*Commentary*
Outputs are normalised (for temperature)	Both NIEIR and Aurora provide Transend with temperature normalised forecasts. Hence, Transend's demand forecasts are temperature normalised.
Outputs are subject to validation and testing	Transend's demand forecasts are reviewed by forecasting staff as well as the System Planning Manager before release. This includes graphically testing forecasts (charting forecasts against historical demand) and testing prior forecasts against historical load (percentage variation).
Outputs are reviewed for accuracy and consistency at different levels of aggregation	Transend reviews both the state maximum demand forecast and the substation level forecast as described above (graphically and percentage variation). Consistency is ensured through the scaling of the diversified forecasts to reconcile with the NIEIR's state maximum demand forecast (suitably adjusted for loss factors).

3.4.1 Conclusion on Transend's forecast outputs

Based on the observations set out above, PB is of the opinion that Transend's forecast outputs are reasonable when compared with the characteristics of a realistic forecast as discussed in section 1.3.

3.5 Summary and recommendations

PB has undertaken a high-level review of Transend's load forecasting process and methodology, focussing on the inputs and assumptions as well as the forecast model. PB also reviewed the key inputs to Transend's forecasting process, and in particular the NIEIR forecasting process and methodology as well as Aurora's substation forecasts.

In PB's opinion, Transend's forecasting process is reasonable when compared with the characteristics of a realistic forecast as discussed in section 1.3 as used by the AER in its recent Aurora determination.

However, while PB is of the view that Transend's forecasting process is reasonable, we consider that the robustness of the process and hence the reasonableness of the forecasting process is at risk from the current spreadsheet based practices. Consequently, PB recommends that Transend considers migrating the forecasting process to an appropriate application running on a suitable database. In particular, this migration should focus on proving robust data management tools that support management of the data definitions (particularly metering data), the provision of audit trails and version control. PB believes that this approach would ensure a consistent and transparent practice, reduce the potential for human error, reduce key person risk, enhance testing and improve change management practices.