TransGrid

TransGrid Revenue Proposal
2018/19 – 2022/23

Appendix I

GHD:

Review and test of AusGrid's connection point demand forecast

Ausgrid's 2016 Inner Sydney Demand Forecast

October 2016

Executive summary

Ausgrid's 2016 Inner Sydney demand forecast provides a reasonable estimate of the potential future demand and is appropriate for use in planning augmentations to the transmission network crossing that corridor. The 2016 forecast shows a range of increasing peak demands, with the most significant contribution to demand growth coming from large new customer loads that have sought connection to Ausgrid's network.

Ausgrid's forecast is prepared taking into account the actual peak demand recorded during summer 2015-16. The forecast is built up from separate forecasts for individual zone substations within the Inner Sydney area. Each of these zone substation forecasts is based in the short term on its own respective historical rate of growth. The forecasts also account for the localised impacts of new customer connections. In the longer term, the whole-of-network impacts of a growing economy, changes in electricity prices and other behavioural effects including the application of energy efficiency regulations and standards and the rate of installation of rooftop photo-voltaic (PV) systems are also taken into account.

Up to 2013, Ausgrid's Inner Sydney peak demand forecasts predicted continuing growth rather than the recently experienced downturn in demand. Ausgrid forecasters were not alone amongst demand forecasters in failing to predict the reduction in demand. Analysis has demonstrated that the unique coincidence of an acceleration in energy efficiency savings with a rapid increase in electricity prices were the main factors contributing to the reduction in the Inner Sydney peak demand.

Ausgrid has enhanced its approach to forecasting demand to improve forecast accuracy. Back-casting analysis completed by Ausgrid demonstrates that the revised forecasting techniques deliver significant improvements in accuracy, achieving forecasts with consistently lower mean absolute percentage errors (MAPEs) than the techniques previously employed.

The most recent Ausgrid forecasts carefully incorporate the impact of historical changes in energy efficiency to better isolate the independent impact of price change.

Ausgrid's 2016 development forecast for Inner Sydney is not directly comparable with the AEMO's forecast for the Sydney region as the two forecasts refer to geographically different load areas.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.2 and the assumptions and qualifications contained throughout the Report.

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Glossary

AEMO, Australian Energy Market Operator

BCA, Building Code of Australia

CER, Clean Energy Regulator

Diversity factor, ratio between the demand at a location at the time of system peak demand to the maximum demand occurring at that location (whenever that maximum may occur)

DNMS, Data Network Management System

ESS, Energy Savings Scheme

EV, Electric vehicle (externally charging)

GSP, gross state product (state equivalent of gross domestic product)

HV, high voltage (in this report 33 kV and above)

kV, kilovolt (1,000 volts)

LGA, Local Government Area

MAPE, mean absolute percentage error, a popular measure of forecast accuracy that:

- measures the average error between a forecast data series and the true value of that series
- allows direct comparisons of forecast accuracy between forecasts of different measures
- does not discriminate between errors due to forecast bias (where errors in one direction are greater than errors in the other) and forecast variance (where errors are evenly distributed around the true value)

MEPS, Minimum Energy Performance Standards

MW, Megawatt (1,000 kW)

MWh, Megawatt-hour (1,000 kWh)

NEFR, National Electricity Forecasting Report

NEM, National Electricity Market

POE10 (POE50, POE90), 10 per cent (50 per cent, 90 per cent) probability of exceedance, or the point on a frequency distribution of peak demands that is statistically likely to be exceeded one in every ten (five in every ten, nine in every ten) years

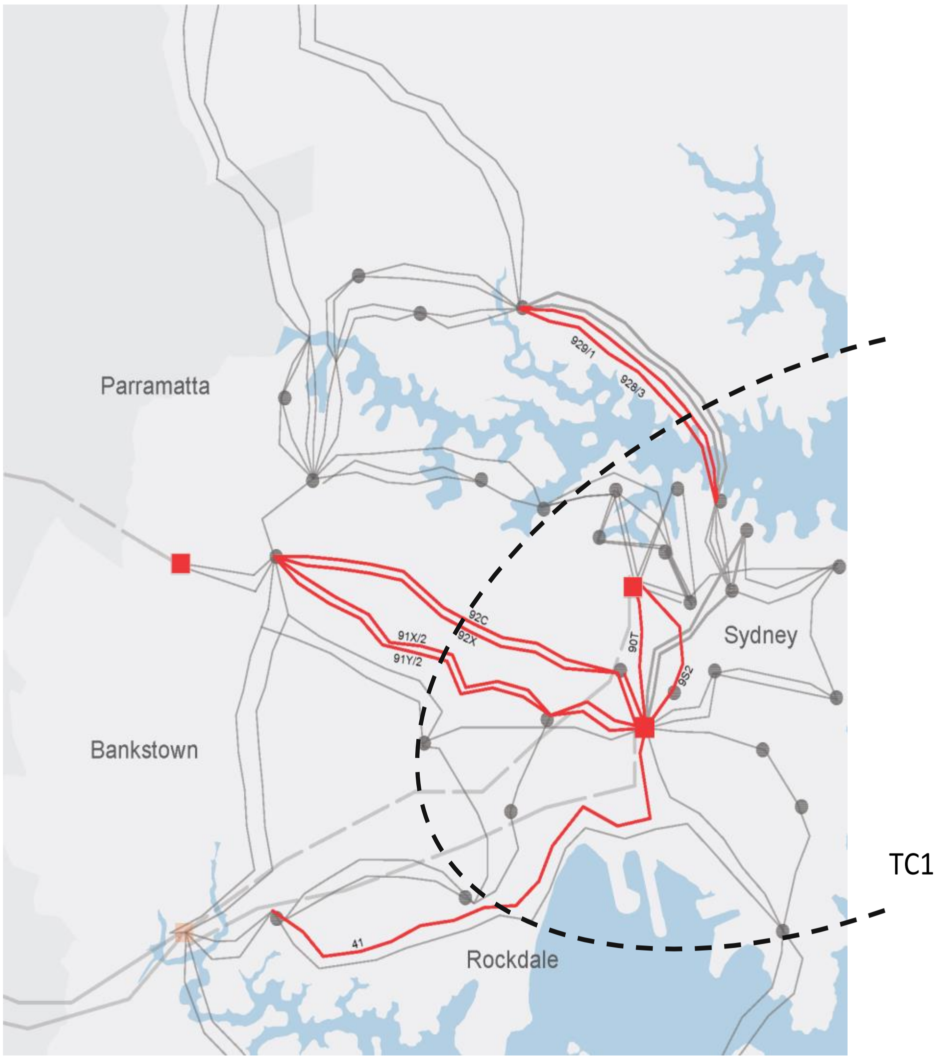
PV, photo-voltaic

SCADA, Supervisory control and data acquisition

TC, Transmission corridor

1. Introduction

In this report, ‘Inner Sydney’ refers to an area within the Sydney metropolitan area which is supplied with electricity from the Ausgrid distribution network via a number of electricity transmission cables. These comprise a number of Ausgrid 132 kV circuits and two TransGrid 330 kV circuits. These cables are shown in Figure 1 and the region they collectively traverse, which is loosely bounded by the dashed line, is designated Transmission Corridor 1 (TC1).



Source: TransGrid.

Figure 1 Transmission corridor TC1 supplying Inner Sydney

Each year Ausgrid produces an updated forecast for the Inner Sydney peak demand taking into account the peak demand recorded during the most recent summer. Ausgrid’s forecast is built up from separate forecasts for individual zone substations within the Inner Sydney area. Each of these zone substation forecasts is based on its respective historical rate of growth and the localised impacts of customer connections, as well as the whole-of-network impacts of a growing economy, changes in electricity tariffs and other effects on a macro level such as the application of energy efficiency regulations and standards and the rate of installation of rooftop photo-voltaic (PV) systems.

Inner Sydney peak demand is typically reached during the periods of hot weather across summer weekday afternoons. Peak demand in the Inner Sydney area generally increased until summer 2010-11, after which it fell substantially for three consecutive years, before resuming growth in 2014-15 and 2015-16. A key issue in forecasting reliability for future years is therefore the ability to explain the recent downturn.

This report describes Inner Sydney electricity demand, presenting information on the historical and forecast peak demand, including the most recent Ausgrid 2016 peak demand forecast for Inner Sydney. The report presents information on the drivers of the observed reduction in the summer peak demand and describes the adjustments that have been made by Ausgrid to improve its demand forecasting processes.

This report also looks at forecasts prepared by the Australian Energy Market Operator (AEMO). Starting in 2014, AEMO produced forecasts of individual National Electricity market (NEM) connection points[1] each year. However, in NSW AEMO's NEM connection point forecasts include a forecast of two aggregate regions to represent all of the demand supplied from the Ausgrid network. AEMO refers to these regions as the Sydney region and the Hunter region. AEMO does not disaggregate these regions further, since the meshed nature of the low voltage system underlying the transmission network in these regions makes it difficult to allocate the forecast load to individual connection points. Neither the AEMO Sydney region nor the Hunter region is equivalent to the Inner Sydney area defined in this report.

1.1 Purpose of this report

This report presents the key characteristics of the Inner Sydney peak demand, explains the multi-year fall and recent recovery in peak demand and describes the processes undertaken by Ausgrid to develop the 2016 peak demand forecast.

The report is intended to inform stakeholders regarding the development of Ausgrid's Inner Sydney peak demand forecasts, the performance of those forecasts and measures implemented to improve forecast performance.

The report consolidates information drawn from a number of Ausgrid reports and data sets presenting the salient information in a readily digestible format.

1.2 Scope and limitations

This report: has been prepared by GHD for our Client (as per our contractual agreement) and may only be used and relied on by our Client for the purpose set out in section 1.1 of this report. GHD disclaims responsibility to any person other than our Client arising in connection with this report.

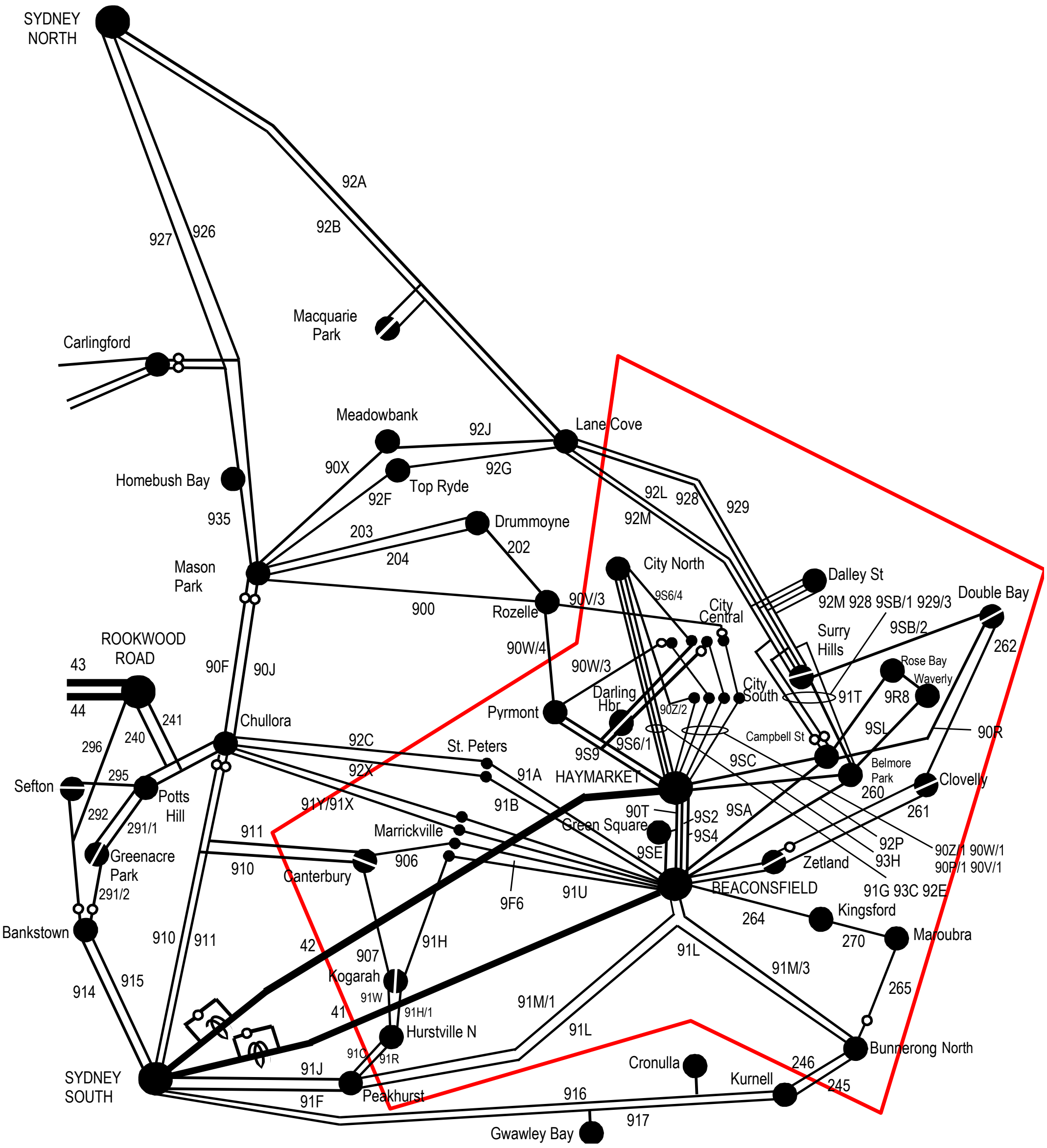
GHD has prepared this report on the basis of information provided by Ausgrid, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information. The opinions and conclusions in this report are based on assumptions made by GHD described in this report.

Measurement of Inner Sydney demand

Electricity demand in the Inner Sydney area of interest is measured by the coincident sum of demands at all Ausgrid zone substations that are directly fed from the transmission network (whether owned by TransGrid or Ausgrid). Figure 2 is a geographic representation of the transmission and high voltage distribution network in Sydney in which the red boundary describes the Inner Sydney area. Each of the smaller dots in Figure 2 named in lower case represents a sub-transmission or zone substation, while the largest dots named in capitals

[1] Sometimes referred to as 'bulk supply points' or 'terminal stations'.

represent TransGrid bulk supply points. The sub-transmission and zone substations supply electrical loads at either 33 kV or 11 kV.



Source: Ausgrid.

Figure 2 Sub-transmission and zone substations supplying TC1 load

Each of the Inner Sydney 132/33 kV sub-transmission substations and the 132/11 kV zone substations that collectively account for demand within the area is listed in Table 1. The table identifies the actual (non-coincident) peak demand that was experienced at each substation across the 2015-16 summer; while the coincident total is constructed by applying diversity factors that account for the fact that individual peak demands occurred at different times to the time of the Ausgrid network peak demand. In the case of Alexandria, Belmore Park and Rockdale, demand is zero which reflects the fact that the substation had not been commissioned prior to the 2015-16 summer. After commissioning, demand within the Inner Sydney area will to a large extent simply be transferred away from existing locations towards the new substations.

Table 1 Substations making up demand in the Inner Sydney area

Substation	Area	Non-coincident 2016 MW	Diversity factor
Alexandria	Sub-transmission station	0.0	
Belmore Park	CBD	0.0	
Bunnerong North 132/33kV	Sub-transmission station	210.4	0.9625
Campbell St 132/11kV	Eastern suburbs	38.7	0.9516
Canterbury 132/33kV	Sub-transmission station	132.4	0.9862
City Central 132/11kV	CBD	107.9	0.9394
City North 132/11kV	CBD	67.8	0.9650
City South 132/11kV	CBD	126.9	0.9488
Clovelly 132/11kV	Eastern suburbs	53.7	1.0000
Dalley St 132/11kV	CBD	105.2	0.9484
Darling Harbour 132/11kV	Blackwattle Bay	50.7	0.9772
Double Bay 132/11kV	Eastern suburbs	58.1	0.9959
Green Square 132/11kV	Eastern suburbs	42.3	0.9153
Hurstville North 132/11kV	St George	23.5	0.8225
Kingsford 132/11kV	Eastern suburbs	39.4	0.9787
Kogarah 132/11kV	St George	67.4	0.9974
Maroubra 132/11kV	Eastern suburbs	44.0	1.0000
Marrickville 132/11kV	Eastern suburbs	47.9	0.9324
Pyrmont 132/33kV	Sub-transmission station	88.9	0.9729
Rockdale 132/11kV	St George	0.0	
Rose Bay 132/11kV	Eastern suburbs	29.2	0.8745
St Peters 132/11kV	Eastern suburbs	48.1	0.9467
Surry Hills 132/33kV	Sub-transmission station	157.3	0.9696
Waverley 132/11kV	Eastern suburbs	19.7	0.9440
Zetland 132/11kV	Eastern suburbs	62.9	0.9467
Coincident Inner Sydney[2]		**1,558.7**	

Source: Ausgrid.

1.3 Report Structure

The remainder of this report is organised as follows.

- Section 2 presents Ausgrid's most recent Inner Sydney peak demand forecast.
- Section 3 describes the approach used by Ausgrid to develop the Inner Sydney demand forecast.
- Section 4 describes the characteristics of the loads that collectively make up the Inner Sydney Load and presents information on the key factors that explain the reduction in peak demand experienced across the three summers commencing in 2011/12.
- Section 5 provides additional detail regarding the 2016 forecast presenting the building blocks used to develop the overall forecast.

[2] The coincident total is the sum product of each demand and its respective diversity factor.

- Section 6 reviews the performance of previous forecasts produced by Ausgrid and AEMO and provides a summary of the key enhancements adopted by Ausgrid to improve forecast performance.
- Section 7 draws some conclusions.

2. Ausgrid's 2016 Inner Sydney summer peak demand forecast

Ausgrid produces forecasts for each of its respective Inner Sydney substations, from which forecasts for the area as a whole are calculated. For consistency between years, forecasts are calculated on a weather corrected basis. Weather correction removes the temporary impact of extreme and annually varying weather conditions to reveal the underlying trend in peak demand. Weather correction is generally undertaken to calculate 10, 50 and 90 per cent probabilities of exceedance, where POE10, POE50 and POE90 refer to the 90th, 50th and 10th percentile of peak demands that are statistically likely in a particular season.

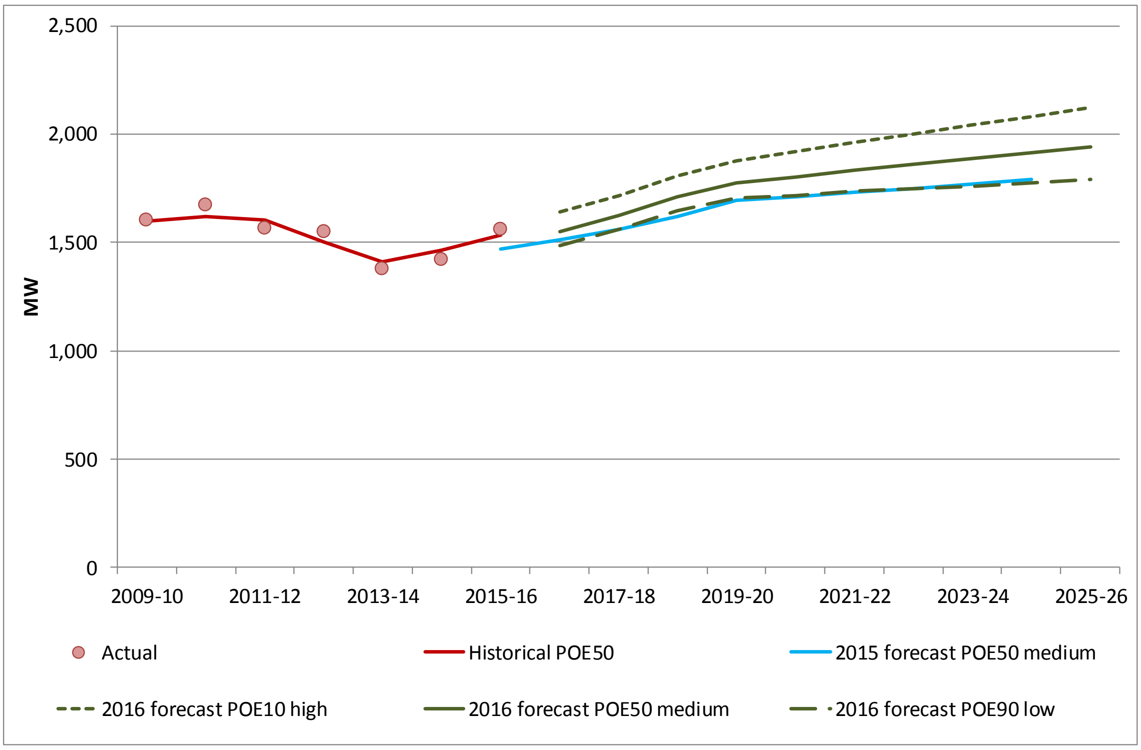
For each percentile forecast there is a high, medium and low future scenario, based on variation in the driver variables used to prepare the forecasts. These would typically include, for example, a high, medium and low range of state economic growth. The different scenarios indicate a potential range within which the peak demand is expected to lie. It is standard practice to produce such a forecast range, since this allows for testing and assessment of the robustness of investment drivers to changes in the demand forecast.

2.1 Inner Sydney peak demand 2016 Development forecast

Figure 3 shows the historical and forecast Inner Sydney peak demand. The pink dots show the actual peak demands, while the solid red line shows the weather corrected historical demands. The POE50 weather corrected peak demand in the Inner Sydney Area reached a maximum of 1,620 MW in summer 2010-11, falling to 1,412 MW in summer 2013-14, before rising in the most recent two summers.

The blue line in Figure 3 shows the 2015 Inner Sydney peak demand forecast, while the dark green lines show various 2016 forecasts[3]. Only the medium scenario, POE50, forecast is shown for 2015. Forecasts shown for 2016 include the high scenario POE10, through the medium scenario POE50 to the low scenario POE90. The first forecast point for the 2016 medium POE50 forecast features little growth compared to the previous year's actual, because the first year of the forecast is derived in relation to the trend lines observed for the respective weather corrected historical demands at each location (rather than in relation to the previous weather corrected actual). This prevents the forecast being overly influenced by the last historically observed demand.

[3] Ausgrid first prepares a Base forecast by considering historical growth rates, committed new connections, economic and demographic driver variables and general changes in consumer behaviour, assuming no changes in network configuration and no additional major customer connections. The Development forecast then builds on the Base by taking into account planned variations in network configuration and allowing for some additional proposed new large customers.



Source: GHD analysis, based on Ausgrid data[4].

Figure 3 Historical peak demand and 2015 and 2016 forecasts

The Ausgrid Development forecast is produced from a Base forecast by adjusting for future load transfers to and from various substations and by adding anticipated variations in large customer loads. The initial steep growth in both the 2015 and 2016 Development forecasts is due to the expectation of a number of new large customer connections, or spot loads[5].

The 2016 Inner Sydney peak demand forecast is higher than the 2015 forecast due primarily to two factors:

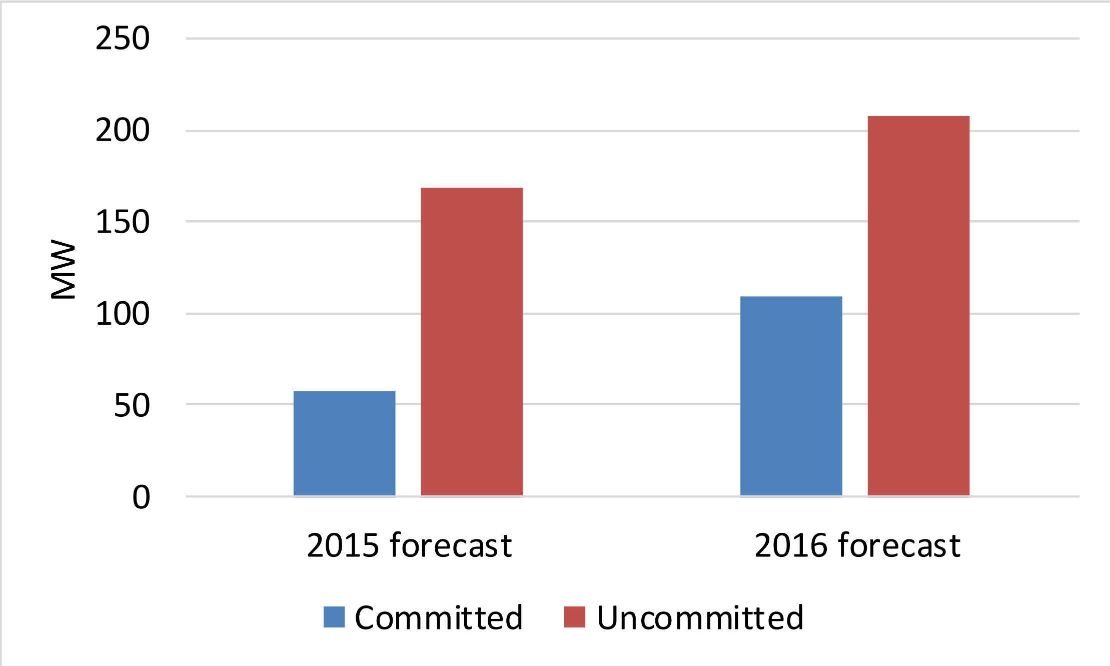
- a significant increase in the volume of major customer connections (spot loads); and
- a material increase in summer peak demand in 2015/16 by residential customers, resulting in an adjustment to the near term trend forecast to account for this customer response.

There are also substantial changes in some individual substation loads within the Inner Sydney area due to planned load transfers. The great majority of such transfers are within the Area and do not significantly impact the overall Inner Sydney peak demand forecast. However due to the retirement of Blakehurst, Arncliffe and the old Rockdale 33/11 kV zone substation between 2019 and 2021, and redistribution of their loads to Kogarah, Hurstville North and the new Rockdale 132/11 kV substation, loads in the order of 60 MW will be brought into the Inner Sydney area from this time.

A key factor in the increase in the Development peak demand forecast between 2015 and 2016 is the increased contribution expected from large spot loads. Figure 4 shows the contribution of spot loads to each of the 2015 and 2016 forecasts, where the blue bars show total committed connections and the red bars show uncommitted connections included in the Inner Sydney

[4] The data in this chart is tabulated in the Appendix.
[5] Spot loads are specific customer loads that are relatively unresponsive to changes in demographics, general economic growth, electricity tariffs and weather (and therefore difficult to capture in a spatial model) and usually also large enough to significantly alter the underlying trend growth rate at a particular location.

demand forecast[6]. The 2016 forecast includes almost 60 MW of additional committed spot loads in the Inner Sydney Area, compared to the 2015 forecast.



Source: Ausgrid.

Figure 4 Major new customer connections included in the forecasts

The step change in anticipated customer connection activity and customer response between 2015 and 2016 has significantly affected the near term component of the forecast and is responsible for virtually all of the increase to 2023 for both the Ausgrid network area and the Inner Sydney area.

Underlying growth in the Inner Sydney peak demand Base forecast is around 1.5 per cent per annum in the longer term from 2021 to 2026. Both the 2015 and 2016 forecasts incorporate similar underlying growth rates in demand.

[6] Commitment criteria are described below in Section 3.2.5. Forecast allowances for uncommitted connections are discounted to account for the relatively greater uncertainty of them proceeding.

3. Forecast development

Ausgrid's 2016 forecast for the Inner Sydney load is the coincident sum of spatial forecasts for each contributing sub-transmission and zone substation within the Inner Sydney boundary. Forecasting each substation demand involves consideration of a wide range of information pertaining to both the network region as a whole and individual locations. Each substation forecast is:

- weather corrected;
- founded on consideration of both the underlying trend in historical load and also estimated relationships (for residential and non-residential sectors) between demand for electricity services, on one hand, and price and income, on the other;
- adjusted to account for future growth in embedded generation, appliance and building energy efficiency and other technological and policy impacts; and
- adjusted to account for significant new spot loads.

The coincident sum of the substation forecasts is the sum of the products of each non-coincident forecast and its respective diversity factor. Forecast diversity factors are the arithmetic means of the last five years of actual ratios between maximum demand at each location and the demand which occurred at the respective location at the time of the broader Ausgrid network maximum demand.

3.1 Overview

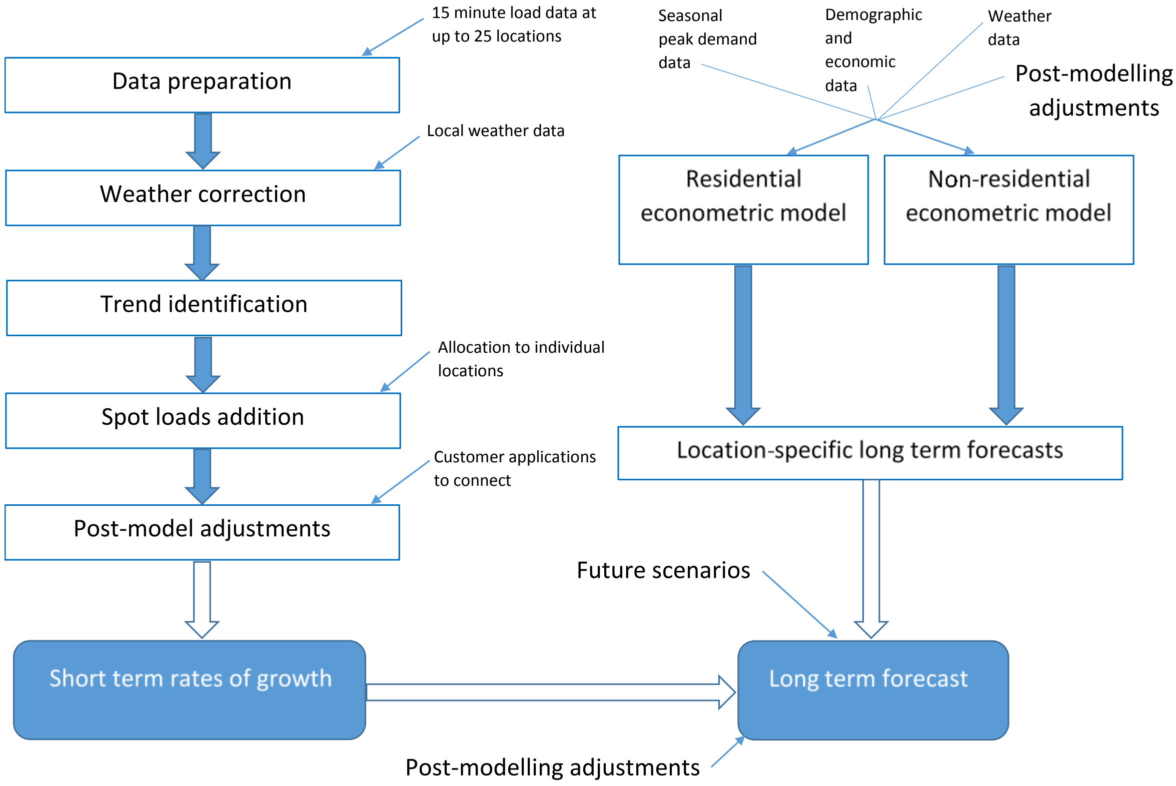
The relationship between the major activities involved in forecast development for each zone substation are shown in Figure 5.

3.1.1 Forecasting activities

Peak demand forecasts for individual zone and sub-transmission substations are derived from five main activities:

1. analysis of individual substation data to develop normalised and weather corrected *historical trends* for the base level of load excluding elements directly accounted for via post modelling adjustments and spot loads;
2. *econometric modelling* of residential and non-residential demand at the whole of network level, to determine the impact of economic growth and electricity prices on the demand for energy services;
3. development of *future scenarios* for economic growth, electricity prices and other input variables to the econometric models in order to develop forecasts from the models;
4. historical and projected '*post-modelling adjustments*', consisting, for example, of the estimated load impact of changes in appliance and building energy efficiency, and contributions of roof top photovoltaic generation and other embedded generation to peak demand; and
5. collection of data on *spot loads* and their level of commitment.

These activities contribute towards the various building block components that make up the forecasts.



Source: GHD.

Figure 5 Forecast preparation overview

3.1.2 Building blocks

The major building blocks that make up the forecasts are the short and long term Base forecasts, and planning-based consideration of future network transfers and major customer loads, used to create the Development forecasts.

Short term Base forecasts

The Base short term forecasts are projections of the identified historical trends from weather corrected historical data, suitably modified where relevant by the addition of post-modelling adjustments and committed spot loads. The historical data is 'cleansed' for abnormal meter readings, changes to high voltage direct connect customers during the trending period are removed and solar PV generation is added to reflect overall customer demand rather than network demand. This data is weather corrected and the year-to-year trend that is derived from the weather corrected series is used to determine the short term rate of growth. Committed spot loads are specifically accounted for in the short term rates of growth.

Long term Base forecasts

The Base long term demand forecasts are also derived from econometric modelling at the whole of network level for residential and (general load) non-residential customer classes. The estimated network economic impact is then shared among each spatial location using weights such as energy use for each customer sector. Alternative long term forecasts may be produced dependent on the scenarios that are developed for the econometric model input variables. Committed spot loads are generally[7] not added in the forecast derived from econometric modelling to avoid double counting the impact of the economic drivers.

[7] Some larger spot loads that are government policy driven, rather by economic drivers, may be added to the econometric forecast.

Complete Base forecasts

Years one and two of the complete Base demand forecasts consist of 100 per cent of each respective short term forecast. Years five onwards of the Base demand forecasts consist of 100 per cent of each respective long term forecast. Years three and four consist of a blend of each respective short and long term forecast, resulting in a smooth transition between the two.

Development forecasts

The Development forecasts are produced by modifying the respective Base forecasts to:

- reflect future network developments, including transfers between substations, for example to reflect the expected future operation of a new zone substation; and
- include a partial allowance for additional uncommitted customer spot loads, where Ausgrid has been approached by potential customers intending to connect and where there is a reasonable likelihood that a connection will take place.

The forecast building blocks and associated activities are described in more detail below.

3.2 Details of forecast production

This section provides further details regarding the steps used by Ausgrid in the development of the 2016 Inner Sydney demand forecast.

3.2.1 Historical weather correction and trend determination

Initial data collection and preparation

Historical interval load data for the spatial demand forecast is sourced from the following two systems:

- SCADA data from the Distribution Network Management System (DNMS) system; and
- Metering data from the Meter Data Warehouse.

This data is adjusted as part of the forecasting process to remove the effects of abnormal loads and abnormal switching. In this step local knowledge is important to understand historical changes in spot loads and load transfers between substations, and make appropriate decisions about outlier identification. Solar PV generation is added to the load data after weather correction for forecasting purposes. The aim of data manipulation at this stage is to capture the underlying use of energy from all sources, rather than energy supplied by the network.

Weather correction

Weather correction involves the estimation of daily demand-temperature sensitivities for each historical year and season of interest, followed by simulations to determine the POE50 levels of peak demand for each season.

Ausgrid's weather correction data sample preparation procedure includes daily maximum demands for the relevant season of the year, the removal of non-weather dependent days and the separate of working days and non-working days. Weather data is collected from the geographically closest BOM weather station[8] to calculate average daily temperature, using the most recent ten years of data in order to account for the effect of long term trend of increasing temperature. A model of the demand versus temperature relationship is then estimated.

The demand-temperature model is used in a Monte-Carlo simulation method to determine the weather corrected maximum demand for each season. While this simulation generates a

[8] The selection of weather stations is dependent on the quality of available data from any given location. The 'best' weather data is that which provides the most reliable correlation with local demand and not may not necessarily be the geographically closest source to where that demand is metered.

number of alternative daily maximum demands for each included day, the outcome of interest is only the seasonal peak for each simulation. Both working and non-working days are included to model the effect of substations that can peak on a non-workday. Probability of exceedance levels are calculated using the relevant percentile from the simulated seasonal peak demands. The POE10 corresponds to the 90th percentile and so on.

Weather correction is not applied to large industrial loads where the load does not exhibit weather dependency for that season or where the load exhibits weather dependency that does not follow the general trend expected for that season, based on examination of the seasonal load versus temperature relationship. This includes dedicated customer loads connected at the sub-transmission level[9].

The outcome of the weather correction process is highly dependent on the correct specification of the demand-temperature relationship, selection of historical weather for the re-sampling that underlies the simulations, accounting for warming trends in climate data (in the longer term) and the number of years of data to include in the estimation for each single season (since the incorporation of multiple years of data using previous year dummy variables may improve both the fit of the demand-weather equation and the smooth transition in the weather corrected outcome from year to year).

3.2.2 Trend growth

Underlying growth rates are generally determined by fitting a trend line to the historical POE50 data. The weather corrected and adjusted trends are reviewed by an internal Ausgrid expert panel to consider factors that could influence the growth rates such as Local Government Plans.

3.2.3 Econometric modelling

Ausgrid uses regression models for whole of network residential and non-residential demand, respectively, to estimate income and price elasticities. To ensure that the regressions measure customer demand response, embedded generation is added to the historical metered demand data. The regressions use a historical 'energy services'[10] measure as the dependent variable, which is constructed using the estimated MW impact of energy efficiency programs. This is done to avoid collinearity with price and consequent over-estimation of price elasticity by attributing above-trend energy efficiency savings to price elasticity.

The residential component models the change in residential electricity demand in response to changes in real retail residential electricity price and average household disposable income. The resultant model outputs and forecasts are adjusted to take into account growth in residential customer numbers and air conditioning penetration rates (although these have now saturated in Sydney at around 65 per cent).

The econometric models determine the residential and non-residential electricity demand response from each of the driver variables which is then allocated to individual substations.

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[9] Large industrial customer loads are not included in weather correction. However, small (11 kV) spot loads are generally not removed prior to weather corection, nor are transfers backed out, due to the impracticality of estimating adjustments to numerous load profiles across multiple years.

[10] 'Energy services' includes metered demand, historical demand impacts from rooftop solar as modelled from customer interval data and estimated historical demand impacts from energy efficiency programs. The use of an energy services measure appears to be unique to Ausgrid. Historically rapid increases in energy efficiency took place between 2008 and 2014, at the same time as increasing real electricity tariffs. Not to account for historical energy efficiency in modelled demand over this period would run the risk of over-attributing the fall in demand to the impact of price and income elasticity. Forecasts generated with such a model would then be oversensitive to future price and income forecasts, compared to the model currently used by Ausgrid.

Data sources for the residential model are as follows:

- Residential electricity price (historical and forecast) from external consultant; and
- Household incomes (historical and forecast) from external consultant.

Air conditioning penetration rates are derived from ABS or similar data and historical residential customer numbers are sourced from Ausgrid billing data, with forecasts provided by an external consultant.

The non-residential component models the change in non-residential electricity demand in response to changes in real retail non-residential electricity price and NSW Gross State Product.

Data sources for the non-residential model are as follows:

- Non-residential electricity price (historical and forecast) from an external consultant; and
- NSW Gross State Product (historical and forecast) from an external consultant.

All data sources provided by an external consultant are the same data as used by AEMO to prepare their 2016 National Electricity Forecast Report (NEFR). Forecast data is generally provided on the basis of high, medium and low scenarios which provides a range of demand forecasts.

3.2.4 Future scenarios development

Demographic and economic forecasts applicable to Ausgrid's network area and for a number of scenarios are provided by AEMO to provide a similar basis for forecast development across the NEM. A brief summary of the broad trends expected for each of the key drivers of energy use are as follows.

Economic growth

Economic projections used for Ausgrid's 2016 forecast, including electricity price, Real Household Disposable Income and GSP projections for alternative scenarios, were provided to Ausgrid by the Australian Energy Market Operator (AEMO). The projections were sourced by AEMO from Jacobs, KPMG and Deloitte Access Economics respectively. They are the same economic forecasts used by AEMO to prepare the 2016 NEFR.

Economic growth drives higher level of energy use as businesses expand their operations. The NSW economy is projected to grow strongly, at least in the short term, with forecast GSP growth of around 2.5-3.0 per cent for 2015/16 and 2016/17.

New residential customers

Population growth continues at a steady pace and may even accelerate due to substantial infrastructure investment proposed or in progress by the NSW Government. Latest projections from NSW Department of Planning in "A plan for growing Sydney" (Dec 2014) have resulted in an increase in population growth projections. From this plan, Ausgrid's network area is expected to accommodate around 310,000 additional households over the next 15 years.

The Department of Planning have recently updated population projections resulting in substantial increases. Further detail is provided in Section 5.2.3.

NSW electricity price

Whilst the historic price increases have been a significant driver of declines in customer demand, prices stabilised between 2013/14 and 2015/16 and were projected to remain relatively stable into the foreseeable future. Price forecasts provided by AEMO projected flat to declining prices in the short to medium term. The 2016 forecast is based upon these price projections.

Retail price rises of about 10 per cent from 1 July 2016 introduced some uncertainty to future customer demand. Further detail is provided Section 5.2.1.

3.2.5 Spot loads

Spot loads are generally identified from connection applications to Ausgrid. In preparing the 2016 forecasts, Ausgrid defined 'commitment' strictly as having paid a connection fee to Ausgrid, by which stage the details of the electrical connection to the network have been arranged and the customer's project is usually ready to proceed. Anticipated committed spot loads are discounted by 27 per cent before being added to the forecast to reflect historical experience with project delays, down scaling and cancellations. Discounted committed spot loads are included in the Base forecasts after the application of growth rates.

A spot load can in principle result in either an increase or decrease in the forecast load (i.e. a new connection will increase load and a disconnection will reduce load). However, future intelligence on business closures is less likely to be available.

In the Development forecast, distribution planners may also apply some discretion to include uncommitted spot loads that are considered abnormal for a given area. For example, a small industrial spot load in an area dominated by residential load would be considered abnormal for that area, even if the spot is below a numeric threshold. Similarly, a cluster of small spot loads resulting from a local council zoning change to an area would be considered as a single spot load increase for each year. Aside from consideration of a handful of large uncommitted spot loads as certain, the majority of uncommitted spot loads are generally included at a discount of 72 per cent, representing the general probability of speculative projects actually going ahead.

3.2.6 Post model adjustments

Post model adjustments is a general term used in formal modelling and forecasting to account for factors that are either not included in the trend or econometric model and so must be specifically adjusted for in the forecast. Ausgrid applies these adjustments in certain cases to adjust data prior to modelling as well as to the results of modelling after the event. As explained in Section 3.2.3, Ausgrid's treatment of energy efficiency includes adjustment of historical data prior to modelling. To ensure that forecast objectives are met, Ausgrid reviews post model adjustments annually to assess any changes to the scope or scale of the adjustments.

Energy efficiency

Post model adjustments for energy efficiency estimate the impact of energy efficiency improvements on electrical appliances, buildings and energy savings initiatives driven by government policy. For the 2016 forecast, post model adjustments for energy efficiency includes impacts from Minimum Energy Performance Standards (MEPS) for appliances, Building Code of Australia (BCA) for buildings and the NSW Energy Savings Scheme (ESS).

Energy efficiency data is obtained from published reports, commissioned reports and internal analysis.

Energy efficiency scenarios are based on variations in MEPS, ESS and BCA. The high forecast scenario is derived by using the low scenarios for each of MEPS, ESS and BCA (low levels of energy efficiency activity result in higher electricity demand), while the low forecast scenario is derived by using the high scenarios for each of MEPS, ESS and BCA.

Energy efficiency impacts are largely driven by government policy decisions on energy efficiency standards for appliances and buildings. A recent update to the expert advice Ausgrid receives on these energy efficiency impacts shows a modest decline in the impact from future standards and programs. While the impact has declined slightly, energy efficiency is expected to have a significant influence on customer energy use as customers replace equipment or buildings with new, more energy efficient options.

Embedded generation

The historical load data includes the impact of downstream embedded generation that was generating at the time of peak. Consequently, the forecast includes the impact of small scale generation (such as rooftop solar installations).

Where a generator has a material impact on peak load that is not accurately reflected in the historical data and information is available about generator output and reliability, the forecast is adjusted to reflect the expected impact of the generator, taking into account:

- The historical reliability of the generator and expectations about its future reliability, including weather dependency where relevant;
- When the generator was installed and whether it is a temporary or permanent installation;
- Contractual obligations for Ausgrid to provide backup or standby supply to a site; and
- Network support agreements with the generator.

Larger generators that are relied on for network support are generally included as a negative spot load.

Post model adjustments for embedded generation estimates the impact of increasing levels of embedded generation in the network such as rooftop solar power for both residential and non-residential customers. The embedded generation impact is determined for each location by calculating the effect of the embedded generation at that location based on the amount of installed embedded generation and the time of day which the peak occurs.

For solar power, records of historical individual installations are used to determine the historical impact of solar power for each zone substation, which is used in the growth rate calculation for each zone substation.

Forecast solar power is determined by firstly projecting future uptake at the whole of network level and then allocating to individual zone substation and factoring in the time of day which an individual zone substation experiences its peak demand. Solar PV data is obtained from Ausgrid systems and checked against Clean Energy Regulator (CER) data. The CER website has solar power installation information by postcode, although the data is generally less up to date than the data collected by Ausgrid.

Prior to any calculations involving solar power for the forecast, internal historical solar power records are checked against the CER data, to serve as a top-down validation of internal records. The CER records are adjusted for fringe postcodes on the edge of the network.

Embedded generation scenarios are based on variations in the forecast MW impacts. For solar power, the process uses the recent monthly installation data to determine appropriate upper and lower limits for the solar power projections.

Similar to energy efficiency, the high embedded generation scenario is applied to the low forecast scenario and the low embedded generation scenario is applied to the high forecast scenario.

Rooftop solar has been growing at a steady but relatively modest pace for the past 2-3 years following the end of the solar bonus scheme and more lucrative up-front grants from the

Commonwealth Government's renewable energy year, and is predicted to have a steady but modest impact on demand growth over the near to mid-term period.

The payback for a solar power system is currently about 6-10 years for residential customers under the present tariffs. Without a change in the cost of solar panels, the growth rate is not expected to change materially and is likely to remain a modest impact on the Ausgrid network.

Battery storage

Detailed Ausgrid analysis based on published forecasts of battery costs and using real customer interval data across a broad spectrum of customers under current tariff structures reveals that storage is not economically attractive under current tariffs. The 2016 base forecast includes projected impacts from the customer take-up of battery storage, with an estimated 7 MW of peak demand reduction in 2025 and 174 MW reduction in 2035 at system total level.

At present, battery storage offers a simple payback greater than 30-40 years for most customers. With warranty periods typically less than 10 years and storage systems requiring a significant investment when batteries are exhausted, investment in storage is predicted to remain limited to early adopters and enthusiasts until prices decline[11].

Allowance for electric vehicles

Ausgrid make no allowance in the Inner Sydney peak demand forecast for a potential uptake of electric vehicles (EVs) over the forecast period. However, as argued by AEMO, this would be unlikely to have any significant impact on forecast peak demand - at least at the broader network level - since the collective EV maximum demand is likely to be non-coincident with system maximum demand[12]. However, any uptake would be likely to increase minimum demands and network utilisation.

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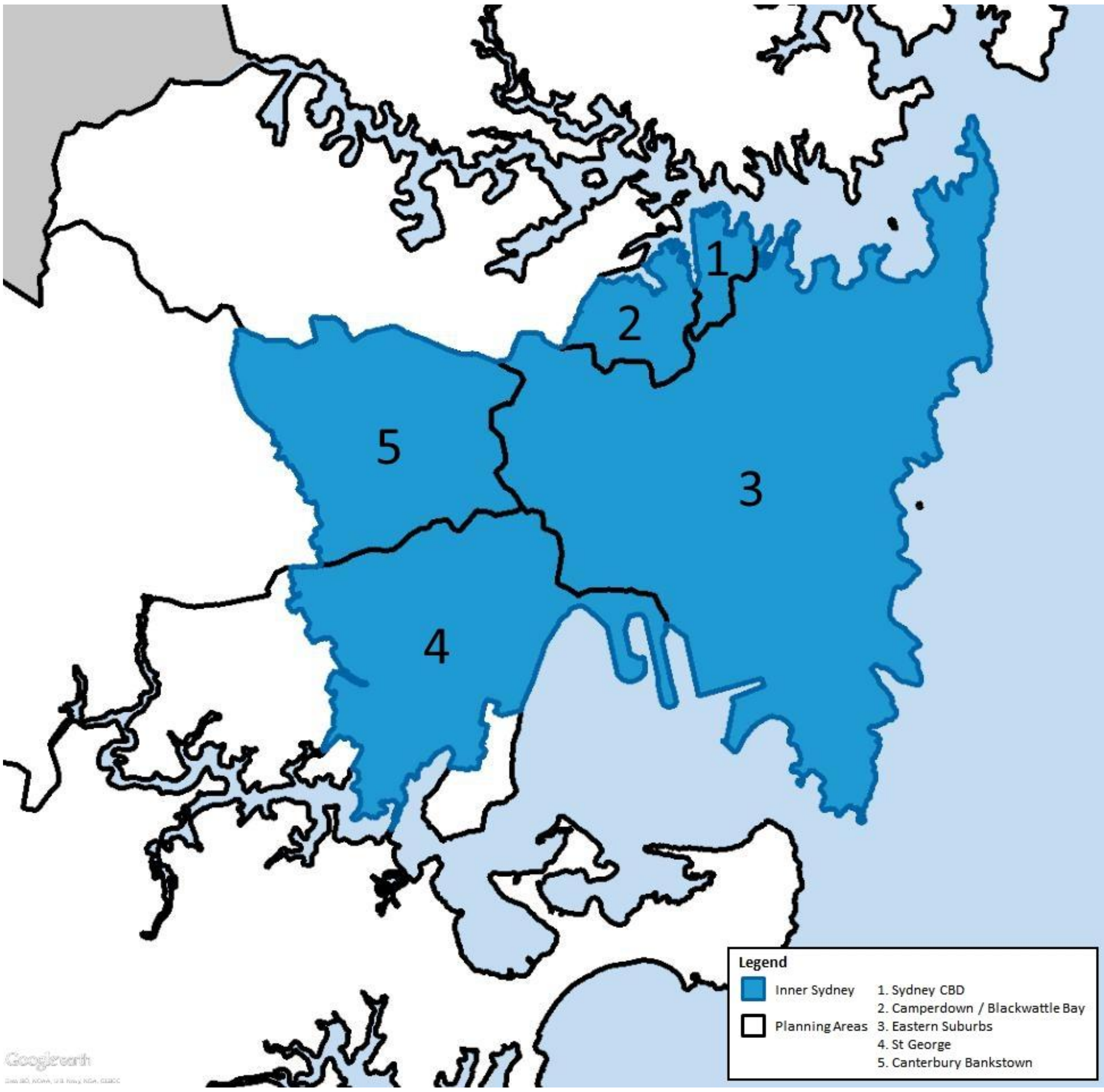
[11] Ausgrid has determined that there will be no meaningful impact from non-residential customer battery storage on peak demand over the forecast horizon. Based on current tariffs and projected increases plus an assumed decline in the cost of batteries, the economics of battery storage is poor and therefore the installation of significant non-residential battery storage is considered unlikely within the forecast horizon unless battery costs fall significantly.

[12] AEMO Insights: Electric Vehicles, August 2016.

4. Inner Sydney demand characteristics

This section describes the key characteristic of the demand in each of the four planning Areas that make up the Inner Sydney Area. Annual electricity consumption in this area – excluding high voltage customers and supply to services such as public lighting and bus shelters – is estimated to be about 32 per cent residential, 19 per cent small business and 49 per cent businesses using more than 160 MWh a year[13]. Total (low voltage) electricity consumption in the area fell from 8,488 GWh in 2010/11 to 7,645 GWh in 2013/14, a fall of more than 10 per cent, before recovering slightly in the last two financial years. A similar trend of continuously falling demand followed by a recent recovery is visible in the aggregate Ausgrid network, the state of New South Wales and, in fact, the entire NEM system.

4.1 Five Area Plan demand areas



Source: Ausgrid.

Figure 6 Ausgrid planning areas

[13] Ausgrid (2015) Average Electricity Consumption by LGA 2015, http://www.ausgrid.com.au/Common/About-us/Corporate-information/Data-to-share/Average-electricity-use.aspx#.WA0pyZ24ZaQ, (viewed 22/10/2016).

To ensure investment is prudent and efficient, Ausgrid's planning of major investments in the network is based on meeting the requirements of geographic areas, defined on the basis that they represent discrete electrical areas and with relative independence from network interconnections. Inner Sydney straddles five distinct planning areas, including the entire CBD, Camperdown and Blackwattle Bay and Eastern Suburbs areas, and sections of the St George and Canterbury Bankstown areas[14]. This is illustrated in Figure 6, where the blue area of Inner Sydney cuts across the St George and Canterbury Bankstown planning areas, but fully encompasses the others.

4.1.1 Sydney CBD

The Sydney CBD network area extends from Circular Quay in the north, west to Darling Harbour, east to Woolloomooloo, and south to Haymarket. Bounded by Darling Harbour, Central Railway Station and the Domain, it comprises an area of less than 3 square kilometres. This is the commercial heart of Sydney and contains approximately 45% of Sydney's office space. Although the Sydney Local Government Area (a somewhat broader area than that defined by the CBD) is home to some 100,000 residents, this amounts to only 11 per cent of all customers in the area. The majority of CBD customers are businesses consuming more than 160 MWh per annum.

4.1.2 The Camperdown and Blackwattle Bay Area

The Camperdown and Blackwattle Bay network area is a predominantly urban area on the fringe of the Sydney CBD. It includes high-density residential developments and commercial areas such as Darling Harbour, Broadway, Pyrmont and Camperdown. Residential customers account for around half the electricity consumed in the Area.

4.1.3 The Eastern Suburbs

The Eastern Suburbs load area includes Sydney's eastern seaboard from South Head to La Perouse, and extends inland to Surry Hills in the north-west, and west as far as Marrickville. The area encompasses a broad spectrum of load types from medium-density residential through to large commercial and industrial customers.

The Eastern Suburbs area contains substantial industrial precincts at Botany, Mascot and Alexandria, as well as major customers such as Sydney's major domestic and international airport, the Garden Island Naval base, the University of New South Wales and the Sydney Cricket Ground/Football Stadium. The City of Sydney[15] views Alexandria as a corridor for commercial and industrial growth in the medium-term future.

Several large load applications in the Alexandria area have been submitted to Ausgrid, and, although they have not progressed to date, Ausgrid views Alexandria as an area for possible major future development.

Peak demand in the Eastern Suburbs area occurs in summer and is driven by demand from residential and commercial customers. It is predominantly driven by temperature, and the associated peak in air-conditioning and appliance usage during the hottest part of the day. Winter demand is relatively close to summer demand in the Eastern Suburbs due to the prevalence of central heating systems in residences, and also because proximity to the harbour and the ocean results in relatively moderate summer temperatures. Peak demand in the Eastern Suburbs area has flattened out over the last five years, possibly attributable to a

[14] Inner Sydney includes an estimated: 79 per cent of Ashfield, Leichhardt and Marrickville in the Canterbury Bankstown Planning Area; and 43 per cent of Bankstown, Canterbury, Hurstville, Kogarah and Rockdale in the St George Planning Area.
[15] City of Sydney (2014) Employment Lands Strategy 2014 – 2019, Sydney City Council.

combination of factors such as mild summers, economic down-turn coupled with increased electricity prices, and increasing penetration of energy-efficient appliances.

4.1.4 The St George Area

Inner Sydney includes part of the St George network area. This area extends west from Arncliffe and Sans Souci on Botany Bay, and inland to Peakhurst. This is a predominantly urban area that includes high density residential developments and commercial areas such as the Hurstville retail district. Population growth continues to drive load growth along the rail corridor. The East Hills and Illawarra railway lines and Princes Highway pass through the area.

4.1.5 Canterbury Bankstown Area

Inner Sydney also includes a substantial part of the Canterbury Bankstown network area. This area in its entirety extends from Leightonfield in the north-west, Revesby in the south, and east as far as Dulwich Hill. The part included in Inner Sydney encompasses a broad spectrum of load types from low density residential through to large commercial and industrial customers. Not included in Inner Sydney are the industrial precincts at Chullora, Leightonfield, Milperra and Padstow.

4.2 Historical electricity demand in Inner Sydney

The recent prolonged fall in electricity consumption and peak demand was reflected across Australia. In New South Wales previous falls in consumption have occurred for at most one year at a time, notably in the early 1980s when several coincident factors came into play, including the first real increase in electricity prices since 1950, a major recession and the introduction of competition from natural gas for heat and cooking. The unprecedented three year fall in NSW electricity consumption from 2010-11 to 2013-14, followed by a recent return to growth, is shown in Figure 7. Inner Sydney peak demand and NSW energy consumption followed a similar pattern of peaking in the 2010-11 summer and recovering from summer 2013-14. It is therefore likely that common factors explain the trend in energy consumption and peak demand.

The reasons for the recent fall in electricity demand are extensively documented by the Australia Institute[16]. Notwithstanding that the downturn coincided with a rise in small scale, behind the meter, solar generation which exacerbated the fall in metered consumption, the main reasons for the fall in demand were:

- national regulations mandating the increased energy efficiency of new appliances, equipment and buildings progressively introduced since 2006;
- the closure of a small number of large electricity consuming manufacturing facilities, likely to have been stimulated in many cases by the decline in minerals prices and the high Australian dollar; and

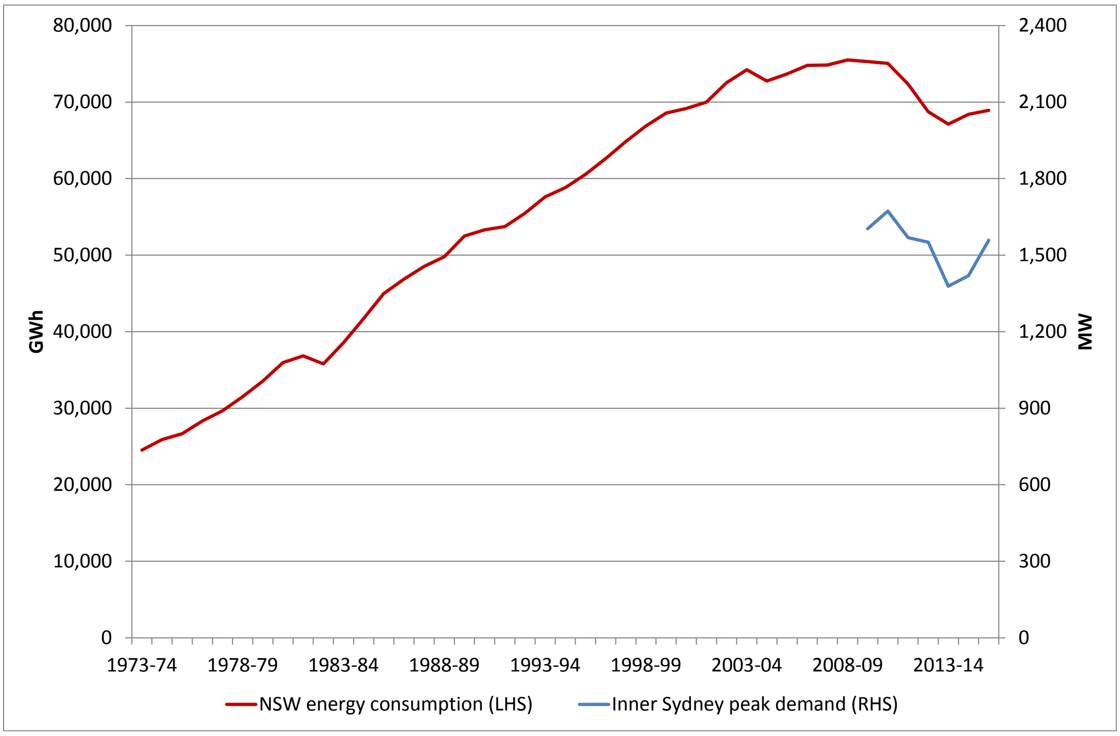
[16] Refer to the following publications:

- Saddler, Hugh (2013) *Power Down: Why is Electricity Consumption Decreasing?* The Australia Institute Paper No. 14, December, Canberra.
- Saddler, Hugh (2015) *Power Down II: The Continuing Decline in Australia's Electricity Demand*, The Australia Institute, July, Canberra.
- Saddler, Hugh (2016) *Is Electricity Demand Growth Returning in Australia?* The Australia Institute Discussion Paper, May, Canberra.

Available at: http://www.tai.org.au/, viewed 23/09/2016.

- the response of electricity consumers, especially residential consumers, to the most significant sustained rise in electricity tariffs in 30 years.

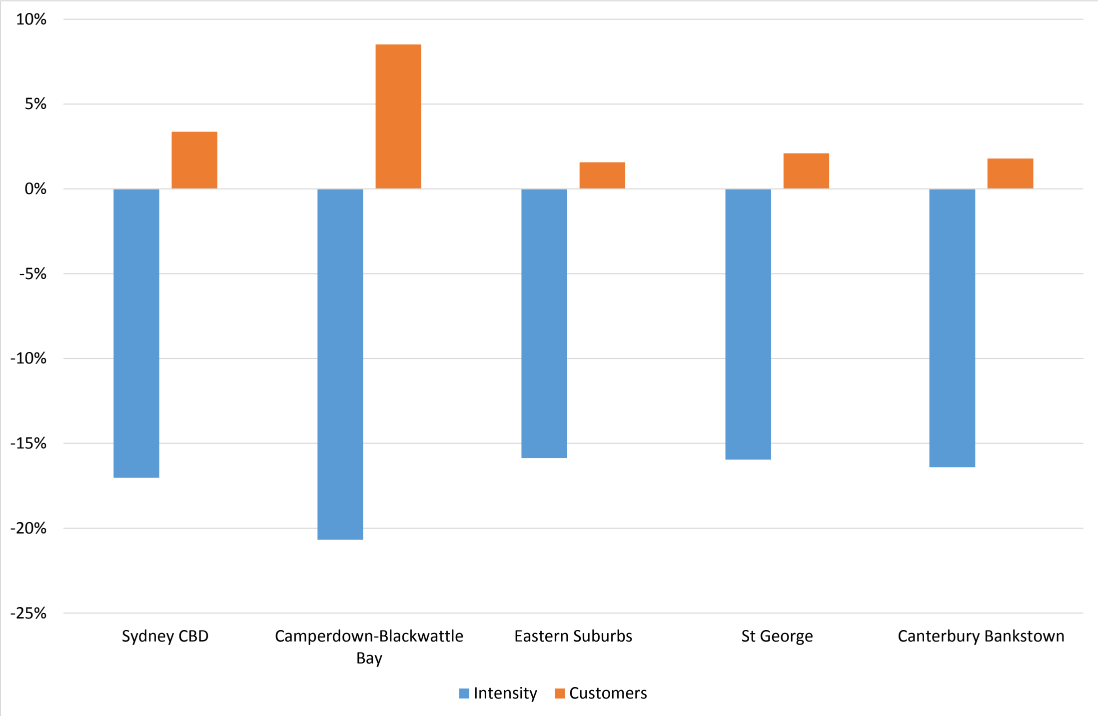
Across the NEM, the contribution of changes in energy efficiency that contributed to lower energy intensity was significant; and increasing energy efficiency was the major contribution to falling residential demand. Changes in intensity were also apparent as a result of reductions in electricity intensity within sectors, most notably by the closures of a few large electricity consuming customers.



Source: GHD analysis based on data published by AEMO, the Department of Industry, Innovation and Science, Office of the Chief Economist and AEMO and Ausgrid data from 2010 to 2016 (Inner Sydney data from 1974 to 2009 is unavailable).

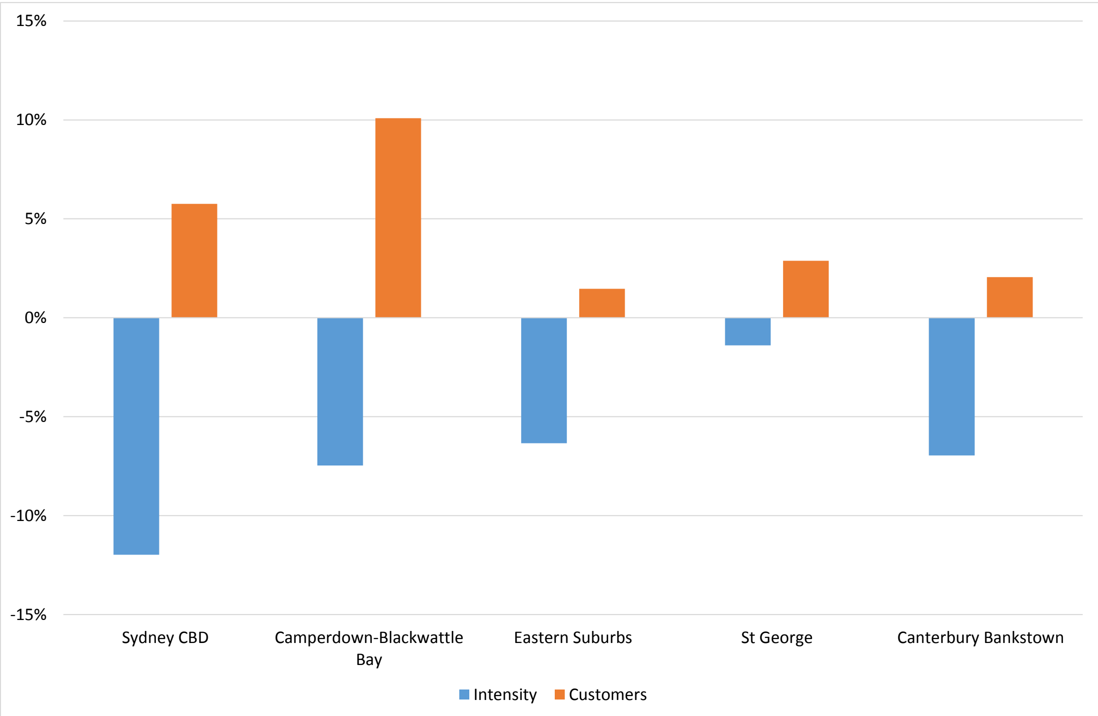
Figure 7 NSW annual electricity consumption and Inner Sydney peak demand

These State-wide patterns of falling demand were reflected in each Area of Inner Sydney, as shown in Figure 8, Figure 9 and Figure 10, which display, for various sectors and Areas, changes between 2010/11 and 2013/14 in both energy intensity (measured in MWh per customer) and the respective number of customers. The continuing growth in customer numbers was generally insufficient to offset the impact of falling usage per customer. In the case of residential and small business customers, the number of new connections increased while average consumption per customer fell. In the case of larger business customers, the number of such businesses across Inner Sydney actually fell while those that remained reduced their average intensity.



Source: GHD analysis based on Ausgrid data17.

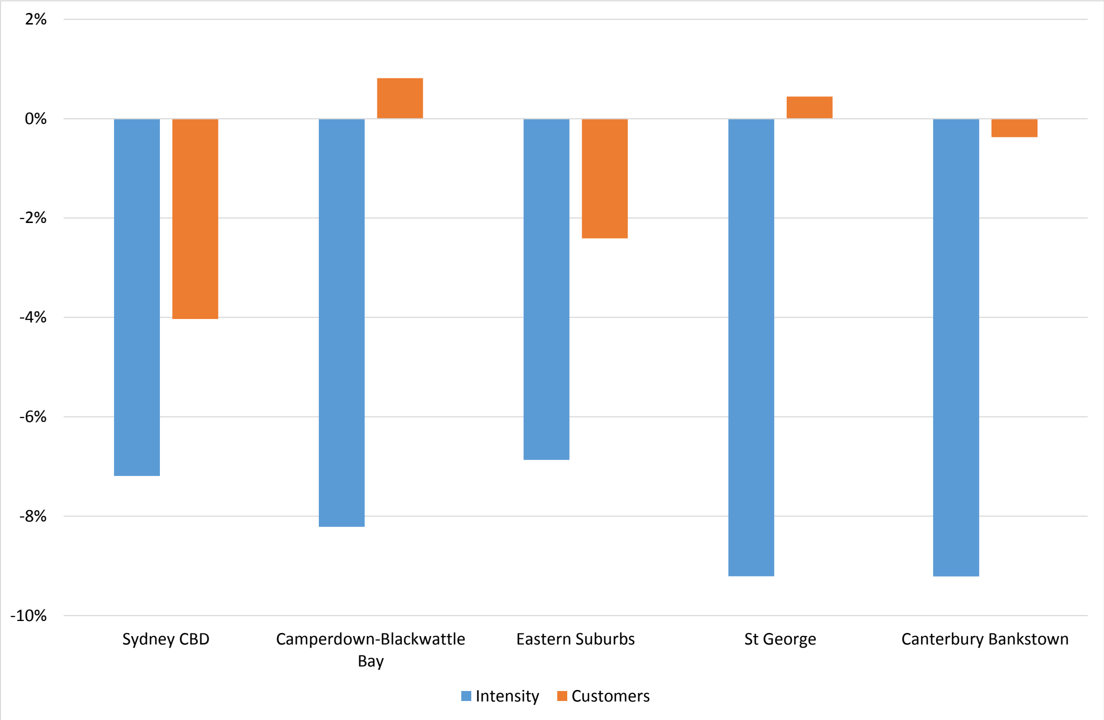
Figure 8 Residential intensity and customer numbers 2011-14



Source: GHD analysis based on Ausgrid data.

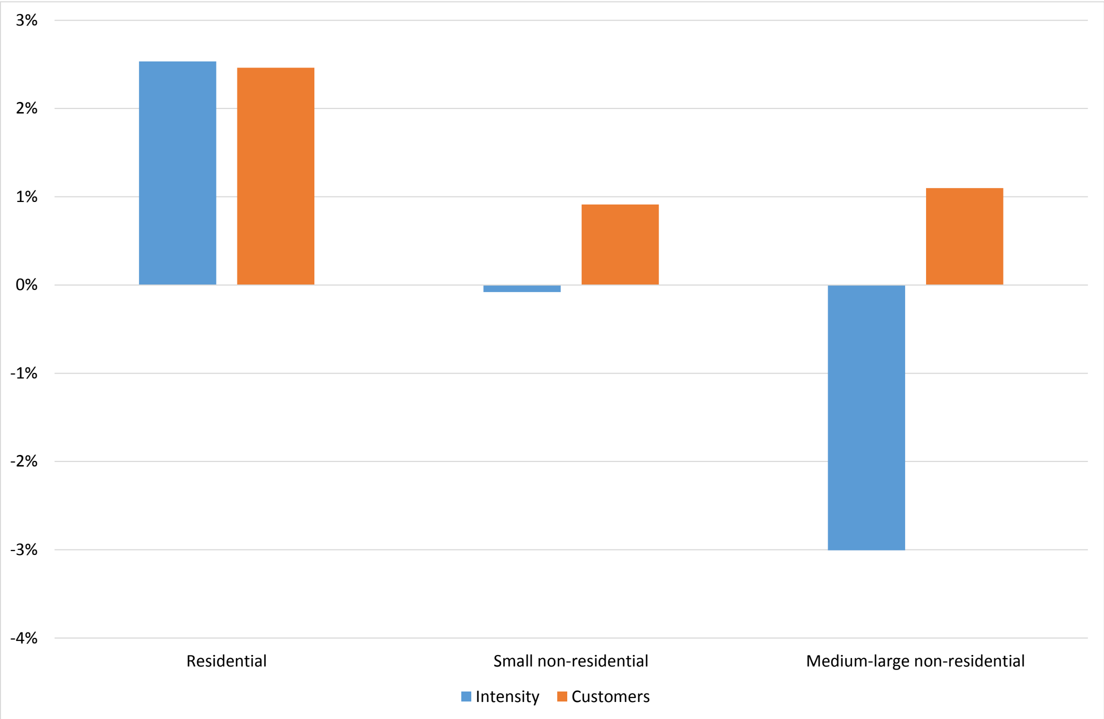
Figure 9 Small non-residential intensity and customer numbers 2011-2014

[17] This section generally relies on from published electricity consumption by Local Government Area data. Data for St George and Canterbury Bankstown have been discounted to represent the approximate proportion that lies in the Inner Sydney area.



Source: GHD analysis based on Ausgrid data.

Figure 10 Medium-large non-residential intensity and customer numbers 2011-14



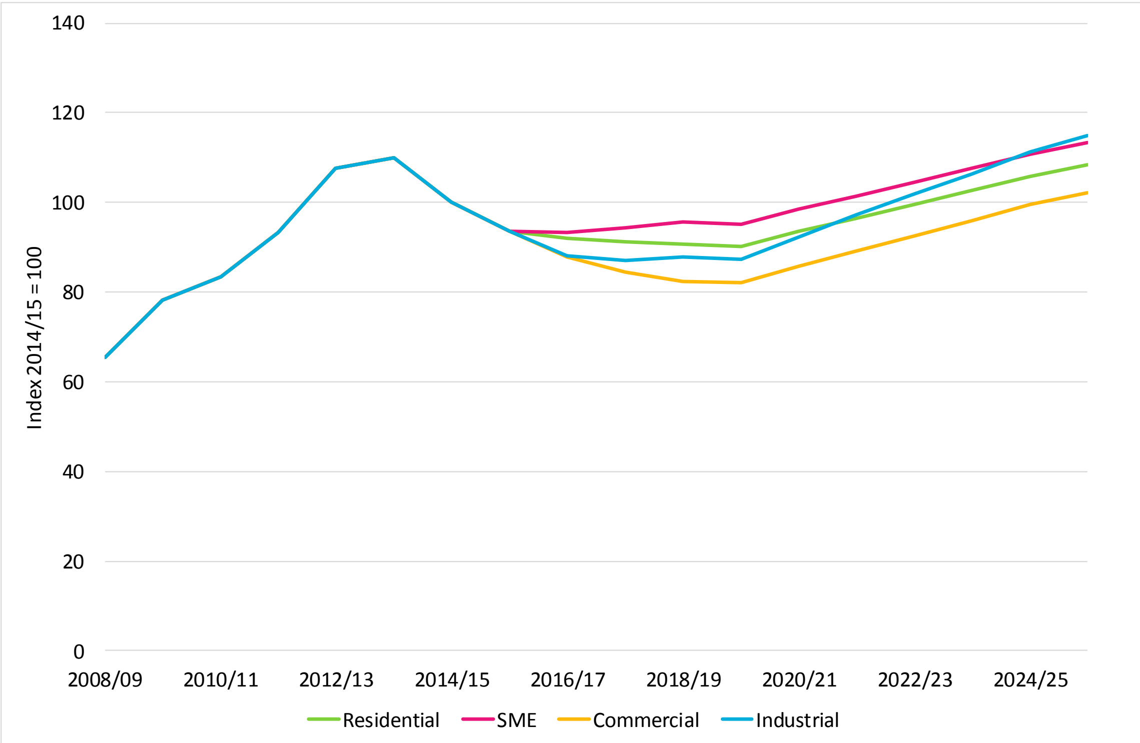
Source: GHD analysis based on Ausgrid data.

Figure 11 Changes in intensity and customer numbers 2014-2015

The gains made by energy efficiency measures that have already been applied will be permanent. However, there is likely to have been a more recent slow-down in the growth of savings from appliance and equipment energy efficiency programs. This is partly because most of the "big" opportunities for appliance standards have already been realised and further tightening of performance standards delivers diminishing returns. However, there has also been a slow-down in the introduction of new regulations, which has contributed to slowing growth in electricity savings. This is reflected in Figure 11, which shows that falls in intensity have turned around in the case of the residential sector and significantly slowed in the non-residential sectors, while customer growth is now positive in all sectors. Figure 11 suggests that large efficiency gains for some medium-large customers are taking longer to feed through than for the majority of customers.

The peak in real electricity prices, recent fall and projected weak increases are shown in Figure 12. This pattern is consistent with recent falling electricity demand and a return to weak growth.

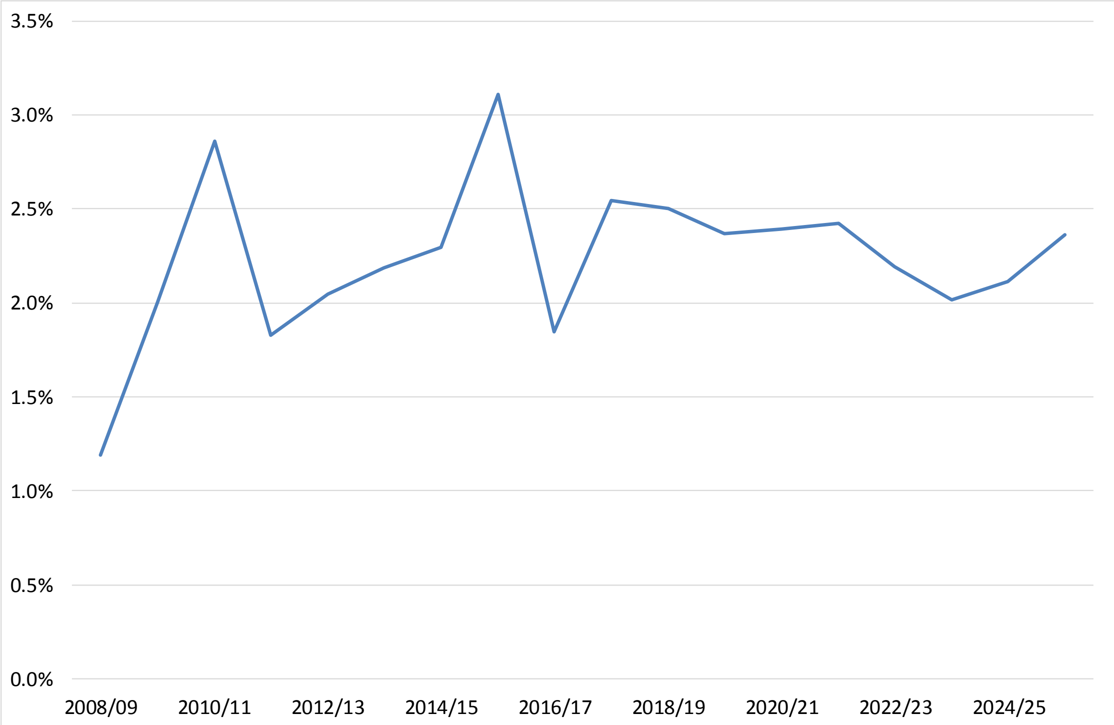
Figure 13 shows changes in NSW real GSP. Despite weak business investment, particularly in the mining sector, the Australian economy in mid-2016 is growing at a faster rate than at any time since 2012, driven by consumption, government spending and net exports. Unemployment is falling, especially in New South Wales, and the outlook for the economy – according to the Reserve Bank of Australia, for example - is for continuing growth at slightly reduced rates[18].



Source: Jacobs (2016) Retail electricity price history and projections, report for AEMO, 23 May.

Figure 12 NSW real electricity prices and projections by customer class

[18] RBA (2016) *Statement on Monetary Policy*, August, http://www.rba.gov.au/publications/smp/2016/aug/, viewed 26/09/2016.



Source: GHD analysis of data from: Deloitte Access Economics (2016) Business Outlook, March.

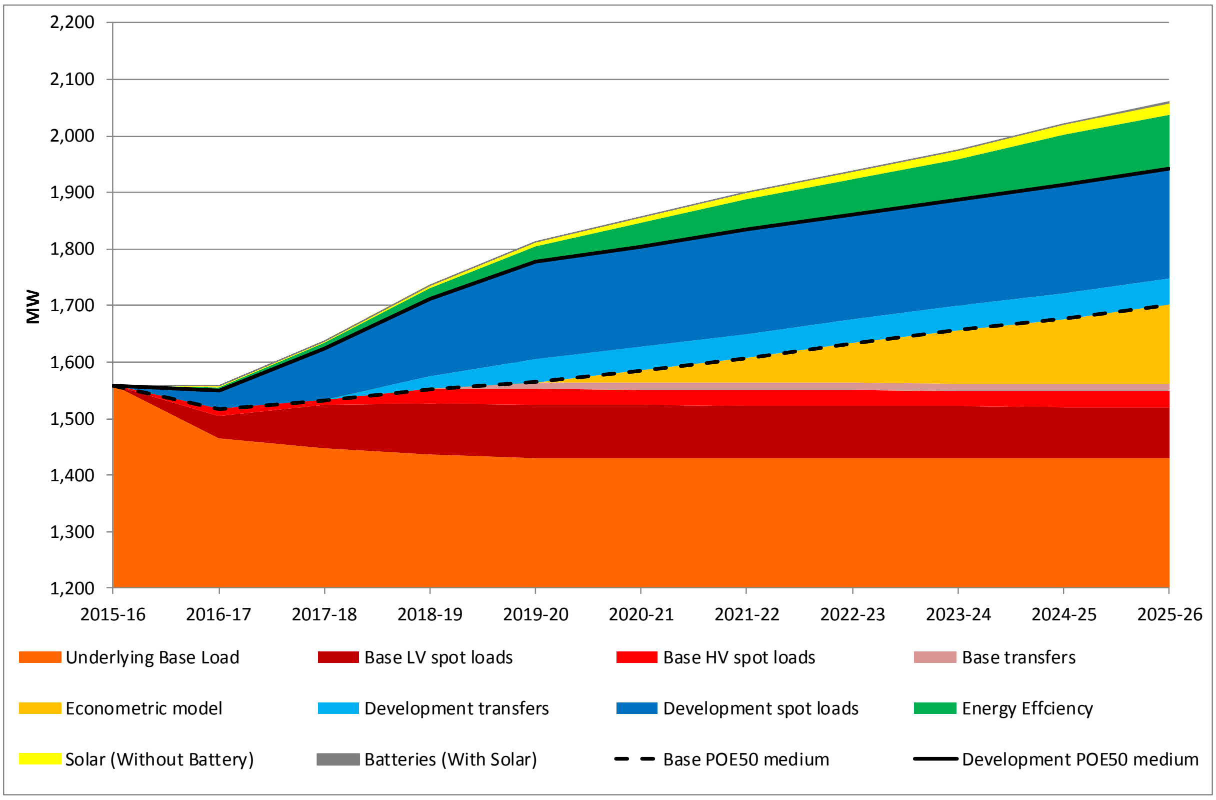
Figure 13 NSW (including ACT) GSP growth and projections

As a consequence of energy efficiency improvements being largely incorporated, together with slightly improved business conditions and an easing in the growth of electricity prices between 2014 and 2016, growth in electricity demand has resumed. This was reflected in both the wider New South Wales and the Inner Sydney area energy consumption and peak demand in 2015 and 2016.

5. Components of the 2016 development forecast

This section provides a more granular view of the 2016 Development forecast and provides key building blocks including historical trends, econometric model-based drivers, post model adjustments including energy efficiency, solar PV and batteries, and adjustments to derive the Development forecast from the Base. Figure 14 shows that in the short term the Development forecast is mainly driven by falling historical trends, which are rapidly offset by increases in spot loads; while in the longer term growth is mainly driven by the econometric-based drivers of real income, electricity price and air-conditioning measures.

The total Development forecast is shown in Figure 14 as the solid black line. The Base forecast is shown as the dashed line, with energy efficiency, solar PV and battery storage all acting to reduce the demand that would otherwise occur at the time of peak. The continuing impacts of recent and proposed energy efficiency standards and regulations, and to a lesser extent growth in solar PV installations and the use of batteries, will together make a significant negative, although relatively minor, contribution towards future peak demand.



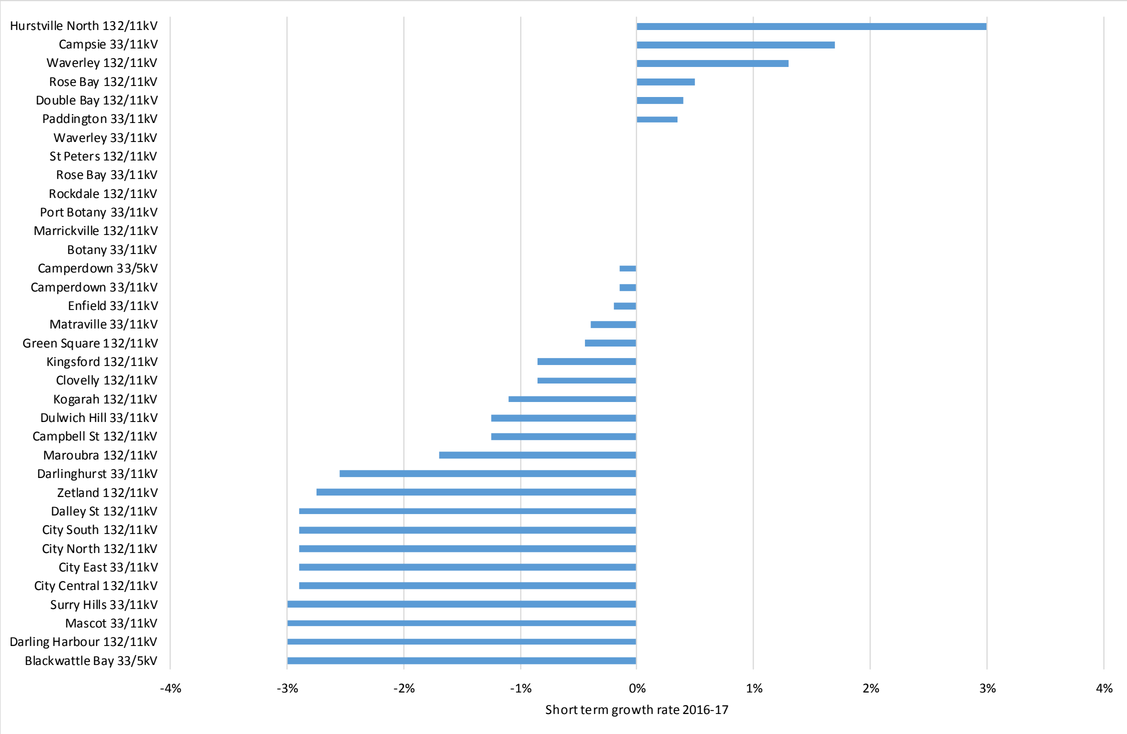
Source: GHD analysis based on Ausgrid data.

Figure 14 Contributions to forecast peak demand growth

The following sections explore each of the major building blocks in the production of the forecast and their variability across the zone substations within the Inner Sydney Area.

5.1 Short term growth rates

Forecast growth rates for the first year of each zone substation forecast include multiple impacts, including the effect of moving from the previous actual to the estimated trend line, the rate of growth in the estimated trend line, spot loads applied in that year, out of trend energy efficiency and the change in solar PV. The diversity in first year forecast growth rates across the Inner Sydney substations is shown in Figure 15. Each bar in the figure represents the percentage change between the 2016-17 summer POE50 peak demand and the equivalent previous year's actual for the respective substation. The lowest (largest negative) growth is in the CBD and its fringes, including Surry Hills and Darling Harbour, while positive growth is associated with the residential growth area around Hurstville North and higher income suburbs such as Rose Bay, Double Bay and Waverley.

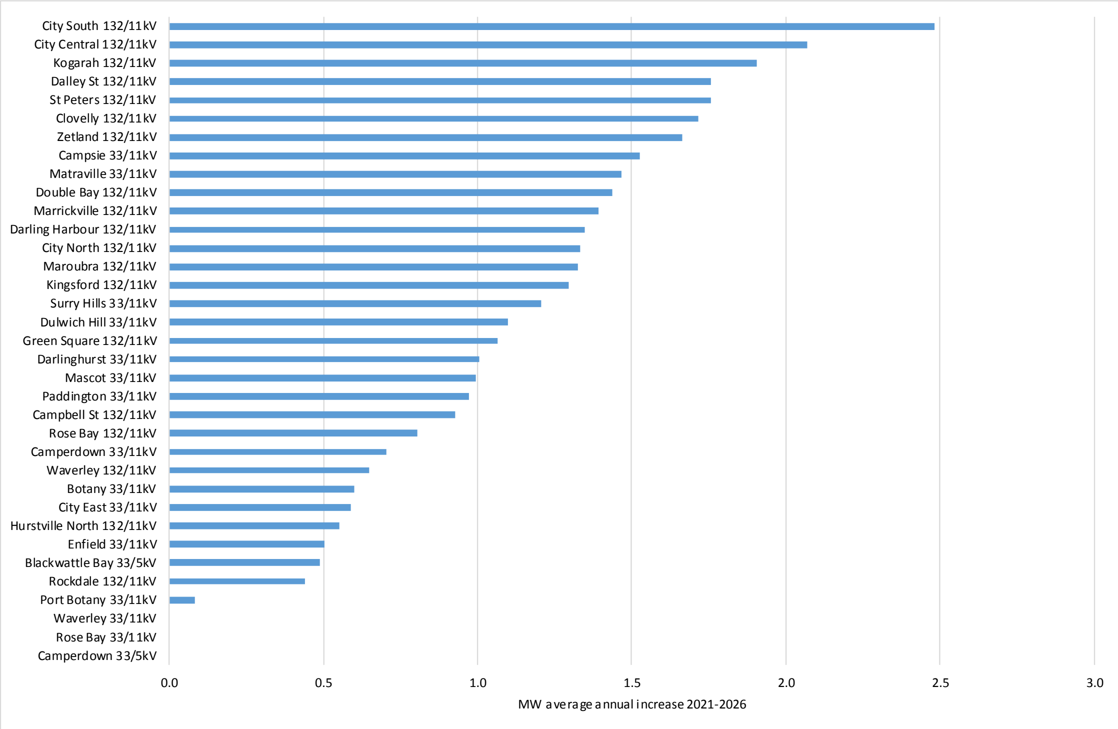


Source: GHD analysis based on Ausgrid data.

Figure 15 Short term growth rates

5.2 Long term econometric model

In the longer term, the forecast is driven by key drivers including real income, electricity price and air-conditioning ownership, as separately modelled by Ausgrid for the residential and non-residential sectors using constructed measures of energy services (normalised, weather corrected demand adjusted for the impact of energy efficiency and self-generation from rooftop solar power systems) as the dependent variables. As can be seen from Figure 16, which shows average incremental growth due to econometrically modelled impacts between 2021 and 2026, the impact of future income growth and moderation in electricity prices has a relatively even impact across zone substations. The greatest impact of real income is felt strongly in the CBD, where the greatest commercial activity takes place, and a number of nearby locations, although this is partly due to the relative size of demand in the CBD, compared to suburban substations.



Source: GHD analysis based on Ausgrid data.

Figure 16 Economic drivers contribution to long run demand growth

5.2.1 Electricity prices

Whilst the historic price increases have been a significant driver of declines in customer demand, prices stabilised between 2013/14 and 2015/16 and were projected to remain relatively stable into the foreseeable future. Price forecasts provided by AEMO projected flat to declining real prices in the short to medium term to 2019/2020. The 2016 forecast is based upon these price projections. Since the publication of the forecast, retail price rises of about 10 per cent were announced, which will place downward pressure on future customer demand.

5.2.2 Real income

Income growth drives higher level of energy use as businesses expand their operations. The NSW economy is projected to grow strongly, at least in the short term, with forecast GSP growth of around 2.5 to 3.0 per cent for 2015/16 and 2016/17.

Economic projections used for Ausgrid's 2016 forecast were obtained from AEMO and are the same economic projections used by AEMO for the 2016 NEFR. The medium scenario projected growth in NSW GSP between 2016/17 and 2025/26 varies between 1.9 per cent and 2.6 per cent per annum[19]. This is broadly similar to the projected economic growth underlying the 2015 NEFR.

5.2.3 New residential customers

Population growth continues at a steady pace and may even accelerate due to substantial infrastructure investment proposed or in progress by the NSW Government. Projections from NSW Department of Planning in "A plan for growing Sydney" (Dec 2014) – which underlie the 2016 Development forecast - resulted in an increase in population growth projections. From this plan, Ausgrid's network area was expected to accommodate around 310,000 additional households by 2031. However, recently updated population forecasts are considerably higher,

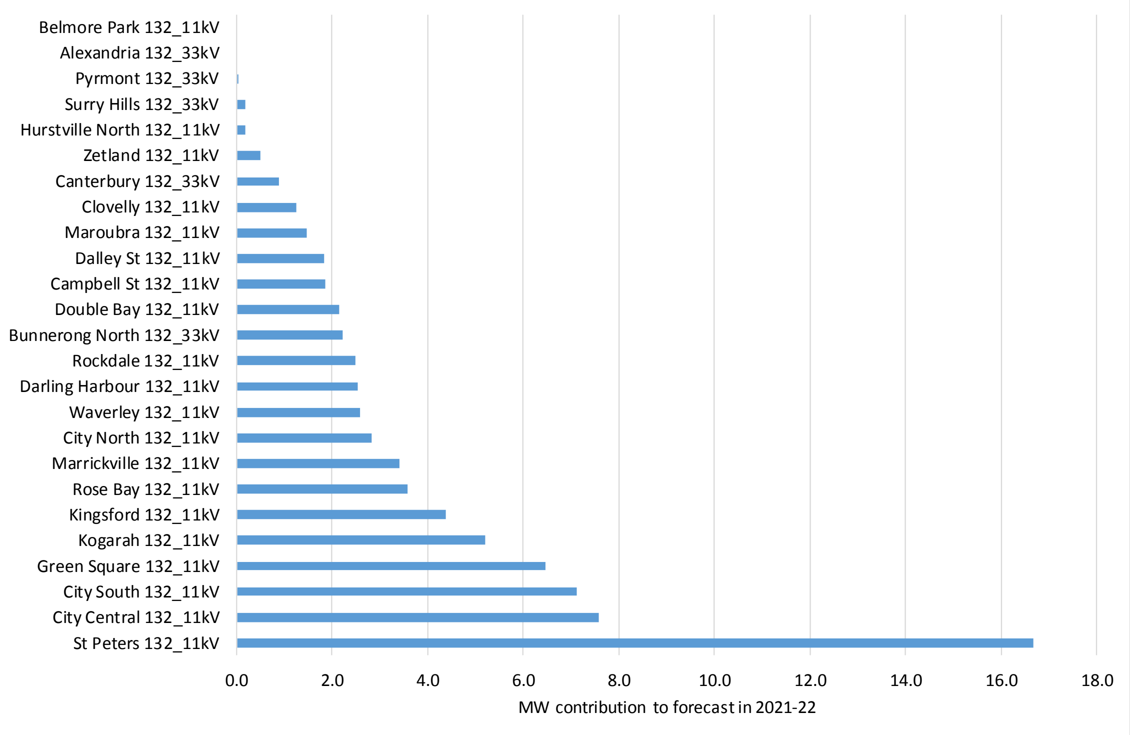
[19] Refer to Deloitte Access Economics (March 2016) Business Outlook for NSW GSP growth.

especially for the Sydney local Government Area (LGA), which introduces upward uncertainty to the long term demand forecast.

5.3 Spot loads

5.3.1 Committed spot loads

The base forecast includes around 120 MW of committed spot loads, with the largest being at St Peters, as shown in Figure 17.



Source: GHD analysis based on Ausgrid data.

Figure 17 Committed spot loads included in the Base forecast

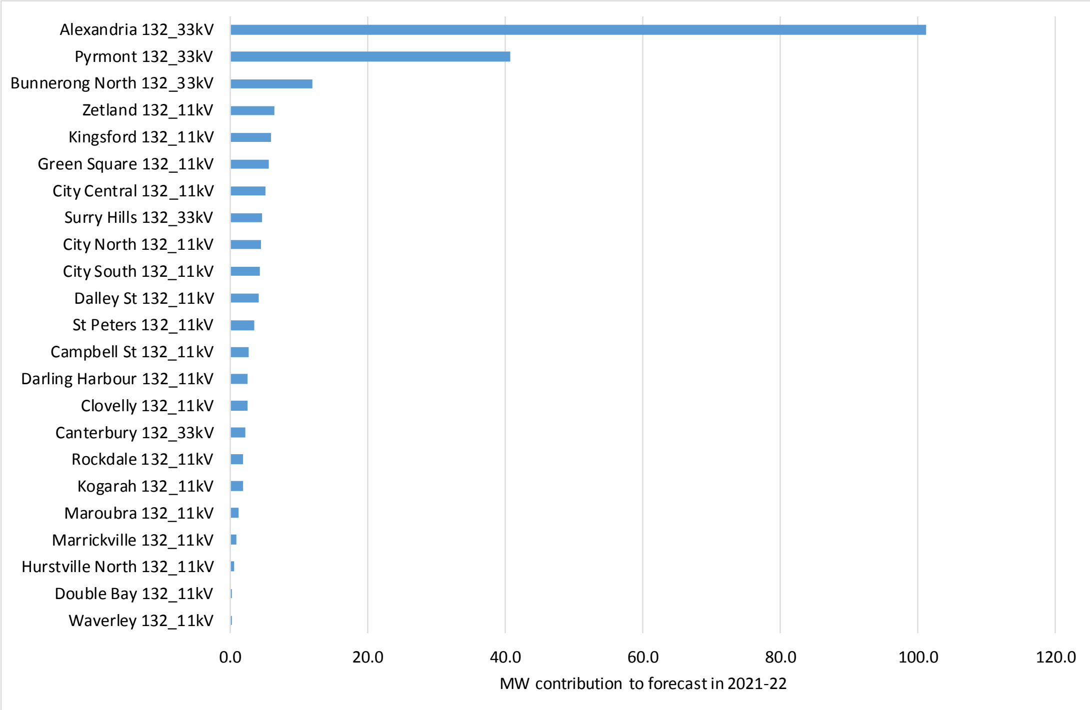
5.3.2 Uncommitted spot loads and transfers included in the Development forecast

Uncommitted spot loads

Proposed but as yet uncommitted spot loads that modify the Base demand forecast to create the Development forecast are shown in Figure 18 for the summer of 2021-22, by which time the load anticipated by these proposed connections reaches a plateau. Total uncommitted spot loads exceeding 30 MW are included in the first year of the forecast. The full impact of around 190 MW in total includes uncommitted spot loads added to the 33 kV network and numerous low voltage proposed connections.

Some of the planned-for 33 kV connections include significant transport infrastructure and new commercial customer loads, expected to be attached to the new Alexandria substation and at Pyrmont. As detailed in Section 3.2.5, the remainder of the uncommitted spot loads included in the forecast are discounted to represent the historic likelihood that approximately 28 per cent of proposed projects requiring connection to Ausgrid's network will go ahead[20].

[20] Project progression and commitment is a moving target. Reported committed and uncommitted spot load inclusions were assessed by Ausgrid for the 2016 zone substation forecasts in March 2016.

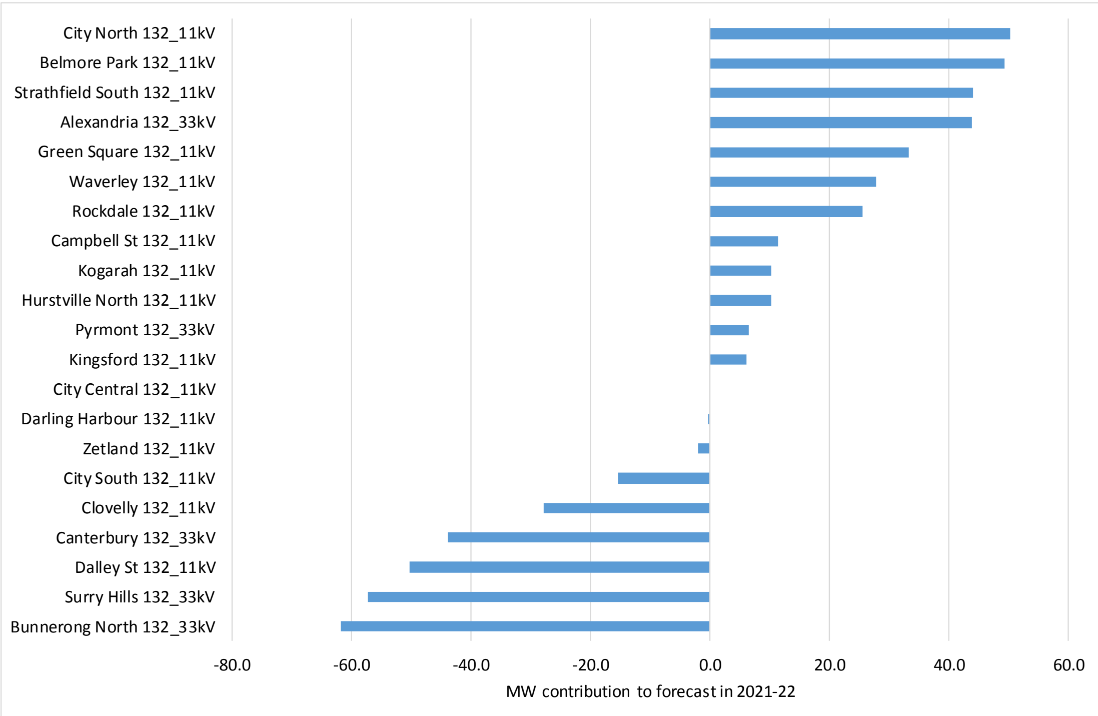


Source: GHD analysis based on Ausgrid data.

Figure 18 Uncommitted spot loads included in the Development forecast

Development load transfers

The impact of Development load transfers on individual substations is shown in Figure 19. The largest transfers are to newly commissioned or yet to be commissioned substations, such as Belmore Park and Alexandria, and away from older locations such as Dalley Street (which is to be decommissioned) and Bunnerong North. Figure 19 includes a net transfer into the Inner Sydney area of 60 MW.

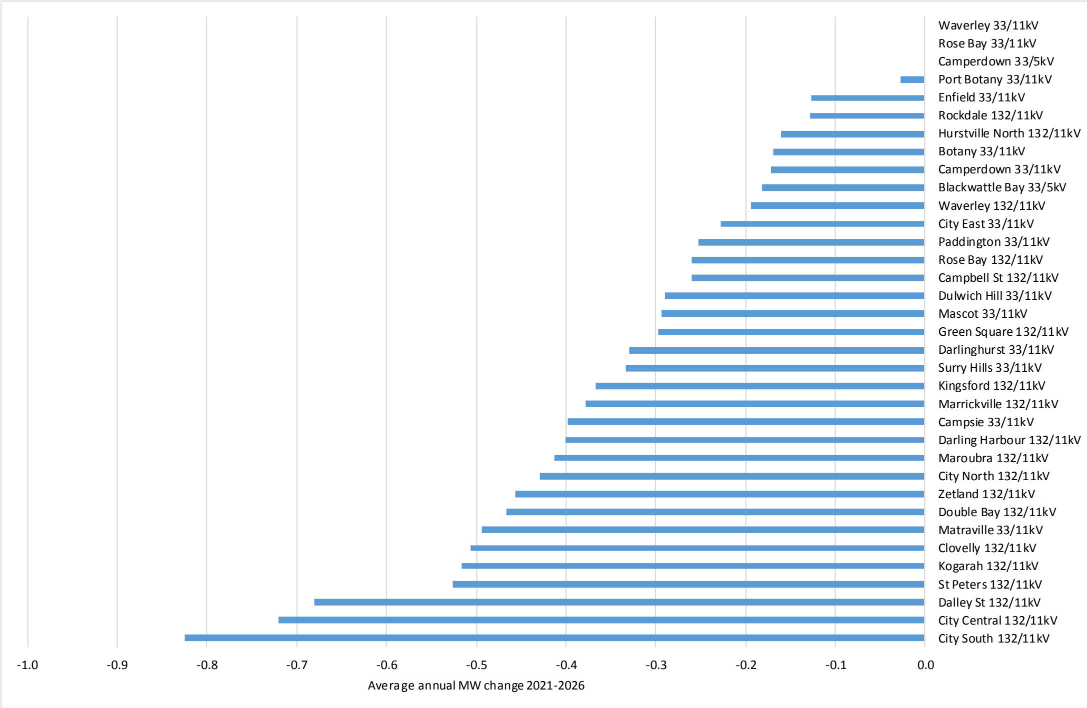


Source: GHD analysis based on Ausgrid data.

Figure 19 Load transfers included in the Development forecast

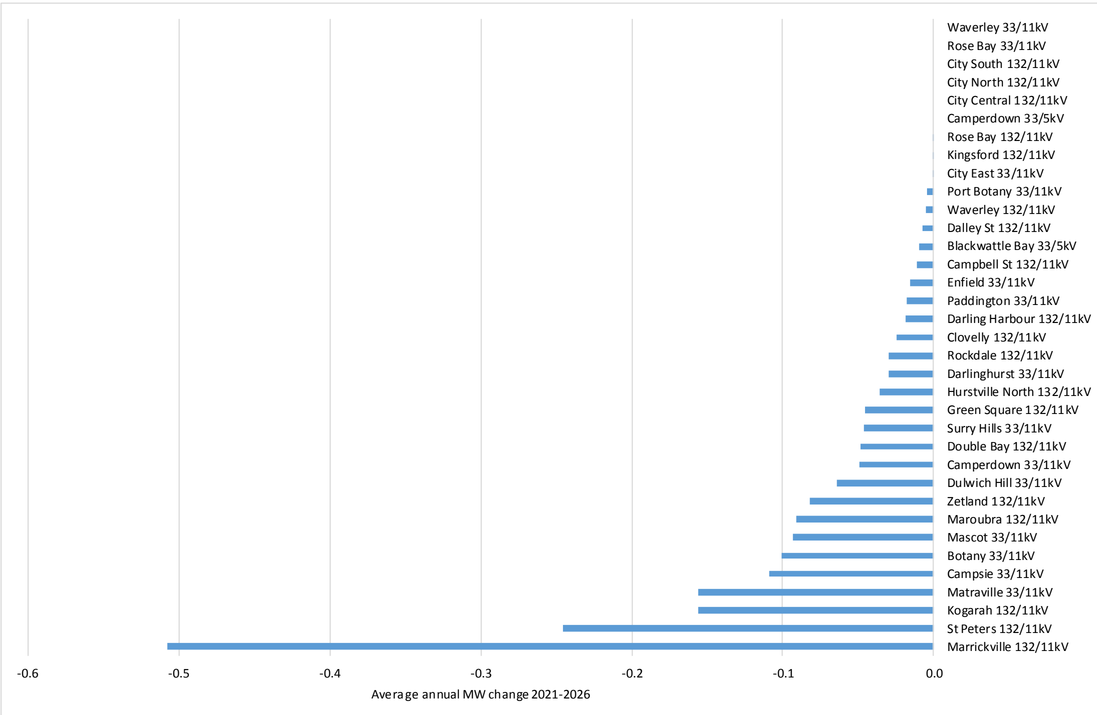
5.4 Post-modelling adjustments

Post-modelling adjustments include ongoing energy efficiency impacts, small-scale PV installations and the uptake of battery storage, which together are expected to reduce peak demands by relatively minor but still material amounts.



Source: GHD analysis based on Ausgrid data.

Figure 20 Energy efficiency contributions to reduced demand growth



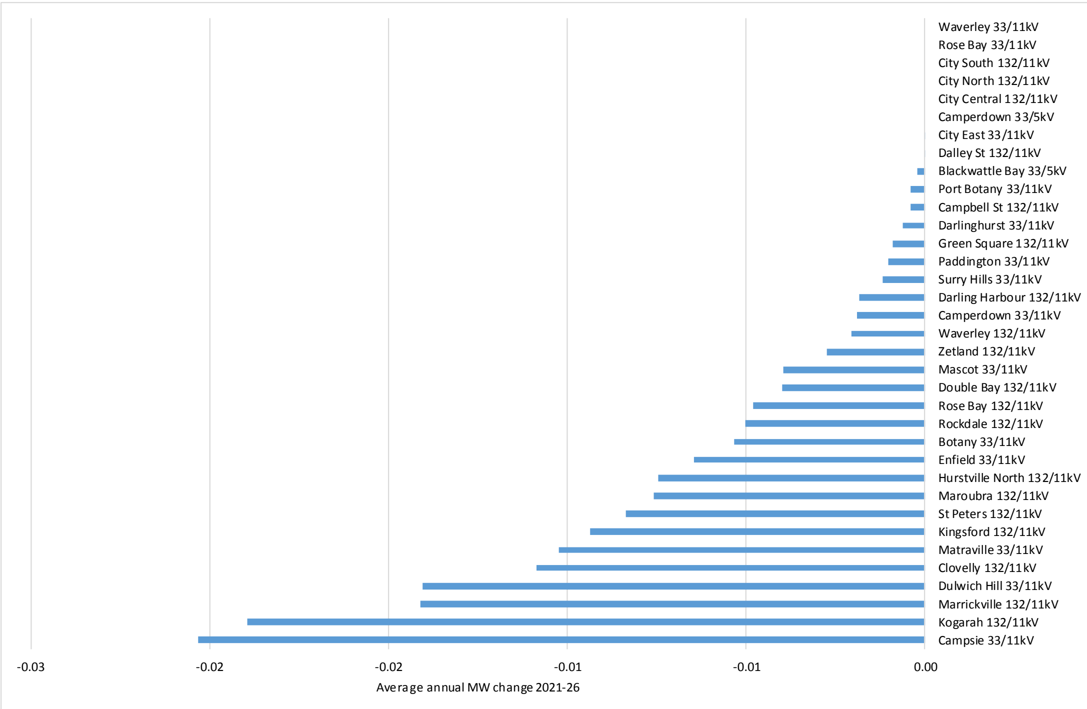
Source: GHD analysis based on Ausgrid data.

Figure 21 Solar PV contributions to reduced metered demand growth

Energy efficiency improvements reduce forecast demand. Demand reductions show some diversity across zone substations, with the largest contributions generally coming from areas with the highest demands and therefore with the greatest to gain – such as the CBD and closest surrounding suburbs - as shown in Figure 20.

Growth in small scale solar PV reduces metered demand growth. This is overall forecast to have a relatively minor impact on forecast peak demand in Inner Sydney. Contributions to demand reduction from solar PV are forecast to be greatest in suburban areas of Inner Sydney with concentrations of houses and least in the CBD with limited roof space and high shading potential among closely packed commercial buildings, as shown in Figure 21.

Increased use of battery storage is forecast to reduce peak demands, although not by significant amounts in the near future. Forecast changes in demand as a result of battery storage are shown in Figure 22 for the 2021-2026 period, at the end of which the total impact on peak demand in Inner Sydney is projected to be less than 0.5 MW. In contrast, 2016 AEMO forecasts for NSW include a significant increase in battery storage as a result of rapidly falling costs. Contributions to Ausgrid’s forecast peak demand reduction from this source may be associated with solar PV installations, since the demand reductions are greatest in suburban areas of Inner Sydney with concentrations of houses and least in the CBD.



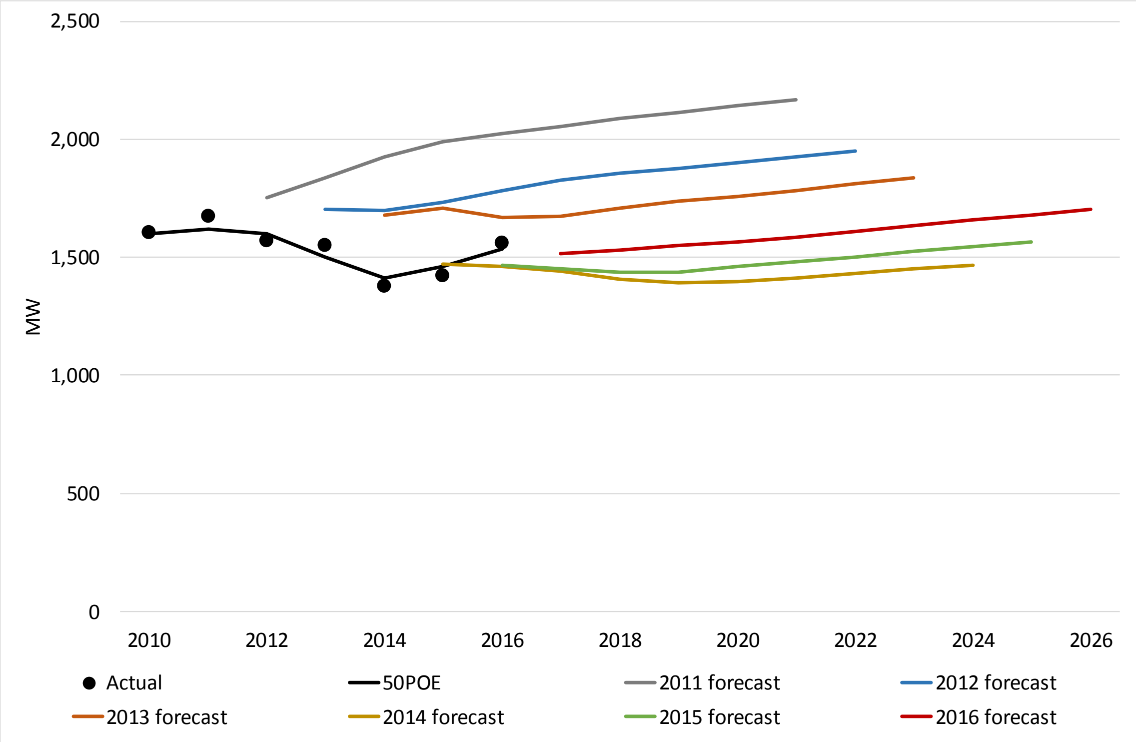
Source: GHD analysis based on Ausgrid data.

Figure 22 Battery storage contributions to reduced peak demands

6. Demand forecast performance

6.1 Previous Ausgrid forecast performance

Previous Ausgrid (Base) forecasts for the Inner Sydney Area are compared with actuals in Figure 23. The highest forecast and earliest, made in 2011, was prepared with heavy reliance on the projection of past trends at each substation. Succeeding forecasts introduced the impact of projected economic drivers. Major changes to forecast preparation were made in 2014, including a blending of short term trend and long term econometric impacts, and better incorporation of energy efficiency impacts through the use of a measure of energy services[21] as the dependent variable in econometric modelling.



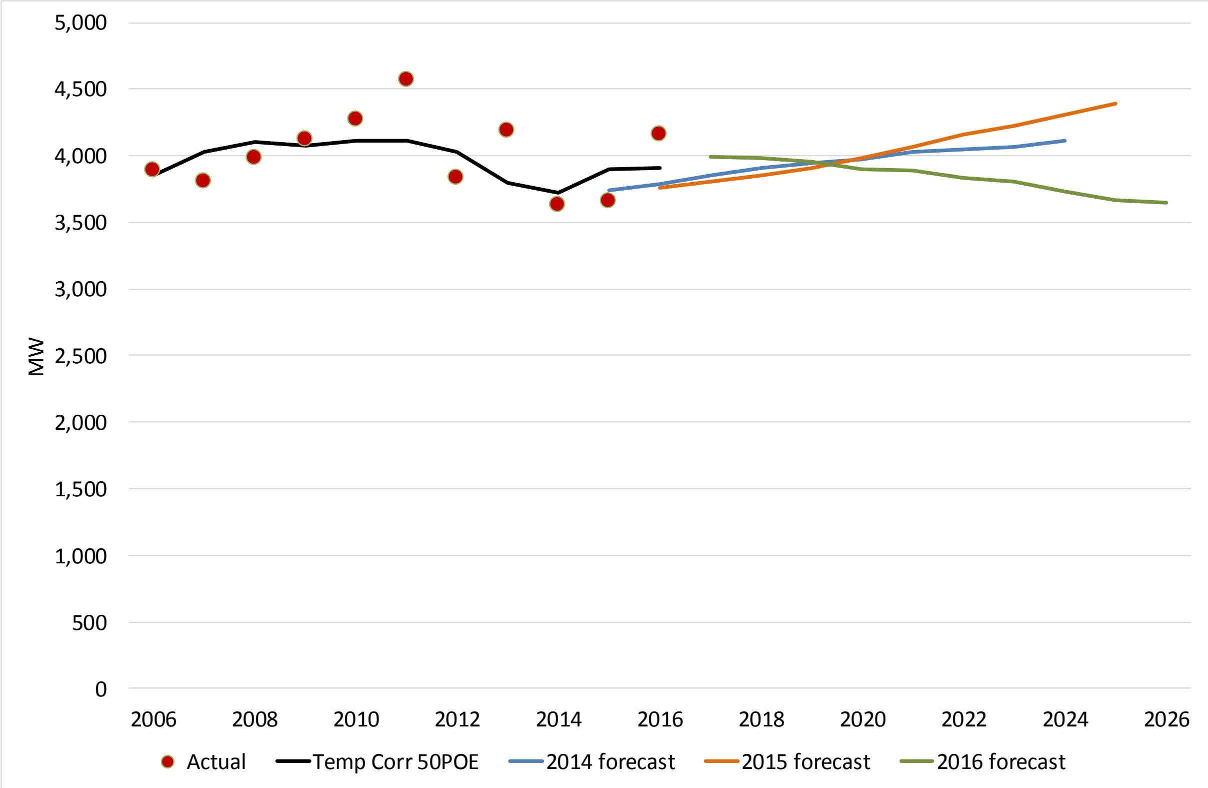
Source: GHD analysis of Ausgrid data.

Figure 23 Current (2016) and previous Inner Sydney Base forecasts

6.2 Comparison with AEMO forecast

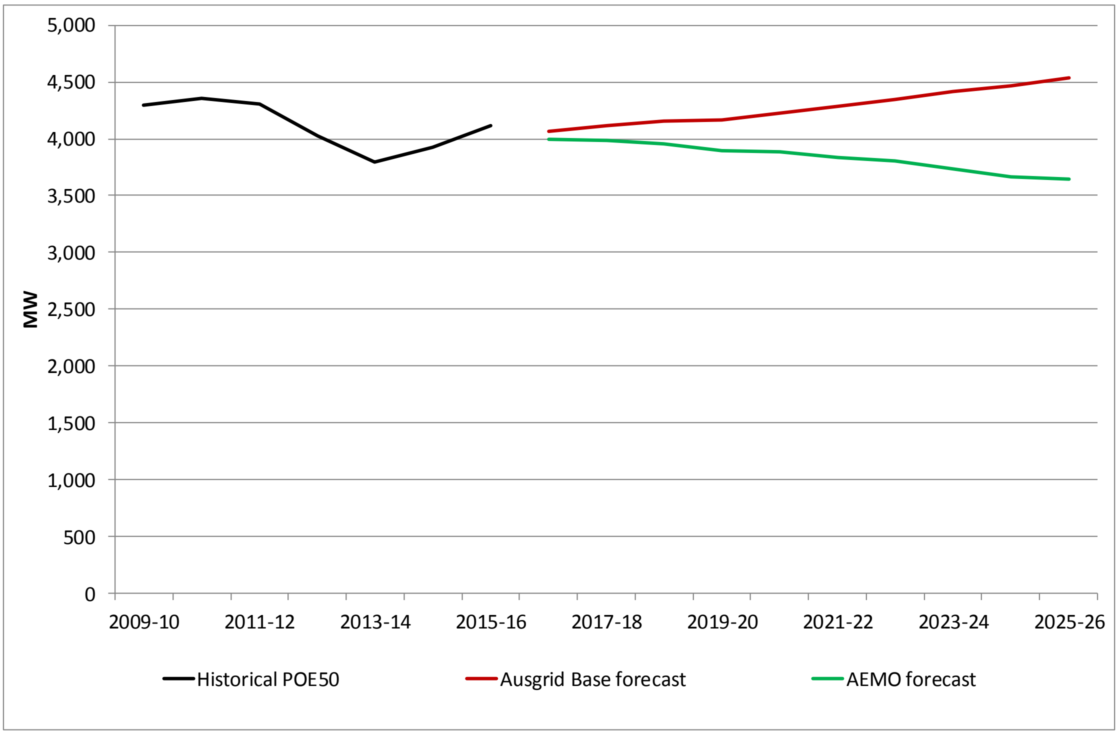
AEMO connection point forecasts include a forecast for the greater Sydney region but not for the individual Ausgrid transmission connection points that make up the total or for the specific Inner Sydney Area which is the subject of this report. Hence it is not possible to make a direct comparison between Ausgrid forecasts for Inner Sydney and the AEMO connection point forecasts. Figure 24 shows that the current 2016 AEMO forecast for greater Sydney projects an extended fall in peak demand, in contrast to previous AEMO forecasts for the same region.

[21] Energy services is constructed by adjusting a historical MW demand measure to account for the impact of energy efficiency. MW contributed by small scale embedded solar PV is also included in energy services measure.



Source: GHD analysis of AEMO data.

Figure 24 Current (2016) and previous AEMO forecasts for Sydney



Source: GHD analysis of data provided by Ausgrid.

Figure 25 Summer peak demand forecasts for AEMO's greater 'Sydney region'

AEMO's forecast for the greater Sydney region includes much of metropolitan Sydney as well as the Central Coast, between Sydney and the Hunter region. AEMO's forecast for this region is derived from analysis of the whole region as a single entity and is then adjusted (along with all other AEMO connection point forecasts for NSW) so that the sum of connection point forecasts matches AEMO's most recent top-down NEFR forecast for New South Wales. In contrast, Ausgrid's forecast for this region is derived from the sum of forecasts for each individual zone substation within the region. Figure 25 shows that there is a growing disparity between the two forecasts from around 2020 onwards.

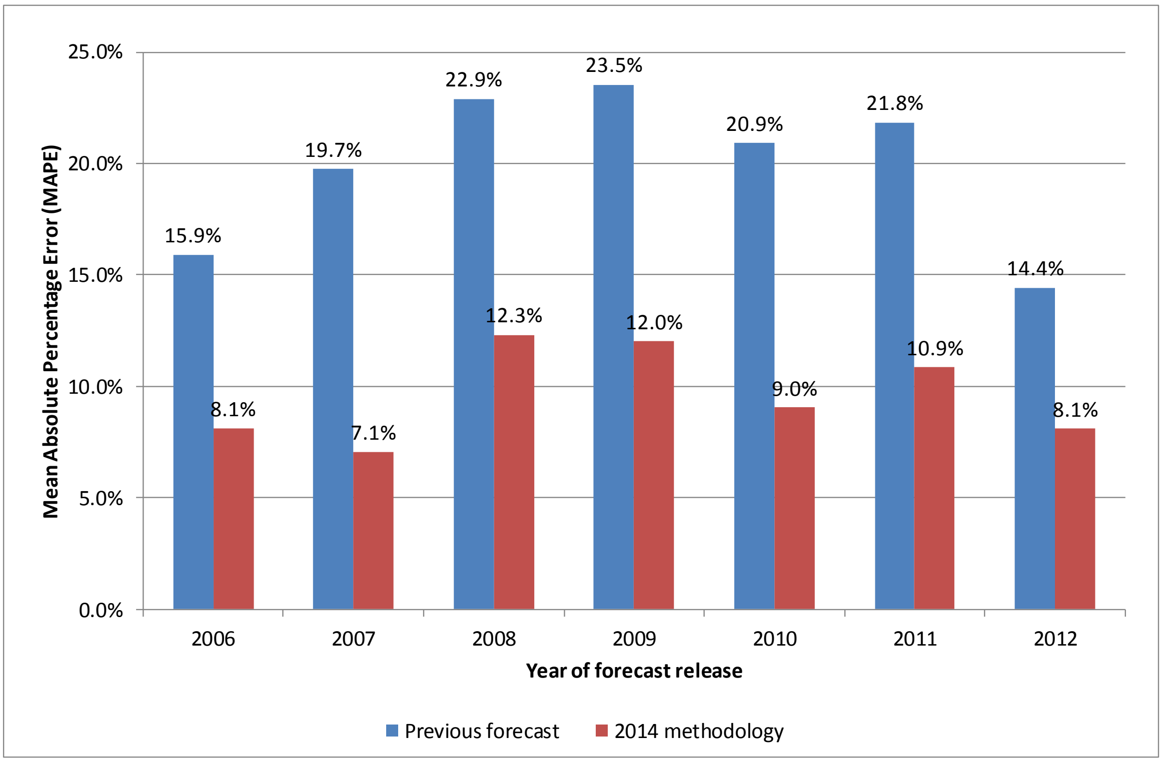
6.3 Key enhancements to the Ausgrid forecasting process

This section identifies enhancements implemented by Ausgrid to improve forecast performance.

The methodology used by Ausgrid to prepare its peak demand forecast does not allow for an immediate departure from immediately past trends, so the current – much lower - forecasts do not generally project an immediate return to growth. This is both empirically sound and reflective of established patterns of economic behaviour. The recently observed downturn in demand growth for the Sydney CBD is generally consistent with trends in other Australian Capital cities and is believed to reflect accelerated increases in appliance efficiency, energy conservation in buildings and replacement of network supply by rooftop PV generation, all of which coincided with a consumer response to sharp increases in tariffs. All of these factors may only be tempered or reversed gradually with a lag of several years. For example, a push to more efficient lighting may have an initial network impact that grows then declines as the take-up rate grows then declines as saturation occurs. If there are no further energy efficiency activities to replace this single event, its overall network impact may be felt over an extended period of time.

Many of the factors that led to the recent downturn in electricity demand were not foreseen by the industry and in particular were not encompassed by Ausgrid's forecasting methodology at that time. Revisions to the methodology since then have focussed on a better empirical understanding of the recent past, so that the latest forecasts are able to better determine how the factors leading to a downturn in demand might influence future demand. The most significant change in this regard is Ausgrid's attempt to measure and forecast energy services, rather than metered energy, where energy services includes all underlying demand for energy including that which is saved as energy efficiency and that which is self-generated as rooftop PV. This differs to the approach used by AEMO and others to account for abrupt changes in energy efficiency, in which above-trend energy efficiency is identified and subtracted from the modelled forecast. The exclusion of energy efficiency from the original model in the AEMO approach forces change to be attributed to those variables that are included, which therefore results in less reliable estimates of the price and income elasticities.

The change in Ausgrid's forecast since 2012 is typical of the scale of change in demand forecasts produced by AEMO and other parties since that time, where the change in starting point is driven by more up to date historical data. The improvement delivered by Ausgrid's new approach of incorporating energy services has been tested using back-casting analysis to examine the improvement in forecast accuracy that would have occurred if the new technique had been used to produce previous forecasts. This analysis indicates that on average the new approach produces more accurate results. Representative of the improved forecasting accuracy of these changes is a significant decrease in mean absolute percentage forecasting error (MAPE) as shown in Figure 26.



Source: Ausgrid.

Figure 26 Results of multi-year back-casting using 2014 and previous methodologies

Although MAPE provides no information about the direction of any systematic bias in the forecast, it is informative of the difference between forecast and actual outcomes regardless of the direction of the difference. Figure 26 shows multiple year MAPEs calculated for succeeding forecast years, where each year's forecast is prepared using only the information available in year. The resulting out-of-sample forecasts thus represent forecasts that would have been made in that year and are compared against actual outcomes that have subsequently become available.

The blue bars in Figure 26 show calculated MAPEs using the previous forecast (i.e. the pre-2014 methodology). The red bars show calculated MAPEs using the 2014 methodology (i.e. the new 2014 methodology). Actuals used in the MAPE calculations are weather corrected. The analysis presented in Figure 26 considers the performance in forecasting the demand for the entire Ausgrid supply area.

The current 2016 methodology has retained the enhancements made to the 2014 methodology and refined the trend and econometric models, with adaptation to new historical data and improved PV data and the inclusion of battery storage. A repeat of this forecast performance measurement exercise will be done later in 2016 to test the continuing improvements in forecasting methodology since 2014.

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7. Findings and conclusion

Up to 2013, Ausgrid's Inner Sydney peak demand forecasts predicted continuing growth rather than the recently experienced downturn in demand. Ausgrid forecasters were not alone amongst demand forecasters in failing to predict the reduction in demand. Analysis has demonstrated that the unique coincidence of an acceleration in energy efficiency savings with a rapid increase in electricity prices were the main factors contributing to the reduction in the Inner Sydney peak demand.

Ausgrid has significantly enhanced its approach for forecasting demand to improve forecast accuracy. Back-casting analysis completed by Ausgrid demonstrates that the revised forecasting techniques deliver significant improvements in accuracy, achieving forecasts with consistently lower mean absolute percentage errors (MAPEs) than the techniques previously employed.

The most recent Ausgrid forecasts carefully incorporate the impact of historical changes in energy efficiency to better isolate the independent impact of price change. The adopted methodology allows for historical growth rates to continue to drive the initial years of the forecasts, while in the longer term the modelled economic scenarios drive underlying growth.

Ausgrid's 2016 development forecast for Inner Sydney is not directly comparable with AEMO's forecast for the Sydney region as the two forecasts refer to geographically different load areas.

The 2016 Ausgrid Inner Sydney forecast shows increasing peak demand, with the most significant contribution to demand growth coming from large new customer loads that have sought connection to Ausgrid's network. These planned new loads, many of which would be 'committed' projects in AEMO's terms, may not have been known to AEMO at the time of their connection point forecast production.

7.1 Conclusion

Ausgrid's Inner Sydney demand forecast provides a reasonable estimate of the potential future demand in Inner Sydney and supplied across Transmission Corridor 1 and is appropriate for use in planning augmentations to the transmission network crossing that corridor.

Appendices

Appendix A - Ausgrid's 2016 Development forecast for the Inner Sydney area (MW)

	Actual	Historical POE50	2015 forecast	2016 forecast POE10 high	2016 forecast POE50 medium	2016 forecast POE90 low
2009-10	1,603	1,598				
2010-11	1,673	1,620				
2011-12	1,569	1,601				
2012-13	1,550	1,499				
2013-14	1,378	1,412				
2014-15	1,420	1,463				
2015-16	1,559	1,536	1,468			
2016-17			1,515	1,640	1,549	1,485
2017-18			1,563	1,714	1,624	1,561
2018-19			1,617	1,807	1,713	1,646
2019-20			1,693	1,878	1,777	1,703
2020-21			1,708	1,918	1,804	1,718
2021-22			1,731	1,961	1,835	1,735
2022-23			1,746	2,002	1,862	1,749
2023-24			1,768	2,040	1,886	1,760
2024-25			1,791	2,081	1,914	1,774
2025-26				2,121	1,942	1,789

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	R Hickling	R Hickling	Richard Hickling	D Bones	DBones	11/10/2016
1	R Hickling	R Hickling	Richard Hickling	D Bones	DBones	12/10/2016
2	R Hickling	R Hickling	Richard Hickling	D Bones	DBones	23/10/2016

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