ACIL ALLEN CONSULTING

REPORT TO
AUSTRALIAN ENERGY REGULATOR

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REVIEW OF DEMAND FORECASTS FOR AUSNET SERVICES

VICTORIAN GAS ACCESS ARRANGEMENT REVIEW FOR THE PERIOD 2018 – 2022

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INTRODUCTION

1.1 Background

The *National Gas Rules* (NGR 72(1)(a)(iii)) require the access arrangement information provided by the service provider to include usage of the pipeline over the earlier access arrangement period showing:

— minimum, maximum and average demand

— customer numbers in total and by tariff class.

In making a decision whether to approve or not to approve an access arrangement proposal, the AER is required under rule 74 of the NGR to be satisfied that forecasts required in setting reference tariff(s) are arrived at on a reasonable basis and represent the best forecast or estimate possible in the circumstances.

1.2 Scope and Approach

The Australian Energy Regulator (AER) has engaged ACIL Allen to provide independent advice on the demand forecasts contained in the access arrangement proposals submitted by the Victorian transmission and distribution businesses. The purpose of this advice is to assist the AER in deciding whether or not the demand forecasts meet the requirements of the NGR and therefore whether or not they should be approved.

The process followed by the AER for assessing proposed access arrangements and access arrangement revisions is set out in the Final Access Arrangement Guideline published in March 2009 (AER, 2009).

1.2.1 Requirements of the Engagement

Under the terms of our engagement, ACIL Allen is required to provide advice on whether the demand forecasts for each business have been arrived at on a reasonable basis and whether they represent the best forecasts for demand in the circumstances.

More specifically, ACIL Allen is required to:

1. critically assess and advise on the businesses' arguments relating to the likely trend in demand forecasts over the regulatory period;
2. ask questions about the demand forecasts in the form of a written information request to the business, via AER staff;
3. where relevant, provide alternative demand forecasts. Provide reasons for this alternative approach and set out the methodology and assumptions for this alternate approach;

4. consider feedback from AER staff, including those with expertise in forecasting;
5. provide draft and final written advice;
6. respond to the businesses' response to the AER's draft decision and any questions/queries from the businesses.

1.2.2 Approach to the review

A key part of the information submitted by a service provider in support of a proposed access arrangement is a forecast of the level of demand for the reference services provided, over the course of the access arrangement period. This typically involves forecasting demand for services for a period of five years from the commencement date of the new access arrangement. It is important to ensure that the forecasts represent best estimates arrived at on a reasonable basis because:

— Demand forecasts may impact the forecast capital expenditure required to meet the new demand of prospective users or the increased demand of existing users and may therefore influence forecast revenue requirements.

— Demand forecasts influence the tariffs set to meet forecast revenue in each year of the access arrangement period, and how this revenue is to be allocated between classes of customer for different reference services.

In undertaking this review, ACIL Allen has considered the following issues:

1. the adequacy of the overall approach and methodology
2. the reasonableness of the assumptions that have been used in applying the chosen methodology
3. the currency and accuracy of the data used
4. the account taken of key drivers of gas demand in each relevant customer sector
5. whether the methodology has been properly applied.

The review has been undertaken as desktop analysis into the methodology, data and parameters, and assumptions used to develop the demand forecasts. ACIL Allen has used its own knowledge of Australian gas markets to inform its advice regarding the reasonableness of the assumptions used.

1.2.3 Data sources

In preparing this review, ACIL Allen has relied on the following data sources:

— the National Gas Rules

— the Access Arrangement Information and Regulatory Information Notice (RIN) submitted by AusNet Services, hereafter "AusNet" (AusNet, 2016)

— the demand forecast prepared for AusNet by the Centre for International Economics, hereafter "CIE" (CIE, 2016)

— various specialist reports as detailed in the Bibliography.

1.2.4 Structure of the report

The remainder of this report is structured as follows:

Chapter 2 sets out the key findings of the report. To the extent that the review takes issue with particular elements of the forecast, it describes the nature of those concerns and recommends action to be taken to address those concerns.

Chapter 3 describes the scope of the AusNet Services operations.

Chapter 4 describes the forecast methodology, assumptions and ascertains their suitability.

Chapter 5 sets out our conclusions regarding the acceptability of the forecasts, and actions that the AER could propose to improve upon the forecasts as submitted.

2 KEY FINDINGS

2.1 The forecasts

The demand forecasts contained in AusNet's Victorian Access Arrangement Information document (AusNet, 2016) are based on forecasts developed by the Centre for International Economics (CIE, 2016). These forecasts cover the period from 2018 to 2022 and are based on a combination of assumptions and econometric regression models.

The CIE forecasts address two components which together determine the demand for gas: usage per customer and number of customers. This applies to the three market segments served by the AusNet distribution business: residential customers (Tariff V – Residential), small commercial and industrial customers (Tariff V – Non-residential) and large industrial customers (Tariff D and Tariff M).

In preparing the AusNet demand forecasts, CIE has considered key drivers of gas demand, including:

1. weather
2. catchment area population growth
3. AusNet network expansion
4. connection cohort
5. type of dwelling
6. government policies, including:
   a) policies related to construction standards and building design
   b) Federal and State-level policies affecting gas usage
7. type of economic activity undertaken by commercial and industrial customers
8. wholesale price of gas
9. price of substitutes.

CIE has tried to take a comprehensive and statistically rigorous approach to the development of the forecasts and the establishment of relationships between demand and its key drivers. CIE has been transparent in terms of its methods and assumptions.

There are some methodological issues with the forecasting approach used by CIE to develop the AusNet demand forecasts that could potentially bias modelling results. The key question is whether further effort directed to improving the model (in terms of either the range of explanatory variables included or the estimation of demand coefficients) would be likely to produce a significantly better or more reliable forecast. Given the data that is available and the difficulties involved in reliably estimating the coefficients associated with each of the variables in a fully specified demand function, it is not clear that such effort would necessarily produce more reliable forecasts.

Accordingly, while recommending that consideration be given in future to the methodological issues identified, we consider that in the current circumstances the approach used by CIE to develop the AusNet demand forecasts is sound, and that the methodology employed is sufficiently rigorous to satisfy the requirement of rule 74 of the NGR that the forecasts are arrived at on a reasonable basis.

CIE has normalised historical demand data, adjusting for weather variations by using established relationships between gas demand and annual Effective Degree Days (EDD) developed by AEMO. CIE has used a projected decline of about 8.5 EDD per year based on work by CSIRO which incorporates the combined impacts of greenhouse warming and the Urban Heat Island (UHI) effect. The CSIRO forecasts are based on long run climate change patterns, and are viewed by ACIL Allen as a reliable source. An alternative would be to use AEMO forecasts. However, given the wide range of AEMO's forecasts for Victorian EDD over the past several years, we see no reason to argue that they should be preferred to those used by CIE based on CSIRO advice. CIE has adjusted consumption for each Tariff Zone and usage block to reflect 'typical' climatic conditions.

2.2 Assessment of the forecasts

Having examined the historical data (from 2008) and forecasts of Tariff V Residential customer numbers, we note that the forecasts show growth in customer numbers at an average 2.1 per cent per year, a somewhat lower rate than in the past. This can reasonably be explained by the fact that growth in metropolitan Melbourne LGAs such as Wyndham, Brimbank and Melton is slowing and growth in smaller LGAs outside of metropolitan Melbourne is not compensating for the lower growth around the higher-density Melbourne area. There has also been a shift in customer preferences which increasingly favour electricity over gas, particularly in new dwellings. For non-residential (commercial) Tariff V customers, connection numbers are forecast to rise at or slightly above the historical rate of growth. Overall we conclude that the Tariff V customer number forecasts do not appear to be unreasonable.

With regard to Tariff V gas consumption per connection, the forecast for residential customers sees a continued decline in average annual consumption at rates similar to the long-run historical downward trend. For commercial Tariff V customers, average consumption per connection is forecast to remain almost flat at around 360 GJ/a, again very close to historical trends. We conclude that the Tariff V consumption per connection forecasts are not unreasonable.

Given that the forecasts of Tariff V annual gas consumption (residential and commercial) are derived from the corresponding connection number and average consumption per connection forecasts—which we have concluded appear to be reasonable—it follows that the annual consumption forecasts should be reasonable. This is indeed the case: the forecasts for annual consumption by both the residential and commercial Tariff V customer classes are very much in line with historical trends which have seen modest growth in total consumption over the past eight years.

With regard to Tariff D demand, the critical determinant is the forecast of Maximum Hourly Quantity (MHQ) across the customer group, since this determines the overall capacity requirements (and hence network capital) as well as reflecting the basis on which Tariff D customer charges are levied.

The historical MHQ data for AusNet Tariff D customers shows a decline from about 10,200 GJ/h in 2008 to 7,900 GJ/h in 2015. The forecasts lie slightly above the historical trend, falling from 7,900 to 6,800 GJ/h over the period 2016 to 2022. On this basis, the forecast levels of MHQ for AusNet Tariff D customers do not appear to be unreasonable.

3 SCOPE OF AUSNET SERVICES OPERATIONS

The following description of the AusNet Victorian gas distribution operations is a summary of the information provided in the Access Arrangement Information (AusNet, 2016).

The AusNet natural gas transmission and distribution network extends throughout western metropolitan Melbourne and south-west and west regional Victoria. AusNet's gas distribution network serves three rapidly developing urban growth corridors to the west of Melbourne, at Hume, Melton and Wyndham. The network distributes natural gas from the principal gas transmission system to individual gas meters that supply customers' appliances.

In total, AusNet delivers gas to approximately 665,000 customers across a geographically diverse region spanning some 60,000 km^2. While most of those customers are residential gas users, the network also serves around 16,500 commercial businesses as well as some 270 medium and large industrial users.

The network includes approximately 11,135 km of pipelines, mainline valves, pressure regulating facilities (including city gates, field and district regulators), service pipes, meters and ancillary equipment. Operating pressures vary across the network, depending on the type of pipeline and its construction material. Trunk mains operate at pressures up to 515 kPa. The low pressure distribution systems operate up to 7 kPa with District Regulators controlling gas supply from AusNet's high and medium pressure networks.

Pipeline corrosion is managed through the installation of corrosion protections units (CPUs) and sacrificial anode beds. Meter and regulator assemblies, which vary from large industrial or commercial units to small domestic units, supply gas to consumers. A meter and regulator setup is provided for each supply point (that is, each customer connection) from the distribution network.

AusNet monitors and controls assets across the network using a SCADA (Supervisory Control and Data Acquisition) system which provides data on the real-time performance of the assets, and data for long-term evaluation of gas demand and network performance.

The gas distribution network has been constructed over a period of more than 100 years, using a variety of pipeline materials with varying performance capabilities. Cast iron and steel were used predominantly until the introduction in the late 1970s of polyvinyl chloride (PVC) for low pressure pipeline replacement and polyethylene for high pressure networks. Today polyethylene is the dominant pipeline material.

The maximum operating pressure in different parts of the network is dictated by the pipeline materials used and affects the overall performance of the network. Cast iron pipes can only be operated at relatively low pressures compared to polyethylene. The ongoing replacement of cast iron mains with polyethylene pipe therefore enhances the capacity and integrity of the network, helping to offset some of the natural age-related deterioration. Polyethylene materials also deliver significant safety benefits over the aging cast iron assets.

4 FORECAST METHODOLOGY AND ASSUMPTIONS

4.1 Objectives

The objectives of the demand modeling exercise undertaken by CIE on behalf of AusNet, as set out in the CIE report (CIE, 2016):

— To provide forecasts over the 2017-2022 period for
  - Customer numbers
  - Average use per customer
— The forecast needs to be specific to
  - Tariff Zones
  - Tariff Class (Residential, Commercial and Industrial)
— The forecast also needs to satisfy standard criteria:

1. National Gas Rules criteria, namely.-
   a) Information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.
   b) A forecast or estimate:
      i) must be arrived at on a reasonable basis
      ii) must represent the best forecast or estimate possible in the circumstances.
2. Criteria earlier articulated by ACIL Allen (ACIL Tasman, 2010):
   a) be accurate and unbiased
   b) incorporate key drivers, including weather
   c) incorporate policy impacts
   d) be transparent and repeatable
   e) address model validation and testing.
3. All inputs should be properly referenced to independent sources.

The next section describes the methodology on which AusNet's forecasts are based.

4.2 Methodology

The demand forecasts contained in AusNet's Victorian Access Arrangement Information document (AusNet, 2016) are based on forecasts developed by the Centre for International Economics (CIE, 2016). CIE states (CIE report, p.28) that it has followed a three-step process to prepare the projections:

- Describing changes in gas use over the period for which data is available. This has typically been undertaken using statistical analysis of AusNet'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.

CIE has 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.

4.3 Econometric modelling

This section reviews AusNet's use of the econometric/modelling approach adopted by CIE. The section concludes with a detailed discussion of the issues that ACIL Allen has identified with the demand forecast provided by AusNet.

4.3.1 Overview of forecasting approach

AusNet, through their consultants (CIE, 2016), has implemented a bottom-up econometric approach to forecast gas demand. For the Tariff V customer group, total gas demand is derived by forecasting the number of customers for each year of the forecast period and multiplying the number of customers by forecast usage per customer.

The forecasts have been developed at a postcode level. This facilitates mapping of the forecasts to AusNet's pricing zones, and also allows use of publicly available data on population and housing trends which is available at postcode or Local Government Area (LGA) level.

Residential customers

The number of customers is forecast as follows.

1. AusNet customer data are available by postcode, and are allocated to LGAs using ABS concordance (Cat. 1270.055). Because the AusNet distribution area is not defined in terms of LGA boundaries, some LGAs lie partly within the AusNet distribution area and partly within an adjoining distribution area (for example, Multinet). This has implications for the forecasting process because it tends to distort estimates of penetration levels in those LGAs not wholly contained within the AusNet distribution area. CIE therefore calculated two penetration rates: one which reflected the penetration rate of all LGAs in which AusNet Services has some customers (however small) and the other which focused only on LGAs in which AusNet Services' network had a large footprint. Regardless of the method of estimation, CIE's analysis shows that penetration rates have fallen across AusNet's network since 2006.
2. Use forecasts prepared by the Victorian Government[1] of occupied private dwellings to project *potential* AusNet customer numbers at the LGA level. These forecasts are only available for certain years, so missing years were interpolated. The interpolation approach was adopted after considering Housing Industry Association (HIA) forecasts which did not generate substantially different forecasts than those generated using Victoria in Future projections. The 2016 ViF data used by CIE was the most recent available at the time and as of May 2017 remains the most up-to-date available. AusNet explains the process used by CIE to reconcile customer number history (at postcode level) with new dwelling forecasts (at LGA level):

   "CIE's customer forecasts are derived by determining how much of a given postcode resides within a specific LGA. The 2016 ViF [Victoria in Future] growth rates for that LGA are then used to grow the number of customers within that postcode. The penetration rate established for that LGA by CIE is then applied to the household growth rate to forecast the number of new gas customers. The result is a customer number forecast at the postcode level, which can be used to forecast the number of customers in each of AusNet Services' pricing zones." (AusNet AAI, p.55)

[1] Victoria in Future Forecasts: http://www.delwp.vic.gov.au/planning/forward-policy-and-research/victoria-in-future-population-and-household-projections/data-tables.

3. Apply forecast assumptions of AusNet's marginal penetration rate[2] by LGA to potential AusNet customer numbers at the LGA level. The CIE assumed marginal penetration rates in line with recent values. Marginal penetration rates have been falling since 2009. AusNet's assumption is that they will not continue to fall, but will remain at levels similar to those experienced in 2016. The CIE (2016) provides reasonable justification for this assumption (CIE report, page 41).

Under the Victorian 'Energy for the Regions Program' (ERP), the gas network is being expanded to Winchelsea, Bannockburn and Avoca (expansion to Huntly is already completed and is not treated as an ERP area). Because there is no history of gas penetration rates in these areas, the forecasts of customer numbers in these areas are estimated differently. Customer numbers for ERP areas are based on targets for number of customers, and an assumption of gradual convergence towards the target (starting from a base of zero customers).

Disconnections are accounted for within the forecasts for the number of customers, and are assumed to occur at the historical 2015 rate of 0.26 per cent of the number of customers in the previous year. The resulting rate of growth of the forecasts for occupied private dwellings in the AusNet Services area are close to historical results – between 2 and 2.5 per cent per year. Residential customers are forecast to grow at a decreasing rate, starting at 2.3 per cent per year in 2016 and falling to 2.1 per cent per year by 2022.

Residential average usage per customer connection is forecast on the basis of an econometric model developed by the CIE (2016), using panel data statistical techniques. The natural logarithm of residential per customer usage is the dependent variable. Explanatory variables include dwelling characteristics, such as whether the dwelling is a fully detached house or a unit (flat), the year it was connected, a time trend, Effective Degree Days (EDD), natural logarithm of gas prices (as a regional index) and a statistical error term. The CIE (2016) chose a fixed effects specification, which allows for individually estimated intercept terms. The price coefficient has been constrained to be identical across all blocks, since allowing the coefficient to vary across blocks led to non-robust estimation results.

AusNet customer data shows that usage per connection is significantly higher for existing connections than for new connections (a result attributable to changes in dwelling characteristics, including smaller building size and better insulation). For this reason, usage per new connection and usage per existing connection are forecast separately. *Usage per new customer* is forecast on a similar basis to existing customers, but with two additional components projected:

- The proportion of new customers that are flats (as distinct from separate free-standing dwellings) 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 forecast average usage levels for both existing and new residential customers (not including appliance switching adjustments) are shown in CIE Figure 6.9. New customers are defined as customers connected from 2016 onwards, while existing customers include all customers connected at 2015. An increase in the proportion of new customers in the total stock of customers will lead to a forecast decline in total average residential usage.

The methodology description contained in the CIE report does not explain explicitly how the two different usage trends (existing and new customers) are combined with the connection number forecast. However, we infer that CIE has applied the existing customer usage rates to all connections prior to 2016 (with that number declining over time in accordance with the projected disconnection rate) and the new customer usage rates applied to all connections from 2016 onwards.

Applying this method, average residential per customer usage is forecast to continue its historical downward trend. The rate of decline during the forecast period is similar to that observed over the historical period (2008 to 2015). CIE also prepared an alternative scenario in which a post-model adjustment was made to account for an anticipated increase in the rate of switching from gas to electric appliances. However, AusNet did not use this scenario in its demand forecasts, stating that:

[2] "Marginal penetration rate" is defined as the net number of new customers (new connections minus disconnections) divided by the net number of new occupied dwellings (new dwellings minus demolitions).

'Given the level of uncertainty as to the precise extent of the acceleration of appliance switching, and the need to limit increases in network charges and promote the use of gas as a fuel of choice, AusNet Services has elected to adopt CIE's forecast excluding the post modelling adjustment for appliance switching. AusNet Services will continue to investigate the drivers underpinning future demand, including via consultation with AEMO between now and the Revised Proposal.'

(AusNet AAI 2016, p.67)

Submission concerns

In its submission to the AER, the Consumer Challenge Panel Sub-Panel (CCP) raised concerns about whether the distribution businesses had adequately allowed for decreases in penetration rates in their forecasts of new connections to reflect the continuing trend of appliance switching from gas to electricity.

As discussed above, CIE explicitly considered the risk of declining penetration rates by preparing an alternative scenario in which a post-model adjustment was made to account for an anticipated increase in the rate of switching from gas to electric appliances. However, AusNet decided to use the forecast without post-model adjustment for increase appliance switching, based on "the level of uncertainty as to the precise extent of the acceleration of appliance switching, and the need to limit increases in network charges and promote the use of gas as a fuel of choice". AusNet also noted that its proposed operating cost allowance for gas marketing over the forthcoming access arrangement period is aimed at increasing the demand for gas and is 'expected to reverse some of the anticipated decline due to appliance switching.' (AusNet, 2016, p. 75).

Proposed update to residential number forecasts

The projected 2.1 per cent per year increase in customer numbers is underpinned by the Victorian Government's projections of strong growth in the overall number of dwellings in AusNet's service region. AusNet notes that if the growth in the number of occupied dwellings in 2018-2022 was the same as 2011-2015, the customer forecasts would be close to 11,000 lower by the end of 2022. To the extent that the Victorian Government forecasts change in 2017, AusNet therefore proposes to reflect the up-to-date forecasts in its Revised Proposal, or to ask that the AER incorporates them into its Final Decision, should the 2017 ViF be released after the Revised Proposal but in time for the Final Decision.

Commercial customers

Commercial customer numbers are forecast as a fraction of residential customer numbers, since this was the most closely correlated variable among the candidate drivers tested by the CIE (including population and Gross State Product). Commercial customer numbers were forecast using the LGA-based forecast of residential customer numbers. The coefficient of determination (R^2) of this relationship was 0.56, much higher than alternatives such as population and GSP. The relationship was estimated to be 11.7 new commercial customers for each 1,000 new residential customers.

As with residential usage per customer, commercial usage per customer is forecast on the basis of an econometric model developed by the CIE (2016) using panel data statistical techniques. The natural logarithm of commercial usage per customer is the dependent variable. Explanatory variables include a time trend, Effective Degree Days (EDD), natural logarithm of gas prices (as a regional index), a customer-specific intercept (a "fixed-effect") and a statistical error term. As with residential usage, the price coefficient has been constrained to be identical across all blocks.

As with residential gas demand, total commercial gas demand is the product of the forecast number of customers and forecast usage per customer.

Industrial Customers

Demand from industrial customers (Tariff D, Tariff M[3]) is specified in terms of maximum hourly quantities (MHQ) since this is the basis on which those customers are charged. Because Tariff D and

[3] Tariff M is essentially a subset of Tariff D demand that applies to customers previously billed as Tariff V, but whose consumption has increased above the Tariff D thresholds. To qualify for Tariff M, a customer previously taking supply under Tariff V Haulage Reference

Tariff M customers are not levied a fixed charge, forecasting the number of these customers in the forthcoming access arrangement period is not required. Further, there is no expenditure associated with connecting new Tariff D and Tariff M customers that is not funded by the customers themselves.[4] Any expenditure associated with the provision of assets to enable the connection is borne by the customer, either through a customer contribution, separate charges (Tariff D) or the Haulage Reference Service charge (Tariff M). Forecasts for the 2017 to 2022 period are based on total Tariff D annual gas system demand forecasts prepared by the Australian Energy Market Operator (AEMO, 2016a). The forecast is based on growth rates for Tariff D volume forecasts under the AEMO medium scenario. In applying the same rate of change of total tariff D system demand/usage to forecast MHQ, CIE has assumed that the rate of change of usage is the same as the rate of change of MHQ. CIE has investigated the historical relationship between tariff D total usage and MHQ and concluded that it is appropriate to project MHQ for tariff D and M using the AEMO projections of total tariff D usage.

Since the CIE report was prepared, AEMO has released an updated National Gas Forecasting Report in December 2016 (AEMO, 2016b). The new NGFR has slightly revised forecasts for annual industrial gas use in Victoria over the next access arrangement period, as shown in **Table 4.1**. While the differences are relatively minor, we suggest that AusNet be asked to update the Tariff D demand forecasts to reflect in its Revised Proposal the latest AEMO forecasts.

TABLE 4.1 COMPARISON OF RECENT AEMO FORECASTS OF INDUSTRIAL GAS CONSUMPTION IN VICTORIA (MEDIUM/NEUTRAL CASE)

	2015 NGFR	2016 NGFR	Differential %
2018	66	67.4	2.1%
2019	65.7	65.7	0.0%
2020	65.6	64.4	-1.8%
2021	65.4	64.6	-1.2%
2022	64.7	64	-1.1%

Source: ACIL Allen compilation of AEMO data

Tariff M data is highly volatile and was not found to be closely correlated with key drivers. For this reason Tariff M usage has not been forecast separately; it has been projected using the growth rates from the AEMO Tariff D forecasts (which include Tariff M). The closures of Ford and Toyota were taken into account for the AEMO forecasts. Because these plants are located in the AusNet service area, CIE considered that they could have a disproportionate impact on AusNet Services' demand compared to Victoria's overall demand. However, CIE also recognized that other Tariff D customer closures (outside the AusNet service areas) were also included in the AEMO forecast, and on balance they considered that forecasting AusNet Tariff D & M MHQ in line with AEMO's Tariff D consumption forecast was appropriate.

4.3.2 Forecasting approach

The CIE forecasts address two components which make-up demand: usage per customer and number of customers. This applies to the three market segments served by the distribution business: Residential customers, small commercial and industrial customers (Tariff V – Non-residential) and large industrial customers (Tariff D and Tariff M).

Table 4.1 provides a detailed breakdown of AusNet's tariff structure. Demand forecasts are constructed in order to match this structure.

Service should be using either more than 10,000 GJ of gas in a 12 month period, or more than 10 GJ in an hour. Tariff M customers are not required to pay any additional charges for delivery point O&M or local capacity charges (LCC) as these have been embedded in the tariff.

[4] According to the AusNet Access Arrangement Information (p.73), any costs associated with the provision of assets to enable such connections are borne by the customer, either through a customer contribution, separate charges (Tariff D) or the Haulage Reference Service charge (Tariff M).

TABLE 4.2 TARIFF BREAKDOWN: AUSNET

Customer type	Time of year	Regions	Tariff types
Domestic	Peak Period – June to September Off-peak Period – October to May	West Central New towns West New towns Central	Supply charge per day connected Charges for usage based on blocks of: – 0-0.1 GJ/day – 0.1-0.2 GJ/day – 0.2-1.4 GJ/day – >1.4 GJ/day
Commercial	Peak Period – June to September Off-peak Period – October to May	West Central New towns West New towns Central	Supply charge per day connected Charges for usage based on blocks of: – 0-0.1 GJ/day – 0.1-0.2 GJ/day – 0.2-1.4 GJ/day – >1.4 GJ/day
Tariff M	All year	West Central New towns West New towns Central	Maximum hourly demand
Tariff D	All year	West Central New towns West New towns Central	Maximum hourly demand

SOURCE: AUSNET, 2016

CIE forecasts the number of customers as well as usage per customer for the breakdown shown in Table 4.1. The forecasts are arrived at by means of a four step approach:

1. Identify fundamental drivers of demand and establish the strength of their effects on demand
   a) For customer numbers, this is done based on analysis of customer numbers and various drivers (see, for example, Figure 5.4 on p. 35, CIE, 2016). For residential customer numbers, the key driver is the number of dwellings. The forecast of commercial customer numbers is based on the number of residential customers, which in turn is based on the number of occupied private dwellings.
   b) For usage per customer, econometric regression models were estimated using AusNet's billing database.
2. Having identified the drivers of demand, CIE then sources projections for these drivers, using publicly available estimates.
3. Generate the demand forecasts by feeding the projections of the key drivers of demand (sourced in step 2) through the models constructed in step 1.
4. Review forecasts by comparing forecasts against other variables, such as population and economic growth forecasts for the regions under consideration.

In preparing the AusNet residential demand forecasts, CIE considers the following drivers for demand:

— Weather – colder climate leads to greater gas demand.
— Catchment area population growth – more residents and businesses will results in more connections and hence customers.
— AusNet network expansion – as the network is expanded, more customers have the option of joining.
— Connection cohort – more recent connections tend to be more energy efficient, in part due to more stringent building standards, thereby lessening demand.
— Type of dwelling – units consume less gas than houses.

— Government policies –

— Policies related to construction standards and building design are seen to have a significant impact on demand. As buildings become more energy efficient, their gas usage (if connected to the network) is lower.

— A variety of Federal and State-level policies impacting gas usage.

— Type of economic activity undertaken by commercial and industrial customers – whether customers are in expanding or contracting economic sectors will affect their gas demand.

— Wholesale price of gas – higher wholesale prices will curtail gas demand.

— Price of substitutes – such as electricity.

Residential Customer Usage

The key regression equations for residential usage proposed by CIE (CIE, 2016) and reflected in AusNet's access arrangement information (AusNet, 2016) are of the following form:

$$Log\left(\frac{Demand}{Customer}it\right) = \beta_0 + \beta_1\ Unit_i + \beta_2\ YearConnected_i + \gamma_1\ Year_t + \gamma_2\ EDD_t +$$
$$\delta_1\ Log(Price_{it}) + \varepsilon_{it} + \mu_i \qquad (1)$$
$$\mu_i = \alpha_0 + \alpha_1 Unit_i + \textstyle\sum_{t=2004}^{2015} \alpha_t YearConnected_i + \varepsilon_i$$

Where:

- t subscripts represent the time period of a variable

- i subscripts identify individual customers

- Log is the Natural Logarithm of a variable

- Demand/Customer$_{it}$ is gas demand for customer i, in year t

- β_0 is an intercept term

- β_1 is the coefficient for a dummy (0,1) variable which specifies whether the customer is a single dwelling or a unit, labeled $Unit_i$

- β_2 is the coefficient on the year in which a dwelling was connected to the network, labeled $YearConnected_i$

- γ_1 is the coefficient on a time trend, labeled $Year_t$

- γ_2 is the coefficient on Effective Degree Days in year t, labeled EDD_t

- δ_1 is the coefficient on the price of gas paid by customers in their region in year t, labeled $Price_{it}$. The price paid in a region is identical for all customers located in that region. It is an index based on data published by the Essential Services Commission of Victoria, assuming consumption of 60 GJ.

- ε_{it} is a dwelling-specific random error term in year t

- μ_i is a dwelling-specific error term (intercept), which is modelled in a two stage process shown in the third line of equation (1), where α_j denote coefficients and ε_i is an error term.

For variables defined in logarithms, the coefficients can be interpreted as the per cent change in the dependent variable associated with a one per cent change in the corresponding explanatory variable, that is, coefficients represent elasticities.

Equation (1) is a common functional form used to estimate demand functions.

Residential regression results are reported in the CIE report (CIE, 2016, tables 6.4 and 6.5 on pages 55-56). Key coefficients were statistically significantly different from zero.

Coefficients on the $Unit_i$ dummy variable vary across blocks and in general take negative values, implying that units exhibit lower gas usage over time. Estimated values range between -0.769 for the Peak 0.2-1.4 PJ block and -0.17 for the Off-peak >1.4 PJ block.

Coefficients on the time trend ($Year_t$) vary by block. Estimated coefficients range between -0.011 for the Off-peak 0-0.1 PJ block and 0.011 for the Peak >1.4 PJ block. In general, smaller blocks showed downward trends over time, while the larger blocks showed upward trends over time.

Coefficients on Effective Degree Days (EDD_t) were positive, and took values of less than 0.0001 for the 0-0.1 PJ block to 0.0026 for the Off-peak 0.2-1.4 PJ block.

Estimation of the gas price coefficient (essentially the own-price elasticity for gas, given that the gas price variable is expressed in log terms) was constrained to be equal across all blocks, and was estimated at -0.053.

This is a much lower residential own-price elasticity estimate than those adopted by AGN (0.30) and Multinet (0.28). We believe the explanation is that the AGN and Multinet values are long-run price elasticities, whereas the AusNet/CIE estimate, being derived from year-on-year changes in panel data, is a short-run price elasticity. As discussed by NIEIR in the Multinet analysis (Multinet 2016, Appendix B, p. 117) the short-run own price elasticity for residential gas demand is much lower than the long-run elasticity: NIEIR estimates that the long-run elasticity effect of 0.28 is spread over a period of four years, with the impact in the first year being 0.05 (similar to the CIE/AusNet estimate), rising to 0.10 in the second and third years after the price shock and 0.03 in the fourth year.

Coefficients on new connections are calculated using a weighted average formula. Estimates range between -0.041 for the Peak 0.1-0.2 PJ block and 0.337 for the Off-peak >1.4 PJ block. In general, smaller blocks had negative coefficients, while the larger blocks (>1.4 PJ) had positive ones.

In ACIL Allen's view, these coefficient estimates are reasonable and the analysis used to estimate them is also reasonably robust.

The next subsection details the approach used in forecasting commercial customer usage.

Commercial Customer Usage

The key regression equations for commercial usage proposed by CIE (CIE, 2016) and reflected in AusNet's access arrangement information (AusNet, 2016) are of the following form:

$$Log\left(\frac{Demand}{Customer}it\right) = \gamma_1\, Year_t + \gamma_2\, EDD_t + \delta_1\, Log(Price_t) + \varepsilon_{it} + \mu_i$$
$$\mu_i = \alpha_0 + \Sigma_{t=2004}^{2015}\alpha_t YearConnected_i + \varepsilon_i \qquad (2)$$

Where:

- t subscripts represent the time period of a variable

- i subscripts identify individual customers

- Log is the Natural Logarithm of a variable

- $Demand/Customer_{it}$ is gas demand for customer *i*, in year *t*

- γ_1 is the coefficient on a time trend, labeled $Year_t$

- γ_2 is the coefficient on Effective Degree Days in year *t*, labeled EDD_t

- δ_1 is the coefficient on the price of gas paid by customers in their region in year *t*, labeled $Price_t$. The price paid in a region is identical for all customers located within that region. It is data published by the Essential Services Commission of Victoria, assuming consumption of 500 GJ per year per business.

- ε_{it} is a customer-specific error term in year *t*

- μ_i is a customer-specific fixed effect (intercept), defined in the second line of equation (2) which is modelled in a two stage process, where α_j denote coefficients and ε_i is an error term.

Where variables are defined in logarithms, the coefficients can be interpreted as the per cent change in the dependent variable associated with a one per cent change in the corresponding explanatory variable, that is, coefficients represent elasticities.

Commercial regression results are reported in the CIE report (CIE, 2016, tables 8.5 and 8.6 on pages 81-82). Key coefficients were statistically significantly different from zero. This analysis shows that weather (through EDD) has a stronger effect on smaller customers.

Coefficients on the time trend ($Year_t$) vary by block. Estimated coefficients range between -0.001 for the Peak 0-0.1 PJ block and 0.013 for the Off-peak >1.4 PJ block. In general, the smallest blocks showed a downward trend over time, while the remaining (larger) blocks showed upward trends over time.

Coefficients on Effective Degree Days (EDD_t) were positive, and took values of less than 0.0001 for the smaller blocks to 0.0003 for the Peak >1.4 PJ block.

Estimation of the elasticity for gas prices was constrained to be equal across all blocks, and was estimated at -0.265. Again this is a short-run own price elasticity. The fact that the short-run own price elasticity is higher for commercial than for residential demand is consistent with commercial users being more likely to respond to price signals relatively quickly.

Coefficients on new connections are calculated using a weighted average formula, similar to that used for the residential sector. Estimates range between 0.033 for the Peak 0-0.1 PJ block and -0.307 for the Off-peak >1.4 PJ block. Smaller blocks had positive coefficients, while the larger blocks (>1.4 PJ) had negative ones.

In ACIL Allen's view, these coefficient estimates are reasonable and the analysis used to estimate them is also reasonably robust.

Industrial Customer Usage

Demand from industrial customers is specified in terms of maximum hourly quantities (MHQ). Forecasts for the 2017 to 2022 period are based on annual gas system demand forecasts prepared by the Australian Energy Market Operator (AEMO, 2016a). The forecast is based on growth rates for Tariff D volume forecasts (includes Tariff M) under the AEMO Medium Demand scenario.

Having presented the context in terms of the methodology/approach and data sources used by CIE to forecast demand on the AusNet network, the next section discusses the main issues ACIL Allen has identified in relation to the forecasts.

4.3.3 Methodological issues

This section presents the main issues identified by ACIL Allen as related to the forecasting methodology.

Issue 1 – Absence of Dynamics in Estimation

The regressions in equations (1) and (2) omit a treatment of dynamic aspects of demand. In the presence of dynamic behaviour, it is often the case that the dependent variable (for the case under consideration, gas demand) is a function of past values of itself.[5] This can arise because the dependent variable may exhibit a sluggish adjustment process; hence past values will continue to affect values in the present.

To account for this, it is customary to introduce a lagged dependent variable among explanatory variables. In this specification equation (1) would take the following form:

$$Log\left(\frac{Demand}{Customer}it\right) = \beta_0 + \beta_1\,Unit_i + \beta_2\,YearConnected_i + \gamma_1\,Year_t + \gamma_2\,EDD_t + \delta_1\,Log(Price_{it}) + \delta_3\,Log\left(\frac{Demand}{Customer}it-q\right) + \varepsilon_{it} + \mu_i \quad (3)$$

5 In econometric terms, the time series for the dependent variable exhibits a certain degree of autocorrelation.

Similarly, equation (2) would now include a lagged dependent variable. Variables and coefficients in equation (3) are as defined previously and δ_3 is the coefficient on the lagged dependent variable, which is lagged by *q* periods (the number of lags, *q*, needs to be estimated). Estimation of a regression such as equation (3) allows the definition of short-run and long-run elasticities of demand. In particular, the coefficient δ_1 represents the short-run own-price elasticity of demand. The long-run elasticity is calculated as $\delta_1/(1-\delta_3)$.

However, the regressions used by CIE, namely equations (1) and (2), omit the lagged dependent variable. Hence, the specification does not capture dynamic demand behaviour, which is necessary to estimate short and long run demand elasticities. The CIE (2016) reports that autoregressive terms were considered but added little explanatory power (p. 52).

Impact

The absence of a long-run versus short-run elasticity estimates leads to a lack of understanding on how changes in the price of gas will affect customer usage over time, since it averages the short and long run effects.

Resolution

Inclusion of a lagged dependent variable in the demand function would allow proper estimation of short and long run demand elasticities. In this case, estimation would need to use Dynamic Panel Data techniques (see for example the approaches in (Arellano; Bond, 1991) and (Arellano; Bover, 1995) which are available in the STATA econometric software used by CIE for their econometric estimation.

Issue 2 – Presence of endogenous variables among explanatory variables

The inclusion of prices as explanatory variables in regression equations (1) and (2) means that endogenous variables (in this case, gas prices) are being treated as exogenous variables. This may result in statistically biased coefficients.

Impact

Estimated coefficients may be statistically biased.

Resolution

Estimation should be conducted using Instrumental Variables techniques.

Issue 3 – Non-linearities in Demand

The regression equations that have been specified in equations (1) and (2) do not capture non-linear aspects of demand, as acknowledge by CIE (2016, p. 64). In particular, as explanatory variables rise or fall, it does not necessarily follow that demand per customer will track these variables by a constant per cent change. At high/low levels for some of these variables, a given per cent change in the variable under consideration will not necessarily lead to the same per cent change in gas demand per customer. Consider the example of weather: businesses or households will not necessarily change their gas demand by the same percentage for a given percentage increase in EDD at different levels of EDD: There may be upper/lower thresholds in demand, above/below which the intensity of demand may taper off or increase.

The non-linearities discussed above can also be present in the price of gas. There may be thresholds in gas prices above or below which a larger or smaller customer response is triggered. Similar logic applies to lower thresholds, as well as own price.

Impact

Not accounting for non-linearities in demand (particularly not accounting for the presence of upper/lower thresholds) can lead to over/under estimation of demand. It is difficult to ascertain *ex-ante* the magnitude or direction of any impact.

Resolution

This issue could be ameliorated by introducing non-linear terms into the regression equations. In particular, introducing higher powers of the relevant variables would capture non-linearities present in the data.

Issue 4 – Omitted Variable Bias

Although the regression models considered provide a reasonable approach to estimation of demand, it is likely that there may be omitted variables.

In particular, electricity prices were included in the specification used for the Victorian Gas Access Arrangement Review for the period 2013 – 2017 but have been removed from the current specification. The reasons for removing this variable were that it was found to be collinear with gas prices. The relative price of gas/electricity was considered, but the estimated coefficients were found to be volatile and of the wrong sign.

Impact

Omitting explanatory variables leads to statistical bias in the estimated coefficients and the associated forecast. *Ex-ante*, it is unclear whether the coefficients might be upward or downward biased.

In relation to the removal of electricity prices, it is likely to affect other coefficients, especially the coefficient of gas prices. However, provided gas and electricity prices continue to exhibit similar correlation to the historical period, the effect of any bias introduced in the gas price coefficient should not be material for the forecast. The historical correlation between gas and electricity prices is based on the degree to which they are substitutes, which is ultimately based on the energy equivalence between gas and electricity. Gas prices may rise relative to electricity prices over the forecast period. For example, in AGN's access submission, Core Energy forecasts that residential electricity prices will fall relative to gas prices of –1.9 per cent per year over the forecast period, leading to a reduction in residential demand of about –0.19 per cent relative to a case in which gas prices remain constant. From a theoretical stand-point ACIL Allen is of the view that it would be preferable to include the cross-price elasticity of gas and electricity in the demand forecasts. However given the current volatility of both gas and electricity prices there is considerable uncertainty regarding future price relativities and the impacts of any such shift are expected to be relatively minor. For these reason we consider it unlikely that the exclusion of electricity prices from the analysis will lead to significant or systematic error in the forecasts.

Resolution

The solution to Omitted Variable Bias is to expand the set of explanatory variables. The dataset contains a large number of observations, so expanding the number of explanatory variables should still leave more than enough degrees of freedom. Having said that, ACIL Allen is of the view that the model as it stands is fairly well substantiated, and while expanding the set of explanatory variables is often a desirable course of action, in this case it is unlikely to yield a material improvement in the quality or direction of the forecasts.

4.4 Summary of Methodology Review

Section 4.3 lays out the key methodological issues identified by ACIL Allen in the demand forecasts prepared by CIE for AusNet. From the discussion above ACIL Allen concludes that notwithstanding the issues that have been identified, the proposed demand forecast methodology provides a sound and reasonable forecasting approach.

ACIL Allen has identified a number of issues that could be taken into consideration in subsequent forecasts. Issue 1 highlights the absence of dynamics in the estimation, with the consequence that the impact of price changes on the trajectory of demand is not well defined. Issue 2 establishes the presence of endogenous variables among explanatory variables, which may lead to statistical bias in coefficients. Issue 3 discusses the absence of accounting for non-linearities in the forecasting methodology. This may become important if there are large changes to the explanatory variables.

However, whilst policy changes are on-going, ACIL Allen does not envisage substantial and unaccounted for shocks to the drivers of demand during the next access arrangement period. In these circumstances, the fact that the model does not account for non-linearities in demand is unlikely to lead to significant errors in the forecast. Issue 4 highlights the potential for omission of variables affecting demand. The consequence of omitting relevant variables is that regression coefficient estimates may be biased, and it is unclear *ex-ante* whether the bias would be up or down. It would be desirable to include a larger number of explanatory variables in the analysis. However, ACIL Allen is of the view that the model as it stands is fairly well substantiated, and while expanding the set of explanatory variables is often a desirable course of action, in this case it is unlikely to yield a material improvement in the quality or direction of the forecasts.

Despite these methodological issues it is not clear that further effort directed to further elaborating the model (in terms of either the range of explanatory variables included or the estimation of demand coefficients) would be warranted or likely to produce a significantly better or more reliable forecast.

After consideration of the above issues we conclude that, while the proposed demand forecast methodology is (like any forecast methodology) imperfect, it is sufficiently rigorous overall to satisfy the requirement of rule 74 of the NGR that the forecasts are arrived at on a reasonable basis.

4.5 Weather normalization of historical data

Weather has a significant impact on gas demand. The need to adjust historical data on gas consumption to take account of variations in weather has been noted, for example, by the Australian Energy Market Operator (AEMO) who in commenting on the Victorian gas distribution system noted that:

"Understanding the factors that affect the consumption of gas is central in evaluating future energy demands. When temperatures are lower than normal, energy demand for residential heating increases. This strong relationship between gas demand and climate highlights the need to identify the weather conditions assumed when calculating forecast demand. In gas forecasts, the actual demand needs to be adjusted for weather before the underlying growth can be calculated. These weather adjustments can be simplified through the use of Effective Degree Day (EDD) variable."

(AEMO, 2009, p. 55)

There are two basic approaches commonly used to adjust temperature data to take account of weather variations: Heating Degree Days (HDD) and Effective Degree Days (EDD).

The HDD approach uses a single measure of weather, namely temperature. HDD is calculated from meteorological data as the sum, over a year, of the negative differences[6] between the average temperature on each day and 18^{o} Celsius.

The EDD approach preferred by AEMO is a multifactor method based on the concept of Heating Degree Days (HDD) but also taking into account measures of average wind velocity, sunshine hours and seasonal variations in consumer propensity to use heating. The EDD approach in effect seeks to extend the HDD method by taking into account other weather-related parameters that may affect consumer behavior in relation to gas consumption for space heating and water heating.

4.5.1 Approach used

The approach to weather normalisation used by CIE is described in Appendix D of the CIE Report (CIE, 2016).

CIE has normalised data using annual effective degree days. As a cross-check, they have also checked system daily consumption against daily weather and tested the validity of the AEMO preferred effective degree day measure.

For the residential demand forecasts, CIE adjusted 2010 per dwelling consumption for each Tariff Zone and each usage block to reflect 'typical' climatic conditions.

6 If the average temperature on a particular day is greater than or equal to 18^{o}C, then HDD for that day is zero.

CIE notes in its report that typical climatic conditions have been modelled using annual effective degree day measures from CSIRO projected forward with a continued decline of about 8.5 EDD per year (CIE, 2016 p.116). This is the estimated combined effect of greenhouse warming and the Urban Heat Island (UHI) effect estimated by Suppiah and Whetton (2012). The estimate accounts for changes in temperature due to anthropogenic climate change and urbanisation leading to a greater UHI effect. CSIRO forecasts are based on long run climate change patterns, and are viewed by ACIL Allen as a reliable source. An alternative would be to use AEMO forecasts.

CIE notes that the approach to weather normalisation used by AEMO in its 2016 NGFR used observations from the Melbourne Regional Office (MRO) station and then Melbourne Olympic Park (MOP) station once the MRO station stopped operations.

CIE has chosen to use Melbourne Airport observations because:

— Melbourne Airport is geographically more centrally located to the AusNet service area than either the MRO or MOP stations. A closer relationship should therefore be expected to exist between gas demand in the AusNet service region and Melbourne Airport weather conditions than with the weather conditions recorded at the other stations.
— 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.

AEMO's forecasts of EDD have shown large swings in recent years. In the 2012 Review of the Weather Standards for Gas Forecasting, AEMO found that there was a warming trend in annual Victorian EDD_{312} of about -7.8 EDD_{312}/year over the period 2000 to 2011. In the 2014 National Gas Forecasting Report, AEMO projected a baseline Victorian EDD level of 1308 in 2015, with a downward trend of -8.05 EDD/year. In the 2015 NGFR, AEMO adopted a higher baseline EDD level of 1340 in 2015, but with zero decline in EDD across all forecast years to 2035. Most recently, in the 2016 NGFR (referenced in the CIE report), AEMO concluded that there would be an annual reduction of 6.8 EDD per year in Victoria over the forecast period to 2035 (AEMO 2016 NGFR Forecasting Methodology Information Paper, p. 53). In reaching this conclusion, AEMO advises that it sought both advice and data from the Bureau of Meteorology and the CSIRO.

Given the wide range of AEMO's forecasts for Victorian EDD over the past several years, we see no reason to argue that they should be preferred to those used by CIE based on CSIRO advice.

CIE has forecast an average decline rate of –8.5 EDD per year over the next access arrangement period. We consider that this estimate is not unreasonable in light of the following comparable estimates for Victoria:

AEMO (2012) –7.8 EDD

AEMO (2014) –8.05 EDD

AEMO (2016) –6.8 EDD

NIEIR (2016) –7.6 EDD.

NIEIR[7] notes that the long-term warming trend over the period 1970 to 2015 was between –9.8 and –5.4 with 95 per cent confidence.

On this basis we consider the CIE use of a –8.5 EDD per year trend over the next access arrangement period to be reasonable.

Revenue sensitivity to weather assumption

CIE has undertaken sensitivity analysis to assess the impact of alternative weather trend assumptions on forecast usage by customer, and consequences for residential constant-price revenue forecasts. This analysis shows that adopting an assumption of zero EDD decline (compared to the base case assumption of about –8.5 EDD per year) would, all else being equal, result in an increase in revenue of about 1.5 per cent ($2.5 million per year) by 2022.

[7] NIEIR, 2016: Review of EDD weather standards for Victorian gas forecasting (March 2016), p.6.

4.6 Gas price assumptions

CIE has estimated changes in the retail price of gas taking into account:

— changes in the wholesale gas price, multiplied by the share of wholesale gas prices in retail prices

— changes in the price level for distribution tariffs multiplied by the share of distribution tariffs in retail prices.

Specifically, CIE has used estimates of Victorian wholesale gas prices based on spot prices in the Victorian market (data compiled by AEMO) and changes wholesale gas prices. Forecasts were taken from AEMO's 2015 National Gas Forecasting Report. The medium price scenario forecast residential retail gas prices to rise from \$17.98/GJ in 2015 to \$21.64 in 2022, an increase of 20.3 per cent over the period.

AusNet notes the (then anticipated) release of the 2016 AEMO National Gas Forecasting Report in December and has proposed that any changes to AEMO's retail price forecasts will be updated in AusNet's revised access arrangement proposal.

CIE has also analysed the sensitivity of residential and commercial constant-price revenues to the assumptions made with regard to gas prices. A range of future gas price paths are considered, corresponding to AEMO's 2015 NGFR medium, high consumption and low consumption gas price scenarios. The analysis shows that alternative gas price projections have a negligible impact on forecast revenue from residential customers. For commercial customers, the revenue impact is more sensitive to the alternate projections of gas prices. Switching from the base to the low price forecast results in an increase of around \$0.1 million (1.3 per cent) in revenue from commercial Tariff V customers by the end of the forecast period in 2022.

CIE's assumptions regarding rising gas prices are consistent with widely-held views on the future price path for natural gas in eastern Australian domestic markets. Wholesale gas prices in eastern Australia have been rising strongly in recent years, and there is a virtually universal expectation that gas prices will continue to rise. For example, the Australian Competition and Consumer Commission in its 2016 Inquiry into the East Coast Gas Market noted that:

"The commissioning of the LNG export facilities has significantly altered the pricing dynamics in the east coast gas market. The LNG facilities have enabled CSG producers in Queensland to access international gas markets and sell their gas at LNG export prices, which are higher than historic gas prices paid by domestic users under bilateral GSAs. By leaving spare capacity in their trains, the LNG projects have created an additional demand option for producers in the east coast gas market, particularly those located in Queensland and central Australia.

… there has been a significant change in the pricing dynamics in the southern states as a result of the decisions made by the Cooper Basin producers, particularly Santos, to commit significant volumes of gas produced in the Cooper Basin to the LNG projects."

Although the emergence of the LNG export industry in central Queensland has been the most important contributor to the upward pressure on domestic gas prices, a number of other factors are also contributing to a tight gas supply outlook in eastern Australia. These include:

— Declining production in a number of areas including Cooper, Otway and Bass Basins.

— New fields in the Gippsland Basin (Kipper/Tuna/Turrum and Sole projects) being offset by declining production in established fields

— Low levels of investment in exploration and appraisal drilling, despite the strong outlook for domestic gas demand.

  – Over the past three years, exploration activity has declined sharply as a result of falling oil prices and restrictive exploration policies in a number of jurisdictions (New South Wales, Victoria, Tasmania and Northern Territory).

Clearly there are a range of factors that could affect future wholesale gas prices. In the context of this review, the question is whether the assumptions made by CIE with regard to wholesale gas prices for the purposes of modeling future gas demand are reasonable. Having reviewed the CIE assumptions and their sources, and based on our knowledge of Australian wholesale gas markets, ACIL Allen considers that the assumptions adopted by CIE regarding changes in wholesale and retail gas prices are reasonable and that they are based on reputable independent sources.

4.7 Joint marketing campaign

The three distribution businesses (AusNet, AGN, Multinet) are proposing to undertake a joint marketing campaign aimed at increasing levels of network utilisation.

In the context of the review of demand forecasts for the distribution businesses we examine the joint marketing campaign purely from the perspective of the anticipated impacts of such a campaign (if approved and implemented) on the demand for services, and the extent to which the demand forecasts for the individual distribution businesses have been adjusted to take into account the anticipated effects of the proposed joint marketing campaign.

We do not seek to address the question of whether the expected benefits of the joint marketing campaign outweigh its expected costs, nor have we attempted to assess the merits of the arguments put forward by the distribution businesses for including the costs of the campaign within their approved operating cost allowances.

Because the Victorian market is supplied by three similarly sized distribution businesses, any marketing carried out by a single distribution business, particularly in areas where the networks are in close proximity (for example, the Melbourne area) would be likely to be subject to the 'free rider effect' and therefore result in sub-optimal levels of marketing. To overcome this impediment, the Victorian distribution businesses are proposing to carry out a joint marketing campaign in the upcoming AA period.

The Australian Energy Market Operator in its latest (December 2016) National Gas Forecasting Report forecast that, under its Medium Scenario assumptions, total gas consumption in Victoria (after losses) will fall from 206 PJ in 2015 to 193 PJ in 2022. In the Tariff V (residential and commercial) segment of the market the corresponding projection is that demand will fall from 121 PJ in 2015 to 117 PJ in 2022.

The study by Axiom Economics that is included as Appendix 7 D in the AusNet Access Arrangement Information provides a more detailed analysis of the projected decline.

Factors seen to be contributing to the decline in gas consumption include:

— rising wholesale gas prices
— a shift away from gas appliances to electric appliances
— improvements in the energy efficiency of buildings and appliances
— changes in the dwelling stock (for example, from houses to smaller apartments and multi-unit developments, including smaller all-electric apartments)
— environmental concerns about unconventional sources of gas
— growth in solar PV.

The joint marketing campaign proposes to focus on the residential segment of the market, its objective being to counter some of the projected decline in residential consumption that is expected to occur in the next AA period.

The three main elements of the proposed joint marketing campaign are:

— an appliance rebate program, which would provide residential customers a financial incentive to purchase gas heaters and hot water systems and, in some cases, to connect to the relevant network
— an advertising campaign to promote the use of gas, reinforce the benefits of using gas appliances and promote the appliance rebate scheme
— enhanced industry representation which would promote the use of gas to intermediaries such as builders, developers, plumbers, gas fitters and appliance retailers.

4.7.1 Anticipated impacts of the Joint Marketing Campaign

Over the next AA period, the proposed Joint Marketing Campaign aims to reduce the projected decline in Tariff V (residential and small commercial) consumption by 25 per cent (about 4 PJ in total) and to increase the number of new connections by 4,000 across the three distribution networks.

It is also anticipated that the campaign would continue to have an effect on residential demand post 2022, with Tariff V consumption increasing by a total of 17.6 PJ over the period 2023 to 2041 when compared to a “business as usual” case.

Implications for AusNet demand forecast

The distribution businesses commissioned a study by Axiom Economics of the additional costs and revenues associated with the joint marketing campaign[8].

According to that study, the proposed marketing program would reverse some of the anticipated decline in residential gas customer numbers (and hence residential gas volumes) due to appliance switching discussed.

Axiom notes that AusNet’s demand projections for the next AA period assume that, in the absence of the proposed marketing campaign, annual residential and small commercial demand could fall by around 0.9 per cent per year, from 37.5 PJ per year to 35.9 PJ per year. Over the five-year term of the AA period, this implies that demand would be about 4 PJ lower than it would have been if demand had remained at the 2017 level.

If the joint marketing campaign proceeds, residential and small commercial demand in AusNet’s network is expected to be 1.33 PJ higher over the AA period. The additional demand expected to arise from the joint marketing campaign would not be sufficient to counter all of the projected decline in demand over the AA period, but it would offset about one-third of it.

Axiom Economics estimates that the joint marketing campaign would lead to an increase of about 264 additional connections per year (on average) over the AA period. This represents an increase of 0.18 per cent above CIE’s forecast gross connections.

The tables below summarise the impact on both customer numbers and energy consumption of the marketing program. The ‘base’ rows show the forecast without the marketing allowance, whilst the ‘marketing’ row shows the forecast with the marketing allowance. All incremental demand is assumed to come from residential customers. **Table 4.3** summarises the forecast impacts of the proposed marketing campaign on residential customer numbers in the AusNet service area.

TABLE 4.3 COMPARISON OF RESIDENTIAL CONNECTION NUMBER FORECASTS (TJ)

Region	Source	2018	2019	2020	2021	2022
Central	AAI Base	515,833	525,991	536,448	547,215	557,601
	AAI Marketing	516,035	526,396	537,055	548,025	558,613
	RIN	517,741	527,956	538,466	549,281	560,060
West	AAI Base	144,353	147,648	151,000	154,411	157,733
	AAI Marketing	144,410	147,761	151,170	154,638	158,016
	RIN	143,958	147,281	150,661	154,099	157,522
Adjoining Central	AAI Base	1973	2283	2525	2715	2867
	AAI Marketing	1,974	2,284	2,527	2,718	2,870
	RIN	1,823	2,179	2,456	2,673	2,844
Adjoining West	AAI Base	10913	11385	11820	12227	12621

[8] Axiom Economics, 2016: Consistency of the Victorian gas distribution businesses’ joint marketing campaign with rule 91 of the NGR. A report prepared for AGN, AusNet Services and Multinet, December 2016.

Region	Source	2018	2019	2020	2021	2022
	AAI Marketing	10,917	11,393	11,831	12,242	12,640
	RIN	10,882	11,384	11,842	12,266	12,671
TOTAL	**AAI Base**	**673,072**	**687,307**	**701,793**	**716,568**	**730,822**
	AAI Marketing	**673,336**	**687,834**	**702,583**	**717,623**	**732,139**
	RIN	**674,403**	**688,801**	**703,425**	**718,319**	**733,097**
	% diff Marketing to Base	**0.04%**	**0.08%**	**0.11%**	**0.15%**	**0.18%**

Source: AusNet Access Arrangement Information Table 4.7; AusNet GAAR 2018-22 Regulatory Information Notice, Tab 27.

Also shown in **Table 4.3** are the residential customer numbers, by region, as reported in the AusNet Regulatory Information Notice (RIN, Table 27). The RIN forecast numbers are slightly higher than the "with marketing" numbers reported in the AAI Table 4.7, the differences in annual total customer numbers ranging between 0.10 per cent and 0.16 per cent.

As shown in **Table 4.4**, the impacts of the proposed marketing campaign on residential consumption forecasts are proportionately greater than the impacts on residential connection numbers. This implies that the market campaign is expected not only to increase customer numbers but also to boost the average level of gas use per connection. Table 4-8 of the AAI summarises residential consumption by region, with and without the impacts of the marketing proposal. The residential consumption numbers shown in AAI Table 4-4 exclude the impacts of the marketing proposal. The residential consumption numbers shown in the Regulatory Impact Notice (RIN) are the same as those shown in AAI Table 4-8; they therefore include the impacts of the marketing proposal.

TABLE 4.4 COMPARISON OF RESIDENTIAL CONSUMPTION FORECASTS (TJ)

Region	Source	2018	2019	2020	2021	2022
Central	AAI Base	24,205	24,333	24,455	24,542	24,457
	AAI Marketing	24,273	24,470	24,660	24,816	24,798
	RIN	24,273	24,470	24,660	24,816	24,798
West	AAI Base	6,806	6,861	6,913	6,955	6,939
	AAI Marketing	6,825	6,899	6,971	7,032	7,035
	RIN	6,825	6,899	6,971	7,032	7,035
Adjoining Central	AAI Base	67	74	79	83	84
	AAI Marketing	67	74	80	84	85
	RIN	67	74	80	84	85
Adjoining West	AAI Base	543	556	567	576	577
	AAI Marketing	544	559	571	581	584
	RIN	544	559	571	581	584
TOTAL	**AAI Base**	**31,621**	**31,824**	**32,014**	**32,156**	**32,057**
	AAI Marketing	**31,710**	**32,002**	**32,281**	**32,512**	**32,501**
	RIN	**31,710**	**32,002**	**32,281**	**32,512**	**32,501**

Region	Source	2018	2019	2020	2021	2022
	% diff Marketing to Base	**0.28%**	**0.56%**	**0.83%**	**1.10%**	**1.37%**

Source: AusNet Access Arrangement Information Table 4.4; AusNet GAAR 2018-22 Regulatory Information Notice, Tab 28.

5 ASSESSMENT OF THE FORECASTS

5.1 Summary of forecast results

AusNet has summarised the key features of the demand forecasts for the period 2018 to 2022 as follows[9]:

— AusNet's customer base is forecast to grow by 2.1 per cent per year, led by strong household growth and recent trends in the proportion of new dwellings whose owners choose to connect to gas.

— The long term trend of warmer weather in AusNet's region and the associated impact on volumes is expected to continue.

— A trend of newer customers using less gas than the existing customer base is expected to continue.

— An increasing tendency for customers to use electricity rather than gas for heating and hot water (that is, appliance switching) will continue to have a downward impact on future demand.

— The above factors mean that on a weather normalised basis, the forecast is for average residential consumption (per customer) to fall by 1.5 per cent per year over 2018-22, compared to the 0.9 per cent fall which took place in 2010-15. This forecast incorporates the positive impacts of the proposed marketing program.

— Total demand for residential and commercial customers (Tariff V) is forecast to grow by only 0.6 per cent in total between 2017 and 2022, compared to the 7.6 per cent growth over the five years to 2015. Strong growth in customer numbers, led by forecast household growth, will be largely offset by reductions in consumption per customer.

— By the end of the period, the additional demand attributable to AusNet's proposed marketing activities is expected to result in Tariff V demand being 1.2% higher than would otherwise be forecast.

— Demand from industrial customers (measured by maximum hourly quantity) is forecast to fall by 12% between 2018 and 2022, in line with AEMO's projections for state-wide Tariff D consumption.

5.2 Assessment of the forecasts

In this section we review the revised forecasts for AusNet, to consider whether the application of the methodologies and assumptions used have produced forecast results that are reasonable in light of historical patterns of demand as well as current and anticipated influences on retail gas demand in the distribution area. We consider separately the forecasts for the Volume and Demand sectors of the market.

[9] AusNet Access Arrangement Information, p.52.

5.2.1 Use of trend extrapolation for forecast verification

In the following analysis, historical trend analysis is used as a cross-check on the results generated using the CIE methodology. ACIL Allen recognises that forecasting on the basis of extrapolation of historical trends involves a risk of overlooking changes in market drivers that could result in future trends differing from historical trends. The fact that a forecast diverges from the historical trend cannot in itself be taken as proof that the forecast is unreasonable. Rather, such divergence may prompt us to ask whether there are good reasons for the break in trend.

The comparison charts include lines representing historical trends as well as the upper and lower bounds of the 90 per cent confidence intervals around the projected historical trends. The historical trends have been generated using an Ordinary Least Squares (OLS) regression on data from 2008 to 2015. However, because of the relatively small number of data points there may be a significant level of uncertainty regarding the true historical trends. The lines labelled “Upper Interval” and “Lower Interval” define the confidence interval within which there is a 90 per cent probability that the true historical trend lies. Where the historical data shows a high degree of correlation, this confidence interval is narrow; data that is less well correlated will show a wider confidence interval.

Note that the scale of the Y axis in the following charts has been chosen to allow the relationships between forecasts, historical trends and confidence intervals to be seen clearly. This may have effect of exaggerating the apparent extent of deviations from historical trends, when in fact the changes may be much less pronounced when viewed in absolute terms. Care should therefore be exercised in interpreting the charts.

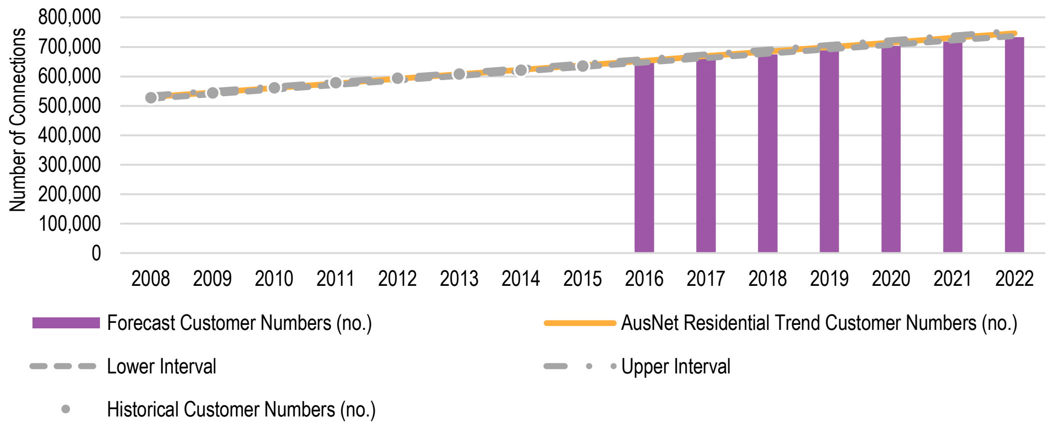
5.2.2 Tariff V History and Forecasts

Tariff V Customer Numbers

Tariff V Residential customer numbers

The forecast of total customer numbers for the Tariff V residential sector is summarised and compared with historical actual customer numbers in **Figure 5.1**. Forecast growth in customer numbers is slightly lower than the historical trend rate. By 2022 the forecast is around 12,800 or 1.7 per cent lower than the historical trend.

FIGURE 5.1 HISTORICAL AND FORECAST CUSTOMER NUMBERS: TARIFF V RESIDENTIAL



SOURCE: AUSNET RIN 2016; ACIL ALLEN ANALYSIS

Figure 5.1 reflects the customer number forecasts shown in AusNet’s Regulatory Information Notice (RIN) and are higher than those shown in the CIE report (Table 6.7). This is because CIE has made a post-model adjustment (downward) to reflect a forecast increased rate of gas-to-electricity switching. AusNet has elected not to apply the appliance switching adjustment to the residential customer number forecast:

"Given the level of uncertainty as to the precise extent of the acceleration of appliance switching, and the need to limit increases in network charges and promote the use of gas as a fuel of choice, AusNet Services has elected to adopt CIE's forecast excluding the post modelling adjustment for appliance switching. AusNet Services will continue to investigate the drivers underpinning future demand, including via consultation with AEMO between now and the Revised Proposal.

Investigating ways to increase the demand for gas is one reason why AusNet Services is proposing an allowance for gas marketing over the forthcoming access arrangement period." (AusNet Access Arrangement Information, p.67).

The rate of growth in residential connections in the AusNet distribution area is forecast to an average 2.1 per cent over the period 2016 to 2022, down from a historic rate of 2.7 per cent over the period 2008 to 2015, and 2.3 per cent over the period 2011 to 2016. The observed rate of growth has therefore been falling, and the forecast is for that trend to continue.

The downward shift in the rate of growth of customer numbers can be attributed to the fact that growth in metropolitan Melbourne LGAs such as Wyndham, Brimbank and Melton is slowing and growth in smaller LGAs outside of metropolitan Melbourne is not compensating for the lower growth around the higher-density Melbourne area.

Looking at the results relative to the historic trend and noting the growth trends in the different parts of AusNet's distribution area, the forecast customer numbers for residential Tariff V do not appear to be unreasonable.

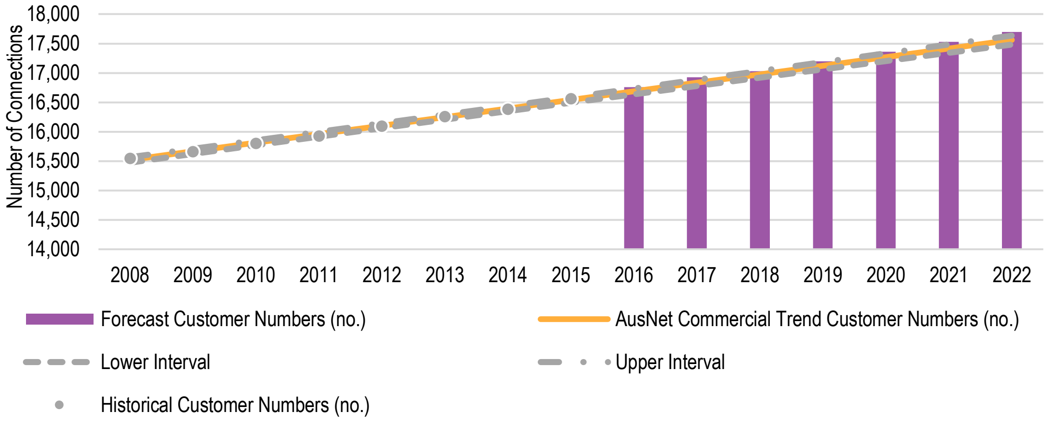
Tariff V Commercial customer numbers

The forecast of total customer numbers for the Tariff V commercial sector is summarised and compared with historical actual customer numbers in **Figure 5.2**.

Historically, growth in commercial customer numbers has been slower than growth in residential customer numbers, with commercial customers having grown on average by 0.9 per cent per year between 2008 and 2015 (based on the average annual commercial customer numbers shown in AusNet RIN, Tab 27).

As discussed in section 4.3.1, commercial customer numbers are forecast as a fraction of residential customer numbers, with an estimated 11.7 new commercial customers for each 1,000 new residential customers. The implied average growth rate over the access arrangement period (2018 to 2022) is 0.97 per cent per year—similar to the historical growth rate for commercial customers.

FIGURE 5.2 HISTORICAL AND FORECAST CUSTOMER NUMBERS: TARIFF V COMMERCIAL



SOURCE: AUSNET RIN 2016; ACIL ALLEN ANALYSIS

On this basis, the forecast customer numbers for commercial Tariff V do not appear to be unreasonable.

Tariff V Consumption per Connection

Tariff V Residential Consumption per Connection

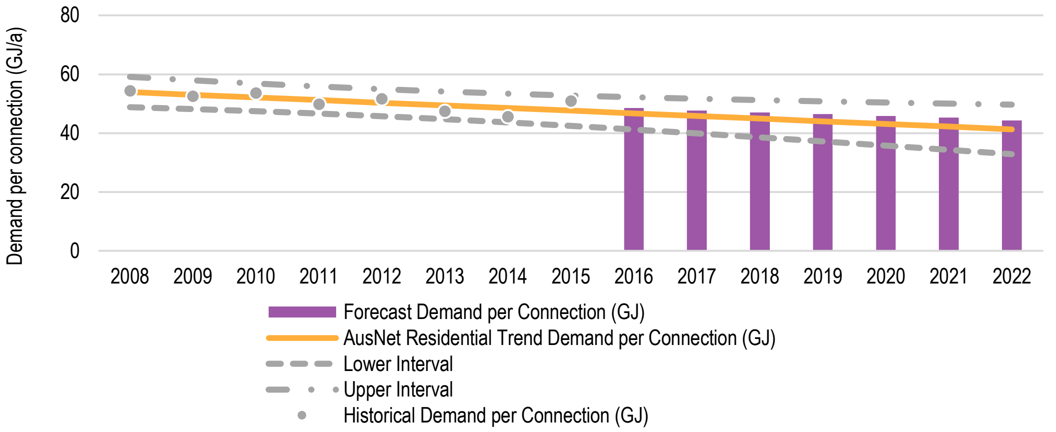
As AusNet notes[10], residential gas consumption per connection has been declining for a number of years. CIE attributes this fall in gas demand to a number of drivers, including:

— improvements in the energy efficiency of new housing stock compared to existing housing stock (that is, new dwellings demand less gas than older dwellings)
— a higher proportion of new connections are smaller units and flats than the overall population of existing connections
— increasing retail gas prices
— increasing consumer preferences for electrical appliances over gas appliances. This trend, known as "appliance switching", has also been noted by AEMO and factored into its electricity and gas forecasts
— a long term trend of a warming climate, as measured by both Effective Degree Days26 and average temperatures.

The combination of the above drivers has seen consumption per customer fall by about 10 per cent over the past 12 years (actual volumes, not weather normalised).

CIE has forecast consumption per residential customer on two different bases, one incorporating a post-model adjustment to account for an increased future rate of appliance switching, and one without the appliance switching adjustment. As explained in section 5.2.2, AusNet has elected not to apply the appliance switching adjustment to the residential customer number forecast. The forecast consumption per connection for residential customers shown in the AusNet RIN (and illustrated in **Figure 5.3**) do not include a post-model adjustment for appliance switching.

FIGURE 5.3 HISTORICAL AND FORECAST CONSUMPTION PER CONNECTION: TARIFF V RESIDENTIAL



SOURCE: AUSNET RIN 2016; ACIL ALLEN ANALYSIS

As shown, the forecast for residential demand per connection shows a continued decline at a rate very close to the historical decline rate and on this basis does not appear to be unreasonable.

Tariff V Commercial Consumption per Connection

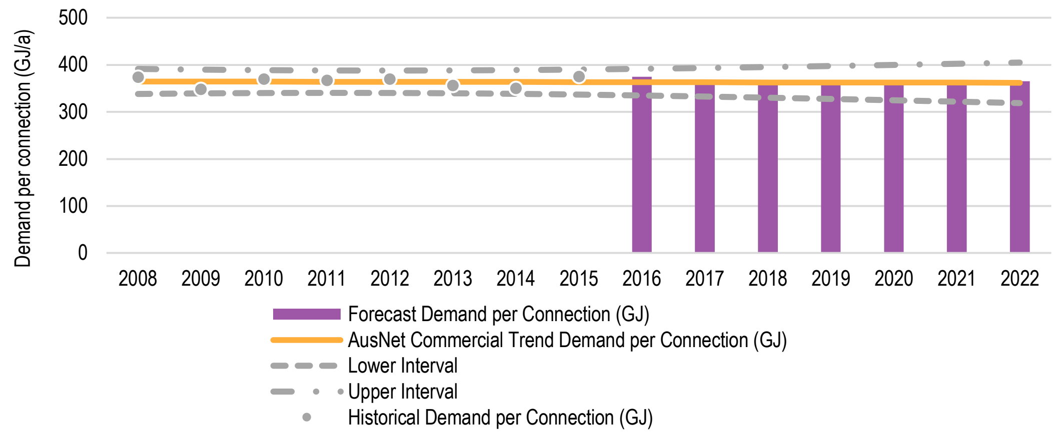
Figure 5.4 shows the historical and forecast consumption per commercial customer connection. The forecast values have been determined using CIE's econometric model of commercial customer usage.

Over the period 2018 to 2022 consumption per commercial customer connection is forecast to decline marginally, at a compound average rate of –0.1 per cent per year.

[10] AusNet 2016, Access Arrangement Information, p. 62.

As shown in **Figure 5.4** the forecast consumption per commercial customer connection lies very close to the historical trend and on this basis does not appear to be unreasonable.

FIGURE 5.4 HISTORICAL AND FORECAST CONSUMPTION PER CONNECTION: TARIFF V COMMERCIAL



SOURCE: AUSNET RIN 2016; ACIL ALLEN ANALYSIS

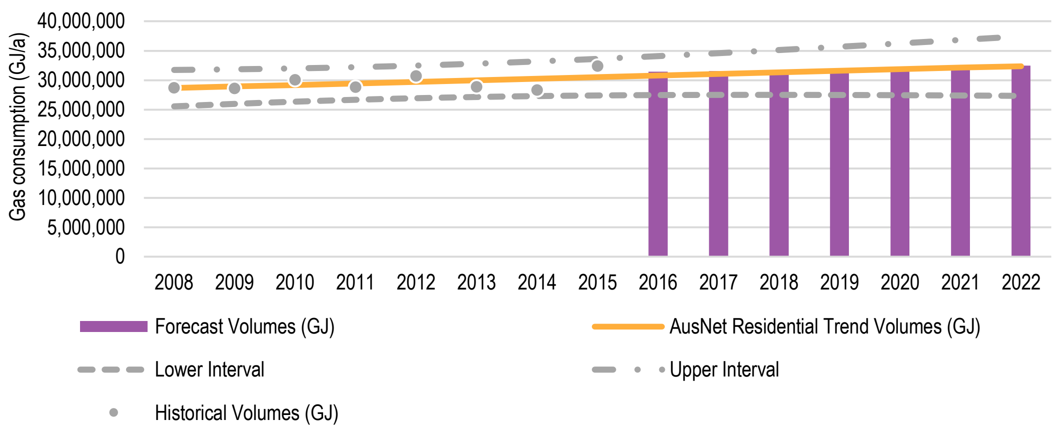
Tariff V Annual Gas Consumption

Tariff V Residential Annual Consumption

Figure 5.5 shows the historical and forecast total annual gas consumption for Tariff V residential customers. The historical consumption values shown are actual consumption (not weather normalised) and therefore illustrate the level of volatility associated with year-on-year weather variations. The forecast consumption has been derived by multiplying together the forecast residential customer numbers (shown in **Figure 5.1**) and the forecast average residential consumption per connection (shown in **Figure 5.3**).

As shown, the forecast total consumption for Tariff V residential customers is very close to the historical trend, and on this basis the forecast does not appear to be unreasonable.

FIGURE 5.5 HISTORICAL AND FORECAST ANNUAL CONSUMPTION: TARIFF V RESIDENTIAL



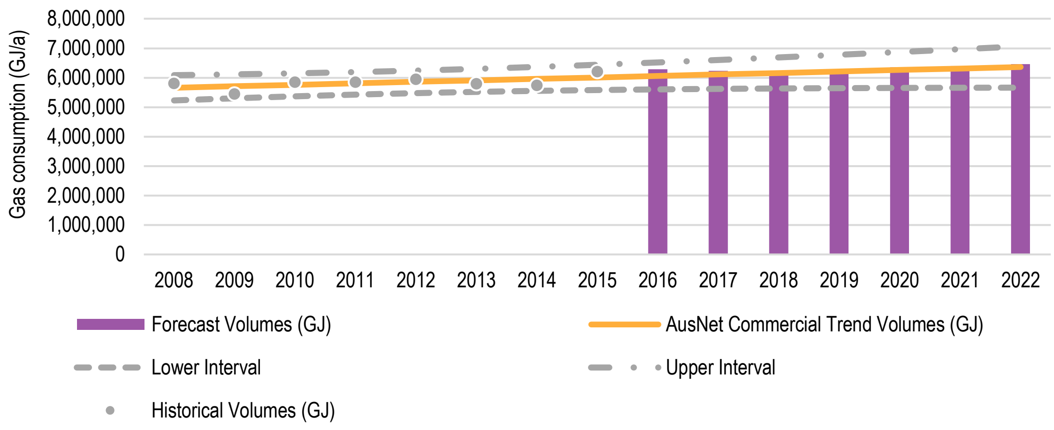
SOURCE: AUSNET RIN 2016; ACIL ALLEN ANALYSIS

Tariff V Commercial Annual Consumption

Figure 5.6 shows the historical and forecast total annual gas consumption for Tariff V commercial customers. The historical consumption values shown are actual consumption (not weather normalised) and therefore illustrate the level of volatility associated with year-on-year weather variations. The forecast consumption has been derived by multiplying together the forecast commercial customer numbers (shown in **Figure 5.2**) and the forecast average residential consumption per connection (shown in **Figure 5.4**).

As shown, the forecast total consumption for Tariff V commercial customers is very close to the historical trend, and on this basis the forecast does not appear to be unreasonable.

FIGURE 5.6 HISTORICAL AND FORECAST ANNUAL CONSUMPTION: TARIFF V COMMERCIAL



SOURCE: AUSNET RIN 2016; ACIL ALLEN ANALYSIS

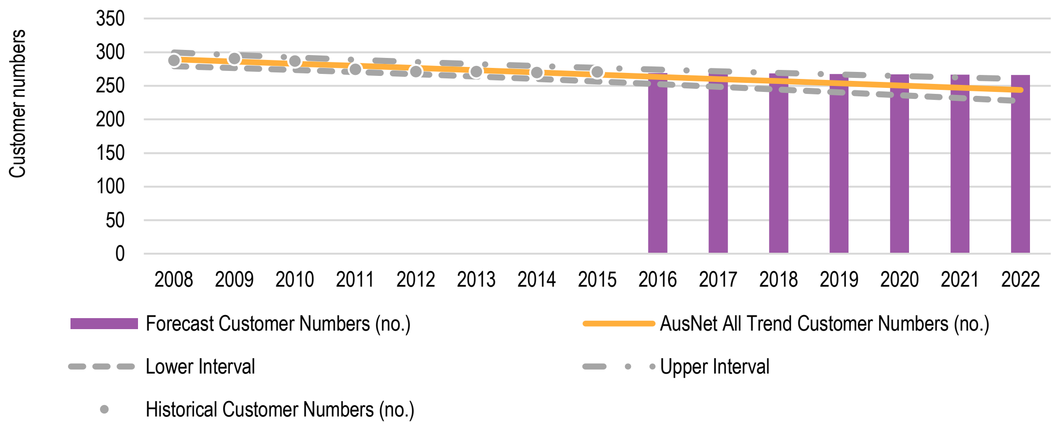
5.2.3 Industrial Tariff D and Tariff M History and Forecasts

In this section we examine the forecasts for industrial customers who are charged on the basis of demand tariffs (Tariff D and Tariff M).

Tariff D and Tariff M Customer Numbers

The forecast of total customer numbers for the Tariff D and Tariff M industrial sector is summarised and compared with historical actual customer numbers in **Figure 5.7**.

FIGURE 5.7 HISTORICAL AND FORECAST CUSTOMER NUMBERS: TARIFF D AND TARIFF M



SOURCE: AUSNET RIN 2016; ACIL ALLEN ANALYSIS

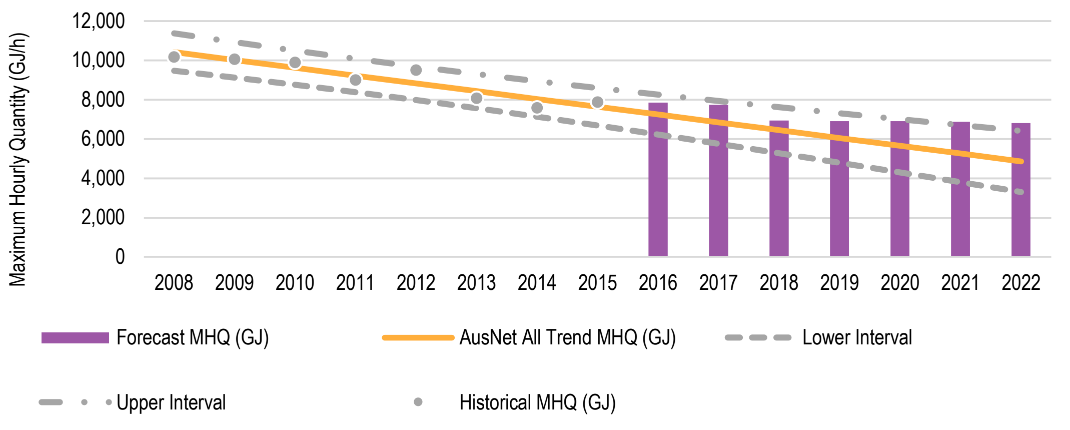
As discussed in section 4.3.1, demand from industrial customers (Tariff D and Tariff M) is specified in terms of maximum hourly quantities (MHQ) since this is the basis on which those customers are charged. Forecasting the number of these customers in the forthcoming access arrangement period is not required because Tariff D and Tariff M customers are not levied a fixed charge and any expenditure associated with connecting new Tariff D and Tariff M customers is funded by the customers themselves, either through a customer contribution, separate charges (Tariff D) or the Haulage Reference Service charge (Tariff M). Nevertheless, the AusNet RIN provides information on historical and forecast industrial customer numbers and so, for purposes of completeness, we have included an assessment of these forecasts.

As shown in **Figure 5.7** the forecast for MDQ customer numbers shows a decline rate somewhat lower than in the past, near the upper bound of the confidence interval around the historical trend line. On this basis the forecast appears to be reasonable.

Tariff D and Tariff M Maximum Hourly Quantity

The forecast of aggregate Maximum Hourly Quantity (MHQ) for large industrial customers is summarised in **Figure 5.8**. As discussed in section 4.3.1 the forecasts for large industrial MDQ are based on total Tariff D annual gas system demand forecasts prepared by the Australian Energy Market Operator (AEMO, 2016). Mapped to the AusNet customer base, it can be seen that the resulting forecast shows a continuing decline in MHQ over the forecast period, but at an average rate somewhat less than the projected historical trend. The resulting forecast lies near the upper bound of the confidence interval around the historical trend.

FIGURE 5.8 HISTORICAL AND FORECAST MAXIMUM HOURLY QUANTITY: TARIFF D AND TARIFF M



SOURCE: AUSNET RIN 2016; ACIL ALLEN ANALYSIS

Given the relatively small number of large industrial customers and the asymmetric nature of their MDQ requirements (that is, a small number of individual sites in the industrial customer cohort account for a large proportion of the total MHQ demand), any forecast of industrial MHQ is subject to significant uncertainty. The start-up or closure of a single very large industrial site could significantly change future MDQ requirements. AusNet has taken into consideration any such changes that have been foreshadowed (such as the closure of vehicle manufacturing plants within its distribution area) and the forecasts take these factors into account.

On this basis we consider the forecasts of large industrial MHQ for AusNet to be reasonable.

6

CONCLUSIONS

Having examined the historical data (from 2008) and forecasts of Tariff V Residential customer numbers, we note that the forecasts show growth in customer numbers at an average 2.1 per cent per year, a somewhat lower rate than in the past. This can reasonably be explained by the fact that growth in metropolitan Melbourne LGAs such as Wyndham, Brimbank and Melton is slowing and growth in smaller LGAs outside of metropolitan Melbourne is not compensating for the lower growth around the higher-density Melbourne area. There has also been a shift in customer preferences which increasingly favour electricity over gas, particularly in new dwellings. For non-residential (commercial) Tariff V customers, connection numbers are forecast to rise at or slightly above the historical rate of growth. Overall we conclude that the Tariff V customer number forecasts do not appear to be unreasonable.

With regard to Tariff V gas consumption per connection, the forecast for residential customers sees a continued decline in average annual consumption at rates similar to the long-run historical downward trend. For commercial Tariff V customers, average consumption per connection is forecast to remain almost flat at around 360 GJ/a, again very close to historical trends. We conclude that the Tariff V consumption per connection forecasts are not unreasonable.

Given that the forecasts of Tariff V annual gas consumption (residential and commercial) are derived from the corresponding connection number and average consumption per connection forecasts—which we have concluded appear to be reasonable—it follows that the annual consumption forecasts should be reasonable. This is indeed the case: the forecasts for annual consumption by both the residential and commercial Tariff V customer classes are very much in line with historical trends which have seen modest growth in total consumption over the past eight years.

With regard to Tariff D demand, the critical determinant is the forecast of Maximum Hourly Quantity (MHQ) across the customer group, since this determines the overall capacity requirements (and hence network capital) as well as reflecting the basis on which Tariff D customer charges are levied.

The historical MHQ data for AusNet Tariff D customers shows a decline from about 10,200 GJ/h in 2008 to 7,900 GJ/h in 2015. The forecasts lie slightly above the historical trend, falling from 7,900 to 6,800 GJ/h over the period 2016 to 2022. On this basis, the forecast levels of MHQ for AusNet Tariff D customers do not appear to be unreasonable.

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A COMPARISON OF KEY MODELLING ASSUMPTIONS

The purpose of this Appendix is to provide a comparison of key assumptions in the demand forecasts prepared by the three Victorian gas distribution businesses for the Access Arrangement Review for the period 2018 to 2022. The gas transmission business (APA VTS) is not included in this comparison because it is relying upon the distribution business forecasts of residential and commercial gas demand, and AEMO forecasts of Tariff D (industrial) demand, rather than generating its own forecasts of demand in these distribution-serviced market segments.

The document is intended to highlight any major discrepancies or inconsistencies in the assumptions that have been used by the distribution businesses in preparing their demand forecasts.

A.1 Overall approach to the demand forecasts

The three distribution businesses have adopted different overall approaches to the development of their demand forecasts. Each distribution business has followed a similar method to that which they used in developing their forecasts for the current access arrangement period:

— Australian Gas Networks (AGN) and its market adviser Core Energy have used a combination of assumptions and econometric regression models. Their methodology for forecasting Tariff V gas demand involves weather normalisation of historical demand per connection data; identification of factors influencing changes in demand per connection and connection numbers; deriving forecasts using regression analysis techniques; and adjustment for demand drivers that are expected to deviate from historical trends. For large (Tariff D) customers AGN/Core used a survey based approach.

— AusNet Energy and its market adviser CIE used a bottom-up econometric approach to forecast gas demand. Their approach involved analysis of AusNet's billing database and daily outcomes using panel data statistical techniques; identification of drivers of change in patterns of gas consumption; development of projections using independent estimates of drivers and incorporating adjustments to reflect the impact of changes not reflected in the historical time series. CIE also 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. Commercial customer numbers were forecast as a fraction of residential customer numbers, since this was found to be the most closely correlated variable among the candidate drivers. Forecasts for Tariff D industrial customers were based on total Tariff D annual gas system demand forecasts prepared by the Australian Energy Market Operator (AEMO, 2016a).

— Multinet and its market adviser NIEIR used what they describe as 'a multi-variate approach which is not a matter of extrapolating trends'. Their modelling methodology was largely a 'top down' approach that relied heavily on NIEIR's in-house economic and energy model which produced forecasts of population, the dwelling stock growth and estimates of gross regional product at Statistical Sub-Division or Local Government Area (LGA) level. The energy projections for Multinet were directly linked to economic indicators for the LGAs comprising the Multinet gas distribution area. Within this broad framework, NIEIR's approach to forecasting demand differed between the three customer types. In general terms, NIEIR adopted the follow approaches:

- Tariff V residential customer forecasts were based on a 'dwelling growth' approach.
- Tariff V business customer and Tariff L forecasts were based on an 'economic modelling' approach
- Tariff D customer forecasts were based on an 'economic modelling' approach supplemented by a survey of the largest of these customers

The fact that each of the three distribution businesses has employed a different approach to the development of demand forecasts raises the question whether one of these is a better, more rigorous or otherwise superior approach that ought to be favoured over the other approaches.

The National Gas Rules (NGR) do not mandate any particular forecasting method. Instead, NGR Rule 74 requires that:

5. information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.
6. a forecast or estimate:
   a) must be arrived at on a reasonable basis; and
   b) must represent the best forecast or estimate possible in the circumstances.

The AER in its 2013 'Better Regulation' program identified a number of principles of 'best practice' demand forecasting. Although developed specifically in relation to electricity networks, there is no obvious reason why these principles should not also be generally applicable to demand forecasts for gas distribution businesses. The principles identified by the AER include requirements for the forecasts to:

- be accurate and unbiased
- be transparent and repeatable
- incorporate key drivers
- incorporate a suitable method of weather normalisation
- be subject to statistical model validation and testing
- use the most recent input information available
- incorporate the maturity profile of the service area
- be subject to regular review.

While the three distribution businesses have adopted different forecasting approaches, each approach is generally consistent with the above principles. All three approaches are, in our opinion, capable of producing reliable forecasts that meet the requirements of the NGR provided the methods chosen are properly applied and the data and assumptions used are as accurate and up to date as possible. We see no reason to conclude that any particular demand forecasting approach is intrinsically superior to the others and ought to be preferred.

A.2 Weather normalisation

Table A.1 provides a comparison of the parameters used by the distribution businesses for weather normalisation of historical data, and to establish the forecast weather trends that will impact on levels of residential and commercial gas demand.

All three businesses have use effective degree days (EDD) as the main input for weather normalisation.

TABLE A.1 COMPARISON OF PARAMETERS: WEATHER NORMALISATION

Parameter	Units	Australian Gas Networks	AusNet Services	Multinet Gas
Long term EDD decline	#/year	-7.3 EDD per year	-8.5 EDD per year	-7.6 EDD per year
Standard EDD Value	#	1342 in 2015	About 1620 in 2015	1314 in 2016

Parameter	Units	Australian Gas Networks	AusNet Services	Multinet Gas

SOURCE: ACIL ALLEN ANALYSIS OF DISTRIBUTION BUSINESS FORECASTS AS SUBMITTED FOR THE ACCESS ARRANGEMENT PERIOD 2018 - 2022

The three businesses have adopted similar forecasts in terms of the rate of decline in EDD, with values ranging from -7.3 to -8.5 EDD/year.

The above values compare favourably with the following alternative forecast of Victorian EDD that have been produced in recent years:

— AEMO (2012) –7.8 EDD/year
— AEMO (2014) –8.05 EDD/year
— AEMO (2016) –6.8 EDD/year

AEMO's forecasts of EDD have shown large swings in recent years. In the 2012 Review of the Weather Standards for Gas Forecasting, AEMO found that there was a warming trend in annual Victorian EDD_{312} of about -7.8 EDD_{312}/year over the period 2000 to 2011. In the 2014 National Gas Forecasting Report, AEMO projected a baseline Victorian EDD level of 1308 in 2015, with a downward trend of -8.05 EDD/year. In the 2015 NGFR, AEMO adopted a higher baseline EDD level of 1340 in 2015, but with zero decline in EDD across all forecast years to 2035. More recently, in the 2016 NGFR (referenced in the CIE report), AEMO concluded that there would be an annual reduction of 6.8 EDD per year in Victoria over the forecast period to 2035 (AEMO 2016 NGFR Forecasting Methodology Information Paper, p. 53). In reaching this conclusion, AEMO advises that it sought both advice and data from the Bureau of Meteorology and the CSIRO.

Given the wide range of AEMO's forecasts for Victorian EDD over the past several years, we see no reason to argue that they should be preferred to those used by the distribution businesses. We consider all three distribution business forecasts of the rates of EDD decline in their areas of business operation to be reasonable.

The AusNet Services Standard EDD value of 1,620 in 2015 is significantly higher than the corresponding values as assessed by AGN and Multinet (1,342 in 2015 and 1,314 in 2016 respectively). The most likely reason for this difference is that AusNet/CIE has used weather data from Melbourne Airport whereas AGN/Core and Multinet/CIE have used weather data from Melbourne Regional Office (Melbourne Olympic Park from 5 January 2015 when MRO ceased to operate). Ausnet chose to use the Melbourne Airport data on the basis that:

— Melbourne Airport is geographically more centrally located to the AusNet service area than either the MRO or MOP stations. A closer relationship should therefore be expected to exist between gas demand in the AusNet service region and Melbourne Airport weather conditions than with the weather conditions recorded at the other stations.
— 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.

From a demand forecasting point of view the key assumption with regard to weather normalisation is the rate of change of EDD, rather than the standard starting value, since it is the *change* in EDD that most strongly affects changes in average gas use per connection.

A.3 Tariff V demand

Table A.2summarises the historical and forecast rates of change in key parameters relevant to forecasting of Tariff V customer demand, and compares the historically observed rates with those implied by the demand forecasts proposed by the three distribution businesses. In order to provide historical comparisons for the forecast parameters, we have calculated rates of change for each parameter over the period 2011 to 2015, based on data presented by the distribution businesses (data drawn from the relevant Regulatory Information Notices (RINs) or set out in the gas demand forecast models prepared by the demand consultants).

A.3.1 Residential Demand per Connection

Historically, average residential demand per connection has declined across all three distribution businesses at rates ranging between -0.7 per cent per year (AusNet) to -1.6 per cent per year (AGN). All three distribution businesses are forecasting increased rates of decline in average residential demand per connection with forecast rates ranging between -1.5 per cent per year (AusNet) to -2.1 per cent per year (AGN). The forecast rates generally preserve the historical relativities between the three distribution businesses. They do not appear to be unreasonable.

TABLE A.2 COMPARISON OF PARAMETERS: TARIFF V DEMAND

Parameter	Units	Australian Gas Networks	AusNet Services	Multinet Gas
Historical Tariff V (2011- 2015)				
Residential demand per connection rate of change	per cent p.a.	-1.6%	-0.7%	-1.5%
Commercial demand per connection rate of change	per cent p.a.	0.9%	0.3%	-1.1%
Residential connections rate of change	per cent p.a.	2.4%	2.5%	0.7%
Commercial connections rate of change	per cent p.a.	0.7%	0.9%	-0.8%
Residential total demand rate of change	per cent p.a.	0.7%	1.8%	-0.8%
Commercial total demand rate of change	per cent p.a.	1.6%	1.3%	-1.8%
Forecast Tariff V				
Residential demand per connection rate of change	per cent p.a.	-2.1%	-1.5%	-1.7%
Commercial demand per connection rate of change	per cent p.a.	0.5%	-0.2%	-1.5%
Residential connections rate of change	per cent p.a.	1.9%	2.1%	0.5%
Commercial connections rate of change	per cent p.a.	0.7%	0.9%	-0.9%
Residential total demand rate of change	per cent p.a.	-0.2%	0.6%	-1.3%
Commercial total demand rate of change	per cent p.a.	0.1%	0.7%	-2.5%

Parameter	Units	Australian Gas Networks	AusNet Services	Multinet Gas

SOURCE: ACIL ALLEN ANALYSIS OF DISTRIBUTION BUSINESS FORECASTS AS SUBMITTED FOR THE ACCESS ARRANGEMENT PERIOD 2018 – 2022

Note: AGN reflects information from Core gas demand model except for Tariff D customer numbers which are taken from the Regulatory Information Notice (RIN). Multinet Gas reflects information from NIEIR detailed volumes spreadsheet except for Tariff D customer numbers which are taken from the RIN. AusNet Services reflects information from the RIN.

A.3.2 Commercial Demand per Connection

Historically, trends in average commercial demand per connection have varied across all three distribution businesses at rates ranging between a decline of -1.1 per cent per year (Multinet) and an increase of +0.9 per cent per year (AGN). Again, all three distribution businesses are forecasting lower rates for average commercial demand per connection with forecast rates ranging between -1.5 per cent per year (Multinet) and +0.5 per cent per year (AGN). The forecast rates generally preserve the historical relativities between the three distribution businesses. They do not appear to be unreasonable.

A.3.3 Residential connection numbers

Historically residential connection numbers have shown positive growth in the AGN and AusNet distribution areas, but have declined at rates that are broadly reflective of levels of housing construction activity. AGN and AusNet Services have had connection growth rates of 2.4 per cent and 2.5 per cent respectively. Multinet has a lower historical rate of growth of new connections—+0.7 per cent—which reflects the fact that Multinet is a more centrally located metropolitan distribution area with fewer areas of new housing development.

All three businesses are forecasting lower rates of growth in new residential connections: AGN (1.9 per cent, down from 2.4 per cent), AusNet Services (2.1 per cent, down from 2.5 per cent) and Multinet (0.5 per cent, down from 0.7 per cent).

The forecast rates generally preserve the historical relativities between the three distribution businesses. They do not appear to be unreasonable, although in the case of Multinet we have concluded that the forecast numbers of net new residential connections are too low.

A.3.4 Commercial connection numbers

Historically commercial connection numbers have shown positive growth AGN and AusNet Services distribution areas but have declined (at an average rate of -0.8 per cent per year) in the Multinet area. AGN and AusNet Services are forecasting that rates of commercial connections growth will remain unchanged in the long run (at 0.7 per cent and 0.9 per cent respectively) although there will be a significant reduction in the recorded number of commercial customer connections in the AGN area during 2017 and 2018 as a result of a program to remove zero-consuming meters from the system. Multinet is forecasting a small increase in the rate of decline in commercial customer connections—from -0.8 per cent to -0.9 per cent—which does not appear to be unreasonable in the current market circumstances.

A.3.5 Residential gas demand

Historically residential gas demand showed positive growth in the AGN and AusNet Services distribution areas but declined in the Multinet area. This reflects the demographics of the Multinet distribution area.

All three businesses are forecasting lower rates of growth (or faster rates of decline) in residential volumes, consistent with the forecast trends in both connection numbers and average gas use per connection. AGN expects residential sales volumes to decrease at an average -0.2 per cent per year (down from +0.7 per cent); AusNet is forecasting 0.6 per cent per year growth (down from +1.8 per cent historically), while Multinet is forecasting an accelerated rate of decline of -1.3 per cent (historically -0.8 per cent). Again, these changes preserve the broad relativities between the distribution businesses and do not appear to be unreasonable.

A.3.6 Commercial gas demand

Similar to residential gas demand, commercial gas demand has shown positive growth in the AGN and AusNet Services distribution areas (+1.6 per cent and +1.3 per cent respectively) but declined in the Multinet area (-1.8 per cent).

All three businesses are forecasting lower rates of growth (or faster rates of decline) in commercial volumes, consistent with the forecast trends in both connection numbers and average gas use per connection. AGN expects commercial sales volumes to grow at an average +0.1 per cent per year (down from +1.6 per cent historically); AusNet is forecasting +0.7 per cent per year growth (down from +1.3 per cent historically), while Multinet is forecasting an accelerated rate of decline of -2.5 per cent (historically -1.8 per cent). The forecast change in commercial gas demand in the AGN area is somewhat more pronounced than in the AusNet and Multinet areas, but all forecast appear to be directionally reasonable.

A.4 Tariff D demand

Table A.3 summarises the historical rates of change in key parameters relevant to forecasting of Tariff D (industrial) customer demand, and compares the historically observed rates with those implied by the demand forecasts proposed by the three distribution businesses.

TABLE A.3 COMPARISON OF PARAMETERS: TARIFF D DEMAND

Parameter	Units	Australian Gas Networks	AusNet Services	Multinet Gas
Historical Tariff D (2011- 2015)				
Customer numbers rate of change	per cent p.a.	2.1%	-1.1%	0.0%
MHQ rate of change	per cent p.a.	-1.7%	-4.1%	1.2%
Forecast Tariff D				
Customer numbers rate of change	per cent p.a.	0.0%	-0.2%	-1.0%
MHQ rate of change	per cent p.a.	0.2%	-2.4%	-0.8%

SOURCE: ACIL ALLEN ANALYSIS OF DISTRIBUTION BUSINESS FORECASTS AS SUBMITTED FOR THE ACCESS ARRANGEMENT PERIOD 2018 - 2022

Forecasts of customer numbers and annual delivery volumes are not of any great importance to the Tariff D forecasts. This is because the Tariff D customer group is highly asymmetrical in terms of individual customer gas demand, and because Tariff D customers are charged for distribution services on the basis of their peak demand (Maximum Hourly Quantity or MHQ) rather than annual throughput.

Nevertheless, we have summarised the historical and forecast numbers of Tariff D customers for each of the three distribution businesses. AGN has seen modest growth in Tariff D customer numbers (at an average rate of 2.1 per cent per year) but is forecasting numbers to remain at current levels. AusNet Services has seen Tariff D customer numbers fall at an average rate of -1.1 per cent per year, and is forecasting a decline rate of -0.2 per cent. Multinet has seen little if any net change in Tariff D customer numbers over the past five years, and is projecting a mild decline in customer numbers (-0.8 per cent per year) over the forecast period.

Given the relatively small number of tariff D customers (a few hundred) in each distribution area, these forecasts of customer numbers are subject to significant uncertainty, particularly in an environment of rising gas prices and tight gas supply.

The more important metric shown in **Table A.3** is the rate of change in aggregate MHQ for the Tariff D customer group. AGN is forecasting a recovery of Tariff D demand (turning around an historic -1.7 per cent per year decline in average MHQ with a forecast increase of 0.2 per cent per year. Ausnet Services has seen an average rate of decline in aggregate tariff D MHQ of -4.1 per cent per year over the past five years and it, too, is forecasting a reduced rate of decline in MHQ (at -2.4 per cent per year). Multinet has seen modest average growth in historical MHQ (+1.2 per cent per year) but is forecasting a turnaround with demand falling at an average -0.8 per cent per year over the forecast period.

Examination of the historical data shows that the year-on-year changes in MHQ for each of the distribution businesses tend to be quite volatile. This reflects the fact that the exit or entry of a single large customer, or even a change in operating regime at an existing large customer, can have a significant effect on total MHQ across the Tariff D portfolio. In light of this, we consider that the forecasts of Tariff D MHQ are not unreasonable. Indeed, given the current market circumstances of rising prices and tight supply, the forecasts may prove to be somewhat optimistic.

A.5 Price elasticity of demand

Table A.4 summarises assumptions made by the three distribution businesses in relation to price elasticity of demand.

TABLE A.4 COMPARISON OF PARAMETERS: PRICE ELASTICITY OF DEMAND

Parameter	Units	Australian Gas Networks	AusNet Services	Multinet Gas
Own price elasticity - residential	#	-0.30	-0.053	-0.28
Own price elasticity - commercial	#	-0.35	-0.265	-0.21
Cross price elasticity - residential	#	0.10	na	0.08
Cross price elasticity - commercial	#	0.10	na	0.08

SOURCE: ACIL ALLEN ANALYSIS OF DISTRIBUTION BUSINESS FORECASTS AS SUBMITTED FOR THE ACCESS ARRANGEMENT PERIOD 2018 - 2022

AGN and Multinet have relied on reviews of Australian and international literature on elasticity of demand for gas and electricity to inform their choice of assumptions about price elasticity. Both have chosen similar elasticity assumptions for own price elasticity, for both residential and commercial customers. The assumptions used by AusNet Services for both residential and commercial price elasticities appear to be very different—and much lower.

The explanation appears to be that the AGN and Multinet values are long-run price elasticities, whereas the AusNet/CIE estimates, being derived from year-on-year changes in panel data, are short-run price elasticities. As discussed by NIEIR in the Multinet analysis (Multinet 2016, Appendix B, p. 117) the short-run own price elasticity for residential gas demand is much lower than the long-run elasticity: NIEIR estimates that the long-run elasticity effect of -0.28 is spread over a period of four years, with the impact in the first year being -0.05 (similar to the CIE/AusNet estimate), rising to -0.10 in the second and third years after the price shock and -0.03 in the fourth year.

The same explanation accounts for the fact that AusNet's market advisor CIE was unable to find a statistically significant cross-price elasticity effect for changes between gas and electricity prices: given that the long-run cross price elasticity is estimated by AGN and Multinet to be no more than 0.10, it is not surprising that CIE was unable to observe a statistically significant year-on-year cross-price influence.

Furthermore, ,Multinet has advised that, given the inelastic response of gas to changes in the electricity prices, NIEIR did not include cross price effects in its modelling of residential and commercial demand.

A.6 Gas prices

Table A.5 summarises assumptions made by the three distribution businesses in relation to residential gas prices.

TABLE A.5 COMPARISON OF PARAMETERS: RESIDENTIAL GAS PRICES

Parameter	Units	Australian Gas Networks	AusNet Services	Multinet Gas
Residential gas price - 2015	$/GJ	$20.57	$17.98	$21.30
Residential gas price - 2022	$/GJ	$24.13	$21.64	$25.50

Note: For AGN prices we have assumed a model annual residential demand of 50 GJ/a in order to calculate unit prices from annual bill levels estimated by Core Energy.

SOURCE: ACIL ALLEN ANALYSIS OF DISTRIBUTION BUSINESS FORECASTS AS SUBMITTED FOR THE ACCESS ARRANGEMENT PERIOD 2018 - 2022

It can be seen that all three distribution businesses adopt similar forecasts of residential gas price trends. In the current market circumstances, the forecast rises in residential gas prices appear to us to be conservative.

B

ESTABLISHMENT OF CONFIDENCE INTERVALS

The following explanation of the construction of confidence intervals is based on information provided in the manual for the Statistica software package.

> The confidence intervals for specific statistics (for example, means or regression lines) provide a range of values around the statistic where the "true" (population) statistic can be expected to be located (with a given level of certainty).
>
> The confidence intervals for the mean give us a range of values around the mean where we expect the "true" (population) mean is located (with a given level of certainty). Confidence intervals can be calculated for any p-level; for example, if the mean in a sample is 23, and the lower and upper limits of the p=.05 confidence interval are 19 and 27 respectively, then we can conclude that there is a 95 per cent probability that the population mean is greater than 19 and lower than 27. If the p-level is reduced to a smaller value, then the interval would become wider thereby increasing the "certainty" of the estimate, and vice versa. The width of the confidence interval depends on the sample size and on the variation of data values. The calculation of confidence intervals is based on the assumption that the variable is normally distributed in the population. This estimate may not be valid if this assumption is not met, unless the sample size is large, say n = 100 or more.

Confidence Intervals (CI's) have the form:

$$Est \ \pm t_{1-\frac{\alpha}{2},(n-2)} SE_{est}$$

For the CI around the y-estimate in the linear regression equation, the CI is given by:

$$CI = Est_y \ \pm t_{1-\frac{\alpha}{2},(n-2)} SE_{est}$$

Where $t_{1-\frac{\alpha}{2},(n-2)}$ is the inverse of the Student's t-distribution for confidence level α given that n is the number of data points (so that n-2 is the number of degrees of freedom in the distribution)

and

$$SE_{est} = SE_y \times \sqrt{\frac{1}{n} + \frac{(x_i - \bar{x})^2}{\sum(x_i - \bar{x})^2}}$$

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