Energy forecast for Aurora Energy, 2012/13 to 2016/17

Review and audit energy forecast report and model for Aurora's Regulatory Proposal

Prepared for Aurora Energy

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ACIL Tasman

Economics Policy Strategy

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Executive summary

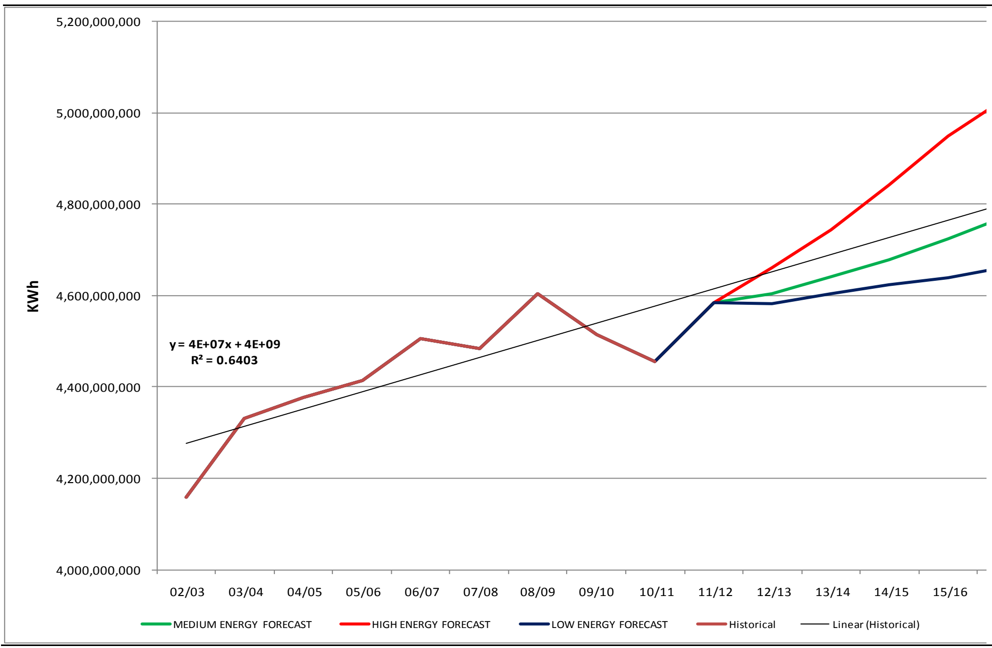
Aurora Energy (Aurora) has requested a review by ACIL Tasman of the methodology adopted by Aurora to derive an energy consumption forecast for the period 2012/13 to 2016/17. Aurora acknowledges that their report to the AER is preliminary only and that further analysis and a revised methodology will improve their energy consumption forecast.

While Aurora plans to submit their energy forecast, ACIL Tasman has identified a number of issues that need to be modified to improve the accuracy of Aurora's forecast and is currently preparing a system level forecast, disaggregated at the Customer class level. ACIL Tasman's forecast will adopt an econometric approach and include a review of the impact of external factors, namely a carbon price and ToU tariffs.

Aurora's methodology uses the demand growth forecasts for Summer and Winter prepared by NIEIR to project the estimated energy for 2011/12 for three major Customer classes, namely Residential, Small Business and Medium Business. Large Business demand is kept constant over the forecast period and there is a growth forecast for Irrigation and UMS (includes street–lighting) customer classes.

The forecast energy consumption with historical data for High, Medium and Low growth cases is shown in Figure ES 1.

Figure ES 1 **Aurora energy forecast (kWh), 2012/13 to 2016/17 by case**

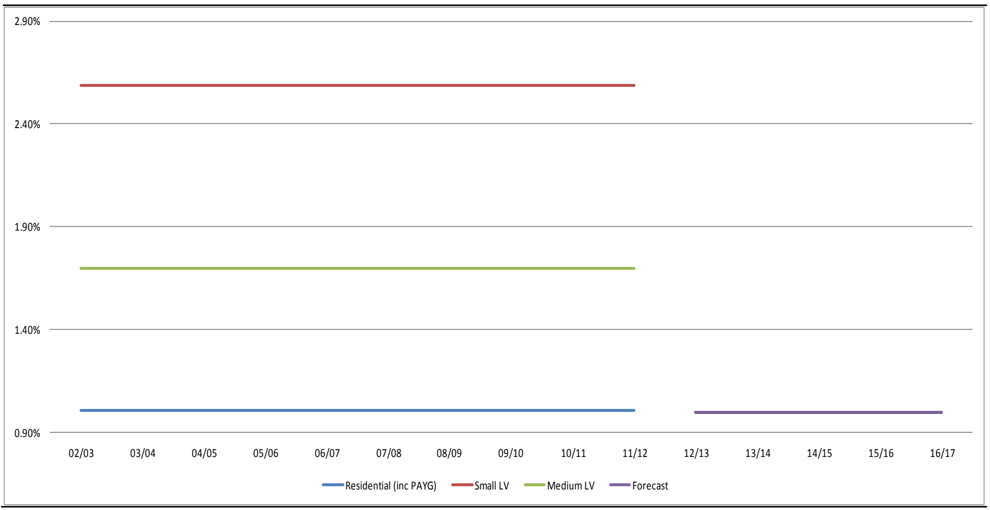


ACIL Tasman confirms that the methodology described in Aurora's document, "NW-#30177245-v3-Consumption_Model_paper_ACIL_Audit" has been followed to derive the energy forecast for the five year period, 2012/13 to 2016/17.

Aurora's overall average energy growth in the forecast period for the Medium growth case of 0.82% pa compares to the historical average growth of 1.09% pa for the nine years to 2011/12 or 0.71% pa for the eight years from 2003/04.

For the Medium case, the average energy growth in the forecast period (based on NIEIR's Winter demand growth) for the three major Customer classes is 0.99% pa compared to historical average energy growth rates of 1.01% pa, 1.70% pa and 2.59% pa for Residential, Medium Business and Small Business customers respectively, as shown in Figure ES 2.

Figure ES 2 **Historical and forecast average growth rates by Customer class - Medium growth case**



ACIL Tasman has reviewed Aurora's adopted methodology and considers that the correlation between demand and energy is weak and that each Customer class has underlying drivers that create different growth factors. Therefore, we recommend a regression-based approach using credible econometric data (if available), including population growth (Residential Customers) and GSP (Small and Medium Business Customers), as supplied by Treasury or other suitable economic forecasters).

This is particularly relevant as energy consumption for the past two years has been less than the historical trend and it is unclear whether this is due to either price or demand (or both) impacts and this issue will be addressed in the next report by ACIL Tasman.

Further, Aurora's forecast has made no allowance for the impact of likely policy initiatives over the forecast period, which could result in the derived forecast needing to be adjusted eg. carbon tax and ToU tariff impacts. This adjustment would be a second step after the base forecast is derived.

1 Introduction

Aurora has developed an energy forecast for its submission to the AER, which is a requirement as part of Aurora's Regulatory Proposal for the 2012-17 period (1 July 2012 to 30 June 2017).

Aurora has developed a model, "Consumption forecast PD – 7 APR11.xls" to project energy consumption forecasts adopting growth rates to forecast annual energy over the forecast period for each Customer class, namely:

- Residential
- Small Business (LV)
- Medium Business (LV)
- Large Business (HV)
- Irrigation
- Unmetered Supplies (UMS) and street-lighting

The various tariffs that apply to each Customer class have been aggregated.

These forecasts include separate growth factors for both winter and summer, for Low, Medium and High cases and 10%, 50% and 90% POE levels to account for both weather variations and economic factors, which are applied to the aggregated tariff class.

ACIL Tasman has recently undertaken a bottom-up load forecast study (maximum demand in MW) for Aurora's terminal and zone substations, which has been reconciled to a system level forecast prepared by NIEIR.

For this current assignment, ACIL Tasman has been asked to both review and audit Aurora's energy forecasting model and associated report. We note that a complete review requires an outline of the best practice approach to energy forecasting, followed by an evaluation of Aurora's methodology against these principles. In the event that shortfalls were identified, we would then provide constructive comment on how the forecasts could be improved.

We do not endorse the approach of using the growth rates from NIEIR's demand study as appropriate for an energy forecast, which should be done independently. The aggregated tariff classes do not allow for an understanding of how customers will switch over time between fixed and ToU tariffs.

2 Historical data

Tariff classes have been aggregated to ensure forecasts provide a high level outcome in establishing trending and to minimise any effects of small customer numbers within individual Tariff classes. Aurora has historical energy data by Customer class, derived from aggregating the relevant tariffs, from 2002/03 to 2009/10 as shown in Table 1. This is for Aurora's network only and does not include load connected directly to Transend's transmission network eg. Comalco's Bell Bay aluminium smelter.

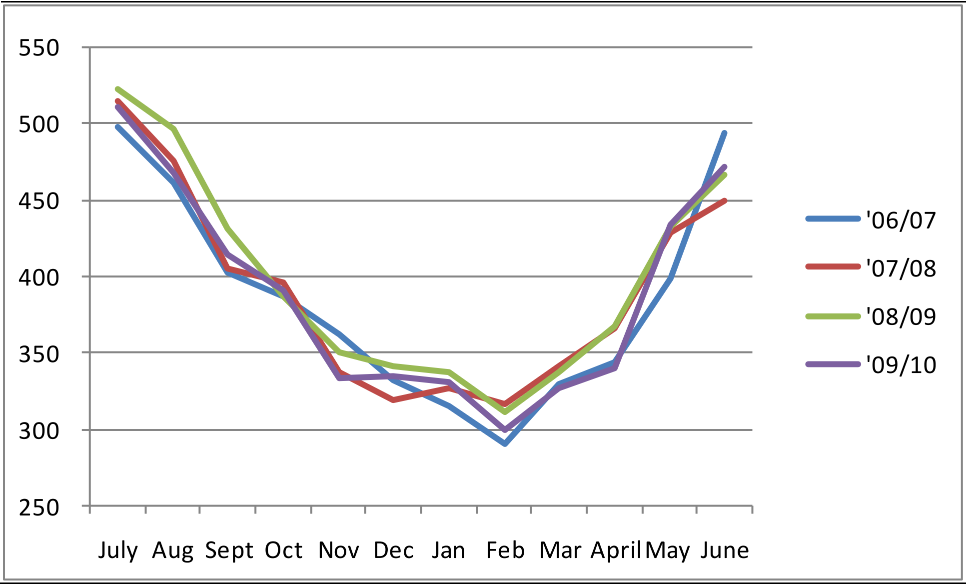
Table 1 **Historical energy data (kWh), 2002/03 to 2009/10**

Summary data	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
Residential (inc PAYG)	1,923,057,637	2,092,323,430	2,072,904,144	2,108,331,074	2,148,339,336	2,108,660,393	2,162,721,886	2,077,408,617
Small LV	762,758,788	798,806,891	807,258,356	818,651,580	842,397,748	853,688,100	905,344,863	935,794,999
Medium LV	462,205,029	491,816,051	487,978,386	503,795,539	517,575,603	540,996,897	568,189,540	537,707,184
Large HV	876,187,523	813,746,915	869,488,559	869,224,333	830,617,787	825,062,873	822,449,679	818,723,561
Irrigation	99,235,868	98,675,231	101,896,435	76,368,014	129,423,522	117,802,627	108,734,335	107,552,982
UMS	35,624,349	36,139,738	36,701,019	36,916,034	36,563,266	37,622,342	37,483,720	36,928,378
Medium case	**4,159,069,193**	**4,331,508,256**	**4,376,226,899**	**4,413,286,574**	**4,504,917,261**	**4,483,833,232**	**4,604,924,023**	**4,514,115,721**
							Actual % increase 02/03 to 09/10 =	**1.18%**

Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

For the past four years, the monthly energy consumption is shown in Figure 1.

Figure 1 **System energy (GWh) by month, 2006/07 to 2009/10**

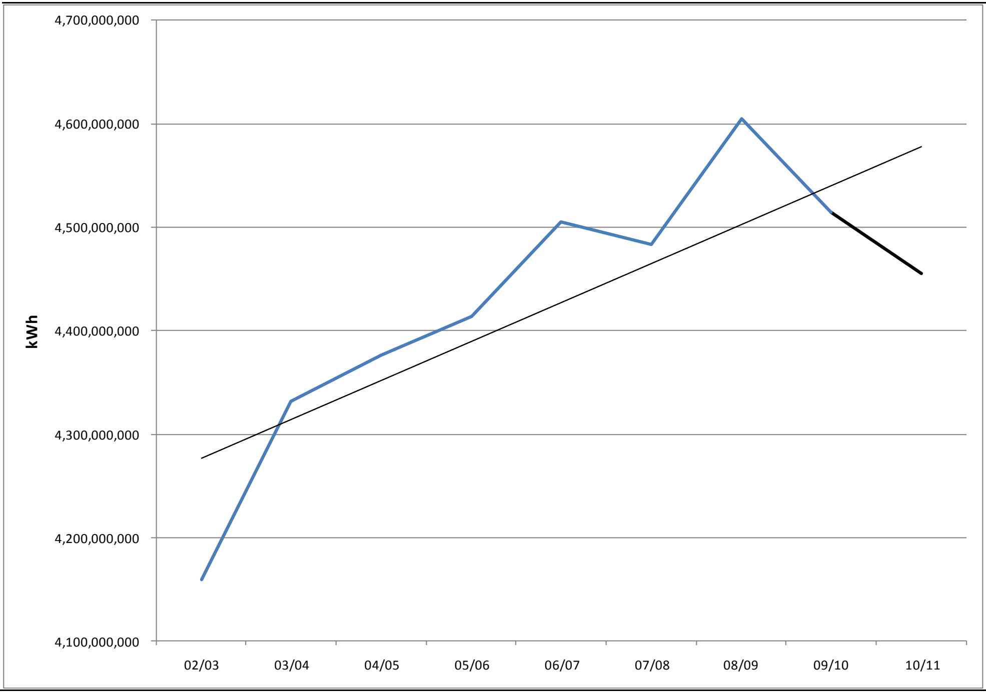


Data source: Aurora

The monthly comparisons over the past four years shows very consistent results with a monthly range generally less than 35 GWh. The system has a winter peak demand (MW) in July and the maximum energy use in each year also occurs in July.

While energy consumption for 2009/10 was below the trend line, lower consumption has continued for the current 2010/11 year (1.3% lower than 2009/10) and the annual estimate (based on data from 8 months to Feb 2011) is 4,455 GWh – a level achieved four years ago – as shown in Figure 2.

Figure 2 **Historical energy data (kWh) to 2009/10, plus estimate for 2010/11**



Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

Energy consumption for the past two years is below trend and reflects moderate weather conditions, particularly during winter when maximum demand and energy use occurs in Tasmania.

2.1 2011/12 estimate

Aurora has revised downwards the estimated energy consumption for 2011/12 to 4,583 GWh, compared to forecast of 4,608 GWh in its previous Regulatory submission. This estimate is relevant as the energy forecast to 2016/17 uses the 2011/12 estimate as the Base Year. We understand this estimate for 2011/12 has not been adjusted for weather normalisation.

The Aurora estimate for 2011/12 is 2.88% higher than for 2010/11. However, when compared to 2009/10, the annual increase reduces to 0.77% pa - compared to the historical average growth of 1.18% pa. This estimate for 2011/12 is less than the long term trend line using data from 2002/03.

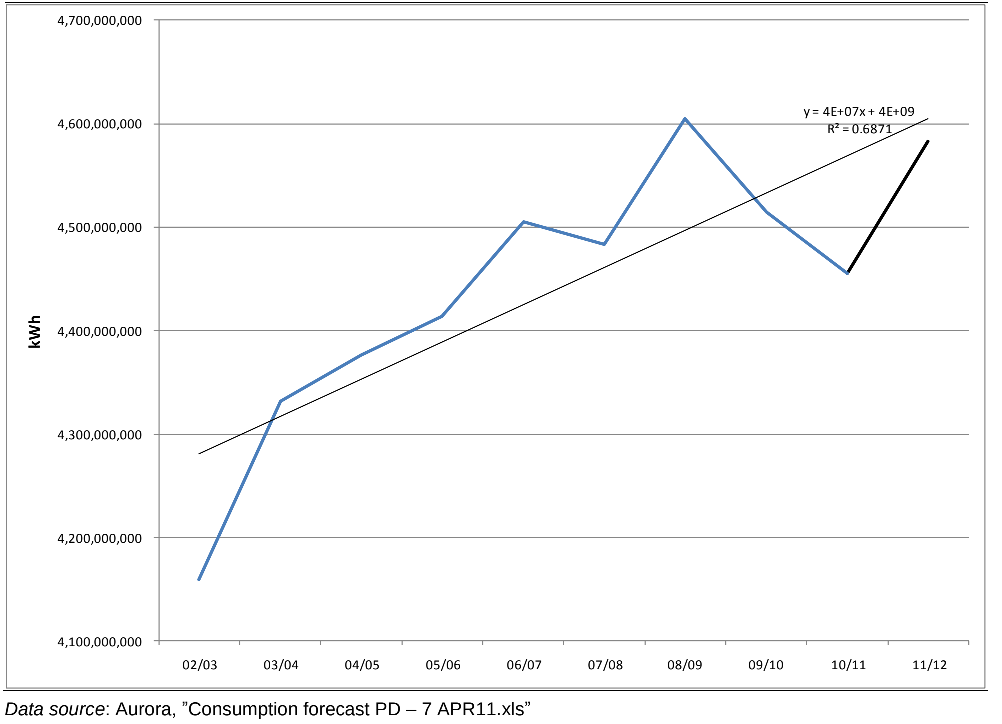
The 2011/12 estimate is shown in Table 2 and Figure 3.

Table 2 **Energy estimate for 2011/12, kWh**

				11/12 estimate	
Summary data	09/10	10/11	11/12	**from 10/11**	**from 09/10**
Residential (inc PAYG)	2,077,408,617	2,069,482,112	2,104,573,905	1.70%	0.65%
Small LV	935,794,999	917,871,940	959,915,063	4.58%	1.28%
Medium LV	537,707,184	518,784,686	537,812,681	3.67%	0.01%
Large HV	818,723,561	830,352,787	838,739,731	1.01%	1.22%
Irrigation	107,552,982	81,900,169	105,573,226	28.90%	-0.92%
UMS	36,928,378	36,882,467	36,882,467	0.00%	-0.06%
TOTAL	**4,514,115,721**	**4,455,274,161**	**4,583,497,073**	**2.88%**	**0.77%**

Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

Figure 3 **Energy (kWh), actual to 2009/10 and estimates to 2011/12**



Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

3 Aurora's methodology

Starting with the 2011/12 estimated data, Aurora has developed a methodology to derive an energy forecast for each Customer class for five years for Medium, High and Low growth cases based on the 50% POE (Probability of Exceedance)[1] level using growth rates from previous work by NIEIR on demand growth.

The respective Winter and Summer annual demand growth rates for each Case for Aurora's distribution network were provided by NIEIR as shown in Table 3 and Table 4 respectively.

Table 3 **NIEIR Winter demand growth rates (MW), 2012/13 to 2016/17**

WINTER - 50 POE Max Demand (MW)	12/13	13/14	14/15	15/16	16/17	Av. Annual growth
High	2.09%	2.18%	2.51%	2.77%	1.95%	2.30%
Medium	0.51%	1.03%	0.97%	1.24%	1.22%	0.99%
Low	-0.06%	0.60%	0.55%	0.33%	0.61%	0.41%

Data source: NIEIR

Table 4 **NIEIR Summer growth rates (MW), 2012/13 to 2016/17**

SUMMER - 50 POE Max Demand (MW)	12/13	13/14	14/15	15/16	16/17	Av. Annual growth
High	2.48%	2.10%	1.11%	0.50%	5.64%	2.37%
Medium	1.24%	-0.09%	1.53%	-0.38%	3.41%	1.14%
Low	-0.01%	0.39%	-0.43%	1.44%	1.53%	0.58%

Data source: NIEIR

The average growth rate of 1.07% pa for the Medium case, averaged over Summer and winter forecasts, is comparable to the historical growth rate of 1.18% pa.

We note that AEMO's Tasmanian energy forecast[2] is considerably lower with an average growth of 0.46% pa for the five year forecast period[3]. This is partly explained due to the total State system having current demand of around 11,500 GWh, while Aurora's network only supplies around 40% of total demand, with the balance of energy supplied directly via Transend's HV

[1] Probability of Exceedance levels (POE):

- 50th percentile: temperature met once in every two years (50% POE)

[2] AEMO's 2010 Electricity Statement of Opportunities, pp57-8

[3] In contrast, winter MD has an annual growth forecast of 0.84%

transmission network. If the non-Aurora supplied load has little or no growth[4], then the effective load for the Aurora-supplied load increases to 1.16%, based on AEMO's forecast for Tasmania.

3.1 Approach

For each Case, Aurora has used the annual Winter NIEIR demand growth rate to produce their energy forecast (Table 3 above) for the following Customer classes:

- Residential (incl PAYG)
- Small Business (LV)
- Medium Business (LV)

Therefore, in the Medium growth case the average growth rate over the forecast period is 0.99% pa (compared with 2.30% pa and 0.41% pa for the High and Low growth cases respectively).

For Large Business (HV), no growth is forecast and the 2011/12 estimate of 839 GWh is constant over the forecast period.

For Irrigation, growth is forecast using the average annual Summer NIEIR growth rate of 1.14% pa (Table 4), using the rationale that most of the demand for water pumping occurs during summer when there is less rainfall and therefore pumping is required to maintain agricultural output).

For UMS/street-lighting, an annual growth rate of 1.57% is used, based on internal analysis by Aurora to derive UMS and forecast demand for street-lighting.

[4] Assumes other loads are for industrial customers with very high load factors ie. average demand is close to maximum demand

3.2 Results

The annual energy forecast (kWh) for the Medium growth case over the forecast period is shown in Table 5 and Figure 4.

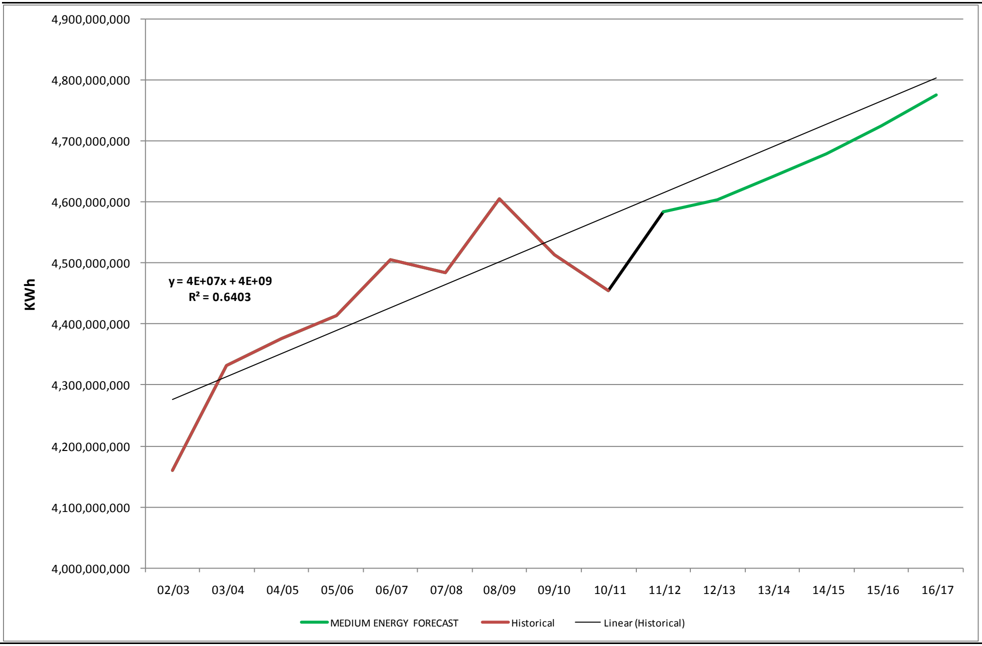
Table 5 **Energy forecast (kWh), 2012/13 to 2016/17 – Medium case**

	ENERGY FORECAST				
Summary data	12/13	13/14	14/15	15/16	16/17
Residential (inc PAYG)	2,115,315,121	2,137,149,723	2,157,927,812	2,184,692,808	2,211,281,719
Small LV	964,814,228	974,773,187	984,250,260	996,458,015	1,008,585,456
Medium LV	540,557,541	546,137,258	551,446,988	558,286,641	565,081,295
Large HV	838,739,731	838,739,731	838,739,731	838,739,731	838,739,731
Irrigation	106,880,506	106,784,180	108,421,721	108,008,896	111,696,803
UMS	37,462,675	38,066,063	38,669,450	39,272,837	39,876,224
Medium case	4,603,769,803	4,641,650,141	4,679,455,962	4,725,458,927	4,775,261,228

Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

Note that while average network growth is 38 GWh pa over the forecast period, it is 21 GWh for 2012/13 as the growth rate is only 0.51% (Table 3).

Figure 4 **Energy forecast (kWh), 2012/13 to 2016/17 – Medium case**

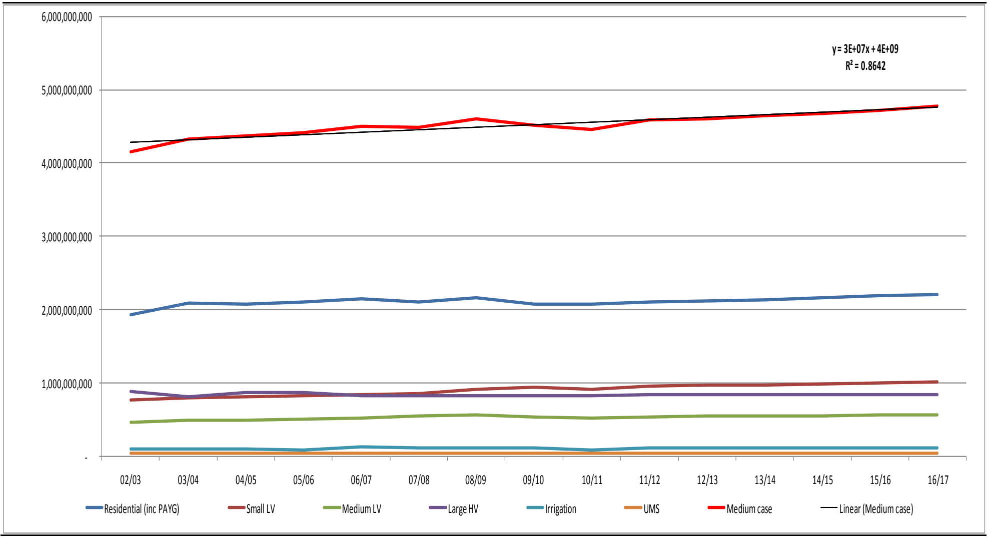


Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

The proposed average annual growth for Aurora's network of 0.82% pa for the forecast period compares to 1.18% pa for the period 2002/03 to 2009/10. The forecast energy consumption is below the trend line for the historical data for 2002/03 to 2010/11 (correlation coefficient or R^2 of 0.64). We note that the historical growth is dramatically reduced to an average 0.69% pa if 2003/04 is the starting year rather than 2002/03.

For this Medium case, the historical and forecast energy consumption from 2002/03 to 2016/17 by customer class is shown in Figure 5.

Figure 5 **Historical and forecast energy (kWh), 2002/03 to 2016/17 – Medium case**

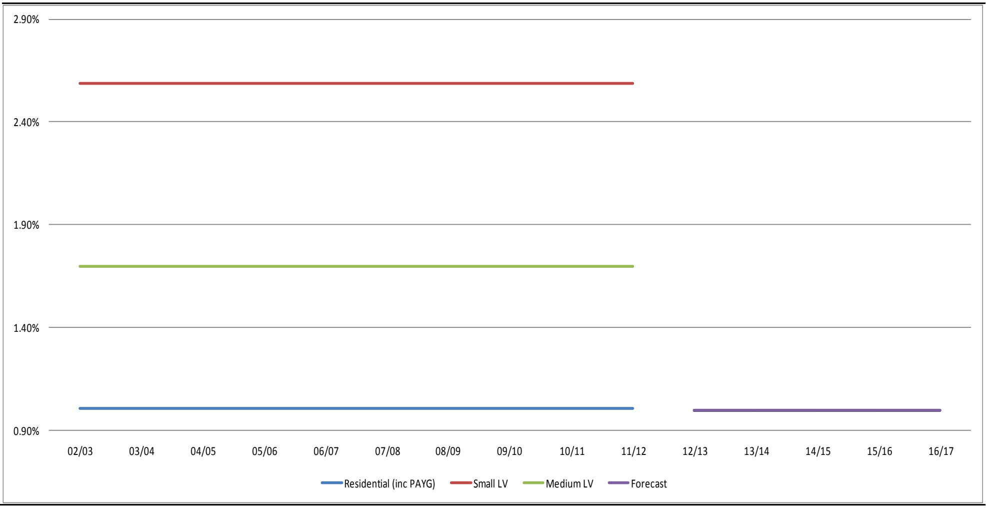


Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

For this Medium growth case, the overall regression line for the total period to 20116/17 has a correlation coefficient or R^2 of 0.864, which suggests growth is reasonably linear. Assuming that Large Business (HV) demand is constant over the forecast period, overall growth is driven by demand in the three major Customer classes, namely Residential, Medium Business and Small Business, which account for around 3,600 GWh of demand or 79% of total in 2011/12 - increasing to 3,784 GWh in 2016/17. Aurora's total growth for the medium case in energy consumption over the forecast period is 192 GWh, compared to AEMO's forecast of 268 GWh for the same period.

There is a significant issue in applying the single growth rate (NIEIR Winter) to the above three major Customer classes. For the Medium case this single forecast growth rate of an average 0.99% pa can be compared to the historical growth for the period, 2002/03 to 2011/12, as shown in Figure 6.

Figure 6 **Historical and forecast average growth rates by Customer class - Medium case**



Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

Despite all three Customer classes having historical average growth rates above 1.0% pa, the forecast average growth for the forecast period is only 0.99% pa. We note Aurora's comments of a flat economic outlook and lower GSP/GDP, as advised by the Tasmanian Department of Treasury and Finance.

While the historical average growth of 1.01% pa for Residential customers is comparable to the assumed forecast average growth of 0.99% pa, this is not the case for both the Medium and Small Business customers with historical average growth rates of 1.70% pa and 2.59% pa respectively. Therefore, even if the overall energy forecast appears reasonable, the single growth rate forecast applied to all Customer classes is considered inappropriate.

Aurora's energy forecast for all three cases (Medium, High and Low) is shown in Figure 7.

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Figure 7 **Aurora energy forecast (kWh), 2012/13 to 2016/17 by case**

Data source: Aurora, "Consumption forecast PD – 7 APR11.xls"

While the Low case forecast reaches 4,663 GWh in 2016/17 (2.34% less than 4,775 GWh for Medium case), the High case forecast of 5,033 GWh is 5.41% higher than for the Medium case.

3.3 Discussion

Aurora revenues are to a large extent based on per unit energy usage charges. These revenues are regulated within an overall cap, with per unit tariffs set for a number of network tariffs such that the overall forecast revenues fit within the cap. Hence the energy forecast is a fundamental element in determining the unit pricing ($/kWh) for each tariff. In the event that the energy forecast lacks accuracy, the actual revenues could be significantly different to the forecast revenues with potentially corporate wide implications.

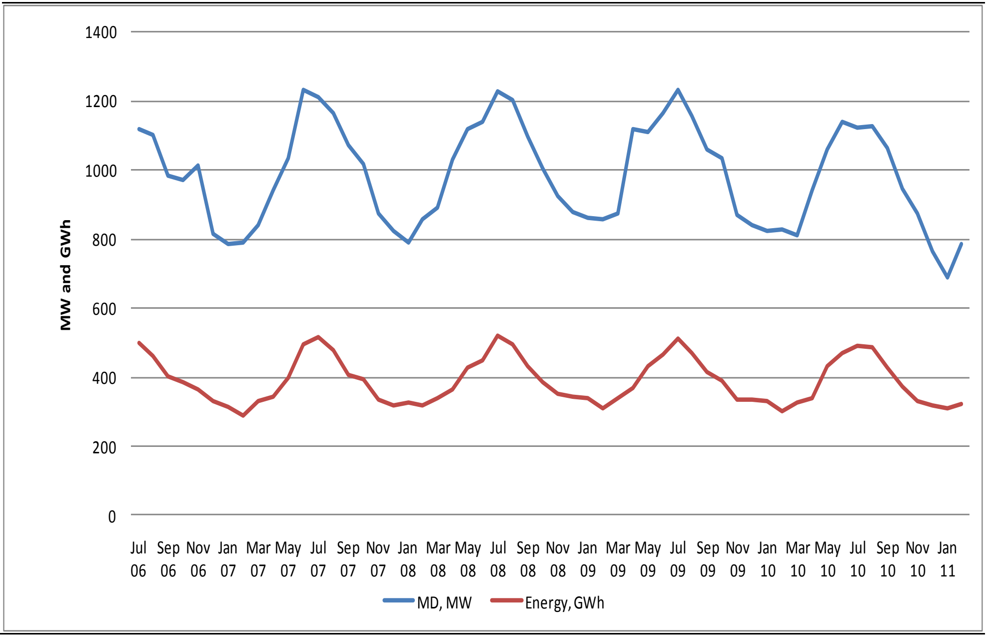
It is not enough to produce a system level energy forecast which is reasonably accurate as any approved tariff increases will be applied to specific energy forecasts within Customer classes and annual revenues could be considerably different and potentially detrimental to Aurora.

The methodology adopted by Aurora has several issues that need to be reviewed. We have previously supplied Aurora with detailed commentary on the key principles that should be followed to develop "best practice" in energy forecasting and these are included in Appendix A.

While the network demand forecast by NIEIR is sophisticated and incorporates weather normalisation and economic impacts, it is simplistic to adopt these same growth factors for an energy forecast, particularly when applied uniformly to different customer classes. In doing so, there is an implicit assumption that the relationship between energy and demand for all Customer classes remains constant over time.

A comparison of monthly energy (GWh) and maximum demand (MW) since July 2006 is shown in Figure 8.

Figure 8 **Monthly demand and energy, from July 2006**



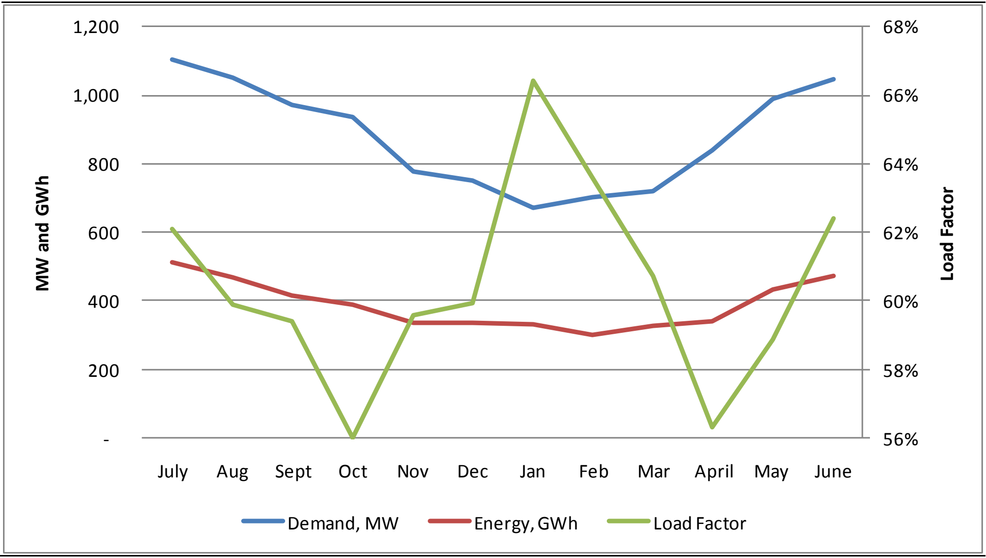
Data source: Aurora

There is some correlation between energy and demand but not enough to allow for accurate forecasting of energy from a demand growth forecast, as adopted by Aurora.

In fact, the load factor[5] varies considerably each month as shown in Figure 9 for 2009/10.

[5] Defined as average energy in MWh divided by maximum demand (MW) for period (month or year)

Figure 9 **Demand, energy and load factor by month, 2009/10**

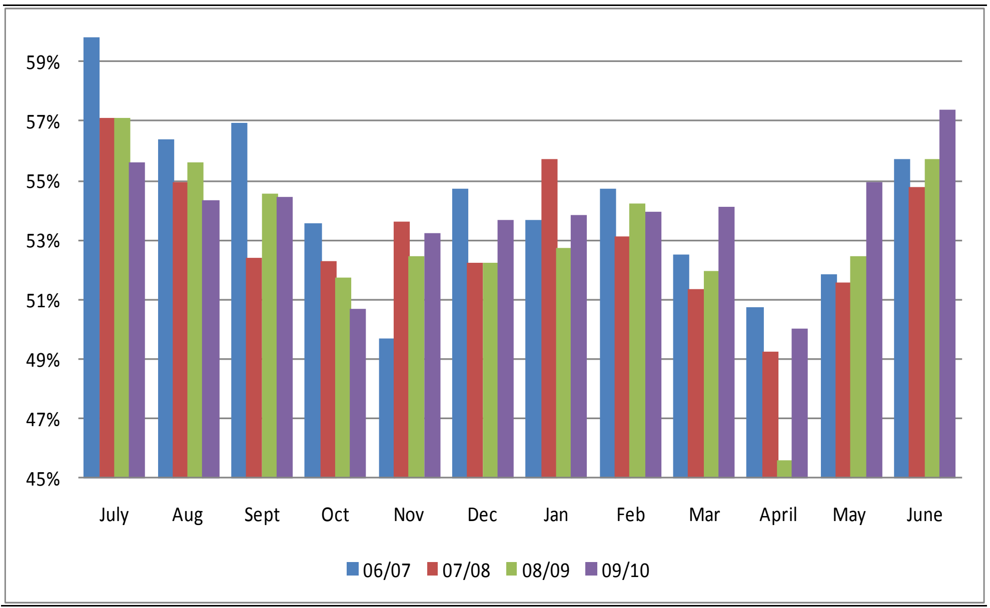


Data source: Aurora

The load factor varies from 56% in October to 66% in February. While energy loosely tracks demand over the year, there is *not* a direct relationship that allows for demand growth to be used as a defacto energy growth measure.

For the four years, 2005/06 to 2009/10, the monthly load factor is shown in Figure 10.

Figure 10 **Monthly load factor, 2005/06 to 2009/10**



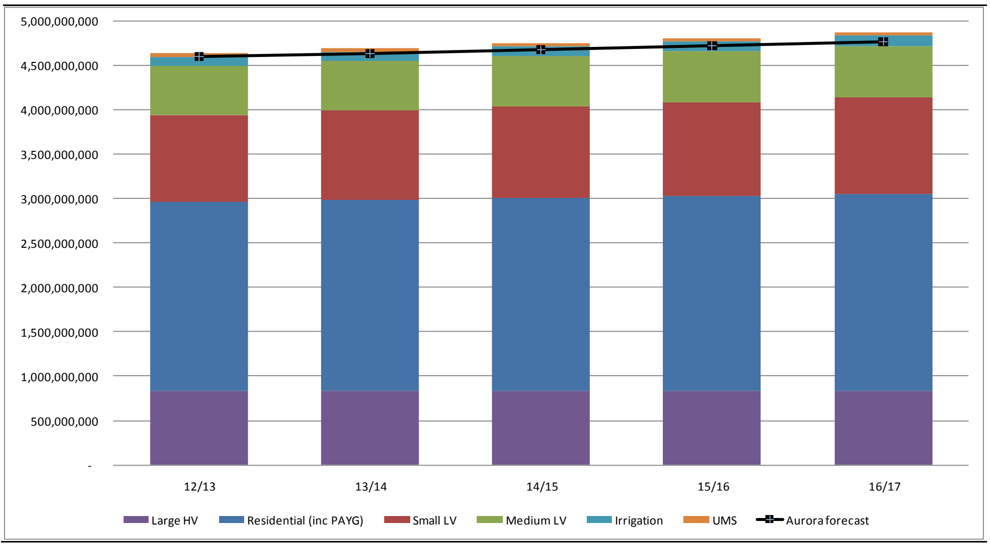
Data source: Aurora

This analysis shows the variability of load factor between years and confirms that the basic assumption underpinning Aurora's energy forecast, based on an assumed demand growth, is inappropriate and is not a recommended methodology for forecasting energy consumption.

While the overall network result for Aurora appears reasonable, the application of the same growth rate for the three major customer classes (Residential, Medium and Small Business) is not considered appropriate and there is only a tenuous linkage between demand growth and energy growth. For example, in AEMO's 2010 Statement of Opportunities[6], average demand growth for the Winter 50% POE Medium growth case for the forecast period is 0.84% pa and energy growth is only 0.46% pa. This is further evidence that there is not a high correlation between and demand and energy growth rates.

Without regard for the projected economic slowdown for the forecast period to 2016/17, a time series forecast for each Customer class based on the respective historical average growth rates for the nine years to 2011/12 (Figure 6 in Section 3.2) for the Medium case would result in the forecast as shown in Figure 11.

Figure 11 **Energy forecast by Customer class using historical average growth rates – Medium case**



Data source: ACIL Tasman

This forecast results in higher energy in 2016/17 of 4,879 GWh or 104 GWh higher (2.17%) than Aurora's forecast (4,775 GWh). While it is accepted that this higher energy forecast does not incorporate Treasury's projected economic decline, and ACIL Tasman is not promoting it as a best practice forecasting approach, it has the advantage of incorporating actual history which provides some guidance for the future, rather than a reliance on demand growth which

[6] Ref: pp59-60

is not a reliable predictor of energy growth. However, as the energy consumption over the past two years has been less than trend, it would be inappropriate to use the historical trend growth from 2002/03 to 2010/11 to forecast energy consumption for the five year period, 2012/13 to 2016/17.

However, it would clearly be preferable to apply an econometric approach using population and/or economic growth as explanatory variables for the various Customer classes.

The possible growth factors to be adopted to develop the energy forecast can be guided by the data in Table 6.

Table 6 **Growth rates by Customer class**

Customer class	NIEIR Winter demand growth	Historical growth	Treasury growth
Residential	0.99%	1.01%	
Small Business	0.99%	2.59%	
Medium Business	0.99%	1.70%	

Even if there was a strong correlation between demand and energy growth rates, there is no rationale for using only NIEIR's Winter average growth forecast and an average of both Summer (1.14% pa) and Winter (0.99% pa) forecasts or 1.07% pa would be more reasonable. If this average demand growth was adopted, the overall energy forecast would increase by 15 GWh to 4,790 GWh in 2016/17 – equivalent to a 7.8% increase in energy consumption over the forecast period.

3.3.1 ACIL Tasman response

ACIL Tasman endorses an approach which segments overall network sales by customer type for which separate forecasts are produced and then added together to obtain a forecast for overall system energy. The rationale for this is because the drivers of energy growth between customer segments are expected to differ:

- The domestic or residential sector is likely to be closely correlated with population growth and household formation.
- Growth in energy sales to the industrial sector is more likely to be driven by overall economic growth.

- Analysis of growth in the commercial sector indicates that it is likely to be more closely correlated with a combination of both economic and population growth.

For this reason, a forecasting methodology that models the separate customer types independently is likely to produce a superior set of forecasts than one which models the entire system in a single model. Also, some consideration should be given to splitting the forecasts into average usage per customer and the number of customer numbers, particularly for the residential and commercial sectors, where there is a high degree of homogeneity between customers. This enables the model to consider the drivers that influence customer numbers separately from those that influence consumption patterns of the average residential/commercial connection.

It should be noted that the impact of any other likely policy impacts in the forecast period (environmental, Governmental etc) have not been incorporated into Aurora's forecast. The impacts of new policy initiatives should be estimated by analysing the impact of similar policies introduced in other jurisdictions, both within Australia and internationally, by considering the results from organised scientific trials on a subset of the population to be affected by the new policies, or through a first principles analysis of the likely impact. The impact of each relevant policy factor should be estimated for the forecast period and the base energy forecast adjusted accordingly.

It is in relation to policy impacts that using the demand growth rate is particularly problematic as new policy impacts are likely to affect energy very differently from demand. ie. they may reduce energy considerably without affecting the peak demand very much. This will depend on the behavioural assumptions that are made when trying to quantify the policy impacts.

A Principles for best practice energy forecasting

This section considers the principles that any forecasting methodology should adhere to in order to be considered best practice.

Accuracy

Any credible forecasting methodology must include the ability to measure the forecasts accuracy, and the level of accuracy must fit within acceptable limits. Where the accuracy is measurable and is acceptable for the purpose at hand, the network planners confidence should be enhanced in planning the augmentation of their network. A forecasting process that delivers inaccurate or less accurate forecasts will make the task of the network planner more difficult. Greater uncertainty arising from an inaccurate forecasting methodology will also increase the cost of the network by requiring a larger buffer to reduce the risk of insufficient capacity from any unforeseen event.

Hence a key aspect of any forecasting methodology is that it should meet minimum accuracy requirements. All models will include errors by nature of the fact that they are an approximation of the real world and these errors will limit the model's accuracy. In order to assess the model accuracy, its forecasting performance should be assessed using both in-sample and out of sample tests.

In particular energy forecasts are used to establish per unit tariffs in order to recover the approved regulated annual revenues for each distribution business. In this practical sense the model errors need to be clearly understood as they potentially will be reflected in similar proportional variations in actual revenues when compared with forecast revenues.

Unbiasedness

An unbiased forecast is one which does not consistently over or under-predict the actual outcomes the methodology is trying to forecast. Forecasting bias can be avoided or at least minimised by careful data management (e.g. removal of outliers, data normalisation etc.) and forecasting model construction (choosing a parsimonious model which is based on sound theoretical grounds and which closely fits the sample data). In the event that a forecasting methodology consistently results in biased forecasts, it may be possible to adjust the forecasts by the amount of the estimated bias to remove the bias from the forecasts.

Transparency and repeatability

A transparent forecasting process is one that is easily understood and well documented.

To achieve this any documentation needs to set out and describe clearly the data inputs used in the process, the sources from which the data are obtained, the length of time series used, and details of how the data used in the methodology are adjusted and transformed before used.

The functional form of any specified models also need to be clearly described, including:

- The variables used in the model
- The number of years of data used in the estimation process
- The estimated coefficients from the model used to derive the forecasts
- Details of the forecast assumptions used to generate the forecasts

The process should clearly describe the methods used to validate and select one model over any others. Any judgements applied throughout the process need to be documented and justified. Adjustments to forecasts that are outside of the formal modelling process that are not documented with a clear rationale justifying that course of action should be avoided. It is therefore crucial that any informal adjustments are documented and justified.

The methodology should be systematic so that any a third party that follows a series of prescribed steps will be able to replicate the results of the forecasting methodology.

Parsimony

The selected model should be as simple as possible for a given level of performance – i.e. parsimonious. This allows the model to focus on explaining the key drivers and also tends to minimise model error – i.e. including less relevant terms in the model can increase model error.

Hence model specifications that are more complex but do not significantly outperform simpler specifications should be rejected in favour of the simpler formulations. By following this principle and minimising unnecessary complexity, the forecasting approach is also more transparent and repeatable than it otherwise would be.

Effective management and selection of data

The forecasting methodology requires effective management of data used in the process. This means keeping a central repository of all the data series utilised in the forecasting methodology in one or more electronic files (most probably Excel spreadsheets).

ACIL Tasman envisages a number of electronic directories being established which would split the data into categories depending on the type of data involved (for example demographic, economic, energy and temperature data) and the extent to which it has been processed.

The Excel spreadsheet files in which the data are contained should be clearly labelled and contain detailed descriptions of the data sources- including links to the relevant websites from which the data has been obtained.

Selection of which data series to use will depend on their:

- Reliability and accuracy
- The reputation of the data source
- The degree of completeness of the data and the absence of significant gaps
- The consistency of the data series through time
- The extent to which they cover a sufficiently long time series

Incorporating key drivers

Any forecasting methodology should incorporate the key drivers either directly or indirectly. This includes the demographic, economic, weather and appliance drivers.

This could potentially include:

- Economic growth
- Population growth
- Growth in the number of households
- Real electricity prices
- Weather data
- Growth in the number of heating systems
- Technology trends

By explicitly incorporating the key drivers, rather than using linear trends, the methodology will have the flexibility to adjust to forecast changes in the drivers that are not necessarily reflective of the past.

Weather normalisation

While weather correction is of major importance in modelling maximum demand due to the fact that a single very cold day can lead to a significant peak, in the case of energy a single cold day leads to very little change in overall annual energy sales. However energy sales can be affected where a year experiences a larger than normal number of hot or cold days in the course of a year. To the extent that a relationship can be identified, it is possible to weather correct energy sales, and generate a distribution of forecasts as we do for demand (i.e. could report 10% POE and 50% POE energy forecasts).

While a single hot or cold day will make only a small contribution to energy sales over a whole year, any measure of weather that attempts to explain energy sales will need to capture the degree to which the summer and winter seasons have been hot or cold on average rather than on a single or small number of days. We do this by introducing the concept of heating degree and cooling degree days.

In the case of energy, the heating and cooling degree days are an aggregate measure to characterise the accumulated nature of weather over the annual cycle. This means using an aggregate measure around an inflexion point more correctly captures the nature of weather on an aggregated basis.

For heating degree days (HDD), the measure works by summing up the total number of degrees Celsius over the financial year, where the average temperature was below 18 degrees. On days where the average temperature is above 18, that day contributes zero to the number of heating degree days.

Heating degree days therefore capture the extent to which a given season was cold on average.

Logical and coherent model structure

Any models specified as part of the forecasting methodology should have a logical and coherent structure. This means that the explanatory variables should have a clear theoretical justification for inclusion in the model and that the estimated coefficients in any calibrated model should have theoretically correct signs. In other words, they should impact on energy sales in the direction expected by our knowledge of the theoretical relationships involved.

Robustness of model to yearly variation

Models may be derived that have high explanatory power in one year but that have poor explanatory power over time. This is particularly the case where model bias is introduced because of too short a time series or where non-linear changes occur in key drivers. These shortcomings can be overcome by choosing an adequate time series and incorporating non linear relationships as variables in the model.

Model validation

Models derived and used as part of any forecasting process need to be validated and tested. This is done in a number of ways;

- Assessment of the statistical significance of explanatory variables
- Goodness of fit
- In sample forecasting performance of the model against actual data
- Diagnostic checking of the model residuals
- Out of sample forecast performance

Documentation

Crucial to any forecasting methodology is detailed and thorough documentation of the process. The documentation needs to:

- Be clear and concise
- Have clearly defined and outlined processes
- Specify all data requirements and sources
- Define individual responsibilities

Well documented processes aid the transparency and repeatability of the forecasting methodology. Well developed documentation also mitigates the risk of any key individual involved in the process departing the organisation without undergoing a transfer of knowledge and expertise to other individuals within the organisation.