AusNet Gas Services Pty Ltd

Gas Access Arrangement Review 2018–2022

Appendix 4A: 2018-2022 GAAR Consumption and Customer Forecasts

Submitted: 16 December 2016

COMMERCIAL IN CONFIDENCE

FINAL REPORT

2018-2022 GAAR Consumption and Customer Forecasts

Prepared for
AusNet Services Ltd

16 September 2016

THE CENTRE FOR INTERNATIONAL ECONOMICS
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Contents

BOXES, CHARTS AND TABLES

Executive summary

AusNet Services has commissioned The CIE to provide forecasts of demand for its Victorian gas distribution network for 2018 to 2022. This report sets out the approach that we have taken, the key assumptions that have been made and the forecasts.

Our approach

Our approach to forecasting demand has been based on three steps.

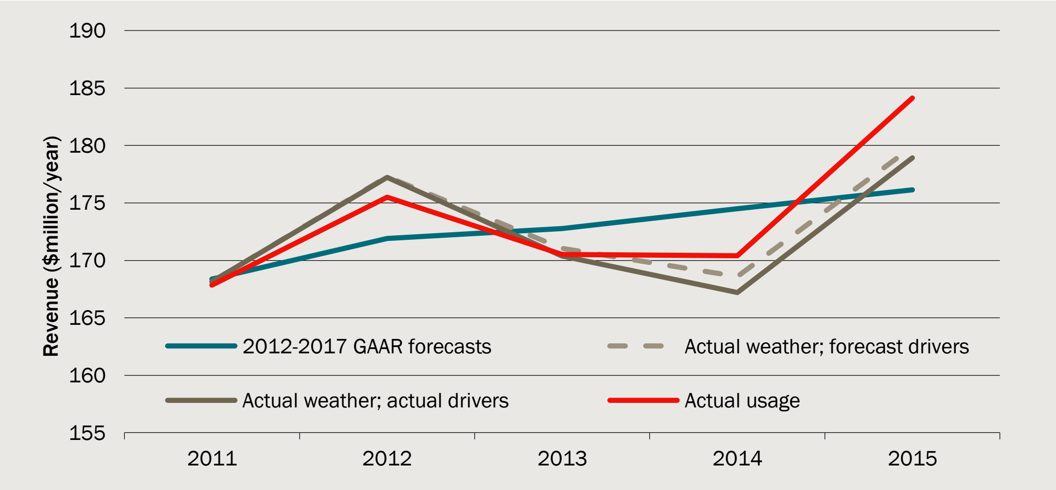
- Understanding the key drivers of demand and the magnitude of the impact of these drivers on demand using statistical analysis of AusNet Services' billing database.
- Projecting forward key drivers using publicly available estimates.
- Projecting forward demand using the relationships established between drivers and demand and the projections of key drivers. In undertaking projections we have continued on the time trends that have historically occurred because we consider that factors such as appliance switching will continue to be important in the 2018 to 2022 regulatory period.

Key findings

Review of previous forecasts

The CIE produced forecasts of AusNet Services gas demand in 2012. After accounting for actual weather outcomes over 2011-2015, forecasts of residential and commercial demand were very accurate while projections of tariff D demand were above actual demand. Chart 1 shows that, after accounting for actual weather outcomes, the revenue implied by the 2012 usage forecasts is very close to revenue implied by actual usage.

1 Performance of total forecasts



Data source: CIE.

Customer numbers

We forecast residential customer numbers in existing areas (where AusNet Services already has a network) and in ERP towns (where the network is set to expand under the Energy to the Regions Program) separately.

- In existing areas, we calculate the average 'marginal penetration rate' (net new customers per net new occupied private dwelling) in 2016 and use this, along with Victorian Government projections for occupied private dwellings, to forecast net new customers. The marginal penetration rate in 2016 incorporates changes in preferences (away from gas and towards electricity) that have occurred over recent years.
- In ERP towns we use AusNet Services' projection of future customer numbers and an assumption for 'take-up' over time. Future customer numbers are split into residential and commercial.

Residential customer numbers are forecast to increase from 644 727 in the March quarter of 2016 to 729 781 in the March quarter of 2022.

2 Total residential customer numbers, dwellings and average penetration rate

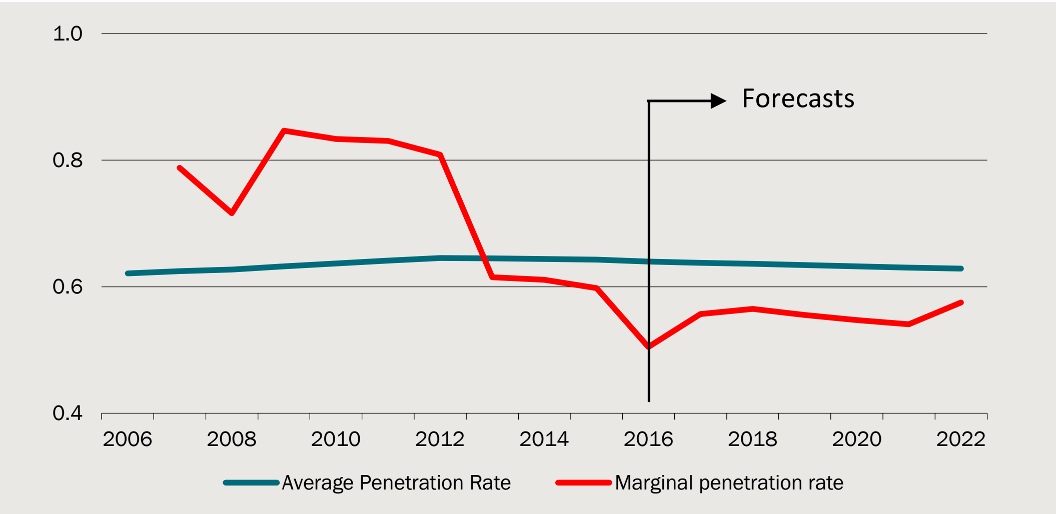
	Residential customers			Occupied private dwellings	Average penetration rate
	Existing areas	ERP towns	Total	Total	Total
2014	618 691	0	618 691	960 599	0.64
2015	633 043	0	633 043	984 615	0.64
2016	644 727	0	644 727	1 007 764	0.64
2017	657 798	309	658 107	1 031 793	0.64
2018	671 210	909	672 119	1 056 590	0.64
2019	684 974	1 359	686 333	1 082 186	0.63

	Residential customers			Occupied private dwellings	Average penetration rate
	Existing areas	ERP towns	Total	Total	Total
2020	699 100	1 696	700 796	1 108 609	0.63
2021	713 600	1 949	715 549	1 135 892	0.63
2022	727642	2 139	729 781	1 160 651	0.63

Source: CIE.

Chart 3 shows the penetration rates for AusNet Services across all areas (existing and ERP towns). The marginal penetration rate (net new customers divided by net new dwellings) is forecast to remain at a low level, following declines in recent years. The average penetration rate (total customers divided by total dwellings) is forecast to continue to decline slowly.

3 Penetration rates for AusNet Services (all areas, existing and ERP)



Data source: CIE.

In existing areas, every 1 000 net new residential customers generates 11.7 net new commercial customer numbers (consistent with recent history). In ERP areas, commercial customer numbers are derived from total projected customer numbers.

Commercial customer numbers are forecast to increase from 16 583 in the March quarter of 2016 to 17 575 in the March quarter of 2022 (see Table 4).

4 Total AusNet Services customers

	Existing	-	-	Total		
	Residential	Commercial	Total	Residential	Commercial	Total
2014	618 691	16 227	634 918	618 691	16 227	634 918
2015	633 043	16 403	649 446	633 043	16 403	649 446
2016	644 727	16 583	661 310	644 727	16 583	661 310
2017	657 798	16 735	674 534	658 107	16 739	674 846
2018	671 210	16 892	688 102	672 119	16 902	689 021

	Existing	-	-	Total		
	Residential	Commercial	Total	Residential	Commercial	Total
2019	684 974	17 052	702 026	686 333	17 068	703 401
2020	699 100	17 217	716 317	700 796	17 237	718 033
2021	713 600	17 386	730 986	715 549	17 409	732 958
2022	727 642	17 550	745 191	729 781	17 575	747 355

Source: CIE.

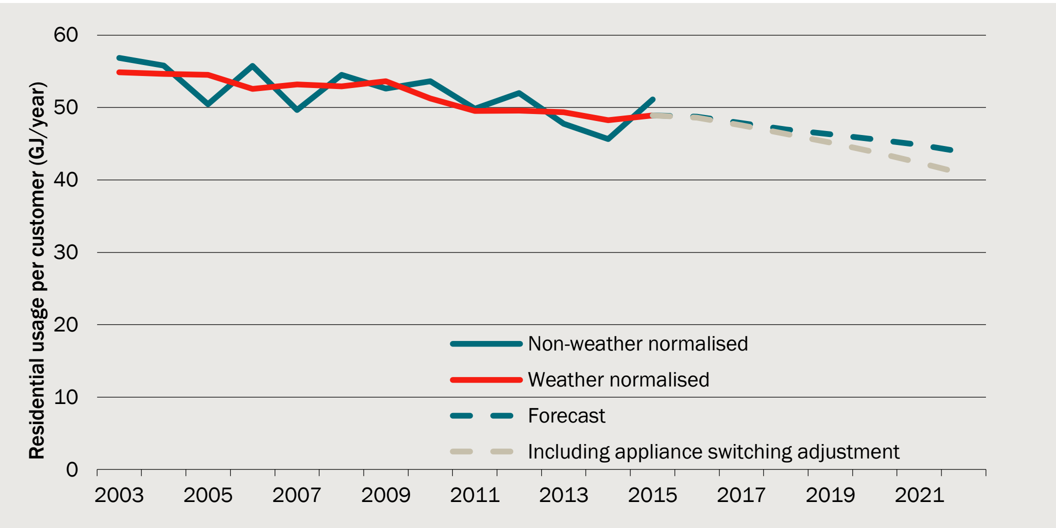
Usage

A few major trends have driven the changes in residential usage per customer.

- New residential houses and units use less gas than existing dwellings of the same type.
- The share of new units in total new dwellings is higher than for the existing customer base.
- Usage per customer is declining over time, likely reflecting improvements in electrical appliances that are substitutes for using gas and more energy efficient housing.

Residential usage per customer will continue to decline. This is consistent with the historical trends evident in the data once weather, gas prices and other factors have been accounted for. Additionally, customers are expected to increasingly switch from gas appliances such as hot water units to solar hot water units or electric appliances. We make a post-modelling adjustment to account for this based on the approach taken by AEMO in the *National Gas Forecasting Report 2015*.

5 Residential usage per customer forecasts

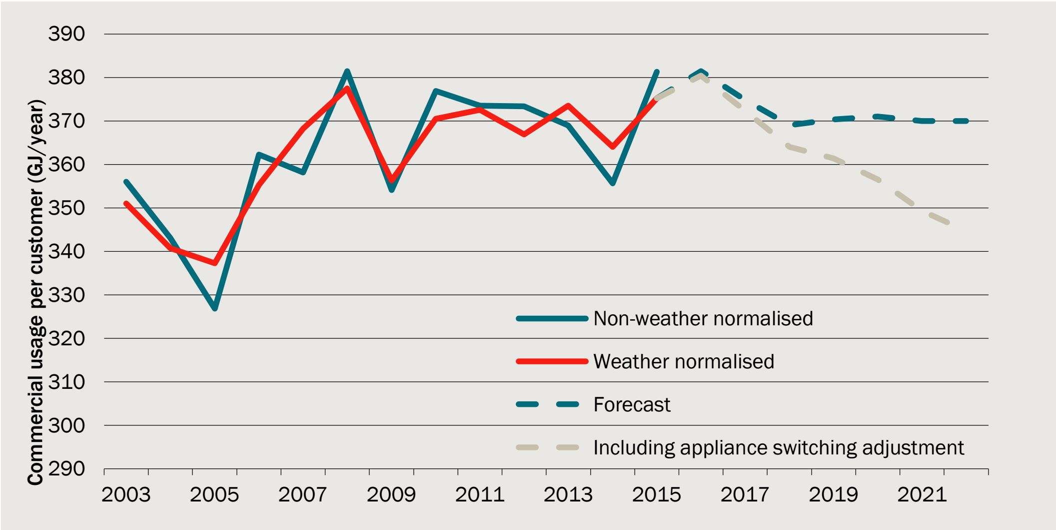


Data source: CIE.

The trends driving changes in commercial usage per customer are less clear, and usage of commercial customers is less homogenous than usage of residential customers.

Forecast commercial usage per customer declines, largely due to the projected rise in gas prices. We also make a post-modelling adjustment for increased appliance switching to forecasts of commercial usage per customer.

6 Commercial usage per customer forecasts



Data source: CIE.

Large customers will decrease their maximum hourly gas demand in line with the AEMO's projections of volume for all large Victorian gas users.

Demand projections

The aggregate growth rates in customer numbers and usage from 2016-2022 are shown in table 7 below. Both residential and commercial usage increase more slowly than customer numbers. We forecast residential and commercial usage per customer to decline.

7 Demand projections - growth

Customer segment	2016	2017	2018	2019	2020	2021	2022
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Residential usage	-3.12	-0.19	-0.46	-0.44	-0.93	-1.32	-1.64
Residential customer numbers	1.85	2.08	2.13	2.11	2.11	2.11	1.99
Commercial usage	0.88	-1.21	-1.29	0.25	-0.36	-1.05	-0.38
Commercial customer numbers	1.10	0.94	0.98	0.98	0.99	1.00	0.95
Tariff D	-0.39	-1.46	-10.29	-0.49	-0.08	-0.35	-1.02

Note: These projections include the impact of appliance switching through a post-modelling adjustment.

Source: CIE.

Risks and sensitivities

There are many risks around projections including whether historical relationships continue and around future dwelling growth, gas prices, and other factors. We consider the effect of variation in the decline in Effective Degree Days (EDDs, a measure of weather outcomes) and gas prices. Residential demand is more sensitive to variation in the assumed EDD trend while commercial demand is more sensitive to projections of gas prices. If EDDs were 3 per cent higher over the entire 2018-2022 period then revenue over the 5 years would be approximately $11 million greater.

A significant source of uncertainty for our forecasts is associated with customers switching from gas to non-gas appliances. The rate of appliance switching is expected to increase over the forecast period. It is difficult to estimate the difference between the rate of appliance switching that occurred historically and appliance switching expected to occur in the future. We make a downward adjustment to our forecasts of residential and commercial usage per customer that is equal to AEMO's estimate of the impact of appliance switching on usage per customer. The cumulative adjustment increases in magnitude to about 7 per cent of total usage per residential and commercial customer in 2022 (see charts 5 and 6).

1 Introduction

Purpose of forecasts

AusNet Services require independent and detailed forecasts of energy use and customer numbers for their gas distribution network for the period of 2018 – 2022. These forecasts will be used for its Gas Access Arrangement Review (GAAR) and general planning and forecasting.

Demand forecasts form a primary input into regulatory decisions. Demand forecasts:

- influence the notional revenue allowance through
  - operating expenditure projections
  - capital expenditure projections and hence the regulatory asset base, which is turn impacts on depreciation and the return on capital; and
- influence prices as prices are set so that demand multiplied by prices is equal to the notional revenue allowance.

Demand forecasts are also a primary input into decision-making by businesses. They can help to inform:

- pricing structures, which can be changed throughout the regulatory period to maximise revenue
- marketing – demand forecasting requires an understanding of the choices customers and potential customers are making, which is useful information for targeting of customers
- risks and risk management – if demand forecasts have a stochastic component rather than being a single forecast, and
- capital and operating expenditure planning decisions.

Background on AusNet Services' distribution network

AusNet Services is a diversified energy business providing the following services:

- Gas distribution network — transporting gas to approximately 660 000 customers across central and western Victoria including some of Melbourne's western suburbs. This network spans an area of 60 000 square kilometres.
- Electricity distribution network — carrying electricity from the high voltage transmission grid to approximately 690 000 customers across eastern Victoria including Melbourne's outer eastern suburbs.

- Electricity transmission network – carrying electricity from power stations to electricity distributors across all of Victoria.[1]

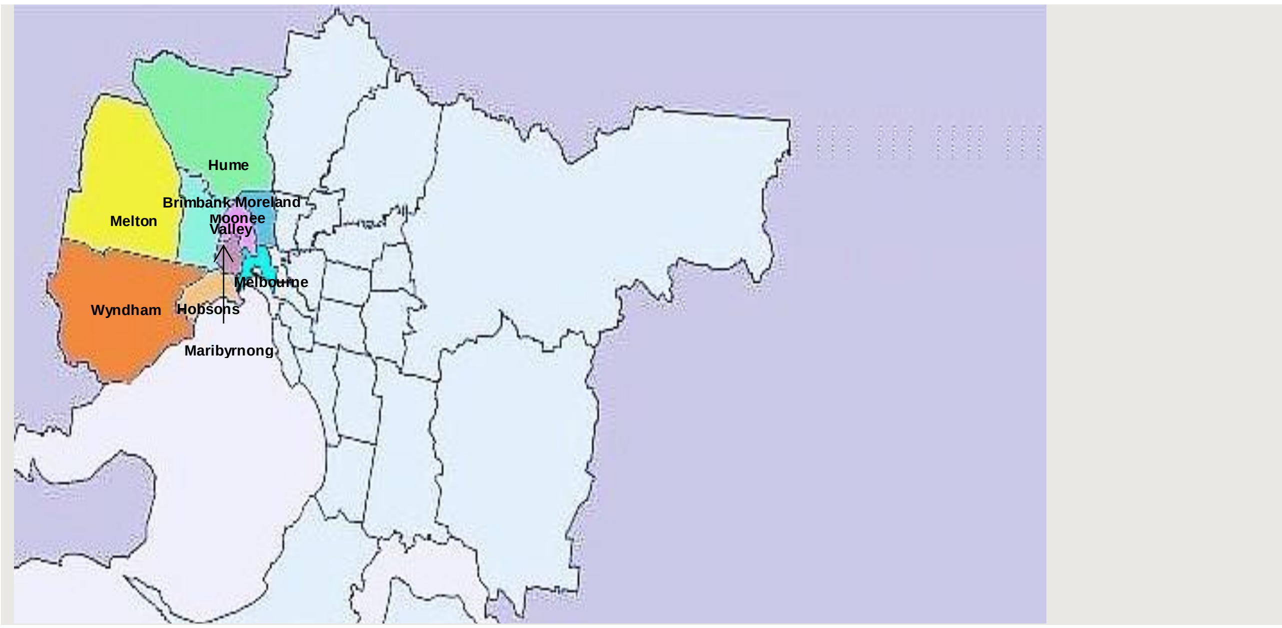
The focus of this study is on AusNet Services' gas distribution network. Charts 1.1 and 1.2 provide maps of AusNet Services' area of operations for its gas distribution network outside of the Melbourne metropolitan area and within the Melbourne metropolitan area. Apart from AusNet Services, there are two other gas distribution network providers in Victoria — Multinet which operates in a part of the Melbourne area and Australian Gas Networks (AGN) which provides services in the central, northeast and eastern parts of Victoria. In most instances each Local Government Area (LGA) is serviced by a different gas distribution network, although there a small number of LGAs which are serviced by more than one network provider.

1.1 LGAs serviced by AusNet outside of the Melbourne Metropolitan Area

Notes: AusNet Services' area of operation includes the following LGAs *outside* the Melbourne Metropolitan Area: Ballarat (C), Campaspe (S), Central Goldfields (S), Colac-Otway (S), Corangamite (S), Glenelg (S), Golden Plains (S), Greater Bendigo (C), Greater Geelong (C), Hepburn (S), Horsham (RC), Macedon Ranges (S), Maribyrnong (C), Moorabool (S), Mount Alexander (S), Moyne (S), Northern Grampians (S), Southern Grampians (S), Surf Coast (S), Warrnambool (C), Yarriambiack (S).
Data source: Wikipedia (2011).

1 AusNet Services, *Annual Report 2016*, p.23.

1.2 LGAs within Melbourne Metropolitan Area



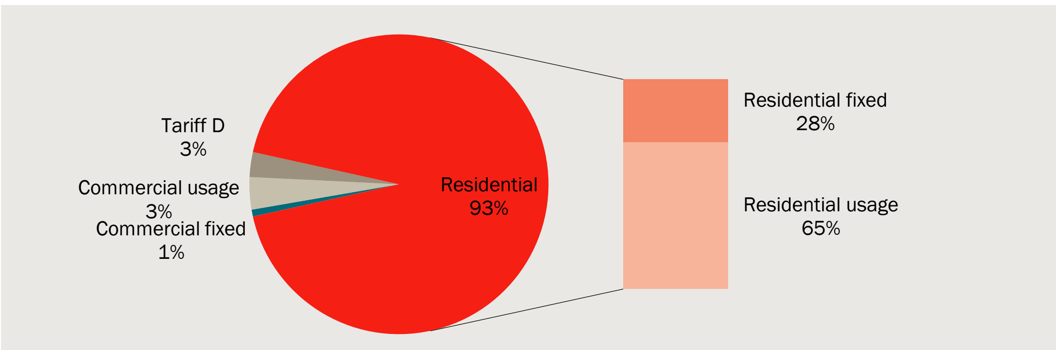
Note: AusNet Services' area of operation includes the following LGAs within the Melbourne Metropolitan Area: Brimbank (C), Hobsons Bay (C), Hume (C), Melbourne (C), Melton (S), Moonee Valley (C), Moreland (C), Wyndham (C).

Data source: Department of Planning and Community Development of Victoria (2011).

Impact of different components of demand on revenue projections

The shares of revenue from different customers and fixed versus variable charges are shown in chart 1.3. Residential uses comprise 93 per cent of revenue, of which about two thirds is from usage charges and one third from fixed charges. For this reason, we have placed the greatest focus on forecasting residential gas use.

1.3 Revenue shares by user and component



Data source: CIE.

Structure of this report

The structure of this report is as follows:

- Chapter 2 assesses the performance of previous forecasts.
- Chapter 3 discusses the key issues in forecasting gas demand.
- Chapter 4 explains The CIE's general approach.
- Chapter 5 projects customer numbers for residential users
- Chapter 6 projects customer usage for residential users
- Chapter 7 projects customer numbers for commercial users
- Chapter 8 projects customer usage for commercial users
- Chapter 9 projects Tariff D maximum hourly quantities
- Chapter 10 considers the risks surrounding projections and whether adjustments to projections are warranted.

2 Performance of the previous forecasts

The CIE prepared 2012-2017 GAAR forecasts for AusNet Services. We have considered the performance of these forecasts as part of deciding on the appropriate methods and assumptions for new forecasts.

In order to evaluate the 2012-2017 forecasts against actual outcomes we undertake the following tasks.

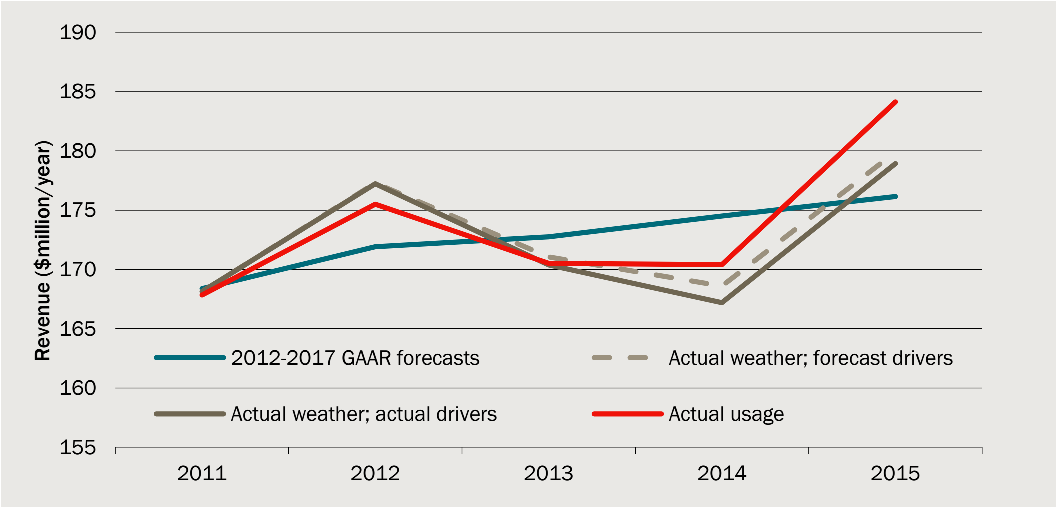
- The unadjusted forecasts are compared to actual outcomes. This is an indicator of the overall performance of the forecasts, and is particularly relevant for considering the revenue outcomes from the forecasts versus actual outcomes.
- The forecasts are adjusted to reflect actual weather outcomes. Weather is the most important short term driver of gas usage. Forecasting weather is inherently uncertain. This comparison allows for the performance of the model to be evaluated after removing the short term fluctuations from weather.
- The forecasts are adjusted to include actual outcomes of other drivers, such as gas price changes and dwelling growth, as well as weather. This allows us to understand the performance of the model in terms of whether drivers were correctly forecast, and whether there are other factors impacting the accuracy and bias of forecasts.

The performance of forecasts in aggregate is presented in terms of the impact of AusNet Services' revenue. This is undertaken by using prices in 2015 as weights for the forecasts. We then consider specific aspects of the performance of the forecasts, such as residential, commercial and industrial.

Aggregate performance of the 2012-2017 forecasts

In aggregate, forecasts were close to actual outcomes, yet less so for 2015. In 2015, the actual outcome was higher than the forecast yet this difference narrowed after accounting for weather outcomes (chart 2.1). The forecasts over the period did not clearly overestimate or underestimate demand, with small errors in both residential and commercial forecasts. In general, the forecasts tended to overstate demand in 2013 and 2014 yet understate demand in 2012 and 2015.

2.1 Performance of total forecasts



Note: All measures are constant-price revenue using 2015 prices.

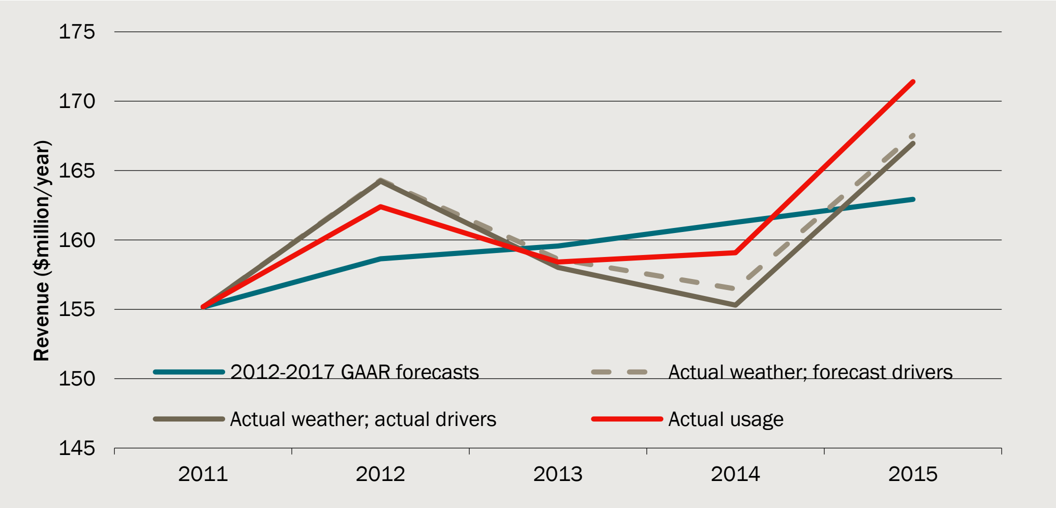
Data source: AusNet Services, CIE.

Performance of the 2012-2017 forecasts — residential

- **Forecasts were very accurate at the beginning of the period and somewhat less accurate as the forecast horizon lengthened.**
- **Forecasts were below actual outcomes in 2012 and 2015, yet above actual outcomes in 2013 and 2014.**
- **Accounting for weather outcomes does not systematically over-correct or under-correct, which may suggest that the weather relationship is accurately estimated and the errors are attributable to other variables**
- **Once actual weather outcomes are included in the model, forecasts were closer to yet still below actual outcomes for 2015. The 2015 outcome suggests a rise in gas demand that was not predicted by the model.**
- **The difference between forecasts of drivers (outside of weather) and actual drivers made a negligible contribution to forecasts, yet the contribution increased over the period as forecast errors of these drivers accumulate over time.**

The outcomes for aggregated residential demand are shown in chart 2.2.

2.2 Forecast performance — aggregate residential



Note: All measures are constant-price revenue using 2015 prices.
Data source: AusNet Services, CIE.

The residential forecasts reflect forecasts of the number of customers and forecasts of the usage of customers (across tariff bands).

- The number of customers was based on forecasts of dwelling growth.
- Usage per customer was based on a model of the drivers of gas usage.

Data on actual dwelling numbers in each local government area is not available post 2011. In order to consider performance, we have assessed dwelling creation based on building approvals and a methodology used by the National Housing Supply Council, explained in more detail in chapter 5.

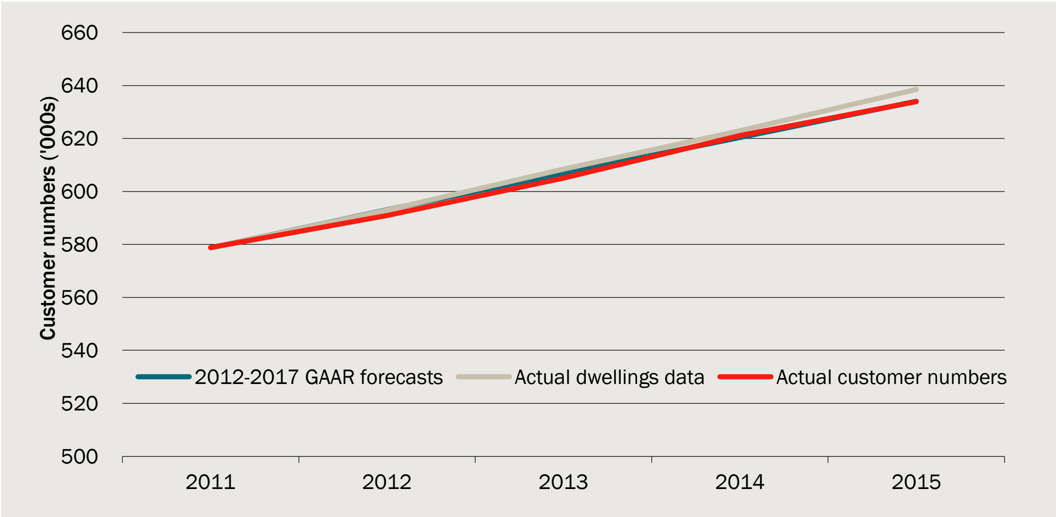
Chart 2.3 compares the forecast of residential customer numbers from 2012-2017 with actual outcomes.

- Forecasts were very close to actuals.
- This reflected offsetting errors in the forecasts
  - dwelling growth was higher than expected
  - the penetration rate — how many dwellings take up gas — was lower than expected. In 2015 in particular there appears to have been a significant slow-down in the number of new residential connections.

The performance of usage forecasts per residential customer is shown in chart 2.4. After adjusting for weather, the forecasts were extremely accurate up until 2015. However, in 2015, forecasts remained lower than what was observed after allowing for the impact of weather outcomes in the model.

This may be partially due to the change in weather station used to produce EDD for this analysis. The 2012 model was estimated using EDD estimates produced from Melbourne Regional Office weather data. This weather station ceased operation in January 2015. Thus, to evaluate the performance of the 2012 model, we have used a measure of EDD produced from Melbourne Airport weather data to forecast usage per customer.[2] That is, we used the Melbourne Airport measure of EDDs to infer what the change in the Melbourne Regional Office EDD measure would have been in 2015. This process may be imprecise, and thus partially accountable for the error in the 2015 forecast.[3]

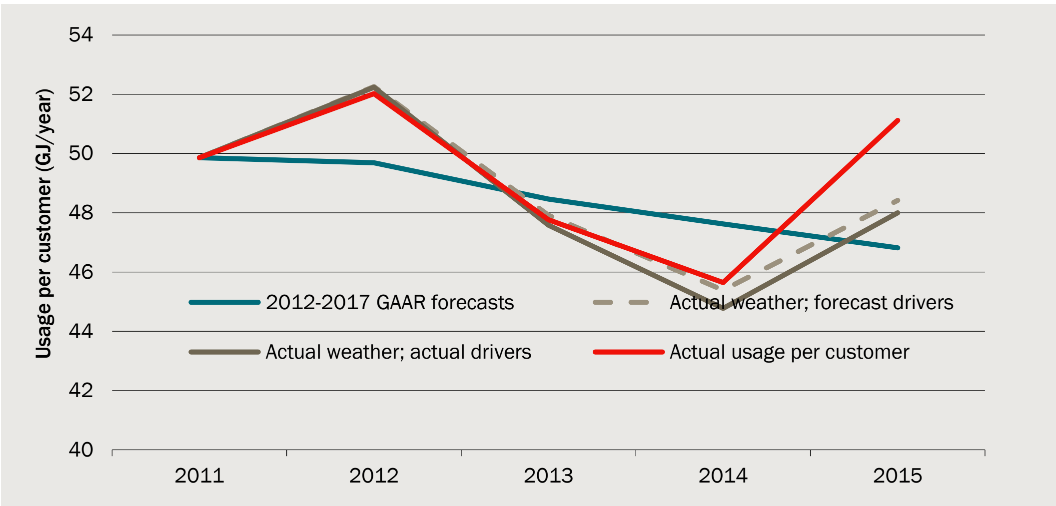
2.3 Forecast performance — residential customer numbers



Data source: CIE.

Chart 2.4 presents the 2012 forecasts of usage per residential customer, which are shown to be very accurate after accounting for actual weather outcomes except for 2015.

2.4 Forecast performance — usage per residential customer



Data source: CIE.

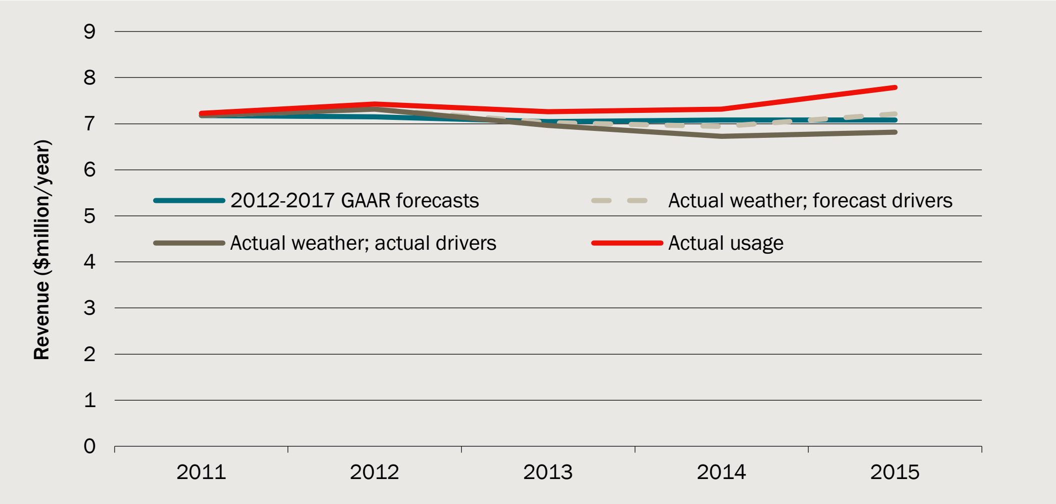
2 This is the source of weather data to produce the EDD measure used in the forecast model for the 2018-2022 GAAR presented in this report.

3 Such a problem will not affect the 2018-2022 forecasts presented in this report. The Melbourne Airport EDD measure is used consistently throughout this report and no adjustment is necessary for the cessation of measurements at the Melbourne Regional Office weather station.

Performance of the 2012-2017 forecasts — commercial

Chart 2.5 compares forecasts of constant-price revenue for commercial customers. The actual outcomes were higher than forecasts. Once adjusting for weather and actual drivers, forecasts were still lower than actuals. Note that drivers significantly pulled down forecasts, with much weaker GSP than expected.

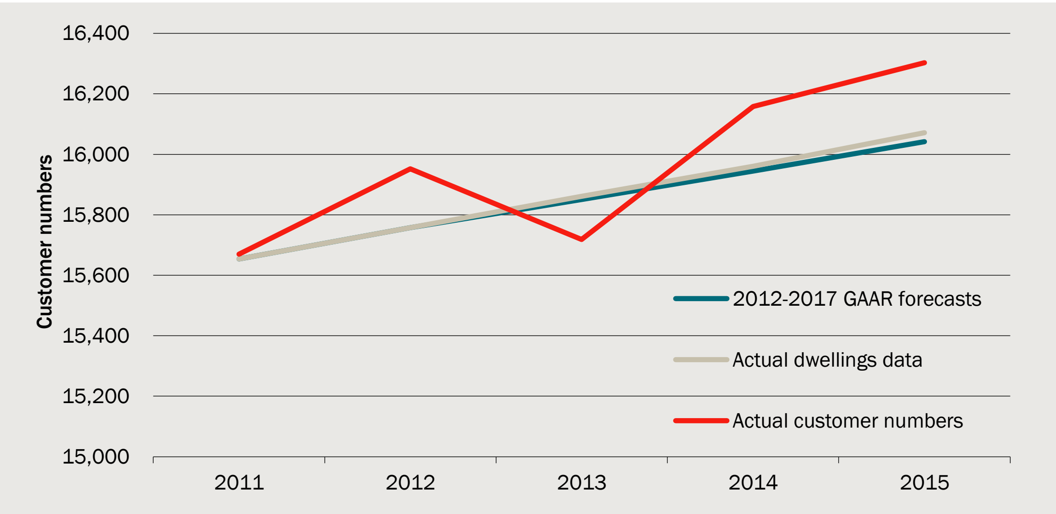
2.5 Forecast performance — aggregate commercial



Data source: CIE.

Actual commercial customer numbers increased more rapidly than anticipated, and fluctuated more than allowed for in forecasts (chart 2.6). Differences are relatively small — actual customer numbers are 1.6 per cent higher in 2015 than forecast.

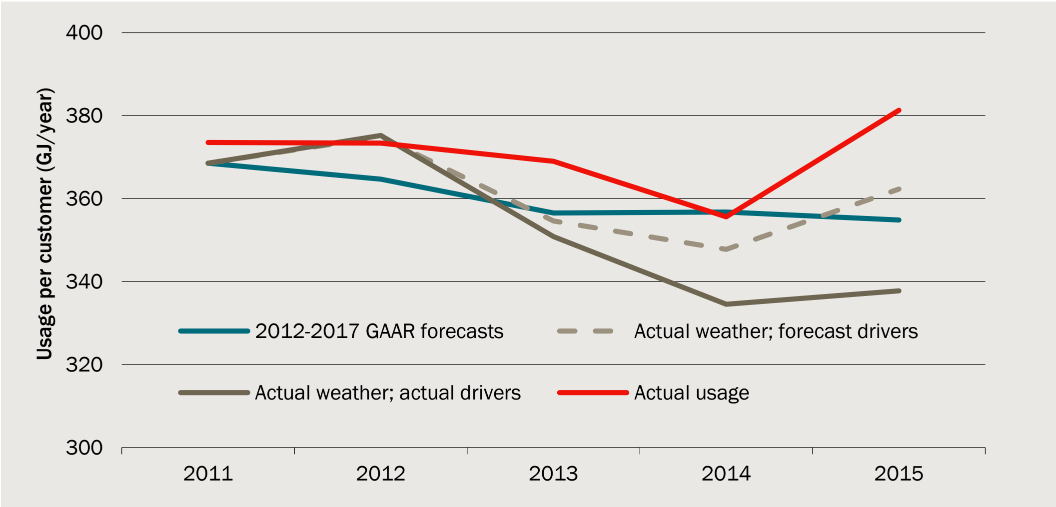
2.6 Forecast performance — commercial customer numbers



Data source: CIE.

Actual usage per commercial customer was also higher than anticipated, after adjusting for the drivers of forecasts (chart 2.7). Forecasts of usage per commercial customer were anticipated to gradually decline, but have actually stayed relatively flat.

2.7 Forecast performance — usage per commercial customer



Data source: CIE.

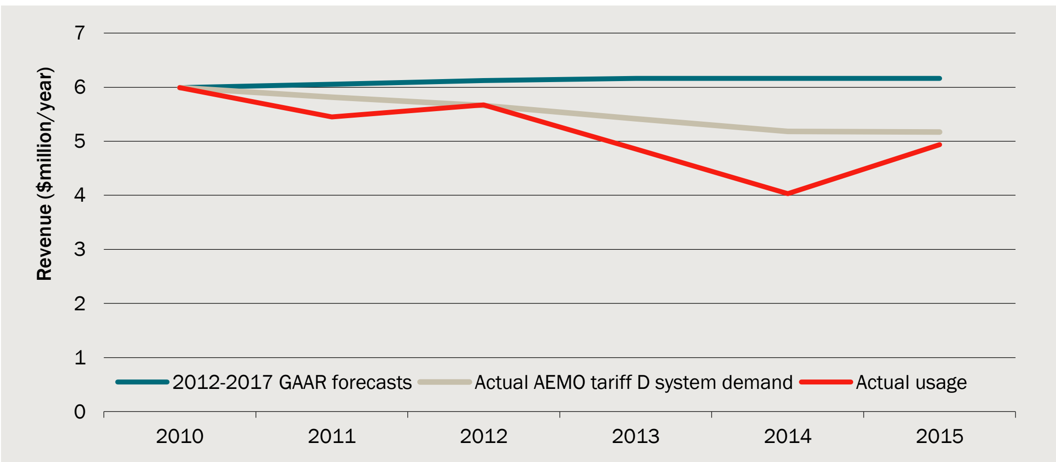
Performance of the 2012-2017 forecasts — tariff D

Tariff D covers large customers, that are billed based on their maximum hourly quantity rather than usage. Chart 2.8 compares constant-price revenue calculated using the 2012-2017 demand forecasts to:

- forecasts using actual AEMO Tariff D system demand (PJ/year), and
- constant-price revenue based on actual demand.

Over the period, tariff D forecasts have overstated actual outcomes, by in the order of $1 million per year. This mainly reflects that AEMO had forecast slight growth in Tariff D demand across the Victorian gas system, while this has actually decline in general, with AusNet Services' outcomes consistent with this decline.

2.8 Performance of Tariff D total demand forecasts



Data source: CIE.

3 *Key issues in forecasting gas for the next regulatory period*

Our analysis of outcomes over the previous regulatory period suggests that there are 5 key issues that the forecasting approach will have to address.

- The 2015 outcome, which could form a starting point for forecasts, requires analysis to understand whether underlying gas demand has risen and this is obscured by the cold winter, or the weather correction used in the models is not appropriate for 2015.
- The decline in the penetration rate for gas for new dwellings appears to be accelerating.
- Usage per residential customer is very different for newer buildings and houses versus flats. Newer buildings that are connected to gas use substantially less gas than existing buildings, likely reflecting building energy efficiency standards. Flats use less gas than houses because they are smaller.
- Usage per customer is declining for existing dwellings.
- Changes in demand profiles will have different impacts on different tariff blocks.

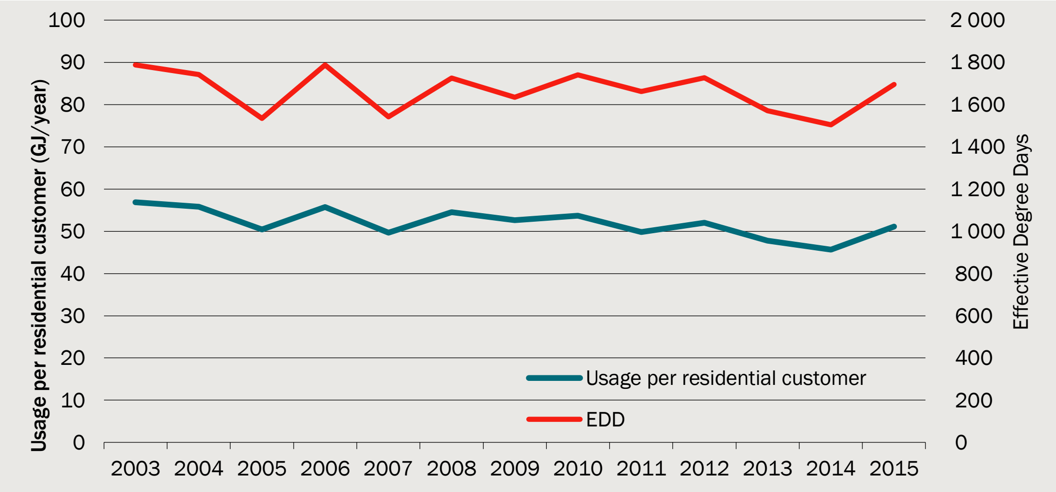
These issues are discussed in this chapter.

Weather adjustment to normalise the 2015 outcome

2015 was a relatively cold winter. This led to an increase in gas use. Chart 3.1 shows the outcome in terms of effective degree days, which is the preferred measure of weather outcomes used for gas forecasting, and residential usage per customer.

The latest outcome may form a starting point for the forecasts, if we continue to use an approach based on adjusting forecasts from the most recent outcome, as we did for the 2012 to 2017 forecasts. It is therefore important to determine if the relationship between consumption and EDD remains similar over time.

3.1 Weather and residential usage per customer

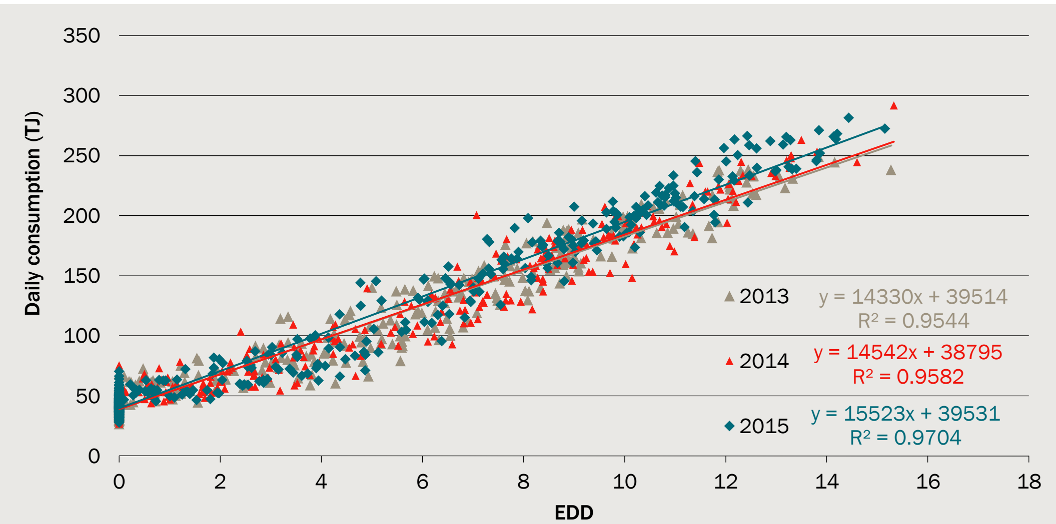


Data source: CIE.

We can examine the daily consumption of tariff V customers (residential and commercial) by using data from flow points in the network, and subtracting usage for tariff D customers.[4]

- In chart 3.2 we set out daily gas use for tariff V customers against effective degree days for 2013, 2014 and 2015.
- The colder outcomes for 2015 can be seen in the somewhat larger number of points with effective degree days greater than 10, compared to previous years.
- There is little difference in consumption for a given level of EDDs, as shown by the similarity in the estimated trend lines for each year.

3.2 Gas use for tariff V customers and effective degree days



Note: 2015 is 2015 and through to March 2016.
Data source: CIE.

4 The residual covers residential usage, commercial usage and system losses. Tariff D consumption can be subtracted because these customers have interval meters and their daily consumption is therefore available.

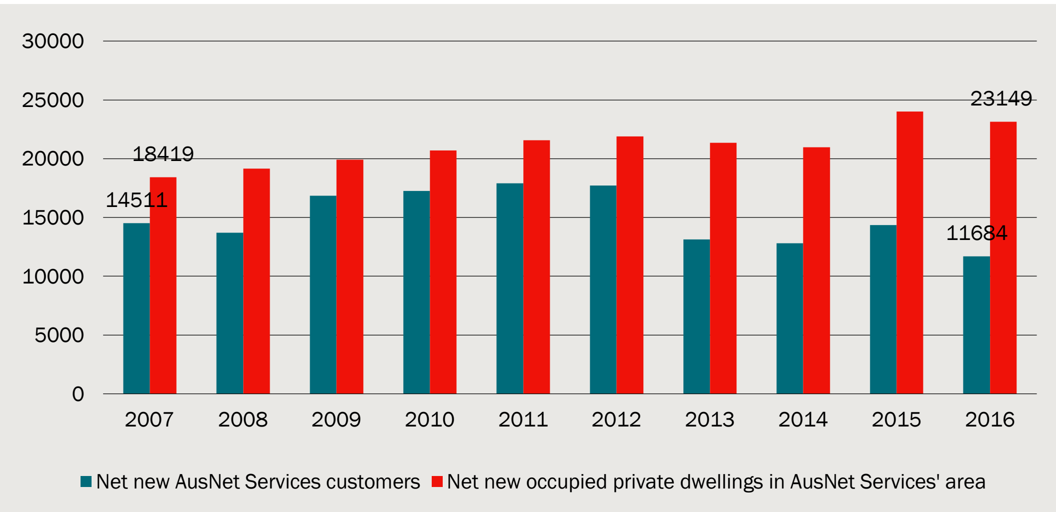
Given that the above provides little evidence of a changed weather relationship, we have based our approach on continuing to develop forecasts in a manner consistent with the 2012 to 2017 forecasts, and adjusting off the 2015 tariff level outcomes.

Penetration rates have been falling

Our previous forecasts anticipated that customers would grow in line with dwellings. In fact, growth in customer numbers has slowed relative to dwelling growth, and 'net new customers' has been falling relative to 'net new occupied dwellings'. This is shown in Chart 3.3. Note the following.

- 'Net new customers' is the change in AusNet Services customers between the March quarters of the relevant year. Data are taken from AusNet services' billing database. March quarter years are used as we have data for the March quarter of 2016. For example, AusNet Services had 633 043 customers and 644 727 customers in the March quarters of 2015 and 2016 (respectively).These data yield 11 684 net new customers in 2016.
- 'Net new occupied dwellings' is the change in occupied private dwellings in the LGAs covered by AusNet Services network between the June quarters of the relevant year (i.e. it is the change in occupied private dwellings for the relevant financial year). We have used ABS data on dwelling approvals and dwelling completions, data on vacancy rates (published in Victoria in Future forecasts from the state government) and fixed assumptions for demolitions rates, completion rates and building time (published by the National Housing Supply Council) to estimate the change in occupied private dwellings. This methodology is explained in Chapter 5.

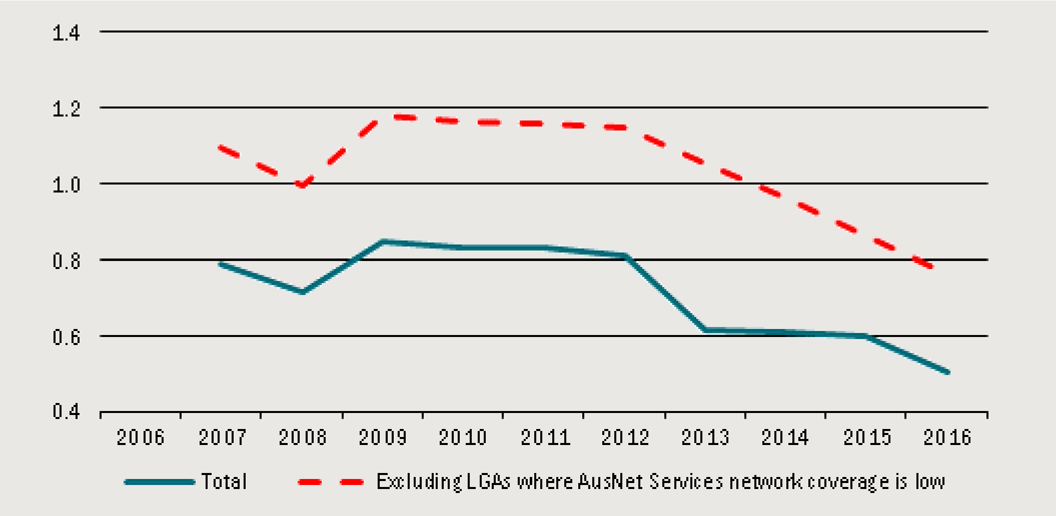
3.3 Net new AusNet customers and net new occupied dwellings



Data source: CIE.

The fall in net new customers relative to net new dwellings is summarised in the 'marginal penetration rate' in Chart 2.4. In 2016, there were 11 684 net new customers for AusNet Services, compared to 23 149 net new occupied private dwellings in AusNet's area. These data combine to give a 'marginal penetration rate' of 0.50.

3.4 Marginal penetration rate in AusNet Services area



Note: The marginal penetration rate is defined as net new customers divided by net new dwellings.

Data source: CIE.

Penetration have fallen because of changing preferences

For cooking, hot-water and space heating households can choose between gas and electricity. Available data and discussion in the literature suggest that preferences of households have switched away from gas and towards electricity. The natural result of this has been the fall in the marginal penetration rate (identified above).

AusNet have provided data on total disconnections, which combined with 'net new customers', allow us to estimate 'new connections'. With these data, we can break 'net new customers' into the following.

- Growth in dwellings. This is growth in dwellings multiplied by some benchmark rate for new connections per new dwelling. For simplicity, we assume the benchmark rate to be the average rate between 2012 and 2015 (0.72), when gas prices changed in-line with electricity prices.
- The deviation between the actual, observed rate for new connections per new dwelling and the benchmark rate.
- Disconnections.

For example, 2016 data for 'net new customers' (11 684, see above) can be broken down as follows.

- There were 1638 disconnections in 2016. Given net new connections of 11 684, this implies there were 13 322 new connections.
- There were 23 149 net new occupied dwellings in AusNet's area in 2016. Given a benchmark rate for new connections per new net occupied private dwellings of 0.72, this dwelling growth would have contributed 16 617 new connections for AusNet (assuming no change in preferences).
- In fact, preferences have changed (away from gas). The actual rate for new connections per net new occupied private dwelling was 0.58. Given the increase in

occupied private dwellings, the deviation in this rate from the benchmark reduced new connections by 3 295.

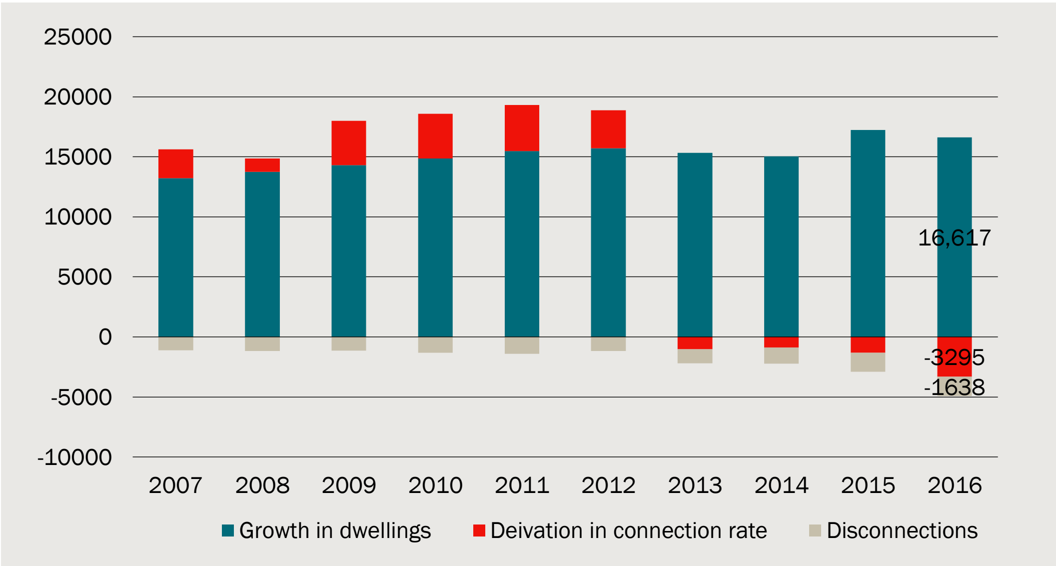
These data are shown in Chart 3.5.

Chart 3.5 shows that strong growth in dwellings in AusNet's area should have resulted in strong growth in customer numbers (especially in recent years). However, strength in dwellings growth has been offset by two factors.

- The actual connection rate (connections per net new occupied dwellings) has fallen.
- Disconnections have picked up.

Recent literature (discussed below) suggests the connection rate (connections per net new dwelling) has fallen and disconnections have increased because customer preferences have shifted away from gas and towards electricity.

3.5 Contribution to net new customers



Data source: CIE.

Customer preferences appear to be switching from gas to electricity

AEMO note the phenomenon of 'gas to electric appliance switching' in its 2016 National Electricity Forecast Report (NEFR). According to AEMO, the key trend here is that an increased number of households have installed reverse cycle air-conditioners, and this has reduced the extent to which households have wanted to connect to gas (for the purposes of space heating). Now, across the National Electricity Market – which covers the eastern states, Tasmania and SA – around half of households have a reverse cycle air-conditioner installed. These air-conditioners can heat space and are actually more efficient than conventional gas heating for doing this (energy use for heating in a reverse cycle air conditioner is typically 20 per cent of the energy use in gas heater).[5]

Consistent with this, a recent survey by the Alternative Technology Association (ATA) found that 65 per cent of respondents were 'much less likely' or 'less likely' to choose a gas appliance now compared with 5 or 10 years ago. ATA believe the trend away from gas is due to 'household economic considerations as well as concern about climate change'.[6]

Further, research undertaken on behalf of AusNet Services by Colmar Brunton has suggested that 10% of current customers expect to disconnect from their current gas service sometime in the next 10 years.[7] Of particular interest to the 2018-2022 forecast are the 4% of customers who expect to disconnect within the next five years. These are existing customers who already have gas appliances and yet a significant proportion do not expect to be connected to AusNet Services' network by the end of the forthcoming GAAR period.

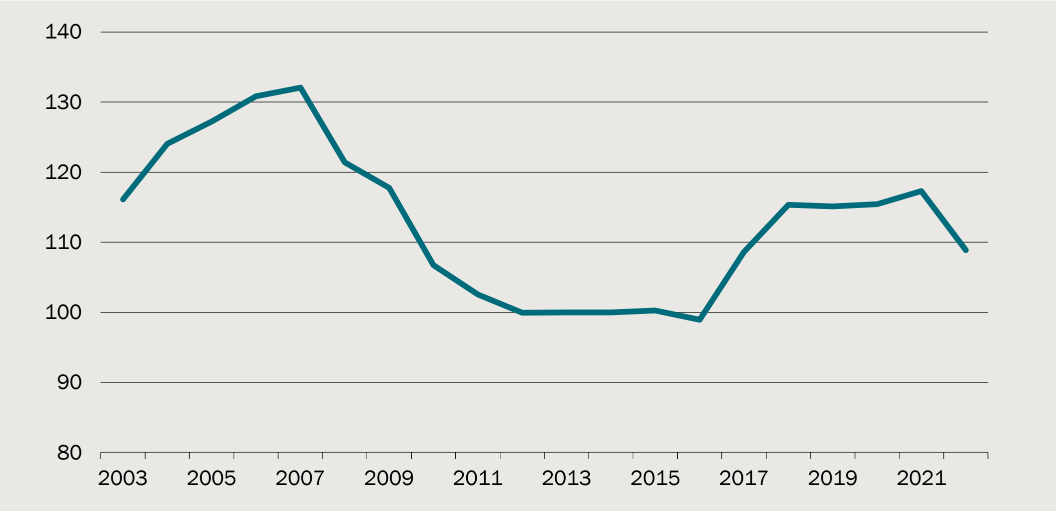
Chart 3.6 (below) shows that the gas price did not increase relative to the electricity price in the period between 2012 and 2016, the period when the marginal penetration rate fell sharply. This suggests that the relationship between relative prices and preferences is being complicated by other factors (or is not straightforward). The chart shows that gas prices are expected to increase relative to electricity prices in the future. It could be that the expectation of future price increases has prompted the change in preferences observed to date.

5 AEMO 2016, *National Electricity Forecast Report*, pp40 (see: http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report, accessed 7/7/2016)

6 Survey results and discussion published by ATA (see: https://www.ata.org.au/news/consumers-moving-away-from-gas-ata-survey)

7 AusNet Services 2016, *Energy Research. Study 2: Online Survey (prepared by Colmar Brunton Research)*, p38 (see: http://ausnetservices.com.au/CA257D1D007678E1/Lookup/DeterminingRevenues/$file/AusNet%20Services_Energy%20Research%20Study%202%20Report.pdf, accessed 12/8/2016)

3.6 Ratio of residential gas prices in AusNet area to electricity price



Data source: AEMO, ABS, ESC, CIE.

Geographical factors

If there was substantial dwellings growth in LGAs where AusNet Services' coverage was low, this could also explain some of the fall in the penetration rate.

For example, in the LGA of Melbourne, AusNet Services' network includes the postcode of 3008 (Melbourne's Docklands area) and 3031 (Kensington and Flemington). Combining Census data and Victoria in Future data, we estimate there were 14 356 occupied private dwellings in these postcodes in 2016, which was only 22 per cent of occupied private dwellings in the LGA of Melbourne (66 250).

In our Methodology (which is explained in Chapter 6), if there was substantial growth in dwellings in the LGA of Melbourne that did not occur in postcodes 3008 and 3031, this would show up as a fall in the marginal penetration rate (because AusNet could not capture any new gas customers from these dwellings).

In addition to Melbourne, other LGAs where this could be an issue are: Campaspe, Darebin, Golden Plains, Hindmarsh, Loddon, Mitchell, Pyrenees, West Wimmera, Whittlesea, Yarriambiack. In these LGAs, the average penetration rate (total customers divided by total occupied private dwellings) was 5.4 per cent or below (Pyrenees had the highest Penetration rate at 5.4 per cent). The next lowest average penetration rate was Corangamite with 23 per cent.

Graph 3.4 (above) shows the marginal penetration rate if we exclude these LGAs. The level of the marginal penetration rate lifts in all years when this adjustment is made, because we focus only on LGAs where AusNet services has a significant network. Clearly, even when these LGAs are excluded from the analysis, the marginal penetration rate has dropped significantly. This suggests geographical factors are not necessarily significant, which adds to our initial argument that preferences have switched away from gas and towards electricity.

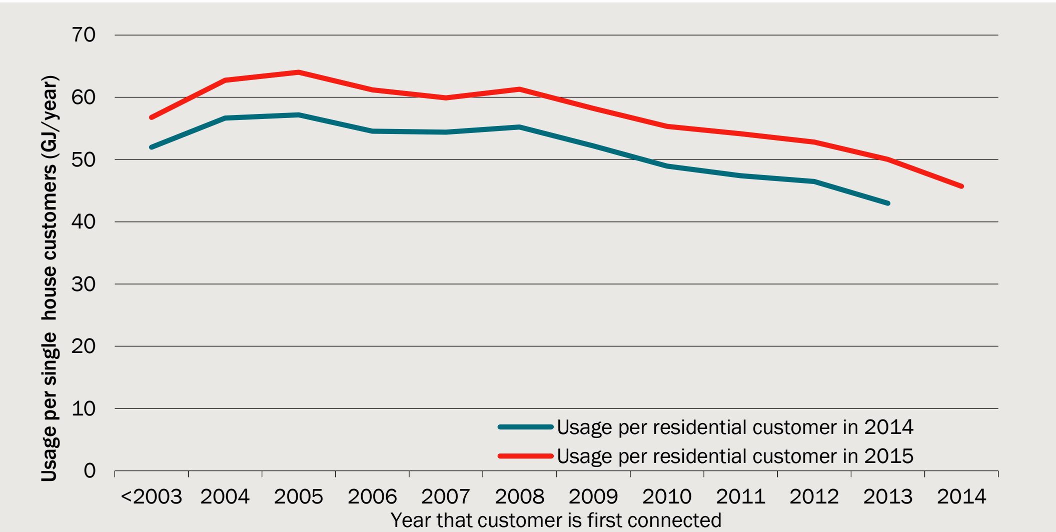
Gas use per residential connection

Gas use per residential connection has shown substantial differences between new and existing dwellings and between houses and flats. Both of these factors tend to drive usage per residential connection lower.

Using the billing datasets for customers, we can approximate when a dwelling was constructed by when the dwelling was connected to gas. This is not fully accurate, as some dwellings will be connected years after construction.

- Usage in 2014 and 2015 shows a marked decline depending on the year connected (chart 3.7 and chart 3.8).
- This is consistent with the introduction and increasing stringency of building standards for energy efficiency over this period. It is also consistent with improvements in substitute electrical appliances (reverse cycle air conditioners/heaters, induction cooktops and solar/heat pump hot water systems).
- The outcome is consistent for flats and single houses.

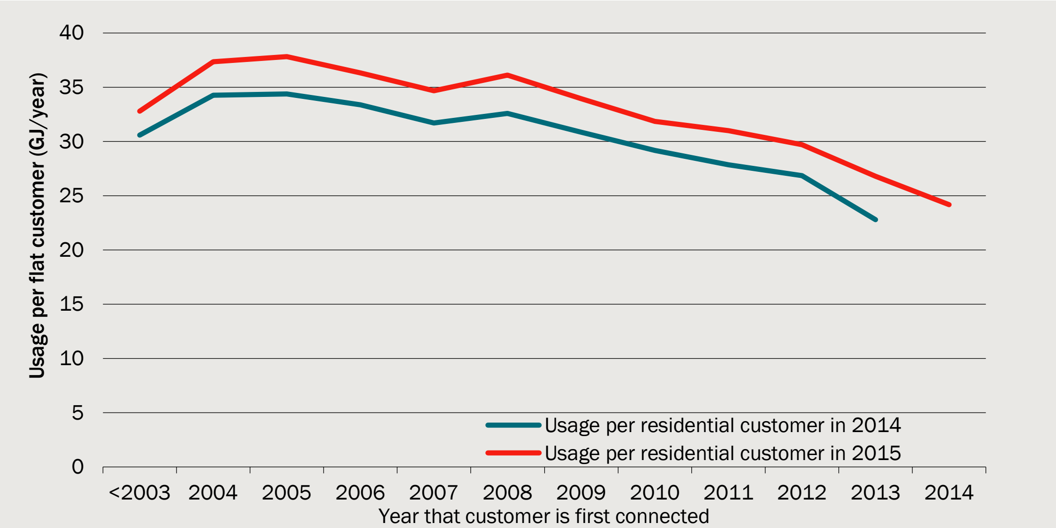
3.7 Usage in 2014 and 2015 based on year when first connected to gas – single houses



Note: The axis label ‘<2003’ indicates that the customer was connected in 2003 or a previous year.

Data source: CIE.

3.8 Usage in 2014 and 2015 based on year when first connected to gas - flats

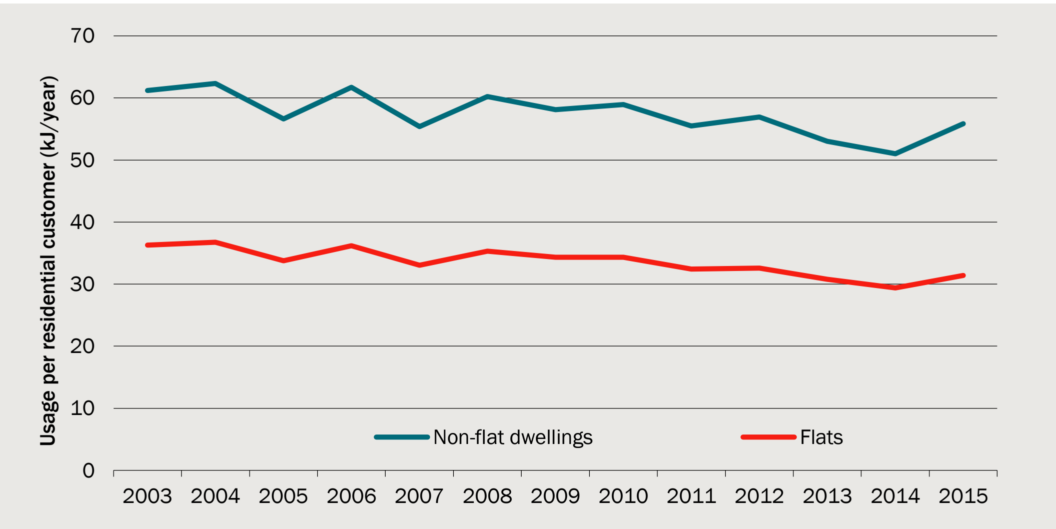


Note: The axis label '<2003' indicates that the customer was connected in 2003 or a previous year.

Data source: CIE.

Gas use is significantly lower for flats compared to single houses, as would be expected (chart 3.9). Analysis of AusNet Services customer number indicates that new AusNet Services residential customers are more likely to reside in flats than the existing dwelling stock.[8] This introduces a slow decline in usage per dwelling.

3.9 Residential usage for flats and non-flat dwellings



Data source: CIE.

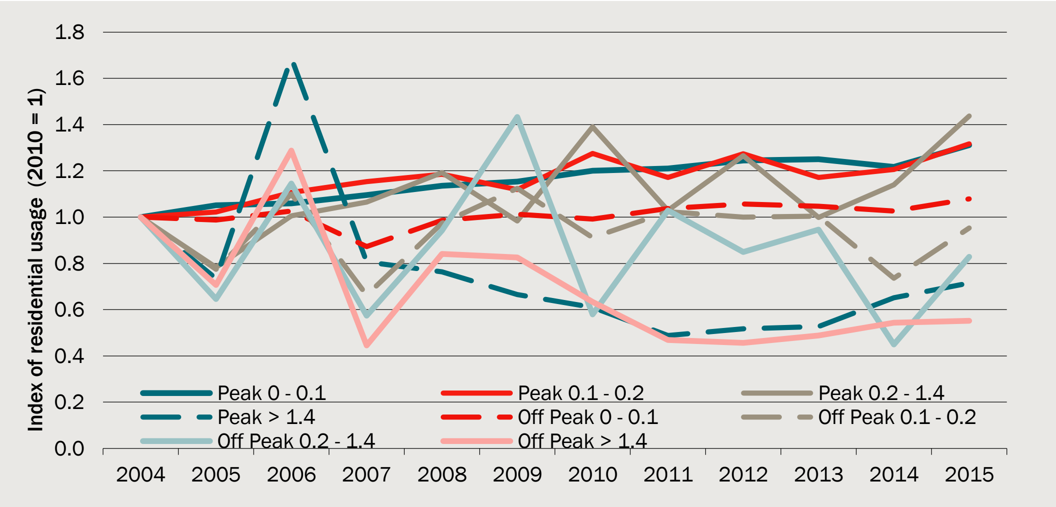
8 The ratio of building approvals for houses relative to total building approvals is falling over time, supporting the conclusion that new customers are more likely to reside in flats than existing customers. Australian Bureau of Statistics, *Building Approvals, Australia, Jul 2016*, Cat 8731.0, Series Numbers A418599F and A422272F.

Demand by block is very different

The trends in usage across blocks are very different.

- Higher blocks are more weather affected and hence more volatile (chart 3.10).
- New dwellings also have different patterns of consumption across blocks — lower average consumption but more consumption in higher blocks. This indicates a greater dispersion in the amount of gas used by new dwellings compared to existing dwellings. That is, there may be simultaneously more new customers with high usage and more with low usage, with fewer new customers of intermediate usage. This would be consistent with observing lower average usage yet more usage in higher blocks.

3.10 Changes in residential usage across blocks



Data source: CIE.

4 The CIE's approach

What is required to be forecast

Table 4.1 summarises the forecasts produced in this report.

4.1 Forecast items

Forecast item	Customer type	Customer zone
Customer numbers	Residential	LGA and postcode
	Commercial	LGA
Usage – by block	Residential	Aggregate, Central, West
	Commercial	Aggregate, Central, West
Maximum hourly quantity	Tariff D/M	Aggregate, Central, West

Source: CIE.

The forecasts are developed to 2022, with a starting year of 2016.

Principles of forecasting

Forecasting is an inherently imprecise science. In arriving at demand forecasts for a regulatory determination:

- it is important that forecasts are unbiased. That is, projections do not systematically understate or overstate demand and hence lead to an overstatement or understatement of prices necessary to generate the allowable rate of return, and
- it is important that forecasts are as accurate as is possible. The less accurate the forecast the greater the risks to the regulated business and customers.

Forecasts can be inaccurate but unbiased if over a sufficiently long period of time the forecast error is zero or in expectation the forecast error is zero. This would be the case for climatic conditions for example which are inherently uncertain.

There are many possible areas where forecast errors can arise. They have been detailed in technical terms by Hendry and Clements 2001 (shown in table 2.3). In plain English, the main areas of forecast error in gas forecasting are likely to be:

- uncertainty around drivers of gas use, such as
  - climatic conditions
  - economic activity, and
  - population

- uncertainty around the impact that past drivers of gas use will have in the future, such as:
  - weather impacts remaining similar to those experienced in the past
  - uptake rates remaining similar to those experienced in the past
  - commercial uses remaining similar to those of the past, and
- impacts of additional policy, with many policies concurrently being undertaken that will impact on gas use.

4.2 Forecast error taxonomy

1 Shifts in the coefficients of stochastic terms	2 Shifts in the coefficients of stochastic terms
3 Misspecification of deterministic trends	4 Misspecification of stochastic terms
5 Misestimation of the coefficients of deterministic terms	6 Misestimation of the coefficients of stochastic terms
7 Mismeasurement of the data	8 Changes in the variances of the errors
9 Errors cumulating over the forecast horizon	

Source: Hendry, D. and M. Clements (2001), "Economic forecasting: some lessons from recent research", *Economic modelling*, vol. 20(2), (March, pp. 301–29).

The uncertainty around demand drivers can have substantial impacts on the ability of a regulated business to achieve its regulated rate of return. For example, if winters were mild over the next five years then gas consumption might be 5 per cent lower than projected under average climatic conditions, leading to significant reductions in the rate of return achieved by the business. The variations in demand forecasts that have the greatest impact on regulated rates of return are those that are systematic. For example, a shift in average climatic conditions due to climate change could lead to regulated revenues being higher or lower than required over a long period of time. In comparison, annual volatility would impact on revenue for a only single year.

Basis of arriving at forecasts

The projections in this report have followed a three step process.

- Describing changes in gas use over the period for which data is available. This has typically been undertaken using statistical analysis of AusNet Services's billing database and daily outcomes, as set out in the previous chapter.
- Understanding the drivers of these changes, particularly those drivers that can be projected forward.
- Projecting forward using independent estimates of drivers and adjustments reflecting the impact of additional change not part of the historical time series, such as policies.

We have then considered projections relative to a continuation of historical trends in new connections and usage per connection, as a top-down check on the validity of projections.

A large part of the work has involved statistical analysis of AusNet Services' billing database, to identify trends in consumption at a much smaller granularity than possible through aggregate analysis. We consider that this allows a better understanding in particular of the consumption of new customers vis-à-vis existing customers and the impact of weather and prices on consumption.

Note that all statistical analysis has been in-sample — i.e. using historical data on usage and drivers and establishing relationships within this sample. We recognise that out-of-sample is preferable for forecasting, as stressed by ACIL Tasman, but that this is not plausible given the data available for this project[9]. In practice, any reasonable forecasting exercise will involve the use of both statistical models and judgement.[10]

The basic conceptual forecasting model that we work with is a set of dependent variables representing demand (a vector of customer numbers, customer consumption, etc) and their relationship to a set of demand driver variables. Mathematically, this can be represented as follows.[11]

$$\tilde{D}_t = B.\tilde{X}_{t/t-1} + \tilde{\varepsilon}_t$$

Where

$\tilde{D}_t$ is a Nx1 vector capturing N different types of demand at time t.

$\tilde{X}_{t/t-1}$ is a Mx1 vector of explanatory variables (such as population level, income level). It can be for variables of the current period (t) or past periods (such as t-1)

B is a NxM matrix of coefficients (such as the response of customer numbers to a higher population)

$\tilde{\varepsilon}_t$ is a Nx1 vector of error terms in the forecasts

For the purposes of forecasting, we are seeking to identify $\tilde{D}_{t+n}$ — i.e. demand in future years with n = 1 to 5. Clearly then, with a model specified as above, this requires some understanding of $\tilde{X}$ in future periods rather than purely population growth from past periods. In the absence of this information, our forecast model has not assisted in improving forecasts. For this reason, we focus on $\tilde{X}$ for which there are *independent and publicly available* projections.

The second main element of the model is the coefficients B. In some instances, these can be arrived at through statistical estimation using historical data. Under the

9 ACIL Tasman 2010, *Victorian electricity distribution price review: review of electricity sales and customer number forecasts*, prepared for the Australian Energy Regulator, April, p. 4.

10 Reserve Bank of Australia 2004, 'Better than a coin toss: the thankless task of economic forecasting', speech by Deputy Governor GR Stevens 17 August 2004, also reported in the Reserve Bank of Australia Bulletin September 2004.

11 Note that this sets out the deterministic components only. We have not sought to model the stochastic component.

assumption that the historical coefficients will remain unchanged in the future these can then be used for projections.

But also note that $\tilde{X}$ can capture future drivers such as policy change, for which coefficients cannot be estimated statistically.

For the purposes of gas demand forecasting for the AER, the distributor has to satisfy the AER that forecasts used in setting reference tariff(s) are arrived at on a *reasonable* basis and represent the best forecast or estimate possible in the circumstances. We consider that this is satisfied by:

- using independent projections of drivers
- estimating B using statistical analysis where possible, and
- where B cannot be estimated empirically using independent studies or assessments of impacts.

We split our analysis into analysis of customer numbers and analysis of usage per customer.

Possible drivers of gas demand

For regulatory purposes gas demand comprises customer numbers, the amount of gas that they use and, for some customers the maximum gas that they use. There are many potential drivers of these measures of demand. For the purposes of forecasting, it is only useful to understand drivers that can themselves be projected or for which there are clearly independent measures of demand available. For example, if it was found that dwelling size was an important driver of residential gas use but there was no independent projections of dwelling size or means to project dwelling size then this would not assist in developing projections of gas demand. Drivers of demand that we consider are:

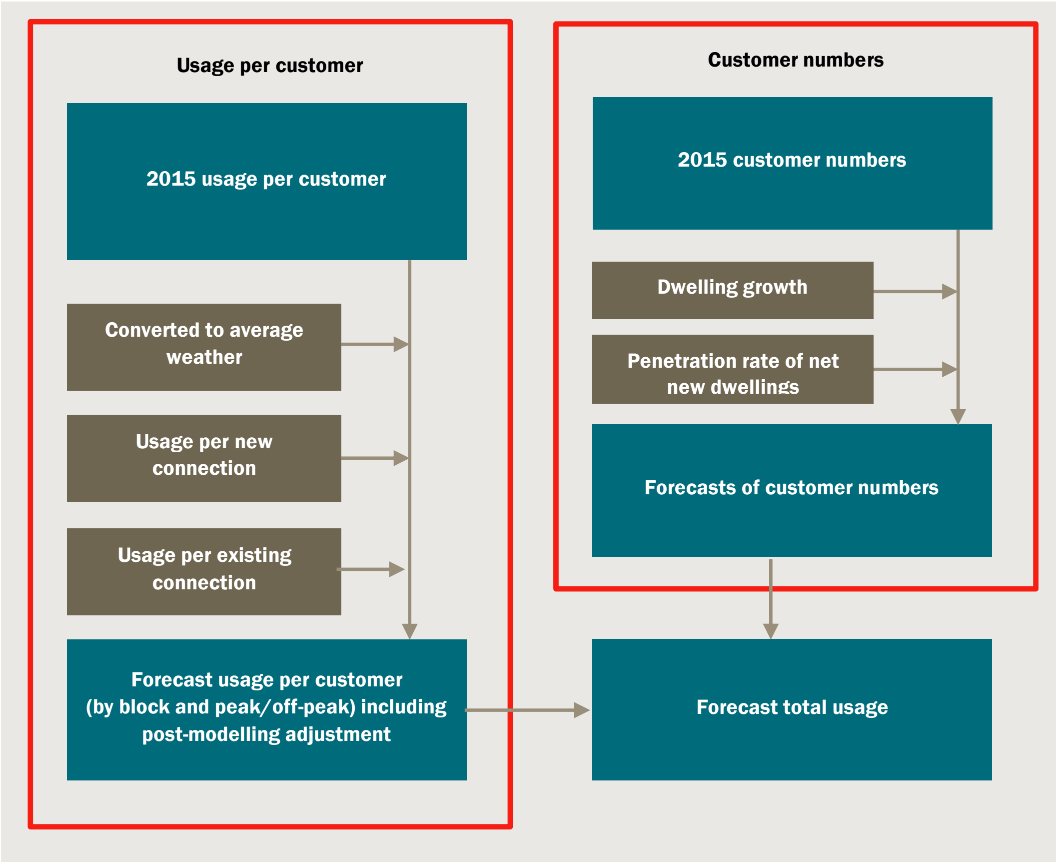
- population growth — the level of population growth is a major driver of the catchment for potential gas customers
- expansions of AusNet Services' network
- weather — consumption is impacted by temperature and other climatic conditions captured in measures of effective degree days
- the age of the connection, with new customers potentially having different characteristics to existing customers
- the composition of dwellings, with flats using considerably less gas than houses
- government policies
  - there are a range of policies at the Australian Government level and Victorian Government level that could impact on gas use and gas connections, ranging from subsidies (eg First Home Owners Grant) to a carbon tax, and
  - policies aimed at building design are likely to be particularly important for gas use
- types of activities businesses are undertaking, such as growth or slowing in retail sectors, and

- prices of wholesale gas and alternative fuels such as electricity.

Models used to develop forecasts

The model used for developing forecasts is set out in chart 4.3. This is the model for residential gas connections and use. A similar model is employed for commercial, albeit with different drivers.

4.3 Forecasts of gas connections and usage



Data source: CIE.

Approach to formal statistical analysis

The formal statistical analysis is undertaken using panel data regression in STATA, a statistical software package. Our approach has allowed for:

- Testing of different models (random effects and fixed effects).
- Undertaking a variable selection process from general to specific, to identify a parsimonious model of gas use.

The models are shown in the relevant chapters.

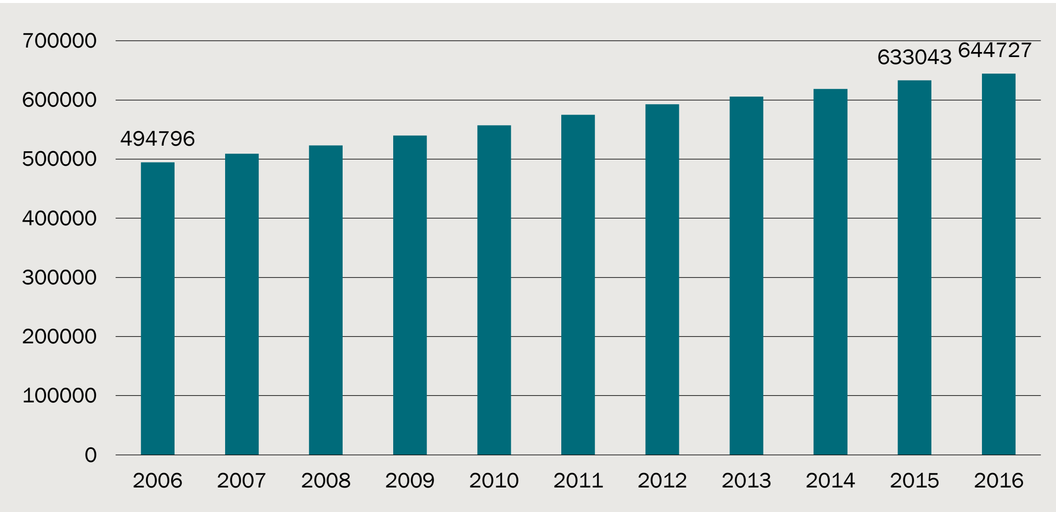
5 Residential customer numbers

Residential customers are connections to the gas network by households. Combined with average use per customer, they drive total gas usage across AusNet Services' gas network. Data on residential customer numbers used in this chapter are taken from the billing database provided to the CIE by AusNet Services.

Snapshot of residential customer numbers

AusNet Services had 647 727 residential customers in the first quarter of 2016, up from 633 043 customers in the first quarter of 2015 (see Chart 5.1). In this project, for each year, we take data on customer numbers from the first quarter of the year, as this allows us to include an observation for 2016. It is reasonable to use customer numbers from one particular quarter as an observation for a year as there is no reason to think gas customer numbers should be 'seasonal'. Since 2006, residential customer numbers have grown on average by 2.7 per cent per year. Growth has been slower in recent years.

5.1 AusNet Services residential customer numbers



Note: For each year, data are taken in the first quarter. This allows us to include an observation for 2016, as data from the first quarter of 2016 are available. This is reasonable, as there is no reason to think gas customer numbers should be 'seasonal'

Data source: AusNet; CIE.

Geographical breakdown of customers

AusNet Services' customers are largely spread in the Western half of Victoria – stretching from the Western suburbs of Melbourne, out to the Western regional and rural areas of the state. Currently, AusNet Services' customers are spread over 108 postcodes. Customer numbers in the largest five postcodes are shown in Table 5.2.

5.2 Residential customer numbers in 2016

Postcode	Main suburb	Residential customers
3030	Werribee	33 924
3029	Hoppers Crossing	29 536
3350	Ballarat	25 406
3064	Craigieburn	21 819
3216	Belmont	21 466
All other	-	512 576
Total	**-**	**644 727**

Source: AusNet; CIE.

As noted below, 'occupied private dwellings' are a key driver of residential customer numbers. The Victorian Government provide long-term forecasts of 'occupied private dwellings' at the LGA level. Given this, we produce the highest quality forecasts of customer numbers if we forecast at the LGA level. Therefore, we allocate AusNet Services' customer numbers, across 108 postcodes to Victorian LGAs using concordance tables between postcodes and LGAs provided by the ABS.[12] This allocation provides customer numbers across LGAs set out in Table 5.3.

5.3 Residential Customer Numbers by LGA, and other data (2016)

	Residential customers	Occupied private dwellings	Average penetration rate
	Number	Number	Share
Ararat (RC)	2 964	4 668	0.63
Ballarat (C)	40 446	42 555	0.95
Brimbank (C)	66 417	68 701	0.97
Campaspe (S)	53	15 583	0.00
Central Goldfields (S)	3 881	5 840	0.66
Colac-Otway (S)	4 492	8 831	0.51
Corangamite (S)	1 539	6 708	0.23
Darebin (C)	109	62 129	0.00
Glenelg (S)	4 439	8 566	0.52
Golden Plains (S)	236	7 564	0.03
Greater Bendigo (C)	37 617	45 262	0.83
Greater Geelong (C)	91 604	95 606	0.96

12 ABS Cat. 1270.055

	Residential customers	Occupied private dwellings	Average penetration rate
	Number	Number	Share
Hepburn (S)	3 036	6 756	0.45
Hindmarsh (S)	0	2 464	0.00
Hobsons Bay (C)	34 285	36 605	0.94
Horsham (RC)	6 129	8 557	0.72
Hume (C)	63 559	65 212	0.97
Loddon (S)	145	3 312	0.04
Macedon Ranges (S)	8 448	17 648	0.48
Maribyrnong (C)	28 153	33 818	0.83
Melbourne (C)	3 482	66 250	0.05
Melton (C)	43 310	46 115	0.94
Mitchell (S)	32	14 955	0.00
Moonee Valley (C)	42 748	48 909	0.87
Moorabool (S)	8 457	12 654	0.67
Moreland (C)	43 126	68 647	0.63
Mount Alexander (S)	4 395	8 138	0.54
Moyne (S)	1 947	6 653	0.29
Northern Grampians (S)	2 360	5 187	0.45
Pyrenees (S)	168	3 115	0.05
Queenscliffe (B)	2 422	1 388	1.75
Southern Grampians (S)	3 783	7 062	0.54
Surf Coast (S)	7 178	11 471	0.63
Warrnambool (C)	12 995	14 132	0.92
West Wimmera (S)	0	1 823	0.00
Whittlesea (C)	61	67 964	0.00
Wyndham (C)	70 710	73 843	0.96
Yarriambiack (S)	0	3 072	0.00
Total	**644 727**	**1 007 764**	**0.64**

Note: Average penetration rate is the number of residential customers divided by the number of occupied private dwellings

Source: CIE.

Drivers of residential customer numbers

There are three main drivers of changes in the number of residential customers, namely:

- changes in potential customers
- changes in preferences, and
- the impact of investment and network expansion (allowing households who were not previously able to connect to gas to connect to gas).

Available data and measurement of drivers

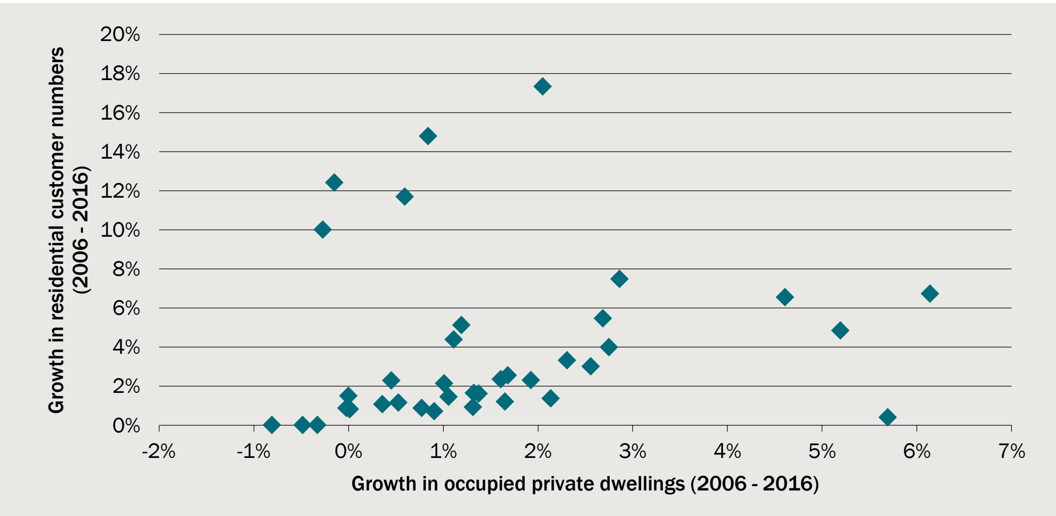
Our starting point is residential customers by postcode and LGA. For this project, we measure and forecast customers at the LGA level, and then project/allocate these customer numbers down to the postcode level. We do this because the preferred measure of 'potential customers' – occupied private dwellings – is projected at the LGA level by the Victorian State Government (see Victoria in Future forecasts).[13]

Measuring 'potential customer numbers'

'Potential customers' are simply households (where households are connected to gas, there is generally one connection per households).

The preferred measure of households is 'occupied private dwellings', which are driven by population growth and demographic changes, including changes in average household size. If we measured growth in households using only population growth, we would miss the these important demographic changes. Chart 5.4 shows the positive relationship between growth in occupied private dwellings and growth in residential customer numbers. While the relationship is positive, it is not one-for-one. In some LGAs, growth in customer numbers has been significantly quicker than growth occupied private dwellings. In these areas, growth in customer numbers may have also been supported by extensions of AusNet's network, which allows more households to connect to gas.

5.4 Growth in OPD vs growth in customers numbers (by LGA)



Data source: CIE.

13 Victoria in Future Forecasts (updated annually – our projections incorporate the 2016 forecasts), see: http://www.delwp.vic.gov.au/planning/forward-policy-and-research/victoria-in-future-population-and-household-projections/data-tables, accessed 31/08/2016

http://www.dtpli.vic.gov.au/data-and-research/population/census-2011/victoria-in-future-2015 (accessed June 2016)

Measuring and forecasting occupied private dwellings

The Victorian Government provide an estimate of occupied private dwellings in each LGA in 2011, in the 'Victoria in Future' forecasts.[14] From these data, we take data on occupied private dwellings in LGAs that are covered by AusNet Services' gas area. We estimate occupied private dwellings forwards and backwards from 2011 using the following methodology.

- Looking backwards, data on occupied private dwellings are also available in the Census from 2006 and 2011. We use growth between the Censuses of 2006 and 2011 to project occupied private dwellings back to 2006.
- Looking forwards, firstly we estimate occupied private dwellings between 2011 and 2016. To do this, we use three sub-steps.
  - From 2011, we use data on dwelling approvals in each LGA (available from the ABS Cat. 8731) and assumptions published by National Housing Supply Commission to make initial estimates of (net) additions to the dwelling stock in each LGA in each year out to 2016. The assumptions used are set out in Table 5.5. We split data on dwelling approvals into houses and units/flats.
  - Using data on dwelling approvals at the state level and the assumptions set out in Table 5.5, we estiamte dwelling completions at the state level in the years between 2011 and 2016. We compare this to actual data on completions at the state level. In each year, at the state level, there is a descrepancy between estimated completions and actual completions. We take this state level descrepancy and use it to adjust our estimates for net additions to the dwelling stock at the LGA level in each year from 2011 to 2016. (Note, to convert from net additions to the dwelling stock to gross addtions (which is what is captured with completions, we use the NHSC assumption for demolitions).
  - The result is an estimate of net additions to the dwelling stock, from 2011 to 2016, at the LGA level. These estimates are derived from data on dwelling approvals in each LGA and NHSC assumptions, and are consistent with state level dwelling completions. To convert from data on the dwelling stock to 'occupied private dwellings' we used data on vacancy rates in the Victoria in Future forecasts (interpolating between 2011 and 2016).
- From 2016 (out to 2022), we grow the level of occupied private dwellings forward using growth rates in Victoria in Future.[15] For growth rates in each year, we interpolate between VIF observations (2016, 2021, 2016, etc).
  - We considered using data on housing starts, including forecasts published by the HIA, to forecast additions to the dwelling stock.[16] Recent strength in housing starts implies relatively strong growth in dwelling completions in the near future. HIA projections (for weak housing starts) implies relatively weak growth in housing completions in the medium term. Over the whole forecast period, using housing starts to forecast additions to the dwelling stock did not generate

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14 Ibid

15 Ibid

16 See: https://hia.com.au/en/BusinessInfo/economicInfo/housingForecasts.aspx (accessed September 2016)

substantially different forecasts than those generated using Victoria in Future projections. For simplicity, we decided to stick with forecasts implied by Victoria in Future.

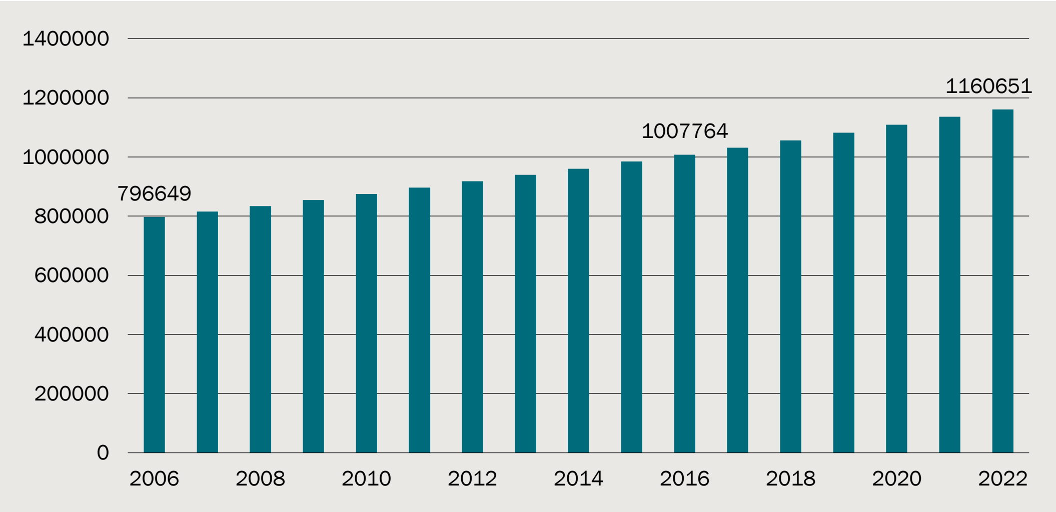
5.5 Assumptions to convert dwelling approvals into additions to the dwelling stock

Area	Definition	Assumption
Demolition rate in Victoria	Existing houses knocked down (per cent of approvals)	7.04 per cent
Houses completions in Victoria	Per cent of houses approvals that are not completed as a dwelling	3.6 per cent
Completions for other dwelling types in Victoria (includes units, flats, etc)	Per cent of approvals for other dwelling types that are not completed as a dwelling	6.85 per cent
Lag for houses –	Lag between dwelling approval and completed house	0 years
Lag for other dwelling types	Lag between dwelling approval and completed dwelling	2 years

Source: NHSC 2011; CIE.

The result of these assumptions, in terms of historical and forecast occupied dwellings, is shown in the following tables and charts. Chart 5.6 shows that, given our estimate of 1 007 764 occupied private dwellings in AusNet Services area in 2016, forecasts in Victoria in Future imply growth to 1 160 651 occupied private dwellings in 2022.

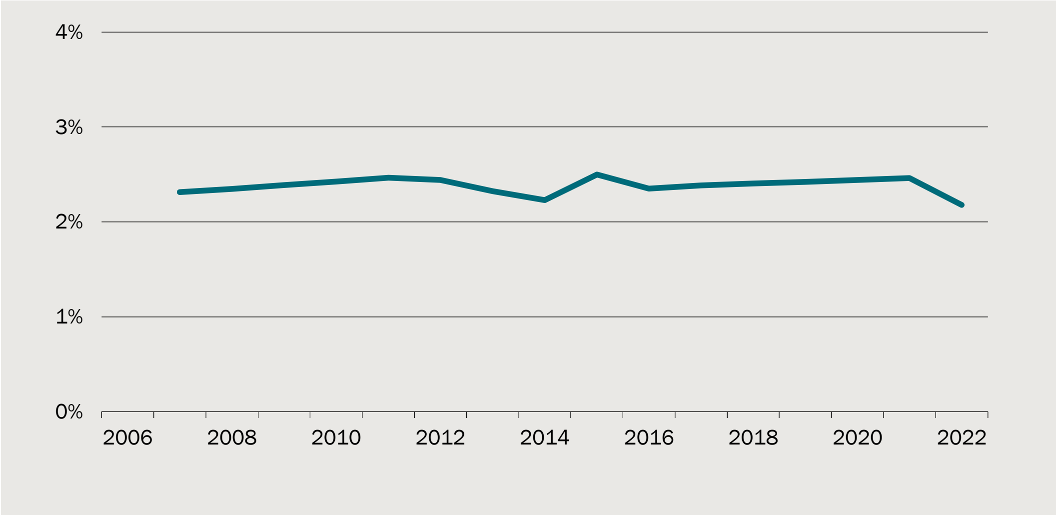
5.6 Occupied private dwellings in AusNet Services area



Data source: CIE.

Chart 5.7 shows the forecast growth in occupied private dwellings broadly matches historical growth (between 2 per cent per year and 2.5 per cent per year).

5.7 Growth in occupied private dwellings in AusNet Services area (per cent)



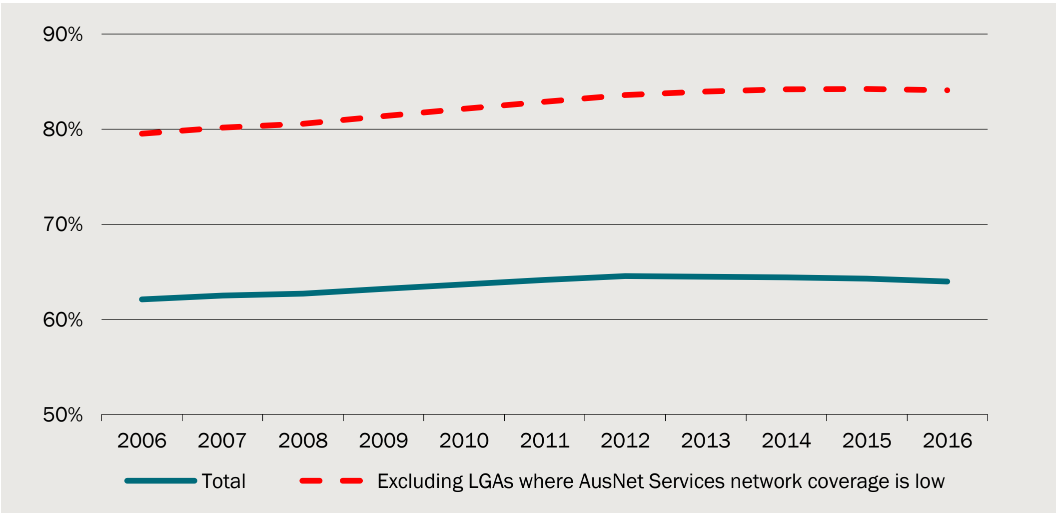
Data source: CIE.

Preferences

The preferences for households are best captured with 'penetration rates'.

In any year, the 'average' penetration rate is the total number of residential customers divided by the total number of occupied dwellings. Chart 5.8 shows the average penetration rate in AusNet Services' area was 62.1 per cent in 2006. From there it rose, peaking at 64.6 per cent in 2012. It has since fallen, reaching 64.0 per cent in 2016. Small changes in average penetration mask substantial changes in take up by new dwellings.

5.8 Average penetration rate for AusNet Services' (existing area)



Note: The average penetration rate in AusNet Services' area is defined as the number of AusNet customers divided by the total number of occupied private dwellings in LGAs that AusNet covers. The data shown are total penetration rates (i.e. ERP towns are included). The distinction between existing areas and total areas (including ERP towns) is explained below.

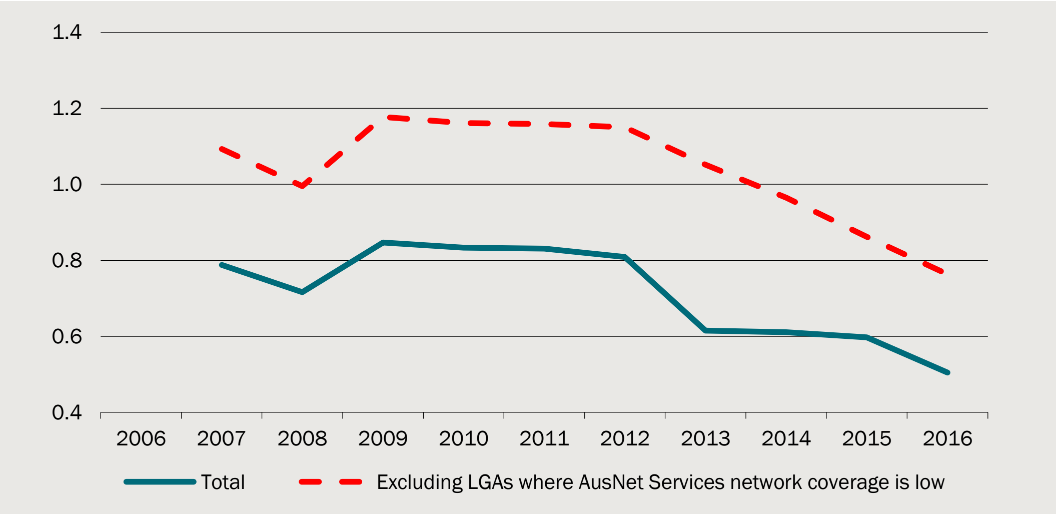
Data source: CIE.

Table 5.3 (above) shows 11 LGAs have low average penetration rates: Campaspe, Darebin, Golden Plains, Hindmarsh, Loddon, Melbourne, Mitchell, Pyrenees, West

Wimmera, Whittlesea, Yarriambiack. In these LGAs, AusNet Services network covers only a small share of the population (Pyrenees and Melbourne have the highest average penetration rates in 2016: 5.4 per cent and 5.3 per cent, respectively). If we exclude data from these LGAs from the analysis, the average penetration rate increases, to 84.1 per cent in 2016. Further, the average penetration rate increased to 2015 before declining in 2016.

For forecasting, the more meaningful penetration rate is the ‘marginal penetration rate’: net new customers divided by net new dwellings (which was introduced in chapter 2). As noted, the marginal penetration rate has fallen in recent years, due to fewer connections being created by new dwellings and due to a pickup in disconnections. These trends have reflected a change in consumer preferences, away from gas and towards electricity (see Chart 5.9, which repeats Chart 3.4).

5.9 Marginal penetration rate for AusNet Services (existing areas)

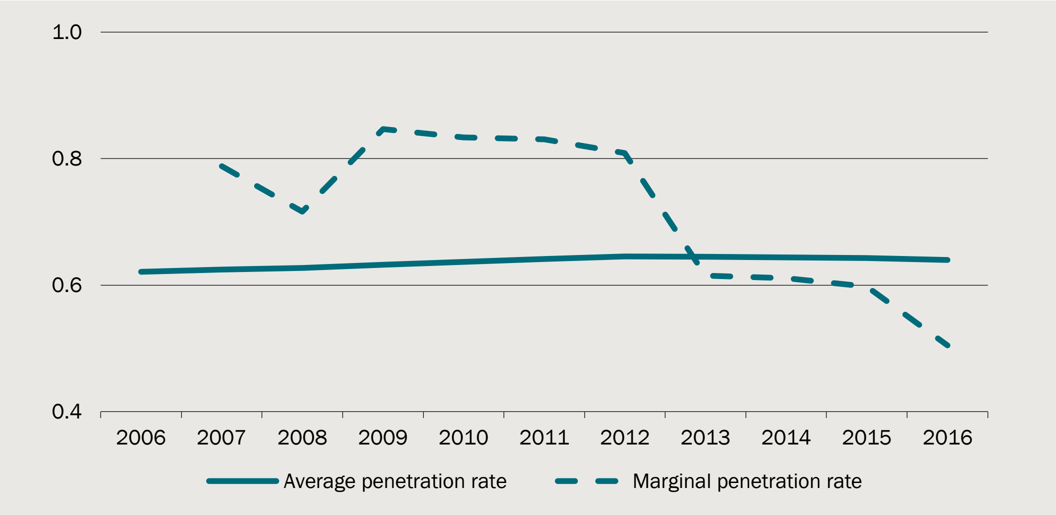


Note: The marginal penetration rate is defined as net new customers divided by net new dwellings. The data shown are total penetration rates (i.e. ERP towns are included). The distinction between existing areas and total areas (including ERP towns) is explained below.

Data source: CIE.

Focusing on all LGAs (including those with low coverage), the average penetration rate has fallen in recent years because it is above the marginal penetration rate. That is, as the penetration is lower amongst new potential customers in AusNet Services are (compared to the penetration rate for existing potential customers), the average penetration rate (for all customers) has been falling. This is shown in Chart 5.10.

5.10 Penetration rates for AusNet Services (total – for all LGAs), existing areas



Note: The data shown are total penetration rates (i.e. ERP towns are included). The distinction between existing areas and total areas (including ERP towns) is explained below.

Data source: CIE.

Households 'preferences' for gas – captured by the marginal penetration rate, can be impacted by investment that expands the gas network, allowing more and more people to connect. That is, there may be customers who 'prefer' to connect to the network but are not able to because they cannot connect. Once the network is expanded to their area, the 'penetration' rate will increase, as these customers connect to the network. (This creates a new customer for AusNet Services, although there is no addition to the dwelling stock).

The impact of ordinary investment that expands AusNet Services' network will be captured in the penetration rate shown in Charts 5.8-5.10.

The impact of investment in the ERP program

The Victorian Government Program - 'Energy for the Regions Program (ERP)' - is seeing the gas network expanded to areas where it previously did not reach. There are four towns in AusNet Services' area that will receive access to the gas network under this program, outlined in Table 5.11.

5.11 Assumptions underpinning forecast for gas customers in ERP towns

	Postcode	Period of investment[a]	Target number of customers	Customers in postcode in 2016	CIE assumption: first year when new customers join network
Winchelsea	3 241	Jun 15-Dec 16	600	0	2017
Bannockburn	3 331	May 15-Oct 17	1 490	0	2018
Avoca	3 467	May 15-Dec 16	650	0	2017
Huntly	3 551	Oct 13-Jun 14	580	5 869 (up from 4 896 in 2014)	-

[a] Assumption for when network expands and reaches new potential customers

Source: See AusNet (http://www.ausnetservices.com.au/Gas/Our+Projects/Energy+for+the+Regions.html).

We consider the towns of Winchelsea, Bannockburn and Avoca separately to the customers in AusNet Services' existing network. (We call these towns 'ERP towns'). In 2016, there were zero AusNet customers in these towns. According to AusNet Services, the expansion in Huntly (postcode 3551) is already be completed. Therefore, we do not consider the Huntly/postcode 3551 as a separate ERP town.

Forecasts of residential customer numbers

To forecast residential customers, we forecast residential customers in existing areas and in ERP towns separately.

Methodology for residential customer numbers in existing areas

Here we forecast Residential customer numbers in the 108 postcodes where AusNet Services had customers in 2016 (that is, we consider the 3 ERP towns separately below).

Firstly, we allocate these customers up to the LGA level.

Secondly, we take forecasts for occupied private dwellings at the LGA level (described above). From this forecast, we calculate net new dwellings in each year (the amount by which occupied private dwellings increase in each year).

Thirdly, we adopt a forecast assumption for the marginal penetration rate (net new customer per net new dwelling). For the years 2017 to 2022 (the forecast period), in each LGA, we assume the marginal penetration is constant and equal to its rate in the year 2016. This is arrived at as follows.

- Clearly the marginal penetration rate has fallen (see Chart 5.9), reflecting a switch in customer preferences away from gas and towards electricity. Therefore, we should be guided by penetration rates in recent years (to ensure we pick-up this change in preferences). As the penetration rate is quite volatile, it is tempting to take an average over recent years. However, if we do this, we may mask (or reduce the importance) of the most recent changes in preferences, as these are most likely to be captured in the 2016 value (the latest data). Therefore, we decide to use the 2016 observation. The 2016 observation for the marginal penetration rate captures all changes in preferences that have been observed to date.
- As the marginal penetration rate has fallen (especially between 2012 and 2016), it is tempting to forecast this to continue. That is, it is tempting to forecast a decline in the marginal penetration rate between 2017 and 2022, down from its 2016 level. However, as it is changes in preferences (from gas towards electricity) that drive changes in the marginal penetration rate, such a forecast would implicitly assume that preferences will change *in the future*. The CIE does not believe there is as basis for adopting such an assumption.[17]

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[17] Chart 3.6 (above) shows that gas prices are expected to increase relative to electricity prices. Comparison with Chart 3.4 reveals that the relationship between relative prices and the marginal penetration rate appears to have been complicated by other factors. Therefore, The CIE thinks that expected increases in the relative price of gas does not necessarily constitute a

Overall, assuming the marginal penetration rate in each LGA remains constant at its 2016 level incorporates changes in preferences that have occurred up to 2016, but assumes no changes in preferences into the future. The CIE believes that given current information, this is the most reasonable forecast.

Forecasts for residential customers in existing areas

Given the methodology and assumptions above, Table 5.12 sets out forecast customer numbers in existing areas. The sum of net new customers across LGAs give us net new customers for AusNet Services.

From its low in 2016 (0.51) the aggregate marginal penetration rate is forecast to to increase over time (reaching 0.57 in 2022). This is because Victoria in Future forecasts imply that most of the increase in net new occupied dwellings will occur in areas where Marginal Penetration rates are higher (especially in the Western parts of Melbourne, Geelong and Ballarat). This causes the aggregate marginal penetration to increase over time, despite it being held constant in each LGA. (This impact is especially evident in 2017 and 2022. Dwelling growth is projected across 5 year spans, from 2011 to 2016 to 2021 to 2026, which means growth rates change in 2017 and 2022).

5.12 Forecast for net new customers (and drivers) in existing areas

	Greater Geelong (C)	Wyndham (C)	Brimbank (C)	Hume (C)	All other LGAs	Total
					Aggregate	Aggregate
Net new dwellings						
2014	1 572	3 020	640	1 437	14 240	20 909
2015	1 623	3 423	755	1 975	16 181	23 957
2016	1 501	3 931	716	1 905	15 042	23 095
2017	1 631	2 913	852	1 989	16 582	23 967
2018	1 659	3 028	863	2 049	17 135	24 734
2019	1 687	3 148	873	2 112	17 711	25 531
2020	1 716	3 272	884	2 176	18 309	26 358
2021	1 745	3 401	895	2 243	18 932	27 216
2022	1 682	2 981	718	2 185	17 118	24 685
Marginal penetration rates						
2014	1.5	0.7	0.8	1.3	0.42	0.61
2015	1.4	0.8	0.8	1.0	0.41	0.60
2016	1.2	0.7	0.6	1.0	0.34	0.51
2017	1.2	0.7	0.6	1.0	0.41	0.55
2018	1.2	0.7	0.6	1.0	0.41	0.54
2019	1.2	0.7	0.6	1.0	0.41	0.54

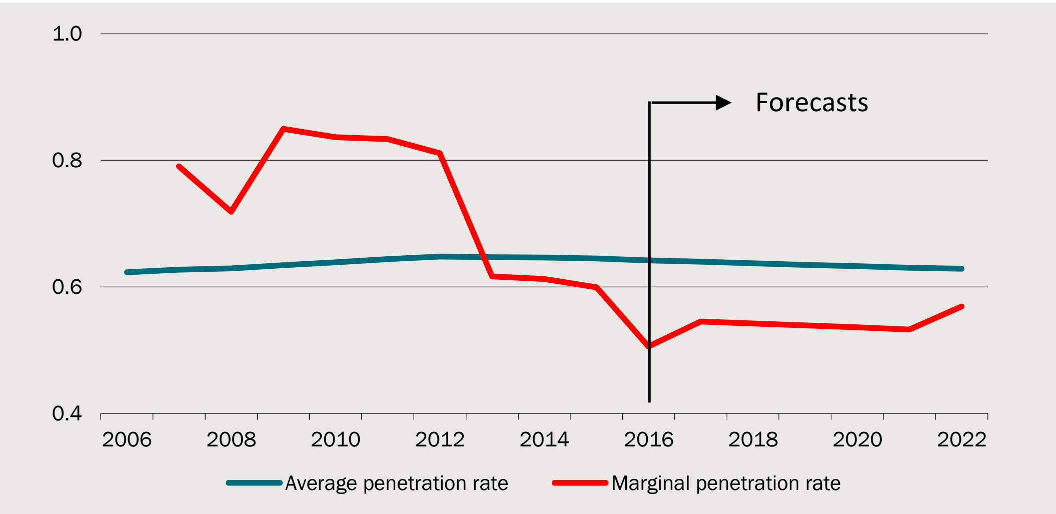
basis from which to forecast future changes in preferences (and in the marginal penetration rate).

	Greater Geelong (C)	Wyndham (C)	Brimbank (C)	Hume (C)	All other LGAs	Total
					Aggregate	Aggregate
2020	1.2	0.7	0.6	1.0	0.40	0.54
2021	1.2	0.7	0.6	1.0	0.40	0.53
2022	1.2	0.7	0.6	1.0	0.44	0.57
Net new customers						
2014	2 303	2 130	541	1 809	6 024	12 808
2015	2 339	2 754	628	1 989	6 642	14 352
2016	1 743	2 578	442	1 821	5 101	11 684
2017	1 894	1 911	526	1 900	6 840	13 071
2018	1 926	1 986	532	1 958	7 009	13 412
2019	1 959	2 064	539	2 018	7 183	13 764
2020	1 993	2 146	546	2 080	7 362	14 126
2021	2 027	2 230	553	2 143	7 547	14 500
2022	1 953	1 955	443	2 088	7 602	14 042

Source: CIE.

As the marginal penetration rate is below the average penetration rate (total customers divided total occupied private dwellings), our forecasts imply to the average penetration rate continues to fall into the future, broadly in-line with its trend in recent years (see Chart 5.13).

5.13 Penetration rates in existing areas



Data source: CIE.

Table 5.14 converts forecasts for net new customers into forecasts for total customers.

5.14 Forecast for residential customers in existing areas

	Net new customers	Total customers	Total occupied private dwellings	Average penetration rate
2014		618 691	957 461	0.65
2015	14 352	633 043	981 417	0.65
2016	11 684	644 727	1 004 512	0.64
2017	13 071	657 798	1 028 479	0.64
2018	13 412	671 210	1 053 214	0.64
2019	13 764	684 974	1 078 745	0.63
2020	14 126	699 100	1 105 103	0.63
2021	14 500	713 600	1 132 319	0.63
2022	14 042	727 642	1 157 004	0.63

Source: CIE.

Forecasts for residential customers in ERP towns

As noted, we treat the ERP areas of Winchelsea, Bannockburn and Avoca (postcodes 3241, 3331 and 3467) separately. There were zero residential customer in 2016.

Once the gas network is extended into these areas, residents will, over time, decide to connect to the network. Therefore, to forecast new customers in these areas, we forecast 'take-up' – the closing of the gap between initial customers (zero) and the target number of customers. Following our previous project with AusNet, we assume the gap between actual customers (in any year) and the target number of customers is 25 per cent.

The other assumptions we need to forecast customer numbers in these areas are outlined in Table 5.11 (above). We assume the 'target' level of customers refers to total customers (residential and commercial). These assumptions generate the forecasts for total customers outlined in Table 5.15.

5.15 Total customers in ERP towns

	Winchelsea	Bannockburn	Avoca	Total
Postcode	3241	3331	3467	
2016	0	0	0	**0**
2017	150	0	163	**313**
2018	263	373	284	**919**
2019	347	652	376	**1 375**
2020	410	861	444	**1 716**
2021	458	1 019	496	**1 972**
2022	493	1 136	534	**2 164**

Source: CIE.

As noted in the chapter on commercial customers our analysis of the customer growth between 2012 and 2016 suggests that for 1000 new residential customer in an area, there are 11.66 new commercial customers (or 0.01166 commercial customers for each new residential businesses). This implies that 98.85% of the new customers in each year in Table 5.15 (above) are residential customers. Applying this assumption year by year yields the number of residential customers in the ERP towns, outlined in Table 5.16.

5.16 Forecast for residential customers (ERP areas)

	Winchelsea	Bannockburn	Avoca	Total
Postcode	3241	3331	3467	
2016	0	0	0	**0**
2017	148	0	161	**309**
2018	259	368	281	**909**
2019	343	644	371	**1 359**
2020	405	851	439	**1 696**
2021	452	1 007	490	**1 949**
2022	488	1 123	528	**2 139**

Source: CIE.

Forecast for total residential customers

Total residential customers are customers in existing areas plus customers in ERP towns. These data are shown in Table 5.17.

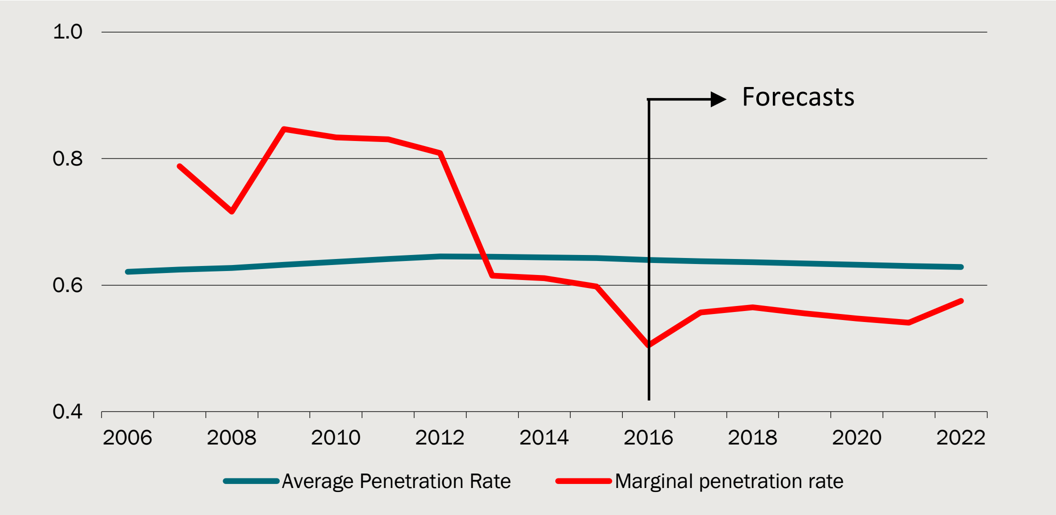
5.17 Total residential customer numbers, dwellings and average penetration rate

	Residential customers			Occupied private dwellings	Average penetration rate
	Existing areas	ERP towns	Total	Total	Total
2014	618 691	0	618 691	960 599	0.64
2015	633 043	0	633 043	984 615	0.64
2016	644 727	0	644 727	1 007 764	0.64
2017	657 798	309	658 107	1 031 793	0.64
2018	671 210	909	672 119	1 056 590	0.64
2019	684 974	1 359	686 333	1 082 186	0.63
2020	699 100	1 696	700 796	1 108 609	0.63
2021	713 600	1 949	715 549	1 135 892	0.63
2022	727 642	2 139	729 781	1 160 651	0.63

Source: CIE.

Chart 5.18 shows the penetration rates for AusNet Services across all areas (existing and ERP towns). The average penetration is projected to fall, broadly in line with its recent trend, as it remains above the marginal penetration rate.

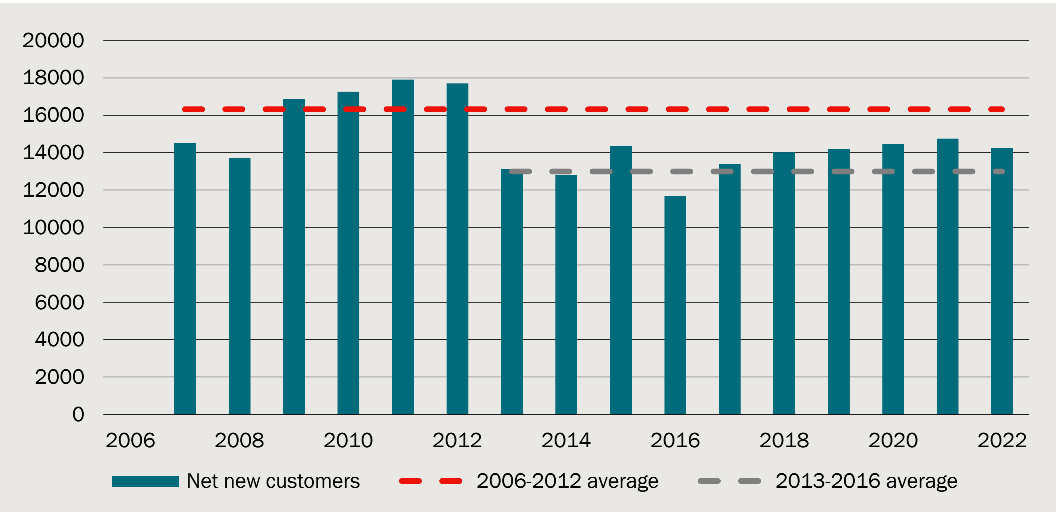
5.18 Penetration rates for AusNet Services (all areas, existing and ERP)



Data source: CIE.

Chart 5.19 shows that the forecast for net new customers in each year lies between the average of 2006-2012 (a relatively strong period) and 2013-2016 (a weaker period).

5.19 Net new residential customers for AusNet Services in each year



Data source: CIE.

Table 5.20 shows that growth in residential customer numbers is declining over time (in absolute terms and relative to growth in occupied private dwellings).

5.20 Annual average growth

	Five year annual average growth to...		
	2011	2016	2022
Residential customer numbers	3.1%	2.3%	2.1%
Occupied private dwellings	2.4%	2.4%	2.4%

Source: CIE.

Forecast for disconnections

AusNet Services have provided data on disconnections. To be consistent with customer data (or 'connections', discussed above), we examine disconnections to the March quarter of each year (i.e. disconnections for 2016 is disconnections between April 2015 and March 2016).

As a percentage of the customers (connections) it the previous year, disconnections have risen. In 2016, disconnections were 0.26 per cent of customers in 2015.

Our forecast methodology for customers is based on 'net new customers', which means it (implicitly) includes trends in disconnections. Therefore, it reasonable to project disconnections as some function of our projection for customers.

For simplicity, and to be consistent with our forecast methodology for connections, we assume that between 2017 and 2022, disconnections are 0.26 per cent of customers in the previous year (the rate observed in 2016).This is shown in Table 5.21.

5.21 Residential customers and disconnections

	Total customers (connections)	Disconnections	
		Number	Per cent of previous year
2006	494 796	-	-
2007	509 307	1 111	0.22%
2008	523 020	1 156	0.23%
2009	539 880	1 143	0.22%
2010	557 148	1 318	0.24%
2011	575 053	1 396	0.25%
2012	592 758	1 180	0.21%
2013	605 883	1 175	0.20%
2014	618 691	1 362	0.22%
2015	633 043	1 569	0.25%
2016	644 727	1 638	0.26%
Forecasts			
2017	658 107	1 668	0.26%
2018	672 119	1 703	0.26%
2019	686 333	1 739	0.26%
2020	700 796	1 776	0.26%
2021	715 549	1 813	0.26%
2022	729 781	1 851	0.26%

Note: Forecast disconnections (Table 5.21) and forecast contributions to net new customers (Chart 5.22) are post model calculations, which are derived from our forecasts for net new customers. Changing the assumptions implicit in the data in Table 5.21 and Chart 5.22 does not alter the forecast for net new customers or total customers.

Source: CIE.

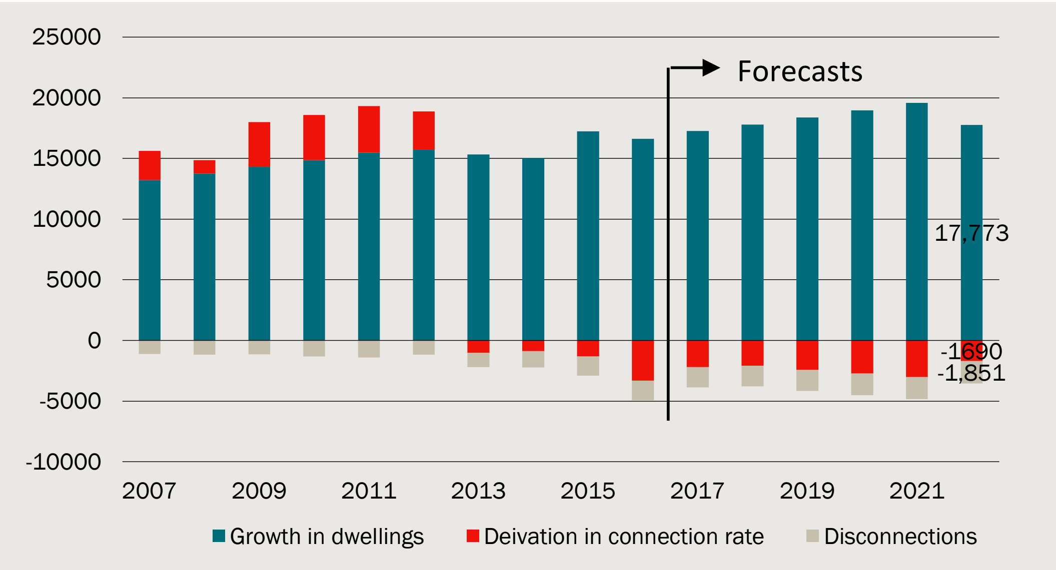
As outlined in chapter 2 (see discussion for Chart 3.5), we can add disconnections to net new customers to get data for connections. We can then break down growth in net new customers into contributions from dwellings (assuming a benchmark connection rate – where preferences have not changed), a deviation between the actual connection rate and the benchmark rate (which incorporates recent changes in preferences) and disconnections. Our forecast for net new customers is broken in this manner in Chart 5.22. The chart shows that the forecast for net new customers (and hence total customers overall) is driven by projected growth in dwellings (which are derived from Victoria in Future 2016, published by the Victorian Government).

Note, Table 5.17 implies there are 14 232 net new residential customers in 2022. Chart 5.22 shows this forecast for net new customers is driven by the following.

- The forecast increase in occupied private dwellings (net new dwellings of 24 759, derived from data in Table 5.17) contributes 17 773 new connections. This assumes there has been no change in preferences, and new connections per net new dwelling are consistent with their benchmark rate, 0.72 (the average for the period 2012-2015).
- The forecast deviation in the connection rate from this benchmark (reflecting the change in preferences that have occurred to date), implies connections will be 1 690 below this.
- Disconnections are projected to be 1 851.

Net new connections of 14 232 equals 17 773 less 1 690 less 1 851.

5.22 Contribution to net new customers



Note: Chart 5.22 is simply Chart 3.5 extended into the forecast period. *Forecast* disconnections (Table 5.21) and forecast contributions to net new customers (Chart 5.22) are post model calculations, which are derived from our forecasts for net new customers. Changing the assumptions implicit in the data in Table 5.21 and Chart 5.22 does not alter the forecast for net new customers or total customers.

Data source: CIE.

6 *Residential customer usage*

Customer numbers (discussed in the previous chapter) and usage (discussed here) combines to generate total demand for gas by households in AusNet Services' area.

The usage of residential customers has changed over the last 15 years. A few major trends have driven the changes in usage.

- New residential houses and units tend to use less gas than existing dwellings of the same type.
- The share of new units in total new dwellings is higher than for the existing customer base.
- Usage per customer is declining over time, likely reflecting improvements in electrical appliances that are substitutes for using gas and more energy efficient housing.

Additionally, total residential usage was high in 2015, associated with colder weather conditions, so this would be expected to reduce in 2016 if weather conditions are closer to average.

These changes and their causes were examined in Chapter 3. This chapter uses these changes as a basis for projecting future gas use for existing and new residential customers. The first part of the chapter describes changes in gas consumption patterns, the second part applies formal statistical techniques and the third and fourth develop the projections.

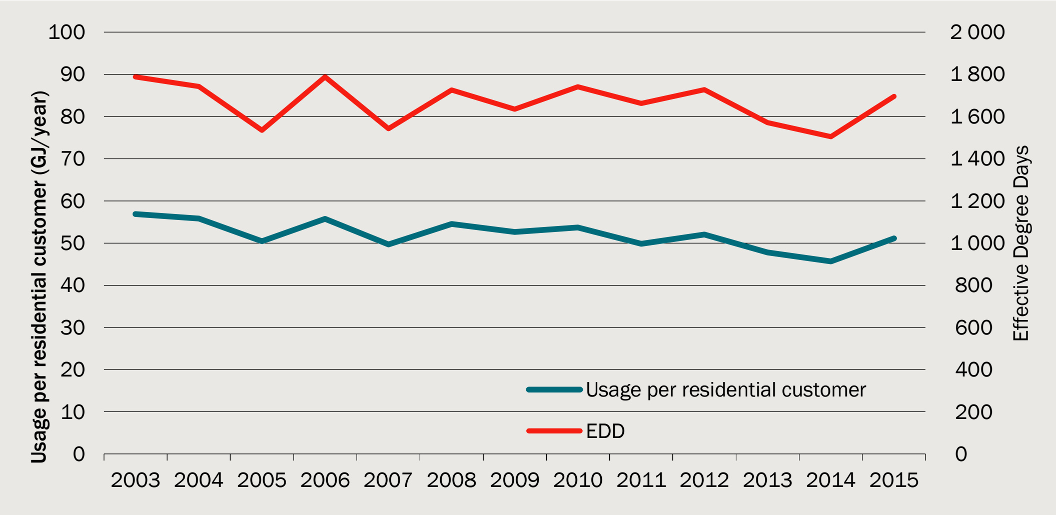
Descriptive analysis

The use of gas by residential customers varies across different customer types and has changed significantly since 2003. Assessing these changes requires looking through the year to year volatility in gas consumption arising from weather outcomes.

Trend in gas use since 2003

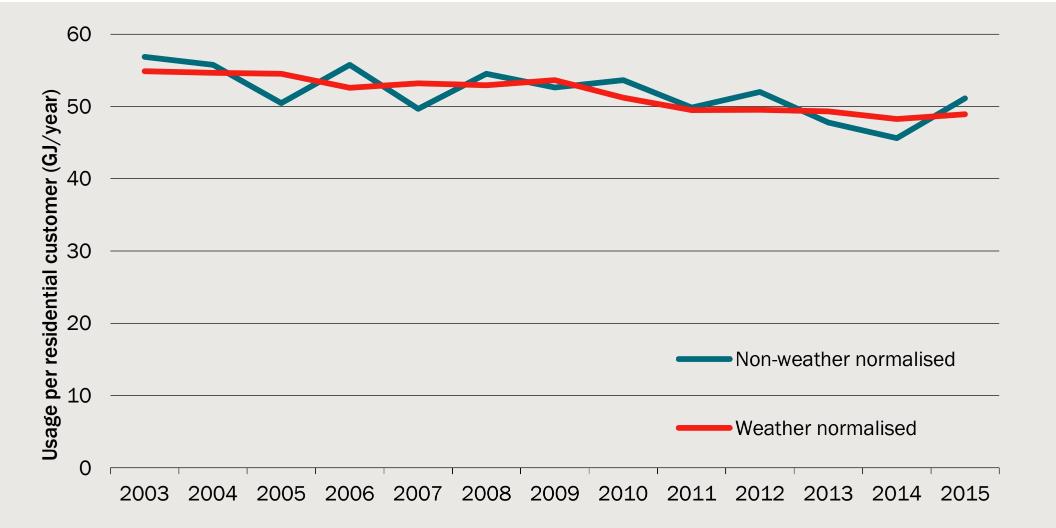
Annual residential usage per customer has been decreasing gradually over time (chart 6.1). Usage increased in 2015. However, this reflected colder weather in the year and there has been a noticeable continuing decline in underlying consumption. There is a clear trend of reducing weather-normalised usage per customer, as shown in chart 6.2.

6.1 Relationship between usage per residential customer and EDD



Data source: CIE.

6.2 Weather normalised usage per residential customer



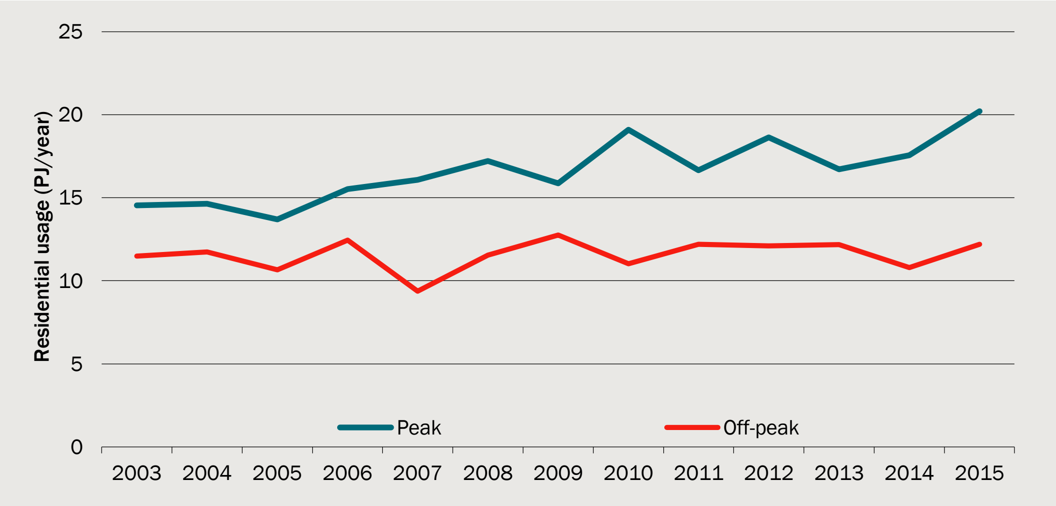
Note: Usage per residential customer is weather normalised using the coefficients estimated in the statistical models presented throughout this chapter.

Data source: CIE.

AusNet Services' tariff structures contain a peak and an off-peak period. The peak period is between 1 June until 30 September, while the off-peak period covers all other times. Approximately 60% of annual gas consumption is consumed in the peak period (assuming average weather conditions).

Peak and off-peak usage of gas vary differently over time. Peak usage has grown over time as the number of customers has grown. Off-peak usage has stayed constant, implying falling usage per customer (chart 6.3). Peak usage also responds more strongly to weather conditions, with a proportionally larger increase in usage in 2015 associated with the cold conditions. These differing patterns suggest that the approach to statistical analysis should account for different relationships between usage and driver variables as well as different trends over time between the peak and off-peak periods.

6.3 Comparison of peak and offpeak usage by residential customers



Data source: CIE.

Formal statistical analysis

Analysis of key areas of change one by one cannot give a good characterisation of all the changes that have occurred together. This can only be done by formal statistical analysis. In this section we conduct formal statistical analysis of historical gas use.

Note that analysis of how change has occurred is only a starting point for the purpose of forecasting. Once we have correctly characterised historical change, we then need to understand why these changes have occurred and whether they will continue over into the next regulatory period.

Model form

There are three sorts of models that could be estimated for residential gas consumption making use of the billing data we have across dwellings and through time. (This data is known as panel data.)

- A fixed effects model — this model allows each household to have a different base consumption and then uses changes in this through time to assess the impact of variables that also change through time. This method is best for identifying impacts of variables that change through time, such as the weather or prices. It cannot be used for variables that remain the same for a dwelling such as the age of the building or type of dwelling.
- A random effects model — this model uses differences across households as well as differences through time to assess the impact of particular household characteristics and variables that change through time. It allows for households to be systematically different through the error term rather than through a constant. It can be used to identify impacts of dwelling age and type for example.
- A pooled regression model — like a random effects model, this sort of model uses differences across households as well as differences through time to assess the impact

of particular household characteristics and variables that change through time. However, it does not allow for households to be systematically different. This model is not pursued further as statistical tests indicate that it is a poor fit for the data.[18]

There are additional models explored in this analysis using autoregressive components, such as lags of usage. However, these did not yield superior predictive power and thus are not reported or discussed further.

The explicit set up of the panel regression model is shown in the equation below.

$$\begin{aligned} q_{it} = \beta_0 + \beta_1.flat_i + \tilde{\beta}_2.year\ connected_i + \mu_i + \\ \gamma_1.year_t + \gamma_2.edd_t + \\ \delta_1.price_{it} + \varepsilon_{it} \end{aligned}$$

The dependent variable, q_{it} is the natural log of the quantity of gas used by dwelling *i* in year *t*. We estimate our model using the log of consumption, as drivers would be expected to have similar percentage impacts on usage rather than similar GJ impacts on usage. The use of natural logs means that parameters can be interpreted as the per cent changes resulting from the change in the parameter.

The first row of explanatory variables contains dwelling characteristics — whether the dwelling is a single dwelling or flat (the *flat* variable), *i* number of (0,1) dummy variables for the year in which the dwelling was connected (the *year connected* variables) and a dwelling specific error term (μ_i).

The second row of explanatory variables is time specific characteristics, such as *year* and effective degree days (*edd*).

The third row of explanatory variables is characteristics that vary by both time and dwelling, which includes *price* and an error term for that dwelling for that year.

If a fixed effects model is used then the first row becomes a constant μ_i estimated for each specific dwelling. We then follow a second-stage process of estimating a model of fixed effects based on characteristics of residential connections. The second stage of the statistical estimation is to estimate the fixed effect against connection characteristics as follows.

$$\mu_i = \beta_0 + \beta_1.flat_i + \sum_{t=2004}^{2015} \beta_t.year\ connected + \varepsilon_i$$

This equation estimates the customer-specific fixed effect using a set of dummy variables indicating the year that the customer was connected. A dummy variable takes either a value of 0 or a value of 1. For the dummy variable for year of connection for 2004 for example, all connections established in 2004 would have a value of 1 and all other connections would have a value of 0. We use a dummy for each year because we would not expect that the impact of year created would be linear. Note that all connections prior to 2003 are recorded in the billing database as 2003, hence strengthening the justification for using dummy variables.

18 The Breusch Pagan test indicates that a random effects regression is a better fit than a pooled ordinary least squares regression.

If a random effects model is used then the total error for each observation is $\mu_i + \varepsilon_{it}$, which allows for a specific error for each dwelling (distributed around zero) and an error for each dwelling and in each time period (ε_{it}).

The fixed effects model specification has been chosen as the base model given the results of testing whether the coefficient estimates are significantly different between the fixed effects and random effects models. These tests show that the random effects estimator will be inconsistent, that is, that it would not tend towards the true value of the coefficient as more observations are available. The tests reject the consistency of the random effects estimator.

These variables have been selected for the modelling based on the data that is available and views about what the important drivers of gas demand are. Consideration has been given to the inclusion of an electricity price variable, and the reasons for not doing so are discussed further in this chapter. Importantly, in estimating these statistical models we determined that these variables have statistically significant relationships in predicting usage per customer.

We do not have income variables for each household or information on household size etc. Hence these cannot be included. It would be possible to include income variables or household size variables at a postcode level, although information would primarily be from the Census and thus not of sufficient frequency to enable accurate estimation of any income effects. This may have implications for forecasting if we could identify new customers with different incomes than existing customers. A more pragmatic alternative would be to allow a dummy variable specific to each tariff class region, however this does not change the results.

The model we estimate is based on levels of usage per household and levels of variables such as prices. Given the time and resource constraints we do not seek to model dynamic processes around the patterns of change. We have tested models of the annual change in usage per customer, and these models do not offer superior predictive power or interpretation, and so are not explored further.

Model estimation

The model form that we estimate for our base model is set out in the section above.

The model is estimated in STATA, which is a data analysis and statistical software package.[19] STATA uses generalised least squares regression to estimate coefficients for panel regressions under random effects and fixed effects assumptions. We allow for error terms in regressions to be clustered by customer in constructing the statistical significance of parameters.

For the exogenous variables we use dummy variables for the year of gas connection creation. (This variable is considered a proxy for year of dwelling creation.) A dummy variable takes either a value of 0 or a value of 1. For the dummy variable for year of connection for 2004 for example, all connections established in 2004 would have a value

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19 See http://www.stata.com/ for more details.

of 1 and all other connections would have a value of 0. We use a dummy for each year because we would not expect that the impact of year created would be linear. Note that all connections prior to 2003 are recorded in the billing database as 2003, hence strengthening the justification for using dummy variables.

We define *year* as year since 2003. We generally do not use a dummy variable approach for year because then we would not be able to differentiate between weather effects and any time trend in consumption. The use of year as a scalar variable implies that the effect is linear — i.e. each year on average leads to the same x per cent change in consumption.

We do not know the price paid by each customer. We have defined price as a price index for each region. This price index is based on a combination of standing offer tariffs reported by the Essential Services Commission of Victoria for consumption of 60 GJ (pre-2011) and an index of residential distribution prices sourced from the National Gas Forecasting Report (NGFR) produced by AEMO (2011-onwards). Therefore, change in prices only differs by region prior to 2011, after which the same per cent change to prices is applied to both regions.

Constraining the price variable

We have not separately estimated the *price* coefficient for each block, given that model testing indicated inconsistent estimates (variously negative and positive). Given the importance of gas prices as a driver of residential usage per customer, we have constrained the *price* coefficient to the value estimated for this coefficient in a model of total residential usage (see table 6.5), which is -0.053. Other coefficients in the model such as those associated with EDD and the time trend have not been constrained. We fit models that estimate these other coefficients consistent with the constrained value of the *price* coefficient.

Model results

Table 6.4 presents the estimated coefficients of the models estimated for each block of residential usage. All coefficients except the *new connections* and *flats* coefficients are directly estimated using fixed effects models for each block of usage.

The *new connections* coefficient is determined according the following formula:

$$New\ connections = \frac{\sum_{t=2013}^{2015} \beta_t \times new\ connected_t}{\sum_{t=2013}^{2015} new\ connected_t} - \frac{\sum_{2004}^{2015} \beta_t \times new\ connected_t}{\sum_{2004}^{2015} new\ connected_t}$$

This formula calculates the difference in the weighted average coefficient of *year connected* dummy variables over the past 3 years compared to the weighted average coefficient of all *year connected* dummy variables that are estimated over 2004-2015. These averages are weighted by the number of new connections in that year. The $new\ connected_t$ variable identifies the number of newly connected customers in that year.

The *flat* coefficient is negative for all blocks, confirming that usage is lower for flats relative to single dwellings after controlling for the year that a customer is connected. The coefficient on the *year* variable can be interpreted as a time trend in percentage terms. For example, the model estimates a time trend in usage for the 'Peak 0-0.1' block of 0.7 per cent decline per year (a coefficient of 0.007).

We have not taken the log transform of the *EDD* variable because analysis of the relationship between daily weather and usage did not suggest a substantial non-linear component to this relationship. Therefore, the coefficient may be interpreted as the per cent change in usage for a block from an additional EDD per year.

The *gas price* variable is in log terms, and thus it suggests that, for all blocks, a 1 per cent increase in the gas price is associated with a 0.053 per cent *decrease* in usage. Other model specifications we tested have yielded estimates of the *price* coefficient that are not consistently positive in different blocks, which may suggest that the effect of other variables was being captured by the *gas price* variable. Thus, we have chosen to constrain the value of the *gas price* coefficient to -0.053, in order to produce forecasts from a model with consistently positive *gas price* coefficients.

6.4 Coefficients used to forecast residential demand

Model/block	*Flat*	*Year*	*EDD*	*Gas price*	*New connections*
Peak 0 - 0.1	-0.343	-0.006	0.0000	-0.053	-0.057
Peak 0.1 - 0.2	-0.417	-0.006	0.0003	-0.053	-0.041
Peak 0.2 - 1.4	-0.769	0.002	0.0010	-0.053	-0.141
Peak > 1.4	0.003	0.011	0.0006	-0.053	0.177
Off Peak 0 - 0.1	-0.418	-0.011	0.0001	-0.053	-0.183
Off Peak 0.1 - 0.2	-0.701	-0.008	0.0017	-0.053	-0.185
Off Peak 0.2 - 1.4	-0.764	0.000	0.0026	-0.053	-0.195
Off Peak > 1.4	-0.170	0.007	0.0011	-0.053	0.337

Source: CIE.

Models of peak and off-peak usage

Table 6.5 presents the estimated coefficients and results of significant tests for models of residential usage. It shows fixed effects models for estimation using total, peak, and off-peak residential usage as dependent variables in different models. It shows the *price* coefficient estimated in the unconstrained total usage per customer model, and the peak and offpeak models estimated with the *price* coefficient constrained to this value.

Examples of interpretation of these results is as follows.

- The *year* coefficient of -0.0110 indicates that there has been a trend decline of 1.10 per cent per year in gas consumption after accounting for other factors.
- The *EDD* coefficient of 0.000374 indicates that an additional EDD is associated with a 0.000374 per cent increase in usage per customer.

6.5 Results of residential usage fixed effects model

Sample	Total	Peak	Offpeak
Year	-0.0110***	-0.0104***	-0.0115***
EDD	0.000374***	0.000359***	0.000418***
Gas price	-0.052859***	-0.052859 [a]	-0.052859
Constant	32.35***	30.62***	32.59***
N	6538679	6508479	6537182

[a] This coefficient has been constrained to the value estimated in the total demand model.

Note: The R^2 of the model is not presented because when coefficients are constrained to a pre-determined value, the R^2 does not have a meaningful interpretation.

P-values are indicated by the asterisks, with p<0.05 = *, p<0.01=*, p<0.001=***.

Source: CIE.

Do electricity prices drive gas consumption

Electricity prices would be expected to be positively related to gas prices because they represent the price of a substitute good. Electricity price data has been obtained from the ABS[20] and forecasts have been obtained from the *National Electricity Forecasting Report 2015*.[21] When electricity prices are high relative to gas prices, customers would be expected to relatively increase their consumption of gas compared to electricity. This behavioural relationship may be reflected in the statistical analysis using two variables:

1 Directly including an electricity price variable in the models.

2 Including a variable measuring the relationship between gas and electricity prices (a *price ratio* variable).

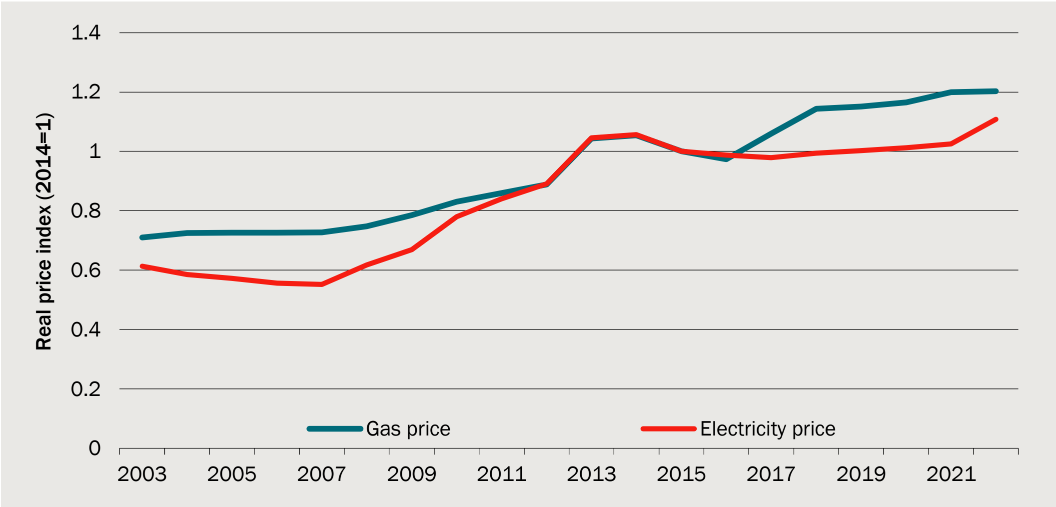
However, electricity and gas prices have tended to vary similarly over the 2003-2015 period, as shown in chart 6.6. This creates a problem of multicollinearity, which will reduce the precision of forecasts when the pattern of correlation between the variables changes in the future.[22] The first method above - including an electricity price variable in the statistical models - leads to significant changes in the coefficient of gas prices. If, as expected in the price forecasts shown in chart 6.6, there is a change in the progression of electricity and gas prices, the forecasts will be less precise.

20 Australian Bureau of Statistics, *Consumer Price Index, Australia*, Dec 2014, Series: A2328106A.

21 AEMO 2015, *National Electricity Forecasting Report 2015* (supplementary data files).

22 Belsley, D., 1984, 'Collinearity and forecasting', *Journal of Forecasting*, 3(2): 183-196.

6.6 Indexes of real gas and electricity prices



Data source: AEMO, ABS, ESC, CIE.

A *price ratio* variable will be dependent on both gas and electricity prices, however is not correlated in the same way with each variable individually. Therefore, the forecasts will not suffer from the same imprecision as with an electricity price variable. Additionally, this variable more directly models the effect of changes in the relative price of the two substitute energy sources. A downside of this approach is that it will not account for an 'income effect', whereby falls in electricity prices and gas prices result in an increase in real income, which would have a positive effect on usage. Variation of both electricity and gas prices in the same magnitude and direction will not change the *price ratio* variable, however would have an effect on usage.

Gas prices are expected to be a more important driver of changes in usage. Thus, to avoid misestimating the coefficient of gas prices, we consider that using including an electricity price variable directly in the estimation would lead to worse forecasts. In testing models including the *priceratio* variable, it was found to has variously negative and positive coefficients in different models. Given that the true effect would be expected to be negative, we choose not to include the *priceratio* variable in our models.

Thus, electricity prices have not been included in the model through either variable.

Forecasts of residential gas use

Forecasts of total residential gas usage combine projections of usage per customer from the statistical modelling described above with forecasts of customer numbers. These two components combine according to the following equation to obtain total usage per block.

$$Q_{brt} = \frac{(customers_t + customers_{t+1})}{2} \times q_{ibt}$$

Q_{bt} is total usage of block *b*, region *r*, in year *t*. It is the product of two components:

- the average number of customers in a year, which is equal to half the sum of customers at the beginning of year *t* and the beginning of year *t+1*, and
- the usage per customer (*i*) of block *b*, region *r*, in year *t*.

As noted earlier in this chapter, the statistical models of residential usage are estimated using data that exclude observations of usage within the same year that a customer is connected. Customers may only be connected for part of the first year they become connected. For this reason, usage per customer is multiplied by the average number of customers in a year to account for customers who connect during the year. This method assumes that customers are connected in equal proportion throughout the year.

Usage per customer is forecast separately for new and existing customers.

Usage per customer is a function of projected *EDD*, *gas price*, the coefficients of these variables and the time trend estimated for each block. The number of existing customers is the number of customers in 2015 for each block.

Usage per new customer is forecast in the same manner as existing customers, however there are two additional components that are projected.

- The proportion of new customers that are flats is assumed to be equal to the average proportion of new customers that are flats over 2013-2015.
- A factor is applied that accounts for new connections having lower usage per customer. The factor applied is determined using the *new connections* variable described above.

Thus, usage per new customer is as follows:

$$\begin{aligned} usage\ per\ customer_{new,t} \\ &= usage\ per\ customer_{existing,t} \times \left(1 + \beta_{flats} flat\right) \\ &\times (1 + \beta_{new\ connections}) \end{aligned}$$

where *flat* is the proportion of new customers that are flats.

Table 6.7 presents projections of residential usage and fixed charge numbers. It shows the actual observed levels in 2015 and projected levels between 2016-2022. The number of fixed charges is based on the customer number forecasts in chapter 7, which have been applied to the starting point determined by actual 2015 fixed charges.[23]

The forecasts presented in table 6.7 include a post-modelling adjustment to account for gas to non-gas appliance switching. We make a downward adjustment to our forecasts of residential usage per customer that is equal to AEMO's estimate of the impact of appliance switching on usage per customer.

23 There are small discrepancies between the number of customers in the billing dataset (used to determine the number of customers by postcode in forecasting customer numbers) and the number of fixed charges. These discrepancies will have a negligible effect on the forecasts because of their small magnitude.

6.7 Projections of residential usage – including appliance switching adjustment

Region/ Block	Unit	2015	2016	2017	2018	2019	2020	2021	2022
		Actual	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast
Tariff V - AusNet Services Central – Domestic									
Fixed Charge	No.	486 958	496 377	505 965	515 833	525 991	536 448	547 215	557 601
Peak 0 - 0.1	GJ	5 102 535	5 181 086	5 191 681	5 188 830	5 187 513	5 162 053	5 117 327	5 055 100
Peak 0.1 - 0.2	GJ	3 833 486	3 790 454	3 788 479	3 776 489	3 765 894	3 737 616	3 695 197	3 640 124
Peak 0.2 - 1.4	GJ	6 451 257	6 043 250	6 040 930	6 023 233	6 009 259	5 967 316	5 903 352	5 826 550
Peak > 1.4	GJ	87 376	86 511	88 224	89 746	91 325	92 497	93 317	93 587
Off Peak 0 - 0.1	GJ	6 916 612	6 918 127	6 874 810	6 813 029	6 753 456	6 662 357	6 547 066	6 418 149
Off Peak 0.1 - 0.2	GJ	1 619 562	1 393 252	1 363 343	1 329 520	1 296 915	1 258 084	1 214 508	1 169 369
Off Peak 0.2 - 1.4	GJ	775 506	612 590	597 702	581 107	565 290	546 739	526 083	504 943
Off Peak > 1.4	GJ	74 527	70 616	71 615	72 441	73 316	73 851	74 085	73 805
Total	**GJ**	**24 860 861**	**24 095 885**	**24 016 784**	**23 874 394**	**23 742 968**	**23 500 513**	**23 170 935**	**22 781 629**
Tariff V - AusNet Services West – Domestic									
Fixed Charge	No.	136 295	137 934	141 116	144 353	147 648	151 000	154 411	157 733
Peak 0 - 0.1	GJ	1 437 747	1 453 358	1 461 554	1 465 584	1 469 654	1 466 475	1 457 582	1 441 728
Peak 0.1 - 0.2	GJ	1 099 527	1 082 383	1 085 827	1 086 093	1 086 445	1 081 370	1 072 004	1 057 447
Peak 0.2 - 1.4	GJ	1 822 141	1 701 037	1 706 458	1 707 132	1 708 446	1 701 373	1 687 738	1 668 032
Peak > 1.4	GJ	18 894	18 590	19 037	19 438	19 847	20 162	20 398	20 486
Off Peak 0 - 0.1	GJ	1 854 183	1 847 589	1 841 831	1 830 642	1 819 555	1 799 471	1 772 532	1 739 678
Off Peak 0.1 - 0.2	GJ	488 500	418 829	411 209	402 259	393 533	382 773	370 463	357 147
Off Peak 0.2 - 1.4	GJ	249 515	196 461	192 328	187 574	183 000	177 472	171 208	164 538
Off Peak > 1.4	GJ	14 519	13 665	13 926	14 148	14 376	14 532	14 626	14 594
Total	**GJ**	**6 985 027**	**6 731 913**	**6 732 169**	**6 712 870**	**6 694 856**	**6 643 628**	**6 566 550**	**6 463 650**

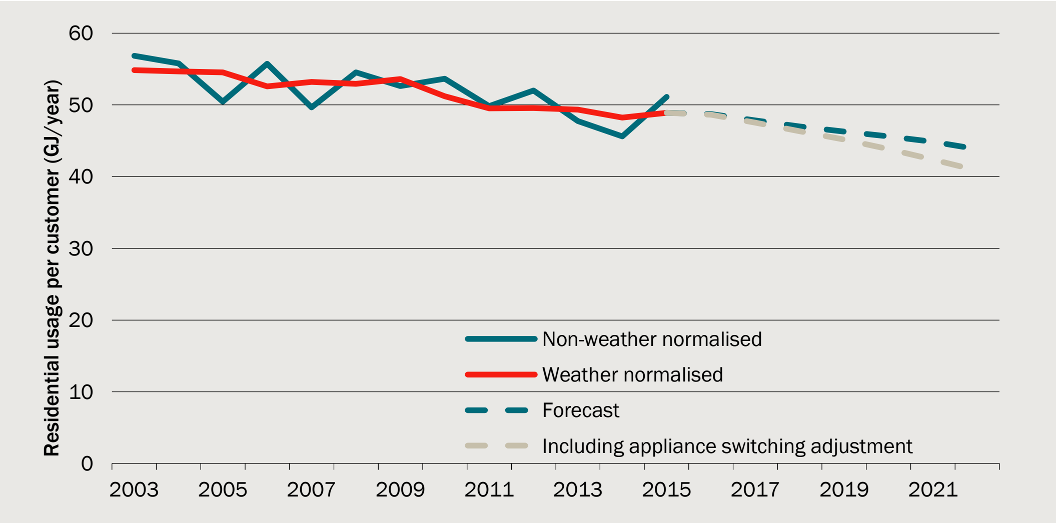
Region/ Block	Unit	2015	2016	2017	2018	2019	2020	2021	2022
		Actual	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast
Tariff V - AusNet Services Central - New Town Domestic									
Fixed Charge	No.	1 457	1 538	1 571	1 973	2 283	2 525	2 715	2 867
Peak 0 - 0.1	GJ	12 478	13 093	14 538	16 924	18 635	19 754	20 427	20 521
Peak 0.1 - 0.2	GJ	7 954	8 129	9 011	10 472	11 508	12 171	12 553	12 576
Peak 0.2 - 1.4	GJ	11 246	10 842	11 867	13 571	14 791	15 575	16 031	16 076
Peak > 1.4	GJ	507	524	607	742	845	919	972	992
Off Peak 0 - 0.1	GJ	14 928	15 361	16 698	18 956	20 512	21 449	21 925	21 837
Off Peak 0.1 - 0.2	GJ	2 829	2 501	2 670	2 972	3 159	3 244	3 256	3 184
Off Peak 0.2 - 1.4	GJ	2 118	1 719	1 827	2 023	2 142	2 192	2 192	2 137
Off Peak > 1.4	GJ	405	402	469	578	659	715	753	764
Total	**GJ**	**52 465**	**52 569**	**57 687**	**66 238**	**72 251**	**76 020**	**78 108**	**78 088**
Tariff V - AusNet Services West - New Town Domestic									
Fixed Charge	No.	9 226	9 789	10 387	10 913	11 385	11 820	12 227	12 621
Peak 0 - 0.1	GJ	94 586	101 653	105 284	107 907	110 006	111 164	111 660	110 995
Peak 0.1 - 0.2	GJ	74 089	77 601	80 202	82 013	83 415	84 090	84 251	83 523
Peak 0.2 - 1.4	GJ	152 606	150 503	155 069	158 261	160 809	162 038	162 336	161 191
Peak > 1.4	GJ	982	1 043	1 107	1 160	1 208	1 245	1 274	1 287
Off Peak 0 - 0.1	GJ	119 149	125 216	128 110	129 836	130 980	131 035	130 331	128 503
Off Peak 0.1 - 0.2	GJ	38 463	34 749	35 001	34 903	34 650	34 088	33 310	32 259
Off Peak 0.2 - 1.4	GJ	25 442	21 093	21 177	21 049	20 836	20 435	19 902	19 213
Off Peak > 1.4	GJ	541	554	588	614	637	654	667	669
Total	**GJ**	**505 858**	**512 412**	**526 537**	**535 743**	**542 540**	**544 749**	**543 731**	**537 640**

Note: These forecasts include an adjustment for gas to non-gas appliance switching.

Source: CIE.

Chart 6.8 shows actual, weather-normalised[24] and forecast levels of usage per residential customer. Usage per customer is forecast to fall in 2016 given that 2015 usage is based on a high EDD observation. The fall in usage between 2015-2016 is associated with the starting point of the forecasts being the weather-corrected level of 2015 usage. Weather correction brings down the starting point due to the high number of EDD in 2015. The forecasts allow for same trend in gas use as occurred historically. The chart also shows the downward effect of the appliance switching adjustment.

6.8 Actual and forecast usage per residential customer

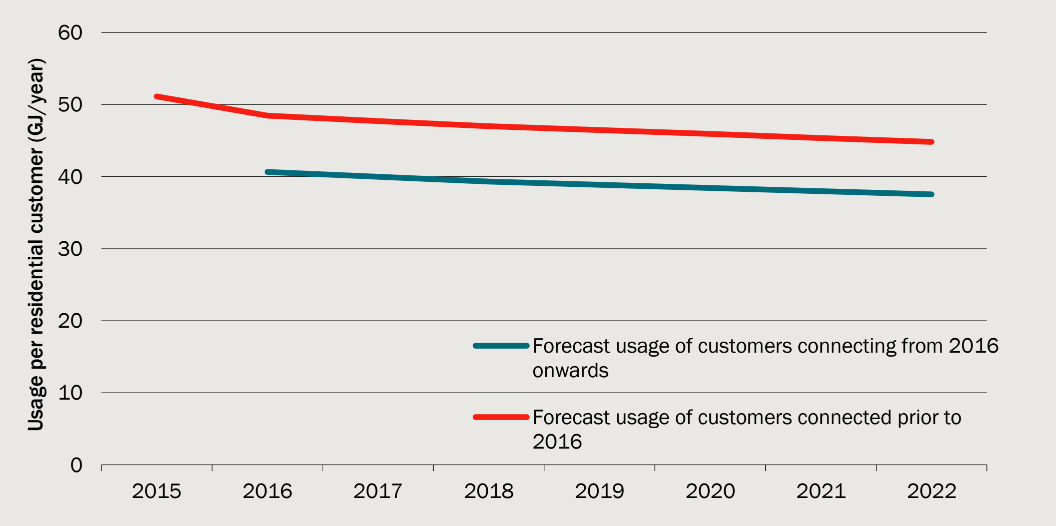


Data source: CIE.

Chart 6.9 shows the forecast usage per customer for existing and new customers. As noted on the chart, new customers are defined as customers connected from 2016-onwards, while existing customers include all customers connected at 2015. The rate of decline of usage among existing and new customers is the same. However, the level of usage of new customers is significantly lower. An increase in the proportion of new customers in the total stock of customers will partially account for the decline in total residential usage evident in chart 6.8.

24 Weather normalised residential usage illustrates the underlying trend in usage after excluding variation due to weather conditions in a given year. This is normalised to a trend level of EDD estimated over the 2003-2015 period, which exhibits a trend decline of approximately 8.4 EDD per year. That is, we adjust the original non-weather normalised usage by the deviation of EDD in a given year from the trend of EDD, multiplied by the estimated coefficients of our model.

6.9 Forecast usage of existing and new residential customers – not including appliance switching adjustment

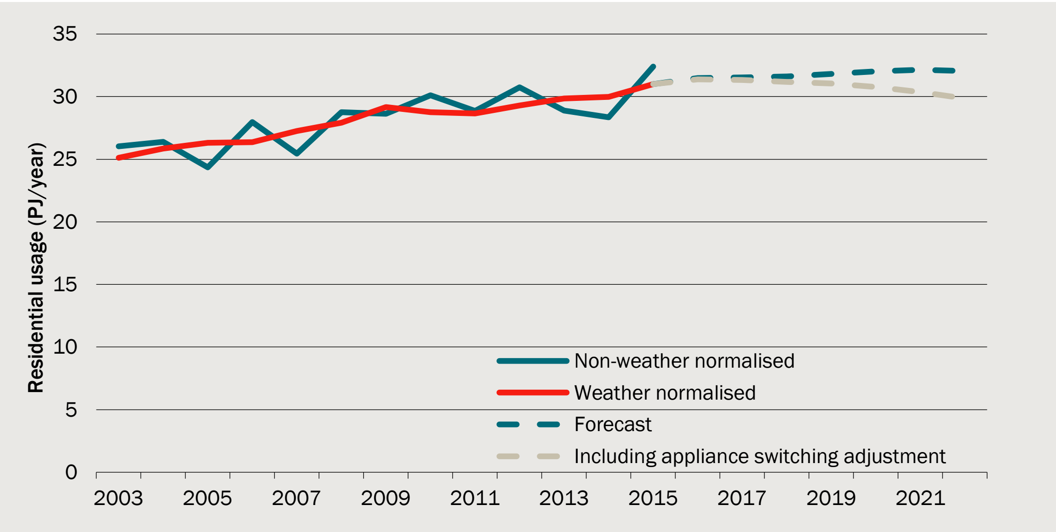


Note: These measures of usage per customer do not include the appliance switching adjustment.

Data source: CIE.

Chart 6.10 presents weather normalised residential usage, which illustrates the underlying trend in usage after excluding variation due to weather conditions in a given year. Our forecasts project a continuation in the upward trend in weather-normalised residential usage. However, the inclusion of the appliance switching adjustment brings down the forecasts, particularly in later years where there is a decline in total residential usage.

6.10 Weather normalised, original and forecast residential usage – including appliance switching adjustment



Data source: CIE.

Appliance switching adjustment

AEMO makes a downward adjustment to usage forecasts to account for increasing appliance switching.

Table 6.11 shows the impact of appliance switching in AEMO's forecasts. It shows that appliance switching has an impact on forecasts that increases to approximately 7 per cent in 2022. AEMO state that reference models were used to adjust base forecasts (produced using statistical models of heating and non-heating usage) for gas to electric fuel switching. The reference model used by AEMO to estimate the impact of appliance switching assumed the following:

- Hot water consumption
  - Existing homes - hot water units are replaced over the next 10 years with solar units or heat pumps, reducing consumption of existing homes.
  - New homes - driven by a changeover of existing hot water units to electric appliances.
- Heating consumption
  - Existing homes – heating units replaced within 20 years by smaller gas space heaters or smaller gas space heaters combined with reverse cycle air conditioners.[25]
  - New homes – insignificant changes to appliance switching.

6.11 Impact of appliance switching in AEMO NGFR forecasts

Calendar Year	Total annual consumption	Total Connections	Impact of Appliance Switching	Usage per connection	Impact of usage per connection of appliance switching	Impact of usage per connection of appliance switching
	PJ/year	No.	PJ/year	GJ/year	GJ/year	Per cent
2005		1 660 862				
2006		1 692 738				
2007		1 725 324				
2008		1 757 878				
2009		1 794 605				
2010	119.76	1 831 503		65.39		
2011	115.59	1 870 369		61.80		
2012	120.87	1 904 986		63.45		
2013	115.09	1 935 831		59.45		
2014	110.45	1 967 830		56.13		
2015	121.53	2 002 350		60.69		

25 The *NGFR 2015 Methodology Report* notes that "40% of the forecast reduced gas heating consumption in existing homes is due to improved building shell fabric" … "as such, an estimated load reduction was reallocated from fuel switching impact to energy efficiency impact". From this we infer that the 'impact of fuel switching' does not include the impact of improved building shell fabric. This impact is associated with energy efficiency, which we believe is sufficiently accounted for by the time trends estimated in our statistical model.

Calendar Year	Total annual consumption	Total Connections	Impact of Appliance Switching	Usage per connection	Impact of usage per connection of appliance switching	Impact of usage per connection of appliance switching
	PJ/year	No.	PJ/year	GJ/year	GJ/year	Per cent
2016	122.88	2 036 865	0.31	60.33	0.15	0.25
2017	122.94	2 068 263	0.81	59.44	0.39	0.65
2018	121.65	2 098 513	1.66	57.97	0.79	1.37
2019	120.70	2 126 642	2.93	56.75	1.38	2.42
2020	119.81	2 155 049	4.68	55.60	2.17	3.90
2021	118.48	2 183 833	6.62	54.25	3.03	5.59
2022	117.77	2 212 527	8.07	53.23	3.65	6.85
2023	117.98	2 240 732	8.81	52.65	3.93	7.47
2024	118.60	2 266 691	9.04	52.32	3.99	7.62

Note: The appliance switching adjustment we make is equal to the per cent impact shown in the last column of the table. For example, our 2022 forecast is adjusted downwards by 6.85 per cent relative to the unadjusted forecast. The 'total annual consumption', 'total connections' and 'impact of appliance switching columns' use data from AEMO, while the other columns are calculated based on this data.

Source: AEMO *National Gas Forecasting Report 2015* supplementary date, CIE.

Our model will implicitly include the effect of appliance switching on demand through the time trend. However, the time trend is limited in accounting for this effect because:

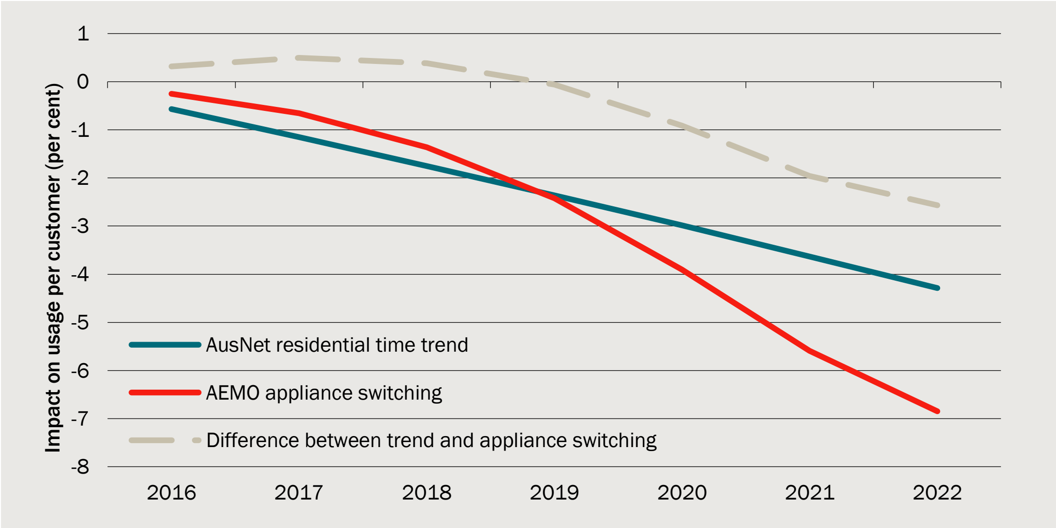
- it models a linear trend in usage, and thus cannot extrapolate an increasing pattern of appliance switching if that was evident historically, and
- the time trend will account for appliance switching only insofar as it has occurred historically, and will not be able to account for an increase in the rate of appliance switching driven by factors not accounted in the model.

Additionally, the time trend includes the effect of other variables, since it may pick up the effect of any variables trending over time that are not explicitly included in the model (such as electricity prices or energy efficiency).

Appliance switching is partially driven by gas prices, and to the extent that gas prices drive appliance switching, part of this effect will be accounted for in our estimates of the gas price elasticity of usage.

Chart 6.12 compares the impact on our forecasts of the estimated time trend for residential usage per customer with the appliance switching adjustment made by AEMO. The adjustment made by AEMO is initially smaller than the estimated time trend. However, it increases at a faster rate over time, resulting in a deviation in 2022 of approximately 2.5 per cent of usage.

6.12 Comparison of residential time trend and AEMO appliance switching adjustment



Data source: CIE.

It is not possible to determine the extent to which the time trend is correctly accounting for appliance switching yet also accounting for other variables with an upward impact on usage. Another factor such as improved customer service from gas companies may enter into the estimated time trend and have an upward impact on demand. Thus the trend may appropriately account for appliance switching despite having a smaller downward impact on usage than AEMO's adjustment.

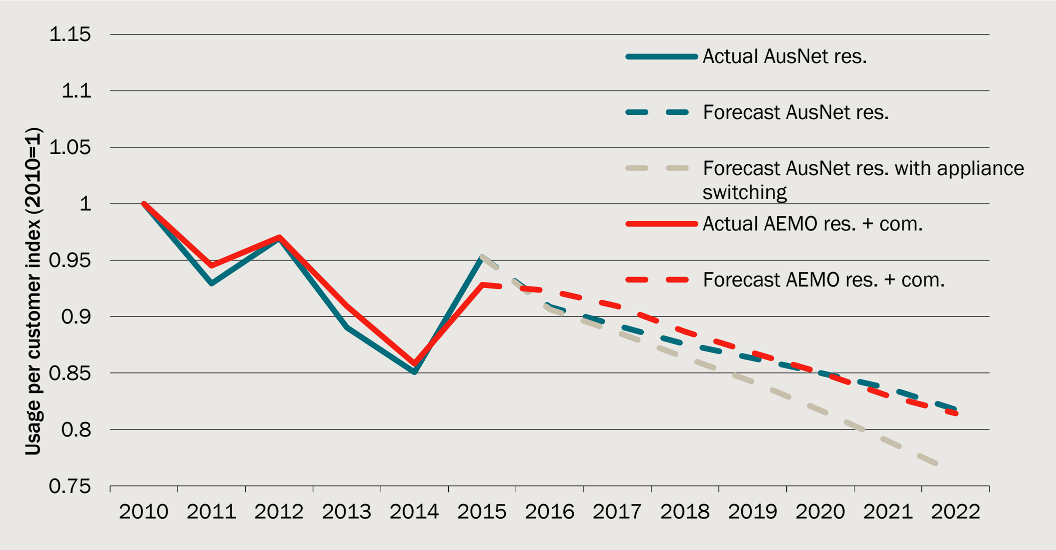
However, given the strong expectation that appliance switching will increase in the future, we have decided to follow AEMO NGFR 2015 and make an adjustment for appliance switching to forecasts of residential usage per customer. We make a downward adjustment to our forecasts of residential usage per customer that is equal to AEMO's estimate of the impact of appliance switching on usage per customer. That is, we make an adjustment equal to the final column of table 6.11, which is the impact of appliance switching on Victoria-wide tariff V usage per customer. For example, our 2022 forecast of residential (and commercial) usage per customer is adjusted downwards by 6.85 per cent.

Comparison of forecasts to other sources

These forecasts are comparable to those produced by AEMO. Chart 6.13 compares our forecasts of AusNet Services usage per residential customer to AEMO's forecasts of Victoria-wide residential and commercial usage per customer. The chart shows an index of residential usage per customer for AusNet Services' network, which follows historical AEMO residential and commercial usage closely. The index uses 2010 as the base year.

In 2016, AusNet usage is forecast to fall more than AEMO's forecasts. However, from 2017-onwards AEMO usage per customer falls more quickly than our unadjusted forecasts forecasts. The inclusion of the appliance switching adjustment results in a forecast of usage per customer falling faster than AEMO's forecasts.

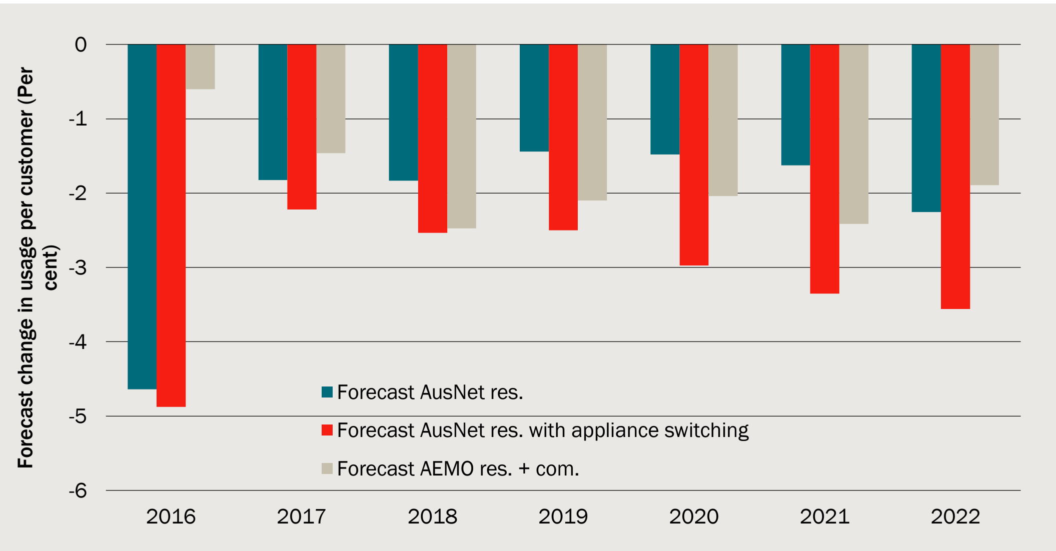
6.13 Comparison of CIE and AEMO residential usage per customer forecasts



Data source: CIE.

Chart 6.14 compares the growth rates in the forecasts, illustrates the larger 2016 weather correction made in our forecasts relative to AEMO. It also illustrates that our adjustment for appliance switching results in forecasts of usage per customer that decline more rapidly than AEMO's forecast of usage per customer.

6.14 Comparison of CIE and AEMO residential usage per customer forecast growth rates



Data source: CIE.

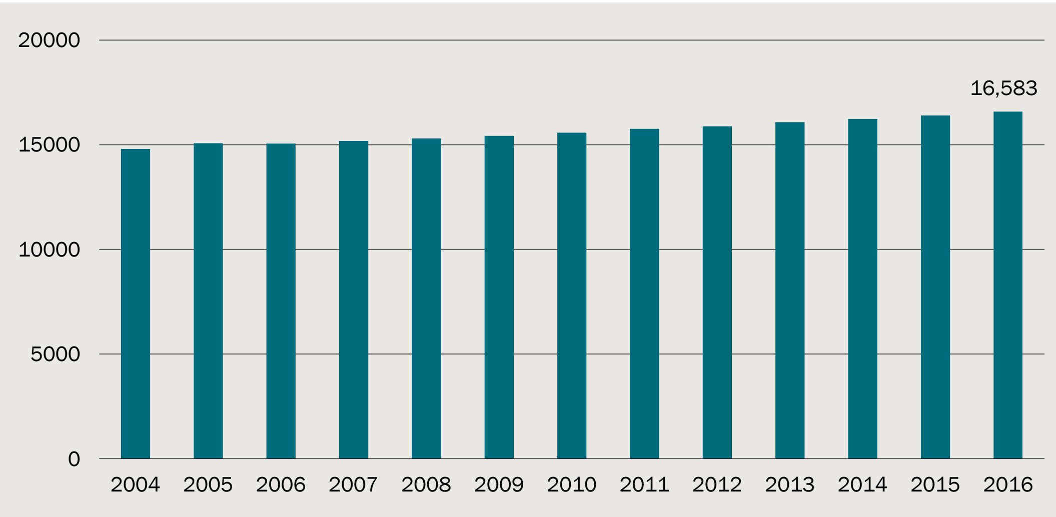
7 Commercial customer numbers

Commercial customers are small or medium businesses connected to the gas network. These businesses will be restaurants and cafes (who use gas for cooking) and other businesses who use gas for heating. Data on residential customer numbers used in this chapter are taken from the billing database provided to the CIE by AusNet. As explained below, in-line with residential customer numbers, we operate at the LGA level.

Snapshot of commercial customer numbers

In the March quarter of 2016, there were 16 583 commercial customers connected to gas in AusNet Services' area (see Chart 7.1). As noted in Chapter 5, this area covers 108 postcodes. Growth in commercial customers has been much slower than growth in residential customers – commercial customers have grew on average by 1.0 per cent per year between 2006 and 2016.

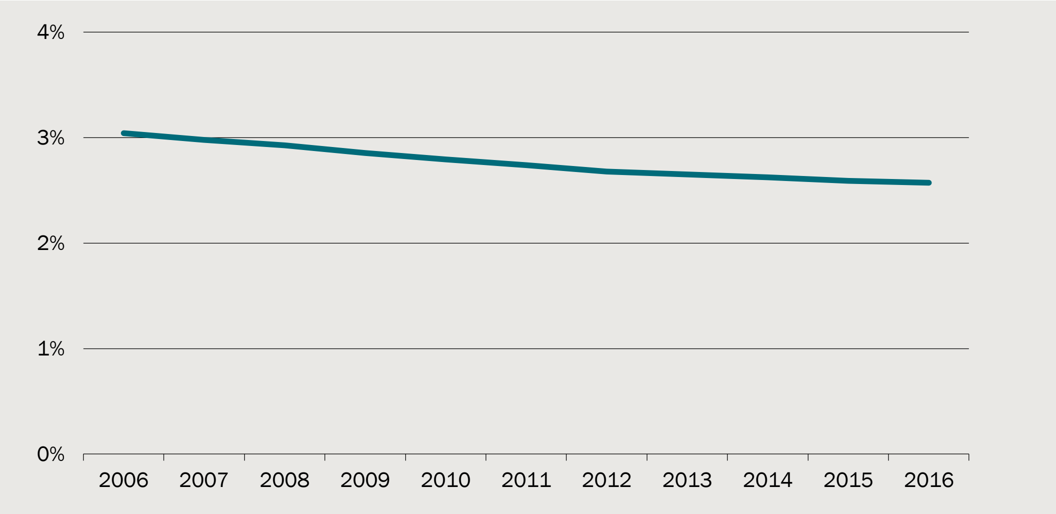
7.1 AusNet Services commercial customers



Data source: AusNet; CIE.

Between 2006 and 2007, commercial customers, measured as percentage of residential customers, declined at a reasonably constant rate (see Chart 7.2).

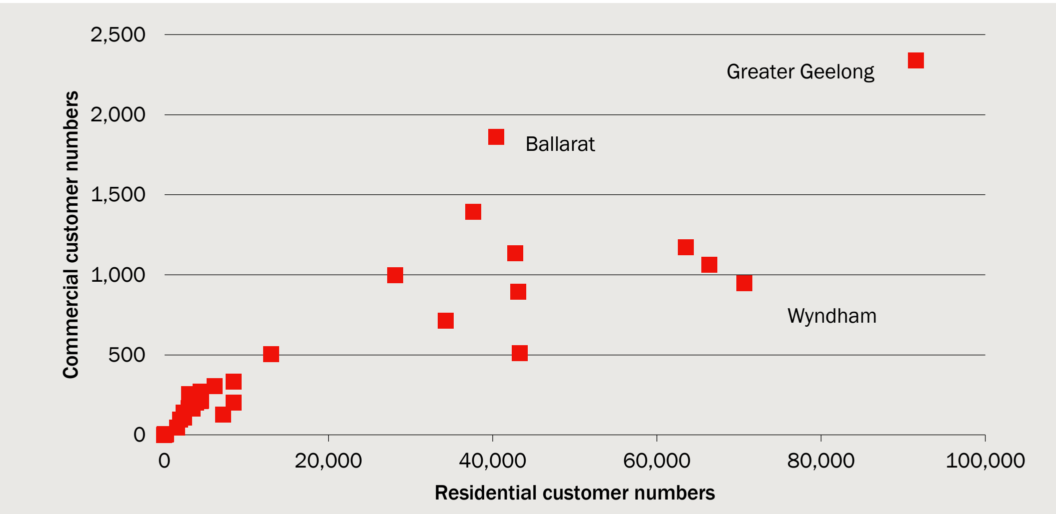
7.2 Commercial customers (as a percentage of residential customers)



Data source: AusNet; CIE.

Commercial customers are spread around AusNet Services' area in a similar pattern to residential customers. There is a moderate, positive, linear relationship between residential customer numbers and commercial customer numbers - see Chart 7.3).

7.3 Commercial customer numbers vs residential customer numbers, 2016 (by LGA)



Data source: CIE.

Drivers of commercial customer numbers

The main drivers of commercial customer numbers are:

- the number of potential customers, which should be (or grow in-line with) the number of businesses, and
- preferences of businesses for gas or electricity, and changes in the availability of the gas network.

Measuring drivers of commercial customer numbers

The number of potential customers

To forecast commercial customers, one potential approach is the 'top-down' approach involving 3 steps:

1 use GSP in Victoria to measure economic conditions

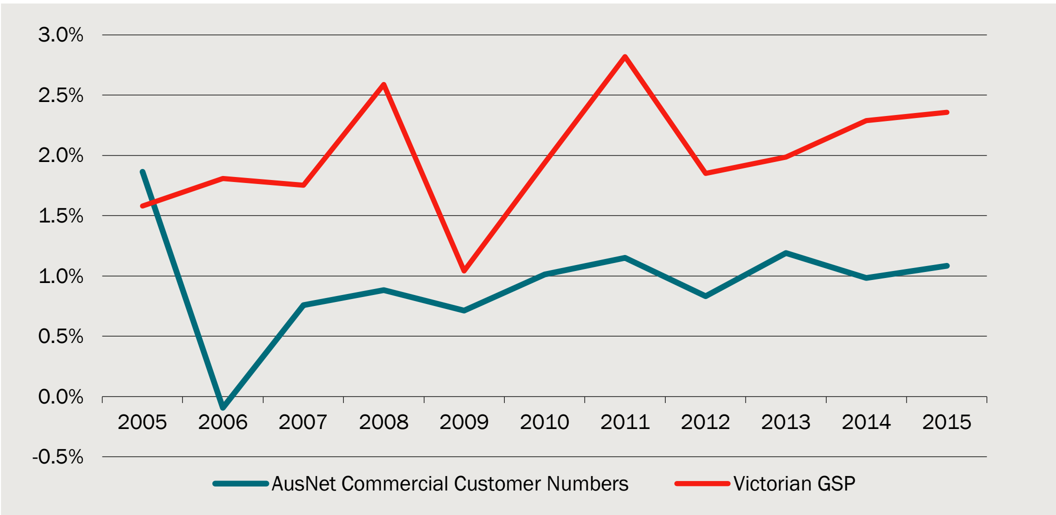
2 use this to project the number of businesses (or customers) in AusNet Services' area, and

3 allocate these customers to LGAs and postcodes.

This is not necessarily preferred, because it assumes there is a reasonably strong link between business creation and economic growth **and** that economic growth is even across the regions of Victoria. Chart 7.4 shows that the relationship between growth in GSP and growth in commercial customers is not especially compelling. However, it is somewhat stronger in the years after 2008.

On top of these points made, if the 'top-down' approach is followed, we risk masking or missing drivers of business activity and creation at the local level.

7.4 Growth in Victoria GSP and AusNet Services' Commercial Customers



Data source: ABS; CIE.

A second potential approach is 'bottom-up', involving two steps:

1 use local drivers to forecast customer numbers at the LGA level, and

2 sum across LGAs to get total customer numbers.

As business conditions can vary from region to region, this method is preferred, as long as we can find reliable indicators at the local level.

Consistent with our methodology for residential customers (see Chapter 5), we sum up data on commercial customers across 108 postcodes to get data on commercial customers across 38 LGAs.

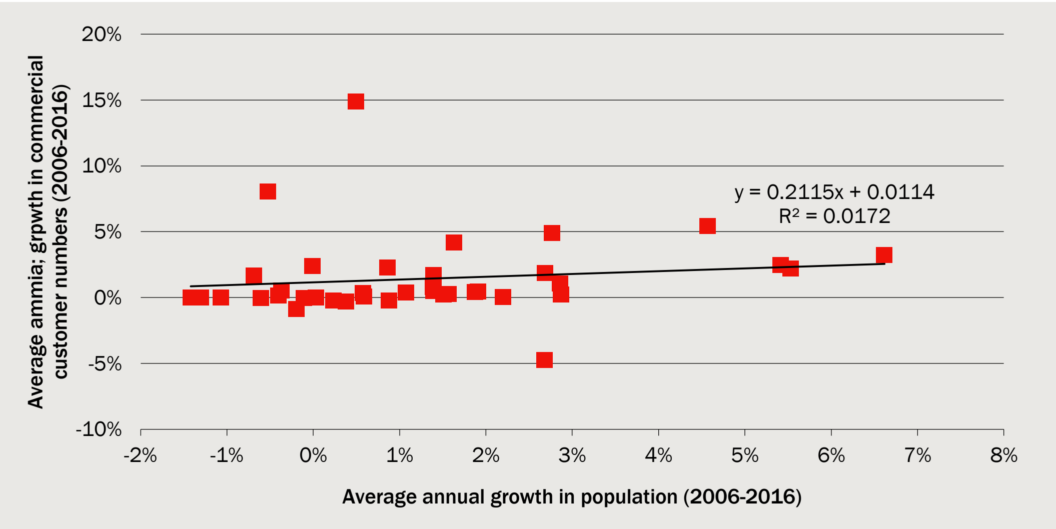
For forecasting, the first option is to use data and forecasts on population at the LGA level.[26] This is most straightforward indicator of economic activity at the local level.

Business preferences and the availability of the network

Businesses will connect to the gas network as preferences change and as the availability of the network changes. At the LGA level, perhaps the best measure of this is residential customer numbers. In addition, residential customer numbers are broadly influenced by population growth, and so therefore pick up economic growth to some extent.

The following two Charts (7.5 and 7.6) show the relationship between growth in commercial customer numbers and growth in residential customer numbers is stronger than the relationship between growth in commercial customer numbers and growth in population. The closeness of the relationship is demonstrated by the higher R-squared.

7.5 Growth in commercial customers vs growth in population (by LGA)



Data source: CIE.

[26] Sourced from the ABS Cat. 3128.0 (see http://www.abs.gov.au/ausstats/abs@.nsf/mf/3218.0) and Victoria In Future (see: http://www.dtpli.vic.gov.au/data-and-research/population/census-2011/victoria-in-future-2015)

7.6 Growth in commercial customers vs growth in residential customer numbers

Data source: CIE.

Overall, we decide to forecast commercial customer numbers with reference to the growth in residential customer numbers.

Methodology used to forecast commercial customer numbers

We forecast the number of commercial customers by estimating the number of new commercial customers that are created when a new residential customer is created.

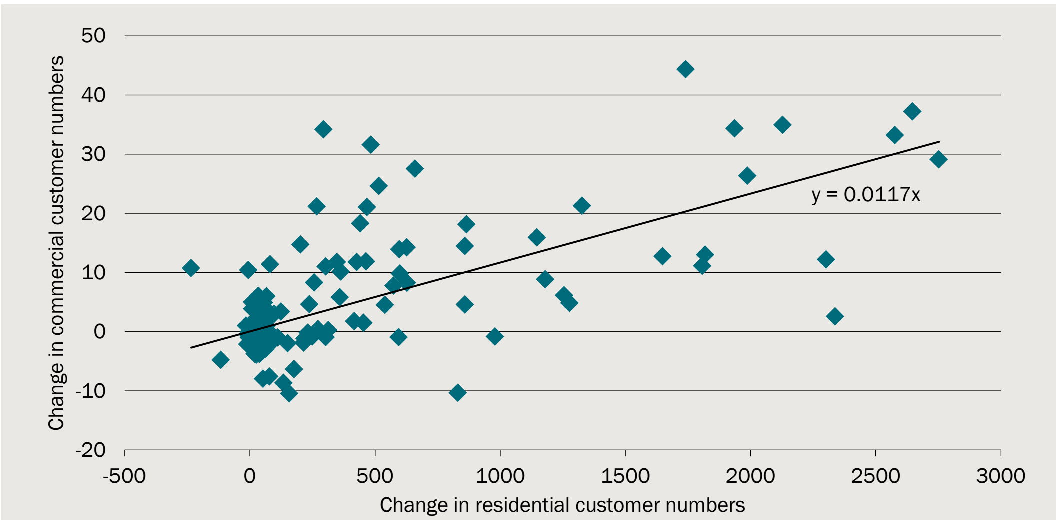
Starting at the aggregate level, Chart 7.7 shows how the relationship between commercial customers and residential customer numbers has evolved. From 2013-onwards, the number of commercial customers created per new residential customer was persistently higher than in earlier years. Because of this, we focus on the relationship in this recent period for the purposes of forecasting.

7.7 Number of new commercial customers created for every new residential customer created (total across AusNet area)

Data source: CIE.

For forecasting we use a pooled model at the LGA level. Across the 38 LGAs considered, data in each year between 2013 and 2016 gives us an observation on the number of commercial customers created when one residential customer is created. These data are shown in Chart 7.8.

7.8 Change in commercial customers vs change in residential customers 2013-2016 (pooled model: across years and LGAs)



Data source: CIE.

Table 7.9 shows regression estimates of the relationship. As shown by the t-stat (which is above the benchmark rate for statistical analysis of (2), the relationship is significant. For each net new residential customer, there are 0.0117 new commercial customers (or 11.7 new commercial customers for each 1 000 new residential customers).

7.9 Linear regression model to forecast commercial customer numbers (2013-2016)

Dependent variable	Independent variable	Coefficient	T-stat
Net new commercial customers	Net new residential customers	0.0117	13.93
R-squared	0.56	-	-
Observations	151		

Source: CIE.

Forecasts

In existing areas, we use the relationship just established (11.7 new commercial customers for each 1 000 new residential customers) and the forecasts for residential customers (outlined above) to forecast the number of commercial customers at the LGA level. We sum these LGA forecasts to generate obtain forecasts of total commercial customers in established areas (shown in Table 7.10, below).

As noted in the previous chapter, we have already used the relationship between commercial customers and residential customers to split residential customers from *total* customers in ERP areas. Therefore, Commercial customers in ERP areas is the difference between the data in Table 5.15 and Table 5.16).

All aggregate forecasts are presented in Table 7.10. Total customers are forecast to be 747 355 in the March quarter of 2022 (up from 661 310 in the March quarter of 2016), including 729 781 residential customers and 17 575 commercial customers.

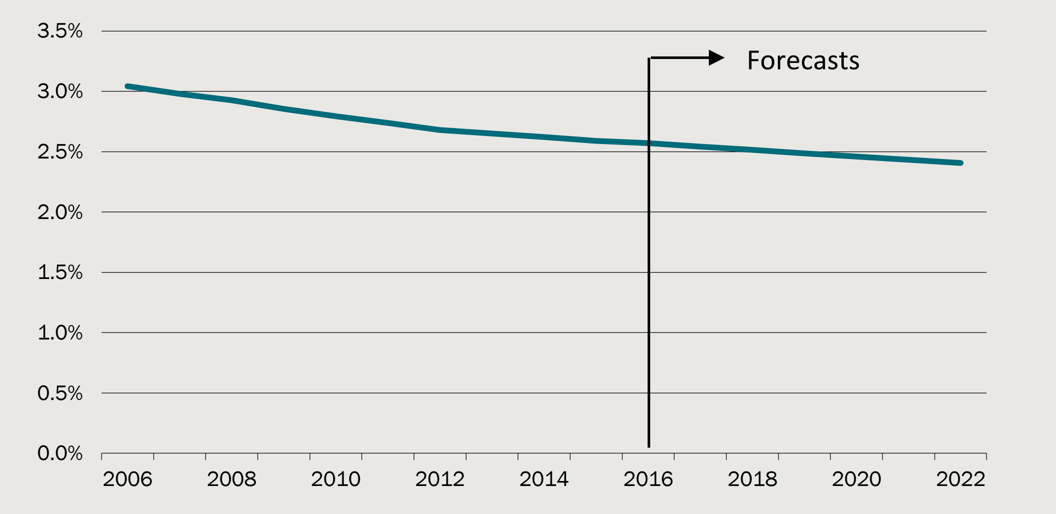
7.10 Total AusNet Services customers

	Existing			Total		
	Residential	Commercial	Total	Residential	Commercial	Total
2014	618 691	16 227	634 918	61 691	16 227	634 918
2015	633 043	16 403	649 446	633 043	16 403	649 446
2016	644 727	16 583	661 310	644 727	16 583	661 310
2017	657 798	16 735	674 534	658 107	16 739	674 846
2018	671 210	16 892	688 102	672 119	16 902	689 021
2019	684 974	17 052	702 026	686 333	17 068	703 401
2020	699 100	17 217	716 317	700 796	17 237	718 033
2021	713 600	17 386	730 986	715 549	17 409	732 958
2022	727 642	17 550	745 191	729 781	17 575	747 355

Source: CIE.

Our forecasts imply that commercial customer numbers, measured as percentage of residential customer numbers, will continue to decline, consistent with their decline over recent years (see Chart 7.11).

7.11 Commercial customers (as a percentage of residential customers)



Data source: CIE.

Disconnections

We treat and forecast disconnections of commercial customers using the same methodology as residential customers. (Note that because our forecast for customers or connections is based on 'net new connections' it implicitly incorporates trends in disconnections. This means it is reasonable to derive a projection for disconnections from our projection of connections). Projections for disconnections among commercial customers is shown in Table 7.12.

7.12 Commercial customers: numbers and disconnections

	Total	Disconnections	
	-	Number	Per cent of previous year
2006	15 057		
2007	15 171	128	0.85%
2008	15 305	76	0.50%
2009	15 414	98	0.64%
2010	15 570	92	0.60%
2011	15 749	108	0.69%
2012	15 880	105	0.67%
2013	16 069	81	0.51%
2014	16 227	120	0.75%
2015	16 403	119	0.73%
2016	16 583	95	0.58%
Forecasts			
2017	16 739	96	0.58%
2018	16 902	97	0.58%

	Total	Disconnections	
	-	Number	Per cent of previous year
2019	17 068	98	0.58%
2020	17 237	99	0.58%
2021	17 409	100	0.58%
2022	17 575	101	0.58%

Source: CIE.

Total disconnections (residential plus commercial) are shown in Table 7.13.

7.13 Disconnections of AusNet Services Customers

	Disconnections		
	Residential	Commercial	Total
2014	1 362	120	1 482
2015	1 569	119	1 688
2016	1 638	95	1 733
2017	1 668	96	1 764
2018	1 703	97	1 800
2019	1 739	98	1 837
2020	1 776	99	1 875
2021	1 813	100	1 913
2022	1 851	101	1 952

Source: CIE.

8 Commercial customer usage

Commercial demand comprises non-residential customers that use less than 10 000 Gigajoules of gas in a 12 month period and less than 10 Gigajoules in an hour. Consumption patterns of different customers vary far more among commercial customers than residential customers, which has consequences for the approach to statistical estimation used.

The first part of the chapter describes changes in gas consumption patterns, the second part applies formal statistical techniques and the third and fourth develop the projections.

Descriptive analysis

Total commercial usage is dominated by the usage of large customers. Usage per commercial customer is more widely distributed in comparison to residential customers.

Table 8.1 shows the distribution of gas usage by tariff class. It is clear that commercial usage per customer is much more spread, with the 99th percentile of usage per customer being over 400 times the magnitude of the 20th percentile of usage, while for residential the 99th percentile is less than 6 times the 20th percentile.

8.1 Distribution of annual usage per customer by tariff class

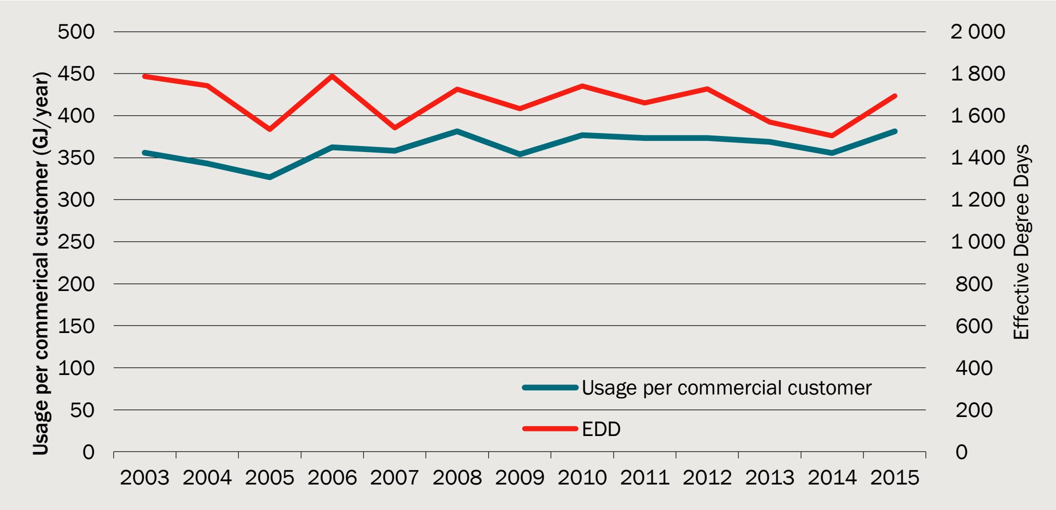
Percentile of usage in class	Tariff class	
	Residential	Commercial
	GJ/year	GJ/year
20th	25	13
40th	40	41
60th	54	98
80th	73	307
90th	89	677
95th	105	1 385
99th	144	5 272

Source: CIE.

Trend in gas use since 2003

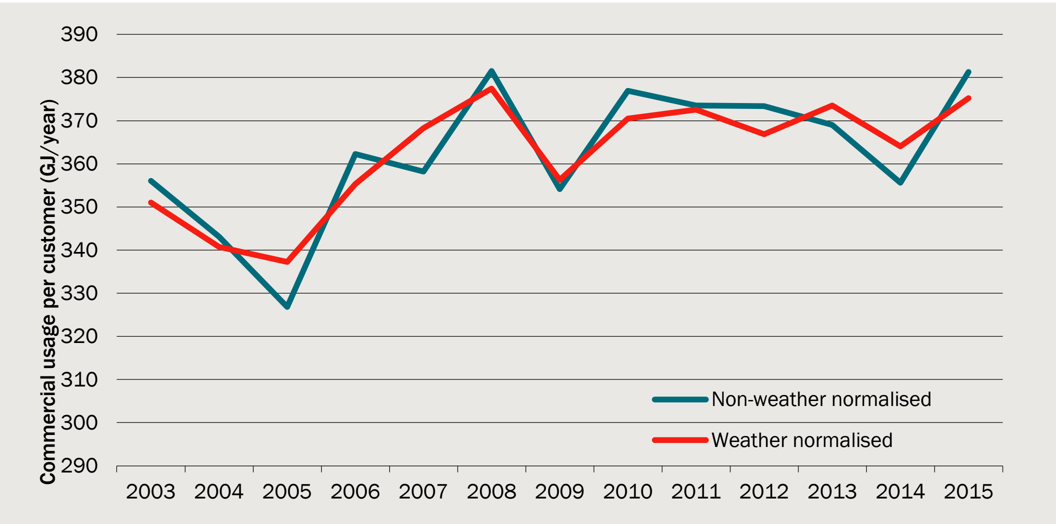
Total commercial usage per year has been relatively stable over time. A weaker relationship is evident between EDD and usage per commercial customer than was the case for usage per residential customer. However, usage per customer does increase in 2015 relative to 2014, in line with the higher number of EDD. Thus, weather-correction will still be important to determine the starting point of the forecasts. Chart 8.2 presents the relationship between usage per commercial customer and EDD. Chart 8.3 shows weather-normalised and non-weather-normalised usage per customer. There is more variation in commercial usage remaining after weather normalisation compared to weather-normalised residential usage.

8.2 Relationship between usage per commercial customer and EDD



Data source: CIE.

8.3 Weather normalised usage per commercial customer

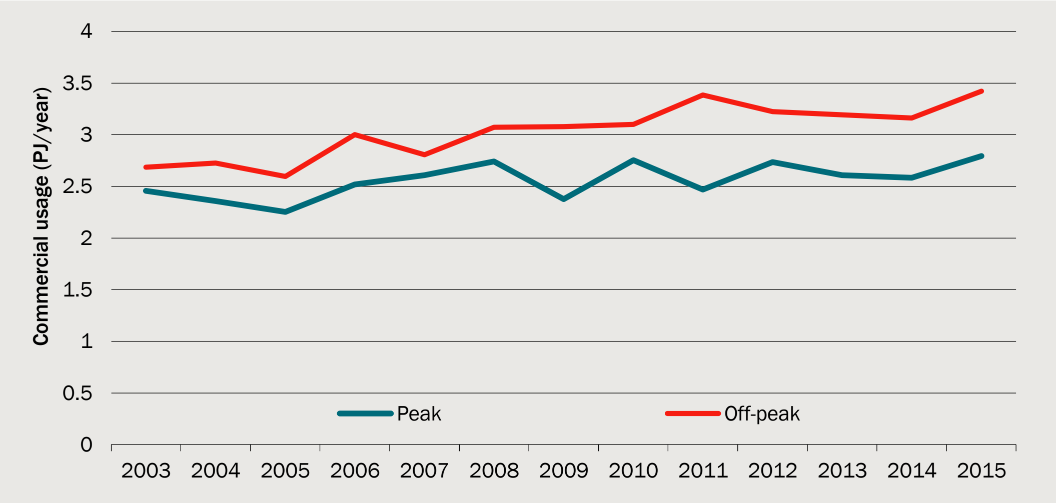


Note: Usage per commercial customer is weather normalised using the coefficients estimated in the statistical models presented throughout this chapter.

Data source: CIE.

Peak and off-peak usage vary differently over time. Total usage has increased over time, with peak usage being a greater contributor to this increase than off-peak usage, which has increased more gradually. Chart 8.4 shows a comparison of peak and off-peak usage by commercial customers.

8.4 Comparison of peak and off-peak usage by commercial customers



Data source: CIE.

Formal statistical analysis

Model form

As seen above, an important characteristic of commercial usage is that total commercial usage is more concentrated among a smaller number of customers than was the case for residential usage. The model specification used for residential demand would not allow for different weighting to be given to large customers and small customers. Weighting large customers more greatly would produce estimates of usage per customer that, when aggregated, would be more accurate estimates of total usage than those produced by an unweighted approach. Failure to weight large customers more would result in a model that would only yield accurate estimates of total usage if large and small customers have the same relationships with driver variables, which is unlikely to be the case.

Therefore, in our statistical modelling we have weighted observations of each customer by their average usage per year over the period they are in the dataset.

A consequence weighting observations in panel data models is that the model must either be a fixed effects or pooled regression model. Random effects models do not allow for weights on observations. We therefore follow a two-stage process of estimating a fixed effects model and then estimating a model predicting these fixed effects based on characteristics of commercial connections.

The fixed effects model is shown in the equation below.

$$\begin{aligned} q_{it} = \mu_i + \\ &v.year_t + \gamma_2.edd_t + \\ &\delta_1.price_{it} + \varepsilon_{it} \end{aligned}$$

The dependent variable, q_{it} is the natural log of the quantity of gas used by commercial customer i in year t. We estimate our model using the log of consumption, as drivers would be expected to have similar percentage impacts on usage rather than similar GJ impacts on usage.

The first row of explanatory variables is the fixed effect for each commercial customer, μ_i.

The second row of explanatory variables is time specific characteristics, such as *year* and effective degree days (*edd*).

The third row of explanatory variables is characteristics that vary by both time and dwelling, which includes *price* and an error term for that commercial customer for that year.

The second stage of the statistical estimation is to estimate the fixed effect against connection characteristics as follows.

$$\mu_i = \beta_0 + \sum_{t=2004}^{2015} \beta_t.year\ connected + \varepsilon_i$$

This equation estimates the customer-specific fixed effect using a set of dummy variables indicating the year that the customer was connected. A dummy variable takes either a value of 0 or a value of 1. For the dummy variable for year of connection for 2004 for example, all connections established in 2004 would have a value of 1 and all other connections would have a value of 0. We use a dummy for each year because we would not expect that the impact of year created would be linear. Note that all connections prior to 2003 are recorded in the billing database as 2003, hence strengthening the justification for using dummy variables.

The variables used have been selected for the modelling based on the data that is available and views about what the important drivers of gas demand are. Consideration has been given to the inclusion of an electricity price variable, and the reasons for not doing so are discussed in Chapter 6 (in the context of residential usage).

In estimating these statistical models we determined that these variables generally have statistically significant relationships in predicting usage per customer in most model specifications. We have chosen to use the same variable selection for all models instead of only choosing variables with statistical significant relationships in a given model. This is done because of the strong theoretical reasons that such relationships would be significant, such as in the case of Effective Degree Days.

We do not have revenue variables for each commercial customer, hence these cannot be included. It is possible to include aggregate measures of income such as Gross State Product (GSP), however precise forecasts of aggregate income variables specific to the AusNet geographical areas are not available.

This may have implications for forecasting if we could identify new customers with different revenue/income than existing customers. A more pragmatic alternative would be to allow a dummy variable specific to each tariff class region and/or apply estimated changes to regions using some level of judgement. We test whether the former changes the results and also test whether there is a need to make locational adjustments because the pattern of new development differs from that of existing development.

The model we estimate is based on levels of usage per customer and levels of variables such as prices. Given the time and resource constraints we do not seek to model dynamic processes around the patterns of change.

Model estimation

The model form that we estimate for our base model is set out in the section above.

The model is estimated in STATA, which is a data analysis and statistical software package.[27] STATA uses generalised least squares regression to estimate coefficients for panel regressions under fixed effects assumptions. We allow for error terms in regressions to be clustered by customer in constructing the statistical significance of parameters.

We define *year* as year since 2003. We generally do not use a dummy variable approach for year because then we would not be able to differentiate between weather effects and any time trend in consumption. The use of year as a scalar variable implies that the effect is linear — i.e. each year on average leads to the same x per cent change in consumption.

We do not know the price paid by each customer. We have defined price as a price index for each region. This price index is based on a combination of standing offer tariffs reported by the Essential Services Commission of Victoria for consumption of 60 GJ (pre-2011) and an index of commercial distribution prices sourced from the National Gas Forecasting Report (NGFR) produced by AEMO (2011-onwards). Therefore, change in prices only differs by region prior to 2011, after which the same per cent change to prices is applied to both regions.

Constraining the price variable

We have not separately estimated the *price* coefficient for each block, given that model testing indicated inconsistent estimates (variously negative and positive). Given the importance of gas prices as a driver of commercial usage per customer, we have constrained the *price* coefficient to the value estimated for this coefficient in a model of total commercial usage (see table 8.5), which is -0.265. Other coefficients in the model such as those associated with EDD and the time trend have not been constrained. These other coefficients have been estimated fit a model given the constraint on *price* coefficients.

Model results

Table 8.5 presents the estimated coefficients of the models estimated for each block of commercial usage. All coefficients except the *new connections* coefficient are directly estimated using the first stage fixed effect models for each block of usage.

The *new connections* coefficient is calculated based on the estimated coefficients from the second-stage regression that estimates the fixed effects from the first-stage model. It is determined according the following formula:

27 See http://www.stata.com/ for more details.

$$New\ connections = \frac{\sum_{t=2013}^{2015} \beta_t \times new\ connected_t}{\sum_{t=2013}^{2015} new\ connected_t} - \frac{\sum_{2004}^{2015} \beta_t \times new\ connected_t}{\sum_{2004}^{2015} new\ connected_t}$$

This formula calculates the difference in the weighted average coefficient of *year connected* dummy variables over the past 3 years compared to the weighted average coefficient of all *year connected* dummy variables that are estimated over 2004-2015. These averages are weighted by the number of new connections in that year. The $new\ connected_t$ is the number of newly connected customers in that year.

We have not taken the log transform of the *EDD* variable because analysis of the relationship between daily weather and usage did not suggest a substantial non-linear component to this relationship. Therefore, the coefficient may be interpreted as the per cent change in usage for a block from an additional EDD per year.

The *gas price* variable is in log terms, and thus it suggests that, considering the 'Peak 0-0.1' block, a 1 per cent increase in the gas price is associated with a 0.265 per cent *decrease* in usage (given the sign of the coefficient is negative).

8.5 Coefficients used to forecast commercial demand

Model/block	*Year*	*EDD*	*Gas price*	*New connections*
Peak 0 - 0.1	-0.001	0.0000	-0.265	0.033
Peak 0.1 - 0.2	0.005	0.0000	-0.265	0.051
Peak 0.2 - 1.4	0.003	0.0001	-0.265	0.122
Peak > 1.4	0.007	0.0003	-0.265	-0.281
Off Peak 0 - 0.1	-0.002	0.0000	-0.265	0.088
Off Peak 0.1 - 0.2	0.006	0.0001	-0.265	0.150
Off Peak 0.2 - 1.4	0.005	0.0001	-0.265	0.037
Off Peak > 1.4	0.013	0.0002	-0.265	-0.307

Source: CIE.

Models of peak and off-peak usage

Table 8.6 presents the estimated coefficients and results of significant tests for models of commercial usage. It shows fixed and random effects models for estimation using total, peak, and off-peak commercial usage as dependent variables in different models.

Examples of interpretation of these results is as follows.

- The *year* coefficient of -0.0083 indicates that there has been a trend decline of 0.83 per cent per year in gas consumption after accounting for other factors.
- The *EDD* coefficient of 0.000258 indicates that an additional EDD is associated with a 0.000258 per cent increase in usage per customer.

8.6 Results of residential usage fixed effects model

Sample	Total	Peak	Offpeak
Year	-0.00832*	-0.00832*	-0.00280
EDD	0.000258***	0.000236***	0.000224***
Gas price	-0.265470 [a]	-0.265470 [b]	-0.265470 [b]
Constant	32.03***	31.10***	20.57**
N	167224	164486	166950

[a] Not significant at 5 per cent level of significant. However, in testing of unconstrained models of usage by block, significant relationships were found. Tests of statistical significance are not useful indicators of predictive power of a forecasting model. See Kostenko, A. & Hyndman, R., 2008, *Forecasting without significance tests?*, available at http://robjhyndman.com/papers/sst2.pdf

[b] This coefficient has been constrained to the value estimated in the total demand model.

Note: The R^2 of the model is not presented because when coefficients are constrained to a pre-determined value, the R^2 does not have a meaningful interpretation.

P-values are indicated by the asterisks, with p<0.05 = *, p<0.01=*, p<0.001=***.

Source: CIE.

Forecasts of commercial gas use

Forecasts of total commercial gas usage combine projections of usage per customer from the statistical modelling described above with forecasts of customer numbers. These two components are combined according to the following equation to obtain total usage per block.

$$Q_{brt} = \frac{(customers_t + customers_{t+1})}{2} \times q_{ibt}$$

Q_{bt} is total usage of block b, region r, in year t. It is the product of two components:

- the average number of customers in a year, which is equal to half the sum of customers at the beginning of year t and the beginning of year $t+1$, and
- the usage per customer (i) of block b, region r, in year t.

As noted earlier, the statistical models of commercial usage are estimated using data that exclude observations of usage within the same year that a customer is connected. Customers may only be connected for part of the first year they become connected. For this reason, usage per customer is multiplied by the average number of customers in a year to account for customers who connect during the year. This method assumes that customers are connected in equal proportion throughout the year.

Usage per customer is forecast separately for new and existing customers.

Usage per customer is a function of projected *EDD* and *gas price* the coefficients of these variables and the time trend estimated for each block. The number of existing customers is the number of customers in 2015 for each block.

Usage per new commercial customer is forecast in the same manner as existing customers, with one adjustment made for new connections having lower usage per customer. The factor applied is determined using the *new connections* variable.

Thus, usage per new commercial customer is as follows:

$$usage\ per\ customer_{new,t} = usage\ per\ customer_{existing,t} \times (1 + \beta_{new\ connections})$$

Table 8.7 contains projections of commercial customer usage and fixed charges. It shows actual observed levels and projected levels from 2016-2022. The number of fixed charges is based on the customer number forecasts in chapter 7, which have been applied to the starting point determined by actual 2015 fixed charges.[28]

The forecasts presented in table 8.7 include a post-modelling adjustment to account for gas to non-gas appliance switching. We make a downward adjustment to our forecasts of commercial usage per customer that is equal to AEMO's estimate of the impact of appliance switching on usage per customer.

28 There are small discrepancies between the number of customers in the billing dataset (used to determine the number of customers by postcode in forecasting customer numbers) and the number of fixed charges. These discrepancies will have a negligible effect on the forecasts because of their small magnitude.

8.7 Projections of commercial usage

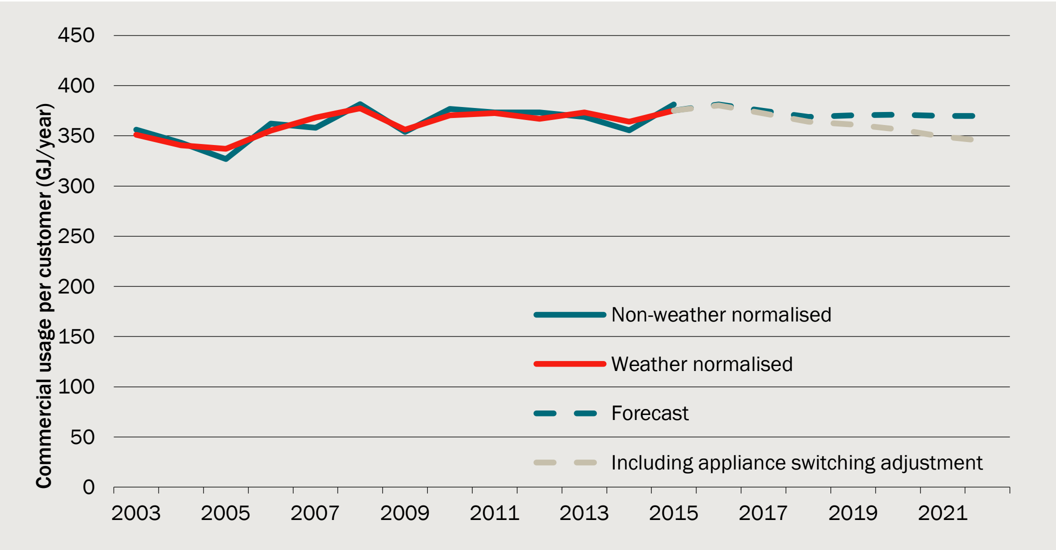
Region/ Block	Unit	2015	2016	2017	2018	2019	2020	2021	2022
		Actual	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast
Tariff V - AusNet Services Central – Commercial									
Fixed Charge	No.	9 958	10 093	10 204	10 319	10 437	10 558	10 683	10 804
Peak 0 - 0.1	GJ	89 742	91 900	90 422	88 868	88 713	88 029	86 729	85 898
Peak 0.1 - 0.2	GJ	74 441	76 576	75 814	74 991	75 328	75 218	74 587	74 327
Peak 0.2 - 1.4	GJ	452 165	460 789	455 326	449 489	450 735	449 292	444 689	442 211
Peak > 1.4	GJ	1 340 104	1 340 741	1 322 197	1 302 732	1 303 975	1 297 386	1 281 857	1 275 356
Off Peak 0 - 0.1	GJ	151 574	154 821	152 195	149 435	149 046	147 765	145 442	143 874
Off Peak 0.1 - 0.2	GJ	106 556	108 884	107 953	106 936	107 590	107 604	106 864	106 602
Off Peak 0.2 - 1.4	GJ	626 137	639 246	632 227	624 708	626 956	625 472	619 630	616 978
Off Peak > 1.4	GJ	1 660 067	1 674 653	1 661 020	1 646 225	1 656 919	1 657 639	1 647 028	1 647 654
Total	**GJ**	**4 500 786**	**4 547 609**	**4 497 154**	**4 443 384**	**4 459 261**	**4 448 404**	**4 406 826**	**4 392 900**
Tariff V - AusNet Services West – Commercial									
Fixed Charge	No.	6 102	6 138	6 175	6 214	6 253	6 292	6 333	6 372
Peak 0 - 0.1	GJ	53 288	54 003	52 867	51 689	51 325	50 652	49 637	49 035
Peak 0.1 - 0.2	GJ	41 688	42 431	41 793	41 122	41 084	40 797	40 235	39 990
Peak 0.2 - 1.4	GJ	223 328	225 027	221 143	217 087	216 441	214 482	211 066	209 309
Peak > 1.4	GJ	474 904	471 678	463 498	454 997	453 708	449 655	442 566	439 502
Off Peak 0 - 0.1	GJ	77 063	77 854	76 127	74 341	73 734	72 683	71 141	70 184
Off Peak 0.1 - 0.2	GJ	47 550	48 029	47 352	46 637	46 647	46 374	45 785	45 544
Off Peak 0.2 - 1.4	GJ	249 949	252 523	248 484	244 252	243 825	241 918	238 375	236 742
Off Peak > 1.4	GJ	451 721	452 499	447 274	441 719	442 964	441 488	437 033	436 413
Total	**GJ**	**1 619 490**	**1 624 045**	**1 598 538**	**1 571 844**	**1 569 727**	**1 558 049**	**1 535 839**	**1 526 719**

Region/ Block	Unit	2015	2016	2017	2018	2019	2020	2021	2022
		Actual	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast
Tariff V - AusNet Services Central - New Town Commercial									
Fixed Charge	No.	12	11	12	16	19	22	24	25
Peak 0 - 0.1	GJ	127	117	137	172	199	217	227	230
Peak 0.1 - 0.2	GJ	105	98	116	146	170	187	197	202
Peak 0.2 - 1.4	GJ	546	499	596	762	890	978	1 032	1 053
Peak > 1.4	GJ	584	545	607	717	805	864	898	913
Off Peak 0 - 0.1	GJ	194	178	211	266	309	337	353	358
Off Peak 0.1 - 0.2	GJ	151	138	166	214	252	278	294	301
Off Peak 0.2 - 1.4	GJ	907	837	986	1 243	1 443	1 580	1 666	1 700
Off Peak > 1.4	GJ	855	806	899	1 062	1 195	1 287	1 345	1 374
Total	**GJ**	**3 469**	**3 219**	**3 718**	**4 583**	**5 262**	**5 727**	**6 013**	**6 130**
Tariff V - AusNet Services West - New Town Commercial									
Fixed Charge	No.	231	240	246	251	255	259	263	267
Peak 0 - 0.1	GJ	2 378	2 516	2 504	2 481	2 490	2 478	2 447	2 426
Peak 0.1 - 0.2	GJ	1 992	2 118	2 122	2 116	2 137	2 141	2 128	2 123
Peak 0.2 - 1.4	GJ	11 845	12 504	12 513	12 458	12 562	12 564	12 464	12 410
Peak > 1.4	GJ	26 507	27 134	26 985	26 742	26 872	26 800	26 527	26 416
Off Peak 0 - 0.1	GJ	3 795	4 011	3 992	3 952	3 963	3 942	3 889	3 852
Off Peak 0.1 - 0.2	GJ	2 795	2 961	2 974	2 971	3 007	3 017	3 004	3 000
Off Peak 0.2 - 1.4	GJ	16 626	17 538	17 551	17 482	17 637	17 650	17 525	17 470
Off Peak > 1.4	GJ	26 433	27 260	27 259	27 169	27 448	27 524	27 395	27 429
Total	**GJ**	**92 370**	**96 042**	**95 900**	**95 373**	**96 115**	**96 116**	**95 379**	**95 126**

Data source: CIE.

Chart 8.8 shows actual, weather-normalised and forecast levels of usage per commercial customer. The forecasts allow for same trend in gas use as occurred historically controlling for other factors. The downward impact of prices and positive time trend counter-act each other to yield a relatively stable forecast of usage per commercial customer. This is in line with the low levels of historical growth in usage per customer. Further, much of the variation in usage remains unexplained by weather outcomes (see chart 8.3). We make the same appliance switching adjustment to commercial usage per customer as was made to residential usage per customer. It has a significant downward effect on the forecasts.

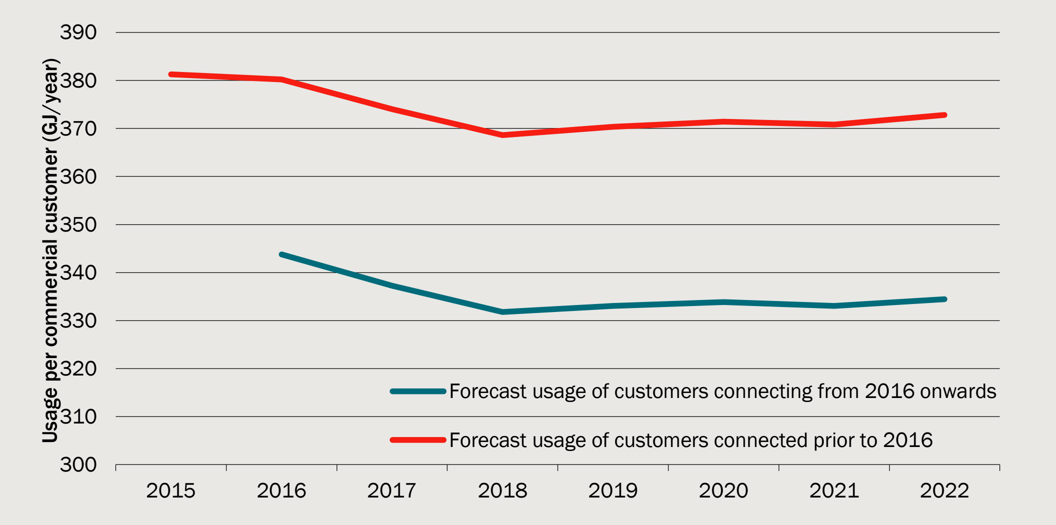
8.8 Actual and forecast usage per commercial customer



Data source: CIE.

Chart 8.9 shows the forecast usage per customer for existing and new customers. As noted on the chart, new customers are defined as customers connected from 2016-onwards, while existing customers include all customers connected at 2015. The rate of decline of usage among existing and new customers is the same. However, the level of usage of new customers is significantly lower. An increase in the proportion of new customers in the total stock of customers will partially account for the decline in total commercial usage evident in chart 8.8. The relatively steep fall between 2016 and 2018 is associated with strongly increasing prices during that period. Usage per commercial customer is forecast to grow very slowly from 2019-onwards, consistent with the positive time trends estimated for most blocks of commercial usage.

8.9 Forecast usage of existing and new commercial customers – not including appliance switching adjustment

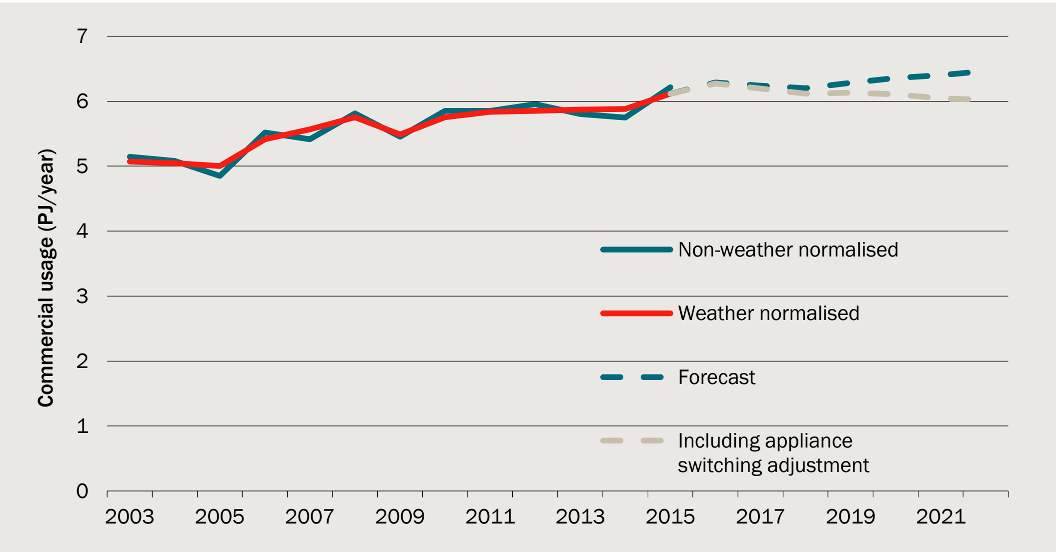


Note: These measures of usage per customer do not include the appliance switching adjustment.

Data source: CIE.

Chart 8.10 presents weather normalised residential usage, which illustrates the underlying trend in usage after excluding variation due to weather conditions in a given year. This is normalised to a trend level of EDD estimated over the 2003-2015 period, which exhibits a trend decline of approximately 8.4 EDD per year. That is, we adjust the original non-weather normalised usage by the deviation of EDD in a given year from the trend of EDD, multiplied by the estimated coefficients of our model.

8.10 Weather normalised, original and forecast commercial usage – including appliance switching adjustment



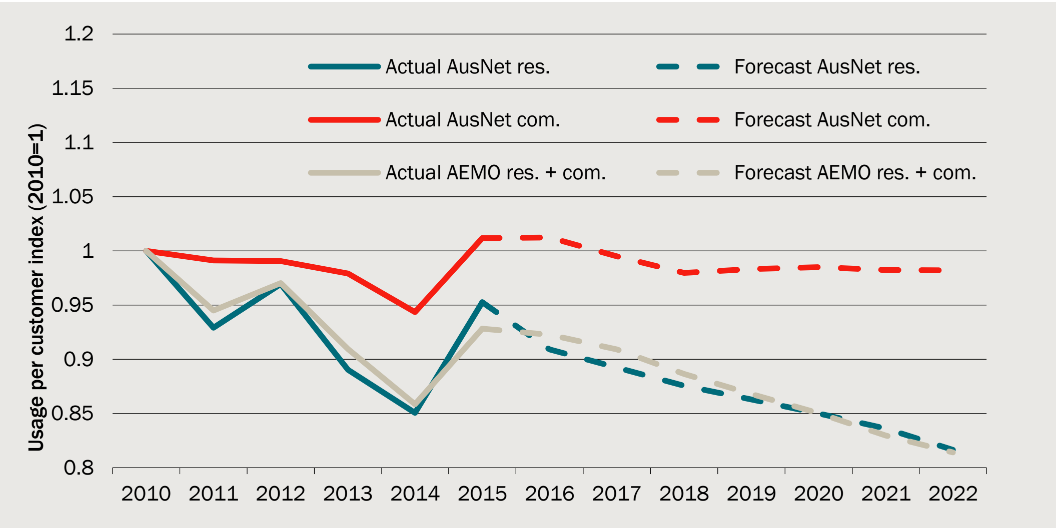
Data source: CIE.

Comparison of forecasts to other sources

AEMO does not produce forecasts of Victorian commercial usage separately from residential usage. Given that residential usage is a much larger component of total usage than commercial usage (for AusNet Services' network, residential usage was 84 per cent of total usage in 2015), it is not appropriate to compare our forecasts of commercial usage with AEMO's forecasts of total residential and commercial usage. However, it is illustrative to compare the sum of our residential and commercial usage forecasts with AEMO's forecast of residential and commercial usage.

Chart 8.11 presents this comparison of our usage per customer forecasts to AEMO's forecasts. It shows that both historical and forecast usage per commercial customer is not comparable to Victoria-wide residential and commercial usage per customer in that it declines more slowly. Since AusNet Services historical usage per commercial customer is much flatter than AEMO's measure of usage per residential and commercial customer, it is appropriate that CIE forecasts of usage per commercial customer are also flatter.

8.11 Comparison of AusNet Services commercial and total usage forecasts to AEMO forecasts – without appliance switching adjustment

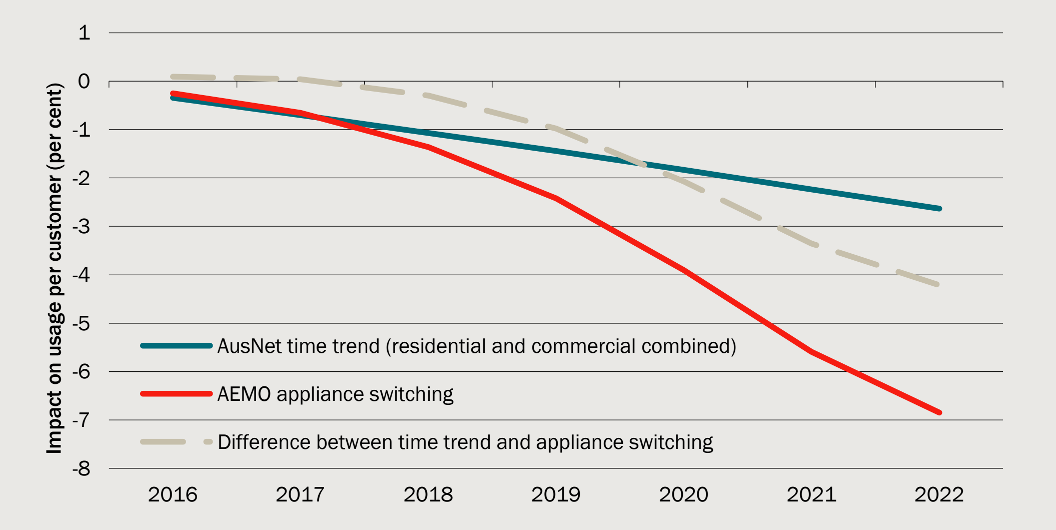


Note: These measures of usage per customer do not include the appliance switching adjustment.
Data source: CIE, *AEMO National Gas Forecasting Report 2015*.

Appliance switching adjustment

In the NGFR 2015 AEMO does not present the magnitude of the impact of their adjustment for appliance switching of commercial customers only. We can compare AEMO's adjustment for appliance switching (which is applied to residential and commercial usage per customer) to the impact of our estimated time trends for residential and commercial usage combined. It shows that the combined effect of the residential and commercial time trends is smaller in magnitude than AEMO's appliance switching adjustment.

8.12 Comparison of residential and commercial combined time trend and AEMO appliance switching adjustment



Data source: CIE.

We make the same appliance switching adjustment to forecasts of usage per commercial customer as were made to forecasts of usage per residential customer (see table 6.11). AEMO notes that 97 per cent of tariff V customers are residential.[29] However, the appliances used by commercial customers are expected to, much like residential customers, gradually be replaced with non-gas appliances. On this basis we make the same adjustment as AEMO makes to forecasts of usage per commercial customer.

29 AEMO, 2015, *Forecasting Methodology Information Paper – National Gas Forecasting Report 2015*, p.27.

9 *Tariff D and M*

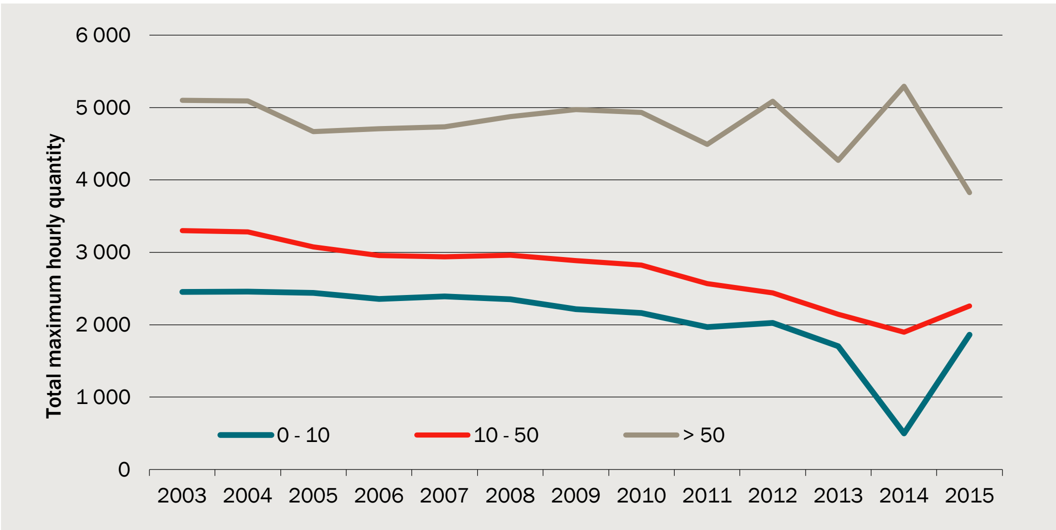
In this chapter we produce forecasts of maximum hourly quantity for tariff D and M customers using projections of Total tariff D system demand produced by AEMO.[30]

Descriptive analysis

AusNet Services has provided data on the daily consumption of tariff D customers from 2010-2016. Additionally, data has been supplied on the total annual MHQ of Tariff D and Tariff M customers from 2003-2016.

Chart 9.1 presents total Maximum Hourly Quantity (MHQ) by block for tariff D customers. Total MHQ for tariff D customers is gradually declining.

9.1 Total Maximum Hourly Quantity by block – Tariff D

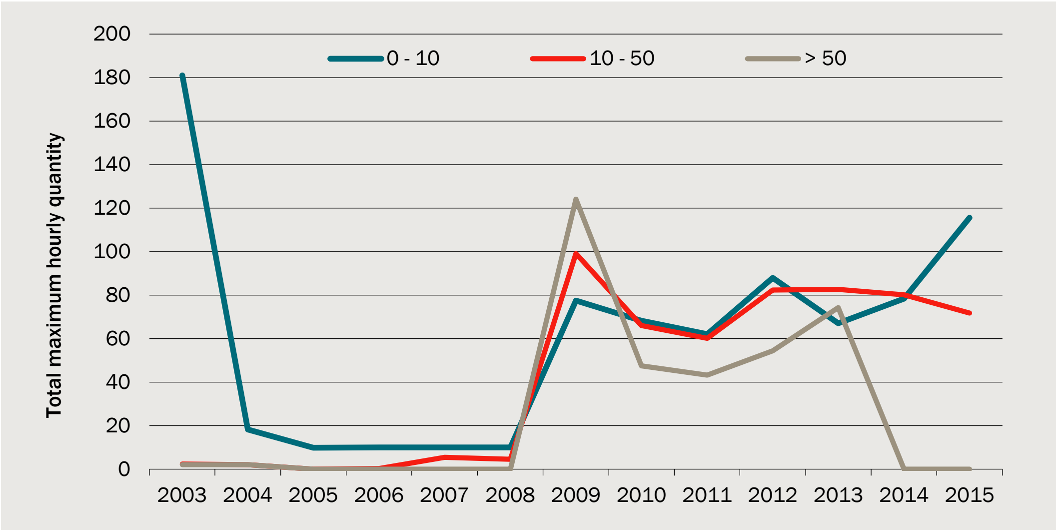


Data source: CIE.

Chart 9.2 shows total MHQ for tariff M customers. Total MHQ is extremely variable for tariff M customers, however the quantity is small relative to tariff D.

30 AEMO 2016, *National Gas Forecasting Report 2015*, supplementary data files.

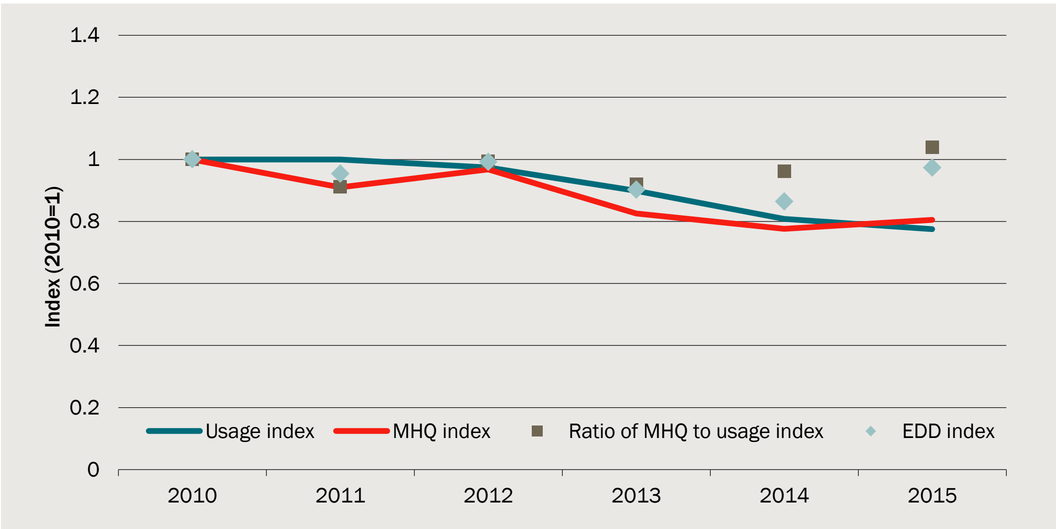
9.2 Total Maximum Hourly Quantity by block – Tariff M



Data source: CIE.

In applying the same rate of change of total tariff D system demand/usage to forecast MHQ, we assume that the rate of change of usage is the same as the rate of change of MHQ. Chart 2.3 shows indexes of usage and MHQ. The dots in grey show the ratio of MHQ to usage, and illustrate that there is no discernible trend change in the ratio between these indexes. The only discernible pattern is that the ratio of MHQ to usage tends to be correlated with EDD. However, there are insufficient data points of Tariff D usage to enable statistical estimation of this relationship. Further, the AEMO usage is weather-normalised[31] so a further adjustment is not necessary.

9.3 Indexes of MHQ and tariff D usage since 2010



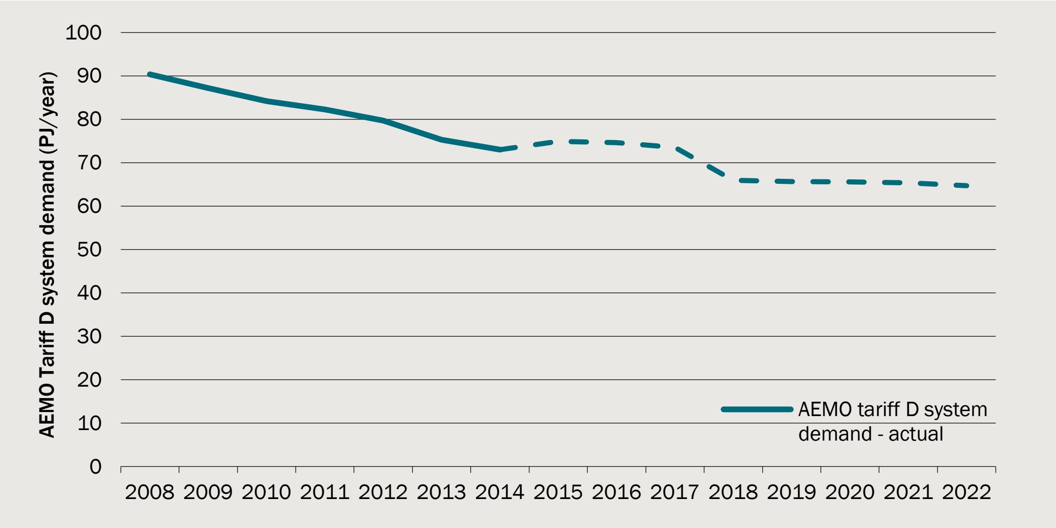
Data source: CIE.

31 AEMO, 2015, *Forecasting Methodology Information Paper – National Gas Forecasting Report 2015*, p.18

Thus we conclude it is appropriate to project MHQ for tariff D and M using the AEMO projections of total tariff D usage.

Chart 9.4 presents the AEMO tariff D system usage projections that drive our forecasts of MHQ. We use the forecasts based on AEMO's medium economic growth scenario.

9.4 AEMO Tariff D system demand actuals and forecasts



Data source: AEMO, CIE.

Adjustments to account for closure of large business customers

Two large businesses are projected to close in the short term.

- Ford - 136GJ MHQ, 0.7 per cent of Tariff D/M demand
- Toyota - 214GJ MHQ, 1.1 per cent of Tariff D/M demand

Closures of this magnitude are not drastically different relative to the size of past closures. In the four most recent years of closure data available (2011-2014), between the gross decrease in MHQ associated with closures/disconnections ranged between 1-4 per cent. That is, between 1-4 per cent of MHQ in these years was associated with customers no longer connected in the following year.

AEMO's projections of Tariff D consumption explicitly account for the closure of automobile manufacturing in 2017-2018 in Victoria.[32] Therefore, the effect of the closure of these businesses is accounted for in our forecasts of Tariff D MHQ to the extent that the closure affects AEMO system-wide Tariff D consumption.

However, this approach may understate the effect of the closure on AusNet, since two of the largest closures (Toyota and Ford) are within the AusNet Services area. Thus, the effect of the closures on AEMO system-wide usage will be smaller than the effect on AusNet Services tariff D usage. This source of error is counteracted by closures that are

32 AEMO, 2015, *Forecasting Methodology Information Paper – National Gas Forecasting Report 2015*, p.23.

occurring outside the AusNet Services area (such as the Holden engine plant in Port Melbourne[33] or non-manufacturing large customers).

Thus, we have chosen not to make a separate adjustment for the closure of Toyota and Ford. Their closure is already accounted for in AEMO's projections of system-wide tariff D consumption that drive our forecasts of MHQ.

Forecasts of Tariff D and M Maximum Hourly Quantity

Our projections of MHQ for tariff D and tariff M customers are presented in table 9.5.

9.5 Projections of Tariff D and M Maximum Hourly Quantity

Region/ Block	Unit	2015	2016	2017	2018	2019	2020	2021	2022
		Actual	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast
Tariff D - AusNet Services									
0 - 10	GJ	1 842	2 022	1 959	1 850	1 794	1 842	1 834	1 808
10 - 50	GJ	2 224	2 442	2 366	2 234	2 167	2 224	2 215	2 183
> 50	GJ	3 826	4 201	4 070	3 844	3 727	3 826	3 811	3 755
Tariff M - AusNet Services Central									
0 - 10	GJ	97	106	103	97	94	97	96	95
10 - 50	GJ	47	51	50	47	45	47	46	46
> 50	GJ	0	0	0	0	0	0	0	0
Tariff M - AusNet Services West									
0 - 10	GJ	19	21	20	19	18	19	19	18
10 - 50	GJ	25	28	27	25	25	25	25	25
> 50	GJ	0	0	0	0	0	0	0	0
Tariff D - AusNet Services New Town West & Central									
0 - 10	GJ	19	21	20	19	18	19	19	18
10 - 50	GJ	34	37	36	34	33	34	34	33
> 50	GJ	0	0	0	0	0	0	0	0
Tariff M - AusNet Services New Town Central									
0 - 10	GJ	0	0	0	0	0	0	0	0
10 - 50	GJ	0	0	0	0	0	0	0	0
> 50	GJ	0	0	0	0	0	0	0	0

33 News.com.au, 2013, *Holden to end car manufacturing in Australia and import cars*, 12th December 2013, available at: http://www.news.com.au/finance/business/holden-to-end-car-manufacturing-in-australia-and-import-cars/story-fnda1bsz-1226781056615

Region/ Block	Unit	2015	2016	2017	2018	2019	2020	2021	2022
		Actual	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast	Forecast
Tariff M - AusNet Services New Town West									
0 - 10	GJ	0	0	0	0	0	0	0	0
10 - 50	GJ	0	0	0	0	0	0	0	0
> 50	GJ	0	0	0	0	0	0	0	0

Source: CIE.

10 Risks and sensitivity

This chapter examines the risks associated with forecasts of usage. It presents sensitivity analysis concerning variation in EDD, gas prices and fuel/appliance switching scenarios. We show the sensitivity of measures of a constant-price revenue (using prices at 2015) from residential and commercial customers.

Effective degree days

We examine the sensitivity of model results to two types of variation in EDDs:

- Changes in the level of EDDs over 2018-2022
- Changes in the trend in EDDs from 2016 onwards.

Changes in the level of EDDs

We consider the sensitivity of results to a series of colder or warmer years. That is, this analysis varies the level of EDDs to be either higher or lower for the 5 years between 2018-2022. Table 10.1 presents actual and trend estimates of EDDs from 1996-2015. It shows the ratio of average EDDs for each 5-year block (e.g. 1996-2000) to the average trend EDD estimate. This indicates the degree to which that 5-year period was above or below-trend. It indicates that the most extreme observation out of the 4-available blocks is 2001-2005 which was approximately 3 per cent below-trend.

10.1 Actual and trend EDDs from 1996-2015

Year	EDD	Trend	Ratio of average EDD to average trend EDD
1996	1 977	1 838	
1997	1 820	1 824	
1998	1 838	1 811	**0.99**
1999	1 663	1 797	
2000	1 697	1 783	
2001	1 743	1 770	
2002	1 636	1 756	
2003	1 787	1 743	**0.97**
2004	1 743	1 729	
2005	1 534	1 716	
2006	1 788	1 702	**1.01**
2007	1 543	1 688	

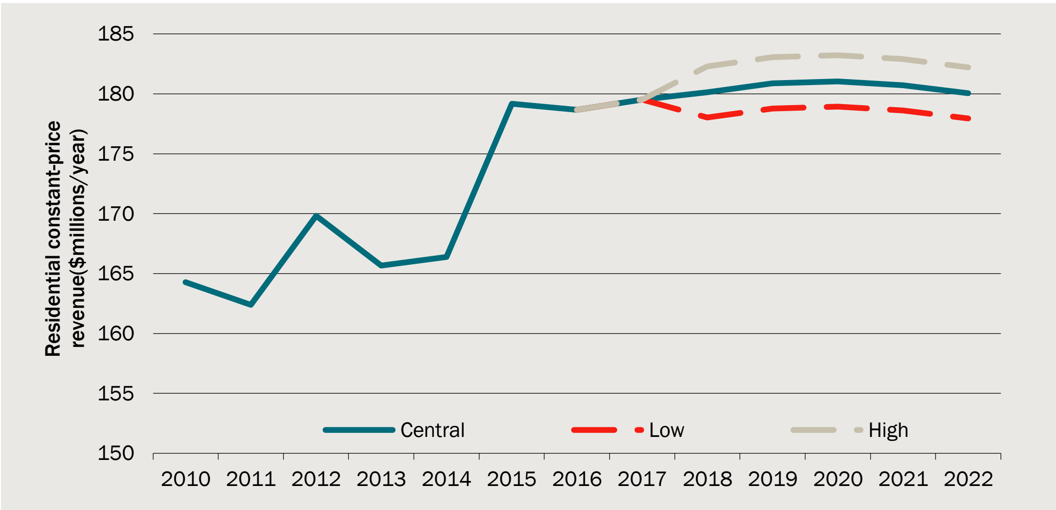
Year	EDD	Trend	Ratio of average EDD to average trend EDD
2008	1 726	1 675	
2009	1 634	1 661	
2010	1 741	1 648	
2011	1 661	1 634	
2012	1 727	1 620	
2013	1 570	1 607	**1.02**
2014	1 505	1 593	
2015	1 695	1 580	

Source: CIE.

While this sample is not sufficient to draw strong conclusions about the distribution of EDDs, it indicates that a deviation of EDDs of at least 3 per cent in either direction has a probability of ¼.

Chart 10.2 shows the change in total revenue associated with projections of EDDs that are 3 per cent below ('low') and above ('high') the trend level forecast ('central'). The total difference in revenue for EDD levels that are 3 per cent above or below trend for 5 years is approximately $11million over 5 years.

10.2 Sensitivity analysis of total constant-price revenue to level shifts in EDDs



Note: These forecasts include a post-modelling adjustment for appliance switching.

Data source: CIE.

Changes in the projected EDD trend

Secondly, we consider the sensitivity of forecasts of usage per customer to alternative weather trend projections by producing forecasts under three scenarios:

1 Central: -8.4 EDD/year trend decline

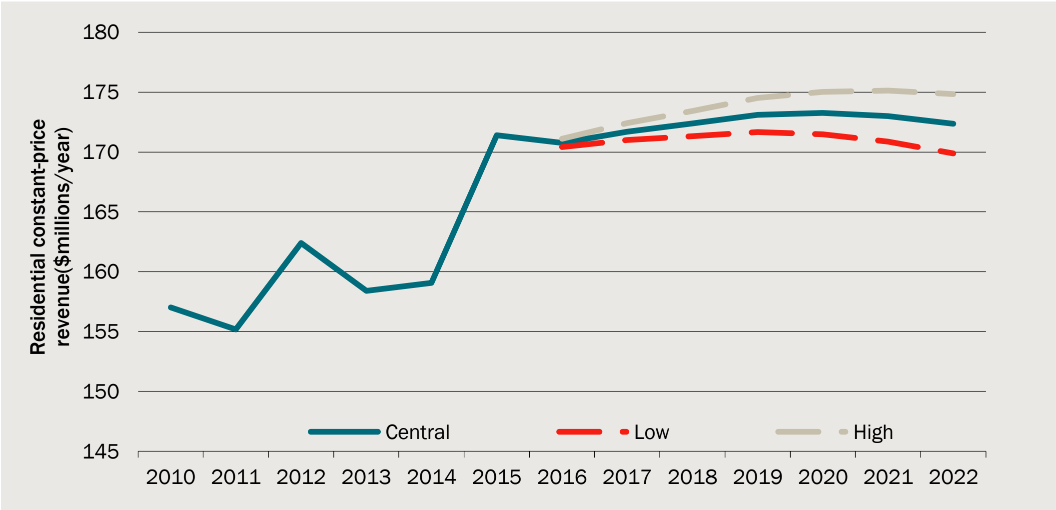
2 Low: -16.8 EDD/year trend decline

3 High: No trend decline in EDD.

Central, low and high refer to central, low and high estimates of EDD. The assumption of the high scenario that there is no trend decline in EDD replicates the assumption made by the AEMO National Gas Forecasting Report (2015).

Chart 10.3 presents residential constant-price revenue forecasts under the three EDD scenarios. Revenue is moderately sensitive to the choice of projection, with the difference in revenue between the high and low projections being approximately 3 per cent ($5 million/year).

10.3 Sensitivity analysis of residential constant-price revenue to shifts in EDD trend

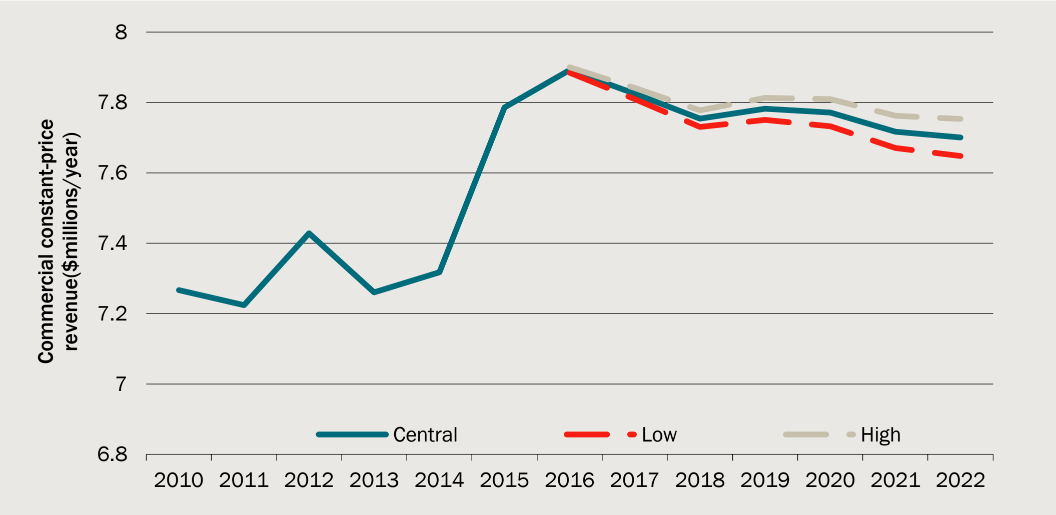


Note: These forecasts include a post-modelling adjustment for appliance switching.

Data source: CIE.

Chart 10.4 presents commercial constant-price revenue forecasts under the three EDD scenarios.Commercial demand is relatively insensitive to the choice of projection, with the difference in revenue between the high and low projections being approximately 1.4 per cent of revenue. Commercial revenue is less sensitive than residential revenue due to the smaller estimated coefficients on the EDD variable in the models.

10.4 Sensitivity analysis of commercial constant-price revenue to EDD scenarios



Note: These forecasts include a post-modelling adjustment for appliance switching.
Data source: CIE.

Gas prices

We consider the sensitivity of forecasts of usage per customer by producing forecasts under three scenarios of residential real gas prices. These scenarios correspond to the low, medium and high consumption scenarios used by AEMO in the 2015 NGFR.[34] They are as follows:

1 Central: This corresponds to the medium gas price scenario from the NGFR 2015.

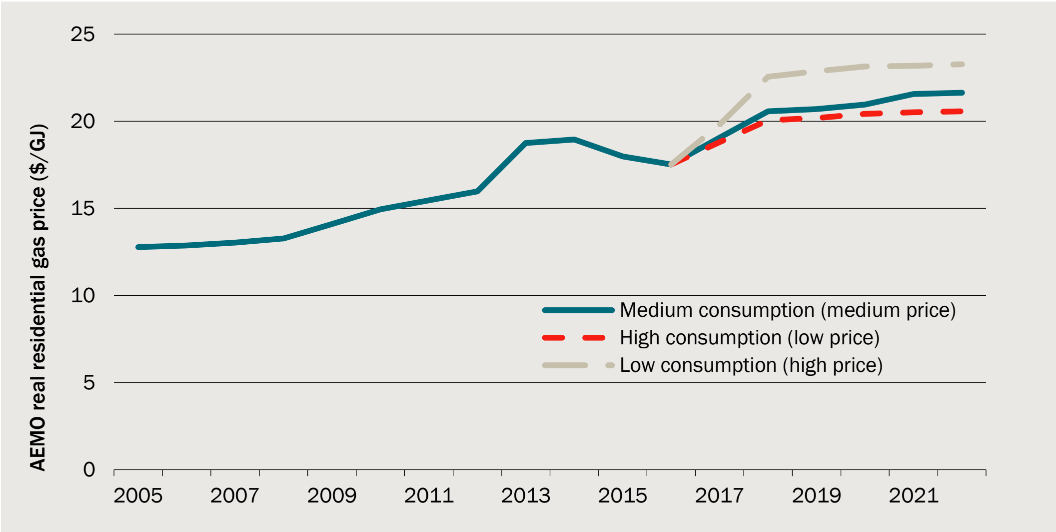
2 Low price (high consumption): This corresponds to the high consumption residential gas price scenario from the NGFR 2015.

3 High price (low consumption): This corresponds to the low consumption residential gas price scenario from the NGFR 2015.

Chart 10.5 presents the gas price scenarios used in this sensitivity analysis.

34 The datafile for the NGFR 2015 is available at: https://www.aemo.com.au/Gas/National-planning-and-forecasting/-/media/E7322F2A23CA417ABFB6CEE85F87330A.ashx

10.5 Gas price scenarios used in sensitivity analysis

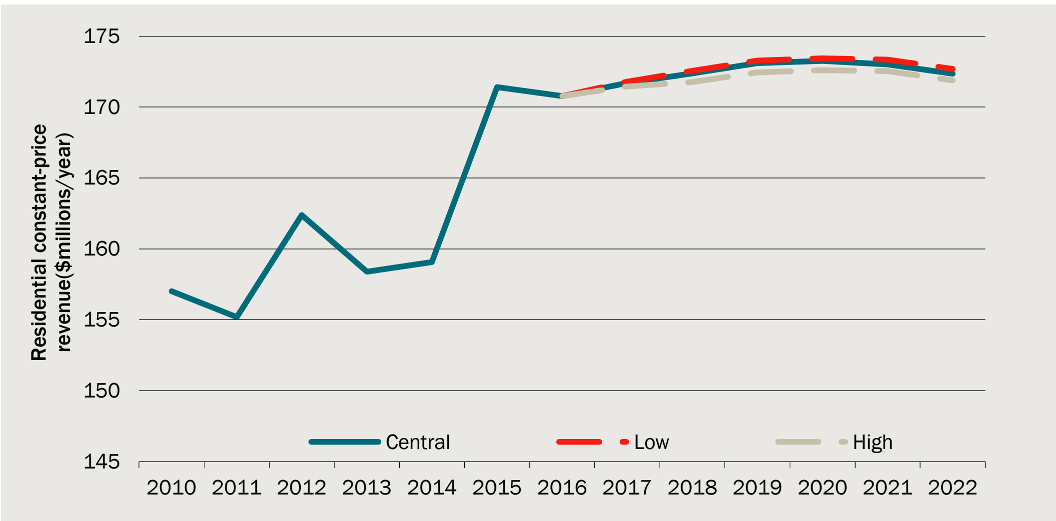


Note: These forecasts include a post-modelling adjustment for appliance switching.

Data source: AEMO *National Gas Forecasting Report 2015*.

Chart 10.6 presents residential constant-price revenue forecasts under the three gas price scenarios. Alternative gas price projections have a negligible impact on forecast revenue from residential customers.

10.6 Sensitivity analysis of residential constant-price revenue to gas price scenarios

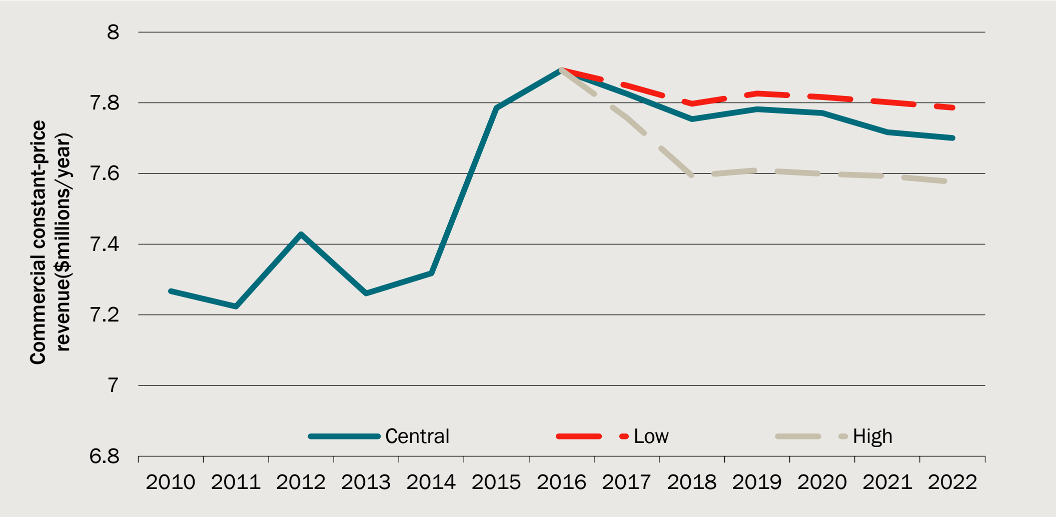


Note: These forecasts include a post-modelling adjustment for appliance switching.

Data source: CIE.

Chart 10.7 presents commercial constant-price revenue forecasts under the three gas price scenarios. Revenue is more sensitive to the alternate projections of gas prices. Forecasts produced using the high price scenario display a sharp fall in revenue between 2016-2018, after which revenue grows at a similar rate to the other scenarios.

10.7 Sensitivity analysis of commercial constant-price revenue to gas price scenarios



Note: These forecasts include a post-modelling adjustment for appliance switching.

Data source: CIE.

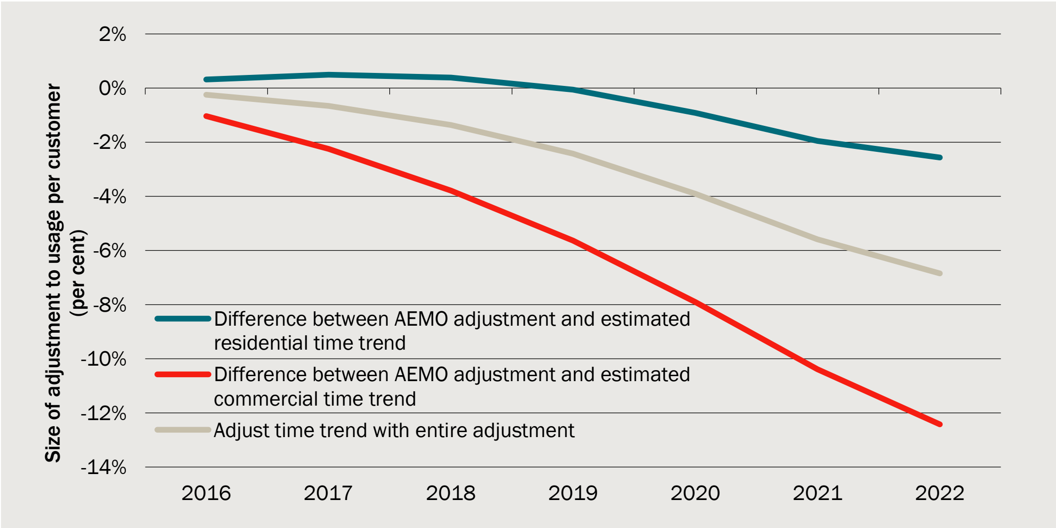
Fuel switching

We consider the effect of post-modelling adjustments for appliance switching on our forecasts of usage per customer and constant-price revenue. We consider 3 options for modelling appliance switching:

1. None: We make no fuel-switching post-modelling adjustment, with appliance switching being modelled only insofar as it is accounted for by other variables such as price and the time trend.
2. AEMO adjustment, remove time trend: We adjust residential and commercial usage (excluding fixed revenue per customer) by full amount of AEMO appliance switching adjustment and discontinue CIE estimated time trends in usage per customer. This method assumes that the CIE estimated time trends are only capturing historical appliance switching, and thus rather than projecting a continuation of this level of appliance switching, instead we assume the same per cent adjustment for appliance switching as AEMO.
3. AEMO adjustment: We adjust residential and commercial usage (excluding fixed revenue per customer) by the full amount of the AEMO appliance switching adjustment. This is the approach we use for our forecasts of tariff V demand presented throughout this report.

Chart 10.8 shows the size of the adjustments made under these scenarios. Option 2 corresponds to the adjustments shown in the teal and red series for residential and commercial usage respectively. Option 3 corresponds to the full adjustment shown by the grey series.

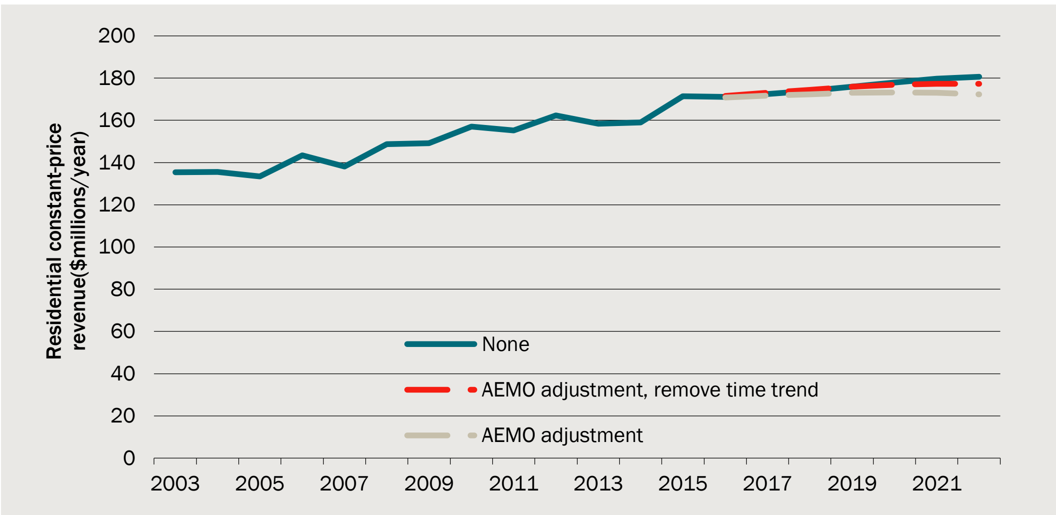
10.8 Post-modelling adjustments for appliance switching



Data source: CIE, AEMO *National Gas Forecasting Report 2015*.

Chart 10.9 presents a comparison of residential constant-price revenue forecasts under these three options. Option 2 (use AEMO adjustment and remove CIE time trend) has a significant effect on revenue, however Option 3 has a larger negative effect. At 2022 the difference in revenue is 1.8 per cent and 4.6 per cent for each adjustment option respectively.

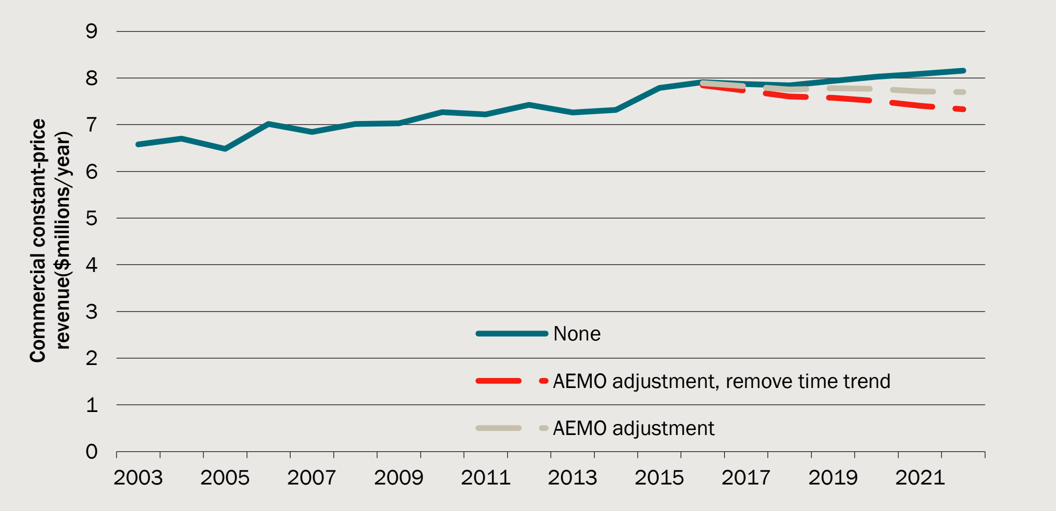
10.9 Sensitivity analysis of residential constant-price revenue to difference fuel switching adjustments



Data source: CIE.

Chart 10.10 presents a comparison of commercial constant-price revenue forecasts under these three adjustment options. Similarly to residential demand, these adjustments have large effects on constant-price revenue. Constant price revenue is 10.2 per cent and 5.6 per cent lower under options 2 and 3 respectively. The second option yields lower forecasts than the third option because the time trend estimated for commercial usage per customer is constrained to be positive in our models. Thus, removing the time trend has a downward effect on the forecasts.

10.10 Sensitivity analysis of commercial constant-price revenue to difference fuel switching adjustments



Data source: CIE.

It is not plausible that the time trends we estimate only account for appliance switching and no other variables, given that other variables such as energy efficiency are changing over time. This assumption is implicit in removing the time trends to make post-modelling adjustments for appliance switching. Thus it is not appropriate to remove the time trend in order to make a post-modelling adjustment for appliance switching.

It is potentially the case that the time trend does not account for any appliance switching. However, appliance switching may also be accounted for the estimated relationship between price and demand in our models. Therefore it is likely that our models are accounting for some amount of appliance switching, and that making AEMO's full adjustment will overstate the effect of customers substituting away from gas appliances.

AEMO make this adjustment for appliance switching to models that also include time trends and price relationships, therefore these effects will likely also be present in their forecasts. We have made the same appliance switching adjustment as AEMO in the forecasts presented in this report.

A Projections of customers by postcode

Chapter 5 and 7 discussed forecasts of customer numbers at the aggregate level and in LGAs. This appendix breaks these customer numbers down into postcodes.

Methodology: residential customers

For postcodes, customer numbers from 2002 to 2016 are contained in AusNet Services' billing database.

To generate forecasts at the postcode level we take the following steps.

- In 2016, we allocate customer numbers in each postcode to 'sub-areas' which are the areas in each postcode in different LGAs. This is done with concordance tables provided by the ABS (Cat. 1270.055).
- For example the postcode 3012 (West Footscray) is spread across 3 LGAs: 0.02 per cent of it is in Brimbank, 7.06 per cent of it is in Hobsons Bay and 92.92 per cent of it is in Maribyrnong. In 2016 there were 111 residential customers in postcode 3012. These 111 customers are allocated to the sub areas: 3022_Brimbank, 3022_Hobson's Bay and 3022_Maribyrnong, using the stated proportions.
- We grow customer numbers in each sub-area at the same percentage rate as the relevant LGA. For example, from 2017 to 2022, customer numbers in the sub-area 3022_Maribrynong grow in line with customer numbers in Maribyrnong.
- From 2017 to 2022, the number of residential customer numbers in each postcode is the sum across the relevant sub-areas. For example, the number of customers in postcode 3022 is the sum of customers in 3022_Brimbank, 3022_Hobson's Bay and 3022_Maribyrnong.
- Projections for occupied private dwellings in LGAs provided by the Victorian Government imply different LGAs are growing at different rates. In this project, we have assumed that growth within LGAs is even. This implies that within postcodes, the importance of sub-areas (in terms of their size and contribution to the total postcode) is changing. Our approach picks up these changes.

Methodology: commercial customers

Our approach for commercial customers is the same as for residential customers.

A.1 Total customer numbers

	2015	2016	2017	2018	2019	2020	2021	2022
Total	649 446	661 310	674 846	689 021	703 401	718 033	732 958	747 355
Residential	633 043	644 727	658 107	672 119	686 333	700 796	715 549	729 781
Commercial	16 403	16 583	16 739	16 902	17 068	17 237	17 409	17 575

Source: CIE.

A.2 Residential customer numbers in existing areas (by postcode)

	2015	2016	2017	2018	2019	2020	2021	2022
3008	14	12	12	12	12	12	12	12
3011	6 697	6 724	6 902	7 086	7 275	7 471	7 674	7 881
3012	9 279	9 390	9 623	9 864	10 113	10 370	10 636	10 907
3013	5 763	5 806	5 960	6 118	6 282	6 451	6 626	6 805
3015	6 838	6 819	6 844	6 870	6 896	6 922	6 949	6 979
3016	5 733	5 733	5 754	5 776	5 798	5 820	5 842	5 867
3018	5 128	5 161	5 180	5 200	5 219	5 239	5 259	5 282
3019	3 066	3 129	3 212	3 297	3 386	3 477	3 571	3 667
3020	15 338	15 544	15 667	15 792	15 918	16 046	16 175	16 279
3021	18 875	18 924	19 074	19 226	19 379	19 535	19 692	19 818
3022	1 257	1 166	1 175	1 185	1 194	1 204	1 213	1 221
3023	19 652	19 844	20 270	20 713	21 173	21 651	22 148	22 682
3024	7 591	7 802	8 014	8 234	8 462	8 700	8 947	9 166
3025	4 733	4 783	4 801	4 819	4 837	4 856	4 874	4 895
3026	18	18	18	19	19	20	20	21
3027	1 955	2 171	2 230	2 291	2 354	2 420	2 488	2 548
3028	11 097	11 161	11 203	11 246	11 290	11 334	11 379	11 428
3029	28 418	29 536	30 334	31 164	32 026	32 922	33 854	34 671
3030	32 800	33 924	34 791	35 691	36 626	37 598	38 607	39 490
3031	6 125	6 113	6 118	6 124	6 129	6 133	6 138	6 145
3032	9 307	9 400	9 528	9 660	9 795	9 935	10 079	10 223
3033	5 514	5 569	5 597	5 626	5 654	5 684	5 713	5 742
3034	4 487	4 485	4 508	4 531	4 554	4 577	4 601	4 624
3036	2 026	2 031	2 048	2 065	2 082	2 100	2 117	2 132
3037	15 882	15 983	16 336	16 702	17 083	17 479	17 891	18 336
3038	9 143	9 190	9 263	9 336	9 411	9 487	9 563	9 624
3039	5 185	5 199	5 225	5 252	5 279	5 306	5 334	5 360
3040	9 247	9 370	9 417	9 465	9 514	9 563	9 613	9 660
3041	4 378	4 443	4 465	4 488	4 511	4 534	4 558	4 581
3042	6 529	6 582	6 619	6 656	6 693	6 731	6 770	6 805
3043	7 095	7 109	7 303	7 503	7 709	7 921	8 140	8 349
3044	10 616	10 764	10 912	11 063	11 217	11 374	11 533	11 659
3045	0	0	0	0	0	0	0	0

	2015	2016	2017	201 8	2019	2020	2021	2022
3046	13 093	13 366	13 550	13 738	13 929	14 123	14 321	14 478
3047	7 066	7 133	7 346	7 566	7 793	8 026	8 266	8 501
3048	5 740	5 746	5 918	6 095	6 277	6 465	6 659	6 848
3049	3 318	3 363	3 464	3 567	3 674	3 784	3 897	4 008
3055	216	214	217	220	223	226	229	232
3058	12 718	12 849	13 026	13 206	13 389	13 576	13 766	13 916
3059	4 312	4 672	4 812	4 956	5 104	5 257	5 414	5 568
3060	4 943	4 988	5 058	5 129	5 202	5 276	5 351	5 411
3061	1 650	1 646	1 695	1 746	1 798	1 852	1 908	1 962
3062	1	1	1	1	1	1	1	1
3064	20 634	21 819	22 473	23 147	23 841	24 557	25 294	26 013
3073	3	3	3	3	3	3	3	3
3212	5 098	5 174	5 280	5 389	5 500	5 612	5 727	5 837
3214	10 278	10 363	10 577	10 795	11 016	11 242	11 471	11 692
3215	8 469	8 588	8 766	8 946	9 130	9 317	9 507	9 690
3216	21 270	21 466	21 917	22 377	22 844	23 319	23 802	24 272
3217	1 132	1 618	1 651	1 685	1 720	1 755	1 791	1 826
3218	5 806	5 813	5 933	6 055	6 180	6 306	6 435	6 559
3219	8 998	8 955	9 140	9 328	9 520	9 715	9 913	10 104
3220	6 743	6 785	6 925	7 068	7 213	7 361	7 511	7 655
3221	4	4	4	4	4	4	4	5
3222	4 935	5 113	5 219	5 326	5 436	5 547	5 660	5 769
3223	3 891	4 059	4 143	4 228	4 315	4 403	4 493	4 580
3224	4 832	5 018	5 122	5 227	5 335	5 444	5 555	5 662
3225	3 182	3 219	3 214	3 208	3 203	3 199	3 194	3 152
3226	6 547	6 706	6 845	6 986	7 129	7 275	7 423	7 566
3227	1 434	1 515	1 548	1 581	1 615	1 650	1 685	1 720
3228	6 498	6 760	7 047	7 340	7 640	7 945	8 256	8 634
3249	0	0	0	0	0	0	0	0
3250	4 430	4 464	4 727	4 990	5 253	5 517	5 782	6 220
3260	948	971	970	968	967	965	964	981
3266	598	595	593	592	590	589	587	597
3277	263	268	277	286	294	303	312	321
3280	12 776	12 853	12 978	13 105	13 233	13 364	13 495	13 601
3282	584	599	641	684	727	771	815	859
3284	1 162	1 222	1 308	1 396	1 484	1 573	1 662	1 753
3300	3 785	3 783	3 783	3 782	3 782	3 782	3 781	3 781
3305	4 453	4 439	4 446	4 453	4 460	4 466	4 473	4 478
3335	835	1 192	1 231	1 272	1 314	1 358	1 405	1 457
3337	12 759	12 984	13 408	13 851	14 313	14 795	15 299	15 865
3338	7 820	8 244	8 513	8 794	9 087	9 394	9 714	10 073
3340	6 922	7 119	7 322	7 531	7 745	7 965	8 192	8 433

	2015	2016	2 017	2018	2019	2020	2021	2022
3342	943	969	997	1 025	1 054	1 084	1 115	1 148
3350	24 917	25 406	26 068	26 742	27 430	28 132	28 847	29 557
3352	1 494	1 535	1 576	1 618	1 662	1 706	1 751	1 797
3355	5 997	5 925	6 079	6 237	6 397	6 561	6 728	6 893
3356	6 914	7 118	7 303	7 492	7 685	7 882	8 082	8 281
3357	1 147	1 164	1 194	1 225	1 257	1 289	1 322	1 355
3363	860	880	895	910	925	941	956	974
3364	14	14	14	15	15	15	15	16
3377	2 977	3 000	3 062	3 124	3 186	3 248	3 310	3 207
3380	2 333	2 338	2 338	2 339	2 339	2 340	2 340	2 340
3400	6 071	6 125	6 182	6 239	6 296	6 354	6 413	6 466
3401	4	4	4	4	4	4	4	4
3427	768	871	899	928	959	990	1 023	1 059
3429	12 857	12 990	13 378	13 779	14 191	14 616	15 054	15 481
3431	688	724	753	782	811	842	873	902
3434	991	1 037	1 078	1 120	1 162	1 206	1 250	1 292
3435	433	449	467	485	503	522	541	560
3437	1 963	2 091	2 174	2 258	2 344	2 431	2 521	2 606
3438	417	430	447	464	482	500	518	536
3440	321	316	328	341	354	367	381	394
3441	103	115	120	124	129	134	139	143
3442	1 232	1 264	1 314	1 365	1 417	1 470	1 524	1 575
3444	2 208	2 238	2 323	2 409	2 497	2 587	2 678	2 766
3450	3 380	3 372	3 407	3 443	3 479	3 516	3 553	3 590
3451	912	954	964	974	984	995	1 005	1 016
3460	1 612	1 620	1 647	1 674	1 702	1 730	1 758	1789
3461	533	545	554	564	574	583	593	604
3464	368	371	374	378	381	384	388	391
3465	3 554	3 579	3 611	3 644	3 677	3 709	3 743	3 773
3550	18 252	18 342	18 850	19 368	19 897	20 437	20 987	21 497
3551	5 435	5 869	6 030	6 195	6 362	6 533	6 708	6 871
3555	8 553	8 588	8 826	9 069	9 316	9 569	9 827	10 065
3556	4 860	4 911	5 046	5 185	5 326	5 469	5 616	5 752
Total	**633 043**	**644 727**	**657 798**	**671 210**	**684 974**	**699 100**	**713 600**	**727 642**

Source: CIE.

A.3 Residential customers (ERP areas)

	2015	2016	2017	2018	2019	2020	2021	2022
3241	0	0	148	259	343	405	452	488
3331	0	0	0	368	644	851	1 007	1 123
3467	0	0	161	281	371	439	490	528
Total	**0**	**0**	**309**	**909**	**1 359**	**1 696**	**1 949**	**2 139**

A.4 Commercial customers (existing areas)

	2015	2016	2017	2018	2019	2020	2021	2022
3008	27	26	26	26	26	26	26	26
3011	420	423	427	431	434	439	443	447
3012	240	237	239	241	243	245	247	250
3013	146	147	148	150	151	152	154	155
3015	123	123	123	124	124	124	124	125
3016	202	199	199	200	200	201	201	202
3018	144	142	142	143	143	143	144	144
3019	101	99	100	101	102	103	104	105
3020	409	415	417	420	422	425	427	429
3021	219	224	225	227	228	229	231	232
3022	25	24	24	24	24	25	25	25
3023	249	258	263	269	274	280	286	293
3024	54	55	56	58	59	61	62	63
3025	134	125	125	126	126	126	126	127
3026	91	87	89	91	93	95	97	99
3027	5	5	5	5	5	6	6	6
3028	93	99	99	99	100	100	100	100
3029	281	302	309	317	324	332	341	348
3030	532	548	560	573	586	600	614	626
3031	243	241	241	241	241	242	242	242
3032	259	262	263	265	266	267	269	270
3033	82	80	80	80	81	81	81	81
3034	41	43	43	43	43	43	43	44
3036	33	34	34	34	35	35	35	35
3037	185	187	191	195	199	204	208	213
3038	88	89	90	90	91	91	92	92
3039	217	228	229	229	230	230	231	231
3040	222	221	221	222	222	223	224	224
3041	125	125	125	126	126	126	126	127
3042	211	212	213	213	214	214	215	216
3043	223	223	227	231	235	239	243	247
3044	123	127	128	129	130	131	132	133
3045	33	38	39	39	40	41	42	43
3046	193	195	197	198	200	201	203	204
3047	155	156	159	162	165	168	172	175
3048	58	60	61	62	64	65	66	67
3049	27	27	28	28	29	29	30	30
3055	3	3	3	3	3	3	3	3
3058	455	447	450	454	458	461	465	468

	2015	2016	2017	2018	2019	2020	2021	2022
3059	25	28	29	29	30	30	31	31
3060	90	91	92	92	93	94	95	95
3061	231	231	235	240	245	249	254	259
3062	15	15	15	16	16	16	17	17
3064	194	202	206	210	214	218	222	227
3073	0	0	0	0	0	0	0	0
3212	77	83	84	85	85	86	87	88
3214	187	189	191	193	194	196	198	200
3215	192	186	188	190	191	193	195	197
3216	374	388	392	396	400	404	408	412
3217	1	2	2	2	2	2	2	2
3218	228	222	224	226	228	231	233	235
3219	188	194	196	198	200	202	203	205
3220	674	682	688	695	702	708	715	722
3221	2	2	2	2	2	2	2	2
3222	73	80	81	82	82	83	84	85
3223	52	59	60	60	61	61	62	62
3224	70	74	75	75	76	77	78	78
3225	144	142	142	142	142	142	142	142
3226	132	135	136	138	139	140	142	143
3227	13	12	12	12	12	13	13	13
3228	97	118	121	125	128	132	135	140
3249	0	0	0	0	0	0	0	0
3250	206	212	215	218	221	224	227	233
3260	21	22	22	22	22	22	22	22
3266	24	24	24	24	24	24	24	24
3277	19	18	18	18	18	19	19	19
3280	500	493	494	496	497	499	500	502
3282	25	25	25	26	26	27	27	28
3284	58	61	62	63	64	65	66	67
3300	228	227	227	227	227	227	227	227
3305	209	210	210	210	210	210	210	210
3335	0	0	0	0	0	0	0	0
3337	186	184	190	196	203	209	217	225
3338	66	68	70	73	75	77	80	83
3340	143	145	147	149	151	153	156	158
3342	48	46	47	47	48	49	49	50
3350	1 310	1 326	1 335	1 344	13 53	1 362	1 372	1 381
3352	34	33	33	34	34	34	35	35
3355	263	264	266	268	269	271	273	275
3356	205	214	215	217	218	220	221	223
3357	36	38	38	39	39	39	39	40

	2015	2016	2017	2018	2019	2020	2021	2022
3363	40	44	44	44	44	44	45	45
3364	0	0	0	0	0	0	0	0
3377	172	169	170	170	171	172	173	171
3380	137	135	135	135	135	135	135	135
3400	309	301	302	302	303	304	304	305
3401	1	1	1	1	1	1	1	1
3427	9	9	9	10	10	10	10	11
3429	229	223	227	232	236	241	245	250
3431	12	13	13	13	13	14	14	14
3434	7	9	9	9	9	9	10	10
3435	8	7	7	7	7	7	7	8
3437	34	38	38	39	39	40	40	41
3438	6	10	10	10	10	10	11	11
3440	7	7	7	7	7	7	7	8
3441	0	0	0	0	0	0	0	0
3442	36	37	37	38	38	39	39	40
3444	235	235	238	240	243	246	249	251
3450	239	239	239	240	240	241	241	242
3451	22	24	24	24	24	24	24	24
3460	163	165	165	166	166	167	167	167
3461	45	45	45	45	45	46	46	46
3464	17	18	18	18	18	18	18	18
3465	192	187	187	188	188	189	189	189
3550	927	937	945	953	962	971	979	988
3551	59	62	63	63	64	64	65	66
3555	256	259	261	264	266	268	271	273
3556	130	128	129	130	131	133	134	135
Total	**16 403**	**16 583**	**16 735**	**16 892**	**17 052**	**17 217**	**17 386**	**17 550**

Source: CIE.

A.5 Commercial customers (ERP regions)

	2015	2016	2017	2018	2019	2020	2021	2022
3241	0	0	2	3	4	5	5	6
3331	0	0	0	4	8	10	12	13
3467	0	0	2	3	4	5	6	6
Total	**0**	**0**	**4**	**11**	**16**	**20**	**23**	**25**

Source: CIE.

B Dwelling growth projections used

Tables B.1 and B.2 contain the projections for occupied private dwellings the CIE used to project residential customer numbers.

B.1 Occupied private dwellings (by LGA)

	2006	2007	2008	2009	2010	2011
Ararat (RC)	4 670	4 674	4 679	4 683	4 687	4 692
Ballarat (C)	35 008	35 812	36 634	37 475	38 335	39 215
Brimbank (C)	59 783	60 829	61 892	62 975	64 076	65 196
Campaspe (S)	14 664	14 769	14 875	14 981	15 088	15 196
Central Goldfields (S)	5 527	5 557	5 587	5 617	5 647	5 677
Colac-Otway (S)	8 422	8 488	8 555	8 622	8 690	8 758
Corangamite (S)	6 799	6 790	6 782	6 773	6 764	6 756
Darebin (C)	54 334	54 974	55 621	56 277	56 939	57 610
Glenelg (S)	8 252	8 316	8 382	8 448	8 514	8 581
Golden Plains (S)	5 986	6 130	6 277	6 428	6 582	6 740
Greater Bendigo (C)	38 120	38 795	39 482	40 182	40 893	41 618
Greater Geelong (C)	81 187	82 558	83 953	85 371	86 813	88 279
Hepburn (S)	5 982	6 072	6 164	6 257	6 351	6 447
Hindmarsh (S)	2 670	2 643	2 616	2 590	2 563	2 537
Hobsons Bay (C)	33 358	33 567	33 778	33 989	34 202	34 417
Horsham (RC)	7 724	7 844	7 966	8 091	8 217	8 345
Hume (C)	50 409	51 687	52 998	54 341	55 719	57 132
Loddon (S)	3 398	3 389	3 379	3 370	3 361	3 351

	2006	2007	2008	2009	2010	2011
Macedon Ranges (S)	14 351	14 651	14 958	15 271	15 590	15 916
Maribyrnong (C)	27 207	27 787	28 380	28 985	29 603	30 235
Melbourne (C)	37 838	39 835	41 938	44 151	46 482	48 935
Melton (C)	27 611	29 403	31 311	33 343	35 506	37 810
Mitchell (S)	11 395	11 684	11 981	12 285	12 597	12 916
Moonee Valley (C)	45 151	45 121	45 091	45 061	45 031	45 001
Moorabool (S)	9 590	9 840	10 095	10 358	10 627	10 904
Moreland (C)	58 019	58 866	59 724	60 596	61 480	62 377
Mount Alexander (S)	7 306	7 393	7 481	7 570	7 660	7 752
Moyne (S)	6 101	6 158	6 216	6 273	6 332	6 391
Northern Grampians (S)	5 174	5 191	5 209	5 226	5 244	5 262
Pyrenees (S)	2 783	2 818	2 853	2 890	2 926	2 963
Queenscliffe (B)	1 385	1 389	1 394	1 399	1 403	1 408
Southern Grampians (S)	7 046	7 061	7 077	7 092	7 107	7 122
Surf Coast (S)	8 616	8 955	9 308	9 674	10 055	10 451
Warrnambool (C)	12 341	12 533	12 728	12 926	13 128	13 332
West Wimmera (S)	1 913	1 912	1 912	1 911	1 911	1 911
Whittlesea (C)	42 948	45 017	47 185	49 458	51 840	54 337
Wyndham (C)	40 407	43 385	46 581	50 013	53 698	57 655
Yarriambiack (S)	3 172	3 172	3 172	3 172	3 172	3 172
Total	**796 649**	**815 068**	**834 213**	**854 122**	**874 835**	**896 396**

Source: Victorian Government Department of Environment, Land, Water and Planning; ABS; National Housing Supply Council; CIE.

B.2 Occupied private dwellings (by LGA)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Ararat (RC)	4 692	4 689	4 673	4 674	4 669	4 668	4 666	4 663	4 661	4 658	4 656	4 660
Ballarat (C)	39 215	40 014	40 606	41 235	42 031	42 555	43 392	44 244	45 114	46 001	46 905	47 802
Brimbank (C)	65 196	66 075	66 591	67 230	67 985	68 701	69 553	70 416	71 289	72 174	73 069	73 787
Campaspe (S)	15 196	15 290	15 341	15 399	15 474	15 583	15 701	15 820	15 941	16 062	16 184	16 298
Central Goldfields (S)	5 677	5 722	5 744	5 777	5 810	5 840	5 879	5 918	5 957	5 996	6 036	6 072
Colac-Otway (S)	8 758	8 800	8 807	8 822	8 828	8 831	8 848	8 866	8 883	8 901	8 919	8 948
Corangamite (S)	6 756	6 751	6 736	6 721	6 715	6 708	6 709	6 711	6 713	6 714	6 716	6 708
Darebin (C)	57 610	58 615	59 359	60 175	61 207	62 129	63 198	64 285	65 390	66 515	67 659	68 602
Glenelg (S)	8 581	8 586	8 599	8 601	8 595	8 566	8 580	8 595	8 609	8 624	8 638	8 648
Golden Plains (S)	6 740	6 957	7 127	7 272	7 426	7 564	7 733	7 906	8 083	8 265	8 450	8 642
Greater Bendigo (C)	41 618	42 541	43 288	44 029	44 736	45 262	46 179	47 114	48 069	49 042	50 036	50 956
Greater Geelong (C)	88 279	89 688	90 910	92 482	94 106	95 606	97 238	98 896	100 584	102 300	104 045	105 727
Hepburn (S)	6 447	6 528	6 572	6 646	6 703	6 756	6 824	6 892	6 961	7 031	7 102	7 181
Hindmarsh (S)	2 537	2 520	2 505	2 492	2 483	2 464	2 449	2 434	2 420	2 405	2 391	2 373
Hobsons Bay (C)	34 417	34 843	35 237	35 679	36 154	36 605	37 031	37 461	37 897	38 337	38 783	39 277
Horsham (RC)	8 345	8 365	8 417	8 456	8 502	8 557	8 615	8 674	8 733	8 792	8 852	8 907
Hume (C)	57 132	58 497	59 895	61 332	63 307	65 212	67 201	69 251	71 363	73 539	75 782	77 967
Loddon (S)	3 351	3 343	3 339	3 329	3 322	3 312	3 313	3 313	3 314	3 315	3 316	3 315
Macedon Ranges (S)	15 916	16 277	16 591	16 978	17 329	17 648	17 997	18 354	18 717	19 087	19 465	19 826
Maribyrnong (C)	30 235	31 008	31 677	32 147	33 404	33 818	34 945	36 110	37 313	38 557	39 842	41 153
Melbourne (C)	48 935	50 850	55 895	59 703	62 223	66 250	69 848	73 641	77 641	81 857	86 302	89 081
Melton (C)	37 810	39 552	40 836	42 426	44 304	46 115	48 151	50 277	52 498	54 816	57 237	59 958
Mitchell (S)	12 916	13 348	13 761	14 111	14 635	14 955	15 512	16 091	16 691	17 313	17 959	18 967
Moonee Valley (C)	45 001	45 638	46 616	47 145	47 859	48 909	49 558	50 215	50 881	51 556	52 240	52 890
Moorabool (S)	10 904	11 342	11 659	11 972	12 319	12 654	13 002	13 360	13 728	14 106	14 495	14 909
Moreland (C)	62 377	63 752	64 692	65 746	67 376	68 647	69 916	71 208	72 524	73 864	75 229	76 308
Mount Alexander (S)	7 752	7 840	7 927	7 996	8 075	8 138	8 221	8 306	8 391	8 477	8 564	8 652

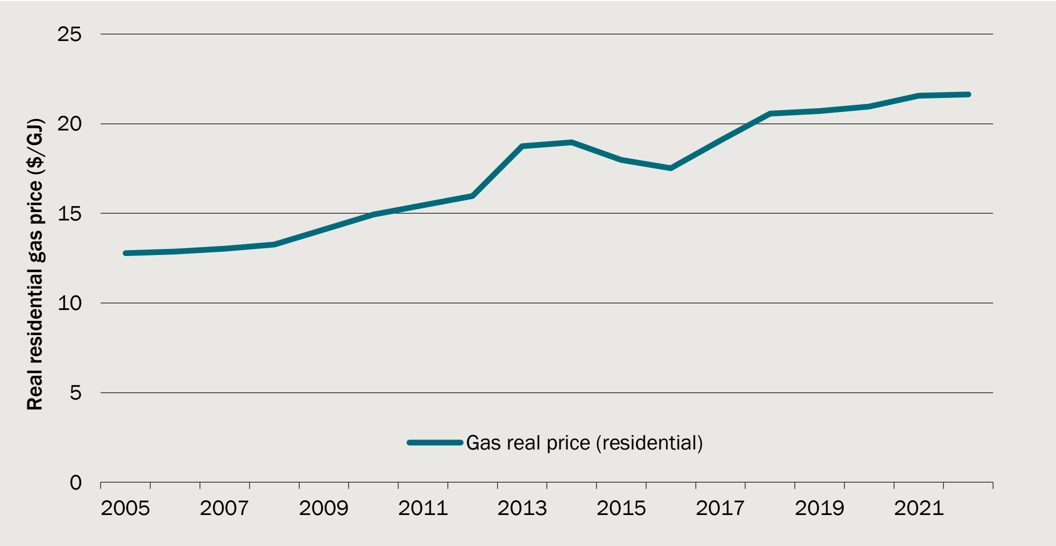
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Moyne (S)	6 391	6 465	6 526	6 562	6 619	6 653	6 715	6 777	6 840	6 904	6 968	7 032
Northern Grampians (S)	5 262	5 251	5 231	5 215	5 206	5 187	5 186	5 184	5 183	5 181	5 180	5 182
Pyrenees (S)	2 963	3 003	3 029	3 053	3 084	3 115	3 142	3 170	3 197	3 225	3 253	3 283
Queenscliffe (B)	1 408	1 404	1 395	1 395	1 392	1 388	1 391	1 394	1 397	1 400	1 403	1 412
Southern Grampians (S)	7 122	7 118	7 111	7 105	7 083	7 062	7 058	7 055	7 051	7 048	7 045	7 040
Surf Coast (S)	10 451	10 668	10 849	11 030	11 266	11 471	11 704	11 941	12 184	12 431	12 683	12 990
Warrnambool (C)	13 332	13 615	13 732	13 847	14 012	14 132	14 318	14 506	14 697	14 891	15 087	15 244
West Wimmera (S)	1 911	1 893	1 875	1 857	1 839	1 823	1 797	1 771	1 746	1 721	1 696	1 677
Whittlesea (C)	54 337	57 330	59 886	62 354	65 531	67 964	70 419	72 962	75 596	78 326	81 155	83 666
Wyndham (C)	57 655	60 958	63 469	66 489	69 912	73 843	76 757	79 785	82 933	86 204	89 605	92 586
Yarriambiack (S)	3 172	3 153	3 137	3 114	3 095	3 072	3 048	3 023	2 998	2 974	2 950	2 927
Total	**896 396**	**918 290**	**939 639**	**960 599**	**984 615**	**1 007 764**	**1 031 793**	**1 056 590**	**1 082 186**	**1 108 609**	**1 135 892**	**1 160 651**

Source: Victorian Government Department of Environment, Land, Water and Planning ; ABS; National Housing Supply Council; CIE.

C Gas price projection used

In this report we have used projections of real residential gas prices The source for this projection is AEMO 2016, *National Gas Forecasting Report 2015* (supplementary data files – provided to The CIE via email).Our models use calendar year variables as inputs. The projections of real residential gas prices are shown on chart C.1.

C.1 Projections of gas prices



Data source: AEMO, ESC, CIE.

D Historical and projected weather data

We have normalised data using annual effective degree days. As a cross-check, we have also checked system daily consumption against daily weather and tested the validity of the AEMO preferred effective degree day measure. The results from this cross-check are discussed in Chapter 3 of this report (see, for example, chart 3.2).

Effective degree days

Gas consumption data is typically normalised to represent consumption for a typical year. This occurs so that forecasting can be based on standard weather assumptions. In the past, this has been done using effective degree day formulas that comprise the deviation of temperature from some base level, wind and sunshine. The EDD formula used by AusNet Services is set out below.

$$EDD = \max(0, DD + Windchill - Insolation + Seasonality)$$

Where subcomponents are calculated according to the following formulae.

$$DD = max(0, 18 - \overline{temp})$$

$$Windchill = 0.037 \times DD \times 0.604 \times windspeed$$

$$Insolation = 0.144 \times sunhours$$

$$Seasonality = 2.cos.\left(2.Pi\left(\frac{day - 190}{365}\right)\right)$$

where $\overline{temp}$ is average temperature, $\overline{windspeed}$ is average wind speed, $sunhours$ is the number of hours with sun and day is the number of days since the first day of the year.

A measure of historical effective degree days has been constructed using historical temperature data from the Melbourne Airport weather station. This differs from the AEMO NGFR approach of using observations from the Melbourne Regional Office (MRO) station and then Melbourne Olympic Park (MOP) station once the MRO station stopped operations. AEMO make an adjustment to temperature data from the MOP station to align it to MRO data.

We have chosen to used Melbourne Airport observations for two reasons:

1 Melbourne Airport is geographically more centrally located to the AusNet Service area than either the MRO or MOP stations, and thus we would expect a closer relationship to exist between Melbourne Airport weather conditions than those of the other stations.

2 Using Melbourne Airport observations consistently over the entire historical period avoids the necessary adjustment of MOP data to MRO data. Such an adjustment may lead to bias in the estimated weather relationships.

Projections of effective degree days

We have projected Effective Degree Days to fall by 8.5 EDD per year. This is the estimated combined effect of greenhouse warming and the Urban Heat Island (UHI) estimated by Suppiah and Whetton (2012).[35] The estimate accounts for changes in temperature due to anthropogenic climate change and urbanisation leading to a greater UHI effect.

A decline of 8.5 EDD per annum is similar to the linear trend estimate produced by NIEIR in their review of EDD standards.[36] NIEIR predicts EDDs to fall by 7.6 per annum.

In contrast, the most recent National Gas Forecasting Report produced by AEMO projected EDDs to remain constant over the forecast horizon.[37] AEMO argues that "while the warming trend has stabilised, it is not possible to determine the direction of the warming trend going forward". Thus, AEMO used a projection of no change in EDD to produce forecasts of demand. However, past AEMO forecasts have incorporated warming trends (using CSIRO projections of increasing temperatures).[38]

Further, it is understood from AusNet Services' discussion with AEMO that AEMO is intending to engage CSIRO to provide climate advice for future editions of AEMO's electricity and gas forecasting reports. This advice may result in a change in AEMO's projections of EDDs and therefore AEMO's current position should not be categorised as a firm conclusion on whether EDDs will remain constant over the forecast period.

It is preferable to use projections of EDDs that are based on long-term temperature projections rather than short-term analysis of EDD data. Weather relationships are complex, and the approach of CSIRO will account for temperature trends predicted using sophisticated models of the UHI effect and greenhouse warming. AEMOs prediction of no growth in EDDs appears to be at odds with recent CSIRO projections of warming temperatures.[39]

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35 Suppiah, R. and Whetton, P., 2007, 'Projected changes in temperature and heating degree-days for Melbourne, 2012-2017, CSIRO, Marine and Atmospheric Research, PMB No. 1, Aspendale, Vic.

36 NIEIR, 2016, *NIEIR Review of EDD weather standards for Victorian gas forecasting*, p.9, available at: http://nieir.com.au/wp-content/uploads/2016/07/NIEIR-EDD-Review-April-2016.pdf

37 AEMO, 2015, *Forecasting Methodology Information Paper – National Gas Forecasting Report 2015*, p.51

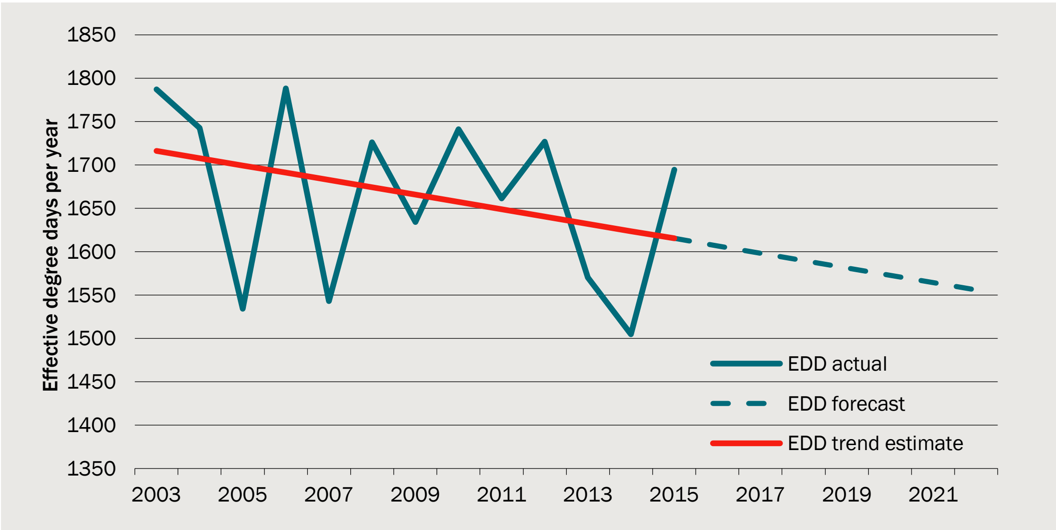
38 AEMO, 2012, *2012 Review of the weather standards for gas forecasting*, available at: https://www.aemo.com.au/Gas/Planning/~/media/Files/Other/planning/14100017pdf.ashx

39 See http://www.csiro.au/en/News/News-releases/2015/New-climate-change-projections-for-Australia

We project this fall in EDDs from a starting point of the 2015 trend-estimated EDD. This implies a large, down-ward weather correction of 2015 usage consistent with EDDs falling from 2015-2016 to their average level.

Chart D.1 shows the actual and projected EDD per year used in our methodology. Note that the starting point for projected EDD is the 2015 trend estimate.

D.1 Actual and projected Effective Degree Days



Data source: CIE.

References

ACIL Tasman 2010*, Victorian electricity distribution price review: review of electricity sales and customer number forecasts*, prepared for the Australian Energy Regulator, April, p. 4.

Australian Energy Market Operator (AEMO) 2012, *2012 Review of the weather standards for gas forecasting*, available at: https://www.aemo.com.au/Gas/Planning/~/media/Files/Other/planning/14100017pdf.ashx

Australian Energy Market Operator (AEMO) 2015, *National Electricity Gas Forecast Report,* March 2016

Australian Energy Market Operator (AEMO) 2015, , *National Electricity Gas Forecast Report Forecasting Methodology Information Paper* , p.23.

Australian Energy Market Operators (AEMO) 2016, *National Electricity Forecast Report*, pp40 (see: http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report, accessed 7/7/2016).

Alternative Technology Association (ATA) 2016, *Consumers moving away from gas*, (see: https://www.ata.org.au/news/consumers-moving-away-from-gas-ata-survey) (access August 2016).

AusNet Services 2016, *Energy Research. Study 2: Online Survey (prepared by Colmar Brunton Research)*, p38 (see: http://ausnetservices.com.au/CA257D1D007678E1/Lookup/DeterminingRevenues/$file/AusNet%20Services_Energy%20Research%20Study%202%20Report.pdf, accessed 12/8/2016).

AusNet Services (undated), *Energy for the regions,* (http://www.ausnetservices.com.au/Gas/Our+Projects/Energy+for+the+Regions.html), accessed July 2016

Commonwealth of Australia, National Housing Supply Council (NHSC) 2011, *State of Supply Report*, December 2011.

Housing Industry Association (HIA) 2016, *Housing Forecasts*, August 2016, see: https://hia.com.au/en/BusinessInfo/economicInfo/housingForecasts.aspx (accessed September 2016).

NIEIR, 2016, *NIEIR Review of EDD weather standards for Victorian gas forecasting*, p.9, available at: http://nieir.com.au/wp-content/uploads/2016/07/NIEIR-EDD-Review-April-2016.pdf

Reserve Bank of Australia 2004, 'Better than a coin toss: the thankless task of economic forecasting', speech by Deputy Governor GR Stevens 17 August 2004, also reported in the Reserve Bank of Australia Bulletin September 2004.

Suppiah, R. and Whetton, P., 2007, 'Projected changes in temperature and heating degree-days for Melbourne, 2012-2017, CSIRO, Marine and Atmospheric Research, PMB No. 1, Aspendale, Vic.

Victorian Department of Environment, Land, Water and Planning 2016, *Victoria in Future 2016*, see: http://www.delwp.vic.gov.au/planning/forward-policy-and-research/victoria-in-future-population-and-household-projections/data-tables, accessed 31/08/2016.

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