Final Report to

Australian Energy Regulator

Review of TransGrid demand forecasts for the period 1 July 2009 to 30 June 2014

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EXECUTIVE SUMMARY

Review of TransGrid Demand Forecasts

The Australian Energy Regulator (AER) is to undertake an assessment of the appropriate revenue required by TransGrid in its provision of prescribed transmission services (revenue determination) over the period 1 July 2009 to 30 June 2014. Demand forecasts play a significant role in determining the required capital expenditures in such a review. The AER has asked McLennan Magasanik Associates (MMA) to review the network level demand forecast methods and processes used by TransGrid in preparing its proposed capital and operating expenditures over the 2009 – 2014 period.

The key forecasts reviewed by MMA are the medium scenario energy sent out forecasts and the medium scenario peak demand forecasts contained in the TransGrid 2007 Annual Planning Report (APR 2007). TransGrid has relied on the forecasts produced in the APR 2007 for its capital expenditure and revenue submissions to the AER. These forecasts were prepared around May 2007. TransGrid has argued that it requires a substantial period of time to prepare for its capital expenditure forecasts for the AER review and that the time available after the production of the 2008 forecasts would not be adequate for this.

MMA notes that since mid 2007, there have been a number of significant developments which are likely to have changed significantly the key assumptions which underlie the APR 2007 forecasts. MMA notes that these developments may have an impact on the demand forecast outcomes of the 2007 APR models and, as such, are relevant to the AER's assessment of TransGrid's revenue proposal.

MMA review of TransGrid methods and models

MMA has carried out a desk-top review of TransGrid's models and methodologies, taking into account previous reviews on the TransGrid processes, models and methodologies carried out by KEMA in 2004 and 2007. MMA has been provided with a copy of the models used by TransGrid and has also had the opportunity to ask TransGrid a number of questions.

There are three components to the TransGrid methodology, Energy Model, Peak Demand Models and Weather Correction and MMA has assessed each in turn.

Energy Model

The Energy Model[1] evaluates energy generated, energy sent out and energy supplied for the region as a whole, on a monthly basis. It takes as key inputs historical energy and historical and forecast income per capita, electricity and gas prices and interest rates as well as weather and calendar variables. According to the model, the two main drivers of

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1 Actually three models with identical structures of different parts of the electricity supply system.

forecast long-run energy use for the region are income (modelled as GSP per capita) and electricity prices.

KEMA found the functional form of the Energy Model to be suitable and the variables used to be appropriate. On the whole MMA also considers this to be the case.

MMA is concerned, however, that the APR 2007 forecasts were framed before some very significant changes to the macro-economic environment, such as the sub-prime crisis with associated "credit crunch" and market volatility were able to be factored in. Indicative MMA analysis suggests that if these are fully factored in this might reduce energy growth rates by some 0.2% pa.

Weather correction

Weather correction is vital for estimating historical load at different POE levels. The APR 2007 weather correction methodology is different from that used by TransGrid in the past and uses simulated modelling of loads for each half hour of the day, i.e. involves 48 models for each year. KEMA has reviewed the TransGrid weather correction methodology and considers it to be thorough, systematic and appropriate to use.

However, while agreeing that the direction being pursued by TransGrid is appropriate, MMA has some reservations about the actual methodology used and its outcomes. The approach produces material differences between the cooling degree-day (cd) sensitivity coefficients on different days of the week, e.g. Monday and Tuesday, for which there is no apparent real underlying cause, and the day of the week having the highest coefficient varies from year to year. The simulation outputs confirm that this results in biases towards the peak demands in each year occurring on the day with the highest cd coefficient, for example on Tuesdays in 2007 and Mondays in 2006, contrary to what one would expect from a random process. While the APR 2007 results are not considered unreasonable because of this, MMA considers that the approach taken needs further validation.

Peak Demand models

The Peak Demand models relate weather normalised summer and winter peak demand, (specifically 10% PoE, 50% PoE and 90% PoE peak demand) derived using the weather correction models, to average energy outputs from the Energy Model (which indirectly captures the impact of economic and price factors on peak demand) and to a factor which captures the impacts of air-conditioning growth. A simple linear relationship is assumed between peak demand and average demand and air-conditioning ownership. MMA estimates that the projected air-conditioning index growth accounts for 78% of the 10% PoE summer peak growth. The winter peaks are all driven primarily by growth in average demand.

The air conditioning index used by TransGrid causes most concern to MMA. It was derived by TransGrid for APR 2007 but does not appear to be related to any actual data relating to air-conditioning penetration, such as that published by the ABS[2] and used by EES[3] in its report on air-conditioning in Australia. The use of an ac index related to actual data is considered essential and MMA considers that it would have a material impact on the 10% POE summer MD. This, together with correcting the mis-specification of a variable in the model may well change the summer MDs forecast by of the order of 500 MW over the period of concern and reduce the overall growth rate in 10% POE summer MD from the forecast 2.5% pa to 2.1% pa over the period 2005/06 to 2013/14, closer to the rate of growth of energy. The effect of reducing forecast energy consumption by (say) 0.2% pa would be expected to further reduce expected growth.

Reasonable expectation of a realistic outcome

MMA is required to provide advice to the AER as to whether or not it is satisfied that the methods and processes used by TransGrid to develop the demand forecasts used for its revenue proposal would reasonably reflect a realistic expectation of the demand forecast.

While MMA has issues with some areas of TransGrid's forecasting methodology, detailed in the report, overall it considers the methods and processes adopted by TransGrid to be appropriate, well-considered and reasonable. MMA has throughout the report recommended changes to the methodology in a number of areas, including re-consideration of the weather correction model which may result in anomalous results and re-specification of a mis-specified variable in the peak demand models.

MMA's main concerns lie with the fact that the inputs into the models may now be out of date as significant changes have taken place to factors such as the macro-economic environment since the APR 2007 was prepared about a year ago. This, together with use of a more appropriate ac index, might, in combination, be expected to reduce forecast annual growth in summer 10% POE MD from the 2.5% pa forecast by TransGrid to closer to 2.1% pa between 2006 and 2014.

While MMA does not necessarily consider the TransGrid APR 2007 forecasts unrealistic in light of the information available at the time, MMA considers a reduced growth rate to be more realistic in light of the new information and use of a more appropriate ac index.

If the APR 2007 forecasts are to be used for the review of capital expenditure forecasts for the 2009-2014 period then MMA's analysis suggests that a conservative approach to capital expenditure requirements is warranted. If the timing of a capital requirement is "on the margin" then MMA would expect that the timing should be assumed to take place later, rather than earlier. TransGrid's APR 2008 should become available within the period of the AER revenue review. If the major methodological recommendations provided within this report have been acted upon, the forecasts provided within APR 2008 may provide further guidance to the AER and its capital expenditure consultants.

[2] ABS 4602.0 reports ac penetration from surveys undertaken in 1994, 1999, 2002 and 2005. ABS 4621.1 reports ac pentration from a single survey undertaken in NSW in 2006.

[3] Energy Efficient Strategies, "Status of air-conditioners in Australia – Updated with 2005 data"., January 2006.

Recommendations related to modelling

MMA has in the main body of the report made a number of recommendations related to the TransGrid forecasting methodology.

1 INTRODUCTION

1.1 Role of the AER in economic regulation of TransGrid

The Australian Energy Regulator (AER) is responsible, under the National Electricity Law (NEL) and National Electricity Rules (NER), for the economic regulation of electricity transmission services provided by transmission network service providers (TNSPs) in the National Electricity Market (NEM).

In respect of prescribed services provided by TNSPs, the AER makes determinations according to Chapter 6A of the NER. The AER's principal task is to set the revenue that a TNSP can receive for the provision of such services.

The AER is to undertake an assessment of the appropriate revenue required by TransGrid in its provision of prescribed transmission services (revenue determination) over the period 1 July 2009 to 30 June 2014 (2009–2014 period).

1.2 Importance of demand forecasts

Demand forecasts play a significant role in determining the required capital (and to a lesser extent operating) expenditures applying to a TNSP. Capital and operating expenditures, in turn, are major inputs into the revenue required by TransGrid over the 2009 to 2014 period.

TransGrid's energy and maximum demand models are used as a basis for developing demand forecasts for its revenue proposal. The maximum demand forecasts are used to determine the future capex requirements for the main system network.[1]

The AER must accept forecasts of required capital and operating expenditures if the AER is satisfied that, among other things, the total of forecast expenditure reasonably reflects a realistic expectation of the forecast demand for prescribed transmission services and associated objectives in the NER.[2]

1.3 Review of demand forecasts

The AER has engaged McLennan Magasanik Associates (MMA) to review the network level demand forecast methods and processes used by TransGrid in preparing its proposed capital and operating expenditures over the 2009–2014 period.

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1 TransGrid advised the AER on 8 February 2008 that, at this stage in developing the revenue proposal, TransGrid believed that about 30 per cent of the capital requirements of its revenue proposal will be based on main system planning.

2 Those objectives include: meet the expected demand for prescribed transmission services; comply with all applicable regulatory obligations associated with the provision of prescribed transmission services; maintain the quality, reliability and security of supply of prescribed transmission services; and maintain the reliability, safety and security of the transmission system through the supply of prescribed transmission services.

MMA is required to undertake a desktop review to inform the AER on the reasonableness of TransGrid's demand forecast methods and processes. This will assist the AER in forming an opinion as to whether TransGrid's revenue proposal reasonably reflects a realistic expectation of the demand forecast. In particular, the consultant must have regard to the methods used by TransGrid to develop maximum demand forecasts. This will assist the AER in considering TransGrid's proposed capital expenditure requirements (capex).

1.4 Forecasts reviewed

Each year TransGrid conducts an Annual Planning Review and produces an Annual Planning Report (APR). The forecasts contained in the APR produced by TransGrid for 2007 (APR 2007) are those relied upon by TransGrid for the purposes of its capital expenditure forecasts for the 2009–2014 period.

1.5 Terms of reference

In relation to TransGrid's approach to demand forecasting as part of its forthcoming revenue proposal, MMA is required to undertake a desktop review of the methods, inputs and data sources used by TransGrid in its energy, maximum demand and weather correction models. MMA has also been asked to comment on the differences between the methods used for the current review and those used for the previous regulatory review (contained in APR 2004).

MMA is then required to provide advice to the AER (in the form of a report) as to whether or not it is satisfied that the methods and processes used by TransGrid to develop the demand forecasts used for its revenue proposal would reasonably reflect a realistic expectation of the demand forecast.

1.6 Process undertaken by MMA

The review process undertaken by MMA has been based largely on material provided by TransGrid.

TransGrid initially provided MMA with copies of the models, inputs and outputs related to the production of forecasts used in APR 2007. TransGrid also provided MMA with some reference material, including a copy of the KEMA (2007)[3] report, the Frontier Economics report[4] and commentary on the major changes to its forecasting models that have taken place between APR 2004 and APR 2007.

This was followed up with a presentation of the APR 2007 models and methodologies, followed by discussion of key aspects of these.

3 KEMA Inc, "Review of TransGrid's load forecasting methods", final report dated June 12 2007.

4 Frontier Economics, "Review of assessment techniques used for analysis of electricity forecasts in NSW", review prepared for NEMMCO, 16 April 2007

TransGrid has then responded to three sets of questions raised by MMA, following the presentation and then following subsequent review of the models and information provided.

Comments on the draft report from TransGrid related to errors of fact and comments from the AER have been taken into account in the production of the final report and advice to the AER by MMA.

1.7 Report layout

Chapter 2 provides an overview of the TransGrid forecasting methodologies and an initial comparison of the forecasts contained in APR 2007 and APR 2004.

Chapter 3 examines the findings of the two KEMA and Frontier Economics reviews of TransGrid methodology.

MMA's comments on the TransGrid approach, process and methodology are provided in Chapter 4.

The conclusions and recommendations of the review are provided in Chapter 5.

1.8 Conventions adopted

Unless otherwise stated, all years referred to in the report are for financial years ending June 30 of the year stated.

TransGrid has prepared medium, high and low electricity energy and demand growth scenarios. Unless otherwise stated, the medium scenario is referred to.

2 TRANSGRID FORECASTING PROCESSES AND METHODOLOGIES

2.1 Forecasts produced by TransGrid

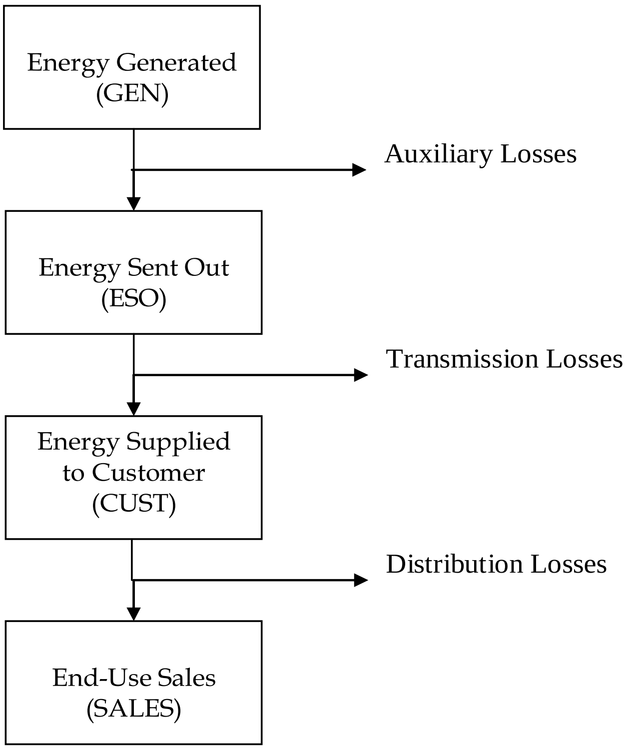
In its APR 2007 TransGrid published the following forecasts on an aggregate basis for the medium scenario for the NSW region:

Energy (GWh)

- Scheduled Energy Sent Out (ESO)
- Scheduled Energy as generated at Power Station (Generator Terminal Basis – GEN)
- Scheduled Energy Supplied at NSW Customers' Connection Points (CUST)
- Scheduled Energy end-use sales (SALES).

Each of these represent flows at different parts of the power system as illustrated in Figure 2-1.

Figure 2-1 Representation of energy forecasts at different parts of the electricity supply system



While the ESO, GEN and CUST forecasts in APR 2007 have been derived directly from TransGrid modelling, the SAL forecasts have been derived after making assumptions about distribution losses and embedded generation.

Maximum Demand

- Summer Scheduled Maximum Demand (MD) on a Generator Terminal basis at the 90%, 50% and 10% Probability of Exceedence (POE) levels for medium, high and low energy usage scenarios.
- Winter Scheduled Maximum Demand (MD) on a Generator Terminal basis at the 90%, 50% and 10% POE levels for medium, high and low energy usage scenarios.

The terms used above are defined in the Glossary.

The above forecasts are of concern to the current review by MMA. Of primary interest are the Maximum Demand forecasts at a 10% POE which use as a key input the energy forecasts at Generator Terminals.

TransGrid also provided in its 2007 APR the summer and winter peak demand forecasts at Connection Point by Distribution Network Service Provider (DNSP). These were not, however, generated by TransGrid but by the DNSPs and are not assessed in this review.

2.2 TransGrid forecasting process and timing

TransGrid owns the majority of the transmission networks in NSW and the ACT (NSW region) and is the Jurisdictional Planning Body (JPB) for NSW. In this latter role TransGrid each year carries out an Annual Planning Review and prepares an Annual Planning Report (APR) by 30 June containing load forecast information for the region. The load forecast information contained in the APR is also included in the Statement of Opportunities (SOO) and Annual National Transmission Statements (ANTS) for the National Electricity Market (NEM) in October. As part of its NER responsibilities, TransGrid is also required to coordinate planning for the region with distributors and this function is also carried out through the Annual Planning Review process.

TransGrid has relied on the forecasts produced in the APR 2007 for its capital expenditure and revenue submissions to the AER. These forecasts were prepared around May 2007. TransGrid has argued that it requires a substantial period of time to prepare for its capital expenditure forecasts for the AER review and that the time available after the production of the 2008 forecasts would not be adequate for this.

Draft inputs for the 2008 APR are currently with TransGrid and being run through the TransGrid models. The 2008 TransGrid forecasts are likely to be produced by end May 2008.

TransGrid has stressed that the forecasts produced for the 2007 APR are produced as part on an on-going process and not produced especially for the sake of the revenue determination for the 2009-2014 period.

2.3 Load Forecasting Reference Group

Information from TransGrid's 2007 APR has been used in the preparation of NEMMCO's Statement of Opportunities (SOO), together with information provided by other JPBs.

Individual JPBs approach the demand forecasting process in different ways but using a common set of high level economic information.

NEMMCO convenes a Load Forecasting Reference Group (LFRG) [5] which has as a main objective ensuring that the JPBs develop their energy and MD forecasts as consistently as possible. TransGrid and the JPBs from other jurisdictions are represented on the LFRG. For the 2007 SOO the high level information including economic and population forecasts provided by the National Institute of Economic and Industry Research (NIEIR). NIEIR also provided other inputs into the SOO including reports about factors affecting electricity demand in the NEM and (together with Greenworld Energy) projections of non-scheduled and exempt generation in the NEM.

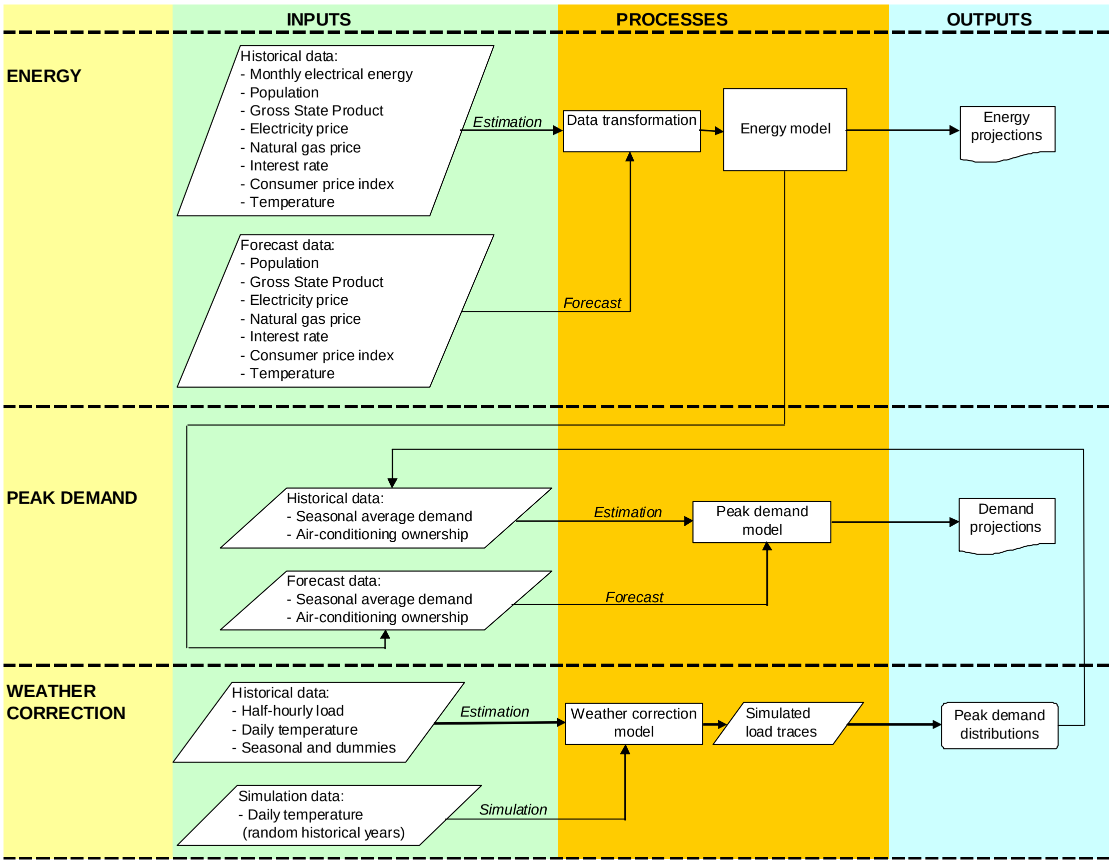
The LFRG is committed to continuous improvement of the load forecasting process, and in late 2004 commissioned KEMA Inc (KEMA) to perform an independent review of the processes for preparing the SOO's energy and MD projections. The results of the KEMA review relating to TransGrid and those of a subsequent review by KEMA as well as a review by Frontier Economics of TransGrid's backcasting methodology are provided in Chapter 3.

2.4 TransGrid's load forecasting models

TransGrid has provided in a diagram a simplified overview of its load forecast models and how they interact. This is reproduced in Figure 2-2.

[5] NEMMCO, "Load forecasting white paper", Statement of Opportunities, 2005.

Figure 2-2 Schematic of TransGrid's load forecasting models



Source: TransGrid TG Load Forecasting Model 2007 page 4.

TransGrid has modelled energy and peak demand for the APR 2007 using three interconnected models:

- The Energy Model uses a combination of historical energy data and external demographic, economic and temperature input data (both historical and forecast) to forecast energy by month over the period of interest.

- The Peak Demand Model takes historical and forecast average seasonal energy from the Energy Model, TransGrid's assumed historical and forecast air conditioning ownership together with peak demand distributions from the Weather Correction Model to generate peak demand projections.

- The Weather Correction Model uses historical data to simulate load traces and provide peak demand distributions which feed into the Peak Demand Model to produce 10%, 50% and 90% POE Maximum Demand forecasts.

Energy and demand for large industrial loads such as the aluminium smelters (Direct loads) are modelled separately (largely as constant energy and demand) based on separate assumptions about energy usage and demand.

Each of these models is considered in turn below.

2.5 Energy Model

The Energy Model is an econometric model derived using cointegration techniques which forecasts energy usage for the NSW region as a whole on a per-capita, monthly basis based on the variables outlined below and discussed in detail in Section 4.1.3:

- q = energy consumption (q/pop i.e. energy consumed per capita is used and derived in the model)
- pop = population of NSW and the ACT
- p = real price of electricity
- g = real gas price
- y = real income per capita (using Gross State Product as a measure of income)
- r = real mortgage interest rate
- hd = heating (degree) days and cd = cooling (degree) days) both measures of temperature and hence contribution to load in winter and summer
- wd = working days in a month
- monthly dummy variables[6].

It is a 'top-down' model that uses high level economic aggregates to explain and forecast energy changes, in contrast to a 'bottom-up' model that would use data on the many end-uses of electricity, for example individual appliance types in the home, and sum these to get the total.

The energy model has a basic error correction form as follows:

$$\Delta(q/pop)_t = \alpha_0 + \alpha 1\mu_{t-1} + \sum \alpha 2i\, \Delta(q/pop)_{t-i} + \sum \alpha 3i\, \Delta p_{t-i} + \sum \alpha 4i\, \Delta g_{t-i}\ \sum \alpha 5i\, \Delta y_{t-i}\ \sum \alpha 6i\, \Delta r_{t-i} + \alpha 7Hd_t + \alpha 8Cd_t + \alpha 9wd_t + \sum \alpha 10i\ monthi + \varepsilon_t$$

In this equation Δ denotes the change in values between time t and t-1, where t is the time in months. Thus the change in energy per capita (q/pop) is expressed as the sum of: a constant; an error correction term μ_{t-1}; sums of changes in values of energy per capita and explanatory variables p, g, y and r; and heating, cooling, working day and monthly effects (all the terms are defined above). All terms are multiplied by coefficients determined by statistical analysis.

In the long-run, if p, g, y, and r stop changing, the overall level of (q/pop) will be determined by the error correction term, which has the structure:

$$\mu_{t-1} = (q/pop)_{t-1} - (\beta_0 + \beta_1 p_{t-1} + \beta_2 g_{t-1} + \beta_3 y_{t-1} + \beta_4 r_{t-1})$$

[6] A dummy variable is also included for a change in measurement of energy data after November 1995.

The equation

$(q/pop)_t = \beta_0 + \beta_1 p_t + \beta_2 g_t + \beta_3 y_t + \beta_4 r_t$

is therefore referred to as the "long-run" energy model and represents consumption in period t given the current values of electricity and gas prices, GSP per capita, and interest rates.

The lagged structure of the energy model enables it to account for the time taken by energy use to adjust to new price and income levels, while adjusting instantly to temporary seasonal effects. Incorporation of the weather variables means that the model outputs are weather normalised even though the inputs are not.

The model initially takes into account total native energy supplied, but the energy usage of large industrial users is subtracted before the regression and forecasts of such usage subsequently added back, while forecasts of non-scheduled and exempt generation are subtracted to produce forecasts of Scheduled energy.

2.6 Weather Correction Model

Half-hourly and peak electricity demands are strongly weather sensitive, hence it is necessary to abstract from actual weather conditions to estimate underlying growth rates in peak demand at the various levels of probability of exceedence that are of interest in planning. The critical POE level for electricity planning is 10% i.e. a level of peak demand that has a 10% probability of being exceeded in any year, or one year in ten. TransGrid also calculates 50% and 90% POE peak demands. The TransGrid weather correction model is used to estimate weather corrected peak demands for use in deriving the peak energy models.

The weather correction model estimates the effects of a number of variables on half-hourly demand. The variables include: cooling and heating degree days (as defined in Table 4-2 below); days of the week; public holidays; and seasonal effects. Cooling and heating sensitivity are assumed to vary from day-to-day. TransGrid has estimated separate weather correction parameters for each half-hourly period in the day for each year from April 1992 to March 2007.

To determine the range of possible demand outcomes in each year, TransGrid has created fifty weather scenarios corresponding to the years ending March 1958 to 2007. The weather correction models were then used to estimate what the half-hourly and peak daily demands would have been under each scenario, i.e. with these weather variables as inputs. This analysis results in fifty estimates of the summer and winter peak demands for each year, one for each scenario, from which the peak demands at the required percentiles can be extracted. This results in estimates of the "actual" 10% POE, 50% POE and 90% POE summer and winter peak demands for each year from 1992 to 2007.

2.7 Peak Demand Models

The Peak Demand Models relate summer and winter peak demand to average demand through each season, which indirectly captures the impact of economic and price factors on peak demand, and to factors which capture the impacts of air-conditioning growth.

The key variables considered are:

- ad or Avg_dem, average seasonal demand, output from the Energy Model
- ac which is an index of air conditioning ownership or penetration.

A simple linear relationship is assumed between peak demand and average demand and ownership of air conditioning:

$pd_t = \gamma 0 + \gamma 1\ ad_t + \gamma 2\ ac_t + \varepsilon_t$

Again, the peak demand model is derived after subtracting expected demand from the Direct large industrial users from the total native demand. Demand from these users is later added back and expected generation from non-scheduled and exempt generation is subtracted.

Demand Side Participation (DSP) is considered by convention to be a source of supply. As such, estimates of DSP which have been available are understood to be added back to historical load, and, by convention, no assumption of DSP availability is assumed going forward.

2.8 Comparison of the APR2004 and APR 2007 forecasts

MMA has reviewed the medium scenario forecasts produced by TransGrid in APR 2004 and APR 2007 against the actual (or estimated actual) results for 2006/07 and 2007/08. MMA has also compared the APR 2004 and APR 2007 forecasts for subsequent years. The results are provided in the following tables.

Table 2-1 Comparison of medium scenario Scheduled Energy Sent Out, APR 2004, APR 2007 and actuals, GWh

	Scheduled Sent Out Energy forecasts APR 2004	Scheduled Sent Out Energy forecasts APR, 2007	Actuals	Diff APR 2004 against actual or APR 2007 forecasts
2003/04	69710		70311	0.9%
2004/05	71560		70882	-0.9%
2005/06	73210		73091	-0.2%
2006/07	74800		73886*	-1.2%
2007/08	76090	75710		-0.5%
2008/09	77730	76900		-1.1%
2009/10	79530	78000		-1.9%
2010/11	81540	78890		-3.2%

	Scheduled Sent Out Energy forecasts APR 2004	Scheduled Sent Out Energy forecasts APR, 2007	Actuals	Diff APR 2004 against actual or APR 2007 forecasts
2011/12	83240	80060		-3.8%
2012/13	84930	81520		-4.0%
2013/14	86870	82900		-4.6%

Note that the annual results have not been corrected for weather or day-type. * The actual result for 2006/07 is based on information provided by TransGrid in April 2008 and is slightly different to the actual used in APR 2007.. Note the different basis of comparison from 2007/08; comparisons using this different basis are highlighted in the Table.

In terms of medium scenario Scheduled Sent Out energy forecasts, the forecasts in the 2004 APR have generally been somewhat higher than actuals but within about 1% of actuals to 2006/07. They diverge more significantly from the most recent APR 2007 forecasts over time, with the APR 2004 forecasts being greater than the APR 2007 forecasts by over 4.5% in 2013/14.

By itself the difference in forecasts means little, probably largely representing an expected slowing of economic growth or increase in non-scheduled energy production. However, the results are more instructive when considered together with forecast changes to maximum demand at the 50% POE and 10% POE levels for both summer and winter.

Table 2-2 Comparison of medium scenario Scheduled Maximum Demand, Generator Terminal basis, APR 2004, APR 2007, Actual and Forecast 50% POE Summer, and 50% POE Winter Medium Scenario, MW, APR 2004 and APR 2007

	50% POE Summer forecasts 2004 APR	50% POE Summer forecasts 2007 APR, MW	Actuals	Difference: Actual or APR 2007 divided by APR 2004
2004/05	12660		12840	1.4%
2005/06	13080		13292	1.6%
2006/07	13480		12876	-4.5%
2007/08	13770	13820	12940	-6.0%
2008/09	14140	14260		0.8%
2009/10	14550	14620		0.5%
2010/11	15010	14970		-0.3%
2011/12	15470	15320		-1.0%
2012/13	15930	15740		-1.2%
2013/14	16370	16140		-1.4%

	50% POE Summer forecasts 2004 APR	50% POE Summer forecasts 2007 APR, MW	Actuals	Difference: Actual or APR 2007 divided by APR 2004
2004	12830		13032	1.6%
2005	13120		13126	0.0%
2006	13300		13076	-1.7%
2007	13500	13700	13871	2.7%
2008	13720	14070		2.6%
2009	13980	14370		2.6%
2010	14320	14650		2.3%
2011	14660	14970		2.1%
2012	14910	15300		2.2%
2013	15200	15580		2.2%
2014	15560	15880		1.7%

Note that the annual results have not been corrected for weather or day-type. The actual results for 2007/08 and 2007 winter are based on information provided by TransGrid in April 2008. Note the different basis of comparison from 2008/09 or winter 2008; comparisons using this different basis are highlighted in the Table.

Actual summer maximum demands over the past 2 years have been lower than forecast at the 50% POE level in APR 2004 while APR 2007 forecasts are within about 1.5%, either way, of APR 2004 forecasts beyond this. Actual winter demands have been similar to those forecast in APR 2004 while the APR 2007 forecasts are consistently higher than the APR 2004 forecasts by about 2%.

Table 2-3 Comparison of medium scenario Scheduled Maximum Demand, Generator Terminal basis, APR 2004, APR 2007, Actual and Forecast 10% POE Summer, and 10% POE Winter Medium Scenario, MW, APR 2004 and APR 2007

	10% POE Summer forecasts 2004 APR	10% POE Summer forecasts 2007 APR	Actuals	Difference: Actual or APR 2007 divided by APR 2004
2004/05	13430		12840	-4.4%
2005/06	13880		13292	-4.2%
2006/07	14310		12876	-10.0%
2007/08	14620	15020	12940	-11.5%

	10% POE Summer forecasts 2004 APR	10% POE Summer forecasts 2007 APR	Actuals	Difference: Actual or APR 2007 divided by APR 2004
2008/09	15020	15500		3.2%
2009/10	15460	15930		3.0%
2010/11	15960	16350		2.4%
2011/12	16440	16760		1.9%
2012/13	16940	17220		1.7%
2013/14	17410	17670		1.5%
2004	13170		13032	-1.0%
2005	13470		13126	-2.6%
2006	13650		13076	-4.2%
2007	13850	13980	13871	0.9%
2008	14070	14370		2.1%
2009	14330	14670		2.4%
2010	14670	14960		2.0%
2011	15010	15280		1.8%
2012	15260	15630		2.4%
2013	15560	15920		2.3%
2014	15910	16230		2.0%

Note that the annual results have not been corrected for weather or day-type. The actual results for 2007/08 and 2007 winter are based on information provided by TransGrid in April 2008. Note the different basis of comparison from 2008/09 or winter 2008; comparisons using this different basis are highlighted in the Table.

Actual summer maximum demands over the past 2 years have been significantly lower than forecast at the 10% POE levels, while APR 2007 forecasts are some 1.5% to 3% higher than the APR 2004 forecasts going forward. Actual winter demands have been similar to or slightly lower than those forecast in APR 2004 while the APR 2007 forecasts are consistently higher than the APR forecasts by about 2%.

A comparison of the forecasts in APR 2004 against APR 2007 forecasts highlight a few issues that require explanation:

- why Scheduled energy sent out is forecast to drop by up to 5% in the APR 2007 forecasts compared to APR 2004 forecasts, however 10% POE maximum demand in summer is forecast to grow by 1.5% to 3.2%.
- why there is such a difference between the 50% POE and 10% POE forecasts for summer in APR 2007.

3 EARLIER REVIEWS OF TRANSGRID METHODOLOGY

As part of the current review MMA has considered a number of papers written by TransGrid personnel as well as three earlier reviews of TransGrid methodology and assessment procedures. The three reviews:

- by KEMA Inc of the SOO process for preparing load forecasts (including procedures and methodologies used by TransGrid) in 2005
- by KEMA Inc of TransGrid's load forecasting methods in 2007
- by Frontier Economics of the assessment techniques used for analysis of electricity forecasts in NSW in 2007.

The salient features of these reviews, relevant to the current review, are provided below. The page numbers provided are those in the reviewing publication.

3.1 KEMA 2005[7]

In late 2004 KEMA was commissioned by NEMMCO to perform an independent review of the processes used by JPBs in preparing the SOO's energy and maximum demand projections.

3.1.1 Processes and methodologies

KEMA described at an overview level the TransGrid modelling methodology (which, in broad outline was similar to that used for APR 2007).

3.1.2 Underlying definition of POE

KEMA discussed the appropriate definition of POE and what this really means in the SOO and LFRG context, stating that the description suggests that the POE is intended to reflect variations due to non-holiday weekday temperatures only (page 25). It provided a definition of xx% (where xx% = 10% or 50% or 90%) POE and commented that the chance of exceeding a particular demand level, in principle, should reflect the uncertainties in all components of the forecast, including wind generation as well as economic conditions and summer weekday temperature (page 25). KEMA considered applying a probability distribution to economic scenarios (page 47) and a probability-weighted average of the high, medium and low economic scenarios for each POE level (page 47). It noted, however, that NIEIR considers this approach to not be practical or meaningful (page 47) and that the medium scenario is used for planning with the high and low providing likely boundaries for economic growth.

[7] KEMA Inc, "Review of the process for preparing the SOO load forecasts", cover dated 17 June 2005.

3.1.3 Methodology used

KEMA noted that the methodology used by TransGrid:

- uses a number of NIEIR forecasts as inputs (page 18) including estimates of renewable and embedded generation developed by NIEIR together with Greenworld Energy. This is the practice applied by all JPBs.
- models peak demand as a two-stage approach, of first modelling average annual energy and then modelling peak demand as a function of average demand, current and lagged, with the only other predictor used being air conditioning (ac) trend which was 0 in 1997/98 and increased linearly after this (page 55).
- handles very large customers such as smelters individually, projecting future use based on historical use and explicit plans known for each customer (page 3) but that the basis for the assumptions behind direct load growth of 0.8% pa is not identified (page 20).

KEMA commented that:

- TransGrid's forecasting approach uses advanced time series analysis methods and a model structure established by recognised experts in energy demand forecasting (page 18)
- the two stage approach described above is standard good practice. It recommended alternative modelling of the relationship of peak to average demand in a way that reflects the change to the relationship at temperatures that drive higher levels of use. (page 56)
- the TransGrid APR provides good details on the forecasting methods used (page 33) with available reports providing full model specifications and estimation parameters , rationale and diagnostic testing (page 33)
- the elasticity estimates produced by the model are reasonable, although the -0.054 for the own-price elasticity is much lower than NIEIR's and about half that reported by TransGrid in 2001 with reasons not discussed (page 37).

3.1.4 Weather correction

KEMA noted that in relation to weather correction, TransGrid has explored the temperature variable, weather station and lagged structure (page 20). At this stage the temperature to POE structure was used taking into account weather sensitivity.

KEMA commented that all models incorporate the effect of temperature on one or two previous days, as well as the current day which is good practice (page 53), that the models used all recognise that a different relationship applies to very hot or very cold days (page 53) and that several models used degree days or change point models with the change point estimated from the data, a practice which should be periodically revisited and that humidity should be considered (page 54).

3.1.5 Peak demand drivers

KEMA commented that there was a need to be careful with the weather sensitive step of the peak demand as this is the main source of divergence between the 50 POE and 10 POE forecasts and that growth in air conditioning is a key source of uncertainty regarding even 50 POE forecasts (page 4). KEMA pointed out that all forecasters recognise the growth in air conditioning as a key source of uncertainty (pages 4, 52), that all use some degree of judgement in this area (page 52).

KEMA commented that its experience shows that the growth in temperature sensitivity is seldom linear, and often far from it, and that good experience has been seen from models which use a moving target average based on a computed saturation level (page 52).

While KEMA recognised that there are no ideal solutions to this issue it recommended that the JPBs consider a framework for making assumptions and estimating trajectories (page 6) and provided suggested approaches to this work (page 52).

3.1.6 Demand side participation

KEMA noted that according to SOO procedures, DSP is captured both as part of actual demand and inherently as part of demand forecasts (page 12). KEMA considered it essential that the level of DSP already included in the demand forecasts be accurately quantified and removed from the forecast DSP levels to avoid any double-counting (quote from SOO page 12). The approach used was to produce forecasts that assume no short-term DSP. That is, historic maximums were adjusted to the levels that would have occurred without the DSP, and the forecasts projected this no-DSP level. Projected DSP is then used by NEMMCO in determining the supply-demand balance. KEMA considered this approach to be standard and appropriate (page 44).

3.1.7 Wind availability

KEMA considered that there was a need for POE demand projections to ideally take into account the joint distribution of wind availability and total load, (page 7) or at least agree on a consistent interpretation and application of the South Australian JPB (ESIPC) estimate of 8% (page 40), and NIEIR results (page 7). KEMA commented that data on wind for specific sites are available (page 41) and provided a methodology for estimating wind availability at time of maximum demand and recommended that, even if this could not be completed, due to limited historical data, that the JPBs and NEMMCO agree on a consistent interpretation of South Australian and NIEIR results (page 58).

3.1.8 Backcasting

KEMA recommended that comprehensive back-casting be carried out, taking into account actual economic and temperature conditions, for more than the first projected year of each set of 10 year forecasts (page 7).

3.1.9 Conclusions and recommendations

Overall, KEMA concluded that, based on its high level review, the TransGrid methods were thorough, sound and had no particular bias and found evidence that TransGrid continues to improve its methods.

KEMA recommended, however, that two components, weather sensitivity and air-conditioner penetration (page 38) be improved.

KEMA recommended that TransGrid refine its modelling through:

- exploring the modelling of relationship between average and peak energy in a way that reflects the change to this relationship at temperatures that drive higher levels of use (page 56)
- developing a more informed model of growth of temperature sensitivity, allowing the development of an AC growth forecast that that takes into account saturation levels (page 57).

3.2 KEMA 2007[8]

KEMA was commissioned by TransGrid to assess whether the load forecasting procedures it used to prepare its draft forecasts for APR 2007 are in accordance with internationally recognised best or good practice and that its load forecasting processes can be relied upon to produce a realistic expectation of demand forecast (page 2-1).

The review was high-level, based on review of documents provided by TransGrid and discussions with TransGrid forecasting staff and took into account KEMA's previous review of forecasting processes for the SOO. It was based on the draft APR 2007 and related reports (Page 2-2). It should be noted that some of the methods used by TransGrid in its draft APR 2007 were not the same as those used in the final APR 2007.

3.2.1 Modelling of Direct load

Direct loads, large generally stable industrial loads which are considered better modelled on a bottom-up basis, are subtracted from the remainder of the load before econometric modelling. After the energy and demand for the remaining bulk of the load are modelled, forecast Direct loads are added back in to make the total native energy and demand for the region.

KEMA considered this approach to be good practice.

3.2.2 Accounting for scheduled, unscheduled and exempt generation

TransGrid initially forecasts the whole region's native energy and demand without regard to how it will be served (i.e. by scheduled or unscheduled or exempt generation). Estimates provided by NIEIR of energy and peak demand served by unscheduled

8 KEMA Inc, "Review of TransGrid's load forecasting methods", final report dated June 12 2007.

generation are then subtracted from regional totals to yield scheduled generation requirements (Page 3-1). Estimates of historic DSP are added back to the total, and the forecasts developed assume no further DSP (Page 3-3).

3.2.3 Key economic, demographic and non-scheduled generation inputs

TransGrid uses as key inputs to its models three NIEIR three reports: economic outlook, greenhouse policy and embedded generation (page 3-2). The review did not address the quality of the NIEIR forecasts (page 3-4).

3.2.4 Two-step approach

As at the time of the KEMA 2007 review, the production of peak demand forecasts was a two-stage process:

- energy was forecast using an econometric Energy Model. The Energy Model excludes the Direct loads associated with specified large industrial users.
- outputs of the Energy Model, together with an air conditioning index and weather correction processes were used to forecast peak demand at the POE 10, 50 and 90 levels.

3.2.5 Energy Model

3.2.5.1 Direct modelling

KEMA noted that in previous years TransGrid had modelled energy from sales to end-use customers and then adjusted this, based on estimated losses at successive stages of the electricity supply chain, to derive the energy generated, energy sent out and energy supplied forecasts required.

However, for APR 2007 TransGrid took a different approach with each of the energy forecasts apart from end-use being modelled directly from consistent and reliable information provided by TransGrid or NEMMCO (3-4)[9]. According to KEMA this was because of the limitations of the sales to end-use customer data. This data was only available on an annual basis (whereas the model is configured for monthly information), and after a long delay of up to a year (page 3-4).

KEMA considers that this change represents an improvement to previous practice (page 1-3) with the energy series in the model having more reliable inputs and loss factors now being estimated from differences between model outputs rather than assumed (page 5-12).

3.2.5.2 Predictor variables, model structure and approach

According to KEMA (pages 3-5 and 3-6), predictor variables included in the Energy Model were:

[9] The three models have identical structure and input information apart from the energy used.

- lagged electricity consumption
- real electricity price
- relative gas price
- real income (using a gross state product as a measure)
- real mortgage interest rate
- heating degree days for winter
- cooling degree days for summer
- number of working days in the month
- monthly dummy variables.

with historical and forecast consumption being calculated on a per capita basis.

The Energy Model structure is an error correction model which provides both long-run response of consumption to economic drivers and the short-run response to changes in these drivers over the past few periods (page 3-5).

KEMA commented that:

- the basic drivers used in the energy model are standard for analysis of this type, and are similar to those used in the NIEIR forecasts (page 4-8). TransGrid had done extensive work to test the time series structure of the modelling and apply appropriate estimation procedures which represents established good practice steps (page 4-7)
- the model accounting for consumption having both long-run (such as building and equipment) and short-run influences (such as weather) is good practice (page 4-8)
- the exploring and handling of weather in the energy model is good practice
- another good practice is the development of a "wealth" weighting of temperature data used in degree day calculations (page 4-8) (note this was not used in the final APR 2007 model)
- while coefficients of key terms in the model (lagged consumption, income, seasonal terms and degree-days) are well determined, coefficients on other terms (electricity and gas prices) are less well determined
- the confidence interval and results of backcasting indicate very good performance and that the methods can be relied upon to provide a realistic estimate (page 4-9).

Modelling is initially on a per capita basis with projections of population growth being used to convert these to total energy consumption.

3.2.6 Weather correction

According to KEMA:

- before modelling, all peak demand values are normalised to standard weather conditions for each season using stations and variable structures explored previously
- a number of wether models were explored prior to producing the APR 2007, with the model ultimately chosen being based on daily observations for a whole year, with each half hour of the day being treated as a separate variable and regressed on daily temperatures
- for each season historical peak demands are all adjusted to the demands that would, according to the model, have been observed at the 10%, 50% and 90% POE levels. These are based on a fitted model for each half-hour using each of 50 historical weather years available with the outcome being a range of peak demands and associated mean and standard deviations, assuming a normal distribution.

KEMA commented that:

- the initial step of weather correcting historical maximum demands is valuable and good practice
- the process of applying the weather correction for the APR 2007 is a refinement of that used in previous years and provides a more appropriate response of the 10%, 50% and 90% POE values
- the method used leads to projections which are fully consistent with the definition of the POE (page 4-10)
- the method used is preferable to that used previously which was based on an ordering process potentially leading to under or over estimation (page 4-10)
- the use of the normal distribution assumption allows exact percentiles to be calculated. TransGrid has reviewed the observed temperature distribution for consistency with the normal distribution prior to applying it. Other smooth distributions could also have been used (page 4-10)
- the particular weather adjustment model used was validated by testing four different models with different structures which all gave similar results (page 4-10).

Overall KEMA found that the weather correction process is handled very thoroughly and systematically and that the process can be relied upon to produce realistic outcomes (page 4-10).

3.2.7 Peak Demand model

According to KEMA in the model examined:

- before modelling, all peak demand values are normalised to standard weather conditions for each season using stations and variable structures explored previously (see weather correction)
- peak demand is modelled by a time series analysis as a function of previous period average demand, previous period peak demand, and increments in average and peak demand for the last few periods" page 3-5. (Note that the lagged component was removed from the final APR 2007 model)
- The only additional predictor parameter used is a trend variable for air conditioning levels. The value of this variable follows an S shaped pattern over time: the trend is zero until the summer of 1991-92, increases linearly with a shallow slope after that, rises more steeply over several years, then falls to a shallow slope again for the last couple of years of the projection period.
- Separate curves are fitted for the 10% POE, 50% POE and 90% POE forecasts.

KEMA has commented that:

- The peak demand model as described uses a structure well established in the literature with the forecast of annual energy as well as the previous year's peak demand being drivers of current year peak demand. This structure ensures consistency between energy and peak demand forecasts and the complex relations modelled in the Energy Model are, by extension, carried over into the Peak Demand Model (page 4-9)
- The model diagnostics show a generally good fit with annual average demand being a strong predictor of the winter peak but a weaker predictor of summer peak (page 4-11)
- Out of sample predictions for a 5 year period show clearly the model's validity and that the model performs very well and can be relied upon to produce realistic outcomes (page 4-11)
- The assumed model of air conditioning growth now incorporates a flattening in later years which constitutes a definite improvement in good practice previously recommended (page 4-11). However, KEMA has recommended that, as this remains a source of great uncertainty, further refinements to this parameter be modelled from experience elsewhere (page 5-13).

3.2.8 Conclusion and recommendations

The KEMA review concluded that the methods used are consistent with good practice and can be relied upon. It commented that the TransGrid structures and relationships appear to be reasonably specified and reasonably stable based on general industry practice and observed model performance, but that a disruption to the economy or a major shift in trends of behaviour, technology or practice could render the estimated models less accurate (page 2-1) – although this caveat was applicable to all forecasting systems, not considered a special weakness of TransGrid's (page 2-2).

KEMA recommended that:

- the air conditioning parameter be further improved
- weather normalised average demand be used in the peak demand models
- TransGrid systematise its selection of the base for calculating heating and cooling degree days.

3.3 Review by Frontier Economics[10]

Frontier Economics was asked by NEMMCO to comment on TransGrid's methodologies for reviewing the historical performance of its forecasts.

The review concluded that the back-assessment and backcasting procedures are valid and have been correctly applied.

3.4 Summary of previous reviews

The previous reviews of TransGrid's forecasting methodologies and backcasting procedures have generally found these to be appropriate, well considered and well applied.

The main qualification and recommendations for improvements are:

- that the air conditioning parameter used in the peak demand model be improved
- that a disruption to the economy or a major shift in trends of behaviour, technology or practice could render the estimated models less accurate
- assessment of wind contribution to peak demands should be improved
- that weather normalised energy be used as inputs into the peak demand forecasts.

[10] Frontier Economics, "Review of assessment techniques used for analysis of electricity forecasts in NSW", review prepared for NEMMCO, 16 April 2007.

4 MMA REVIEW OF THE TRANSGRID METHODOLOGY AND MODELS

The TransGrid methodology and models have evolved over the past several years. This section reviews the model described in the APR 2007 and also considers changes between the methodology and models used to prepare the 2004 and 2007 APRs.

4.1 Energy Model

An overview of the Energy Modelling approach and structure has been provided in Section 2.5 and the KEMA reviews of the structure have been provided in Chapter 3.

This section of the report considers some of the issues related to the Energy Model in further detail.

4.1.1 Functional form

The functional form of the energy models is the same for each of the three energy models and has been described in Section 2.5. As noted, the long-run level of per capita energy use is determined by four economic parameters, the real electricity and gas prices, real income per capita and real mortgage rates, while seasonal and short-run effects are determined by weather and seasonal factors together with lagged responses to the economic parameters.

The functional form (error correction and lagged variables) has in the past been selected on the basis of a thorough statistical investigation of the time series properties of the input and output variables, in particular the non-stationary nature of the economic parameters.

The variables used have nevertheless changed over time without a full explanation of the reasons for/benefits of the changes and their impacts. For example the air-conditioning variables have been dropped in the 2007 version and the cooling and heating degree days terms have been modified by exclusion of the weighting parameter (wealth) with little or no explanation given. This issue is explored in Section 4.4.

Compared to the 2004 version the 2007 energy model has a slightly higher income elasticity (0.86 in 2007 compared to 0.67 in 2004). The increase would add 0.2-0.3% p.a. to modelled energy growth. The 2007 electricity and gas price elasticities are also higher in absolute terms but this has relatively little impact on the forecast.

Several of the DNSPs in NSW have in the past used sectoral models in their forecasting to take into account expected changes to key drivers over the period of concern. Thus, for example, two of the DNSPs have modelled separately the residential and non-residential sectors and have, for the residential sector, taken into account the impacts of Government policy changes, such as Basix which required new homes in NSW to be more energy and water efficient than existing houses. This issue is discussed in Section 4.1.5.

TransGrid has used an average consumption per capita approach for the bulk of the load, while projecting separately usage by large industrial users. It has commented that while it would have liked to consider using such a sectoral approach the information required to implement such a model (for example, customer numbers and usage by different customer classes) are not available to TransGrid.

Instead, TransGrid uses information to which it has good access in its models. This includes using information which is directly available (from TransGrid or NEMMCO) on a timely basis. In this regard, TransGrid has since the APR 2004 changed the basis of its modelling of GEN, ESO and SUPPLY energies from end-use SALES with assumptions about transmission and distribution losses to information directly available on a timely basis (as discussed in Section 3.2.5.1). This approach allows the transmission and distribution losses to be directly derived from the models rather than assumed. As does KEMA, MMA considers this to be an improvement in methodology.

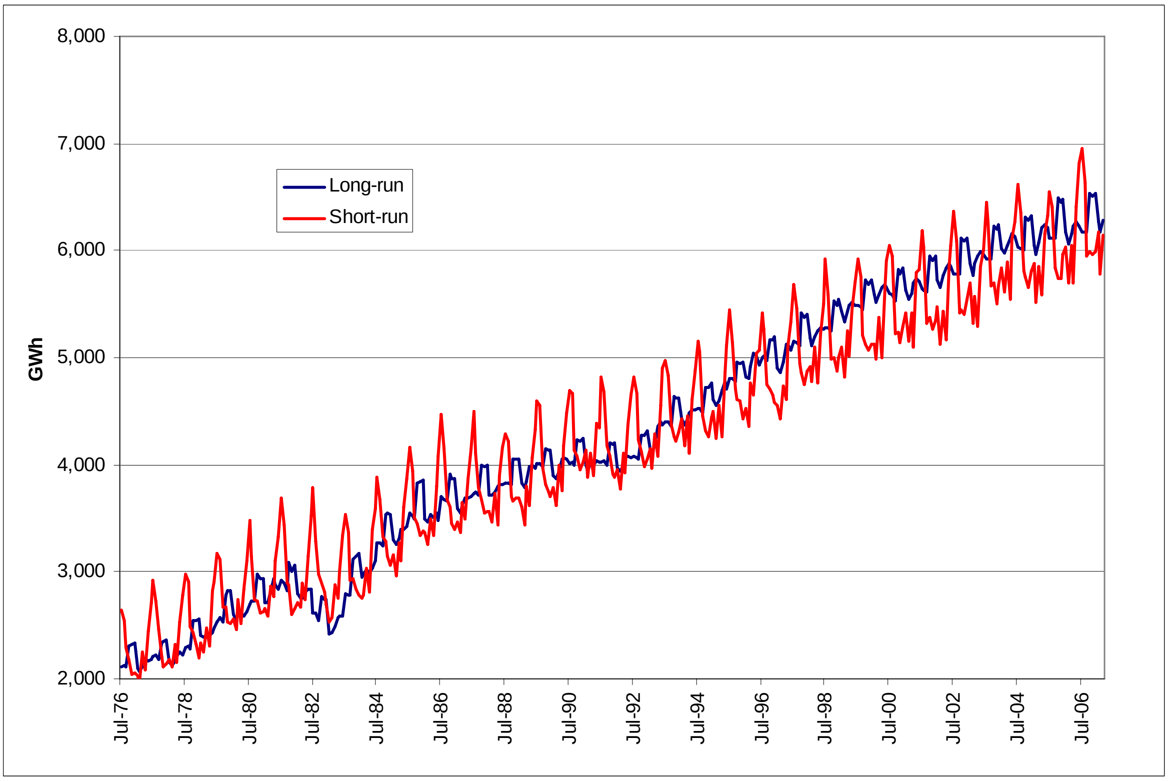
Overall, MMA considers that the functional form of the model to be appropriate to the information available and forecasting requirements of TransGrid. There are, however, some concerns about the inability of such a model to take into account structural changes, such as energy efficiency policies, discussed later in Section 4.1.5. In addition, MMA is concerned that there are a number of changes which take place to the model on an ad hoc basis, apparently without a full analysis or justification. This is discussed in Section 4.4.

4.1.2 Model interpretation

The energy forecasting model is described in Table A2.2 NSW Energy Forecasting Model on page 72 of the APR 2007 APR. It is a complex model including over 50 terms and the corresponding estimated coefficients. It is noted that a number of model coefficients are not statistically significant at the 95% level but that they have been included in the model implementation.

As such it not possible to derive an intuitive understanding of the model's behaviour simply by examining the coefficients and these are not reproduced here. Figure 4-1, based on MMA's reconstruction of the models, illustrates the relationship between the short and long-run effects, particularly during the recessions of the early 1980s and early 1990s. Reductions in income during these recessions are clear in the long-run model which responds immediately to income but less clear in the short-run model, which has only a partial, lagged response. Similarly, during the continuous economic growth from the mid 1990s, the short-run model lags behind the long-run model.

Figure 4-1 Long-run vs short-run models, historical



Source: MMA estimates.

Interpretation of the model is also aided by consideration of the long-run elasticities of demand, which facilitate comparison with other models. The estimated elasticities of the long-run model, defined as the proportional change in (q/pop) in response to a change in electricity and gas prices, GSP per capita, and interest rates, are presented in Table 4-2. This shows that income growth is likely to be the most significant determinant of per capita energy growth and that the mortgage rate will have almost no effect.

Table 4-1 Long-run elasticities

Input variable	Long-run elasticity
Real electricity price	-0.15
Real gas price	0.10
Real income/capita	0.86
Real mortgage rate	0.001

Source: TransGrid elasticities spreadsheet.

Compared to the 2004 version the 2007 energy model has a slightly higher income elasticity (0.86 in 2007 compared to 0.67 in 2004). The increase would add 0.2-0.3% p.a. to modelled energy growth. The 2007 electricity and gas price elasticities are also higher in absolute terms but this has little impact on the forecast.

4.1.3 Model variables

The definition and stated source of variables used in the 2007 Energy Model are provided Table 4-2.

Table 4-2 Variables used in the 2007 Energy model

Symbol	Units	Definition	Source of data
q	GWh	Estimate of Native Energy (Scheduled Energy plus Non-Scheduled and exempt generation)[11] on a monthly basis minus large Direct industrial loads and Snowy Hydro pumping loads both of which are modelled separately.	Historical from TransGrid. Forecasts output from the model. Forecast Direct industrial and Snowy Pumping assumed by TransGrid. History and forecasts of Non-Scheduled energy largely from NIEIR
pop	Thousands	Combined estimated residential populations of NSW and ACT	Australian Bureau of Statistics (ABS) for population. NIEIR for population growth forecasts
p	c/kWh	Average retail price of electricity divided by Sydney CPI	Original price information from ESAA in 2004. Subsequently NIEIR for both changes to average prices and forecasts
g	c/MJ	Average retail price of gas divided by Sydney CPI	Original price information from ESAA. Subsequently NIEIR for both changes to average prices and forecasts. Historical gas penetration is also included in this measure
y	$/capita	Income per capita defined as real Gross State Product for NSW and ACT divided by population	Historical from ABS data and Access Economics. Forecast growth in GSP and population from NIEIR.
r	% pa	Standard variable mortgage interest rate minus the yearly change in Sydney CPI	Historical from Reserve Bank data. Forecast changes from NIEIR
cdd	Degree days	Cooling Degree Days measured on a monthly basis as the sum of the divergences of daily average temperatures above 21 degrees[12]	Historical from Bureau of Meteorology. Forecast from TransGrid assumptions.
hdd	Degree days	Heating Degree Days measured on a monthly basis as the sum of the divergences of daily average temperatures below 18 degrees	Historical from Bureau of Meteorology. Forecast from TransGrid assumptions.
wd	Working	Number of working days in a	Calendar

[11] This also takes into account historical Tweed Shire loads whiich were prior to March 2006 included in a different region and load shedding when this occurred.

[12] For example, the CDD of three days with average temperatures of 24, 27 and 20 degrees C is 3 + 6 + 0 = 9.

Symbol	Units	Definition	Source of data
	Days	month	
Monthly (Jan to Nov) dummy		regular seasonal effects	Calendar
Measurement dummy		Dummy to account for change in measurement of energy data	1 to November 1996 and 0 thereafter

Source: TransGrid APR 2007 page 71, response to questionnaire and MMA understanding.

Most of the historical and forecast inputs used by TransGrid in its model are derived internally or from respected sources and their use is considered appropriate. As discussed in Section 4.1.1, the variables of key concern due to their materiality are income and electricity price.

For its income parameter TransGrid uses historical GSP data from the Australian Bureau of Statistics (ABS) together with information from Access Economics. For its forecast growth rate of GSP TransGrid relies on NIEIR economic forecasts commissioned by NEMMCO for all JPBs.

NIEIR is a respected forecasters in this field and, as stated above, has provided economic input assumptions to all JPBs for their SOO forecasts for a number of years. MMA considers the reliance by TransGrid on NIEIR GSP forecasts to be appropriate.

NIEIR is also the source of the forecasts and presumably some of the historical data relating to energy prices, both electricity and gas. As we understand it for the most recent information, TransGrid has used data from the Energy Supply Association of Australia (ESAA) publication in 2004 and has subsequently relied on NIEIR for both historical and forecast information.

Energy price information has become increasingly difficult to source since the break-up of energy utilities in the 1990s. ESAA has not published electricity prices for NSW since 2004 and TransGrid has relied upon NIEIR's history of price movements and price forecasts for these variables. As we understand it, the NIEIR price forecasts are provided to TransGrid as movements only, with little or no further substantiating data. MMA is concerned about the source, meaning[13] and reliability of these historical energy prices used. While MMA has no specific alternative index to recommend, it considers that TransGrid should seek from NIEIR further information about the source of its historical and forecasts numbers and if then considered necessary, explore other indexes and avenues as a source of such information.

13 There are, for example, questions about how the information is collected, whether it covers NSW and the ACT, whether it is a weighted average delivered price, whether the prices apply to all users or just those covered by the model (ie excluding Direct users) and how prices are forecast and adjusted historically.

MMA notes that for its APR 2007 Energy Model forecasts TransGrid now applies a slight increasing trend of CDDs and a slight decreasing trend in HDDs over the period 2007-08 to 2017-18. MMA considers incorporation of such a trend to appropriate in light of recent experience across Australia but has not reviewed the actual numbers used. The impacts on the Energy Model, however, are likely to be small.

Overall, MMA considers that most of the variables used in the TransGrid model to be appropriate and well defined and documented. While MMA considers that the price variables and inputs and CDD and HDD inputs would benefit from further review and documentation, this is not considered a material consideration for the APR 2007.

4.1.4 Other key inputs into the energy forecasts

Other key inputs into energy forecasts are:

- Historical and projected future consumption by Direct industrial loads
- Historical and projected future generation by Non-scheduled and exempt generators.

4.1.4.1 Direct industrial loads

The Energy Model excludes consideration of Direct industrial loads. Instead these are modelled on a "bottom up" basis.

TransGrid has access to historical information about the energy and demand of its large Direct customers. It also speaks regularly to these customers. KEMA has stated that it considers a bottom up approach to be appropriate to use for these customers and MMA agrees with this finding.

TransGrid has assumed in its forecasts of Direct users that the energy usage by these customers increases by 1.5% between 2006/07 and 2007/08 and then remains constant over the remainder of the forecast period (Inputs Medium Scenario spreadsheet). In terms of demand, TransGrid has assumed that demand of these customers remains at 1362 MW, June 2006 levels (Demand_Medium_Scenario spreadsheet) throughout the forecast period.

Both energy usage and demand of these customers has increased over recent years. TransGrid has stated that it has taken a conservative approach with these customers by assuming there will be growth only when plans are committed to. However, MMA has seen no evidence of systematic discussions with customers about forecasts to justify this assumption.

In the KEMA 2005 report it was stated that projections for very large customers were based on historical use and explicit plans but that the basis behind the forecast growth of 0.8% was not known (see Section 3.1.3 above). MMA considers that the continued lack of provision of any detailed justification for the energy and demand forecasts of Direct customers remains a shortcoming of the TransGrid methodology.

4.1.4.2 Non-scheduled and exempt generation

TransGrid states that it has based its forecasts of non-scheduled and exempt generation on reports produced by NIEIR in association with Greenworld Energy.[14] The reports, commissioned by NEMMCO for use by all JPBs in the preparation of SOO reports, forecasts energy and demand by such renewable and non-renewable generators and cogenerators.

MMA understands that the basis of the projections used in the TransGrid forecasts for APR 2007 are Tables B1 to B3 in the Appendix. However, MMA could not quite reconcile the energy and demand forecasts with these Tables and with TransGrid's Table A4.5 in the APR 2007 even after taking into account the statement by TransGrid that:

Non-scheduled and exempt generation "…was based on the NIEIR projection with only two modifications: (1) the timing of some "prospective" projects between 2008 and 2011 was pushed back (after internal discussion within TransGrid); and (2) the Eraring Attemperating Weir (3 MW) was incorrectly taken out.

From 2011/12 onwards, "Nosex" is based directly on the NIEIR data. "Nosex" is however modified to eliminate double counting as a portion of the "Direct" component is included in the NIEIR non-scheduled projections (659 GWh).

In terms of MW, the NIEIR "capacity" projections were further transformed into "available at peak" projections by the application of capacity factors (generally 100% for all except hydro, wind, existing sugar mill bagasse and emergency fuel oil, which were 0%)."[15]

Forecast non-scheduled and exempt generation subtracts directly from the native loads forecast. MMA considers it reasonable that TransGrid personnel should review the NIEIR forecasts and make changes as appropriate. However, again, MMA considers that the basis behind the decision should be documented. The omission of the Eraring Weir from the TransGrid forecasts is considered immaterial.

As discussed above, MMA considers it important to reconcile the TransGrid information with that published by NIEIR. The reconciliation spreadsheet provided by TransGrid[16] and the above explanation has allowed a reconciliation of the non-scheduled generation forecasts. It has also allowed a reconciliation of the non-scheduled capacity differences between the NIEIR forecasts and TransGrid assumptions included in APR 2007, but not between the TransGrid assumptions provided in APR 2007 and those subtracted as non-scheduled capacity from the peak demand model outputs (see also Section 4.3.4).

4.1.5 Energy policy and efficiency

The LFRG lists nine key factors which influence demand end energy projections. These include economic growth, population, prices, temperature, non-scheduled generation and

[14] National institute of Economic and Industry Research in association with Greenworld Energy, "Projections of non-scheduled and exempted generation in the NEM, 2006-07 to 2022-23, a report for NEMMCO, June 2007.
[15] TransGrid answer to Question 1 from 10 April 2008.
[16] Spreadsheet entitled "Reconciliation of ambedded generation assumptions" sent on 8 May 2008.

use of air conditioning, all of which are explicitly handled through the TransGrid methodology. However, two key factors raised by the LFRG, environmental policies and technological innovations, are not handled explicitly by the TransGrid methodology. MMA considers that while the technological innovations may be reasonably captured implicitly through the model, the impact of the raft of recent Federal and State environmental policies aimed at reducing energy usage (through a combination of measures such as Basix (which, for example, strongly encourages a move away from electric hot water systems) and banning of incandescent light bulbs) are likely to constitute a system structural change of the type envisaged by KEMA in Section 3.2.8.

The energy model captures a long-run trend in efficiency of energy use per unit of GSP though the GSP elasticity, discussed in Section 4.1.2. As the per capita GSP elasticity is less than 1, energy use increases more slowly than GSP, reflecting a long-run improvement in per capita efficiency.

However, as a top down model the energy model cannot directly address the impacts of energy efficiency programs such as Basix and the introduction of new Minimum Efficiency Performance Standards (MEPS), which are designed to accelerate efficiency improvements, and, in effect, reduce the energy elasticity.

Such programs will also impact differently on different end uses, and while most will reduce energy growth, some will also change the demand profile, for example by the replacement of off-peak water heaters with solar-boosted water heaters. This structural change also cannot be captured using the TransGrid methodology.

The impacts of programs and energy efficiency programs can only be estimated on an end-use basis, in the context of a bottom up modelling approach. In a top-down framework the impacts may be best taken into account by making ex-post adjustments. TransGrid has considered such ex-post adjustment when taking into account policies such as the banning of incandescent light bulbs and their replacement with the more energy efficient compact fluorescent lamps for APR 2008.

While such an ex-post adjustment may be considered to weaken the statistical rigour of the forecasting process, MMA considers that the impact of such policies are increasing in significance and the incorporation of some adjustment to account for these is likely to be necessary in future.

Such adjustments are currently considered more likely to impact on energy than on demand projections. While considered important for the future, MMA accepts that such adjustments may not be material in terms of the maximum demand forecasts.

4.1.6 Timeliness – use of recent information

As well as a good functional form and historical data a model requires good input assumptions in order to be considered realistic. This means that the input assumptions need to be timely. APR was being prepared around early to mid 2007. However, MMA notes that since mid 2007, there have been a number of significant developments which are likely to have changed significantly the key assumptions which underlie the APR 2007 forecasts. Some of the significant developments likely to be relevant to the forecasts include:

- the changes to world macroeconomic outlook from the sub-prime crisis and associated "credit crunch" and market volatility which are expected to result in a significant slowing of growth in the USA and reduced economic growth in Australia
- the election of a new Federal Government in 2007 and associated signing of the Kyoto Protocol and expectation of an emission trading scheme to be operational within the regulatory period and likely to result in increases in electricity prices
- the release of census 2006 data which suggest that population growth in NSW has been stronger than previously forecast
- increase in interest rates.

MMA notes that these developments may have an impact on the demand forecast outcomes of the 2007 APR models and, as such, are relevant to the AER's assessment of TransGrid's revenue proposal. Of these the first two are likely to be of most material concern to the Energy Model and are discussed in this Section.

The use of survey data related to air conditioning penetration, which was available prior to APR 2007, is of concern to the Peak Demand model and is discussed in Section 4.3.1.1.

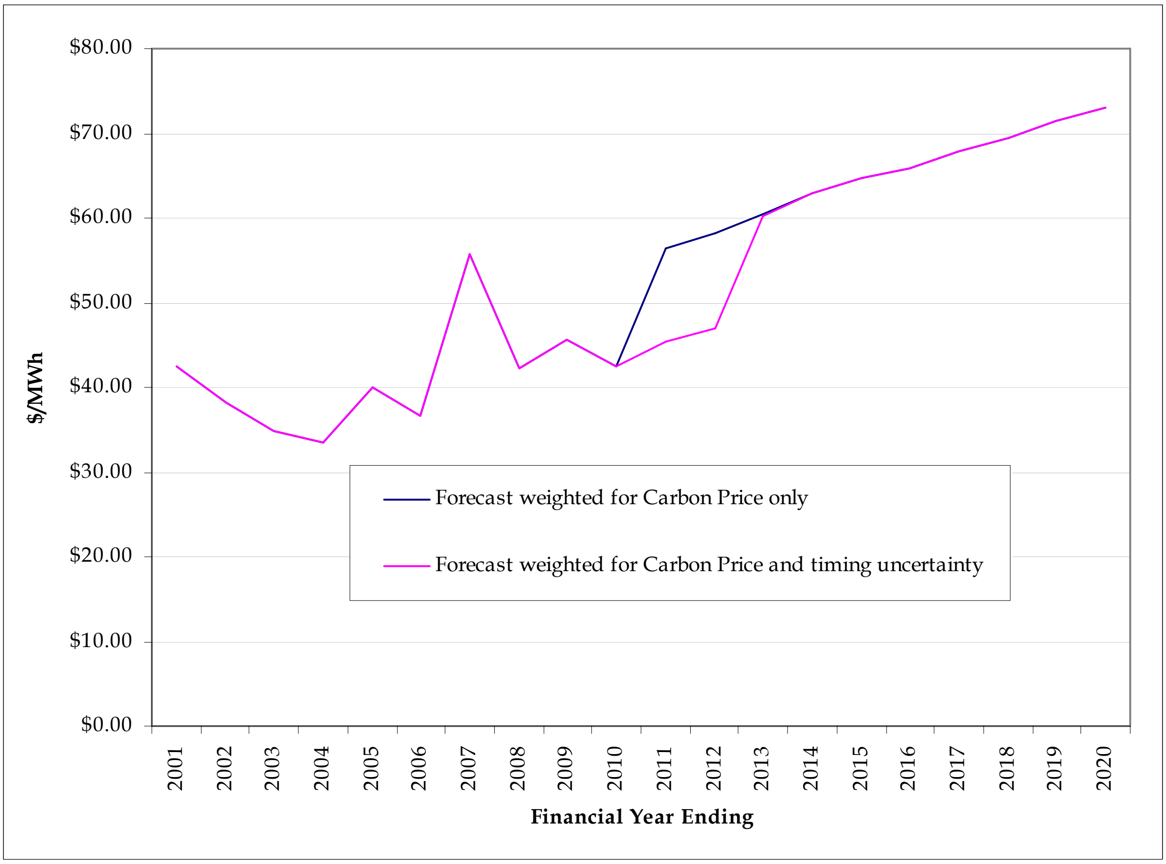
4.1.6.1.1 Economic growth

For the APR 2007 TransGrid assumed economic growth between 2006-07 and 2013-14 of about 2.4% pa. MMA does not have at hand the latest NIEIR forecasts, however, recent forecasts of NSW and ACT GSP growth by Econtech, another respected economical forecaster, suggests that growth over the period to 2012-13 is expected to be only 2.1% pa. Given the elasticity to economic growth of 0.86 (Section 4.1.2), with everything else being equal this would be expected to reduce energy forecasts in the long-run by about 0.23% pa or some 1.5% between 2006-07 and 2012-13. This is a not insignificant amount.

4.1.6.1.2 Electricity prices

Indicative MMA analysis of the impact of the recent drought and forecast emission trading on NSW pool prices over the coming decade is illustrated in Figure 4-2.

Figure 4-2 Recent MMA time-weighted pool price forecast for NSW, $/MWh in constant June 2007 dollars



The diagram shows that pool prices are expected to increase by of the order of $25 to $30/MWh in real terms over the period 2003-04 to 2013-14. Given that the real average delivered price of electricity in 2003-04 was estimated (as a model input) at about 9.4 c/kWh, or $94/MWh, an increase of $25-$30/MWh, if all cost increases are passed through and other costs remain unchanged, would result in a real price increase of about 25% over the period. The uncertainty about the timing of the implementation of emission trading scheme is illustrated in the two different paths.

The TransGrid assumptions (based on NIEIR forecasts) are for prices to increase in real terms by about 15% over the same period. Although there are undoubtedly likely to be other reasons for the difference, if they were all due to the timing of Emission Trading MMA considers that this could result in an increase of real prices by of the order of 10 percentage points by 2013-14. Using the own-price elasticity of -0.15, this would result in a reduced energy forecast of about 1.5% over the period, or some 0.15% pa.

4.1.6.1.3 Population forecasts

The other major component of the forecasts is population growth. TransGrid has been using NIEIR population growth information prepared before the Census 2006 results. MMA understands that the results of the census have been to revise slightly upwards population numbers, and presumably growth between census years. Although it is not clear what the impacts of re-staging recent population numbers together with changed population forecasts would have on energy forecasts, MMA considers that the likely impact would be a slight increase in population growth, and hence energy forecasts, possibly by the order or 0.1-0.2% pa.

4.1.6.1.4 Materiality of changes to key economic assumptions

It is clear that there have been significant changes to the macroeconomic climate since the forecast was carried out in early 2007. However, it is unclear whether the overall impact on energy forecasts (and then on demand forecasts) of the three most significant changes, to forecast economic growth, electricity prices and population are material. They may, indicatively, reduce energy growth overall by some 0.2% pa over the longer term.

4.2 Weather correction model

4.2.1 Functional form

The functional form of the TransGrid weather correction equation did not initially raise any concerns for MMA. However, an examination of the weather correction equation coefficients for various time periods for the year ending April 2007 revealed unexpected patterns among the cd coefficients, namely that there are statistically highly significant differences among them, with cdtue the highest and cdwed the lowest for the time periods examined. This raises the concern that the equations may predict that Tuesdays will always yield the peak demand, for every one of the fifty weather scenarios, and we cannot think of any plausible reason why this would be so.

The weather equation outputs confirm that there is a strong bias towards the simulated 2007 summer peak occurring on Tuesdays (refer to Table 4-3) (59% of occurrences) and not on Wednesdays (0%). For the 2006 summer peak there is an equally strong bias towards Mondays.

Table 4-3 Day of week on which peak demand occurs in the fifty weather scenarios

	2007	2006
Sunday	0	0
Monday	8	26
Tuesday	29	9
Wednesday	0	8
Thursday	6	4
Friday	7	3
Saturday	0	0

It is difficult to believe that such outcomes would be associated with a fully effective normalisation of the 2007 or 2006 peak demands. At present we cannot offer a full explanation of either the causes or effects of this phenomenon but suggest the following:

- Causes: For 2007, one or more Tuesdays with high demand relative to cdd's, perhaps due to unusual weather conditions, leading to a high cdtue coefficient. It is noted that relatively few days each year contribute to defining the coefficients.
- Effects: cd coefficients for individual days that are not representative of the real weather sensitivity that would apply to other weather conditions, as in the fifty scenarios, leading to potentially biased estimates of peak demand.

Evidence of a related phenomenon is provided by the cd parameters of the multi-year weather normalisation model described in a TransGrid information paper[17]. The cd parameters for time period 31 from 2000 to 2006 are detailed in Table 4-4. While the cd coefficients for each day of the week all trend strongly upwards over the period, the trends are not smooth and not even correlated, as one might expect them to be if they were all being driven by a single factor such as air-conditioning penetration (Table 4-5). Thus, it appears that this approach of modelling each half-hour of each day is likely to provide at least one anomalously high cd coefficient in each year. This is not a concern when determining the accuracy of the model across all days of the year but when it comes to estimating peak demands the anomalously high coefficients will always tend to determine the peaks, as shown in Table 4-3.

On the basis of this evidence we suggest that this approach as it stands may in future require re-thinking and that TransGrid should consider either:

- reverting to its earlier model, the Baseline model, where this problem is avoided because a single cd coefficient covering all relevant days is estimated
- re-specifying the current model to ensure that this phenomenon is avoided, e.g. by constraining the relationships among the cd coefficients.

Table 4-4 Multi-year weather normalisation cd parameter estimates

	cdsun	cdmon	cdtue	cdwed	cdthur	cdfri	cdsat
2000	97	215	223	233	240	250	171
2001	256	284	272	269	273	280	183
2002	181	245	216	277	218	201	236
2003	266	254	273	248	276	282	236
2004	204	247	324	262	244	301	243
2005	260	346	361	268	278	298	268
2006	363	407	353	352	324	350	349

17 Issues in Ascertaining the Probability Distribution of Peak Demand

Table 4-5 Multi-year weather normalisation cd parameter estimate changes, year-on-year

	cdsun	cdmon	cdtue	cdwed	cdthur	cdfri	cdsat
2001	159	69	49	36	33	30	12
2002	-75	-39	-56	8	-55	-79	53
2003	85	9	57	-29	59	81	0
2004	-62	-7	51	13	-33	19	7
2005	57	99	38	7	34	-3	25
2006	103	61	-8	83	46	52	81

4.2.2 Changes in the methodology for 2007

In 2004, the weather correction methodology comprised derivation of weather normalisation models for each year from 1994 to 2003, as with the current approach. However, instead of applying the weather scenarios directly to these models to derive peak demand distributions and then estimating the 10%, 50% and 90% POE peak demands, 10%, 50% and 90% POE weather parameters were derived from the weather data from 1957 to 2004 and these parameters were inserted into the models to calculate the 10%, 50% and 90% POE peak demands. The 2004 approach is more commonly used in peak demand forecasting but MMA considers the 2007 approach to be superior as it allows the non-temperature variables to influence the peak demand estimates, consistent with the observation that peak demand is frequently associated with very high but not-quite peak temperatures.

4.2.3 Recommended changes

MMA considers that the 2007 methodology could be further improved by using the normalisation models stochastically rather than deterministically, i.e. in parallel with applying the sample of 50 weather scenarios to the weather correction models, apply a sample representing the distribution of the error term. This will enable the models to generate more representative peak demand distributions but we do not believe that it will overcome the above issues related to the functional form of the model.

4.3 Peak Demand model

4.3.1 Variables used and functional form

As discussed in Section 2.7, the Peak Demand models relate summer and winter peak demand to average energy outputs from the Energy Model (which indirectly captures the impact of economic and price factors on peak demand) and to a factor which captures the impacts of air-conditioning growth. The key variables are provided in Table 4-6.

Table 4-6 Variables used in the 2007 Peak Demand model

Symbol	Units	Definition	Source of data
Pd	MW	Peak demand, summer or winter, 10% POE, 50% POE or 90% POE.	Estimated from actuals using the weather correction model. Forecasts output from the model.
Ad	MW	Average seasonal demand. Summer = average of December to March. Winter = Average of June to August	From energy usage
Ac	Index of air-conditioning ownership	The index represents air-conditioning penetration multiplied by population. Different definitions are used for ac for summer and winter.	None

As discussed below, the ac index is a key driver in the model of growth in peak demand. The choice of air conditioning index is discussed below.

4.3.1.1 Effects of the choice of air-conditioning index

The air-conditioning index has been developed by TransGrid based on assumptions about growth in air conditioning. KEMA recommended in its 2005 report that the ac index used by TransGrid be improved. In its 2007 report KEMA found that the ac index used for APR 2007, which estimated reduced growth in the final couple of years of the period was an improvement over the previous version, but recommended further improvement (see Section 3.2.7).

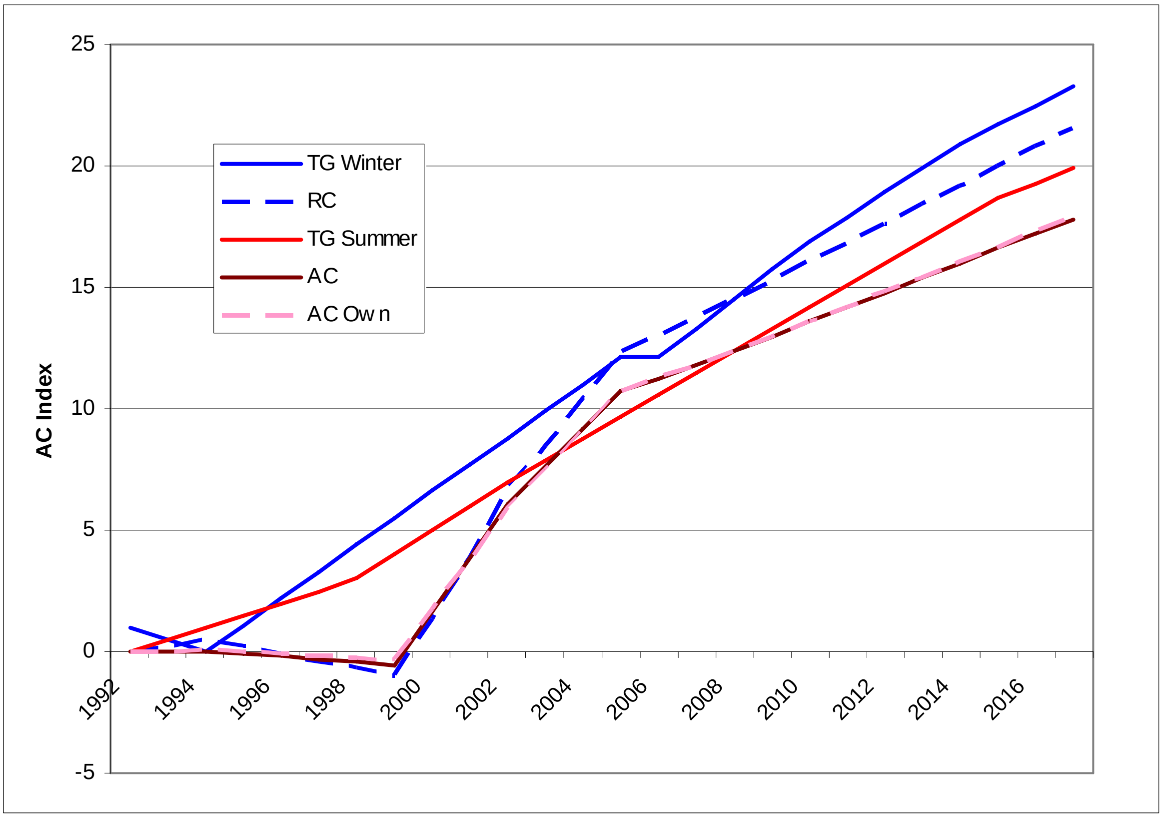
Data regarding ac penetration has been collected and published by the ABS since 1994. This and other data based on surveys and census information prior to 1990 was summarised by EES[18] in 2006. MMA is concerned that TransGrid does not appear to have used this accessible information in deriving its ac indexes. Use of alternative ac indexes may change both the parameters in TransGrid's models and the projections of the indexes. Estimating the impact on model parameters is beyond the scope of this assignment but MMA has investigated the impact of using EES' indicative projections in the TransGrid peak demand models.

Figure 4-3 compares the TransGrid summer and winter ac indices with indices constructed by MMA from EES data on reverse cycle (RC) air conditioning penetration (relevant to winter) and total ac penetration and total ac ownership (which incorporates multiple appliance ownership). MMA has multiplied the EES percentage penetration data by population and scaled this[19] to match the TransGrid indices in 1992 and 2008, to enable comparison.

[18] Energy Efficient Strategies, "Status of air-conditioners in Australia – Updated with 2005 data"., January 2006.

[19] In order to facilitate comparisons, we have zeroed in 1992 and then used a scaling factor which allowed index results to match in 2008.

Figure 4-3 TransGrid AC Index and EES Air-conditioning data



The TransGrid indices are clearly very basic approximations to the EES historical data, which MMA considers representative of the best that is currently publicly available. TransGrid has indicated its intention to use the EES data in its 2008 forecasts, which may result in changes to both the models and the projections. MMA has prepared indicative projections using the current TransGrid models with projected ac indices based on the slower growth rates suggested by EES, noting EES' disclaimer that its forecasts are not based on a rigorous methodology. It is noted that at the time of preparing the 2007 APR TransGrid also commented on a slow-down of air-conditioning driven peak demand load (as reflected in the DNSP's forecasts)[20] but does not appear to have incorporated such a slowdown in its ac index projection until 2016, after the end of the regulatory period.

Use of the EES projections results in potentially significant reductions in summer peak forecasts but less significant reduction in winter peak forecasts. It is noted however, that these reductions may not be representative of the changes that would result from use of the EES data in model estimation and more considered ac penetration forecasts.

[20] TransGrid 2007 APR p 20.

Table 4-7 Estimated reductions in peak forecasts using EES ac projections, MW

	Summer			Winter		
	10% POE	50%POE	90%POE	10% POE	50%POE	90%POE
2008	0	0	10	-50	-50	-50
2009	-130	-90	-50	-100	-100	-110
2010	-240	-170	-100	-130	-140	-140
2011	-360	-250	-150	-160	-160	-160
2012	-470	-330	-190	-180	-180	-180
2013	-580	-410	-240	-200	-200	-220
2014	-700	-490	-290	-210	-210	-210
2015	-810	-570	-330	-210	-210	-220
2016	-810	-570	-330	-210	-210	-220
2017	-810	-570	-330	0	0	0

Source: MMA estimates using current TransGrid models.

4.3.1.2 *Mis-specification of a variable in model implementation*

In examining TransGrid's Eviews implementation of the peak demand models, MMA found that the average demand parameter in the Peak Demand model had been mis-specified. In defining the data for the average demand, ad, Direct industrial usage has been deducted from total energy in the definition of ad inputted to Eviews and the models have been constructed using "ad minus Direct industrial" as an independent variable, thereby subtracting direct industrial load twice. MMA understands that this was not intended.

TransGrid has advised[21] that constructing the models using a re-specified ad parameter results in a reduction to summer peak demand forecasts of 210 MW (50% POE) and 180 MW (10% POE) by 2013/14, the final year of the regulatory period. The result of the re-specification alone is a reduction of summer 10% POE growth rates from 2.5% to 2.4% pa between 2006 and 2014.

4.3.2 Functional form

A simple linear relationship is assumed between peak demand and average demand and air-conditioning ownership.

$$pd_t = \gamma 0 + \gamma 1\, ad_t + \gamma 2\, ac_t + \varepsilon_t$$

This relatively simple form was used for the first time in the 2007 APR. In previous years lagged versions of the model were used but in 2007 these were, according to TransGrid, found to offer little improvement in accuracy (see Section 4.4). The parameter coefficients for the various models are presented in Table 4-8.

[21] R Hickling, Teleconference 23 April 2008.followed by an email attaching the spreadsheet "Corrected summer demands"

Table 4-8 Peak demand model coefficients

	Summer peak			Winter peak		
	10% POE	50% POE	90% POE	10% POE	50% POE	90% POE
Constant	5496	4023	2551	3569	3671	3773
Ad	0.53	0.81	1.09	1.08	1.02	0.96
Ac	402	284	165	122	123	125

The peak demand equations have a very simple structure and it is straightforward to determine the contributions of each input to peak demand growth (Table 4-9).

Table 4-9 Peak demand input factor growth rates[22] and contributions to peak demand growth rates

	Summer peak			Winter peak		
Factor	ad	ac	Total growth	ad	ac	Total growth
Factor growth	2.81%	5.40%		2.52%	5.41%	
10% POE contribution	0.64%	2.20%	2.84%	1.47%	0.86%	2.33%
50% POE contribution	1.08%	1.72%	2.80%	1.42%	0.89%	2.31%
90% POE contribution	1.64%	1.12%	2.76%	1.38%	0.92%	2.29%

Projected air-conditioning index growth accounts for 78% of the 10% POE summer peak growth, 61% of the 50% POE summer peak growth and 41% of the 90% POE summer peak growth, which is driven more by growth in average demand. The winter peaks are all driven primarily by growth in average demand.

While the relative total growth outcomes for the 10%, 50% and 90% POE summer peak demand forecasts appear logical, in that there is an ever widening gap between the 10% and 90% POE projections, the extreme dependence of the 10% POE forecast on the air conditioning index would lead to a narrowing gap if the ac index grew more slowly. MMA estimates that if air-conditioning penetration stopped growing in 2018, so that the ac index grew only at 0.9% in proportion to population growth, then the summer peak models would result in converging 10%, 50% and 90% POE summer peak forecasts, with a cross over in about 2040. This outcome is of course impossible and illustrates the potential pitfalls of modelling the three POE levels separately and the care that needs to be taken in deriving and using the models.

The issue is of concern because the ad parameter in the 10% POE summer peak demand model has an unsatisfactory significance level, possibly due to overstated correlation of 10% POE peaks with the artificially constructed ac index. This suggests that the ac parameter may be significantly over estimated. One option for avoiding the above

22 Average growth rate from 2008 to 2017.

outcome would be to constrain the ad parameters in each POE model to be the same, for example by estimating them simultaneously. This approach may also eliminate the unsatisfactory significance level of the ad parameter in the 10% POE summer peak model and would almost certainly reduce the differences between the ac parameters in the models, thus reducing the growth differential between the forecasts.

Finally, MMA notes that the simple functional form of the Peak Demand models also does not directly capture the effects of efficiency programs, for the same reasons as the energy model does not. Adjustments may in future need to be made to take into account structural changes in energy efficiency as in the energy models (see Section 4.1.5).

4.3.3 Summary of MMA's review of the Peak Demand model

MMA has a number of concerns related to the Peak Demand model as set out above, related mainly to the choice of ac ownership index.

MMA considers that there is a material likelihood that, when re-calculated using the available air conditioning data and taking into account the variable mis-specification mentioned above there would be a material impact on summer MD growth rates, especially the 10% POE summer peak forecast, quite possibly of the order of 500 or more MW by 2014.

MMA considers that TransGrid should re-estimate its peak demand models using an ac index based on more realistic data (refer to Section 4.3.1.1) and re-specified ad variable (see Section 4.3.1.2) and if the structural problems described in Section 4.3.2 persist, a constrained parameter estimation approach should be tested.

4.3.4 Non-scheduled and exempt generation

The treatment of non-scheduled and exempt generation has been described in 4.1.4.2. As discussed in that section, for demand as well as for energy there are some issues related to reconciliation between the NIEIR/Greenworld forecasts and those used as non-scheduled and exempt generation by TransGrid[23].

An additional issue also arises with respect to the availability of such non-scheduled and exempt generation on peak days. TransGrid has used the assumption that the capacity of non-scheduled and exempt generation available at NSW peak time is 100% of all generation from non-renewable fuels apart from fuel oil[24] and new sugar mill bagasse[25] while the existing sugar mill bagasse, hydro and wind capacity is assumed to not contribute at all to peak generation.

23 On the demand side the difference between the growth of such generation forecast by NIEIR and that used in the TransGrid models is estimated at about 85 MW from 2008.

24 Which is apparently a 50 MW generator at Broken Hill which operates during times of emergency only.

25 According to TransGrid, existing sugar mill bagasse does not contribute to peak demand in summer or winter but new bagasse will contribute because fuel will be stored to allow generation throughout the year.

There is little wind generation currently operating in NSW, but the NIEIR report projects strong growth, from 16 MW in 2006 to 333 MW by 2010. The TransGrid assumption means that none of this wind is expected to contribute to peak day demand.

KEMA has previously commented on the need to make a reasonable assessment of the likely wind availability during peak times (Section 3.1.7). If there is wind generation in NSW MMA expects that it will make some contribution to peak load. However, given that much of the wind generation in NSW remains speculative, and that other states have estimated a low (7-8% contribution), MMA considers the 0% peak contribution assumed by TransGrid to be reasonable for the current regulatory review.

4.3.5 Demand side participation

According to KEMA the TransGrid treatment of DSP is to add back estimated historical DSP into historical native demand and then forecast with this load added in. DSP would then constitute a further available source of supply (Section 3.1.6).

While a conservative approach (because it does assume no reduction in load due to DSP going forward) this appears to be the convention adopted by NEMMCO and the JPBs and is considered appropriate.

However, MMA understands that the DSP is modelled separately by TransGrid as a direct 130 MW add-in after the model outputs have been generated. If this is the case it is not in line with the methodology previously considered appropriate by KEMA and needs to be reviewed

4.4 The process for making changes to forecasting methodologies

As discussed in Section 2.3, the LFRG promotes continuous improvement of process and methodology and the TransGrid models have certainly undergone a number of changes over the past several years.

While MMA considers the continuous improvement objective to be laudable, it believes that the rationale behind any material changes to methodology need to be provided, fully evaluated (including the actual impact of the change on forecasts) and fully documented in order to allow the full implications of the change to be assessed.

As described in Section 3.2, the KEMA 2007 report reviewed the forecasting methodology used by TransGrid in producing its draft APR 2007 forecasts. The KEMA report is dated June 2007 and is understood to have been largely written early in the 2007 year. The report is largely supportive of the methodology used by TransGrid in the production of its forecasts.

Between the time of the KEMA review of the draft APR 2007 and the actual APR 2007 forecasts being produced we understand there to have been at least two components of the models used by TransGrid which were changed.

- the cooling and heating degree day terms which had been multiplied by a "wealth index" in the Energy Model (including an air conditioning component for cooling degree days) were changed so the wealth component was excluded.
- the Peak Demand model which had included a lagged peak demand term was changed so the lagged term was excluded.

To explain the first change TransGrid stated:

"At the time no actual data were available for a/c stocks and it appeared to be an empirically better model when simplified.[26]"

In terms of the second change to the Peak Demand model, TransGrid has commented:

"The separate models for the summer and winter and for each of 3 different weather normalisations, or POE levels, like the energy models, were also developed as VECs (vector error correction form). However, the dynamics were found to be largely insignificant and so the actual models consist of just the long-run components[27]."

In a meeting with TransGrid on 10 April 2008 the process for decision making relating to changes to the load forecasting methodology and models was discussed. According to TransGrid the proposed forecasting methodology improvements are identified by the main forecaster who discusses them with colleagues. The changes are also reviewed up the management chain. The changes are "well tested" and documented in the APR. Documents are also exchanged within the LFRG – although feedback is often limited. It is intended that all changes should be fully justified. Indeed, according to TransGrid the KEMA 2007 report was used to support the TransGrid methodology and forecasts to the TransGrid Board prior to the APR 2007 forecasts being approved.

The changes between the draft and final APR 2007 forecasts may have been carried out after discussions with KEMA, although there is no evidence of this in the KEMA report. The impact of these changes may also have been insignificant. As TransGrid did not formally document its changes to the models since the KEMA report, MMA has not been able to identify the need for the changes nor assess the ramifications.

TransGrid has made material judgements about the need to refine inputs in its handling of assumptions about non-scheduled and exempt generation with a shift in timing of the inputs proposed by the NIEIR report (see Section 4.1.4.2 above). Similarly, the TransGrid post-processing model allows for judgmental "shifts" to be made. For APR 2005[28] TransGrid added loads of up to 300 MW by 2015 to the modelled summer peak demand on the basis of judgement. A load of 100 MW was subtracted from winter maximum demands in 2007 in APR 2007 largely for presentational issues.

While these assumptions and "shifts" may well be based on appropriate judgements, MMA considers that these need to be fully justified and documented.

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[26] TransGrid response to question 6 of Further Questions from 11 April.
[27] TransGrid Appendix to Backcast questions, "TransGrid Load Forecast Methodology " page 2.
[28] TransGrid Annual Planning Review 2005, page 136.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

Scheduled energy sent out in NSW grew at about 2.5% pa between 1995-96 and 2005-06. In APR 2007 it is forecast to grow at about 1.6% pa between 2005-06 and 2013-14. Meanwhile, the forecast growth rates of 10% POE summer MDs are expected to reduce from about 3.8% pa between 1995-96 and 2005-06 to about 2.5% pa between 2005-06 and 2013-14 and winter 10% POE MD from 2.7% to 2.0% over the same periods[29].

At first glance both the reduced energy growth rates and the relativities in growth rate appear reasonable. However, the underlying methods and assumptions behind the TransGrid forecasts need to be considered in the light of recent information before such a conclusion can be drawn.

As well, there appears to have been a significant change in the TransGrid forecasting methodologies and assumptions between 2004 and 2007 APRs. This has seen energy forecasts covering the period 2008 and 2014 reduce while 10% POE maximum demand forecasts for both summer and winter have increased. The reason for this apparent divergence also needs to be understood.

5.2 MMA review of TransGrid methods and models

MMA has carried out a desk-top review of TransGrid's models and methodologies, taking into account previous reviews on the TransGrid processes, models and methodologies carried out by KEMA in 2004 and 2007. MMA has been provided with a copy of the models used by TransGrid and has also had the opportunity to ask TransGrid a number of questions.

There are three components to the TransGrid methodology, Energy Model, Peak Demand Models and Weather Correction and MMA has assessed each in turn.

5.3 Energy Model

The Energy Model[30] evaluates energy generated, energy sent out and energy supplied for the region as a whole. It takes as key inputs historical energy and historical and forecast income per capita, electricity and gas prices and interest rates as well as weather and calendar variables. According to the model the two main drivers of forecast long-run energy use for the region are income (modelled as GSP per capita) and electricity prices.

KEMA found the functional form of the Energy Model to be suitable and the variables used to be appropriate. On the whole MMA also considers this to be the case.

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29 Note that the summer and winter medium scenario MDs are after weather normalisation to the required POE levels by TransGrid and inclusion of Tweed Loads and adding back of 130 MW of DSP.

30 Actually three models with identical structures of different parts of the electricity supply system.

MMA is concerned, however, that the APR 2007 forecasts were framed before some very significant changes to the macro-economic environment, such as the sub-prime crisis with associated "credit crunch" and market volatility were able to be factored in. Indicative MMA analysis suggests that if these are fully factored in this might reduce energy growth rates by some 0.2% pa.

5.4 Weather correction

Weather correction is vital for estimating historical load at different POE levels. The APR 2007 weather correction methodology is different from that used by TransGrid in the past and uses simulated modelling of loads for each half hour of the day, i.e. involves 48 models for each year. KEMA has reviewed the TransGrid weather correction methodology and considers it to be thorough, systematic and appropriate to use.

However, while agreeing that the direction being pursued by TransGrid is appropriate, MMA has some reservations about the actual methodology used and its outcomes. The approach produces material differences between the cooling degree-day (cd) sensitivity coefficients on different days of the week, e.g. Monday and Tuesday, for which there is no real underlying cause, and the day of the week having the highest coefficient varies from year to year. The simulation outputs confirm that this results in biases towards the peak demands in each year occurring on the day with the highest cd coefficient, for example on Tuesdays in 2007 and Mondays in 2006, contrary to what one would expect from a random process. While the APR 2007 results are not considered unreasonable because of this, MMA considers that the approach taken needs further validation.

5.5 Peak Demand models

The Peak Demand models relate summer and winter peak demand to average energy outputs from the Energy Model (which indirectly captures the impact of economic and price factors on peak demand) and to a factor which captures the impacts of air-conditioning growth. A simple linear relationship is assumed between peak demand and average demand and air-conditioning ownership. MMA estimates that the projected air-conditioning index growth accounts for 78% of the 10% PoE summer peak growth. The winter peaks are all driven primarily by growth in average demand.

The air conditioning index used by TransGrid causes most concern to MMA. It was derived by TransGrid for APR 2007 apparently without reference to publicly available data, including views that the rate of growth of penetration would fall. Use of publicly available data would be expected to have a material impact on the 10% POE summer MD. This, together with correcting the specification of a variable in the model may well change the summer MDs forecast by over 500 MW by 2014 and reduce the overall growth rate in 10% POE summer MD between 2006 and 2014 to 2.1% pa, closer to the rate of growth of energy. The effect of reducing forecast energy consumption by (say) 0.2% pa would be expected to further reduce expected growth.

5.6 Reasonable expectation of a realistic outcome

MMA is required to provide advice to the AER as to whether or not it is satisfied that the methods and processes used by TransGrid to develop the demand forecasts used for its revenue proposal would reasonably reflect a realistic expectation of the demand forecast.

While MMA has issues with some areas of TransGrid's forecasting methodology, detailed in the report, overall it considers the methods and processes adopted by TransGrid to be appropriate, well-considered and reasonable. MMA has throughout the report recommended changes to the methodology in a number of areas, including re-consideration of the weather correction model which may result in anomalous results and re-specification of a mis-specified variable.

MMA's main concerns lie with the ac index as discussed above and the fact that the inputs into the models may now be out of date as significant changes have taken place to factors such as the macro-economic environment since the APR 2007 was prepared about a year ago. These might in combination be expected to reduce forecast annual growth in summer 10% POE maximum demand to a figure closer to 2.1% pa between 2006 and 2014 rather than the forecast 2.5% pa.

While MMA does not necessarily consider the TransGrid APR 2007 forecasts unrealistic in light of the information available at the time, MMA considers a reduced growth rate to be more realistic in light of the new information and use of a more appropriate ac index.

If the APR 2007 forecasts are to be used for the review of capital expenditure forecasts for the 2009-2014 periods, then MMA's analysis suggests that a conservative approach to capital expenditure requirements is warranted. If the timing of a capital requirement is "on the margin" then MMA would expect that the timing should be assumed to take place later, rather than earlier.

In addition, TransGrid's APR 2008 should become available within the period of the AER revenue review. If the major methodological recommendations provided within this report have been acted upon, the forecasts provided within APR 2008 may provide further guidance to the AER and its capital expenditure consultants.

5.7 Recommendations related to modelling

MMA has in its report made a number of recommendations related to the TransGrid forecasting methodology. These include that TransGrid:

- should confirm its understanding of the historical and forecast basis of electricity and gas price inputs and examine other available sources. (Section 4.1.3)
- should systematise the basis on which it holds discussions with large Direct industrial customers and fully document the discussions and the basis on which it prepares its bottom up forecasts (Section 4.1.4.1).

- should establish a formal change procedure to justify, assess and document the approval process for all methods and processes related to demand forecasting (Section 4.4). The change procedure should be used to:
  - justify and document any changes from inputs of information from external sources such as NIEIR
  - justify and document any changes from outputs of the models into the final APR
  - justify and document any material changes to the models.

- estimate the likely impacts of policies on energy efficiency on both energy and demand forecasts and make adjustments to account for these, possibly on an ex-post basis (Section 4.1.5)
- review its weather correction methodologies in light of the analysis and potentially anomalous outcomes described in Section 4.2.1and, if the analysis is correct, either
  - revert to TransGrid's earlier model, the Baseline model, if the problem described in that section cannot be avoided, because a single cd coefficient covering all relevant days is then estimated or
  - re-specify the current model to ensure that this phenomenon is avoided, e.g. by constraining the relationships among the cd coefficients
- further improve the 2007 weather correction methodology by using the normalisation models stochastically rather than deterministically, which would enable the models to generate more representative peak demand distributions (Section4.2.3)
- re-specifying the current model to ensure that this phenomenon is avoided, e.g. by constraining the relationships among the cd coefficients. Establish and use an estimate better than 0% for the availability of wind at times of peak demand
  - prepare a new ac index based on consideration of the most recent information available, probably the EES report (Section 4.3.1.1)
  - re-estimate its peak demand models using the above ac index based on more realistic data and a re-specified ad variable (Section 4.3.1.2) and if the structural problems described in Section 4.3.2 persist, test a constrained parameter estimation approach
  - establish and use an estimate better than 0% for the availability of wind at times of peak demand (Section4.3.4)
  - ensure that the DSP methodology described in KEMA is actually used in modelling (Section 4.3.5).

APPENDIX A GLOSSARY

2009 – 2014 period	The next regulatory period for TransGrid from 1 July 2009 to 30 June 2014
ac	Air conditioning
ad or Avg-Dem	Average demand
AER	Australian Energy Regulator
ANTS	NEMMCO's Annual National Transmission Statements
APR, APR 2007, APR 2004	Annual Planning Report. The APR published for 2007 and 2004 respectively.
Auxiliary use or loss	Use of electricity by power stations and transformer losses
Cd or Cd or CDD	Cooling Degree Days measured as the number of degrees C by which the average daily temperature is above 21 C
CUST	Scheduled Energy supplied at customer Connection Points (excluding auxiliary and transmission losses)
Direct industrial loads	Large industrial loads such as aluminium smelters, paper plants and steel mills which are modelled separately on a bottom up basis
DSP	Demand Side Participation - when users of electricity or market participants reduce their consumption of electricity in response to an increase in prices or congestion or government request or agreement with a market participant.
EES	Energy Efficient Strategies
Embedded Generation	Generation connected to a distribution network. This is often Non-Scheduled but may be Scheduled.
Energy Sent Out (ESO) or Sent Out Energy	This is the energy in GWh supplied by generators into the transmission network or into the distribution network for embedded generation. It includes customer usage and transmission and distribution system losses, but not auxiliary usage by the generator and power station.

ESAA	Energy Supply Association of Australia (ESAA)
Exempt Generators and Generation	Generation which is exempt from NEM registration
GEN	Scheduled Energy generated at power stations on a generator terminal basis
Generator Terminal Basis	Demand measured at the Generator Terminal. This demand measure includes supply to customers, transmission and distribution losses and also auxiliary loads.
Hd or Hd or HDD	Heating Degree Day measured as the number of degrees C by which the average daily temperature is below 18 C
JPB	Jurisdictional Planning Body
KEMA	KEMA Inc of Madison Wisconsin
LFRG	Load Forecasting Reference Group
Maximum Demand (MD)	Single highest measurement of half-hourly average of instantaneous demand over a period, typically winter or summer.
MEPS	Minimum Efficiency Performance Standards
MMA	McLennan Magasanik Associates
Native Energy	Total energy demand supplied by both scheduled generating units and significant non-scheduled generating units, on a Sent Out basis, over the period.
NEM and NEMMCO	National Electricity Market and National Electricity Market Management Company Limited
NER	National Electricity Rules
NIEIR	National Institute of Economic and Industry Research
Non-Scheduled Generation	Generation which is less than 30 MW or which is intermittent (e.g. wind or biomass).
Non-Scheduled Generators and Generation	Generation which is registered as market non-registered or non-market non-registered or exempt from registration. Generally generation which is less than 30 MW or which is intermittent (e.g. wind or biomass).

NSW Maximum Demand	The maximum of half hourly total Scheduled Generation within NSW plus net imports into the region measured in MW and calculated on a Generator Terminal basis.
NSW Region	Region defined for electricity purposes encompassing both NSW and the ACT
NSW Scheduled Energy	Defined on a Sent Out basis as the supply into the transmission network of energy (measured in GWh) by Scheduled generators located within NSW plus net imports into the region.
Probability of Exceedence (POE)	MD projections for each season and year are typically represented by a statistical distribution which takes into account key factors such as temperature and day type (e.g. whether a working or non-working day). An MD at a specified POE level is the estimated MD which is likely to be equalled or exceeded at that probability level. For example, a summer MD specified as 10% POE means that the probability of this MD being equalled or exceeded in the summer of that year is estimated to be 10% or 1 year in 10. A 50% POE MD is expected to be equalled or exceeded, on average, 1 year in 2. Transmission network planning is typically based on 10% POE forecasts.
RC	Reverse Cycle Air Conditioning (capable also of heating)
SALES	Scheduled Energy supplied to end-use customers (excluding auxiliary and transmission and distribution losses and non-scheduled embedded generation)
Scheduled Generation	NEM generating units are classified as Scheduled (coordinated by central dispatch), non-scheduled or exempt from registration. Scheduled generators are typically larger (> 30 MW) and not intermittent. TransGrid forecasts relate primarily to Scheduled generation.
Sent Out Basis	Energy and demand measured at the point of connection between the generating units and the transmission network (or the generating units and the distribution network for Embedded Generation).

	This includes supply to customers, transmission and distribution losses but not auxiliary loads.
SOO	NEMMCO's annual Statement of Opportunities
Supplied Energy	The Energy measured at the supply points between the transmission and distribution networks.
TNSP	Transmission Network Service Provider

Sources: TransGrid APR 2007, NEMMCO, Energy and demand projections white paper, July 2007, MMA.