ACIL ALLEN CONSULTING

REPORT TO
AUSTRALIAN ENERGY REGULATOR
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REVIEW OF DEMAND FORECASTS FOR MULTINET

VICTORIAN GAS ACCESS ARRANGEMENT REVIEW FOR THE PERIOD 2018 – 2022

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1 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 Multinet Gas, hereafter "Multinet" (Multinet Gas, 2016)

— the demand forecast prepared for Multinet by the National Institute of Economic and Industry Research ("NIEIR") (NIEIR, 2016a), (NIEIR, 2016b), (NIEIR, 2016c).

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 Multinet gas distribution 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 Multinet's Victorian Access Arrangement Information document (Multinet Gas, 2016) are based on forecasts developed by the National Institute of Economic and Industry Research (NIEIR, 2016a), (NIEIR, 2016b), (NIEIR, 2016c). These forecasts cover the period from 2018 to 2022 and are based on what NIEIR describes as "a multi-variate approach which is not a matter of extrapolating trends".

NIEIR's modelling methodology relies heavily on its in-house economic and energy model which produces forecasts of population, the dwelling stock growth and estimates of gross regional product at Statistical Sub-Divisions Local Government Areas level.

The energy projections for Multinet are directly linked to economic indicators for the LGA's comprising the Multinet gas distribution area.

Within this broad framework, NIEIR's approach to forecasting demand differs between the three customer types. The difference in approach reflects differences in the number of customers of each type, the way they use gas and the economic and other factors influencing their levels of gas usage.

In general terms, NIEIR forecasts gas demand as follows:

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

NIEIR has considered the implications for demand of changes in gas price through own-price and cross price elasticity assumptions. NIEIR proposes using long-run own-price elasticity of demand values of – 0.28 for residential consumers, – 0.21 for commercial consumers and – 0.32 for industrial consumers. Multinet states that NIEIR has assumed a cross-price elasticities of demand of 0.08. Based on a review of international and Australian literature as well as prior decisions and the submissions of other distribution businesses, these assumptions do not seem unreasonable.

With regard to future gas prices, NIEIR has taken into account a range of factors potentially affecting future gas prices, and the forecast residential and commercial gas prices used in the modelling appear to be reasonable in the context of current domestic gas market conditions.

With regard to the effects of weather on gas demand, Multinet has relied on detailed analysis by NIEIR of trends in winter EDD (adopting the widely-used EDD_{312} standard) and summer SDD based on data from 1970 to 2015. Using regression analysis NIEIR established an average EDD decline rate of –7.6 EDD per year and a normalised EDD weather standard of 1314 for the first projection year

(2016). These results are comparable to those from several other studies of Victorian weather data and appear to be reasonable.

A number of policy measures implemented by the Victorian and Commonwealth Governments will potentially impact demand for gas during the coming regulatory period. Multinet's forecasts have been prepared with reference to a range of policy measures discussed by NIEIR. The NIEIR demand model includes specific adjustments to forecast levels of average usage per new connection that take into account improved building efficiency standards and Minimum Energy Performance Standard (MEPS) for heaters. For the forecasts of usage per existing connection, NIEIR has included adjustments to account for anticipated impacts of Victorian Energy Efficiency Target (VEET) insulation and appliance rebates, MEPS hot water and space heating targets and increasing uptake of energy efficient shower heads. The effects of other policy measures are assumed to be already embedded in the historical data and the modelled demand drivers.

With regard to the methodologies employed by NIEIR to develop the Multinet forecasts, we consider that they are generally reasonable. One issue requiring clarification relates to the projections of residential customer numbers in which the quoted results for total connections do not correspond, as should be expected, to the sum of existing connections and cumulative new connections.

The residential customer number projections set out in the Multinet Regulatory Information Notice (RIN) are slightly higher than those contained in the NIEIR report, the difference being attributable to the effects of the proposed Joint Marketing Campaign which, if implemented, is expected to result in a modest increase in the number of residential connections. This issue also potentially impacts on the projected gas volumes for residential customers, and the implied consumption per new customer connection.

The proposed Joint Marketing Campaign, if it proceeds, is estimated to result in an increase in residential and small commercial demand in Multinet's network of some 1.4 PJ over the access arrangement period, effectively offsetting about 17 per cent of the anticipated decline in demand. The marketing effort is expected to result in an increase of about 281 connections per year (on average) over the access arrangement period, an average increase of 0.12 per cent above NIEIR's forecast gross connections.

The forecast of Tariff V business customer numbers and demand has been developed by NIEIR using an "existing commercial equation" which takes into account weather, gas and electricity prices, and the economic output of various industry sectors. While there is a lack of information such as diagnostic statistics that would normally be used to evaluate the performance of such a model, the results produced (in terms of the forecast numbers of Tariff V business customers and the total gas consumption for that customer group) do not appear to be unreasonable.

The forecasts of Tariff D gas consumption and maximum hourly quantity (MHQ) have been developed using NIEIR's model of economic activity in Multinet's region. This provides forecasts of growth in the activity of each sector which, coupled with estimates of the relationship between economic activity and gas consumption, allows the model to produce forecasts of gas consumption. The modelled Tariff D results have then been adjusted to take into account the results of a survey of large industrial customers aimed at gaining direct information on their future gas use expectations. We consider the use of survey techniques to be an appropriate supplement to the economic modelling approach.

The approach taken by NIEIR to assessment of peak demand (MDQ, MHQ) for the Tariff D customer group appears to be comprehensive and methodologically sound.

2.2 Assessment of the forecasts

With regard to the forecast results, the NIEIR forecasts for Multinet over the forthcoming Access Arrangement period show that:

For **residential Tariff V** customers

— Customer numbers will grow on average by about 0.5 per cent per year, down from 0.8 per cent per year over the period 2008 to 2015.

- Average consumption per connection will decline on average by about –1.8 per cent per year, faster than the historical rate of–1.4 per cent per year over the period 2008 to 2015 (weather adjusted data).
- Total consumption will decline at about –1.3 per cent per year, compared to –0.6 per cent per year over the period 2008 to 2015 (weather adjusted data).

For **small business and commercial Tariff V** customers:

- Customer numbers will decline on average by about –1.0 per cent per year, faster than the –0.6 per cent per year rate over the period 2008 to 2015.
- Average consumption per connection will decline on average by about –1.7 per cent per year, similar to the historical rate of –1.6 per cent per year over the period 2008 to 2015 (weather adjusted data).
- Total consumption will decline at about –2.7 per cent per year, compared to –2.2 per cent per year over the period 2008 to 2015 (weather adjusted data).

For **large industrial Tariff D** customers:

- Customer numbers will decline on average by about –1.2 per cent per year, from 267 in 2015 to 251 by 2022.
- Total Tariff D MHQ fall by about 0.9 per cent per year, reversing a slight upward trend (of around 0.2 per cent per year) over the period 2008 to 2015.

We have reviewed these forecasts, considering whether the application of the methodologies and assumptions used have produced results that are reasonable in light of historical patterns of demand as well as current and anticipated influences on gas demand in the Multinet distribution area. We have concluded that the forecasts are not unreasonable, with one exception. The forecast rate of growth in residential Tariff V customer numbers used by NIEIR for purposes of demand forecasting is significantly lower than an alternative forecast (based on data from the Australian Construction Industry Forum, ACIF) used by Multinet for its capital expenditure projections.

Multinet (in response to an Information Request from the AER) has stated that "NIEIR's forecast is not consistent with historic actual connections ... NIEIR data was not considered to be an accurate forecast by MG."

We consider that Multinet should be required to amend the forecast of new Tariff V residential customer connections, aligning it with the ACIF forecasts used in the capital expenditure projections. This adjustment will require consequential changes to the forecast of total consumption in the residential Tariff V sector.

3 SCOPE OF MULTINET OPERATIONS

Multinet distributes gas to more than 690,000 customers in Melbourne's inner and outer eastern suburbs, the Yarra Ranges, and South Gippsland through a network of transmission and distribution pipelines covering approximately 1,860 square kilometres. The network comprises more than 10,000 kilometres of gas mains and associated facilities as shown in **Figure 3.1**.

FIGURE 3.1 LOCATION MAP: MULTINET GAS DISTRIBUTION NETWORK

SOURCE: HTTPS://WWW.MULTINETGAS.COM.AU/OUR-VISION-VALUES/

Multinet's pipeline network covers about 43 per cent of Melbourne's metropolitan area, extending from Port Melbourne, near Melbourne's central business district, north-east along the Yarra River to the Dandenong Ranges, south-east to Gembrook, west to Lysterfield, south-west to Patterson Lakes on the shores of Port Phillip Bay and back along the bay to Port Melbourne.

In 2005, Multinet extended the metropolitan network to nine towns in the Yarra Ranges as far east as Millgrove. The network also serves customers in the South Gippsland and Yarra Ranges townships as part of the State Government's 'Energy for the Regions' program. The most recent extension to the Multinet system was to supply the town of Warburton.

Residential consumers account for around 98 per cent of Multinet's total customer base and 70 per cent of total network consumption. They contribute about 94 per cent of Multinet's total revenue. Compared to the two other gas distribution network businesses in Victoria (AusNet, Australian Gas Networks), Multinet has a higher residential connection density per kilometre of pipe. This is because Multinet's service area is more compact than the other Victorian gas distributors. Residential gas consumption per customer on the Multinet network is also higher than both the other Victorian gas distributors (Multinet Gas, 2016, p. 8).

Commercial and industrial customers account for approximately 30 per cent of Multinet's overall consumption and cover a broad range of industries.

4 FORECAST METHODOLOGY AND ASSUMPTIONS

4.1 Overview of supporting information

The information Multinet provided the AER in support of its demand forecasts is in the following documents:

1. Multinet's Access Arrangement Information (AAI), particularly chapter 9 (Multinet Gas, 2016)
2. three reports to Multinet from NIEIR that were attached to the AAI, entitled:
   a) Natural gas, customer number and MHQ forecasts for Multinet gas to 2026 (Calendar year basis) Volume One (attachment 9.1 to AAI) (NIEIR's energy report; (NIEIR, 2016a))
   b) peak day, peak hour and postcode projections for Multinet Gas to 2026 VOLUME TWO (attachment 9.2 to AAI) (NIEIR's peak demand report; (NIEIR, 2016b))
   c) NIEIR Review of EDD weather standards for Victorian gas forecasting (Attachment 9.4 to AAI) (NIEIR's weather review; (NIEIR, 2016c))
3. Two spreadsheets named (collectively attachment 9.3 to AAI):
   a) *Multinet Gas - 9.3 - NIEIR - Gas projection models for Volumes 1 and 2 - Gas Projection Model_Tariff V Melbourne - 20161221.xlsx* (Gas projection model)
   b) *Multinet Gas - 9.3 - NIEIR - Gas projection models for Volumes 1 and 2 - Peak Day Model V4 - forecasts - 20161221 - PUBLIC.xlsx* (peak day model)
4. A third spreadsheet
   a) *Multinet Gas - 0.8 - NIEIR detailed volumes - 20161221 – PUBLIC.xlsx* (detailed volumes)
5. Multinet's response to an information request from the AER (#13)

NIEIR's **energy report** is in three broad parts:

1. the *first* part sets out NIEIR's views on the economic outlook for Victoria and Multinet's area
2. the *second* part of NIEIR's report provides brief descriptions of NIEIR's forecasting method
3. the *third* part describes a series of Government policies that relate broadly to energy usage.

There are few references in the second part of NIEIR's report that link it to either the first or third parts of the report. The references that are made are non-specific; for example there is a reference to 'a commercial output driver' but it is not made clear whether the driver mentioned is one of those discussed in the first part of the report. Similarly, the third part of the report provides generic information relating to various policies, but stops short of saying what, if anything, NIEIR has done to take account of those policies in Multinet's forecasts.

Many of these issues were clarified by Multinet in response to a request for further information (AER Information Request #13).

Insofar as the first part of the report is concerned, Multinet's answers are incorporated into our discussion of the forecasting methodology below. With regard to the use made for modelling purposes of the information included in Part 3 of the NIEIR report relating to government policies, we conclude from the information response that NIEIR treated each policy as summarised in **Table 4.1**.

TABLE 4.1 MULTINET FORECASTS – POLICY ADJUSTMENTS

Policy	Adjustment for modelling	Comment
LRET	Nil	Incorporated in electricity price
SRES	Nil	
Water heater replacement/ phase out	Adjustment to average annual gas use per connection for existing customers for replacement with MEPS compliant appliances.	
VEET	Minor once-off downward adjustment to average annual gas use per connection for existing customers, in 2019 only, for VEET insulation and appliance rebates.	
Uptake of reverse cycle air conditioning	Nil	No specific policy mentioned – relates to a broader trend in preferences
Commercial building energy efficiency	Nil	
Energy Efficiency Opportunities Act	Nil	EEO program was discontinued in 2014
MEPS	Building shell and water heating	See discussion in section 4.4.1

SOURCE: MULTINET RESPONSE TO INFORMATION REQUEST #13

There is no link in any of the written material to the accompanying spreadsheets. The values in the 'Gas projection model' and 'Peak day model' do not match the corresponding values in other places. The values are close, but not the same and no explanation for the differences is provided in the energy report.

From the materials provided initially, it was not clear how the two spreadsheets were intended to be used. When asked this question, Multinet advised that:[1]

"The additional spreadsheets provided to the AER were intended to provide more detailed insights into the modelling undertaken by NIEIR. In particular:

- *…*
- *'Peak day model' - Multinet Gas - 9.3 - NIEIR - Gas projection models for Volumes 1 and 2 - Peak Day Model V4 - forecasts - 20161221 – PUBLIC.xlsx – this provides further detail of the NIEIR Volume 2 report in excel format (document reference MG_9.2)*
- *'Gas projection model' - Multinet Gas - 9.3 - NIEIR - Gas projection models for Volumes 1 and 2 - Gas Projection Model_Tariff V Melbourne – 20161221.xlsx- this provides an example of the residential model for Melbourne in excel format.*

4.2 Description of forecasting approach

In framing its proposed access arrangement, Multinet relied on demand forecasts prepared by NIEIR. The demand forecasts underpinning Multinet's current access arrangement (2012–2017) were also prepared by NIEIR. In this regard, Multinet noted that:

"The AER accepted our consumption forecast for the current access arrangement period, which was prepared by NIEIR. We estimate that there will be less than a 1.0 per cent difference between our actual

[1] Multinet response to AER information request #13.

total Tariff V consumption and the forecast that the AER accepted. The high level of accuracy of NIEIR's forecast supports their credibility and justifies our continued reliance on them for the forthcoming access arrangement period." (Multinet Gas, 2016, p. 27)

NIEIR's modelling methodology relies heavily on its in-house economic and energy model which produces forecasts of population, the dwelling stock growth and estimates of gross regional product across 11 Statistical Sub-Divisions and 31 Local Government Areas in greater Melbourne.

The energy projections for Multinet are directly linked to economic indicators for the LGA's comprising the Multinet gas distribution area.

NIEIR's has forecast gas consumption in Multinet's distribution area for three types of customers, namely:

1. **Tariff V** residential and small to medium business customers using less than 10 TJ/year and less than 10 GJ MHQ. These customers are billed on the basis of fixed daily charges and variable charges reflecting the volume of gas delivered.
2. **Tariff L** smaller industrial and large commercial customers using more than 1TJ/year but less than 10TJ/year and less than 10 GJ MHQ. These customers are billed on the basis of seasonal stepped usage charges and two demand charges related to MHQ. Tariff L customers have consumption characteristics that would classify them as Tariff V business customers, but they are billed on a different basis. There are very few Tariff L customers (15 in 2015, which is less than 0.01 per cent of total Multinet customers) and together they consume only about 70 TJ/year of gas (less than 0.2 per cent of total consumption on the Multinet system).
   Because Tariff L customers comprise an insignificant proportion of Multinet's overall gas demand and revenue base, we do not give any further consideration to Tariff L demand forecasts in this report.
3. **Tariff D** large commercial customers using more than 10,000GJ a year or more than 10GJ MHQ.

NIEIR's general description of the forecasting methodology describes it as "a multi-variate approach, which is not a matter of extrapolating trends". The forecasting approach takes account of:

- the relevance of weather for gas consumption
- differences in the amount of gas used in new and old dwellings
- the effect of policies to improve the efficiency of domestic appliances
- economic drivers including:
  - income and economic activity
  - the price of gas and electricity.

Within this broad framework, NIEIR's approach to forecasting demand differs between the three customer types. The difference in approach reflects differences in the number of customers of each type, the way they use gas and the economic and other factors influencing their levels of gas usage.

In general terms, NIEIR forecasts gas demand as follows:

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

4.3 General modelling considerations

4.3.1 Gas price outlook

With regard to gas prices, NIEIR has assumed (Table 5.15) that residential retail gas prices will increase in real terms from $21.40/GJ in 2015–16 to $26.10/GJ in 2025-26. For commercial (or "business") retail gas prices NIEIR projected an increase from $8.50/GJ in 2015–16 to $13.90/GJ in 2025-26. In formulating its gas price forecasts NIEIR noted the following influences:

- a relatively tight demand supply balance on the eastern seaboard with the ramp up of LNG exports partly offset by reduced gas use from power generation

- low oil prices as a result of which contact prices are more likely to be driven by the cost of supply rather than market perceptions
- a number of retail and large customer contracts expected to expire over the 2017 to 2020 period
- upward pressure from supply side factors contributing around $1.60 [/GJ] to the increase in gas prices from 2015 levels
- easing in the South Australian electricity demand supply imbalances leading to a significant fall in gas prices over 2017, with total decline of nearly $2/GJ in 2017, continuing to a lesser extent post 2017 as further interconnector upgrades are commissioned
- a small $10 carbon tax or equivalent is factored to be reintroduced in 2021. This increases gas prices by around $0.70/GJ.

We note that there is considerable uncertainty surrounding a number of these influences.

For example, the longer term impact of the Gladstone LNG plants on the eastern Australian supply–demand balance is not yet clear. Given the very large gas requirements of the LNG plants (around 1,500 PJ/a of gas feed, compared to around 650 PJ/a consumption for the entire eastern Australian domestic market) the LNG projects have the potential to exert strong leverage on wholesale gas prices in the domestic market.

Similarly, the question of whether or not a carbon tax will be reintroduced, and if so when and at what level, is not settled. Current Australian government policy is not to reintroduce a carbon tax. However our analysis suggests that meeting the current stated target of reducing CO_2 emissions to 26–28 per cent below 2005 levels by 2030 is likely to require an explicit carbon price or other equivalent mechanism. We have estimated that the $23/tonne CO_2 emission price under the former Carbon Pollution Reduction Scheme would equate to a cost of around $1.40/GJ of gas combusted. In this light, NIEIR's estimate of $0.70/GJ for a $10/tonne CO_2 carbon price does not seem unreasonable notwithstanding that it contradicts current Government policy.

The forecast increase in residential gas prices appears to be reasonable in the context of a domestic gas market in which supply is expected to remain tight for the foreseeable future and there is general upward pressure on prices.

For these reasons we consider that NIEIR's forecasts of commercial retail gas prices are reasonable, and that the drivers identified are appropriate.

4.3.2 Projected decline in heating requirement

The need to take account of the impact of weather on gas demand is widely accepted. It 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 for 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[2] between the average temperature on each day and 18° Celsius.

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

[2] If the average temperature on a particular day is greater than or equal to 18°C, then HDD for that day is zero.

NIEIR's measures of weather for these purposes are EDD in winter and Summer Degree Days (SDD or CDD) in summer. SDD is the sum of the daily differences between 'temperature' and a threshold. In calculating SDD, temperature is the mean of the daily maximum and minimum. The threshold is 18°C. NIEIR states that the use of SDD is motivated by how extremely hot summers can also affect the level of gas demand. As an example, the need for water heating is reduced in the summer as customers are more likely to take cooler showers and ambient water temperatures are higher.

NIEIR's SDD coefficients are negative and small (relative to the coefficients on EDD), implying that demand for gas is lower in warmer conditions. This is consistent with a declining use of gas particularly for water heating in summer.

There are also dummy variables in NIEIR's model for weekend days (separately) which generally have negative coefficients, implying that, all else being equal, gas demand is lower on the weekend than during the week. This suggests that the weather analysis is based on combined residential and commercial data.

Using regression analysis NIEIR derived a linear trend through annual EDDs from 1970 to 2015 (adopting the widely-used EDD_{312} standard). This established an average EDD decline rate of –7.6 EDD per year and a normalised EDD weather standard of 1314 for the first projection year (2016).

NIEIR has also assumed (NIEIR, 2016a, p. 44) that SDD will increase at a rate of 4.14 SDD each year from a 2016 base of 501.

The NIEIR analysis of EDD weather standards for Victoria was concluded in April 2016. Subsequently, in February 2017, AEMO published the results of a detailed analysis of weather standards throughout eastern Australia, including a close analysis of Victorian weather data (AEMO, 2017). Working with climate experts in CSIRO and the Australian Bureau of Meteorology, AEMO concluded that EDD will decline in Victoria at an average rate of –6.8 EDD per year over the next 20 years.

NIEIR's projected EDD decline rate of –7.6 EDD per year compares with the following alternative forecast of Victorian EDD that have been produced in recent years:

- AEMO (2012) –7.8 EDD
- AEMO (2014) –8.05 EDD
- AEMO (2016) –6.8 EDD
- CIE (2016) –8.5 EDD (The CIE, 2016)
- Core Energy (2016) –7.3 EDD (Core Energy Group, 2016)

The NIEIR analysis also established a 95 per cent confidence interval for the long-term warming trend ranging from –9.8 and –5.4 EDD per year. All of the above forecasts lie within this confidence interval.

On this basis we consider the NIEIR use of a –7.6 EDD per year trend over the next access arrangement period to be reasonable.

4.3.3 Price elasticity of demand

Each of the DNSPs has made assumptions regarding the price of gas over the regulatory period with each projecting that it will increase. In Multinet's submission, residential gas price is forecast to increase from $21.40 per GJ in 2015/16 to $25.50 per GJ in 2021/22.

In addition to gas price increases, ACIL Allen expects that the price of electricity will also increase over the regulatory period, which is also an important factor in forecasting gas demand over the regulatory period. Increases in gas price are likely to lead to a reduction in gas demand through the price effect. Increases in electricity price (relative to gas) are likely to lead to an increase in demand for gas as an alternative to electricity through the substitution effect. It is difficult to estimate the likely size of these competing effects with any confidence.

Each of the relationships can be described using an elasticity. The price effect is summarised using the 'own price elasticity of demand for gas'. The substitution effect is summarised using the 'cross price elasticity of demand for gas'. These two elasticities are discussed in turn below.[3]

[3] The own price elasticity of demand is relevant to the estimated impact of the carbon price as well as to the impact of rising gas prices generally.

Own price elasticity of demand for gas

The own price elasticity of demand, (commonly 'price elasticity') describes the relationship between the price of a good and the quantity of it that will be demanded. Being an elasticity it is expressed in percentage terms. For example a price elasticity of -1 suggests that for a one per cent increase (decrease) in price, the quantity demanded will decrease (increase) by one per cent.

The price elasticity of demand is an important input into the forecasting process. Given the gas price increases forecast for the coming regulatory period, choosing too high an estimate of price elasticity would lead to gas demand forecasts being understated which, in turn, would lead to tariffs being set at a higher level than necessary.

NIEIR has described the basis for its assumptions regarding the own-price elasticity and cross-price elasticity of demand for gas. It has provided a review of numerous Australian and overseas studies, leading to a set of recommendations (Table B.6) for short run and long run gas own price elasticities for the residential, commercial and industrial sectors. NIEIR proposes using long-run own-price elasticity of demand values of – 0.28 for residential consumers, – 0.21 for commercial consumers and – 0.32 for industrial consumers.[4] NIEIR notes that:

"These represent a slight decrease to own gas price elasticities used for previous access arrangements submitted by gas networks around Australia and accepted by the AER. This continues the downward trend found in own gas price elasticities found within the literature survey."

(NIEIR, 2016a, p. 117)

Cross price elasticity of demand

The cross price elasticity of demand summarises the relationship between the price of one good and the quantity demanded of another. In this case, the cross price elasticity of interest summarises the relationship between the price of electricity and the quantity of gas demanded.

A positive cross price elasticity suggests that as the price of one good increases demand for the other good also increases. These goods are defined as substitutes.[5]

Given that electricity and gas can be used similarly (at least in some applications) it would be reasonable to expect that they are substitutes (with a positive cross price elasticity of demand). The need to change appliances to allow substitution to occur suggests that the cross price elasticity of demand may become larger (that is, more positive) as it is measured over a longer time frame.

With regard to cross-price elasticity of demand (electricity – gas) the Multinet Access Arrangement Information states that:

"To reflect this inelastic response [of consumers with sunk investments in central heating systems, particularly in the short term], NIEIR used a cross price elasticity of 0.08, based on a survey of literature."

(Multinet Gas, 2016, p. 32)

NIEIR (Appendix B) surveys a number of studies of cross-price elasticities of demand but does not state what assumptions it has used. The 0.08 value reflected by Multinet appears to be a short-run cross price elasticity determined in an Australian empirical study (Brian and Schuyers, 1981).

NIEIR notes that:

The estimates of cross-price elasticities of gas demand to changes in the price of electricity show that the residential and commercial markets are quite responsive to the price of electricity. In contrast, industrial customers seem to adjust their gas demand only marginally to the price of electricity in the long run (at least this seems to be the Australian experience).

(NIEIR, 2016a, p. 117)

[4] Appendix B (pp.112–118) of the NIEIR Forecasts Report (Volume 1).
[5] A negative cross price elasticity suggests that as the price of one good increases demand for the other good falls. These goods are defined as complements.

4.3.4 Policy factors affecting the forecasts

A number of policy measures implemented by the Victorian and Commonwealth Governments will potentially impact demand for gas during the coming regulatory period.

Multinet's forecasts have been prepared with reference to the policy measures listed in page 67-68 of NIEIR's report.As summarised in **Table 4.1** above, NIEIR has incorporated some adjustments within the demand model to take account of government policies potentially impacting on energy use. Specifically, the NIEIR model includes specific adjustments to the forecasts of average use per customer for new connections to take account of improved building efficiency standards and Minimum Energy Performance Standard (MEPS) heaters. For existing connection use per connection forecasts, NIEIR has included adjustments to account for anticipated impacts of Victorian Energy Efficiency Target (VEET) insulation and appliance rebates, MEPS hot water and space heating targets and increased uptake of energy efficient shower heads. The effects of other policy measures are assumed to be already embedded in the historical data and the modelled demand drivers..

4.4 Summary of the Forecasts

4.4.1 Tariff V residential customers

To produce forecasts of gas consumption by Multinet's residential customers, NIEIR forecasts dwelling formation and destruction and assigns average consumption values to new and existing dwellings separately.

Residential customer numbers projection

Neither Multinet's AAI nor NIEIR's report provides detailed information regarding the way that residential customer number forecasts were prepared. NIEIR's report says that the residential customer numbers forecast is "based upon forecasts of Victorian dwelling completions and the consequent growth in Multinet Gas dwelling stock." Elsewhere, NIEIR states that:

"Tariff V meter numbers for residential were driven by the dwelling stock forecasts by postcode. The projected growth was adjusted by the difference between historical meter growth and historical dwelling stock growth. In addition, some exogenous adjustments were made to some postcodes with known expansions or developments."

(NIEIR, 2016b, p. 48)

Elsewhere, NIEIR reports that "dwelling stock is projected to increase by 1.1 per cent between 2015-16 and 2025-26". This is slower than the 1.5 per cent growth projected for Victoria over the same period (NIEIR, 2016a, p. 35). Given that no other source is cited for these projections we assume that these projections are NIEIR's own.

The only information provided as to the methodology by which dwelling stock, and therefore customer numbers, is projected is on p.37 of NIEIR's report, which says that:

"The centrepiece of the modelling methodology was the application of NIEIR's economic and energy (industry based) projection models.

Victoria's regional energy model …produces forecasts of population, the dwelling stock growth and estimates of gross regional product for [Multinet's distribution area]"

In response to a request for information as to how the residential customer number growth rates were derived, Multinet said only that they are:

…derived from the projections for dwelling stock growth for the total Multinet region and an assumed take up rate for gas connections.

Elsewhere in the response to an Information Request, Multinet said that 41 per cent of new dwellings in its region are connected to mains gas and that the "assumed take up rate for gas connections" is as shown in **Table 4.2**.

TABLE 4.2 FORECAST GAS PENETRATION RATES FOR NEW DWELLINGS IN MULTINET REGION

	2018	2019	2020	2021	2022
Average gas takeup	34%	42%	41%	41%	47%

SOURCE: MULTINET GAS RESPONSE TO INFORMATION REQUEST #13

In summary, the information that has been provided to date does not provide sufficient basis for us to reach a conclusion as to whether the *methodology* used to forecast residential customer numbers is reasonable. We can say that:

— Multinet's proposed customer numbers are based on NIEIR's dwelling stock projection, which is produced using an economic model the details of which (in terms of both computational logic and input assumptions) have not been disclosed.

— A proportion of new dwellings are assumed to be connected to gas – the proportion grows from 34 per cent to 47 per cent from 2018 to 2022, though there is no discussion of the reasons for these variations nor is there any explanation of how these values were derived.

In the absence of specific information on the forecasting method we have considered the forecasts themselves. In particular, we have compared the NIEIR forecasts with an alternative forecast of new residential connection numbers based on Australian Construction Industry Forum (ACIF) data. This forecast has been used by Multinet in the context of its capital expenditure submission for new customer connections. In response to an Information Request from AER, Multinet confirmed that the NIEIR forecasts of residential connections and disconnections are as set out in **Table 4.3**.

TABLE 4.3 NIEIR FORECAST CONNECTIONS AND DISCONNECTIONS

Customers	2018	2019	2020	2021	2022
Residential gross connections	6,545	6,692	6,684	6,682	6,536
Residential abolishments	3,182	3,196	3,211	3,225	3,238
Residential net connections	3,363	3,496	3,473	3,457	3,297

SOURCE: MULTINET, RESPONSE TO INFORMATION REQUEST NO. 24

Multinet further advised that historical connection and disconnection numbers were as set out in **Table 4.4**. The NIEIR connection forecasts are well below historical outcomes on both a gross and net basis.

TABLE 4.4 HISTORICAL CONNECTION AND DISCONNECTION NUMBERS

Customers	2008	2009	2010	2011	2012	2013	2014	2015
Residential gross connections	7,537	7,743	6,890	7,670	7,922	7,592	8,230	9,115
Residential abolishments	3,033	2,672	3,031	3,546	2,883	2,706	3,551	3,731
Residential net connections	4,504	5,071	3,859	4,124	5,039	4,886	4,679	5,384

SOURCE: MULTINET, RESPONSE TO INFORMATION REQUEST NO. 24

Multinet provided a forecast of gross residential customer connections based on the ACIF model, as shown in **Table 4.5**. This forecast matches much more closely to the historical data.

TABLE 4.5 FORECAST GROSS TARIFF V CONNECTIONS BASED ON ACIF

Residential customers Tariff V	2016E	2017	2018	2019	2020	2021	2022
Gross customer connections	8,535	8,669	8,633	8,173	7,741	7,888	8,169

SOURCE: MULTINET, RESPONSE TO INFORMATION REQUEST NO. 24

In response to a question regarding the inconsistency between the two forecasts, Multinet provided information demonstrating a strong relationship between ACIF indices and Multinet's actual connections capex over the period 2008 to 2017. Furthermore, Multinet stated that:

"In 2008 to 2012 period our total number of connections was 37,763; in the 2012 to 2017 period the total number of connections is 42,141. These two Access Arrangement periods are consistent with our forecast (no marketing) [based on ACIF data] for the 2018 to 2022 period of 40,604. ***The NIEIR forecast of 33,138 is clearly an outlier and cannot be relied upon for connections forecasting*** *…* ***There has been no period since privatisation (we do not have records prior to 1999) that connections in an Access Arrangement period have been as low [as] the NIEIR forecast.*** *[emphasis added]."*

Multinet response to Information Request No. 21

Subsequently (in response to Information Request No. 24) Multinet advised that:

"NIEIR's forecast is not consistent with historic actual connections. With all of the economic assumptions provided as part of our submission there is nothing that points to a lower number of actual gross connections than our historic actual data. Therefore NIEIR data was not considered to be an accurate forecast by MG. ACIF forecast however was consistent with all the macro assumptions and it is consistent with historic actual connections."

Multinet went on to say that:

"Our strong view is that ACIF is more accurate for connections as it goes to more detail and is more consistent with historic gross connections. As to why NIEIR's differ our explanation is that we use NIEIR for demand forecasting not connection forecasting. We did not engage with NIEIR strongly to fully test their assumptions on connections as we do not rely on them."

Accurate forecasts of gross and net new connection numbers are fundamental to the reliability of the demand forecasts because the demand forecasts are calculated from the forecasts of connection numbers and average use per connection. It is not at all clear why Multinet would consider that NIEIR's connection number forecast—which they find to be unacceptably low for purposes of estimating future capital expenditure requirements—could be considered acceptable for purposes of demand forecasting. If NIEIR's connection forecasts are too low, as Multinet states, then it follows that their forecasts of Tariff V demand are very likely to be too low.

We expect the differences to be material. The NIEIR residential demand forecast is calculated according to the formula:

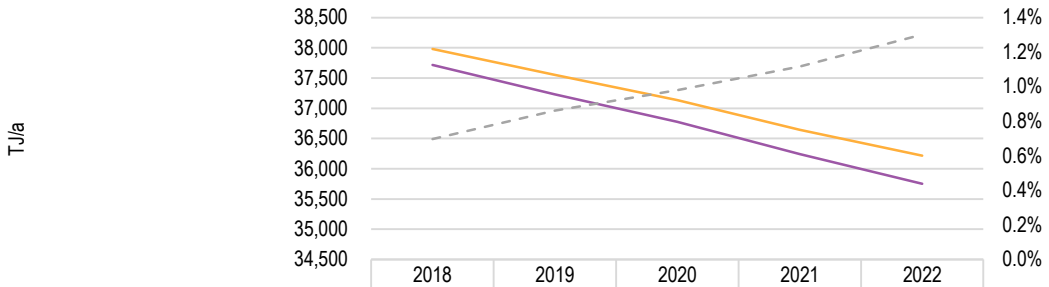
Existing*Re +GrossNew*Rn

where Re and Rn are the average gas use per connection for existing and new connections respectively.

Assuming that the values for Existing, Re and Rn remain the same, adoption of the ACIF values for GrossNew results in residential demand forecasts that are 0.6% higher than NIEIR in 2018, and end up 1.2% higher by 2022.

On this basis, we consider that the NIEIR forecasts of customer number connections should not be accepted. Multinet should be required to submit revised forecasts for Tariff V customer numbers based on the ACIF data and consistent with the connection forecasts used by Multinet for capex forecasting purposes.

FIGURE 4.1 COMPARISON OF RESIDENTIAL DEMAND FORECASTS BASED ON NIEIR AND ACIF CONNECTION FORECASTS



	2018	2019	2020	2021	2022
Residential Total Demand - NIEIR Gross New "AS PRESENTED"	37,715	37,231	36,777	36,241	35,748
Residential Total Demand - ACIF Gross New	37,978	37,552	37,137	36,646	36,213
% difference ACIF vs NIEIR	0.7%	0.9%	1.0%	1.1%	1.3%

SOURCE: ACIL ALLEN ANALYSIS

Residential gas consumption projection

Multinet and NIEIR's provides little information on the way that residential consumption (per connection) was forecast. NIEIR's report says that:

> *Residential sales were forecast using an end-use type modelling approach. Average gas usages of new and existing customers were modelled separately.*
>
> *(NIEIR, 2016a, p. 38)*

However, the reports provide no meaningful information as to *how* this was done.

The spreadsheet entitled "*Multinet Gas - 9.3 - NIEIR - Gas projection models for Volumes 1 and 2 - Gas Projection Model_Tariff V Melbourne – 20161221*" shows a mechanism for projecting consumption per connection which is applied separately to existing and new connections. Under this mechanism, annual consumption per customer is a function of real household disposable income, household gas price, climate change and policy responses. The policy responses are 'hard coded' in the spreadsheet, but appear to relate to Minimum Energy Performance Standards for water and space heating as well as unspecified 'behavioural policy responses'.

We have interpreted the 'climate change' component as relating to space heating, which is a key use for gas that is reflected in NIEIR's forecasts for both new and existing customers. Broadly, according to NIEIR's report, the projected gas use of:

- *All* customers reflects a projected decline in the demand for gas for heating, which is expressed as a decline in the number of Effective Degree Days (EDD).
- *New* customers reflects (in addition) the increasing use of electricity as a fuel for space heating, which is linked to the ongoing uptake of reverse cycle air conditioners. NIEIR argues that this is especially important in Multinet's area given that most of it is already built up, so new customers are typically 'urban infill' type customers. However, no information is provided regarding the basis for this view.

However, the results in the 'Gas projection model' differ from the corresponding values in 'detailed volumes' spreadsheet also provided as part of the access arrangement information. The difference is small, but the 'detailed volumes' spreadsheet corresponds to NIEIR's report while the 'Gas Projections' model values are close to those derived from the RIN customer numbers and gas volumes. This appears to be a result of adjustments made to take into account the proposed Joint Marketing Campaign, as shown in Table 9-7 of the Access Arrangement Information. The customer numbers shown in the RIN differ from those shown in the NIEIR report because unlike NIEIR, the RIN has included the impacts of the proposed Joint Marketing Campaign (increasing both customer

numbers and, to a greater extent, gas volumes, and therefore implicitly increasing the average consumption per customer).

There is no information provided that allows us to examine and assess the basis of the policy adjustments, and in particular the 'behavioural policy response' adjustment for which no explanation seems to have been provided.

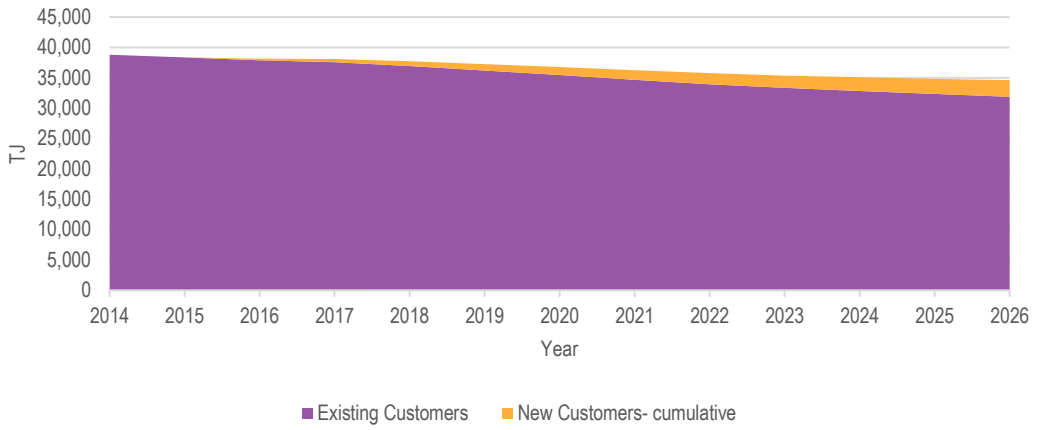
The information provided does not allow us to critically assess how the "average use per customer" forecasts for existing and new customers were derived, only to see the results and to consider the forecasts themselves which we are told (Multinet Gas, 2016, p. 35) are "based on average consumption for new and existing customers and customer growth".

We consider the volume forecasts in the next section.

Aggregate residential forecasts

Figure 4.2 shows Multinet's aggregate volume forecasts for residential customers, depicting consumption by new and existing customers separately.

FIGURE 4.2 MULTINET – PROJECTED RESIDENTIAL GAS CONSUMPTION



SOURCE: ACIL ALLEN ANALYSIS OF DATA SUPPLIED BY MULTINET

As discussed above, the NIEIR forecast of residential gas consumption cannot be accepted because it is based on customer connection number forecasts which are, according to Multinet, too low.

In accordance with the recommendation that Multinet should be required to adopt residential customer connection forecasts consistent with the AFIC-based forecasts used for purposes of determining capex requirements, Multinet should also be required to submit revised forecasts for Tariff V demand based on the ACIF customer connection numbers.

4.4.2 Joint Marketing Campaign

The three distribution businesses (Multinet, AusNet, AGN,) 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 14.3 in the Multinet Access Arrangement Information provides a more detailed analysis of the projected decline (Axiom Economics, 2016).

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.

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 Multinet demand forecast

The study by Axiom Economics (Axiom Economics, 2016) considers the additional costs and revenues associated with the joint marketing campaign.

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 Multinet's demand projections for the next access arrangement period assume that, in the absence of the proposed marketing campaign, annual residential and small commercial demand could fall by around 1.4 per cent per year, from 43.0 PJ per year to 40.1 PJ per year. Over the five-

year term of the access arrangement period, this implies that demand would be about 8.3 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 Multinet's network is expected to be 1.4 PJ higher over the access arrangement 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 access arrangement period, but it would offset about 17 per cent of it.

Axiom Economics estimates that the joint marketing campaign would lead to an increase of about 281 connections per year (on average) over the access arrangement period. This represents an average increase of 0.12 per cent above NIEIR'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 NIEIR forecast residential customer numbers without the marketing allowance, whilst the 'AAI marketing' row shows the forecast with the marketing allowance (as set out in the Multinet AAI Table 9.7, p.37). All incremental demand is assumed to come from residential customers. **Table 4.6** summarises the forecast impacts of the proposed marketing campaign on residential customer numbers in the Multinet service area.

TABLE 4.6 COMPARISON OF RESIDENTIAL CONNECTION NUMBER FORECASTS

Region	Source	2018	2019	2020	2021	2022
	Base (NIEIR)	684,783	688,279	691,752	695,209	698,507
	AAI Marketing	685,064	688,840	692,594	696,332	699,910
	RIN (31 December)	685,064	688,840	692,594	696,332	699,910
	% diff Marketing to Base	0.04%	0.08%	0.12%	0.16%	0.20%

Source: (NIEIR, 2016a), Multinet Access Arrangement Information Table 9.7; Multinet GAAR 2018-22 Regulatory Information Notice, Tab 27.

Also shown in **Table 4.6** are the residential customer numbers as reported in the Multinet Regulatory Information Notice (RIN, Table 27). The RIN forecast numbers the same as the "with marketing" numbers reported in the AAI Table 9.7.

As shown in **Table 4.7**, 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 9-7 of the AAI summarises residential consumption with and without 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 9-7; they therefore include the impacts of the marketing proposal.

TABLE 4.7 COMPARISON OF RESIDENTIAL CONSUMPTION FORECASTS (TJ)

Region	Source	2018	2019	2020	2021	2022
TOTAL	Base (NIEIR)	37,715	37,231	36,777	36,241	35,748
	AAI Marketing	37,810	37,421	37,061	36,620	36,222
	RIN (31 December)	37,810	37,421	37,061	36,620	36,222
	% diff Marketing to Base	0.25%	0.51%	0.77%	1.05%	1.33%

Source: (NIEIR, 2016a), Multinet Access Arrangement Information Table 9.7; Multinet GAAR 2018-22 Regulatory Information Notice, Tab 28.

4.4.3 Tariff V business customers

According to NIEIR, Business Tariff V gas consumption represented around 1.0 per cent of total Multinet sales volumes in 2015. Forecast growth over the 2016 to 2026 period is -1.8 per cent per year.

The information provided about the way NIEIR estimated gas consumption by tariff V business customers is more limited than the description about tariff D customers. NIEIR's report says that, in relation to tariff V business customers:

- it received 8 years of consumption data
- it did not consider this to be enough data to justify developing a model
- therefore, it relied on "an existing commercial equation estimated previously using Department of Industry, Innovation and Science energy consumption data for Victoria"[6] which uses commercial output and real gas prices to drive tariff V business gas consumption forecasts.

Beyond this, there is no information to describe the basis on which these forecasts were prepared. In particular, it is our view that an oblique reference to "an existing…equation" cannot be interpreted as a meaningful description of the basis of the forecasts.

In response to Information Request No.13 Multinet described this equation and, briefly, the data sources and analytical techniques upon which it was based. It also confirmed that the 'commercial output' driver is intended as a reference to NIEIR's forecast of economic activity in Multinet's area, which causes the tariff V business forecasts to align conceptually with the tariff D forecasts.

Multinet advised that:

> *"NIEIR's commercial gas equation is estimated on an annual basis at the Victorian state level of gas demand. This is a high level equation that was used to inform the parametrisation of the Multinet Gas region equations of gas demand by industry class (for the commercial sectors). The equation has also been constrained to reflect a literature review of related Australian and international gas demand studies.*
> *The proprietary NIEIR commercial equation used for the Multinet Gas forecasts was derived using OLS and linear programming techniques in 2016 …"*
>
> *(Multinet, response to Information Request No. 13)*

This description of the equation is followed by a table of coefficients and variables and a general statement of data sources, which are either NIEIR, the Australian Bureau of Statistics or the Bureau of Meteorology.

The equation considers:

- weather, using the EDD_{312} approach
- gas prices, with a lagged structure that takes account of changes in the current year as well as the previous three years[7]
- electricity price.

The sign and magnitude of the coefficients on gas and electricity prices are consistent with theory as summarised, for example, NIEIR's literature review of this issue (see section 4.3.3).

The equation also takes account of Victorian commercial output using NIEIR's projection of output in the following sectors:[8]

- wholesale trade
- retail trade
- transport and storage
- communication
- finance

[6] NIEIR energy report, p. 39.
[7] We assume that the model was estimated annually – it is possible that it relates to other time periods. This is not important for present purposes.
[8] While the materials do not make this explicit, it appears that NIEIR's analysis is based on the 1993 ANZSIC classification rather than the 2006 update.

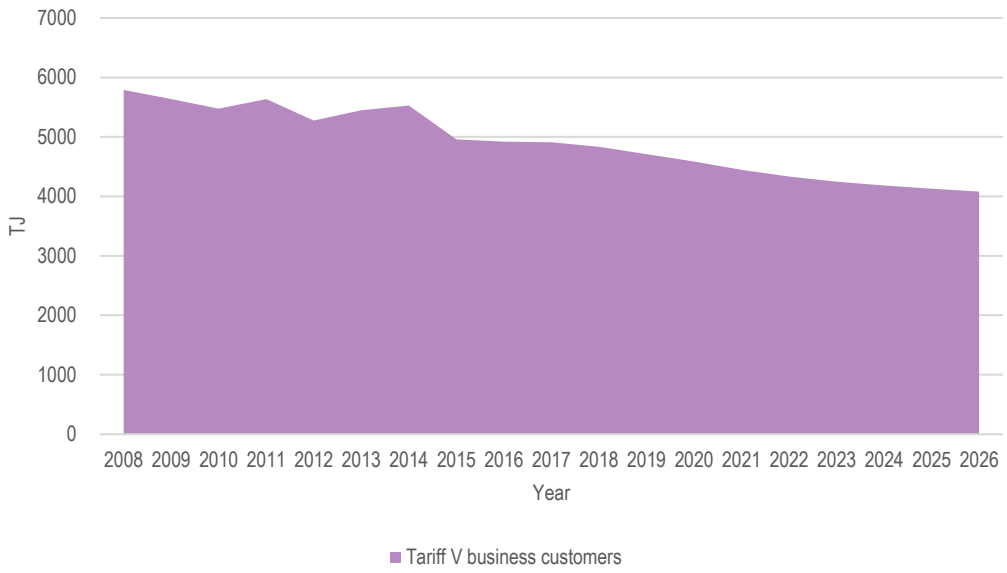
— property and business services
— cultural and recreation
— personal and other services.

The equation takes account of economic activity in the current year as well as the previous year. The coefficient on the previous year has a negative sign. While this is not entirely intuitive, is it not necessarily a problem.

While the above information allows us to conclude that the "commercial equation" used by NIEIR to estimate Tariff V business gas consumption takes into account a range of factors that might reasonably be expected to influence tariff V business demand we have no information to allow us to draw a firm conclusion as to the reasonableness or otherwise of NIEIR's 'commercial equation'. Specifically, the information available does not extend to conventional diagnostic statistics that would normally be used to evaluate the performance a model estimated using Ordinary Least Squares regression (as Multinet says this model was estimated).

The forecasts themselves are shown in **Figure 4.3**.

FIGURE 4.3 MULTINET GAS – CONSUMPTION FORECASTS - TARIFF V BUSINESS



SOURCE: ACIL ALLEN ANALYSIS OF DATA SUPPLIE DBY MULTINET

Table 4.8 shows the recent and projected growth rates. In this case Multinet expects an acceleration in the rate of decline of tariff V business gas consumption, followed by a slowing of the rate of decline in later years. This is broadly consistent with the recovery forecast in the commercial sectors of Tariff D.

4.4.4 Tariff D industrial customers

Multinet's large industrial customers include two tariff classifications:

— Tariff D defined as customers using more than 10,000 GJ a year (10 TJ/a) or more than 10GJ MHQ
— Tariff L defined as customers using more than 1TJ/a but less than 10TJ/a and having MHQ demand of less than 10GJ per hour.

NIEIR has produced separate forecasts for Tariff D and Tariff L gas consumption. However, as previously indicated Tariff L customers comprise an insignificant proportion of Multinet's overall gas demand and revenue base. For this reason we do not give any specific consideration to Tariff L demand forecasts in this report.

Tariff D gas consumption

NIEIR's approach to forecasting gas consumption by Tariff D customers is based on energy (gas in this case) being an input to production and therefore economic activity.

Broadly, NIEIR forecasts economic activity in Multinet's distribution region and uses that estimate to produce forecasts of the gas needed to support that activity.

To do this, NIEIR obtained consumption data for individual Tariff D customers. It then categorised those customers using the ANZSIC industry classification system and used postcode data to assign customers to tariff zones.

NIEIR's model of economic activity in Multinet's region provides forecasts of growth in the activity of each sector. Coupled with estimates of the relationship between economic activity in each sector and gas consumption, the model provides forecasts of gas consumption. That is, NIEIR estimates changes in the economic activity in Multinet's area on a sectoral basis. It then uses these estimates, through an output elasticity, to produce forecasts of gas consumption by Tariff D customers in the same area.

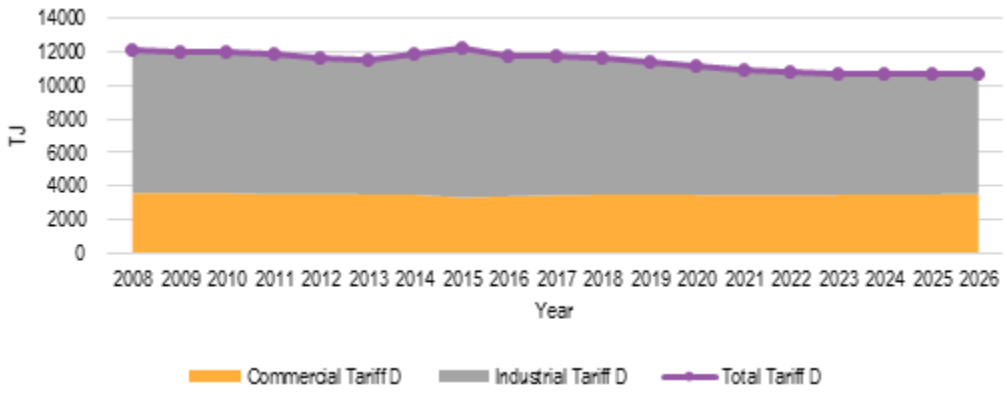
These 'economic model' forecasts are considered in light of a survey of Tariff D customers, conducted by NIEIR in 2016. The results of the survey are taken into account through a post-modelling adjustment. The rationale for this approach is that the economic modelling approach will tend to overlook large changes in consumption that may occur when the circumstances of an individual customer change significantly. A good example would be the closure of a car manufacturing operation.

In the current context, with a relatively small number of large users, missing a key change would be problematic for the forecasts. We therefore regard use of survey techniques as an appropriate supplement to the economic modelling approach. To this end, Multinet surveyed its top 30 Tariff D customers, who collectively account for approximately one-third of Multinet's Tariff D gas consumption and a little over 20 per cent of Tariff D maximum hourly quantity. Around one-third of those customers responded to the survey. The respondents were at the 'larger end' of the survey and together account for almost 30 per cent of Multinet's Tariff D consumption.[9]

The Tariff D forecasts for gas consumption are summarised in **Figure 4.4**. The forecasts are in two parts: Industrial and Commercial. Both parts consists of multiple sectors shown in **Figure 4.5** and **Figure 4.6** respectively.

Tariff D gas consumption is projected to decline over the regulatory period. The rates of decline vary by industry sector, with the most rapid fall being -6.82 per cent per year in the textiles, clothing and footwear sector. Growth is forecast in several of the commercial sectors, with the most rapid being 0.83 per cent per year in Finance, Insurance, Property and Business services (which includes cogeneration).

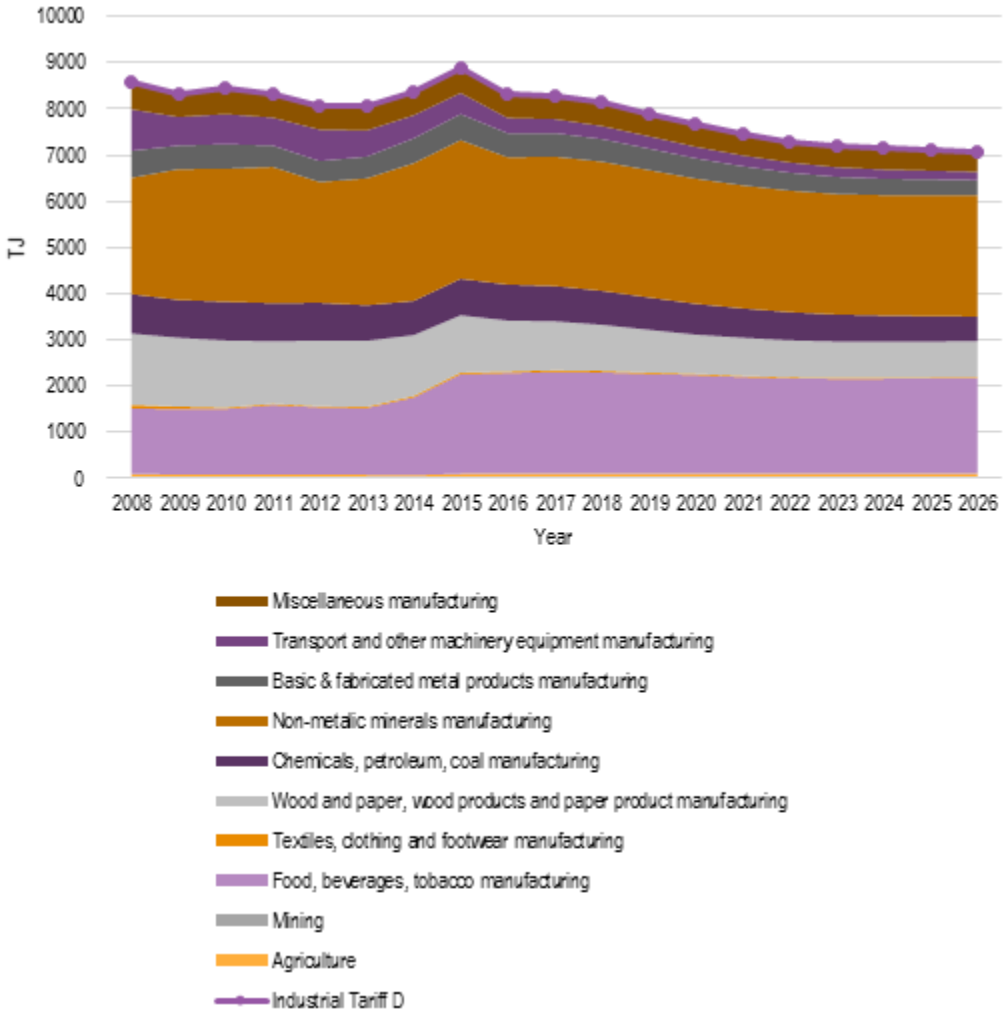
FIGURE 4.4 MULTINET GAS - TARIFF D ANNUAL GAS CONSUMPTION – HISTORICAL AND FORECAST



[9] The customers who responded to the survey are identified in Multinet's response to information request #13.

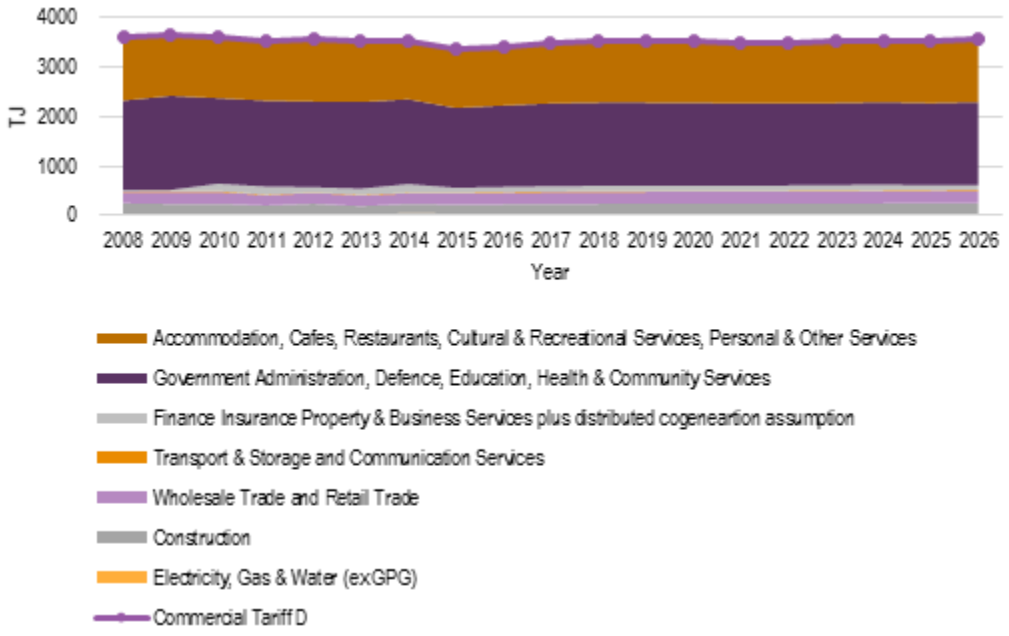
SOURCE: ACIL ALLEN CONSULTING COMPILATION OF DATA FROM (NIEIR, 2016A)

FIGURE 4.5 INDUSTRIAL TARIFF D: ANNUAL GAS DEMAND BY INDUSTRY SECTOR



SOURCE: ACIL ALLEN CONSULTING COMPILATION OF DATA FROM (NIEIR, 2016A)

FIGURE 4.6 COMMERCIAL TARIFF D: ANNUAL GAS DEMAND BY INDUSTRY SECTOR



SOURCE: ACIL ALLEN CONSULTING COMPILATION OF DATA FROM (NIEIR, 2016A)

Table 4.1 shows growth rates in the current regulatory period and projected growth in the next regulatory period for each of the ANZSIC sectors within Multinet's Tariff D customer group. The third column shows the extent to which the decline in consumption is projected to increase or decrease: negative numbers mean a faster decline or slower increase in the next regulatory period than has been observed recently. Conversely, positive numbers mean a slower decline or faster increase in the next regulatory period.

The table highlights the fact that NIEIR is forecasting increased rates of decline in gas consumption in most Tariff D sectors.

TABLE 4.8 HISTORICAL AND FORECAST RATES OF CHANGE IN TARIFF D GAS CONSUMPTION, BY INDUSTRY SECTOR

Heading	2011 – 2016	2017 - 2021	Change in rate
Total Tariff D	0.44%	-1.90%	-2.34%
Commercial Tariff D	-0.34%	-0.15%	0.19%
Electricity, Gas & Water (ex GPG) [a]	41.74%	-0.97%	-42.71%
Construction	2.01%	0.76%	-1.25%
Wholesale Trade and Retail Trade	1.88%	0.05%	-1.83%
Transport & Storage and Communication Services	11.50%	0.23%	-11.27%
Finance Insurance Property & Business Services plus distributed cogeneration assumption	-3.51%	0.83%	4.35%
Government Administration, Defense, Education, Health & Community Services	-1.10%	-0.42%	0.68%
Accommodation, Cafes, Restaurants, Cultural & Recreational Services, Personal & Other Services	-0.41%	-0.04%	0.37%
Industrial Tariff D	0.78%	-2.69%	-3.47%
Agriculture	7.10%	-0.30%	-7.40%

Heading		2011 – 2016	2017 - 2021	Change in rate
	Food, beverages, tobacco manufacturing	11.07%	-1.49%	-12.56%
	Textiles, clothing and footwear manufacturing	5.78%	-6.82%	-12.60%
	Wood and paper, wood products and paper product manufacturing	-7.13%	-5.35%	1.77%
	Chemicals, petroleum, coal manufacturing	-0.18%	-4.63%	-4.44%
	Non-metallic minerals manufacturing	0.49%	-1.51%	-2.00%
	Basic & fabricated metal products manufacturing	2.07%	-5.47%	-7.54%
	Transport and other machinery equipment manufacturing	-14.63%	-6.33%	8.30%
	Miscellaneous manufacturing	0.46%	-2.58%	-3.04%

[a] no gas consumption was reported in the electricity, gas & water category in the historical period.

SOURCE: ACIL ALLEN ANALYSIS OF DATA SUPPLIED BY MULTINET

Tariff D peak demand

For purposes of economic regulation, the most important measure of demand from industrial customers (Tariff D) is **peak demand**, measured on the basis of maximum hourly quantities (MHQ). This is the basis on which Tariff D customers are charged, and also the best measure of the demands which these large customers place on the capacity of the pipeline system. Because Tariff D customers are not levied a fixed charge, forecasting the number of these customers and their total gas consumption in the forthcoming access arrangement period is not important for purposes of tariff setting and revenue calculation. There is no expenditure associated with connecting new Tariff D customers that is not funded by the customers themselves.

Methodology for projecting Tariff D peak demand

NIEIR's approach to forecasting of peak day and peak hour gas demand for Multinet is described in (NIEIR, 2016b).

NIEIR describes that the forecasts for Tariff D for volumes, customers and maximum hourly quantity were prepared on an industry basis. Tariff D for each business was modelled on the basis of actual Tariff D usage plus losses. NIEIR obtained individual Tariff D customer data from Multinet Gas. These customers were then ANZSIC or industry coded. In some cases, NIEIR drew on previous work in this area for AEMO and the individual businesses. Where zone based data was required, postcode identifiers were used to allocate Tariff D customers to each pricing zone.

Projections of maximum hourly quantity (MHQ) for Multinet were also derived on an industry basis, with the projections of MHQ linked to **energy growth** by industry and a **load factor** by industry.

NIEIR's model of peak demand considers two components, namely:

— weather insensitive demand

— weather sensitive demand.

The following is a summary of the method used by NIEIR to estimate peak day and peak hour for the system as a whole (separately including Tariff V and Tariff D demand).

— Regression models for peak day are developed for the Melbourne region Tariff V and Tariff D with the historical 1-in-2 and 1-in-20 level peak day demands.

— These equations are refitted with peak day weather standards using the 1-in-2 and 1-in-20 coldest day EDD standards.

— Forward estimates of intercept and coefficients of these equations are the key drivers of the peak demand projections. These parameters are linked to NIEIRs volume forecasts, which are in turn driven by NIEIRs economic and industrial outlook for Victoria and the Multinet distribution area; policy and technology outlook; and prices.

— Forecast weather standards for the 1-in-2 and 1-in-20 coldest day EDDs are also key inputs of future gas demand.

Daily gas demand equations for Tariff D were taken directly from the annual weather normalisation equations, as reported in the volumes forecasts.

Peak demand projections are often presented as a probability distribution of possible peak demand levels. Consistent with the regulatory regime, NIEIR has used historical MHQ based on 1-in-2 and 1-in-20 level peak day demands as the starting points for its MHQ forecast for Tariff D customers.

To obtain these historical MHQ levels, NIEIR has conducted regression analysis of daily MHQ on daily weather (EDD) measures at 1-in-2 and 1-in-20 standards. Indicators for weekends, Friday, Monday and public holidays are also included as explanatory variables to account for industrial activity being substantially different during these times compared to normal working days. The fitted values implied by these regressions then form the 1-in-2 and 1-in-20 level MHQ for each year from 2008 to 2015.

To forecast MHQ, NIEIR has used econometric models to establish a relationship between historical MHQ and output growth by ANZSIC code.

The results of these models were supplemented with data from a survey of Multinet's 30 largest customers (NIEIR, 2016a, p. 50). Post modelling adjustments were made for anticipated changes in future loads based on the results of this survey.

Data

The primary data sets used by NIEIR to forecast MDQ and MHQ were:

— daily gas demand for Tariff V and Tariff D customers back to 2001 for the Melbourne System Withdrawal Zone (Melbourne SWZ) and South Gippsland regions

— hourly and daily gas demand for Melbourne total system withdrawals, Melbourne Tariff D and South Gippsland total withdrawals and South Gippsland Tariff D from 2007 to early 2016.

NIEIR independently obtained weather data from the Bureau of Meteorology to develop the Effective Degree Day 312 Index (EDD_{312}). This data includes Melbourne temperature, sunshine hours, and wind speed.

Assessment

The approach taken by NIEIR to assessment of peak demand (MDQ, MHQ) for the Tariff D customer group appears to be comprehensive and methodologically sound.

5 ASSESSMENT OF THE FORECASTS

5.1 Summary of forecast results

Multinet has summarised the key features of the demand forecasts prepared by NIEIR for the period 2018 to 2022 as follows (Multinet Gas, 2016, p. 27):

- Residential customer numbers will grow on average by about 0.5 per cent per year
- Residential gas consumption will decline at about 1.3 per cent per year.
- Tariff V small business customer numbers will decline on average by about 1.0 per cent per year
- Tariff V small business customer consumption will decline at about 2.7 per cent per year.
- For large industrial (Tariff D) customers, total MHQ will fall by about 0.9 per cent per year over the forthcoming Access Arrangement period.

5.2 Assessment of the forecasts

In this section we review the revised forecasts for Multinet, 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.

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 NIEIR 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**. The forecast reflects the customer numbers shown in Multinet's Regulatory Information Notice (RIN) and are slightly higher than those shown in the NIEIR report (Table 7.2). This is because the RIN values include adjustments to account for the anticipated impacts of the proposed Joint Marketing Campaign (see section 4.4.2)

The forecast growth in customer numbers averages 0.5 per cent per year, which is significantly below the historical trend rate of around 0.8 per cent (over the period 2008 to 2015). By 2022 the forecast is around 11,900 or 1.7 per cent lower than the historical trend.

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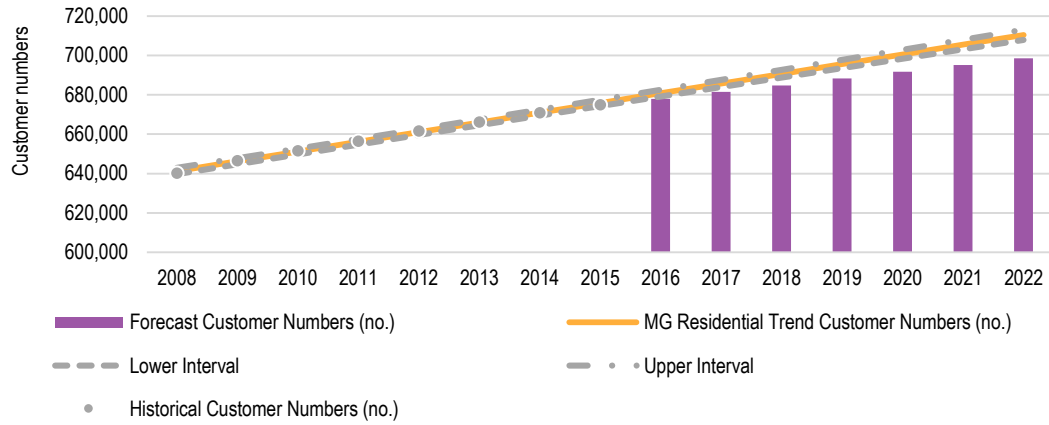
FIGURE 5.1 HISTORICAL AND FORECAST CUSTOMER NUMBERS: TARIFF V RESIDENTIAL



SOURCE: NIEIR 2016; ACIL ALLEN ANALYSIS

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As discussed in section 4.4.1, the NIEIR forecasts of customer numbers are, by Multinet's own admission, too low and are inconsistent with both historical connection outcomes and the customer connection forecasts (based on ACIF data) that have been used by Multinet for purposes of forecasting capital expenditure. Accordingly we recommend that the NIEIR forecasts of customer number connections should not be accepted, and that Multinet should be required to submit revised forecasts for Tariff V customer numbers based on the ACIF data and consistent with the connection forecasts used for capex forecasting purposes.

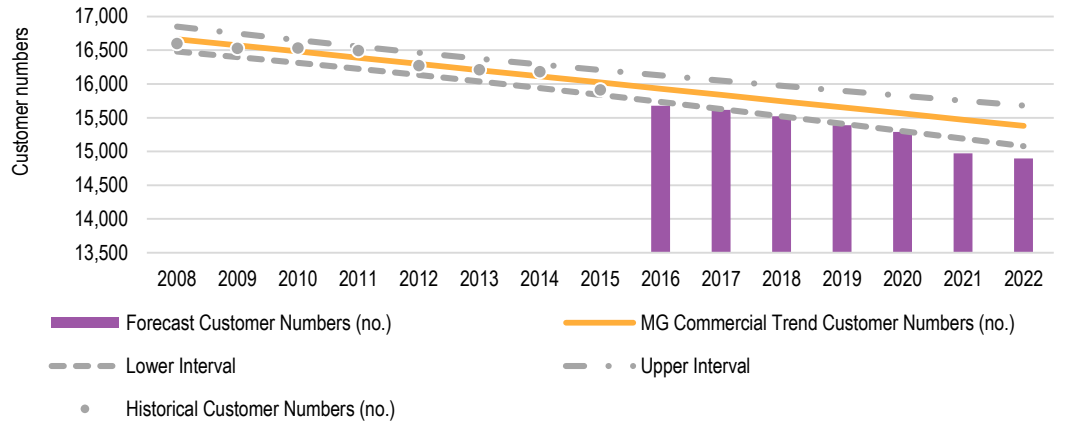
Tariff V Business customer numbers

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

Historically, the downward trend in the number of Tariff V business customers in Multinet's distribution area has been quite different to the situation in the AusNet and AGN areas where Tariff V business customer numbers have been growing.

As shown in **Figure 5.2** Multinet is anticipating a continuation in this downward trend in business customer numbers, at a rate somewhat higher than in the past and with some acceleration of the rate of decline in the last two years of the forecast period.

FIGURE 5.2 HISTORICAL AND FORECAST CUSTOMER NUMBERS: TARIFF V BUSINESS



SOURCE: NIEIR 2016; ACIL ALLEN ANALYSIS

Given the challenges currently facing the retail gas industry in terms of supply, price and competition from electrical appliances, the forecast customer numbers for Tariff V business customer numbers do not appear to be unreasonable.

Tariff V Consumption per Connection

Tariff V Residential Consumption per Connection

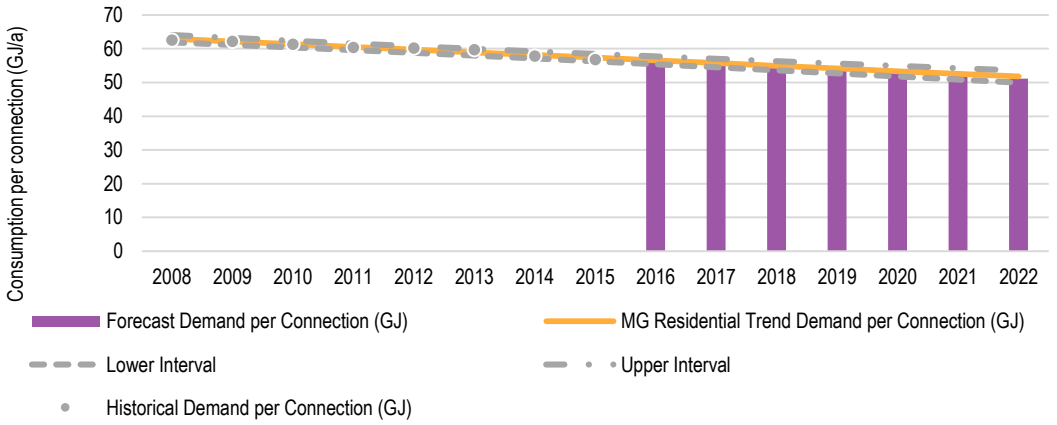
As NIEIR notes[10], residential consumption per connection has been declining steadily in Victoria and average usage in the Multinet Gas region has fallen from 63.0 GJ in 2008 to 56.8 GJ per connection in 2015. NIEIR attributes this fall in gas demand to a number of factors, including:

- improvements in the energy efficiency of new housing stock compared to existing housing stock (that is, new dwellings demand less gas than older dwellings)
- the shift away from detached houses to small townhouses and apartments in the Multinet Gas area
- improvements in appliance efficiencies
- the substitution of electricity for gas in space heating.

The trend rate of decline in average consumption in the Multinet Gas region was –1.4 per cent between 2008 and 2015. Over the review period, 2018 to 2022, a somewhat higher rate of decline is forecast at 1.8 per cent per annum. Average usage falls to 51.2 GJ per connection by 2022.

[10] (NIEIR, 2016a, p. iii).

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



SOURCE: NIEIR 2016; ACIL ALLEN ANALYSIS

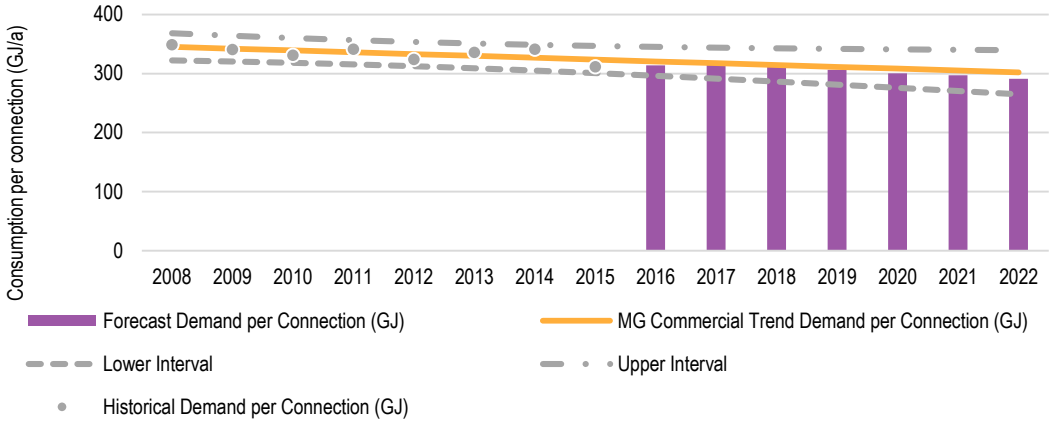
As shown, the forecast for residential demand per connection shows a continued decline at a rate close to the historical decline rate and on this basis does not appear to be unreasonable.

Tariff V Business Consumption per Connection

In the Tariff V Business sector, consumption per connection has declined significantly in Multinet's distribution area, from 349 GJ/year in 2008 to 312 GJ/year in 2015 (weather adjusted)—an average rate of decline of –1.7 per cent per year. This decline is forecast by NIEIR and Multinet to continue at a similar rate of –1.8 per cent per year over the next access arrangement period, with average consumption per business connection falling to 291 GJ/year by 2022.

Figure 5.4 shows the historical and forecast consumption per commercial customer connection. The forecast consumption per business 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 BUSINESS



SOURCE: NIEIR 2016; ACIL ALLEN ANALYSIS

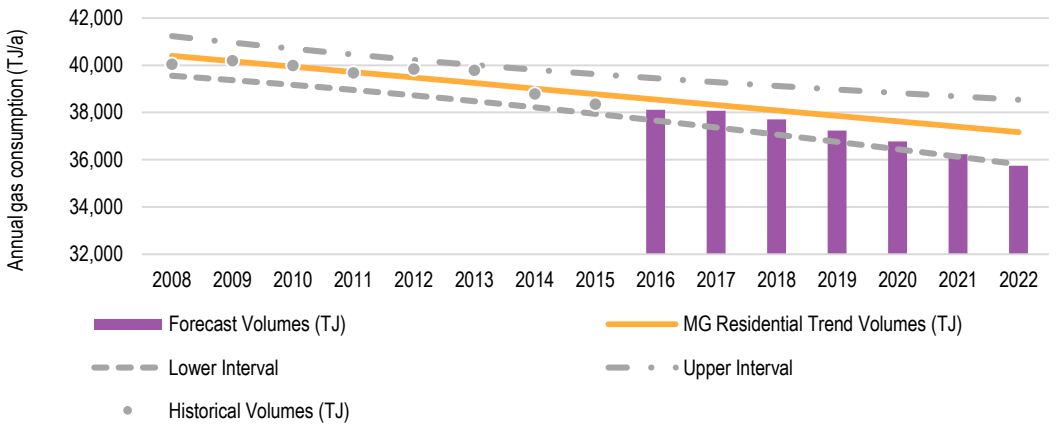
Tariff V Annual Gas Consumption

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 weather normalised and therefore illustrate the underlying trend in consumption. 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**).

It follows from our finding in relation to the NIEIR forecasts of customer connections that the forecasts for Tariff V residential annual consumption are likely to be too low and will need to be recalculated to take account of the revised (increased) connection number forecasts.

FIGURE 5.5 HISTORICAL AND FORECAST ANNUAL CONSUMPTION: TARIFF V RESIDENTIAL



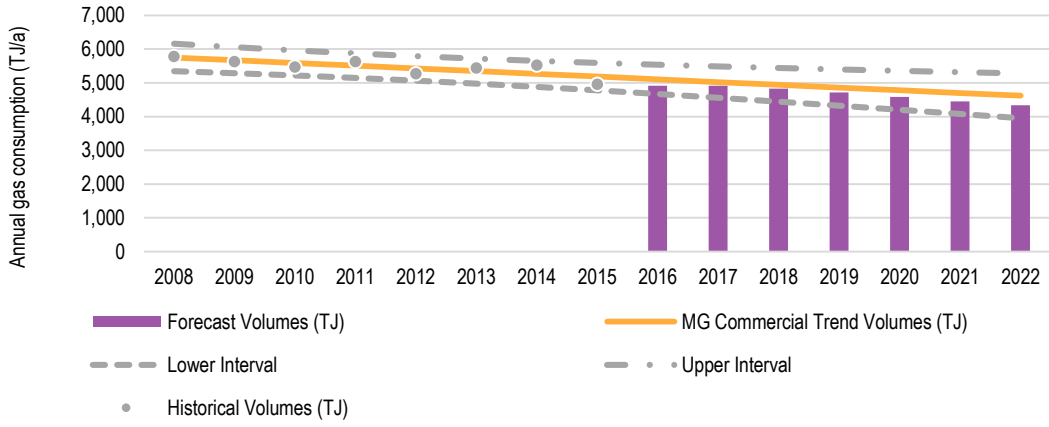
SOURCE: NIEIR 2016; ACIL ALLEN ANALYSIS

Tariff V Business Annual Consumption

Figure 5.6 shows the historical and forecast total annual gas consumption for Tariff V business customers. The historical consumption values shown are weather normalised and therefore illustrate the underlying trend in consumption. 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 business customers is close to the historical trend, declining somewhat over the course of the next access arrangement period consistent with the forecast accelerating decline in business connection numbers. On this basis the forecast does not appear to be unreasonable.

FIGURE 5.6 HISTORICAL AND FORECAST ANNUAL CONSUMPTION: TARIFF V BUSINESS



SOURCE: NIEIR 2016; ACIL ALLEN ANALYSIS

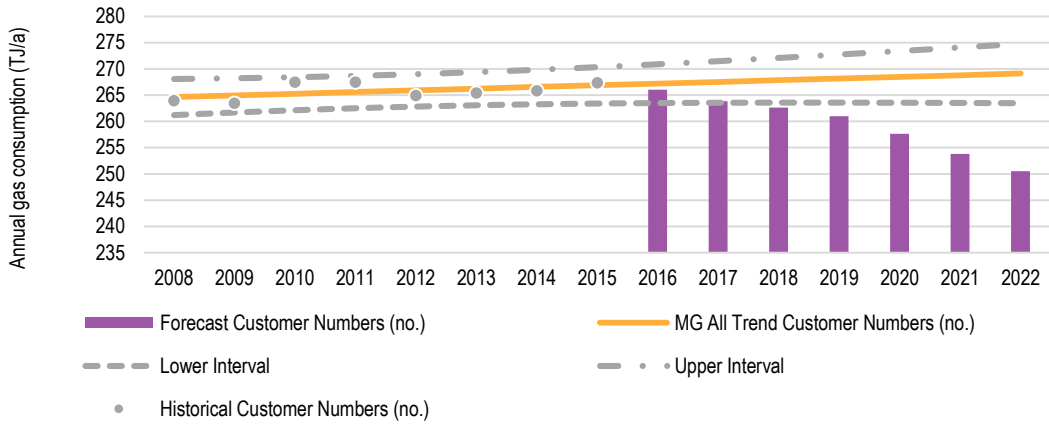
5.2.3 Industrial Tariff D History and Forecasts

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

Tariff D Customer Numbers

The forecast of total customer numbers for the Tariff D 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



SOURCE: NIEIR 2016; ACIL ALLEN ANALYSIS

As discussed in section 4.4.4, demand from industrial customers (Tariff D) 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 customers are not levied a fixed charge and any expenditure associated with connecting new Tariff D customers is funded by the customers themselves. Nevertheless, the NIEIR Report and Multinet RIN provide information on historical and forecast industrial customer numbers and so, for purposes of completeness, we have included an assessment of these forecasts.

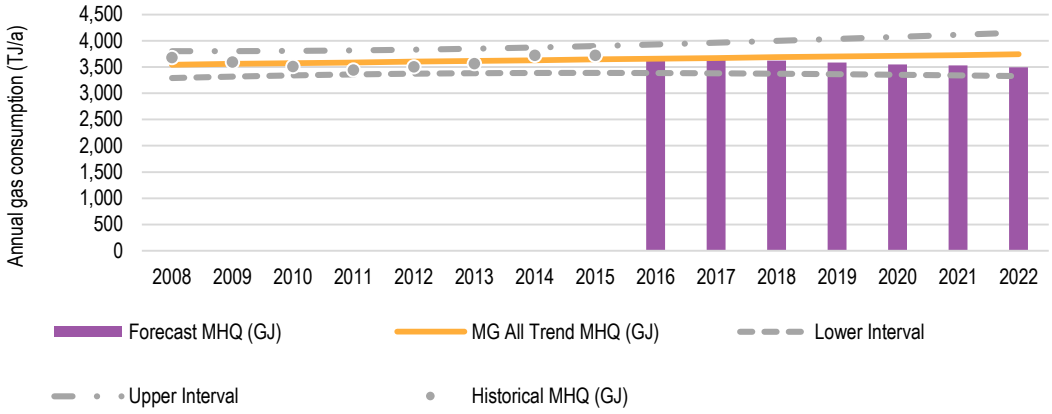
As shown in **Figure 5.7** the forecast for Tariff D customer numbers shows a decline rate somewhat lower than in the past, below the upper bound of the confidence interval around the historical trend

line. This reflects an expectation that a number of existing industrial connections will close over the forthcoming access arrangement period. Given the well-publicised challenges currently being faced by industrial gas customers in securing gas supply arrangements on viable terms, the forecast does not appear to be unreasonable.

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**. The basis for the large industrial MDQ forecast is discussed in section 4.4.4. The resulting forecast shows a small decline in MHQ over the forecast period, whereas the historical data shows a slight upward trend. However, given the high degree of variability in individual load characteristics across the large industrial connection group, the differences are not considered to be significant. The forecast lies within the bounds of the confidence interval around the historical trend.

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



SOURCE: NIEIR 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. Multinet and NIEIR have taken into consideration any such changes that have been foreshadowed through the large customer survey process and the forecasts take these factors into account.

On this basis we consider the forecasts of large industrial MHQ for Multinet 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 a somewhat lower rate than in the past. The reduction in growth of customer numbers is consistent with trends anticipated by the other Victorian distribution businesses, but shows lower overall growth reflecting both the relatively "mature" demographic nature of the Multinet distribution area (with few new housing areas and greater reliance on urban infill) and the expected reduction in marginal penetration rates and consumers increasingly choose electrical appliances over gas appliances. The forecast rate of growth in residential Tariff V customer numbers is significantly lower than the corresponding forecast of new residential connection numbers, based on ACIF data, used by Multinet for its capital expenditure projections. Multinet (in response to an AER Information Request) has stated that "NIEIR's forecast is not consistent with historic actual connections ... NIEIR data was not considered to be an accurate forecast by MG." On this basis we consider that the NIEIR forecast of residential connection numbers should be rejected and Multinet should be required to amend the forecast, aligning it with the forecasts used in the capital expenditure projections. This adjustment will require consequential changes to the forecasts of total consumption in the residential Tariff V sector.

For non-residential (business) Tariff V customers, connection numbers are forecast to continue on a historical downward trend, at a rate somewhat higher than in the past and with some acceleration of the rate of decline in the last two years of the forecast period. Given the challenges currently facing the retail gas industry in terms of supply, price and competition from electrical appliances, the forecast customer numbers for Tariff V business customer numbers do not appear to be unreasonable. 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 somewhat higher rates than in the past. For commercial Tariff V customers, average consumption per connection is forecast to continue to decline at rates very close to historical trends. We conclude that the Tariff V consumption per connection forecasts are not unreasonable.

As noted above, the forecasts of Tariff V residential annual gas consumption will need to be amended to take account of the higher forecast of new customer connections.

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 Multinet Tariff D customers shows a slight increase from about 3,680 GJ/h in 2008 to 3,730 GJ/h in 2015, but with rates as low as 3,450 GJ/h in intervening years. The forecasts lie slightly below the historical trend, falling to 3,330 GJ/h by 2022. On this basis, the forecast levels of MHQ for Multinet 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:

7. information in the nature of a forecast or estimate must be supported by a statement of the basis of the forecast or estimate.
8. 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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